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Evaluation of the Captive Breeding Potential of Selected Amphibian and Reptile Taxa Included in Appendices I and II at CITES CoP18

Federal Agency for Nature Conservation

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Results of the identical F+E-project (FKZ: 3520 53 2054)

Christian Langner
Beate Pfau
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Cover picture: From top left to bottom right: *Ceratophora stoddartii* (F. Hulbert); *Pseudocerastes urarachnoides* (S. Scholz); *Goniurosaurus luii* (M. van Schingen-Khan); *Cuora picturata* (B. Pfau); *Cachryx defensor* (C. Langner); *Tylototriton ziegleri* (M. Bernardes)

Authors adresses:

Christian Langner — Allwetterzoo Münster, Altätte 23, 48727 Billerbeck, E-Mail: langner@allwetterzoo.de

Dr. Beate Pfau — Rathenaustrasse 14, 65326 Aarbergen, E-Mail: pfau@dght.de

Marta Bernardes — c/o Kölner Zoo, Riehler Straße 17, 50735 Köln, E-Mail: mrtbernardes@gmail.com

Dr. Uwe Gerlach — Im Heideck 30, 65795 Hattersheim, E-Mail: duamger@yahoo.de

Felix Hulbert — Wörthstraße 29, 65343 Eltville am Rhein, E-Mail: felix.hulbert@t-online.de

Dr. Mona van Schingen-Khan, Ulrich Schepp — Federal Agency for Nature Conservation (BfN), Konstantinstraße 110, 53179 Bonn, E-Mail: mona.van.schingen-khan@bfn.de, ulrich.schepp@bfn.de

Dr. Clara Arranz — Im Saffergarten 1, 79730 Murg Niederhof, E-Mail: clara.arranz.10@gmail.com

Mario Riedling — Türmle 2, 75031 Eppingen, E-Mail: mario.riedling@freenet.de

Dr. Axel Kwet — Managing Director DGHT, Deutsche Gesellschaft für Herpetologie und Terrarienkunde e. V., Vogelsang 27, 31020 Salzhemmendorf, E-Mail: kwet@dght.de

Scientific Supervision at BfN:

Dr. Mona van Schingen-Khan — Division II 1.1 „Wildlife Conservation“

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Contents

Abbreviations

Abbreviation	Explanation
AAZA	American Zoo & Aquarium Association.
asl	Above sea level.
ATP/IMC	Asian Turtle Program/ Indo-Myanmar Conservation.
BArtSchV	In German: Bundesartenschutzverordnung. Federal Species Protection Regulations.
BfN	Bundesamt für Naturschutz, German Federal Agency for Nature Conservation
BMEL	Federal Ministry of Food and Agriculture [Bundesministerium für Ernährung und Landwirtschaft], editor of the guideline “Mindestanforderungen an die Haltung von Reptilien”.
BNatschG	In German: Bundesnaturschutzgesetz. Federal Nature Conservation Act in the version promulgated on 06 August 2009 (Federal Law Gazette [Bundesgesetzblatt] I page 2542).
CB	“Captive Bred”, an animal that was born or hatched in captivity.
CL	Carapacial length, length of the chelonian shell measured in straight line.
DGHT	Deutsche Gesellschaft für Herpetologie and Terrarienkunde – German Society for Herpetology and Herpetoculture.
EAZA	European Association of Zoos and Aquaria.
ESF	European Studbook Foundation.
F1, F2	First or second offspring generation (= filial generation).
IUCN	International Union for Conservation of Nature.
IZS	International Center for the Conservation of Asian Turtles in Münster Zoo, Germany [Internationales Zentrum für Schildkrötenschutz, Zoo Münster].
s.l./ s.str.	Sensu lato/ sensu stricto. Sensu is used in the taxonomy of living creatures to specify which circumscription of a given taxon is meant, where more than one circumscription can be defined. Sensu lato (“in the broad sense”) used when referring to more than one valid taxon, sensu stricto (“in the strict sense”) refers to the one taxon out of a taxon group, mostly to the nominate form.
SD	Sex determination – TSD: Temperature dependent sex determination/ GSD: Genetic sex determination.
SVL	Snout-vent length
TL	Total Length
TSD	Temperature-dependent sex determination (Review in Pieau 1996).
WC	Wild caught animal.

Preface

The European Union (EU) is one of the global major importers of living reptiles, as well as their parts and products (such as leather). Additionally, Germany is a main transit country in the reptile trade within the EU and therefore has a high responsibility for the conservation of traded species.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species affected by it. Whereas in the past mainly wild caught specimens were traded, currently more than 83% of traded reptiles and amphibians are claimed to be not of wild source. However, in some cases the source codes are highly questionable. While legal trade in captive bred specimens may contribute to species conservation, trade in wild specimens falsely labelled to be captive bred in order to circumvent trade restrictions, can be highly detrimental to wild population.

As such, the verification of the captive breeding of specimens in trade poses an increasing challenge to national and international CITES authorities and became of increasing significance for the work of international bodies of the convention. In order to check the plausibility of captive breeding, comprehensive information on the reproduction biology and husbandry requirements of the relevant species are crucial. However, especially for species that are rarely kept in captivity, newly listed in CITES, newly described to science or poorly studied, such relevant data may be lacking or not accessible. In Germany, there are numerous specialist keepers who have great experience in keeping and breeding of rare reptile and amphibian taxa, but in many cases the relevant data and experience remain unpublished.

The German Society of Herpetology and Herpetoculture (DGHT) was commissioned to compile relevant reproduction data for those reptile and amphibian taxa, which were included or uplisted in the CITES Appendices I and II at the previous CITES CoP18. Data was obtained from private keepers, commercial traders, zoological institutions and literature and – in addition to own expertise – used to develop the present guidance.

This guidance aims to assist CITES authorities in carrying out the plausibility check for the captive breeding of certain species and to improve the implementation of the CITES convention. In addition, the information provided herein can be used e.g., for conservation breeding programs or by scientists.

Sabine Riewenherm

President of the Federal Agency for Nature Conservation

Aims of the project

Germany ranks amongst the major importers of live reptiles for the pet industry, both within the EU and on a global scale. Considering the significance of this trade and its inherent intricacies (e.g., regarding correct taxa identification, implementation of appropriate legal measures), one particular, but widely frequent problem can be identified: The use of fake certificates of origin, declaring that specimens are captive-bred (e.g., “farmed”) stocks, when in reality are wild caught. Such laundering undermines the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulates the trade in certain species. Commercial trade in wild caught specimens may be allowed in Appendix-II species if specific requirements are met, but is generally prohibited in Appendix I species. However, commercial trade may be possible in specimens of Appendix I-species that were legally bred in captivity. National and international CITES authorities and scientific institutions within Germany and the EU are thus faced with increasing questions related to the verification and validation of allegedly captive-bred specimens of CITES listed species.

From 2018-2019, the DGHT was commissioned by the Federal Agency for Nature Conservation (BfN) to carry out a pilot project entitled "Evaluation of the breedability of selected reptile taxa listed in Appendices I and II since CITES CoP17", compiling the available data on captive-breeding and assessing the possibility of reproduction in captivity of the aforementioned CITES-listed reptile species.

The information on each species, compiled for the first time on such a large scale, aid scientists and representatives of authorities to carry out plausibility checks on alleged captive-bred animals from questionable sources and to identify falsely declared animals. A simple traffic light system allows a first rough assessment of the difficulty and frequency of reproduction in captivity as well as on the possible number of offspring, under different husbandry conditions. In cases of doubt, the specialists in the DGHT can be contacted. The respective document has been published as BfN-Skripten, publication no. 609 (see below in references, BfN-Skripten).

At the following Conference of the Parties, CITES CoP18, that has taken place in 2019, many additional reptile and amphibian species were listed in the CITES Appendices, or transferred from Appendix II to Appendix I. Subsequently, the DGHT was again commissioned to compile similar information on the reproductive biology and necessary conditions for breeding in captivity for these species as well.

As species are sometimes difficult to identify correctly, in some cases it was necessary to compile the available information on breedability not only for the individual species dealt with at CITES CoP18, but also for similar-looking species that had often already been included in CITES Appendices earlier. Taxa were herein presented in species groups as far as possible, highlighting the diagnostic characters of the species within each group in more detail. This was intended in particular to assist authorities in discerning between taxa.

It has to be noted that this study only reflects the presently available knowledge, which may change and increase in the future. As such, this document aims to provide a guidance for authorities only and makes no claim to completeness.

Methods

As a first step, a questionnaire prepared by the BfN in the frame of the previous project on the reptiles listed at CoP17 was amended to each of the three superordinate reptile groups (lizards, snakes, turtles). Additionally, a further version was prepared for the caudates.

The authors of taxon specific chapters identified keeper and breeder of the species in Germany, Europe, North America and Asia, and then sent out the questionnaires respectively (German or English version). Other breeders were contacted personally and interviewed less formally (by e-mail and also by phone) to increase the return rate of requested data.

Furthermore, a close cooperation with the different DGHT Work Groups (especially in the Work Groups Agamas, Chelonians, Lizards, Iguanids, Snakes, and Urodela) was essential. These working groups unite numerous specialists, who are intensively involved in the keeping and breeding of certain species in the respective reptile and amphibian groups and have a broad network of further contacts in the private "breeder scene". The DGHT Work Groups benefit from comprehensive sources of information, such as experiences in the successful captive breeding and research on certain taxa for decades. The German Chelonia Group within the DGHT, for example, has been continuously collecting breeding data for more than 40 years, which are used in valuable offspring statistics. The AG Urodela also collected respective offspring statistics for caudates for many years in the form of the newt register.

In addition, the DGHT's collaborated with Species360, by using the ZIMS database to identify numerous zoos that keep and breed one or more of the target species. These zoos were then contacted and questioned via Species360.

Based on the returned questionnaires as well as the outcome of mail and phone correspondences, and including the relevant existing information from an extensive literature research, taxon-specific profiles with all currently available data on the relevant reproductive parameters and husbandry requirements were compiled.

The present profiles contain species-characteristic photos as well as information on diagnostic characters, the distribution and habitat, the protection and IUCN Red List status, and above all the essential information on reproduction in nature and under human care.

A literature list, tailored to each species or species group, as well as a glossary complete the work.

How to use this document

The present document is intended to assist scientists and government officials/ authorities in making plausibility checks on captive-breeding as well as to have an idea on the source of purported offspring, and to assist in the identification of falsely declared specimens.

In the case of import applications into the EU, the responsible authority usually has to do this plausibility check based on a written application, only. The application form contains, amongst others, the scientific name of the species as well as the source. This source code specifies for example whether the animal is captive bred (source code “C”) in accordance with CITES Resolution Conf. 10.16 (Rev.)* and Article 54 of Commission Regulation (EC) No 865/2006. Other common source codes for living animals can be F or R (see the table on page 263, as well as the references for the glossary).

In addition, the application may include a description of the specimens and of the proposed housing conditions.

In order to evaluate such an application, it is necessary to determine whether the species name information is correct. To facilitate an evaluation of this information by the competent authorities and interested parties, the document is ordered according to taxonomic groups, either by individual species or, if possible and useful, by species groups. For this purpose, these "taxon profiles" contain information on the taxonomy and diagnostic features of the individual species in the first chapters. However, such a compact presentation cannot replace comprehensive identification literature or the evaluation by an expert. In the taxon profiles presented herein, particular attention was paid to the main characters that distinguish similar species, especially if they have a different protection status. In addition, when available, informative photographs were included to show significant characters of the taxa. The technical terms are explained in the glossary.

The next sections of taxon profiles deal with distribution and habitat, as well as with the conservation status and major threats for each species, and are intended to assist the assessment of the sustainability of the trade (especially regarding wild specimens). The Council Regulation (EC) No 338/97, on the protection of species of wild fauna and flora by regulating trade therein, specifies that the scientific authorities of the importing member state is of the opinion that the introduction into the community of specimens of Annex A and B species has no detrimental effect on the wild population of the species in the region of origin (NDF = Non-Detriment Finding). This is especially relevant for imports of wild caught specimens (source code "W"), but also for imports of animals that are claimed to be born in captivity (source code "F") but do not meet the criteria for source code "C". Such exports from the countries of origin can negatively affect the maintenance or growth of the wild population, as the volume of breeding stock removed from the wild population may likely be detrimental to the wild population. On the other hand, a regulated and sustainable harvest of animals can contribute to the conservation of the respective species in the area of origin by providing income for local communities and creating incentives to protect the species and their habitats, and to not use the latter for alternative purposes (such as agriculture).

The final sections, on reproduction biology, husbandry and captive breeding, should aid to make a plausibility check of the given number of juveniles per breeding female, and/or the conditions under which the breeding allegedly took place. The tables contain a compilation of data from the scientific literature, from herpetoculture magazines and, in particular, from interviews with experts for the relevant species by the questionnaire, but also by direct communication.

The numerical data on reproduction parameters should be seen as a range with natural variation, and not as absolute values. The number of alive offspring from captive breeding for example depends on various factors such as on the age or size of the breeding female, diet, temperature regime, incubation conditions and often also on the breeding group composition. If such influencing factors, as well as average values and probable maximum values were known, they were herein specified further. In particular, the fact that a species was not yet known to have been bred in the F2 or subsequent generations at the time of writing does not mean that this is absolutely impossible. For some species, F2 breeding may have occurred in the meantime, which simply had not been published or determined via the questionnaires at the time of compilation. The information in this chapter therefore represents the current state of knowledge, based on the experience of the volunteer participants and the literature, while the knowledge on the respective species grows with increasing experience in captive-breeding.

This document is therefore not intended as a binding basis for decision-making, but as a guidance only, and does not claim completeness. In cases of doubt, it is always advisable to re-research the newest information, and to directly contact specialists. For this reason, the taxon authors and the date of preparation were given for each species profile, and reference was often made to other specialists who are also willing to provide more detailed information. The BfN supervisors and the relevant subgroups of the DGHT are also happy to provide additional information, if required.

Target species

Since CoP18 the following reptile species are listed in CITES Appendix I (Annex A of the Council Regulation (EC) No 338/97; The commercial trade in wild caught individuals is prohibited, while trade in captive-bred specimens or trade for non-commercial purposes may be permitted in exceptional instances, if the trade is non-detrimental to the wild population): Five Agamid species from Sri Lanka (*Ceratophora erdeleni* – Erdelen's horn lizard, *Ceratophora karu* – Karu's horn lizard, *Ceratophora tennentii* – Leaf-nosed agama, *Cophotis ceylanica* – Ceylon deaf agama and *Cophotis dumbara* – Knuckles deaf agama) as well as *Gonatodes daudini* – Union Island gecko. In addition, five Testudines species were transferred from CITES Appendix II to Appendix I: *Cuora bourreti* – Central Viet Nam box turtle, *Cuora picturata* – Southern Viet Nam box turtle, *Mauremys annamensis* – Vietnamese pond turtle, *Geochelone elegans* – Indian star tortoise, and *Malacochersus tornieri* – Pancake tortoise.

Since CoP18 the following reptile species were included in CITES Appendix II (Annex B of the Council Regulation (EC) No 338/97;: Sustainable use and controlled commercial trade in wild specimens may be permitted, if the trade is non-detrimental to the wild population): all other species of *Ceratophora* – Horn lizards that were not listed in Appendix I, *Lyriocephalus scutatus* – Lyre-headed lizard, all species of the genus *Goniurosaurus* – Tiger geckos except the species from Japan, *Gekko gecko* – Tokay gecko; *Paroedura androyensis* – Grandidier's Madagascar ground gecko, as well as all species of the genus *Ctenosaura* sensu lato, i.e. including the genus *Cachryx* – Spiny-tailed iguanas, four of which were previously listed on Appendix II already, and also *Pseudocerastes urarachnoides* – Iranian spider-tailed viper.

In addition, the following amphibian (Urodela) species were newly listed in Appendix II at CoP18: *Echinotriton chinhaiensis* Chinhai spiny crocodile newt, *Echinotriton maxiquadratus* – Mountain spiny crocodile newt, all (currently 14) species of the genus *Paramesotriton* – Warty newts, and all species (currently 31) of the genus *Tylototriton* – Crocodile newts.

At the beginning of the project, at the end of July 2020, there were exactly 90 taxa for which data and information on reproduction were to be collected in the corresponding fact sheets. In the course of the project, however, it became apparent that species that were described later or that were very difficult to distinguish from the target species also had to be included. The present document now contains information on more than one hundred taxa.

Sauria

Agamidae

***Ceratophora* spp.**				
Species	**Description author and date**	**Common name English**	**Common name German/ Singhalese**	**Known in the trade**
Ceratophora aspera	Günther, 1864	Rough-horn lizard	Raunasen-Hornagame, Spitznase/ Ralu angkatusså, Kuru angkatusså	yes
Ceratophora erdeleni	Pethiyagoda & Manamendra-Arachchi, 1998	Erdelen's horn lizard	Erdelens Hornagame/ Erdelenige angkatusså	no
Ceratophora karu	Pethiyagoda & Manamendra-Arachchi, 1998	Karu's horn lizard	Karu Hornagame/ Karuge angkatusså	no
Ceratophora stoddartii	Gray, 1834	Rhino-horned lizard	Stoddarts Hornagame, Nashornagame/ Kangamuwa angkatusså, Rhino angkatusså	yes
Ceratophora tennentii	Günther, 1861	Leaf-nosed agama	Blattnasenagame, Tennenti Hornagame/ Pathra angkatusså, Dumbara angkatusså, Pethi angkatusså	yes
Ceratophora ukuwelai	Karunarathna, Poyarkov, Amarasinghe, Surasinghe, Bushuev, Madavwala, Gorin & De Silva, 2020	Ukuwela's Rough-horn lizard	Ukuwelas Hornagame/ Ukuwelage ralu-angkatusså	no

The agamas of the genus *Ceratophora* show the common characteristic of a horn-like extension at the tip of the snout. This horn is boneless, formed by soft tissue. Within the family Agamidae, a similar anatomic feature can only be found in species of the genus *Aphaniotis*, *Harpesaurus* and in the genus *Thaumatorhynchus,* which often is used a synonym of *Harpesaurus*. The morphology of this extension varies greatly among the species of the genus *Ceratophora* and can be used as diagnostic character. In the species *C. erdeleni* and in ♀♀ of the other *Ceratophora* species this horn is reduced, often only slightly noticeable, and sometimes even missing.

The tympanum is hidden below the skin.

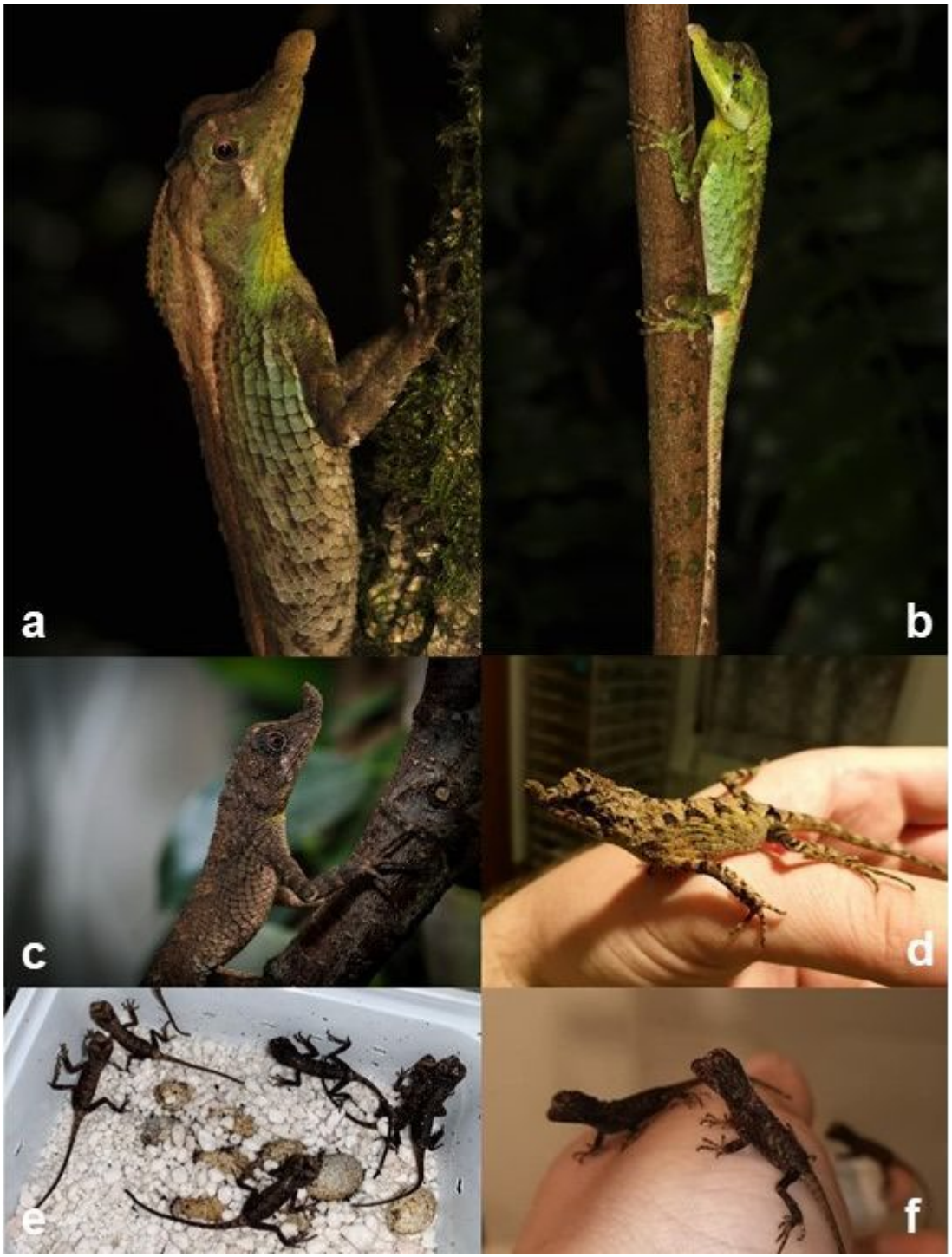

Fig. 1a: *Ceratophora tennentii* ♂ in its habitat (P. Janzen);
b: *Ceratophora tennentii* ♀ in its habitat (P. Janzen);
c: *Ceratophora tennentii* captive bred subadult ♀ (J. Suchanek);
d: *Ceratophora tennentii* F2 captive bred juvenile 2020 (J. Suchanek);
e: *Ceratophora tennentii* hatching in the incubator (J. Suchanek);
f: *Ceratophora tennentii* hatchlings (J. Suchanek).

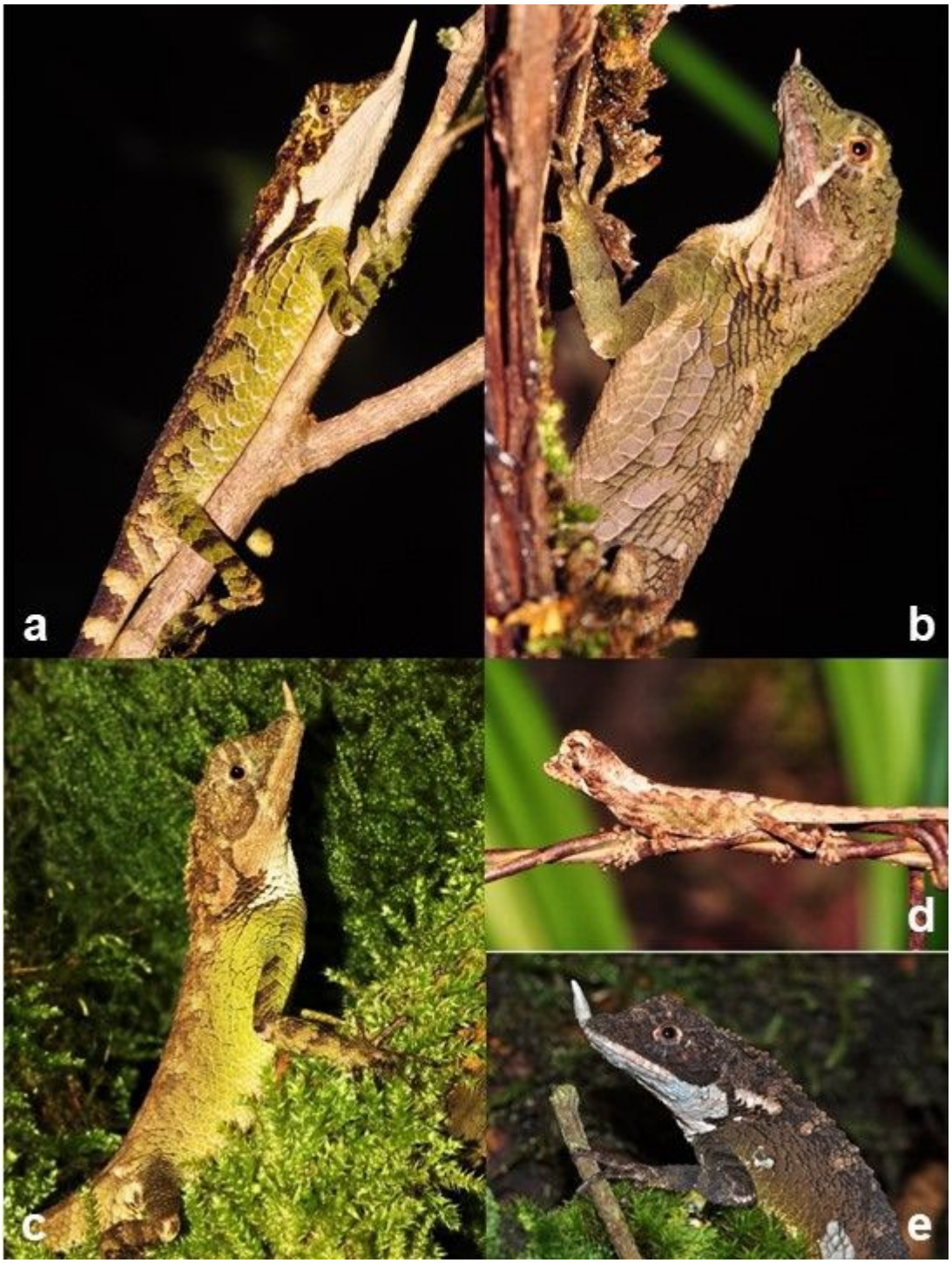

Fig. 2a: *Ceratophora stoddartii* ♂ in the natural Habitat (P. Janzen);
b: *Ceratophora stoddartii* ♀ in the habitat (P. Janzen);
c: *Ceratophora stoddartii* captive bred ♂ (Ch. Langner);
d: *Ceratophora stoddartii* juvenile in the natural habitat (P. Janzen);
e: *Ceratophora stoddartii* captive bred ♂ (F. Hulbert).

Fig. 3a: *Ceratophora erdeleni* (P. Janzen);
b: *Ceratophora aspera* (P. Janzen);
c: *Ceratophora ukuwelai* (P. Janzen);
e: *Ceratophora karu* with epizoic plant growth (W. Henkel);
f: *Ceratophora karu* ♀ (W. Henkel).

Morphology and Taxonomy

The genus *Ceratophora*, as well as *Lyriocephalus* and *Cophotis* (see below), are taxonomically classified in the subfamily Draconinae (Grismer *et al.* 2016).

Ceratophora aspera, *C. stoddartii* and C. *tennentii* were described at the beginning and the middle of the nineteenth century, whereas *C. erdeleni*, *C. karu* and *C. ukuwelai* were only recently discovered and described.

Ceratophora ukuwelai was described in 2020 based on two specimens and is currently only known from a very small region. This taxon was therefore not yet considered in Cop18 proposal 24, which aimed to list the entire genus in CITES Appendix I. However, only *C. erdeleni*, *C. karu* and *C. tennentii* have been listed in Appendix I, while *C. aspera* and *C. stoddartii* were listed in Appendix II with a zero quota for wild specimens for commercial purposes.

Karunarathna *et al.* (2020) argue that *C. ukuwelai* is a split-out species from *C. aspera*. Therefore, it has the same CITES protection status as the species of origin, and should be treated like being listed on CITES Appendix II.

The six species of the genus *Ceratophora* can be identified by the following characteristics:

Ceratophora aspera – this species can be differentiated from its congeners, with exception of *C. ukuwelai*, by the presence of a complex cylindrical rostral appendage which has significantly more scales than the usual rostralia. Such a prominent appendage with triangular scales is otherwise only known from the similar species *C. ukuwelai*. The rostral appendage is in ♂♂ very conspicuous, while in most ♀♀ it is smaller, and even lacking in some cases. In juveniles, this appendage is not yet developed. The length of this rostral appendage is larger than the distance between eyes and nostril. An "X" shaped bar on the back of the head is also distinctive. In contrast to the other species, a knob-like structure in the dorsoanterior area of the postorbital scale is missing in *C. aspera*. Length: SVL 3.0–4.0 cm; TL 7.0–9.0 cm. The ground color is often brown to olive green. The oral mucosa and the tongue are blue-grey. The supralabialia and part of the throat can be orange in ♂♂.

Ceratophora erdeleni – this species can easily be distinguished from all other species of the genus by its rudimentary rostral appendage formed by few small (few mm) scales. This appendage can be missing in both sexes. The scales of the flanks are large and irregular. ♂♂ show a slightly domed neck area with slightly larger neck scales than in ♀♀. Length: SVL 7.0–8.5 cm; TL 21.5–24.5 cm. The animals of this species are variable in color and sometimes have bright green spots on the limbs and venter. Cross bands of rows of black scales are sometimes on the dorsum and are separated by green to beige rows of scales. They have alternating dark and light bands on the tail.

Ceratophora karu – ♂♂ have a small rostral appendage formed by small pointy triangular scales (the fleshy protrusion, which is characteristic of *Ceratophora,* is missing). In ♀♀, the rostral appendage is missing. The length of the appendage is significantly smaller than the distance between eyes and nostril. The supraorbital crest has a row of large, rough, grooved, or conical, scales. On the dorsum there are several “M” shaped skin folds which, when viewed from above, form a diamond shaped pattern up to the root of the tail. The prominent supraocular bulges, spiny scales in the cheek area as well as a prominent spiny scale on the neck area gives this species a very spiny appearance. Length: SVL 3.0–4.0 cm; TL 7.0–9.0 cm. The ground color is mainly brown with some white areas. The diamond shaped pattern on the dorsum can appear grey and be bordered by single rust red scales rows.

Ceratophora stoddartii – the spiny rostral appendage is present in both sexes. This species can be distinguished from the other Ceratophora species by the presence of a prominent conic and spiny rostral appendage which is limited to and formed by the rostral scales. In females it is often less prominent and exceptionally not visible. C. stoddartii has an erectable skin fold in the neck. The dorsal scales are irregular and overlap in a shingled way. Length: SVL 7.0–8.5 cm; TL 21.5–24.5 cm. The flanks and tail are colored olive green. Females are less contrasty. In the dorsum there are several cross bands and narrow dark longitudinal stripes formed by a single row of scales. The tail has dark cross bands which get wider towards the tip. The supralabialia as well as the throat region, neck and horn are often white. Also, the eye is surrounded by a circle of white, sometimes yellow scales. Sometimes, orange-colored spots appear in males behind the eyes or in the neck region.

Ceratophora tennentii – eponymous for the Leaf-nosed agama is the leaf shaped appendage at the tip of the nose. This appendage is less pronounced in females. It is composed of

soft tissue, covered by small scales and can swell depending on the specimens' mood. It is white to brownish, rarely turquois blue. ♂♂ have an erectable neck crest. Length SVL: 5.5–7.0 cm; TL 18.5–21.5 cm. ♂♂ are more colorful and have more green parts than ♀♀. The color can darken, depending on the specimens' mood and temperature. The throat can be bright yellow to orange or green. A white stripe elongates over the labialia to the end of the snout and continues to the rostral appendage. A white spot can be present in the neck area. The color of the flanks varies. The flanks are composed of homogeneous and relatively large scales in a roof tile like pattern which are bright blue, brown-grey, or green colored. A brownish dorsal stripe stretches from the eye to the tail base. The oral mucosa and the tongue are shiny dark blue.

Ceratophora ukuwelai – the Ukuwela's' Rough-horn lizard can be distinguished from the other *Ceratophora* species by a combination of morphological and meristic features: The rostral appendage of the ♂♂ is formed by several scales and is lacking in ♀♀. The body is long with a relatively short anterior part. A neck crest is only weakly pronounced. The dorsum has heterogeneous keeled scales interspersed with smooth flat scales. Almost all scales on the head, body, limbs and tail have 1–18 mechanoreceptive pores (per single scale). Further characteristics are: 5–7 enlarged keeled scales on the flanks; nine supraciliary scales; 40–44 paravertebral scales; 72–77 central scales on the body; 72–75 central scales on the venter. Maximum SVL 3.8 cm; TL 8.1 cm. The dorsum of the head, body and limbs are grey-brown. they have a white spot on the front. The interorbital area has a "Y"-shaped mark. The back of the head has a "W"-shaped dark mark. Four grey diamond shaped marks of black dotted lines run along the spine. The tail is mainly brown with a faded zigzag mark. Gular and ventral scales are dirty white, interspersed with red-brown color components. The iris is copper orange and the oral mucosa blue-grey (Karunarathna *et al.* 2020).

Distribution and Habitat

Distribution

Ceratophora aspera is endemic to Sri Lanka, and limited to the south of the island at elevations between 100 and 900 m asl. Type locality: Ceylon (Sri Lanka).

Ceratophora erdeleni is endemic to the south of Sri Lanka. Currently the occurrence is only recorded from Morningside near Rakwana and Silverkanda as well as in Enasalwatte near Deniyaya at elevations between 1,000 and 1,300 m. Type locality: Morningside Forest reserve near Rakawana.

Ceratophora karu is endemic to the south of Sri Lanka. The species occurs in the Sinharaja's Morningside Forest Reserve, the bordering Thangamalai Plains, Gingla, and Enasalwatte near Deniyayain. Elevation: up to 1,060 m asl. Type locality: Morningside Forest, near Rakwana, at 1,060 m asl (06°24'N, 80°38'E).

Ceratophora stoddartii is endemic to Sri Lanka. The species was recorded from Nuwara Eliya, Hakgala, Pattipola, Ohiya, Horton Plains, Hewathea, Dimbula, Namunukula, Galaha, Pidurutalagala, Loolcondera estate, Agarapatana, and Peak Wilderness Sirpadha/Samanala kanda) vor. Elevation: between 1,500 and 2,200 m asl. Only from Namunukula an exceptionally low elevation occurrence, located at about 200 m above sea level, is known. Type locality: Ceylon [Sri Lanka].

Ceratophora tennentii is endemic to Sri Lanka and only occurs in the Knuckles Ranges at 700–1200 m asl. Type locality: Ceylon [Sri Lanka].

Ceratophora ukuwelai is endemic to Sri Lanka. Up to date only few specimens have been found at the type locality. Type locality: rain forest near streams in Salgala Forest, Kegalle District, Sri Lanka (7.120219°N, 80.251892°E, WGS1984; at 242 m asl).

Habitat

Ceratophora aspera is a saxicolous species and lives in leaf litter in dense, shady forests. Deraniyagala (1953) reports that the species is to be found near groves of the endemic Ceylonese palm Katu Kithui (*Oncosperma fasciculatum*). This species has a slow locomotion and relies on its good cryptic camouflage. Specimens are usually found in pairs (Somaweera & Somaweera 2009).

Ceratophora erdeleni is a tree dwelling species which is found in shady forests (Somaweera & Somaweera 2009).

Ceratophora karu is a ground-dwelling species which is found in the litter of dense, shady forests often at 800 m asl. This species is diurnal and has a fast locomotion.

Ceratophora stoddartii is a semi-arboreal species, which is usually found on tree trunks, hedges and lianas in a vertical position. It can occasionally be found on the ground. When specimens are spotted, they hide themselves on the other side of the tree. The species has a slow locomotion. Foraging occurs both on the forest floor and in the vegetation layer. Juveniles live on the ground.

Ceratophora tennentii is a tree dwelling species which inhabits tree trunks covered with moss as well as lower bushes in cardamom plants (*Elettaria cardamonium*) or in lianas. It has a slow locomotion, while males can be very agile when attacking rivals. When threatened, specimens sometimes open their snout to present their bright orange oral mucosa.

Ceratophora ukuwelai has been found near streams in lowland rainforests below 300 m asl (Karunarathna *et al.* 2020).

Conservation Status and Main Threats

The listing of *Ceratophora* spp. in the CITES-appendices was decided on in 2019 at the CoP18 based on Proposal 24.

The national Red List status in Sri Lanka was taken from Wickramasinghe (2012).

Species	**CITES-Appendix**	**EU Council Regulation (EC) No. 338/97**	**Protection in Germany under BNatSchG [BG]**	**IUCN Red List status**	**Sri Lankan national Red List status**
Ceratophora aspera	II	Annex B	Particularly protected. Status: b.	Vulnerable (B1ab(iii), assessed June 30, 2009).	Endangered (B1ab(iii) + 2ab(iii)).
Ceratophora erdeleni	I	Annex A	Particularly and strictly protected. Status: s.	Not yet assessed.	Critically Endangered (B1ab(iii)).
Ceratophora karu	I	Annex A	Particularly and strictly protected.	Not yet assessed.	Critically Endangered (B1ab(iii)).

Species	CITES-Appendix	EU Council Regulation (EC) No. 338/97	Protection in Germany under BNatSchG [BG]	IUCN Red List status	Sri Lankan national Red List status
			Status: s.		
Ceratophora stoddartii	II	Annex B	Particularly protected. Status: b.	Not yet assessed.	Endangered (B1ab(iii) + 2ab(iii)).
Ceratophora tennentii	I	Annex A	Particularly and strictly protected. Status: s.	Endangered ((B1+2bc), assessed August 1, 1996).	Critically Endangered (B1ab(iii)).
Ceratophora ukuwelai	Pending.			Assessed as critically endangered (B2-b (iii)) (Karunarathna *et al.* 2020)).	

Ceratophora ukuwelai has been described in 2020, and has therefore not yet been mentioned in the evaluation for CITES Cop18. The IUCN assessment, probably resulting in the listing on CITES Appendix I, or on CITES Appendix II, is still pending.

Threats

Most species of this genus have a very small distribution range which makes them vulnerable to climate change and habitat destruction. The rapid loss of tropical rainforests is the main threat of all the species of this genus. Primary forests disappear and are concentrated in few protected areas. Logging and land grabbing, due to a rapid increase in population are the main problems. Nevertheless, the government's recent announcement that they will not expand palm oil plantations in the future gives hope for a positive development. Nature conservation legislation is strict and violations are rigorously punished, at least those performed by tourists. Even photographing reptiles in the wild is prohibited.

Nevertheless, specimens were regularly traded to Europe, USA, and Japan, in small numbers. In the 70's and 80's trade occurred mainly as "by-pack" in fish shipments.

Ceratophora stoddartii and *C. tennentii* – and to a minor extent also *C. aspera* – are being bred in captivity in small numbers in Europe since the 80's.

Reproduction

Topic	Data
Secondary sexual traits	In the genus *Ceratophora*, the size and the form of the rostral appendage can be used to identify the sex. In ♂♂ it is larger and more prominent, in ♀♀ it is reduced or lacking. Males of *C. erdeleni, C. stoddartii* and *C. tennentii* are usually more colorful and higher in contrast than females.
Reproduction	Oviparous.
Mating season	Possibly all year round.
Number of eggs/ clutches per season	*Ceratophora aspera*: 2 eggs; *Ceratophora erdeleni*: 2–3 eggs (7 x 13 mm); *Ceratophora karu*: 2 eggs (8 x 5 mm); *Ceratophora stoddartii*: 4–8 eggs (7 x 14 mm), and up to three clutches per year;

Topic	Data
	Ceratophora tennentii: 2–4 eggs.
Gestation period	*C. Ceratophora stoddartii*: 3 months.
Incubation and hatching	*Ceratophora stoddartii*: Incubation 100 days at 23 °C.; hatchling size ca. 25 mm (SVL); sex ratio 50:50; hatching rate 90 %.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Keeping the individuals solitary, in terraria with dense vegetation, high humidity and enough ventilation, is required. Branches covered with moss should be present. Annual temperature should be moderate and should not exceed 20–22 °C during daytime, and during nighttime decreasing to 15 °C or lower. At temperatures above 25 °C, *C. stoddartii* (and probably other species as well) become lethargic and weak with the risk of death. The species *C. aspera*, which is also widespread in lower altitudes, can withstand slightly higher temperatures of up to 24 °C.
Husbandry requirements	The larger species *C. erdeleni*, *C. tennentii* and *C. stoddartii* should be kept individually in terrariums with a minimum size of 80 x 60 x 100 cm (L x W x H). The smaller, mostly ground-dwelling species, *C. aspera*, *C. karu* and *C. ukuwelai* should be kept individually in terraria with a minimum size of 50 x 40 x 40 cm. *C. aspera* is considered to be compatible and is often found in pairs in the wild (Somaweera & Somaweera 2009). A proper ventilation can be achieved by large ventilation grids in the front and the top of the terrarium. A ventilator at the front should be used to achieve a proper air movement. For lighting, T5-tubes and LED lighting should be used. The terrarium should be automatically sprayed/misted three times a day for ca. two minutes. The humidity should be between 70 % and 80 %. Additionally, manual spraying, particularly for the plants, and to provide drinking water, is important. Also, a fountain could be placed because the moving water can be visually perceived by the agamas. The terrarium setup should be as natural as possible. Leaf soil, covered by leaf litter, should be used as substrate. Branches of different diameters should be vertically placed. Plants, such as ferns, *Ficus* species, small-growing *Araceae* and small-growing orchids are recommended. Tree-fern plates can be used for terrarium walls. The diet contains the usual, commercially available food insects (grasshoppers, crickets, cockroaches). Also, earthworms are particularly accepted by *Ceratophora*. Food should be supplemented with the commercially available mineral and vitamin powders.
General characteristics, difficulties with keeping and breeding	The species of the genus *Ceratophora* have high requirements regarding climatic conditions. These rare and highly endangered species should only be kept by experienced keepers who can meet these requirements all year round. For a successful keeping and breeding of the species, a temperature-stable basement room, or an air-conditioned terrarium room, are basic requirements. Continuous high temperatures must be avoided. The keeping and breeding of *C. stoddartii* is considered easy, if climatic requirements are met.
Care of the young, technical and time effort	The rearing of *C. stoddartii* is unproblematic. The juveniles are mainly ground dwelling. The young lizards should be kept individually, with the same setup as for the adults. Terraria should be smaller in size, so that the juveniles can catch the food insects more easily, and to better monitor the wellbeing of animals.
Frequency of breeding in captivity	Rare, since these agamas are only kept by few keepers due to their high husbandry requirements.

Topic	Data
Mortality in the first years of life	*C. stoddartii* :10 %.
Breeding difficulty evaluation	Very demanding due to the climatic requirements.
F2 generation bred	*C. stoddartii*: up to F4.
Interviews/ Surveys/ Consultations	Several private breeders.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Amarasinghe, A.A.T., D.M.S.S. Karunarathna & D. Warakagoda (2007): The endangered Sri Lanka whistling thrush *Myophonus blighi* eats an endangered lizard. BirdingASIA **7**: 83-84.

Amarasinghe, A.A.T., U. Manthey, E. Stöckli, I. Ineich, S.O Kullander, F. Tiedemann, C. McCarthy & D.E. Gabadage (2009): The original descriptions and figures of Sri Lankan agamid lizards (Squamata: Agamidae) of the 18th and 19th centuries. Taprobanica **1**(1): 2-15.

Bahir, M.M. & T. Surasinghe (2005): A conservation assessment of the Sri Lankan Agamidae (Reptilia: Sauria). Raffles Bulletin of Zoology, Supplement **12**: 407-412.

Bartelt, U. (1995): Bemerkungen zur Haltung und Nachzucht der Hochlandagame *Ceratophora stoddartii* Gray, 1834 (Sauria: Agamidae). Sauria (Berlin) **17**(4): 11-16.

Bartelt, U. & P. Janzen (2007): Die Hornagame *Ceratophora stoddartii* im Biotop und im Terrarium. Draco **8**(2) (30): 34-37.

Botejue, W., S. Madhava & J. Wattavidanage (2012): Herpetofaunal diversity and distribution in Kalugala proposed forest reserve, Western province of Sri Lanka. Amphibian & Reptile Conservation **5**(2): 65-80(e38).

Boulenger, G.A. (1885): Catalogue of the lizards in the British Museum (Nat. Hist.) I. Geckonidae, Eublepharidae, Uroplatidae, Pygopodidae, Agamidae. London: 450 pp.

Boulenger, G.A. (1890): Reptilia and Batrachia. *In:* Blandford, W.T. (Ed.): The Fauna of British India, Including Ceylon and Burma. London (Taylor & Francis) Vol. xviii: 541 pp.

CITES (2019): CoP18 Proposal 24: To include the genus *Ceratophora* on Appendix I. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 14.08.2021).

Das, I. & A. Das (2017): A Naturalist's Guide to the Reptiles of India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka. Oxford (John Beaufoy Publishing Ltd.): 176 pp.

De Silva, A. (1990): Observations on some vanishing relict lizards of Sri Lanka. Hamadryad **15**(1): 34-35.

De Silva, A. (1994): An introduction to the herpetofauna of Sri Lanka. Lyriocephalus **1**(1-2): 3-19.

De Silva, A., S. Goonewardene, A.M. Bauer & J. Drake (2005): *Ceratophora tennentii* Gunther & Gray, in Tennent, 1861 (Reptilia: Agamidae) some notes on its ecology. Lyriocephalus **6**(1-2): 55-62.

De Silva, A., R. Meek, A.M. Bauer, S. Goonewardene, J. Drake, R.D.C.S.K. Dasanayaka, A.M.R.K. Amarakoon & M.M. Goonasekera (2005): First studies on the thermal ecology

of *Ceratophora tennentii* (Sauria: Agamidae) inhabiting the cloud forests of the Knuckles Massif, Sri Lanka. Lyriocephalus **6**(1-2): 65-71.

Dieckmann, M. (2011): *Ceratophora stoddartii* (Gray, 1834). Iguana Rundschreiben **24**(2): 17-22.

Gibson, C., A. de Silva, M.F. Tognelli & S. Karunarathna (Eds.) (2020): Assess to Plan: Conservation Action Planning for the Snakes and Lizards of Sri Lanka. IUCN Conservation Planning Specialist Group, Apple Valley, MN, USA: 80 pp.

Grismer, J.L., J.A. Schulte, A. Alexander, P. Wagner, S.L. Travers, M.D. Buehler, L.J. Welton & R.M. Brown (2016): The Eurasian invasion: phylogenomic data reveal multiple Southeast Asian origins for Indian dragon lizards. BMC Evolutionary Biology **16**: 1-12.

Imhof-Garoni, E. (1972): *Ceratophora tennentii* Günther, 1861, ein seltsamer Fremdling aus Ceylon. Aqua Terra **9**(12): 122-126.

Janssen, J. & A. de Silva (2019): The presence of protected reptiles from Sri Lanka in international commercial trade. TRAFFIC Bulletin **31**(1): 9-15.

Janzen, P. (2003): Sinharaja - Der Regenwald des Löwenkönigs. Draco **4**(15): 26-33.

Janzen, P., P. Klaas & S. Ziesmann (2007): Die Agamen der Insel [Sri Lanka]. Draco **7**(30): 24-33.

Johnston, G.R., M.S.Y. Lee & T.D. Surasinghe (2013): Morphology and allometry suggest multiple origins of rostral appendages in Sri Lankan agamid lizards. Journal of Zoology (London) **289**(1): 1-9.

Karunarathna, S., N.A. Poyarkov, C. Amarasinghe, T. Surasinghe, A.V. Bushuev, M. Madawala, V.A. Gorin & A. de Silva (2020): A new species of the genus *Ceratophora* Gray, 1835 (Reptilia: Agamidae) from a lowland rainforest in Sri Lanka, with insights on rostral appendage evolution in Sri Lankan agamid lizards. Amphibian & Reptile Conservation **14(**3) [Taxonomy Section]: 103-126 (e259).

Krvavac, M., M. Bopage, K. Wewalwala, O. Bjelic-Cabrilo, E. Popovic & O. Jovanovic (2015): Reproductive behavior of the vulnerable Rough Nose Horned Lizard, *Ceratophora aspera* (Sauria, Agamidae) from Sri Lanka. Russian Journal of Herpetology **22**(2): 145-148.

Nixon, R. & C. Langner (2017): Erster Hinweis auf epizoisches Algenwachstum an Segmenten der Rassel der mexikanischen Zwergklapperschlange *Crotalus intermedius gloydi* Taylor, 1941 [First indication of epizoic algal growth on segments of the rattle of the Oaxacan Small-headed Rattlesnake, *Crotalus intermedius gloydi* Taylor, 1941]. Sauria **39**(1): 47-50.

Pethiyagoda, R. & K. Manamendra-Arachchi (1998): A revision of the endemic Sri Lankan agamid lizard genus *Ceratophora* Gray, 1835, with description of two new species. Journal of South Asian Natural History **3**(1): 1-50.

Rodrigo, R.K. & D. Jayantha (2004): An observation of the foraging behavior of *Ceratophora tennentii* Günther, 1861 Knuckles Forest Range in Sri Lanka. Reptile RAP **6**: 11.

Somaweera, R. & N. Somaweera (2009): Lizards of Sri Lanka: a colour guide with field keys. Frankfurt (Edition Chimaira): 304 pp.

Somaweera, R., N. Wijayathilaka, G. Bowatte & M. Meegaskumbura (2015): Conservation in a changing landscape: habitat occupancy of the critically endangered Tennent's Leaf-nosed Lizard (*Ceratophora tennentii*) in Sri Lanka. Journal of Natural History **49**(31-32): 1961-1985.

Schulte, J.A., J.R. Macey, R. Pethiyagoda & A. Larson (2002): Rostral horn evolution among agamid lizards of the genus *Ceratophora* endemic to Sri Lanka. Molecular Phylogenetics and Evolution **22**(1): 111-117.

Senanayake, F.R. (1979): Notes on the lizards of the genus *Ceratophora*. Loris **15**(1): 18-19.

Senanayake, F.R. (1980): The status of the endemic lizards, genus: *Ceratophora*, in Sri Lanka. Tigerpaper (Bangkok) **7**(4): 26-28.

Sri Lanka Department of Wildlife Conservation (1993): Fauna and Flora Protection Ordinance. Part III: Vertebrates and Invertebrates [Subs by s 34 of Act 49 of 1993.] https://www.srilankalaw.lk/Volume-III/fauna-and-flora-protection-ordinance.html (accessed 06.07.2021).

Tomey, W.A. (1983): Von Stachelnasen, Stumpfnasen, Blattnasen und Spitznasen - Agamen von Sri Lanka (Ceylon) (1). Aquarium (Bornheim) **17**(167): 268-272.

UNEP-WCMC (2020): Captive breeding of Sri Lankan agamids. Cambridge (UNEP-WCMC): 24 pp.

Wickramasinghe, L.J.M. (2012): The taxonomy and conservation status of the reptile fauna in Sri Lanka, pp. 99-113. *In:* Weerakoon, D.K. & S. Wijesundara (eds.): The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka.

Willey, A. (1906): Viviparity of *Cophotis ceylanica* and oviparity of *Ceratophora stoddartii*. Spolia Zeylanica **3**: Unpaginated.

Christian Langner (20.06.2021)

***Cophotis* spp.**				
Species	**Description author and date**	**Common name English**	**Common name German/ Singhalese**	**Known in the trade**
Cophotis ceylanica	Peters, 1861	Ceylon deaf agama, Sri Lanka deaf agama	Ceylonesische Taubagame, Sri Lanka Taubagame/ Kuru bodilimá, Kaňdukara katussá	yes
Cophotis dumbara	Samarawickrama, Ranawana, Ra-japaksha, Ananjeva, Orlov, Ranasinghe, & Samarawickrama, 2006	Knuckles deaf agama, Sri Lanka deaf agama	Dumbara Taubagame/ Dumbara Kuru bodilimá	yes

Fig. 4a: *Cophotis ceylanica* ♂ (H. Mohr);
b: *Cophotis ceylanica* ♀ (H. Mohr);
c: *Cophotis dumbara* ♂ (H. Mohr);
d: *Cophotis dumbara* captive bred juvenile (H. Mohr).

Morphology and Taxonomy

The genus *Cophotis* was for almost 150 years considered monotypic, until a second species, *Cophotis dumbara*, was newly described in 2006. Curiously enough, this species was first described by two different researcher groups almost at the same time and with similar name: as *Cophotis dumbarae* by Manamendra-Arachchi, de Silva & Amarasinghe on 6th December 2006; and as *Cophotis dumbara* by Samarawickrama, Ranawana, Rajapaksha, Ananjeva, Orlov, Ranasinghe & Samarawickrama on 25th November 2006. In the end, the eleven days earlier publication date was decisive for the prioritization in support of *Cophotis dumbara***.**

The species *C. sumatranus*, from Sumatra, which had been included in this genus until the end of 90s, has been placed in the new genus *Pseudocophotis* (Manthey & Grossmann 1997) or in *Pseudocalotes* (Hallermann & Böhme 2000).

Both *Cophotis* species belong to the few agama species which are viviparous. Only one species from each of the genera *Harpesaurus* and *Phrynocephalus* is also known to have a viviparous mode of reproduction.

Both *Cophotis* species are endemic to Sri Lanka and have a small distribution area.

The most prominent characteristics of the genus are their large, shingle-like scales and the prehensile tail, which is also unusual for agamid lizards**.** These lizards can move their eyes independently, as chameleons do, and they lack a visible tympanum (as their name implies).

Description

Both species are very similar and are difficult to distinguish at first sight. The use of pholidosis characters is needed for species identification.

Cophotis dumbara – this species has, contrary to *C. ceylanica*, more and smaller gular scales (35 versus 27). These are triangular and smooth. The mid-gular scales are granular, thick, and ordered in continuous rows. In *C. ceylanica*, these throat scales are larger, pointed and the rear edge is strongly keeled. The ventral scales are elongated, pointy, almost triangular and slightly keeled. In addition, the few specimens of *C. dumbara* found so far, are slightly smaller than *C. ceylanica*. *C. dumbara* has 9–10 supralabial and 7–8 infralabial scales, and *C. ceylanica* has 8–10 supra- and 7–9 infralabial scales (Ranawana *et al.* 2006, Samarawickrama *et al.* 2006, Hallermann *et al.* 2007). Based on pictures available on the internet, specimens identified as *C. dumbara* are more strikingly colored with intensive green-coloration and patterns higher in contrast than *C. ceylanica*. Genetic studies on the taxonomic status of both species are still pending.

Cophotis ceylanica – this species can reach 14.8 cm in total length (SVL 7 cm). The roof tile-like scales are irregular in size and shape. The ventral scales are smaller, softer, and keeled. The three pronounced neck spines are followed by a row of approx. 13 dorsal spines, which are more conspicuous in males. When in a neutral mood, the entire dorsal crest is laid to the side**.** The coloration is variable. White or in some cases also bright red, long and brownish stripes from the snout to the forelimbs are present. The ground color is brownish with olive-green areas which are interrupted by dark cross bands. The prehensile tail has alternating bright and dark cross bands. Specimens are well camouflaged if resting on branches covered with moss, thanks to their moss and lichen-like pattern and coloration (Mohr & Cabrera 2013).

Distribution and Habitat

Distribution

Cophotis ceylanica is endemic to Sri Lanka and only occurs in the Central Hills in the central highlands of Sri Lankas. It only occurs at elevations between 1,900 and 2,100 m asl. The distribution ranges of both species are separated by the plain of the river Mahaweli. Type locality: Ceylon (Sri Lanka).

Cophotis dumbara is endemic to Sri Lanka and only occurs in the Dumbara Hills (Knuckles Range) in the central highlands of Sri Lankas. It only occurs at elevations between 1,000 and 1,500 m asl. The distribution areas of both species are separated by the plain of the river Mahaweli. Type locality: Dothalugala Man Biosphere Reserve, Knuckles Forest range, Central-Province, Sri Lanka, 07°20' 31.4" N, 80°50' 25.6" O, in cardamom plantations, at 1,425 m asl.

Habitat

Cophotis ceylanica – the primary habitat are trees covered with moss of the originally predominant cloud forests. The secondary habitat are *Cypressus* plantations in gardens and parks around Nuwara Eliya at ca. 2,000 m asl (Mohr & Cabrera 2013).

Cophotis dumbara – the habitat in the Dumbara mountains are trees in cardamom plantations. The Knuckles deaf agamas are found at heights of one and a half to three meters in trees densely covered with moss **(**Samarawickrama *et al.* 2006).

Conservation Status and Main Threats

CITES-Appendix I since 2019 (CoP18 Proposal 25).

Council Regulation (EC) No. 338/97: Annex A.

In Germany particularly and strictly protected under BNatSchG [BG] Status: s.

IUCN Red List status

Cophotis dumbara: Critically Endangered (B1ab(iii), assessed July 17, 2008);

Cophotis ceylanica: Not yet assessed.

National Red List status Sri Lanka

Cophotis ceylanica: Endangered (B1ab(iii) 2ab(iii) (Wickramasinghe 2012));

Cophotis dumbara: Critically Endangered (B2ab(iii) (Wickramasinghe 2012)).

Threats

Both *Cophotis* species are especially threatened by anthropogenic impacts, due to their relict-like and extreme small-scale distribution. Their habitats in the cloud forests and adjacent secondary forests, which are considered as replacement habitats, are threatened by habitat loss and – to a given extent – by climate change. Recurring, unusually long periods of drought have led to major losses in sub-populations over the past decades (Mohr & Cabrera 2013).

The entire range of *C. ceylanica* is estimated to only encompass about 60 km² (Palihawadana 1998). Due to the establishment of tea plantations in the region, the natural habitat has been shrinking significantly. A different microclimate in the tea-monocultures, the lack of shade and, ultimately, the use of pesticides exclude tea plantations as possible secondary habitats. The large-scale forest decline of the Horton Plains described by De Silva (2007) is considered a result of acid precipitation in form of rain and fog.

Impacts of climate change can also be recorded in the tropical cloud forests. Long term monitoring from the past 120 years in Nuwara Eliya showed an average raise of temperature of 1.5 °C, and a decrease in rainfall of about 20 % (Schäfer 1998). Due to the unusual cool climate for Sri Lanka, the region around Nuwara Eliya is known as a growing area for non-tropical vegetables. Large areas between Nuwara Eliya and the Horton Plains have been transformed into pasture land for milk production. Small patches of forest within the farmland are isolated from each other and the distances are too large for genetic exchange between sub-populations or recolonization to occur. A dramatic population collapse of *C. ceylanica* took place in 1992 and 1994/1995, when in the first month of the year hundreds of dead specimens were collected daily (Palihawadana 1998, Somaweera & Somaweera 2009). In literature, so far, climate change has been blamed for the mass extinction in the past. The individual statements, compiled like a mosaic, however, point to a combination of factors (Mohr & Cabrera 2013).

The increase in average temperature also results in a shift in the distribution limits of other animals. Kästle (1966) mentions that the population of *C. ceylanica* has been declining since the 1940s due to the pressure of the greater coucal (*Centropus sinensis parroti*). These early observations were confirmed by Karunarathna & Amarasinghe (2008). The coucals, which previously did not occur in these high-altitude zones, are also likely to spread to higher altitudes in the course of climate change (Karunarathna & Amarasinghe 2008).

Predation by the Indian jungle crow (*Corvus culmitatus*) has been reported as a further threat for *C. ceylanica* (Gibson *et al.* 2020).

Furthermore, the illegal collection for the pet market can also pose an additional threat to these highly endangered species.

Reproduction

Topic	Data
Secondary sexual traits	Sexes can be differentiated by the size and the shape of the dorsal crest which is larger in males. With some experience, the sex can be identified already at a few months of age (Mohr & Cabrera 2013).
Reproduction	Viviparous, probably ovoviviparous.
Mating season	All year round.
Number of hatchlings/ clutches per season	1–9.
Gestation period	ca. 65 days (Tomey 1982); 4 months (22 °C), 5 months (19 °C) (Mohr & Cabrera 2013).
Sperm storage	Yes (Mohr & Cabrera 2013).

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Specimens should be kept individually in terraria with dense vegetation and high humidity and enough ventilation. Branches covered with moss should be present. Annual temperature should be moderate and should not exceed 20 °C during daytime and decrease to 15 °C or lower during nighttime (Mohr & Cabrera 2013).
Husbandry requirements	The animals should be kept individually in terraria measuring 35 x 35 x 50 cm. A proper ventilation can be achieved by large ventilation grids in the front and the top of the terrarium. A ventilator at the front should be used to achieve a proper

Topic	Data
	air movement. For lighting, T5- tubes and LED lighting can be used. The terrarium should be automatically sprayed/misted three times a day for two minutes. The air humidity should be between 70 % and 80 %. Additionally, manual spraying, particularly for the plants, and to provide drinking water, is important. The terrarium setup should be as natural as possible. Leaf soil covered by moss should be used as substrate. Branches (elder, oak) of different diameter should be provided. Branches covered with mosses and lichens should be used. Plants such as *Selaginella* species, ferns, *Dischidia*, small-growing Araceae, *Ficus quercifolia* and small-growing orchids are recommended. For the terrarium wall tree fern plates can be used. An air conditioning should be used and set at a maximum temperature of 19 °C (Mohr & Cabrera 2013). The diet contains the usual, commercially available food insects (grasshoppers, crickets, cockroaches). Food should be supplemented with the commercially available mineral and vitamin supplements.
General characteristics, difficulties with keeping and breeding	Both species have high requirements regarding climatic conditions. These rare and highly endangered species should only be kept by experienced keepers who can meet these requirements all year round. For successful keeping and breeding of these species, a temperature-stable basement room, or an air-conditioned terrarium room, are basic requirements. High temperatures must be avoided during female gravidity to ensure the vitality of the young.
Care of the young, technical and time effort	If the young are vital, the effort to raise them is feasible. Newly hatched juveniles that do not climb branches immediately and independently, but rather stay on the ground, are usually not viable. Most of these usually appear to have hatched before being fully developed. The concern for a vital litter begins with optimal conditions in the captive care of the adult females. High temperatures during gravidity must be avoided. Already on the first day after hatching, the young begin feeding. Depending on the vitality of the young, small Drosophila are taken. The fruit flies can be easily supplemented with vitamin, which is more difficult with springtails. Firebrat (*Thermobia domestica*) and woodlice (isopods) offered in small smooth-walled vessels are also accepted by the young (Langner pers. obs.). Similar to adult animals, the juveniles take water only from drops on branches or leaves. The young should be kept individually with a similar setup as for the adults. The enclosures should be smaller in size, so that they are able to catch the food insects more easily, and for the keeper to have a better control.
Life expectancy in captivity	Minimum 10 years.
Frequency of breeding in captivity	Rare, since these agamas are only kept by few keepers, due to the very specific habitat requirements.
Breeding difficulty evaluation	Very demanding due to the climatic requirements.
Mortality in the first years of life	Relatively high if specimens are kept/ raised collectively, and/ or when the gravid females are kept too warm.
F2 generation bred	Yes.
Interviews/ Surveys/ Consultations	Several private breeders.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Amarasinghe, A.A.T., U. Manthey, E. Stöckli, I. Ineich, S.O. Kullander, F. Tiedemann, C. McCarthy & D.E. Gabadage (2009): The original descriptions and figures of Sri Lankan agamid lizards (Squamata: Agamidae) of the 18th and 19th centuries. Taprobanica **1**(1): 2-15.

Ananjeva, N.B. (2012): К ВОПРОСУ О ЖИВОРОЖДЕНИИ У АГАМОВЫХ ЯЩЕРИЦ (Sauria, Acrodonta, Agamidae) [To viviparity in agama lizards (Sauria, Acrodonta, Agamidae)]. Zoologicheskii Zhurnal **91**(11): 1358-1365.

Bahir, M.M. & T. Surasinghe (2005): A conservation assessment of the Sri Lankan Agamidae (Reptilia: Sauria). Raffles Bulletin of Zoology, Supplement **12**: 407-412.

Barts, M. & A. Kwet (2007): Wettlauf um eine Baumagame - *Cophotis dumbara* oder *Cophotis dumbarae*? Draco **7**(30): 91-92.

Barts, M. & T. Wilms (2003): Die Agamen der Welt. Draco **4**(14): 4-23.

Botejue, W.M.S & J. Wattavidanage (2012): Herpetofaunal diversity and distribution in Kalugala proposed forest reserve, Western province of Sri Lanka. Amphibian & Reptile Conservation **5**(2): 65-80.

Boulenger, G.A. (1890): Reptilia and Batrachia. *In:* Blandford, W.T. (Ed.): The Fauna of British India, Including Ceylon and Burma. London (Taylor & Francis) Vol. xviii: 541 pp.

Das I. & A. de Silva (2005): A Photographic Guide to Snakes and Other Reptiles of Sri Lanka. London (New Holland): 144 pp.

Das, I. & A. Das (2017): A Naturalist's Guide to the Reptiles of India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka. Oxford (John Beaufoy Publishing Ltd.): 176 pp.

De Silva, A. (1990): Observations on some vanishing relict lizards of Sri Lanka. Hamadryad **15**(1): 34-35.

De Silva, A. (1994): An introduction to the herpetofauna of Sri Lanka. Lyriocephalus **1**(1-2): 3-19.

De Silva, A., A.M. Bauer, S. Goonewardene, J. Drake, S. Nathanael, W.P.R. Chandraratne & S.A.U.S. Somathilaka (2005): Status of the agamids in the Knuckles Massif with special reference to *Calotes liocephalus* Günther, 1872 and *Cophotis ceylanica* Peters, 1861. Lyriocephalus **6(**1-2): 43-52.

Erdelen W.R. (2012): Conservation of biodiversity in a hotspot: Sri Lanka's amphibians and reptiles. Amphibian and Reptile Conservation **5**(2):33-51(e37).

Gibson, C., A. de Silva, M.F. Tognelli & S. Karunarathna (Eds.) (2020): Assess to Plan: Conservation Action Planning for the Snakes and Lizards of Sri Lanka. IUCN Conservation Planning Specialist Group, Apple Valley, MN, USA. 80 pp.

Goonewardene, S., J. Drake & A. de Silva (2006): The herpetofauna of the Knuckles Range. Project Knuckles 2005 & 2006. University of Edinburg Research Expedition, Amphibia and Reptile Research Organisation (ARROS), Kandy: 208 S.

Hallermann, J. (2005): Mit Hörnern, Kämmen und Gleithäuten - die bizarren Baumagamen. Reptilia (Münster) **10**(51): 18-25.

Hallermann, J. (2005): The bizarre arboreal agamids. Reptilia (GB) (**42**): 8-15.

Hallermann J. & W. Böhme (2000): A review of the genus *Pseudocalotes* (Squamata: Agamidae), with description of a new species from West Malaysia. Amphibia-Reptilia.

21(2): 193-210.

Hallermann, J. & W. Böhme (2007): On the validity of two recently described species of the endemic Sri Lankan genus *Cophotis* Peters, 1861 (Squamata: Agamidae) from the Knuckles Forest Range. Salamandra **43**(3): 187-190.

Janssen, J. & A. de Silva (2019): The presence of protected reptiles from Sri Lanka in international commercial trade. TRAFFIC Bulletin **31**(1): 9-15.

Janzen, P., P. Klaas & S. Ziesmann (2007): Adams Zufluchtsort: Sri Lanka. Draco **7**(30): 4-17.

Janzen, P., P. Klaas & S. Ziesmann (2007): Die Agamen der Insel [Sri Lanka]. Draco **7**(30): 24-33.

Karunarathna, D.M.S.S. & A.A.T. Amarasinghe (2009): Beobachtung einer Dickschnabelkrähe (Aves: Corvidae) beim Erbeuten von Ceylon-Taubagamen, *Cophotis ceylanica* (Reptilia: Agamidae), im Horton Plains Nationalpark auf Sri Lanka. Sauria **30**(4): 59-62 [2008].

Kästle, W. (1966): Beobachtungen an ceylonesischen Taubagamen (*Cophotis ceylanica*). Salamandra **2**(3): 78-87.

Keerthirathna, W.L.R & W.A.D Mahaulpatha (2019): Microhabitat preferences and associated behavior patterns of endemic pigmy lizard: *Cophotis ceylanica* in Horton plains. Sri Lanka Journal of Entomology and Zoology Studies **7**(4): 924-928.

Laurens, B. (1988): De dove agame van Ceylon (*Cophotis ceylanica*). Lacerta **46**(9): 134.

Macey, J.R., J.A. Schulte, A. Larson, N.B. Ananjeva, Y. Wang, R. Pethiyagoda, N. Rastegar-Pouyani & T.J. Papenfuss (2000): Evaluating trans-Tethys migration: an example using acrodont lizard phylogenetics. Systematic Biology **49** (2): 233-256.

Manamendra-Arachchi, K., A. de Silva & T. Amarasinghe (2006): Description of a second species of *Cophotis* (Reptilia: Agamidae) from the highlands of Sri Lanka. Lyriocephalus **6** (Suppl. 1): 1-8.

Manthey, U. & N. Schuster (1999): Agamen, 2. Aufl. Münster (Natur und Tier Verlag): 120 pp.

Mohr, H. & J. Cabrera (2013): *Cophotis ceylanica* - Biologie, Haltung und Nachzucht der Ceylonesischen Taubagame. Terraria-Elaphe **2013**(6): 58-71.

Oberleuthner, A. (2019): Weitere Reptilien- und Amphibienarten auf Cites! HYLA - Fachzeitschrift für Herpetologie und Terraristik **18:** 28-37.

Palihawadna, A. (1998): An ecological study of *Cophotis ceylanica*. Pp. 253-260. *In:* De Silva, A. (Ed.): Biology and conservation of the amphibians, reptiles and their habitats in South Asia. Proceedings of the International Conference on the Biology and Conservation of the Amphibians and Reptiles of South Asia, held at the Institute of Fundamental Studies, Kandy and University of Peradeniya, Sri Lanka, August 1-5, 1996. Colombo (Amphibia and Reptile Research Organization of Sri Lanka, ARROS): 364 pp.

Peters, W. (1861): On a new genus of lizards from Ceylon.Annals and Magazine of Natural History. Series 3, Volume 9, 1862, **53**: 419-420.

Peters, W.C.H. (1861): Eine neue Gattung von Eidechsen, *Cophotis ceylanica*, aus Ceylon. Monatsberichte der königlichen Akademie der Wissenschaften zu Berlin **1861**: 1103-1105.

Pethiyagoda, R. (Ed.) (2012): Horton Plains: Sri Lanka's cloud-forest national park. Colombo (Wildlife Heritage Trust): 320 pp.

Rogner M. (1992): Echsen 1 - Geckos Flossenfüße, Agamen, Chamäleons und Leguane.

Stuttgart (Eugen Ulmer Verlag): 281 pp.

Samarawickrama, V.A.M.P.K., K.B. Ranawana, D.R.N.S. Rajapaksha, N.B. Ananjeva, N.L. Orlov, J.M.A.S. Ranasinghe & V.A.P. Samarawickrama (2006): A new species of the genus *Cophotis* (Squamata: Agamidae) from Sri Lanka. Russian Journal of Herpetology. **13**(3): 207–214.

Schäfer, D. (1998): Climate change in Sri Lanka? Statistical analyses of long-term temperature and rainfall records. Pp. 103-117. *In:* Domrös, M. & H. Roth (eds.): Sri Lanka - Past and Present: Archaeology, Geography, Economics. Selected Papers on German Research. Weikersheim (Margraf Verlag).

Schleich, H.H. & W. Kästle (1979): Hautstrukturen als Kletteranpassungen bei *Chamaeleo* and *Cophotis* (Reptilia: Sauria: Chamaeleonidae, Agamidae). Salamandra **15**(2): 95-100.

Schleich, H.H.& W. Kästle (1982): Hautstrukturen an Zehen und Schwänzen einiger Agamiden (Reptilia: Sauria: Agamidae). Salamandra **18**(3-4): 322-329.

Schulte, J.A., J.R. Macey, R. Pethiyagoda & A. Larson (2002): Rostral Horn Evolution among Agamid Lizards of the Genus *Ceratophora* Endemic to Sri Lanka. Molecular Phylogenetics and Evolution **22**(1): 111-117.

Smith, M.A. (1935) The fauna of British India, including Ceylon and Burma. Reptiles and Amphibia, Vol. II. Sauria. Landon (Taylor and Francis): 440 pp.

Somaweera, R. & N. Somaweera (2009): Lizards of Sri Lanka: A colour guide with field keys. Frankfurt (Edition Chimaira): 304 pp.

Sri Lanka Department of Wildlife Conservation (1993): Fauna and Flora Protection Ordinance. Part III: Vertebrates and Invertebrates [Subs by s 34 of Act 49 of 1993.] https://www.srilankalaw.lk/Volume-III/fauna-and-flora-protection-ordinance.html (accessed 06.07.2021)

Taylor, E.H. (1953): A review of the lizards of Ceylon. University of Kansas Science Bulletin **35**(12): 1525-1585.

Tomey, W.A. (1982): Seltene Baumagame *Cophotis ceylanica*. Aquarium (Bornheim) **16**(160): 549-552.

Tryon, B.W. (1979): Notes on the reproduction of the lizard *Cophotis ceylonica*. British Journal of Herpetology **5**(12): 845-847.

Wickramasinghe, L.J.M. (2012): The taxonomy and conservation status of the reptile fauna in Sri Lanka, pp. 99-113. *In:* Weerakoon, D.K. & S. Wijesundara (eds.): The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka.

Willey, A. (1906): Viviparity of *Cophotis ceylanica* and oviparity of *Ceratophora stoddartii*. Spolia Zeylanica **3**: Unpaginated

Christian Langner (30.05.2021)

Lyriocephalus scutatus (Linnaeus, 1758)

Hump-nosed Lizard, Lyre-headed Lizard

German name: Lyrakopf-Agame

Singhalese/ Tamil: Karamal bódilimå, Gatahombu katussa/ Kaňdu-kara bódilimå

Fig. 5a: *Lyriocephalus scutatus* in Sri Lankan habitat (P. Janzen);
b: *Lyriocephalus scutatus* breeding pair in their terrarium (A. Böhle);
c: *Lyriocephalus scutatus* just hatched in the incubator (A. Böhle).

Morphology and Taxonomy

Lyriocephalus scutatus is the only species of the genus *Lyriocephalus*.

Hump-nosed Lizard ♂♂ can reach up to 34 cm total length (SVL ca. 17 cm) ♀♀ are smaller with a max. total length of 24 cm.

Lyriocephalus scutatus has a unique prominent raised nose thanks to which is hard to confused with other lizard species. On the tip of the snout, they have a spherical extension, which is particularly pronounced in ♂♂ and reduced or only hinted at in ♀♀. At the back of the head, it has a pair of conspicuous spines which are elongated supraciliar scales. In the head of adult hump-nosed lizards the supraciliar scales form a bony arch which gives this species its name. A prominent, hump-like, erectable neck crest interspersed with several rows of enlarged, barely spiny scales extend over the nuchal region. The crest is followed by a row of enlarged spiny scales up to the beginning of the tail. The neck crest is less noticeable in ♀♀. The body is laterally compressed. They have a gular sac, which in ♂♂ is more colorful and conspicuous and which is used in display behavior and opponent threatening.

Their color is very variable, and it can change both within and between populations. Furthermore, this species is capable of, mainly mood-dependent, physiological color change. The color can vary from bright grass green to olive green or brown and sometimes yellow. Occasionally, they can show a lichen imitating pattern with a combination of these colors (Kiehlman 1980). Predominantly ♂♂ show bright colors. In doing so, their rostral appendage can even be lemon- to yolk-yellow and the flanks and venter white to striking blue. During nighttime the adults are mainly intense green. This species can move each eye independently as chameleons and anoles do (Kiehlman 1980). Juveniles are inconspicuous brown to olive green. A visible tympanum is missing.

Distribution and Habitat

Distribution

The species is endemic to Sri Lanka and widely distributed in moist tropic lowland and hill country. It mainly occurs in the southwest and central Sri Lanka and can be found at up to 1650 m in elevation in the central hills. Type locality: in the original description only “Asia” is mentioned.

Habitat

This species is commonly found in open forests with scarce ground vegetation (Prinz & Prinz 1986). The climate is tropic – equatorial with up to 2.000 mm annual precipitation and without a distinctive dry season. Nighttime temperatures rarely drop below 20 °C and during day time they can reach 28 °C. The lizards sit, head upwards, about one to two meters high in young trees with 3–30 cm of diameter (Kiehlmann 1980). Kiehlmann (1980) reports an unbalanced sex ratio of nine to one (males: females) and a minimum distance of 40 m to each other while Prinz & Prinz (1986) report a more balanced sex ratio of 12:14 (males: females). Usually, the lizards stay still and do not flee when approached.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 26).

Council Regulation Nr. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN-Red list status: Near Threatened (assessed June 30, 2009).

Sri Lanka national Red List status: Vulnerable, B1ab(iii) (Wickramasinghe 2012)

Threats

As everywhere in the tropics, also in Sri Lanka the main threat is a rapid loss of rain forest. Primary forests are rapidly shrinking and are now mainly concentrated on a few protected areas. Logging and land grabbing for a rapidly increasing population are the main cause. Nevertheless, the government's recent announcement on rejecting palm oil plantation shows a positive development.

Lyriocephalus scutatus is still considered dangerous by local people and is therefore killed (Gibson *et al.* 2020).

Nature conservation legislation is dealt restrictively, and violations are rigorously punished, at least those performed by tourists. Even photographing reptiles in the wild is prohibited. Nevertheless, in the past, small numbers of animals were traded to Europe, USA and Japan. In the 1970's and 1980's mainly as "by-pack" in ornamental fish shipments. The species is continuously being bred since the 1980's in Europe, although in low numbers.

Reproduction

Topic	Data
Secondary sexual traits	*Lyriocephalus scutatus* shows sexual dimorphism and dichromatism. ♂♂ show a larger and more robust body, a pronounced rostral appendage and the root of the tail is swollen due to the hemipenis bulges. The color is brighter in ♂♂ and more colorful with often a bright green ground color. In Females the ground color is predominantly brown olive. The dorsal crest is in females less pronounced.
Reproduction	Oviparous.
Sexual maturity	From the age of 10–12 months on.
Mating season	All year round.
Number of eggs/ clutches per season	6–18 eggs; every 6–8 weeks.
Gestation period	8–10 weeks.
Egg size/ hatchling size	18.4–20.7 mm x 11.5–13.0 mm; 1.5–1.9 g; juveniles 45–61 mm total length.
Incubation and hatch-ing	Incubation 170–190 days at 23–26 °C; 141–146 days (no data on temperature given); Hatching rate 90 % sex ratio 50:50.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	A continuous high humidity is crucial to stimulate mating. Changing the water of the pond can also help.
Husbandry requirements	The minimum space requirements for keeping reptiles (Federal Ministry for Food, Agriculture and Forestry 1997) is 5 x 4 x 4 (L x W x H) the size of snout-vent-length. This results in a minimum terrarium size of 85 x 70 x 70 cm. The author considers this dimension to be unfavorable and definitely too small for this tree dwelling species. As a minimum size 80 x 80 x 120 cm (L x W x H) should be considered. Kiehlman (1980) argues for 160 x 80 x 100 cm; Prinz & Prinz (1986) for 160 x 70 x 160 cm and 190 x 80 x 180 cm (L x W x H). The terraria should contain several structures and vertical branches to climb on. It should be densely planted with tropical indoor plants and a large part of water with a small waterfall should be present. This stimulates the animals to search for water, thus the water should be filtered and regularly changed. A mixture of soil and sand, or coconut humus which should be kept slightly moist, is recommended. The diet should be varied on the usual, commercially available food insects (grasshoppers, crickets, cockroaches, *Zophobas* larvae, snails and slugs, etc.). The main food, however, is earthworms. Food should be supplemented with the commercially available mineral and vitamin supplements. For lighting T5- tubes or LED lighting should be used. A common spotlight can be used as a heat and UV source to achieve a day temperature between 24–28 °C. It has been explicitly mentioned both in the literature and in the questionnaires that gravid females require higher UV radiation, which can be achieved by using an Ultra Vitalux lamp for up to 30 minutes, but then care should be taken to observe the necessary safety distance. During nighttime, the temperature can decrease down to room temperature. The humidity should be between 70 % and 80 % and should increase slightly during nighttime. To this end an ultrasonic nebulizer and an automatic sprinkler system can be used. Aggression within species is high, therefore the keeping of more than one male in a terrarium, even if large, should be avoided. Similarly, the keeping in pairs or one male with several females can lead to stress and losses. Spatial separation of incompatible animals should be considered.
General characteristics, difficulties with keeping and breeding	During reproduction period a substrate layer of minimum 25 cm must be provided. For incubation, a mixture of sand and peat is recommended. Incubation temperature should be between 23–26 °C and humidity between 90–100 %.
Care of the young, technical and time effort	The juveniles should be kept in small to medium size terraria e.g., 45 x 30 x 30 cm (L x W x H) with same setup as for the adults. The diet for the juveniles corresponds to that of adults. Aggression is high in juveniles and therefore they should be kept in small groups or ideally individually. Enough vitamin and mineral supplement as well as adequate UV supply should be provided. The effort for the juvenile's care takes about 15–30 minutes daily.
Life expectancy in captivity	More than 10 years.
Frequency of breeding in captivity	Rare, since these agamas are only kept by few keepers.
Breeding difficulty evaluation	Breeding of this species is possible when the requirements are met and has been successful on several occasions up to F2 generation. However, it requires some experience in handling sensitive lizards. This sensitive and stress prone

Topic	Data
	species are absolutely not suitable for beginners.
Mortality in the first years of life	10 %, in older literature also higher.
F2 generation bred	Yes.
Interviews/ Surveys/ Consultations	Several private breeders.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Amarasinghe, A.A.T., U. Manthey, E. Stöckli, I. Ineich, S.O Kullander, F. Tiedemann, C. McCarthy & D.E. Gabadage (2009): The original descriptions and figures of Sri Lankan agamid lizards (Squamata: Agamidae) of the 18th and 19th centuries. Taprobanica **1**(1): 2-15.

Bahir, M.M. & T. Surasinghe (2005): A conservation assessment of the Sri Lankan Agamidae (Reptilia: Sauria). Raffles Bulletin of Zoology, Supplement **12**: 407-412.

Bambaradeniya, C.N.B., P.K. Samarawickrema & K.B. Ranawana (1997): Some observations on the natural history of *Lyriocephalus scutatus* (Linnaeus, 1776) (Reptilia: Agamidae). Lyriocephalus **3**(1): 25-28.

Bandara, I.N. (2011): Territorial and site fidelity behavior of *Lyriocephalus scutatus* (Agamidae: Draconinae) in Sri Lanka. Amphibian and Reptile Conservation **5**(2): 101-113.

Bartelt, U. (2003): Anmerkungen zur Haltung und Nachzucht der Lyrakopfagame, *Lyriocephalus scutatus* (Linnaeus, 1758). Draco **4**(2) (14): 64-68.

Bartelt, U., H. de Bitter H. & de Bitter M. (2004): *Lyriocephalus scutatus*: Namkweek tot F3. Lacerta **62**(1): 21-31.

Bartelt, U., H. de Bitter & M. de Bitter (2005): *Lyriocephalus scutatus*: the lyrehead lizard. Reptilia (GB) **42**: 29-36.

Das, I. & A. Das (2017): A Naturalist's Guide to the Reptiles of India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka. Oxford (John Beaufoy Publishing Ltd.): 176 pp.

De Silva, A. (1990): Observations on some vanishing relict lizards of Sri Lanka. Hamadryad **15**(1): 34-35.

Deraniyagala, P.E.P. (1932): Herpetological Notes. Ceylon Journal of Science (B) **17**: 44-55.

Gibson, C., A. de Silva, M.F. Tognelli & S. Karunarathna (Eds.) (2020): Assess to Plan: Conservation Action Planning for the Snakes and Lizards of Sri Lanka. IUCN Conservation Planning Specialist Group, Apple Valley, MN, USA. 80 pp.

Goonawardene, S. & A. de Silva (2005): Observations of the lyre head dragon: *Lyriocephalus scutatus* (Linnaeus, 1758) (Reptilia: Agamidae) in the central province. Lyriocephalus **6**(1-2): 313-323.

Hallermann, J. (2005): Mit Hörnern, Kämmen und Gleithäuten - die bizarren Baumagamen. Reptilia (Münster) **10**(51): 18-25.

Hallermann, J. (2005): The bizarre arboreal agamids. Reptilia (GB) (**42**): 8-15.

Hoffmann, S. (2018): Sri Lanka - auf der Suche nach Leopard- und Lyrakopfagame. Terraria-Elaphe **2018**(1): 44-49 [2017].

Janssen, J. & A. de Silva (2019): The presence of protected reptiles from Sri Lanka in international commercial trade. TRAFFIC Bulletin **31**(1): 9-15.

Janzen, P. (2011): Morningside, ein abgelegener Hotspot in Sri Lanka. Iguana Rundschreiben **24**(1): 5-11.

Janzen, P., P. Klaas & S. Ziesmann (2007): Adams Zufluchtsort: Sri Lanka. Draco **7**(30): 4-17.

Janzen, P., P. Klaas & S. Ziesmann (2007): Die Agamen der Insel [Sri Lanka]. Draco **7**(30): 24-33.

Janzen, P. & M. Bopage (2011): The herpetofauna of a small and unprotected patch of tropical rainforest in Morningside, Sri Lanka. Amphibian & Reptile Conservation **5**(2): 1-13.

Karunarathna, D.M.S.S. & A.A.T. Amarasinghe (2013): Behavioral ecology and microhabitat use by *Lyriocephalus scutatus* (Linnaeus, 1758): a monotypic genus in Sri Lanka (Reptilia: Agamidae: Draconinae) with notes on the taxonomy. Russian Journal of Herpetology **20**(1): 1-15.

Kiehlmann, D. (1980): Über die Lyrakopfagamen, *Lyriocephalus scutatus* (Linnaeus 1758). Herpetofauna **2**(8): 12-20.

Kiehlmann, D. (1982): *Lyriocephalus scutatus* (Linnaeus). Revue Française d'Aquariologie et Herpetologie **9**(2) (Suppl. 239): 2 pp.

Kiehlmann, D. (1983): *Lyriocephalus scutatus* (Linnaeus) (11). Revue Française d'Aquariologie et Herpetologie **9**(4): 2 pp.

Manthey, U. (1981): Die Echsen des Ceylonischen Regenwaldes und seiner Randgebiete. Sauria **3**(2): 25-35.

Manthey U. (2010): Agamid Lizards of Southern Asia. Draconinae 2 -Leiolepidinae. Terralog Vol. 7b. Frankfurt (Edition Chimaira): 168 pp.

Manthey, U. & N. Schuster (1999): Agamen, 2. Aufl. Münster (Natur und Tier Verlag): 120 pp.

Moody, S. & P. Hutterer. (1978): Karyotype of the agamid lizard *Lyriocephalus scutatus* (L., 1758), with a brief review of the chromosomes of the lizard family Agamidae. Bonner Zoologische Beiträge **29**(1-3): 165-170.

Nijhuis, F. (1979): Dankbare aber seltene Pfleglinge sind *Lyriocephalus scutatus*. Aquarium (Bornheim) **13**(116): 80–81.

Nizam, B.Z. (2005): A note on egg laying of *Lyriocephalus scutatus* in the northern flank of the Knuckles region. Lyriocephalus **6**(1-2): 275.

Prinz, H. & T. Prinz (1986): Beobachtungen an der Lyrakopfagame (*Lyriocephalus scutatus*), ihre Haltung und Aufzucht. Herpetofauna (Weinstadt) **8**(43): 28-34.

Samarawickrama, V.A.M.P.K., H.I.G.C. Kumara & D.R.N.S. Samarawickrama (2019): Diversity of Reptiles in the Eastern and Southern parts of the Sinharaja Rain Forest. Journal of Tropical Forestry and Environment **9**(1): 37-47.

Smith, M.A. (1935): The fauna of British India, including Ceylon and Burma. Reptilia and Amphibia, Vol. II. Sauria. London (Taylor and Francis): 440 pp

Somaweera, R. & A. de Silva (2010): *Lyriocephalus scutatus*. The IUCN Red List of Threatened Species 2010: e.T170409A6778615.

Sri Lanka Department of Wildlife Conservation (1993): Fauna and Flora Protection Ordinance. Part III: Vertebrates and Invertebrates [Subs by s 34 of Act 49 of 1993.] https://www.srilankalaw.lk/Volume-III/fauna-and-flora-protection-ordinance.html (accessed 06.07.2021)

Taylor, E.H. (1951): Egg-laying behavior of an Oriental agamid lizard. Herpetologica **7**(2): 59-60.

Taylor, E.H. (1953): A review of the lizards of Ceylon. University of Kansas Science Bulletin **35**(12): 1525-1585.

Tomey, W.A. (1983): Von Stachelnasen, Stumpfnasen, Blattnasen und Spitznasen - Agamen von Sri Lanka (Ceylon) (2). Aquarium (Bornheim) **17**(168): 321-326.

Vidyalankara, K.N.K. & R.W. Bandara (2004): Some observations on *Lyriocephalus scutatus*. Lyriocephalus **5**(1-2) Special Issue: The herpetology of Sri Lanka: current research: 151.

Wickramasinghe, L.J.M. (2012): The taxonomy and conservation status of the reptile fauna in Sri Lanka, pp. 99-113. *In:* Weerakoon, D.K. & S. Wijesundara (eds.): The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka.

Christian Langner (04.04 2021)

Iguanidae

Cachryx alfredschmidti (*Ctenosaura alfredschmidti*) and *Cachryx defensor (Ctenosaura defensor*)

Species	Description author and date	Common name English	Common name German/ Spanish	Known in the trade
Cachryx alfredschmidti (genus name used according to CITES nomenclature reference: *Ctenosaura alfredschmidti)*	Köhler, 1995	Campeche spiny-tailed iguana	Campeche-Schwarzleguan/ Garrobo de Campeche	yes
Cachryx defensor (genus name used according to CITES nomenclature reference: *Ctenosaura defensor*))	(Cope, 1866)	Yucatán spiny-tailed iguana	Yucatán-Schwarzleguan/ Garrobo de Yucatán; Chop	yes

Recent studies (Malone *et al.* 2017) show that the species *Ctenosaura alfredschmidti* and *Ctenosaura defensor* are genetically significantly different from the other species of the genus. Therefore, the species *C. alfredschmidti* and *C. defensor* were placed in the revalidated genus *Cachryx* (Cope, 1866) and it was shown that the closest related taxa are not species of the genus *Ctenosaura*, but the iguanas of the Galápagos Islands of the genera *Amblyrhynchus* and *Conolophus*. This taxonomic change is widely accepted, however, not considered by the CITES nomenclature, yet. In this fact sheet we acknowledge and follow the taxonomic findings of Malone *et al.* 2017 and thus recommended to modify the nomenclature currently used by CITES, the IUCN red list etc. Nevertheless, we emphasize here particularly, that the genus name currently used in CITES is *Ctenosaura* (document status 2021).

Both species have a spiny tail with large scales which leads to its common name spiny-tailed iguana. A further characteristic of both species is their small size, which is also shared with representatives of the former genus *Enyaliosaurus*. In contrast to these species, the representatives of the genus *Ctenosaura* (see below: "*Ctenosaura* – Large Mainland Species" and "*Ctenosaura* – Island Species") are large in size and often longer than one meter, and they have a relatively longer and less spiny tail.

According to new data (Malone *et al.* 2017), the spiny-tailed iguanas of the genus *Cachryx* are not closely related to the genus *Ctenosaura*, thus the similar morphology might be due to a convergent adaptation to a similar habitat and ecologic niche.

Fig. 6a: *Cachryx defensor* Yucatán, Mexico (Ch. Langner);
b: *Cachryx alfredschmidti* Campeche, Mexico (Ch. Langner);
c: *Cachryx defensor* captive bred juveniles (Ch. Langner);
d: *Cachryx alfredschmidti* hatchlings (Ch. Langner);
e: *Cachryx alfredschmidti* hatching (Ch. Langner).

Morphology and Taxonomy

The species of the genus Cachryx can be identified by the following characteristics:

Cachryx alfredschmidti – total length up to 30 cm (snout–vent length ca. 17 cm); females are slightly smaller than males. Their body shape is slimmer than that of *C. defensor.* Both species of the genus are similar in morphology at first sight.

The tail of *Cachryx alfredschmidti* is longer than that of *C. defensor.* The ratio tail length to SVL is 0.79–0.85. The number of tail whorls varies between 27 and 29. The parietal eye is small, but visible. The row of enlarged medial dorsalia is regular and it extends into the pelvic region. *C. alfredschmidti* shows an astonishingly high individual and mood- and temperature-dependent variability in coloration. The color of the head of adult Campeche Spiny-tailed iguanas is dark grey or malachite blue and the throat is bright grey with scattered red dots. The upper half of the dorsum is almost black, the other half brown to red. The venter is white to grey. It has two dark cross bands on the forelimbs. The back limbs and the tail are dark grey to black. The root of the tail is often bluish. Juveniles have a dark brown cross band on the back and the tail which disappears with age. In both *Cachryx* species, green colored juveniles where never observed (Köhler 2002, Langner pers. communication).

Cachryx defensor – total length maximum 25 cm (SVL ca. 14.5 cm); females are slightly smaller in size than males. The species has a shorter tail than *C. alfredschmidti*, and its body shape is rounder than that of the Campeche Spiny-tailed iguana. The ratio of tail length to SVL is 0.65–0.74. It has 22 to 24 tail whorls. The parietal eye is not identifiable. The row of enlarged medial dorsalia is regular and reduced. Generally, no complete row of intercalaria (intermediate tail scales) is present between the first eight whorls of enlarged thorny tail scales. The top of head is grey-green colored in adult Yucatán Spiny-tailed iguanas; the throat is bright grey with irregular red dots. On the anterior half of dorsum three wide, black cross bands are present, which extend into the venter in males. Between these bands there are irregular, netlike dots. In adult males the cross bands reach each other on the venter resulting in a black coloration. The back half of the back is brown to brick red in adult specimens and the venter whitish. On the forelimbs are two dark cross bands. The back limbs and the top of the tail are dark grey. The root of the tail of males has sometimes some partly blue coloration. Juveniles have dark brown cross bands on the dorsum and on the tail which disappear with age.

Juveniles of the two *Cachryx* species do not show any green body parts or coloring (Köhler 2002, Langner pers. obs.).

Distribution and Habitat

Distribution

***Cachryx* [*Ctenosaura*] *alfredschmidti*:** Mexico (Campeche, Quintana Roo); older records on the occurrence in Guatemala actually referred to *Cachryx defensor* (Malone *et al.* 2017). Type locality: 70 km east of Escarcega on the road to Chetumal, Campeche, Mexico.

***Cachryx* [*Ctenosaura*] *defensor*:** Mexico (Campeche, Yucatán, Quintana Roo), Guatemala (Río Azul). Type locality: Yucatán. Restricted to Chichén Itzá, Yucatán, Mexico (Smith & Taylor 1950).

Habitat

Cachryx [*Ctenosaura*] *alfredschmidti* inhabits dead hollow branches in dry deciduous forest at 140 to 282 m asl Morales-Mávil *et al.* (2016) found the iguanas primarily in *Haematoxylum* sp. trees at heights between 50 cm and 6 m. Similar to *C. defensor*, and all the species from the *Ctenosaura quinquecarinata* group, *C. alfredschmidti* also closes the entry of its hole with its spiny tail. Contrary to *C. defensor, C. alfredschmidti* is completely tree-dwelling. The author observed individuals only in their den in the wild. Outside of their hiding places, even with the help of binoculars, no specimens could be observed. Even when disturbed by lighting, *C. alfredschmidti* would not come out of their hiding places, a behavior that could be verified by patient hours of observation (Köhler 2002, Langner pers. observation).

Cachryx [*Ctenosaura*] *defensor* inhabits open areas in rocky terrain in dry forests. The limestone rocks are of coralline origin and show many holes and cavities. *Cachryx defensor* is saxicolous and uses the crevices in limestone rocks as retreat. The species also uses its spiny tail to close up the entry of the hiding holes. In rare cases individuals have been found in other hiding places like weathered fence posts when natural crevices were scarce. All individuals were observed in their hiding places only (Langner pers. observation). This is in line with the observations made by Köhler (2002). Köhler (2002) also observed that the lizards would only cautiously leave their hiding spots many hours after they were first spotted. This author also states that only in very rare cases, hiding places other than rock caves, such as hollow branches were used.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

Council Regulation (EC) Nr. 338/ 97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Cachryx [Ctenosaura] alfredschmidti: Near Threatened (assessed April 30, 2004);

Cachryx [Ctenosaura] defensor: Vulnerable (A3cd; B1ab(iii,v)+2ab(iii,v), assessed April 30, 2004).

Threats

The two species of the genus *Cachryx* are particularly threatened by massive habitat destruction and the associated loss of habitat. Subtropical and tropical dry forests belong to the most endangered habitats in central America.

Forests in the small distribution range of *C. alfredschmidti* on the Yucatán Peninsula are extremely endangered. Extensive clearing of the dry forest for agriculture, road- and other construction projects or the extraction of wood and charcoal reduces their habitat dramatically from year to year. In the course of the last 20 years, the author of this fact sheet observed, in addition to the rapidly advancing habitat loss, a drastic decrease in the abundance of Campeche Spiny-tailed iguanas in largely intact habitats (Langner, personal observation). The density of *C. alfredschmidti* was estimated to be 5.1 individuals per hectare (Morales-Mávil *et al.* 2016).

Both *Cachryx* species are used for various purposes. *C. defensor*, also known as “chop” by the locals, has played a role in traditional medicine, probably since the times of the ancient Maya. The larger *C. alfredschmidti* is also used for food consumption. The capture for the illegal animal trade poses a further threat to both species.

Reproduction

Topic	Data
Secondary sexual traits	There is a very subtle sexual dimorphism. Males are slightly bigger and have larger heads. Femoral pores and hemipenis bulges are prominent in males. The color is slightly more intense in males than in females.
Reproduction	Oviparous.
Number of eggs/ clutches per season	*Ctenosaura alfredschmidti* – 3–7 eggs per clutch; Number of clutches unknown; *Ctenosaura defensor* – 2–8 eggs per clutch; Number of clutches unknown.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Breeding is stimulated with the simulation of rainy and dry season. In Central Europe, during summer months between June and October, it should be extensively sprayed and from November to May the animals should be kept significantly drier.
Husbandry requirements	According to the minimum husbandry requirements that are valid in Germany (Federal Ministry for Food Agriculture and Forestry 1997), the minimum size of the terrarium should be 5 x 4 x 4 (L x W x H) the size of snout-vent length. The author considers this dimension for the arboreal species C. alfredschmidti to be unfavorable and also too small. The minimum size should be 80 x 80 x 120 cm. For the more ground-dwelling species *C. defensor*, it should be at least 70 x 60 x 60 cm. The terrarium should be sufficiently structured and contain and branches to climb on. Hollow cork pieces or nest boxes can be used as hiding places. The terrarium should have no plants due to the species' vegetarian diet; only plastic plants could be used. A substrate layer of soil-sand mixture or of pine bark, which is kept slightly moist to avoid dust, is recommended. The diet should be varied and contain the usual, commercially available food insects (locusts, crickets, cockroaches, *Zophobas* larvae, etc.), as well as a wide range of various herbs, leaves and fruits (e. g. dandelion, broad leaf plantain, clover, milk thistle, chicory, endive, cucumber, tomatoes, eventually also leaves of fruit trees etc.). The diet should be complemented with minerals and vitamins. Fresh water should always be available. Fluorescent or LED light should be used. A common spotlight can be used as a heat and UV source to achieve a day temperature between 28 and 32 °C and 45 °C under the spotlight. During night, the temperature can decrease to room temperature. Humidity should be between 50 and 60 % during the day, and should increase to about 70-80 % at night. A sprinkler system can be used to simulate the rainy season in summer.
General characteristics, difficulties with keeping and breeding	During the reproduction season a sufficiently high layer of substrate should be provided. Otherwise, the egg clutch may be dropped (Köhler 2002). It is recommended to use perlite, vermiculite, foam or a sand and peat mixture as incubation substrate. The temperature should be constant between 28 and 31 °C with a humidity of 90 to 100 %. The substrate should be kept moderately moist (Köhler 2002).
Care of the young, technical and time effort	The juveniles should be kept in small to medium terrarium 60 X 40 X 60 cm (L X W X H). Juveniles generally require a similar diet as described for the adults, but are mainly insectivore during the first weeks. However, during the first weeks they are mainly insectivores. The proportion of plants in the diet should increase with age. Sufficient food supplementation and UV light should be provided for the juveniles as well. The care of the young requires about 15–30 minutes daily.

Topic	Data
Frequency of breeding in captivity	Offspring of both species is regularly offered. They are popular due to their relatively small body size and colorful appearance. However, the rather demanding requirements on husbandry and the shy nature of most individuals reduces the number of keepers of these species.
Breeding difficulty evaluation	Taking the requirements into account, breeding is possible. Both species have been bred successfully. However, respective experience in the husbandry and breeding of large lizards is needed. The keeping of Spiny-tailed iguanas is not recommended for beginners.
Interviews/ Surveys/ Consultations	Several private breeders.

References

Alberts, A.C., R.L. Carter, W.K. Hayes & E.P. Martins (eds.; 2004): Iguanas: Biology and Conservation. Berkeley, California (University of California Press): 373 pp.

Bailey, J.W. (1928): A revision of the lizards of the genus *Ctenosaura*. Proceedings of the US National Museum **73**(2733): 1-58.

Buckley, L.J., K. de Queiroz, T.D. Grant, B.D. Hollingsworth, J.B. Iverson, S.A. Pasachnik & C.L. Stephen (2016): A Checklist of the Iguanas of the World (Iguanidae; Iguaninae): 4-46. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph 6).

Calderón-Mandujano, R. & L. Mora-Tembre (2004): New Distributional Records and Comments on Amphibians and Reptiles from Quintana Roo, México. Herpetological Review **35**(3): 295-296.

Constantin, T. (1999): Beobachtungen bei der Nachzucht des Yucatán-Schwarzleguans, *Ctenosaura defensor*. Iguana Rundschreiben **12**(1) (21): 31-33.

Cope, E.D. (1866): Fourth contribution to the herpetology of tropical America. Proceedings of the Academy of Natural Sciences of Philadelphia **18**: 123-132.

De Queiroz K. (1995): Checklist and key to the extant species of Mexican iguanas (Reptilia: Iguaninae). Publicationes Especiales del Museo de Zoologia, Universidad Nacional Autonoma de Mexico **9**: 1-48.

Duellman, W.E. (1965): Amphibians and reptiles from the Yucatán Peninsula, México. University of Kansas Publications, Museum of Natural History **15**: 577-614.

Dundee, H.A., D.A. White & V. Rico-Gray (1986): Observations on the distribution and biology of some Yucatán Peninsula amphibians and reptiles. Bulletin of the Maryland Herpetological Society **22**(2): 37-50.

González-Sánchez, V.H., J.D. Johnson, E. García-Padilla, V. Mata-Silva, D.L. DeSantis & L. D. Wilson (2017): The Herpetofauna of the Mexican Yucatán Peninsula: composition, distribution, and conservation status. Mesoamerican Herpetology **4**(2): 264-380.

Köhler, G. (1995): Zur Systematik und Ökologie der Schwarzleguane (Gattung *Ctenosaura*) Dissertation Universität Frankfurt, 118 pp.

Köhler, G. (1995): Eine neue Art der Gattung *Ctenosaura* (Sauria: Iguanidae) aus dem südlichen Campeche, Mexico. Salamandra **31**(1): 1-14.

Köhler, G. (1996): Freilanduntersuchungen zur Morphologie, Verbreitung und Lebensweise des Yucatán-Schwarzleguans (*Ctenosaura defensor*). Salamandra **32**(3): 153-162.

Köhler, G. (2000): Reptilien und Amphibien Mittelamerikas, Bd. 1: Krokodile, Schildkröten, Echsen. Offenbach (Herpeton Verlag): 158 pp.

Köhler, G. (2002): Schwarzleguane - Lebensweise, Pflege und Zucht. Offenbach (Herpeton Verlag): 144 pp.

Köhler, G. (2002): Das Leguanportrait: *Ctenosaura defensor* Cope 1866. Iguana Rundschreiben 15(2): 6-8.

Köhler, G. (2004): *Ctenosaura alfredschmidti*. The IUCN Red List of Threatened Species 2004: e.T44180A10856950.

Köhler, G. (2004): *Ctenosaura defensor*. The IUCN Red List of Threatened Species 2004: e.T44182A10857610.

Köhler, G. (2008): Reptiles of Central America. 2nd ed. Offenbach (Herpeton Verlag): 400 pp.

Köhler, G., W. Schroth & B. Streit (2000): Systematics of the *Ctenosaura* group of lizards (Reptilia: Sauria: Iguanidae). Amphibia-Reptilia **21**(2): 177-191.

Lee, J.C. (1996) The amphibians and reptiles of the Yucatán Peninsula. Comstock, Cornell University Press, Ithaca, 500 pp.

Lee, J.C. (2000): A field guide to the amphibians and reptiles of the Maya world. Cornell University Press, Ithaca, 402 pp.

Malone, C.L., V.H. Reynoso & L. Buckley (2017): Never judge an iguana by its spines: Systematics of the Yucatán spiny tailed iguana, *Ctenosaura defensor* (Cope, 1866). Molecular Phylogenetics and Evolution **115**: 27-39

Morales-Mávil, J.E., E.A. Bello-Sánchez & C.R. Corona-López (2016): Distribution and Natural History of the Campeche Spiny-Tailed Iguanas (*Ctenosaura alfredschmidti*). 168-176. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph 6).

Noel, V. & D.L. de L'Hermoine (2008): *Ctenosaura defensor* (Cope 1866). Basiliscus **1**: 67.

Radachowsky, J., R.G. Anleu & G. Köhler (2004): First record of *Ctenosaura alfredschmidti* Köhler, 1995 in Guatemala. Salamandra **40**(1): 11-13.

Christian Langner (04.02.2021)

***Ctenosaura quinquecarinata* group (*Enyaliosaurus*)**				
Species	**Description author and date**	**Common name English**	**Common name German/ Spanish**	**Known in the trade**
Ctenosaura clarki	Bailey, 1928	Balsas armed lizard	Michoacán Schwarzleguan/ Nopiche	yes
Ctenosaura flavidorsalis	Köhler & Klemmer, 1994	Yellow-backed spiny-tailed iguana	Gelbrücken-Schwarzleguan	yes
Ctenosaura oaxacana	Köhler & Hasbun, 2001	Oaxaca spiny-tailed iguana	Oaxaca Schwarz-leguan/ Garrobo de Oxaxca	yes
Ctenosaura quinquecarinata	(Gray, 1842)	Five-keeled spiny-tailed iguana	Fünfkiel Schwarz-leguan	yes

Fig. 7a: *Ctenosaura clarki* (G. Köhler);
b: *Ctenosaura clarki*, Michoacán, Mexico (Ch. Langner);
c: *Ctenosaura oaxacana* ♀ (G. Köhler);
d: *Ctenosaura oaxacana*, Oaxaca, Mexico (Ch. Langner).

Morphology and Taxonomy

The species of the group presented in this fact sheet are characterized by a coarse scales spiny tail, which gives its common name. The species *Ctenosaura alfredschmidti* and *C. defensor,* which also have spiny tails but are smaller in size, have been assigned to a distinct genus, *Cachryx* (Cope 1866) as *Cachryx defensor* and *Cachryx alfredschmidti* respectively. According to the CITES standard nomenclature reference, the genus name *Ctenosaura* is still valid for all taxa of this group. Whereas the species of the genus *Ctenosaura* reach one meter in length, the species described in this fact sheet, as well as the two species of the genus *Cachryx,* do not exceed 30 cm in length.

The species of this group had been included in the genus *Enyaliosaurus,* which is no longer valid today, but occasionally given as subgenus

The species *Ctenosaura praeocularis,* described only in 2009 by Hasbun & Köhler, is meanwhile considered as synonym of *C. quinquecarinata,* and thus will not be treated as distinct species in this fact sheet.

The species of this group can be identified by the following characters:

Ctenosaura clarki – up to 30 cm total length (SVL ca. 16 cm). Males are often slightly larger than females. The tail is moderately spiny. All caudal whorls are thorny and each is separated by a row of small, flat scales. The color of the dorsum is olive-brown to black with bright cream color, and brown; orange dots are commonly present in males. The color of venter is cream and the throat is orange or yellowish. Typically, males show higher contrasts in color than females and have conspicuous femoral pores. The juveniles do not have the typical green coloration which is typical in juveniles of other spiny tailed iguana species.

Ctenosaura flavidorsalis – total length up to 40 cm (SVL ca. 17 cm); females are often smaller. In contrast to *C. quinquecarinata,* it has no dorsal spines, a row of large scales is present instead. Tail with whorls of large scales each separated by a row of small flat scales. The color of dorsum is bright brownish-grey with yellow marks and several dark brown cross bands, which reach the venter in males. Cross bands are also present on limbs and tail. The throat is often orange. Males show higher color contrast than females. The dorsum of the juveniles is green.

Ctenosaura oaxacana – total length of ca. 40 cm (SVL ca. 17 cm); females are usually smaller in size. Males have a conspicuous dorsal crest and females have a row of large scales instead. Tail with whorls of large scales, each separated by a row of small flat scales. It has a conspicuous throat fold. The throat is often olive to yellow green and sometimes black. The color of the dorsum is grey to olive brown. The dorsum has a bright longitudinal band of dots and dark cross bands, which extend to the venter. The color of the venter is uniform bright brown to grey. Most of the bright grey cross bands differ in width. Juveniles are similar in color to adults but slightly greener (Köhler 2002).

Ctenosaura quinquecarinata – is the largest of the four species. Total length up to 52 cm (SVL ca. 20 cm); females are slightly smaller in size. Males have a spiny dorsal crest and females have a row of large scales instead. Tail with whorls of large scales each separated by a row of small flat scales. The color of the throat, which has a conspicuous fold, is often olive, sometimes yellow and in rare occasions black. The color is olive brown to black with bright cream or brown dots. It has cross bands on the dorsum which sometimes are formed by dots. The tail has cross bands of differing width. The venter is bright brown to grey. The juveniles have green coloration which fades with time (Villa & Scott 1967, Köhler 2002).

Distribution and Habitat

Distribution

Ctenosaura clarki: Western Mexico (Jalisco, Michoacan: Rio Tepalcatepec valley, Guerrero). Type locality: Ovopeo, Michoacán, Mexico 304.8 m asl.

Ctenosaura flavidorsalis: Honduras, El Salvador, Guatemala. Type locality: 1 km south of La Paz, 750 m asl, 14° 16' N, 87° 40' W, La Paz, Honduras.

***Ctenosaura oaxacana*:** Mexico (Oaxaca). Type locality: Tehuantepec (Oaxaca, Mexico).

***Ctenosaura quinquecarinata*:** Nicaragua (Chontales, Matagalpa, Jinotega, Boaco, Managua, Granada), El Salvador, NW Costa Rica (Guanacaste); the data for Mexico (Reptile Database) are not valid since they refer to the species *C. oaxacana.* Type locality: unknown. "Demerara?" according to (Köhler 1995). The terra typica restricta - Tehuantepec, Oaxaca, (Bailey 1928) - for *C. oaxacana*.

Ctenosaura praeocularis: described by Hasbun & Köhler (2009) was considered a synonym of *Ctenosaura quinquecarinata* by McCranie (2018) and other authors. Based on taxonomic data and the similar biology of the two "taxa", *C. praeocularis* it will be referred to as *C. quinquecarinata* in this fact sheet.

Habitat

Ctenosaura clarki: Open dry forest. Dead branches or dead giant cactus, if available, are the preferred retreat place. Alternatively, holes in fence posts are also used. The animals are rarely found far away from their hiding place, which they use individually. All three species use their spiny tail to close up their hole which makes them a difficult prey to catch (Köhler 2002, Langner, pers. obs.). Around 60 % of the individuals studied by Duellman & Duellman (1959) had lost their tail tip. In the case of traded specimens, this could be an indication of wild caught specimens.

Ctenosaura flavidorsalis: The species predominantly inhabits rocky dry areas. The typical habitat is characterized by hot and dry landscapes, covered with thorny bushes and with occasionally rock piles in La Paz, Honduras. Contrary to the other species of this group, *C. flavidorsalis* is mainly saxicolous (Köhler 2002).

Ctenosaura oaxacana: Dry forests with thorny bushes, low deciduous trees and cacti in the Mixtequilla hills. The habitats near the coast are more humid. The species inhabits mainly old trees and fence posts. Specimens are strictly solitary and only one individual inhabits a tree. Hollow trees and rock crevices are used as dens, which are closed up with their spiny tail.

C. quinquecarinata: The species inhabits subtropical dry forests with rocky substrate. Animals can be found in rock piles and stone walls as well as trees or fence posts, where they have their retreat holes. This species also uses its spiny tail to close up its hiding place. These iguanas are omnivorous, as the other species, and eat a variety of insects as well as leaves and fruits (Köhler 2002).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Ctenosaura clarki: Vulnerable (B2ab(iii), assessed April 30, 2004);

Ctenosaura flavidorsalis: Near Threatened (B1b(ii,iii,v), assessed March 10, 2020);

Ctenosaura oaxacana: Critically Endangered (B1ab(iii,v), assessed April 30, 2004);

Ctenosaura quinquecarinata: Data Deficient (assessed March 17, 2020).

Threats

All four species are extremely threatened by rapid habitat destruction and loss. Currently, subtropical and tropical dry forests belong to the most threatened habitats in Central America.

Furthermore, Spiny-tailed iguanas are consumed by locals and the small-sized species are used in traditional medicine, which poses a non-neglectable threat. Therefore, individuals are still often sold in markets or in streets. Specimens are often brutally treated and observed tied up with their own tendons which are pulled out of the toes alive. Often also the snout is sewed with the tendons and claws (Langner, pers. obs.).

C. clarki is mistakenly considered as highly venomous by the local population of Michoacán and rigorously pursued (Köhler 2002). Smuggled individuals of these species are occasionally found in the pet market. Offspring of individuals bred in the USA have been imported into Europe. Wild caught specimens of *C. quinquecarinata* were regularly legally imported into Europe in the past.

Reproduction

Topic	Data
Secondary sexual traits	All four species present sexual dimorphism and dichromatism. Males are larger and stronger in shape than females. The femoral pores and hemipenis bags are very prominent in males. Neck crests are mostly only partially recognizable in ♀♀ and very clearly pronounced in males with exception of *Ctenosaura flavidorsalis*. Males are generally brighter and more colorful than females.
Reproduction	Oviparous.
Nesting season	*Ctenosaura flavidorsalis* – ca. 6–13 eggs were laid in February and March. *Ctenosaura oaxacana* – nesting season January/ February.
Number of eggs/ clutches per season	*Ctenosaura clarki* – ca. 5–7 eggs per clutch; *Ctenosaura oaxacana* – 5 eggs have been observed in a clutch laid in April (Werler 1970). 9 eggs in a clutch of a mating of *C. oaxacana* x *Ctenosaura quinquecarinata* in 1999 (Burré 2004).
Egg size/ hatchling size	*Ctenosaura clarki* – egg size: 33–36 mm x 19–20 mm; hatchlings 55–56 mm (SVL). In June, juveniles with still navel attachment were ca. 57 mm (SVL) juveniles (Duellman & Duellman 1959). *Ctenosaura oaxacana* – egg size: 26.6–29.2 mm x 16.7–18.5 mm *Ctenosaura oaxacana x Ctenosaura quinquecarinata* – egg size: Burré (2004), incorrectly stated egg dimensions of 1.5 x 2.9 mm, it can be assumed that there

Topic	Data
	is a unit error. Therefore, the data has been corrected to 14.8 x 28.5 mm (W x L); hatchling size 36 mm SVL, TL 87 mm.

Husbandry and Captive Breeding

Indoor Terraria

Outdoor Enclosures

Topic	Data
Trigger for reproduction	Simulation of dry and rainy season as in their site of origin. To this end, it should be extensively sprayed from June to October; from November to May animals should be kept dryer.
Husbandry requirements	The minimum space requirements (Federal Ministry for Food Agriculture and Forestry 1997) are 5 x 4 x 4 (L x W x H) the size of the snout-vent-length. This results in a minimum terrarium size of 100 cm x 80 cm x 80 cm. For tree dwelling species such a terrarium would be unsuitable and too small. Instead, a minimum size of 120 x 80 x 80 cm is recommended. For the saxicolous species *C. flavidorsalis*, the minimum size requirements are 120 cm x 80 cm x 80 cm (L x W x H). The terrarium should be sufficiently structured and contain branches to climb. Hollow cork pieces or nest boxes can be used as hiding places. The terrarium should not contain living plants due to the species' vegetarian diet; plastic plants may be used. A substrate of slightly moist soil- sand mixture or pine bark to avoid dust is recommended. The diet should be varied and contain the usual, commercially available food insects (grasshoppers, crickets, cockroaches, *Zophobas* larvae, etc.), as well as a wide range of various herbs, leaves and fruits (e.g., dandelion, broad leaf plantain, clover, milk thistle, chicory, endive, cucumber, tomatoes, eventually also leaves of fruit trees etc.). The diet should be complemented with minerals and vitamins. Fresh water should always be available. Fluorescent or LED light should be used. A common spotlight can be used as a heat and UV source to achieve a day temperature between 28 and 32 °C and 45 °C under the spotlight. During night time, the temperature can decrease to room temperature. During day time a humidity between 50 and 60 % is recommended and should be higher at night time, raising to about 70-80 %. A sprinkler system can be used to simulate the rainy season in summer.
General characteristics, difficulties with keeping and breeding	During the reproduction season, a high layer of substrate should be provided to avoid egg-binding or similar reproduction problems (Köhler 2002). It is recommended to use perlite, vermiculite, foam or a sand and peat mixture as incubation substrate. The temperature should be constant between 28 and 31 °C and the humidity should be between 90 and 100 %. The substrate should be moderately moist.
Care of the young, technical and time effort	The juveniles should be kept in small to medium terraria, e.g., 60 X 40 X 60 cm (L X W X H). They require a similar diet as the one for the adults. However, during the first weeks, they are mainly insectivore. The amount of plant food in the diet should increase with the age of the animals. The leaves should be cut and offered only in small pieces, since it is common that juveniles die by suffocation when eating long plant pieces. Enough UV light should be provided for the juveniles. The care of the young requires about 15–30 minutes daily.
Frequency of breeding in captivity	Rare, since these iguanas are only kept by few keepers.

Topic	Data
Breeding difficulty evaluation	Taking the above-mentioned recommendations into account, successful breeding is possible. However, some experience in husbandry of large lizards is needed. Spiny tailed iguanas are not suitable for unexperienced keepers.
Interviews/ Surveys/ Consultations	Several private breeders.

References

Abraham, G. (1978): Schwarze Leguane aus dem Brutkasten. Zeitigung der Eier und Aufzucht der Jungen. Aquarien Magazin **12**(10): 484-486.

Alberts, A.C., R.L. Carter, W.K. Hayes & E.P. Martins (eds.; 2004): Iguanas - Biology and Conservation. Berkeley (University of California Press): 373 pp.

Bailey, J.W. (1928): A revision of the lizards of the genus *Ctenosaura*. Proceedings of the US National Museum **73**(2733): 1-58.

Buckley, L.J., K. de Queiroz, T.D. Grant, B.D. Hollingsworth, J.B. Iverson, S.A. Pasachnik & C.L. Stephen (2016): A Checklist of the Iguanas of the World (Iguanidae; Iguaninae): 4-46. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph 6).

Burré, G. (2004): Bastardierung zwischen *Ctenosaura quinquecarinata* und *C. oaxana*. Iguana Rundschreiben **17**(1): 17-21.

Castañeda-Hernández, C., L. Canseco-Márquez & M.E. Vargas-Orrego (2015): Distribution Notes: Additional distributional records for the state of Oaxaca, Mexico. Mesoamerican Herpetology **2**(3): 368-370.

Corneil, J.P., C.E. Montgomery & V.H. Reynoso (2015): Natural History Notes: *Ctenosaura oaxacana* (Oaxacan Spiny-tailed Iguana). Predation. Herpetological Review **46**(4): 630–631.

De Queiroz K. (1995): Checklist and key to the extant species of Mexican iguanas (Reptilia: Iguaninae). Publicationes Especiales del Museo de Zoologia, Universidad Nacional Autonoma de Mexico **9**: 1-48.

Duellman, W.E. & A.S. Duellman (1959): Variation, distribution, and ecology of the iguanid lizard *Enyaliosaurus clarki* of Michoacan, Mexico. Occasional Papers of the Museum of Zoology. University of Michigan **598**: 1-10.

Duellman, W.E. (1961): The amphibians and reptiles of Michoacán, Mexico. University of Kansas Publications, Museum of Natural History **15**(1): 1-148.

Duges, A. (1897): *Enyaliosaurus quinquecarinatus*. Naturaleza **2**(2): 523-524.

Eisenberg, T. (2001): *Ctenosaura flavidorsalis* (Köhler & Klemmer, 1994). Gelbrücken-Schwarzleguan. Reptilia (D) **6**(27): 51-54.

Gicca, D.F. (1982): *Enyaliosaurus clarki* (Bailey). Balsas Armed Lizard. Catalogue of American Amphibians and Reptiles (CAAR) **301**: 1-2.

Gicca, D.F. (1983): *Enyaliosaurus quinquecarinatus* (Gray). Central American Armed Lizard. Catalogue of American Amphibians and Reptiles (CAAR) **329**: 1-2.

Hasbun, C.R. & G. Köhler (2001): On the identity of the holotype of *Ctenosaura quinquecarinata* (Gray 1842) (Reptilia, Squamata, Iguanidae). Senckenbergiana Biologica **81**(1-2): 247-255.

Hasbun, C.R., G. Köhler, J.R. McCranie & A. Lawrence (2001): Additions to the description of *Ctenosaura flavidorsalis* Köhler & Klemmer, 1994 and its occurrence in south-western Honduras, El Salvador, and Guatemala (Squamata: Sauria: Iguanidae). Herpetozoa **14**(1-2): 55-63.

Hasbun, C.R. & G. Köhler (2009): New species of *Ctenosaura* (Squamata, Iguanidae) from southeastern Honduras. Journal of Herpetology **43**(2): 191-204.

Hidalgo, H. (1980): *Enyaliosaurus quinquecarinatus* (Gray) and *Leptodeira nigrofasciata* Gunther in El Salvador. Herpetological Review **11**(2): 42-43.

Huy, A. (2008): Erfahrungen und Nachzucht des Fünfkiel-Schwarzleguans (*Ctenosaura quinquecarinata*). Iguana Rundschreiben **21**(2): 5-9.

Kartje, M.E., J.P. Corneil, C.E. Montgomery & V.H. Reynoso (2016): Natural History Notes: *Ctenosaura oaxacana* (Oaxacan Spiny-tailed Iguana). Predation. Herpetological Review **47**(3): 463.

Köhler, G. (1989): Anmerkungen zu *Enyaliosaurus quinquecarinatus*. Sauria (Berlin) **11**(3): 21.

Köhler, G. (1994): Zur Maximalgrösse des Fünfkiel-Schwarzleguans *Ctenosaura quinquecarinata*. Iguana Rundschreiben **7**(1) (13): 27-28.

Köhler, G. (1995): Zur Systematik und Ökologie der Schwarzleguane (Gattung *Ctenosaura*) Dissertation Universität Frankfurt, 118 pp.

Köhler, G. (1995): Neue Schwarzleguane der Gattung *Ctenosaura* aus Honduras und Mexico. Iguana Rundschreiben **8**(1) (14): 21-23.

Köhler, G. (1995): Freilanduntersuchungen zur Morphologie und Lebensweise des FünfkielSchwarzleguans *Ctenosaura quinquecarinata* am Isthmus von Tehuantepec, Mexiko. Herpetofauna (Weinstadt) **17**(97): 21-26.

Köhler, G. (2002): Schwarzleguane - Lebensweise, Pflege und Zucht. Offenbach (Herpeton Verlag): 144 S.

Köhler, G. (2004): *Ctenosaura clarki,* Balsas Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2004: e.T44194A10861033: 6 pp.

Köhler, G. (2004): *Ctenosaura oaxacana,* Oaxaca Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2004: e.T44190A10859692: 6 pp.

Köhler, G., W. Schroth & B. Streit (2000): Systematics of the *Ctenosaura* group of lizards (Reptilia: Sauria: Iguanidae). Amphibia-Reptilia **21**(2): 177-191.

Köhler, G. & C.R. Hasbun (2001): A new species of Spiny-tailed Iguana from Mexico formerly referred to *Ctenosaura quinquecarinata* (Gray 1842) (Reptilia, Squamata, Iguanidae). Senckenbergiana Biologica **81**(1-2): 257-267.

Köhler, G. & K. Klemmer (1994): Eine neue Schwarzleguanart der Gattung *Ctenosaura* aus La Paz, Honduras. Salamandra **30**(3): 197-208.

Otero, O.C. & C. Mendoza-Galan (2011): Altitudinal distribution of *Ctenosaura quinquecarinata* subpopulations in western municipalities of Nicaragua. Mesoamericana **15**(1): 77-82.

Palacios-Aguilar, R. & O. Flores-Villela (2018): An updated checklist of the herpetofauna from Guerrero, Mexico. Zootaxa **4422**(1): 1-24.

Reynoso, V.H., M.G. González & A.J. González–Hernández (2011): Geographic Distribution: *Ctenosaura oaxacana* (Oaxacan Spiny-tailed Iguana). Herpetological Review **42**(3): 391.

Reynoso, V.H., M. Ubeda, M. Vázquez-Cruz, R.C. Rivera-Arroyo, C.L. Malone & T.D. Grant (2020): *Ctenosaura quinquecarinata,* Five-keeled Spiny-tailed Iguana. The IUCN Red List

of Threatened Species 2020: e.T44193A2993977: 14 pp.

Reynoso, V.H., M. Vázquez-Cruz, R.C. Rivera-Arroyo, C.L. Malone & T.D. Grant (2020): *Ctenosaura flavidorsalis,* Yellow-backed Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2020: e.T44188A2993811: 13 pp.

Rohde, H. (1989): Zur Pflege von *Enyaliosaurus quinquecarinatus* (Gray 1842). Sauria (Berlin) **11**(2): 11-13.

Ulber, T. & H. Rohde (1989): Zur Nomenklatur, Verbreitung und zum Aggressionsverhalten von *Enyaliosaurus quinquecarinatus*. Sauria (Berlin) **11**(3): 21.

Valenzuela-Ceballos, S., G. Castañeda-Gaytan, T. Rioja-Paradela, A. Carrillo-Reyes & E. Bastiaans (2015): Variation in the thermal ecology of an endemic iguana from Mexico reduces its vulnerability to global warming. Journal of Thermal Biology **48**: 56-64.

Villa, J.D. (1971): Notes on some Nicaraguan reptiles. Journal of Herpetology **5**(1/2): 45-48.

Villa, J.D. & J.N. Scott (1967): The iguanid lizard *Enyaliosaurus* in Nicaragua. Copeia **1967**(2): 474-476.

Werler, J.E. (1970): Notes on young and eggs of captive reptiles. International Zoo Yearbook **10**(1): 105-108.

Christian Langner (30.01.2021)

Ctenosaura – Large Mainland species

Species	Description author and date	Common name English	Common name German / Spanish	Known in the trade
Ctenosaura acanthura	(Shaw, 1802)	Northeastern spiny-tailed iguana	Ostmexikanischer Schwarzleguan/ Garrobo del Noreste; Garrobo del Golfo de México	yes
Ctenosaura macrolopha	Smith, 1972	Sonoran spiny-tailed iguana	Sonora–Schwarz-leguan/ Garrobo de Sonora	?
Ctenosaura melanosterna	Buckley & Axtell, 1997	Black-chested spiny-tailed iguana	Schwarzbrust–Schwarzleguan	yes
Ctenosaura palearis	Stejneger, 1899	Motagua spiny-tailed iguana	Guatemala–Schwarzleguan	yes
Ctenosaura pectinata	Stejneger, 1899	Guerreran spiny-tailed iguana	Westmexikanischer Schwarzleguan/ Garrobo de Roca	yes
Ctenosaura similis)	(Gray, 1831)	Common spiny-tailed iguana, Black iguana	Mittel-amerikanischer Schwarzleguan/ Garrobo Negro	yes

The species presented in this fact sheet have been grouped together because all are large sized iguanas of Central America mainland. All six species have a robust body with a total length between 80 cm and more than one meter.

The species *C. palearis* and *C. melanosterna* were recently described as heterospecific (Buckley & Axtell 1997). In older literature without precise descriptions of origin, the assignment to one of the two species could cause difficulties. Similarly, the distribution range of *C. pectinata* and *C. acanthura* remained uncertain, however new studies have been performed. Due to the evident genetic differences, a revalidation of the taxon "*brachylopha*" Cope, 1886, formerly synonymized with *C. pectinata,* was performed. Should this revalidation prevail, a reevaluation of the respective threats is needed as well as a revision of the conservation status. In the same study, a hybridization zone between *C. pectinata* and *C. acanthura* was demonstrated. Genetically, populations from Cuicatlán in the state of Hidalgo, Mexico, corresponded to *C. pectinata* (Canseco-Márquez & Gutiérrez-Mayén 2010, Zarza *et al.* 2008, 2019).

In the early 70's, a few specimens of black iguanas similar to *C. macrolopha* were released on the terrain of the Arizona-Sonora Desert Museum in Tucson, Arizona. Since then, these animals have established a population that still exists. Genetic studies show that this population are hybrids between *C. macrolopha* and *C. conspicuosa* (Edwards *et al.* 2005).

Fig. 8a: *Ctenosaura similis*, National Park Manuel Antonio, Puntarenas, Costa Rica (Ch. Langner);
b: *Ctenosaura acanthura* (Ch. Langner);
c: *Ctenosaura palearis* ♂ (F. Hulbert);
d: *Ctenosaura melanosterna* ♂ (G. Köhler);
e: *Ctenosaura pectinata* ♂ (G. Köhler);
f: *Ctenosaura pectinata*, juvenile, Michoacán, Mexico (Ch. Langner);
g: *Ctenosaura macrolopha X C. conspicuosa*, Arizona-Sonora Desert Museum (Ch. Langner).

Morphology and Taxonomy

The species of this group can be identified by the following characters:

Ctenosaura acanthura – this species can get up to 1 m in total length (SVL ca. 315 mm). ♀♀ are about 30 % smaller. Adult ♂♂ have a conspicuous dorsal crest which in ♀♀ is less pronounced. In east Mexican specimens the scales of the tail vertebrae are very thorny (keel angle over 30 degrees) with a straight keel. Some specimens show a reduction of the intercalaria up to a complete row between the 5th and the 8th intercalaria. The enlarged caudal whorls are particularly strong in *C. acanthura* (Köhler & Streit 1996).

The color of adult iguanas is often very dark. Animals often have a uniform black or dark brown appearance with a bright, irregular spot on the throat region. Juveniles show an intensively grass-green coloration (Köhler 2000, 2002). Subadult specimens with a dark green ground color and wide black cross bands could be observed in Veracruz (Langner pers. observation).

Ctenosaura macrolopha – Sonoran spiny-tailed iguanas can reach over 1 m in total length (SVL ca. 40 cm); ♀♀ are 30 % smaller. Contrary to ♀♀, adult ♂♂ have a prominent dorsal crest which extends to the pelvic region. Contrary to the sister species *C. nolascensis*, the venter of the body and the extremities lack black spots. The color of the head is bright brown to grey. Between the tympanic membrane and the lower jaw there is a narrow bright stripe. The shoulder area often shows two dark bands set off by narrow lighter stripes. On the dorsum, irregular dark spots are scattered on a grey background color. On the dorsal side of the rear back region, and sometimes also over the base of the tail, cross bands can be present. The juveniles are partly, but not completely green (Köhler 2000, 2002).

Ctenosaura melanosterna – the larger ♂♂ can reach a total length of 76 cm (SVL 31 cm); ♀♀ are ca. 30 % smaller. Contrary to females, adult ♂♂ have a prominent throat dewlap and a high dorsal crest. This species has 8–10 supralabial scales in comparison to the similar species *C. palearis*. The tail has whorls of large scales, each separated by a row of intercalaria. The head color is beige to grey; the chest area is mainly brown. The dorsum shows several cross bands separated by a row of bright spots. The large throat dewlap is predominantly dark with few interspersed light areas. The dorsum of forelimbs shows irregular spots. In the neck area are three, sometimes incomplete, black cross bands. The rear part of the back shows a light grey cross banding. The forelimbs are mostly jet black in males and rather grey banded or spotted in females. The venter shows – contrary to *C. palearis* – no spots. The juveniles are uniformly grass green (Köhler 2000, 2002).

Ctenosaura palearis – the large ♂♂ can reach a total length of 76 cm (SVL 31 cm). Contrary to females, adult ♂♂ have a prominent throat dewlap (up to 4 cm long) and a high dorsal crest. This species has 12 supralabial scales, contrary to *C. melanosterna*. The venter has several small black spots. The rear part of the back has no banding. The color of the body is predominantly grey brown and can be almost white in some specimens. The shoulder and throat region, as well as the forelimbs, can be jet black in both sexes. Males have cross bands on the neck region. The juveniles show green coloration on the front part of the head and the body (Köhler 2000, 2002). A specimen with tail trifurcation has been depicted for this species (Ariano-Sánchez & Gil-Escobedo 2016).

Ctenosaura pectinata – this species can reach more than one meter in total length (SVL ca. 35.3 cm). Females are ca. 30 % smaller. Adult ♂♂ have a conspicuous dorsal crest which is less pronounced in ♀♀. The crest extends to the pelvic region. Between the third and fifth caudal whorls are three complete rows of intercalaria of enlarged thorny caudal scales present (Köhler 2000, 2002). This species has a variable pattern and coloration. Most specimens

are predominantly grey to black. Bright colors, such as orange and red, also occur in this species. A popular color morph is the yellow morph (aka “bananas”). More color morphs such as black and white spotted and a zebra like black and white pattern have been depicted (Zarza *et al.* 2016). Juveniles are bright green (Köhler, 2002, Langner pers. observation). Cupul-Magaña & Escobedo-Galván (2016) report a specimen with a bifurcated tail.

Ctenosaura similis – total length up to 1 m (SVL ca. 27 cm); estimations of maximal SVL of 35 cm (Köhler 2000). Adult *C. similis* ♂♂ have the largest dorsal crest of all Spiny-tailed iguanas, honoring their name (*Ctenosaura* = “comb lizard”). The crest extends into the tail without interruption. Dorsal crests are much less pronounced in ♀♀. This species has several dark dorsal cross bands which often have a bright center. Between the third and fifth caudal whorls are three complete rows of intercalaria of enlarged thorny caudal scales (Köhler 2000, 2002). *C. similis* is, together with *C. pectinata,* the most variable species regarding pattern and color of all Spiny-tailed iguanas. This variability is even noticeable within a population. There are specimens which are high in contrast and others with faded colors and in extreme cases, the stripe pattern is only vaguely visible. The light color elements can vary from cream-colored, pink to orange or yellowish. The tail has cross bands (Köhler 2000, 2002, Langer pers. observation). Mora (1990) reports on an albinotic *C. similis*. Juveniles are normally bright green, but also brown hatchlings have been reported. The different coloration of the juveniles can possibly occur seasonally, also within the same population (Van Devender 1982, Fitch & Hackforth-Jones 1983).

Distribution and Habitat

Distribution

Ctenosaura acanthura: Eastern Mexico (from Liera and Tepehuaje de Arriba in Tamaulipas southwards to Isthmus de Tehuantepec in southeast Veracruz and Chiapas, east Oaxaca; San Luis Potosí, Hidalgo, Puebla), northern Guatemala. Type locality: not given by Shaw (1802). Terra typica restricta: Tampico, Tamaulipas (Bailey 1928)

Ctenosaura macrolopha: Endemic to Mexico, (Chihuahua, Sonora, Sinaloa). Type locality: La Posa, San Carlos Bay, 10 Miles northwest of Guaymas, Sonora, Mexico.

In the US, some animals of a hybrid form of *Ctenosaura macrolopha x Ctenosaura conspicuosa* were released within area of the Desert Museum, Tucson Arizona (Edwards *et al.* 2005).

Ctenosaura melanosterna: Honduras (Aguan Valley and the Cayos Cochinos/Hog Islands). Type locality: 2 km south of Coyoles Central, Yoro, Honduras.

Ctenosaura palearis: Endemic to southeast Guatemala (valley of Rio Motagua). Type locality: Gualan, Guatemala.

Ctenosaura pectinata: West Mexico (north from Culiacan in Sinaloa, southwards up to Isthmus of Tehuantepec in southeast Oaxaca, Isla de las Tres Marias, west from Nayarit in Durango, Jalisco, Colima, Michoacán, Morelos, Chiapas, Guerrero, Puebla, México, Aguascalientes), USA (non-autochthonous occurrences in Florida and in south Texas). Type locality: Terra typica restricta: Colima (city), Colima, Mexico.

Ctenosaura brachylopha**:** The former *C. pectinata* subspecies “brachylopha” has meanwhile been elevated to species rank (Zarza *et al.* 2019). Occurs in Mexico (Nayarit, Sinaloa, North Jalisco). Type locality: Mazatlan, Sinaloa, Mexico.

Ctenosaura similis**:** Southern Mexico (Chiapas, Oaxaca, Yucatan, Campeche, Quintana Roo), Nicaragua, Guatemala, El Salvador, Honduras, Belize, Costa Rica, Panama, Columbia

(Old Providence Island, San Andres Island, but the autochthonism of this occurrence is questionable). Introduced and established populations are known from in Venezuela and in USA (Florida). Type locality: Unknown by Gray (1831). Terra typica restricta: Tela, Honduras (Bailey 1928). The type locality of *Ctenosaura similis multipunctata* is Old Providence Island, San Andres Island, Colombia, but the subspecies status is still in discussion.

Habitat

Ctenosaura acanthura: East Mexican Spiny-tailed iguanas are considered to be tree dwellers. Semi-moist tropical forest and deciduous dry forest belong to the original habitat. Today these species also inhabit different human modified secondary habitats. Cattle pastures, agricultural land as well as peripheral areas of settlements and ruins are inhabited (Canseco-Márquez &Gutiérrez-Mayén 2010, Köhler 2002, Morales-Mávil & Suárez-Domínguez 2010, Suárez-Domínguez *et al.* 2011). Specimens of all age classes can be observed on avenue trees, on fence posts and even on artificial piles of stones on the ground in Veracruz (Langner pers. observation). This species is found below 500 m asl (Garrido & Sandoval 1992, Morales-Mávil *et al.* 2016).

Ctenosaura macrolopha: There is few data available about the ecology and habitat of this species. McDiarmid & Hardy (1969) report that *Ctenosaura macrolopha* predominantly inhabits rocky habitats and switches to larger trees, if rocks are missing. Rock crevices and cavities are preferred as hiding places.

Ctenosaura melanosterna: Main habitat types are dry and cacti forests. It is considered to be very elusive (Köhler 2002), tree dwelling, and is rarely found on the ground (in such cases mostly juveniles).

Ctenosaura palearis: This tree dwelling species inhabits the deciduous dry forest of the river Montagua basin. With an average annual rainfall of less than 500 mm, the habitat is one of the driest regions in Central America (Coti & Sánchez 2008). The trees are densely covered with Tillandsia (Köhler 2002). Also, the forest ground is covered with fallen bromeliads and tillandsias. Hollow dead branches and cacti are used as hiding places. Köhler (2002) reports a very low population density of this highly endangered species. During a survey of four days and with six people, only 15 specimens were found.

Ctenosaura pectinata: The habitat is characterized by dry areas, often interspersed with rocks and lava with scarce vegetation cover (Hartweg & Oliver 1940, Evans 1951, Duellman 1961, Hardy & McDiarmid 1969). Specimens of all age classes can be observed in walls along streets in Michoacán and in trees of dry forests. The specimens that inhabit dry forests are much shyer than the ones in urban areas. In Jalisco, several specimens could be observed in large rock blocks along a river. The males of this population were striking orange-red (Langner, pers. observation).

Ctenosaura similis: Typical habitat are tropical dry forests, savannas, sandy beaches as well as boulders and ruins. They are found up to 1,000 m asl. Males are very territorial and protect and defend their territory against other male rivals. Juveniles and females are tolerated. Females show a strong hierarchical system, as well (Köhler 2002). In many areas, the species inhabits areas heavily frequented by tourists as the Maya pyramids in Yucatán or the national park Manual Antonio in Costa Rica. The animals here are relatively tame and are also fed in many places (Langner, pers. observation).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

Council Regulation (EC) Nr. 338/ 97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Ctenosaura acanthura: Least Concern (assessed March 05, 2020);

Ctenosaura macrolopha: Least Concern (assessed March 05, 2020);

Ctenosaura melanosterna: Endangered (B1ab(i,ii,iii,iv,v, assessed March 01, 2012);

Ctenosaura palearis: Endangered (A2acd; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v), assessed Mai 23, 2018);

Ctenosaura pectinata: Least Concern (assessed March 05, 2020);

Ctenosaura similis: Least Concern (assessed February 07, 2010).

Threats

All the species presented in this fact sheet are predominantly threatened by hunting and collection.

Spiny-tailed iguanas are hunted nationally and locally for human consumption and persecuted as crop pests. Ongoing economic problems as well as an increase of social tensions in the countries of origin have led to an increase of harvesting of these iguanas as a source of protein. The majority of the iguanas are hunted for local consumption (Bustos-Zagal *et al.* 2019). Yet, some specimens are still sold on the streets and markets. The animals are often brutally treated and have been observed to be tied up with their own tendons, which were pulled out of the toes alive. Often also the snout is sewed shut with the tendons and claws (Langner, pers. observation). The ongoing rapid habitat loss in most of Central America plays a smaller role as a threat factor, since several large mainland iguana species adapt well to human modified influenced areas. For *C. melanosterna* and *C. palearis* habitat loss is, however, a main threat.

In this context it is reported that *C. palearis* plays an important role in the distribution of seeds of the cactus *Stenocereus pruinosus* (Vásquez-Contreras & Ariano-Sánchez 2016). *C. similis* plays a similar role in dry forests for seed dispersal for several tree species (Traveset 1990).

The pet trade does not play a big role in Central America for these large species due to their large space requirements. In areas of the USA, where the climate is adequate, these large species can be kept in outdoor aviaries, and captive breeding covers the local demand (Bloom, written communication).

C. pectinata and *C. similis* are neozoa in some areas of USA where the climate is adequate. Conservationists are concerned that both species might have a long-term negative impact on native flora and fauna. Mazzotti & Harvey (2012) show a picture of *C. similis* from Florida that had the remains of an endangered gopher tortoise (*Gopherus polyphemus*) in its digestive tract. Also, Avery *et al.* (2009) report on iguanas that preyed on young gopher tortoises. *C. similis* also competes with adult gopher tortoises for their burrows. Furthermore, these iguanas have been observed killing a southern black racer (*Coluber constrictor priapus*) without eating it (Engeman 2009).

On the island of Gasparilla, efforts are put into reducing the spread of *C. similis*. In order to finance a state pest control program, the islanders levied taxes on themselves, because the damage caused by the invasive lizards in gardens and sometimes in attics was considerable. It is estimated that the population originates from only three iguanas released by locals about 40 years ago. Currently, a large population has established itself on the island and on the adjacent areas of the mainland (Avery et al 2014, Engeman *et al.* 2011). Acetaminophen (Paracetamol) and zinc phosphide are used to combat this plague (Avery *et al.* 2011).

Reproduction

Topic	Data
Secondary sexual traits	All four species present sexual dimorphism and dichromatism. Males are larger and stronger in shape than females. The femoral pores and hemipenis bulges are very prominent in males. Neck crests are mostly only partially recognizable in ♀♀ and very clearly pronounced in males. Males are generally brighter and more colorful than females.
Reproduction	Oviparous.
Sexual maturity	Can be reached at the age of 14 months (general data for the genus *Ctenosaura* (Kelly 2012); at 3 years at *C. palearis*; a dissection of a one-year-old *C. similis* showed gonad activity (Van Devender 1982).
Mating/ nesting season	*C. melanosterna* – mating March–June (Habitat); nesting season: March to May, occasionally they nest again in autumn. *C. pectinata* – mating March; nesting season: April–May; *C similis* – mating dependent on the origin: Belize – March–April; Costa Rica – April to May; nesting period: February to March.
Number of eggs/ clutches per season	*Ctenosaura acanthura* – 18–48 eggs per clutch. *Ctenosaura macrolopha* – Sheetz *et al.* (2007) reported that females collected in July showed relatively advanced follicle development of 9 to 10 eggs. *Ctenosaura melanosterna* – 11–41 eggs per clutch. *Ctenosaura palearis* – 20–30 eggs per clutch. *Ctenosaura pectinata* –10–49 eggs per clutch. *Ctenosaura similis* –12–88 eggs per clutch; egg deposition during nighttime has been reported (Mora 1989a). Also, communal oviposition of several *C. similis* ♀♀ has been reported, with huge nest tunnels being created, which can reach a length of up to 22 m (Fitch & Hackforth-Jones 1983). Furthermore, there are reports of shared oviposition sites by *C. similis* and *Iguana iguana* (Mora 1987, 1989a). The common Mexican python (*Loxocemus bicolor*) is considered to be an important predator of clutches (Mora 1987).
Egg size/ hatchling size	*Ctenosaura acanthura* – egg size: 25–33 mm x 17–24 mm; egg weight: 5.0–7.2 g; hatchling size: 41–58 mm (SVL); hatchling weight: 3.9–6.4 g. *Ctenosaura macrolopha* – no data available. *Ctenosaura melanosterna* – egg size: 23–33mm x 14–16 mm; egg weight: 4–6 g; hatchling size: 41–52mm (SVL); hatchling weight: 4 g. *Ctenosaura palearis* – literature data refer to *C. melanosterna* (see *C. melanosterna*). *Ctenosaura* pectinata – egg size: 26–40 mm x 20–25 mm; egg weight: 7–8 g; hatchling size: 41–58 mm (SVL), total length 126 mmm; hatchling weight: 3.9–6.4 g. *Ctenosaura similis*: egg size: 30–40 mm x 20 mm; egg weight: 7–8 g; hatchling size: 48–59 mm (SVL), hatchling weight: 3.5–5.0 g.

Topic	Data
Incubation and hatching	*Ctenosaura melanosterna* – 85–89 days (29–30°C); 65–80 days (30–31 °C) (these data have been published also under the name of *C. palearis* due to the confusion with this species (Köhler 1995)). Data from habitat: Hatching period from June to August (Montgomery *et al.* 2014). *Ctenosaura palearis* – 90 days at 29 °C; hatching rate of 50% observed; *Ctenosaura pectinata* – 70–90 days (no data on temperature); 46–48 days (at controlled 28–30 °C). *Ctenosaura similis* – less than three months in the wild, 80–100 days at 28–30 °C and 90–100 % relative humidity.

Husbandry and Captive Breeding

Indoor Terraria

Outdoor Enclosures

Topic	Data
Trigger for reproduction	Simulation of dry and rainy season as in their site of origin. In non-range countries, it should be misted extensively from June to October, and from November to May the enclosures or terraria should be kept dryer. In *C. palearis* lowering of temperature and shortening the duration of illumination stimulates the readiness for reproduction.
Husbandry requirements	These large sized iguanas are large reptiles which have high demands on space and energy (light and warmth) for their keeping in terrariums. When buying a juvenile, the space requirements of adult individuals have to be considered. Also, the life expectancy has to be considered, since they get 20 years and even older. Due to their space requirements, it is not easy to rehome the animals, in case keeping is no longer possible. According to the minimum requirements valid in Germany (Federal Ministry for Food Agriculture and Forestry 1997) the minimum size of the terrarium should be 5 x 4 x 4 (L x W x H) the size of snout-vent-length. For the species covered in this fact sheet, this results in a minimum size of 500 cm x 400 cm x 400 cm. A height of 4 m is usually, and even in zoological gardens, difficult to provide, however a height of 2–2.2 m has been shown to be sufficient. The terrarium should have enough structures and branches to climb on. Hollow cork pieces or nest boxes can be used as hiding places. The terrarium should have no plants due to the mostly vegetarian diet of these animals; only plastic plants should be used. A substrate of soil- sand mixture or slightly moist pine bark to avoid dust is recommended. The diet should be varied and contain the usual, commercially available food insects (locusts, crickets, cockroaches, *Zophobas* larvae, etc.), and occasionally small rodents like mice. The plant part of the diet should contain a wide range of herbs, leaves and fruits (e.g., dandelion, broad leaf plantain, clover, milk thistle, chicory, endive, cucumber, tomatoes, eventually also leaves of fruit trees etc.). Their diet should be regularly complemented with minerals and vitamins. Fresh water should always be available. Fluorescent or LED light should be used. A common spotlight and perhaps a heating mat or central heating can be used as a heat and UV source. For these heat-loving iguanas, the spotlight and heating should be large enough to achieve a day temperature between 28–32 °C and locally 45 °C under the spotlight.

	Additionally, extra radiation for 20–30 minutes with an Ultra Vitalux lamp, for example, should be planned, to achieve the needed UV radiation. During daytime, a humidity between 50 and 60 % is recommended, which should be even higher at nighttime, raising to about 70–80 %. A sprinkler system can be used to simulate the rainy season in summer.
General characteristics, difficulties with keeping and breeding	During the reproduction season, a substrate layer of sufficient height should be provided, otherwise the egg clutch may just be dropped (Köhler 2002). It is recommended to use perlite, vermiculite, foam or sand and peat mixture as incubation substrate. The temperature should be constant between 28 and 31 °C and the humidity should be between 90 and 100 %. The substrate should be moderately moist (Köhler 2002).
Care of the young, technical and time effort	The juveniles should be kept in medium terraria, e.g., 100 x 60 x 80 cm (L x W x H) with the same setup as for the adults. They require a similar diet as the adults do. However, during the first weeks they are mainly insectivores. The proportion of plants in the diet should increase with age. Leaves should be cut and offered only in small pieces, since juveniles commonly die from suffocation when eating long, fibrous plant pieces. Enough UV radiation, e.g., with Ultra Vitalux, should be provided for the juveniles (with a minimum distance of 50–60 cm) as well. The care of the young requires about 15–30 minutes daily.
Frequency of breeding in captivity	Rare, since these iguanas are only kept by few keepers.
Breeding difficulty evaluation	Taking the above-mentioned recommendations into account, successful breeding is possible. However, sufficient experience in the husbandry of large lizards is needed. Spiny-tailed iguanas are not suitable for inexperienced keepers.
Interviews/ Surveys/ Consultations	Several private breeders and 2 zoological institutions.

References

Abraham, G. (1978): Schwarze Leguane aus dem Brutkasten. Zeitigung der Eier und Aufzucht der Jungen. Aquarien Magazin **12**(10): 484-486.

Acevedo, M., M. Vesely, J. Sunyer & Q. Dwyer (2009): Geographic distribution: *Ctenosaura acanthura* (Northeastern Spinytail Iguana). Herpetological Review **40**(4): 451.

Aguirre, H.V., V.H. Reynoso & G.E. Pérez (1998): Análisis poblacional e implementación de criaderos con el fin de diseñar estrategias de conservación de la iguana negra (*Ctenosaura pectinate*) en una población sujeta a una alta incidencia de caza. Primer taller nacional sobre manejo de iguanas en cautiverio. Dirección General de Vida Silvestre y Delegación Federal de la Secretaría del Medio Ambiente, Recursos Naturales y Pesca: Pátzcuaro (Michoacán) México **12**: 27-30.

Anon. (2016): Plan De Manejo Para el Criadero Intensivo De Iguana Negra (*Ctenosaura pectinata*), en la localidad de San Jeronimo, Municipio de San Lucas, Michoacán. https://www.academia.edu/7780915/Plan_de_Manejo_Iguanas_Negra (accessed 01.08.2021)

Alberts, A.C., R.L. Carter, W.K. Hayes & E.P. Martins (eds.) (2004): Iguanas - Biology and Conservation. Berkeley (University of California Press: 373 pp.

Allentoft, M.E. (2005): *Ctenosaura similis* - dragerne ved Tulum. [*Ctenosaura similis* - the dragons at Tulum]. Nordisk Herpetologisk Forening **48**(2): 47-54.

Alvarez del Torro, M. (1982): Los Reptiles de Chiapas. 3rd ed. México: Tuxtla Gutiérrez, 248 pp.

Bailey, J.W. (1928): A revision of the lizards of the genus *Ctenosaura*. Proceedings of the US

National Museum **73**(2733): 1-58.

Anderson, C. & K.M. Enge (2011): Geographic distribution: *Ctenosaura similis* (Gray's Spiny-tailed Iguana). Herpetological Review **42**(4): 568.

Andrade-Soto, G., A. Pérez-Pérez, A.E. López-Moreno, G. Suárez-Varón, O. Suárez-Rodríguez, K.M. Gribbins & O. Hernández-Gallegos (2017): Miscellaneous notes: A new locality for *Ctenosaura pectinata* (Wiegmann, 1834) (Squamata: Iguanidae) in central Mexico, with implications for its conservation. Mesoamerican Herpetology **4**(1): 222-224.

Arcos-García, J.L. (2001): Evaluación de dietas, crecimiento y sexado de iguana negra (*Ctenosaura pectinata*) criadas en cautiverio. Colegio de Postgraduados. Montecillo (Estado de México) México. Tesis de doctorado: 114 pp.

Arcos-García J.L., P.M.A. Cobos, V.H. Reynoso, M.G.D. Mendoza, C.M. Ortega & S.F. Clemente (2002): Caracterización del crecimiento de la iguana negra (*Ctenosaura pectinata*) en cautiverio. Growth characterization of black iguana (*Ctenosaura pectinata*) in captivity. Veterinaria México OA **33**(4): 409-419.

Arcos-García J.L., V.H. Reynoso, M.G.D. MendozaS.F. Clemente, A.L.A. Tarango & G.M.M. Crosby (2005): Efecto del tipo de dieta y temperatura sobre el crecimiento y eficiencia alimenticia de iguana negra (*Ctenosaura pectinata*). Revista Cientifica de la Facultad de Ciencias Veterinarias de la Universidad del Zulia**15**(4): 338-344.

Arcos-García J.L., V.H. Reynoso, G.D. Mendoza & D. Hernández (2005): Identificación del sexo y medición del crecimiento en iguana negra (*Ctenosaura pectinata*) en las etapas de cría y juvenil. Sex identification and growth measurement in the black iguana (*Ctenosaura pectinata*) in juvenile and newborn stages. Veterinaria México OA **36**(1): 53-62.

Arcos-García J.L., M.A. Cobos, D. Hernández, V.H. Reynoso, G.D. Mendoza & B.C. Aguilar (2007): Digestibilidad de iguana negra (*Ctenosaura pectinata*) alimentadas con dietas a base de diferentes componentes de insectos y vegetales. Revista Científica De La Facultad De Ciencias Veterinarias De La Universidad Del Zulia **17**(3): 255-261.

Ariano-Sánchez, D. & J. Gil-Escobedo (2016*): Ctenosaura palearis* (Guatemalan Spiny-tailed Iguana) tail trifurcation. Herpetological Review **47**(3): 463-464.

Arndt, R.G. (1999): Predation by the black iguana (*Ctenosaura similis*) on the painted ghost crab (*Ocypode gaudichaudii*) in Costa Rica. Florida Scientist **62**(2): 111-114.

Arriaga-Noguez, A. (2003): Aspectos generales de la ecología de la iguana negra *Ctenosaura similis* (Iguanidae) de Isla Contoy, Quintana Roo. Boletin de la Sociedad Herpetologica Mexicana **11**(1): 25-26.

Avery, M.L., J.D. Eisemann, K.L. Keacher & P.J. Savarie (2011): Acetaminophen and zinc phosphide for lethal management of invasive lizards *Ctenosaura similis*. Current Zoology **57**(5): 625-629.

Avery, M.L., E.A. Tillman & K.L. Krysko (2009): Natural history notes: *Gopherus polyphemus* (Gopher Tortoise), *Ctenosaura similis* (Gray's Spiny-tailed Iguana). Predation. Herpetological Review **40**(4): 435.

Avery, M.L., E.A. Tillman, C. Spurfeld, R.M. Engeman, K.P. Maciejewski, J.D. Brown & E.A. Fetzer (2014): Invasive black spiny-tailed iguanas (*Ctenosaura similis*) on Gasparilla Island, Florida, USA. Integrative Zoology **9**(5): 590–597.

Avilés-Novelo, J.R., P.E. Nahuat-Cervera, L. Guerrero & J.R. Cedeño-Vázquez (2019): *Ctenosaura similis* (Black Iguana) Diet. Herpetological Review **50**(3): 571-572.

Ayala-Guerrero, F. & S. Huitron-Resendiz (1991): Sleep patterns in the lizard *Ctenosaura pectinata*. Physiology & Behavior **49**(6): 1305-1307.

Ayala-Guerrero, F. & L. Vargas Reyna (1987): Sleep and wakefulness in the lizard *Ctenosaura similis*. Boletin de Estudios Medicos y Biologicos Universidad Nacional Autonoma de Mexico **35**(1-2): 25-33.

Bailey, J. W. (1928): A revision of the lizards of the genus *Ctenosaura*. Proceedings of the United States National Museum **73** (2733): 1-55.

Barbour, T. & B. Shreve (1934): A new race of rock iguana. Occasional Papers of the Boston Society of Natural History **8**: 197-198.

Barragán-Ramírez, J.L., M. Vásquez-Bolaños & U.O. Garcia-Vazquez (2012): *Ctenosaura pectinata* (Mexican spiny-tailed iguana). Albinism. Herpetological Review **43**(2): 332-333.

Barrio-Amorós, C.L. & G. Rivas-Fuenmayer (2008): Spiny-tailed iguanas (*Ctenosaura similis*) in Venezuela: A preliminary report. Iguana **15**(3):160–161.

Benitez Malvido, J., E. Tapia, I. Suazo, E. Villasenor & J. Alvarado (2003): Germination and seed damage in tropical dry forest plants ingested by Iguanas. Journal of Herpetology **37**(2): 301-308.

Braun, D. (1993): Erfahrungen bei der Pflege und Zucht von *Ctenosaura palearis*. Iguana Rundschreiben **6**(2) (12): 13-18.

Brown, T.W., A.C. Algar & N. Molina (2019): Die Echsen *Ctenosaura similis* (Iguanidae) und *Hemidactylus frenatus* (Gekkonidae) als Nahrung der Grünen Spitznatter *Oxybelis fulgidus* (Colubridae) auf der Insel Utila, Honduras [Predation of the lizards *Ctenosaura similis* (Iguanidae) and *Hemidactylus frenatus* (Geckonidae) , by the Green Vinesnake *Oxybelis fulgidus* (Colubridae) on Utila Island, Honduras]. Sauria **41**(2): 43-49.

Buckley, L.J. & R.W. Axtell (1990): *Ctenosaura palearis* Stejneger. Paleate spiny-tailed iguana. Catalogue of American Amphibians and Reptiles **491**: 1-3.

Buckley LJ. & R.W. Axtel (1997): Evidence for the specific status of the Honduran lizards formerly referred to *Ctenosaura palearis* (Reptilia: Squamata: Iguanidae). Copeia 1997(**1**): 138-150.

Buckley, L.J., K. de Queiroz, T.D. Grant, B.D. Hollingsworth, J.B. Iverson, S.A. Pasachnik & C.L. Stephen (2016): A Checklist of the Iguanas of the World (Iguanidae; Iguaninae): 4-46. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph 6).

Burger, J. & M. Gochfeld (1990): Risk discrimination of direct versus tangential approach by basking black iguanas (*Ctenosaura similis*): variation as a function of human exposure. Journal of Comparative Psychology **104**(4): 388-394.

Burger, J. & M. Gochfeld (1991): Burrow site selection by black iguana (*Ctenosaura similis*) at Palo Verde, Costa Rica. Journal of Herpetology **25**(4): 430–435.

Burger, J. & M. Gochfeld (1993): The importance of the human face in risk perception by black iguanas, *Ctenosaura similis*. Journal of Herpetology **27**(4): 426-430.

Burger, J., M. Gochfeld & B.G. Murray (1991): Role of a predator's eye size in risk perception by basking black iguana, *Ctenosaura similis*. Animal Behaviour **42**(3): 471-476.

Burger, J., M. Gochfeld & B.G. Murray (1992): Risk discrimination of eye contact and directness of approach in black iguanas (*Ctenosaura similis*). Journal of Comparative Psychology **106**(1): 97-101.

Bustos-Zagal, M.G., R. Guzmán-Ramírez, R. Castro-Franco, A. García-Flores & P. Trujillo-Jiménez (2019): Ecology and use of iguanas *Ctenosaura pectinata* (Sauria: Iguanidae) in two rural communities in Morelos, México. Research & Review: Journal of Zoological Sciences (RRJZC) **7**(1): 5-12.

Canseco-Márquez, L. & M.G. Gutiérrez Mayén (2010): Anfibios y Reptiles del Valle de Tehuacán-Cuicatlán. National Commission for Knowledge and Use of Biodiversity (CONABIO), Foundation for the Cuicatlán Biosphere Reserve, A.C. and the Benemérita Autonomous University of Puebla. 118 pp.

Castro-Franco, R., M.G. Bustos-Zagal & F. R. Méndez-de la Cruz (2011): Variation in parental investment and relative clutch mass of the spiny-tail iguana, *Ctenosaura pectinata* (Squamata: Iguanidae) in central México. Revista Mexicana de Biodiversidad **82**:199-204.

Cedeño-Vàzquez, J.R. & P.M. Beutelspacher-Garcìa (2016): *Ctenosaura similis* (Black Iguana) Diet. Herpetological Review **47**(2): 297.

Charruau, P., J.G. Pérez-Juárez, M. Medina, F.R. Méndez-de la Cruz & J. Pérez-Flores (2020): Bacterial flora of wild black (*Ctenosaura similis* Gray, 1831) and green (*Iguana iguana* Linnaeus, 1758) iguanas from a Mexican Caribbean atoll. Herpetology Notes **13**: 369-376.

Clark, W.H., S.D Farley & R.D. Bratz (1980): A longevity record for *Ctenosaura pectinata* (Reptilia: Iguanidae). Herpetological Review **11**(2): 33.

Cooper, W.E., Jr., & J.A. Lemos-Espinal (2001): Coordinated ontogeny of food preference and responses to chemical food stimuli by a lizard *Ctenosaura pectinata* (Reptilia: Iguanidae). Ethology **107**(7): 639-653.

Cope, E.D. (1863): Descriptions of new American Squamata in the Museum of the Smithsonian Institution. Proceedings of the Academy of Natural Sciences of Philadelphia **15**(1863**)**: 100–106.

Cope, E.D. (1866): Fourth contribution to the herpetology of tropical America. Proceedings of the Academy of Natural Sciences of Philadelphia, **18**(1866): 123-132.

Cope, E.D. (1886): On the species of Iguaninae. Proceedings of the American Philosophical Society **23** (2): 261-271.

Coti, P. & D. Ariano (2008): Ecology and traditional use of the Guatemalan black iguana (*Ctenosaura palearis*) in the dry forests of the Motagua Valley, Guatemala. Iguana **3**: 142-149.

Cruz-Sáenz, D., D. Lazcano, E. Bailon-Cuellar & B. Navarro-Velázquez (2016): Notes on the Herpetofauna of Western Mexico 15: A New Food Item for the Western Spiny-tailed Iguana, *Ctenosaura pectinata* (Wiegmann, 1834). Bulletin of the Chicago Herpetological Society **51**(11): 1-4.

Cupul-Magaña, F.G. & A.H. Escobedo-Galván (2016): *Ctenosaura pectinata* (Wiegmann, 1834). Bifurcated tail. Mesoamerican Herpetology **3**(3): 719-721.

Curlis, J.D., D.C. Macklem, R. Davis & C.L. Cox (2016): Sex-specific antipredator response to auditory cues in the Black Spiny-tailed Iguana. Journal of Zoology (London) **299**(1): 68-74.

de Queiroz K. (1995): Checklist and key to the extant species of Mexican iguanas (Reptilia: Iguaninae). Publicationes Especiales del Museo de Zoologia, Universidad Nacional Autonoma de Mexico **9**: 1-48.

Diener, E. (2007): Die Erdspitznatter *Oxybelis aeneus* und die Lianennatter *Leptophis mexicanus* als Prädatoren der Schwarzleguane *Ctenosaura similis* und *C. bakeri*. Elaphe **15**(3): 59-62.

Dion, K. & L.W. Porras (2014): *Ctenosaura similis*. Diet. Mesoamerican Herpetology **1**(1): 157-158.

Dirksen, L. (2004): Beobachtung eines Paarungsversuchs zwischen einem Hybrid-Männchen (*Ctenosaura bakeri x similis*) mit einem *Iguana iguana*-Weibchen. Iguana Rundschreiben **17**(2): 15-17.

Durtsche, R. (1999): The ontogeny of diet in the Mexican spiny-tailed iguana, *Ctenosaura pectinata*: Physiological mechanisms andecological consequences. PhD Thesis. Norman: University of Oklahoma.

Durtsche, R.D. (2000): Ontogenetic plasticity of food habits in the Mexican Spiny-tailed Iguana, *Ctenosaura pectinata*. Oecologia (Berlin) **124**(2): 185-195.

Durtsche, R.D. (2004): Ontogenetic variation in digestion by the herbivorous lizard *Ctenosaura pectinata*. Physiological and Biochemical Zoology **77**(3): 459-470.

Duellman, W.E. (1961): The amphibians and reptiles of Michoacán, Mexico. University of Kansas Publications, Museum of Natural History **15**(1): 1-148.

Edwards, T., K.B. Bonine, C. Ivanyi & R. Prescott (2005): The molecular origins of the Spiny-tailed Iguanas (*Ctenosaura*) on the grounds of the Arizona-Sonora Desert Museum. Sonoran Herpetologist **18**(11): 122-125.

Enge, K., K.L. Krysko & A.P. Borgia (2006): Geographic distribution: *Ctenosaura similis* (Black Spiny-tailed Iguana). Herpetological Review **37**(4): 494.

Engeman, R.M., M.L. Christie, B. Constantin & R. Christie (2007): Natural history notes: *Ctenosaura similis* (Black Spiny-tailed Iguana). Predation. Herpetological Review **38**(4): 454.

Engeman, R.M., B.U. Constantin, M.L. Christie & P.T. Hall (2009): Natural history notes: *Ctenosaura similis* (Black Spiny-tailed Iguana), *Gopherus polyphemus* (Gopher Tortoise). Concurrent burrow use. Herpetological Review **40**(1): 84.

Engeman, R.M., M. Kennedy, B.U. Constantin, M.L. Christie & P.T. Hall (2009): Natural history notes: *Ctenosaura similis* (Black Spiny-tailed Iguana), *Coluber constrictor priapus* (Southern Black Racer). Non-predatory killing. Herpetological Review **40**(1): 84-85.

Engeman, R., E. Jacobson, M.L. Avery, & W.E. Meshaka (2011): The aggressive invasion of exotic reptiles in Florida with a focus on prominent species: A review. Current Zoology **57**(5):599−612.

Evans, L.T. (1948): Social habits of the black iguana, *Ctenosaura pectinata*. Anatomical Record **101**: 646.

Evans, L.T. (1951): Field study of the social behavior of the black lizard, *Ctenosaura pectinata*. American Museum Novitates **1493**: 1-26.

Farallo, V.R., M. Sasa, D.K. Wasko, & M R.J. Forstner (2010): Reduced foraging in the presence of predator cues by the Black Spiny-tailed Iguana, *Ctenosaura similis* (Sauria: Iguanidae). Phyllomedusa **9**(2): 109-119.

Faria, C.M.A., E. Zarza, V.H. Reynoso & B.C. Emerson (2010): Predominance of single paternity in the black spiny-tailed iguana: conservation genetic concerns for female-biased hunting. Conservation Genetics **11**(5): 1645-1652.

Fitch, H.S. (1977): Age and sex differences in the ctenosaur (*Ctenosaura similis*). Milwaukee Public Museum Contributions in Biology and Geology **11**: 1-11.

Fitch, H.S. & R.W. Henderson (1978): Ecology and exploitation of *Ctenosaura similis*. University of Kansas Science Bulletin **51**(15): 483-500.

Fitch, H.S. & J. Hackforth-Jones (1983): *Ctenosaura similis* S. 394-396. *In:* Janzen, D.H. (Hrsg.): Costa Rican Natural History. Chicago & London (University of Chicago Press).

Flanigan, W.F. (1973): Sleep and wakefulness in iguanid lizards *Ctenosaura pectinata* and

Iguana iguana. Brain, Behavior and Evolution **8**(6): 401-436.

Flores, D. & L.F. Esqueda (2008): First record of the Spiny-tailed Iguana *Ctenosaura similis* (Gray, 1831) (Squamata: Iguanidae) in Venezuela. Herpetotropicos **4**(1): 41.

Francisco V.Z. & P.D.B. Vázquez (2002) *Ctenosaura pectinata*, Biología, Problemática, Investigación y Conservación de una Especie Endémica de México. Reptilia ES) **31**: 33-38.

Fuentes I.L. (1994): Características Reproductivas de *Iguana iguana* y *Ctenosaura pectinata* (Reptilia: Iguanidae) en Maruata, Michoacán México. Tesis Profesional. Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo.

García-Padilla, E., V. Mata-Silva, D.L. DeSantis & L.D. Wilson (2015): Distribution notes: *Ctenosaura similis* Gray, 1830. Mesoamerican Herpetology **2**(4): 540–541.

García-Padilla, E., D.L. DeSantis, A. Rocha, V. Mata-Silva, J.D. Johnson & L.D. Wilson (2020): Conserving the Mesoamerican herpetofauna: the most critical case of the priority level one endemic species. Amphibian & Reptile Conservation **14(**2): 73-131.

García-Rosales, A., A. Arriaga-Noguez & A. Ramírez-Bautista (2020): Natural history of the black iguana *Ctenosaura similis* (Squamata: Iguanidae) in isla Contoy, Quintana Roo, Mexico. Acta Biologica Colombiana **25**(3): 394-402.

Garrido Estrada, A.A. (1992): Estado actual y perspectivas del conocimiento de las iguanas (*Iguana*) y los garrobos (*Ctenosaura*) en Mexico. Tesis de Licenciatura. Universidad Nacional Autónoma de México, México.

Goldberg, S.R. (2009): Note on reproduction of the Sonoran Spiny-tailed Iguana, *Ctenosaura macrolopha* (Squamata: Iguanidae). Bulletin of the Chicago Herpetological Society **44**(3): 42-43.

Gómez-Mora, A., I. Suazo-Ortuño & J. Alvarado-Díaz (2012): Distribución, abundancia y uso de hábitat de la iguana negra (*Ctenosaura pectinata*) y la iguana verde (*Iguana iguana*) en el municipio de Buenavista, Michoacan. Entomología **14** (2):67-74.

Gonzalez Corona, G. (2005): Produccion intensiva de iguana negra (*Ctenosaura pectinata*) bajo la modalidad de unidad de manejo para la conservacion de vida silvestre (UMA) en la comunidad de Valle Luz, San Miguel Totolapan, Guerrero dentro del Programa La Universidad en tu comunidad. Tesis de licenciatura. Escuela Nacional de Estudios Profesionales Aragon, Universidad Nacional Autónoma de México 164 p.

Gonzalez-Garcia, A., J. Belliure, A. Gomez-Sal & P. Davilla (2009): The role of urban green-spaces in fauna conservation: the case of the iguana *Ctenosaura similis* in the 'patios' of Leon City, Nicaragua. Biodiversity and Conservation **18**(7): 1909-1920.

Greenwood, K., S. Cranston, H. Darlington, & L. Gomersall (2000): Thermoregulation and activity patterns in captive ground iguanas (*Ctenosaura similis*). Herpetological Bulletin **73**: 10–16.

Gutman, A.J. (2005): Getting Rid of the Gasparilla Island Ctenosaurs: The Lizards Don't Want to Leave. Iguana: Journal of the International Iguana Society, **12**(1): 58.

Gutsche, A. (2010): Mehrere Amphibien- und Reptilienarten neu in das Washingtoner Artenschutzabkommen (CITES) aufgenommen. Reptilia (Münster) **15**(83): 3-8.

Gutsche, A. & G. Köhler (2004): A fertile hybrid between *Ctenosaura similis* (Gray 1831) and *C. bakeri* Stejneger 1901 (Squamata: Iguanidae) on Isla de Utila, Honduras. Salamandra **40** (3-4): 201-206.

Gutsche, A. & G. Köhler (2008): Phylogeography and hybridization in *Ctenosaura* species (Sauria, Iguanidae) from Caribbean Honduras: insights from mitochondrial and nuclear DNA. Zoosystematics and Evolution **84**(2): 245-253.

Ortiz Guzmán, J.J., J.L. Arcos-García, G.D. Mendoza Martínez, F.X. Plata Pérez, G. Fuentes Mascorro, & G. Ruelas Inzunza (2013): Effect of Lysine Addition on Growth of Black Iguana (*Ctenosaura pectinata*). Zoo Biology **32**: 277-280.

Johnson, S. (2018): Black Spiny-tailed Iguana (*Ctenosaura similis*) on New Providence Island, The Bahamas. IRCF Reptiles & Amphibians **25**(3): 212-213.

Hanley, K.A., M.L. Elliott & J.A. Stamps (1999): Chemical recognition of familiar vs. unfamiliar conspecifics by juvenile iguanid lizards, *Ctenosaura similis*. Ethology **105**(8): 641-650.

Heimes, P. (1994): Schwarze Leguane im Lande der Mayas. DATZ (Die Aquarien- und Terrarien-Zeitschrift) **47**(2): 99-101.

Henderson, R.W. (1973): Ethoecological observations of *Ctenosaura similis* (Sauria: Iguanidae) in British Honduras. Journal of Herpetology **7**(1): 27-33.

Henderson, R.W. & H.S. Fitch (1979): Notes on the behaviour and ecology of *Ctenosaura similis* (Reptilia, Iguanidae) at Belize City, Belize. Brenesia **16**: 69-80.

Hernández-Gallegos, O., F. Rodríguez-Romero & G. Granados-González (2008): Natural History Notes. *Conophis lineatus* (Road Guarder) Diet. Herpetological Review **39**(4): 467.

Herrera, M.M., S.S. Machorro, J.L. Arcos-García & M.G.D. Mendoza (2008): Regresión polinomial de la longitud total en la iguana negra (*Ctenosaura pectinata*) en relación con el tiempo. XI Reunión Nacional Sobre Iguanas. Subcomité Técnico Consultivo para la Conservación, Manejo y Aprovechamiento Sustentable de las Iguanas en México. Puebla, Puebla. 21 al 23 de mayo: 99-108.

Heuvel, W. van den (2001): Beobachtungen an *Ctenosaura melanosterna* in der Natur und im Terrarium. Iguana Rundschreiben **14**(2): 11-18.

Heuvel, W. van den (2003): Beobachtungen an *Ctenosaura melanosterna* Buckley & Axtell, 1997 in seinem natürlichen Verreitungsgebiet und im Terrarium. Elaphe **11**(3): 33-39.

Hollingsworth, B.D. (2004): The evolution of iguanas: an overview of relationships and a checklist of species in *Ctenosaura.* 19-44 *In:* Alberts, A.C., R.L. Carter, W.K. Hayes & E.P. Martins (Eds.): Iguanas, Biology and Conservation. Berkeley, California (University of California Press).

Jackson, J.A. & B.J.S. Jackson (2007): An apparent mutualistic association between invasive exotics: Brazilian pepper (*Schinus terebinthifolius*) and Black Spiny-tailed Iguanas (*Ctenosaura similis*). Natural Areas Journal **27**(3): 254-257.

Janzen, F.J. & E.D. Brodie (1995): Visually-oriented foraging in a natural population of herbivorous lizards (*Ctenosaura similis*). Journal of Herpetology **29**(1): 132-136.

Johnson, S. (2018): Black Spiny-tailed Iguana (*Ctenosaura similis*) on New Providence Island, The Bahamas. IRCF Reptiles & Amphibians **25**(3): 212-213.

Kelly, P. (2012): Spiny Tailed Iguana Care-Sheet. Reptiles. Magazine August 7, 2012.

Kelly, P. (2013): Breeding Spiny-Tailed Iguanas of The Genus *Ctenosaura.* Reptiles Magazine November 13, 2013.

Köhler, G. (1991): *Ctenosaura similis* (Gray, 1831). Sauria **13** Suppl.: 193-196.

Köhler, G. (1995a): Zur Systematik und Ökologie der Schwarzleguane (Gattung *Ctenosaura*) Dissertation Universität Frankfurt, 118 pp.

Köhler, G. (1995b): *Ctenosaura palearis* Stejneger, 1899. Sauria **17** Suppl.: 329-332.

Köhler, G. (1995c): Die Lokalnamen der Leguane der Gattung *Ctenosaura* Wiegmann. Sauria **17**(2): 11-12.

Köhler, G. (2000): Reptilien und Amphibien Mittelamerikas, Bd. 1: Krokodile, Schildkröten,

Echsen. Offenbach (Herpeton Verlag): 158 pp.

Köhler, G. (2002): Schwarzleguane - Lebensweise, Pflege und Zucht. Offenbach (Herpeton Verlag): 144 S.

Köhler, G. (2008): Reptiles of Central America. 2nd Ed. Offenbach (Herpeton Verlag): 400 pp.

Köhler, G. & E. Blinn (2000): Natürliche Bastardierung zwischen *Ctenosaura bakeri* und *Ctenosaura similis* auf Ultila, Honduras. Salamandra **36**(1): 77-79.

Köhler, G. & B. Streit (1996): Notes on the systematic status of the taxa *acanthura*, *pectinata*, and *similis* of the genus *Ctenosaura* (Reptilia: Sauria: Iguanidae). Senckenbergiana biologica **75**(1/2):33-43.

Köhler, G., W. Schroth & B. Streit (2000): Systematics of the *Ctenosaura* group of lizards (Reptilia: Sauria: Iguanidae). Amphibia-Reptilia **21**(2): 177-191.

Köhler, G. & M. Vesely (1996): Freilanduntersuchungen zur Morphologie und Lebensweise von *Ctenosaura palearis* in Honduras und Guatemala. Herpetofauna (Weinstadt) **18**(102): 23-26.

Kraus, F. (2009): Alien Reptiles and Amphibians. A Scientific Compendium and Analysis. Dordrecht (Springer): 563 pp.

Krysko, K.L. (2009): Geographic distribution: *Ctenosaura pectinata* (Mexican Spiny-tailed Iguana). USA: Florida. Herpetological Review **40**(1): 112.

Krysko, K.L., F.W. King, K. Enge & A.T. Reppas (2003): Distribution of the introduced black spiny-tailed iguana (*Ctenosaura similis*) on the southwestern coast of Florida. Florida Scientist **66**(2): 74-79.

Krysko, K.L., K.W. Larson, D. Diep, E. Abellana & E.R. McKercher (2009): Diet of the nonindigenous Black Spiny-tailed Iguana, *Ctenosaura similis* (Gray 1831) (Sauria: Iguanidae), in southern Florida. Florida Scientist **72**(1): 48-58.

Krysko, K.L., L.A. Somma, D.C. Smith, C.R. Gillette, D. Cueva, J.A. Wasilewski, K.M. Enge, S.A. Johnson, T.S. Campbell, J.R. Edwards, M.R. Rochford, R. Tompkins, J.L. Fobb, S. Mullin, C.J. Lechowicz, D. Hazelton & A. Warren (2016): New Verified Non-indigenous Amphibians and Reptiles in Florida Through 2015, With a Summary of Over 152 Years of Introduction. IRCF Reptiles & Amphibians **23**(2): 110−143.

Krysko, K.L., J.P. Burgess, M.R. Rochford, C.R. Gillette, D. Cueva, K.M. Enge, L.A. Somma, J.L. Stabile, D.C. Smith, J.A. Wasilewski, G.N. Kieckhefer III, M.C. Granatosky & S.V. Nielsen (2011): Verified non-indigenous amphibians and reptiles in Florida from 1863 through 2010: Outlining the invasion process and identifying invasion pathways and stages. Zootaxa **3028**:1-64.

Lara-Resendiz, R.A., I. Beltrán & A.H. Díaz de la Vega-Pérez (2016): Nature notes: *Trimorphodon biscutatus*. Diet, prey size and accidental mortality (*Ctenosaura pectinata*). Mesoamerican Herpetology **3**(3): 749-751.

Lemos-Espinal, J.A. & R.E. Ballinger (1994): Natural history notes: *Ctenosaura pectinata* (Mexican Spiny-tailed Iguana). Predation. Herpetological Review **25**(1): 26.

Lemos-Espinal, J.A., G.R. Smith & J.C. Rorabaugh (2019): A conservation checklist of the amphibians and reptiles of Sonora, Mexico, with updated species lists. ZooKeys **829**: 131-160.

Lemos-Espinal J.A. & G.R. Smith (2020): A conservation checklist of the amphibians and reptiles of the State of Mexico, Mexico with comparisons with adjoining states. ZooKeys **953**: 137-159.

Loc-Barragán, J.A. & A. Madueño-Molina (2017): Predatory attempts on *Ctenosaura pectinata* (Wiegmann, 1834) and *Tropidodipsas philippii* (Jan, 1863) by *Felis catus*, Schreber, 1777 (Mammalia: Felidae). Mesoamerican Herpetology **4**(4): 986-987.

Locey, K.J., C.J. Butler & D.L. Martin (2008): Natural history notes: *Ctenosaura pectinata* (Spiny-tailed Iguana). Population status. Herpetological Review **39**(3): 348-349.

López-Ruvalcaba, O.A., J.L. Arcos-García, G.D. Mendoza-Martínez, R. López-Pozos, S.J. López-Garrido & L. Velez-Hernández (2012): Parámetros reproductivos de la lagartija negra hembra (*Ctenosaura pectinata*) en condiciones intensivas. Revista Cientifica (Maracaibo) **22**(1): 65-71.

McDiarmid, R.W., & L.M. Hardy (1969): The amphibians and reptiles of Sinaloa, Mexico. University of Kansas Publications. Museum of Natural History **18**: 39-252.

Machorro, S.S., M.M. Herrera, J.L. Arcos-García, R. López-Pozos, M.G.D. Mendoza & M.G.E. Leyte (2009): Aplicación de la regresión polinomial en el modelado de crecimiento hocico-cloaca en relación con el peso en iguana negra *Ctenosaura pectinata* (Reptilia: Squamata: Iguanidae). Ciencia y Mar **37**:21-28.

Mackay, R.S. (1968): Observations on peristaltic activity versus temperature and circadian rhythms in undisturbed *Varanus flavescens* and *Ctenosaura pectinata*. Copeia **1968**(2): 252-259.

Malfatti, M. (2007): A Look at the Genus *Ctenosaura*: Meet the World's fastest lizard and its kin. Reptiles Magazine **15**(11): 64-73.

Maryon, D., T.W. Brown & D.C. Lee (2020): Love thy neighbor: Predation of a Utila Spiny-tailed Iguana (*Ctenosaura bakeri*) by a Common Spiny-tailed Iguana (*C. similis*) on Utila Island, Honduras IRCF Reptiles & Amphibians **27**(1): 84-86.

Mata-Silva, V., E. García-Padilla, D.L. DeSantis, A. Rocha & L.D. Wilson (2016): Distribution notes: *Ctenosaura pectinata* (Wiegmann, 1834). Mesoamerican Herpetology **3**(3): 769.

Mata-Silva, V., A. Rocha, E. García-Padilla, D.L. DeSantis & L.D. Wilson (2016): Distribution notes: *Ctenosaura pectinata* (Wiegmann, 1834). Mesoamerican Herpetology **3**(3): 767-768.

Mazzotti, F.J. & R.G. Harvey (2012): The Invasion of Exotic Reptiles and Amphibians in Florida. Wildlife Ecology and Conservation Department, UF/IFAS Extension.

McCoid, M.J. (2002): Geographic distribution: *Ctenosaura pectinata* (Spinytail Iguana). Herpetological Review **33**(4): 321.

McCranie, J.R. (2015): A checklist of the amphibians and reptiles of Honduras, with additions, comments on taxonomy, some recent taxonomic decisions, and areas of further studies needed. Zootaxa **3931** (3): 352-386.

Mendelson, J.R. & A.M. Kelly (2016): Geographic Distribution: *Ctenosaura similis* (Gray's Spiny-tailed Iguana). Herpetological Review **47**(4): 628.

Mendoza-Quijano, F., A. Mejenes-Lopez, M. Hernandez-Aquino & G. Köhler (2002): *Ctenosaura acanthura* (Shaw, 1802). An addition to the known fauna of the Mexican state of Hidalgo. Herpetozoa **15**(1/2): 91-92.

Merlau, R. (2003): Zum Höchstalter bei *Ctenosaura pectinata*. Iguana Rundschreiben **16**(2): 31.

Meshaka, W.E. (2011): A Runaway Train in the Making: The Exotic Amphibians, Reptiles, Turtles, and Crocodilians of Florida. Monograph 1. Herpetological Conservation and Biology **6**: 1-101.

Meshaka, W.E., H.T. Smith, E. Golden & E.M. Cowan (2008): The black Spinytail Iguana (*Ctenosaura similis*) and its apparent response to high-density raccoon (*Procyon lotor*)

predation in a south Florida park. Florida Scientist **71**(3): 215-219.

Montgomery, C.E., S.A. Pasachnik, L.E. Ruyle, J.A. Frazier & S.E.W. Green (2014): Natural history of the black-chested spiny-tailed iguanas, *Ctenosaura melanosterna* (Iguanidae), on Cayo Cochnino Menor, Honduras. Southwestern Naturalist **59**(2): 280–285.

Mora, J.M. (1986): Actividad nocturne de *Ctenosaura similis* (Gray) (Reptilia: Iguanidae) en Palo Verde, Guanacaste, Costa Rica. Vida Silvestre Neotropical **1**(1): 81-82.

Mora, J.M. (1987): Predation by *Loxocemus bicolor* on the eggs of *Ctenosaura similis* and *Iguana iguana*. Journal of Herpetology **21**(4): 334-335.

Mora, J.M. (1989a): Eco-behavioral aspects of two communally nesting iguanines and the structure of their shared nesting burrows. Herpetologica **45**(3): 293-298.

Mora, J.M. (1989b): *Ctenosaura similis* (spiny–tailed iguana) Nest emergence. Herpetological Review **20**(2): 53.

Mora, J.M. (1990): An instance of albinism in the ctenosaur lizard, *Ctenosaura similis*, in Costa Rica. Bulletin of the Chicago Herpetological Society **25**(4): 70.

Mora, J.M. (1991a): Cannibalism in the ctenosaur lizard, *Ctenosaura similis*, in Costa Rica. Bulletin of the Chicago Herpetologial Society **26**: 197-198.

Mora, J.M. (1991b): Comparative Grouping Behavior of Juvenile Ctenosaurs and Iguanas. Journal of Herpetology **25**(2): 244.

Mora, J.M. (2010): Natural history of the black spiny-tailed iguana (*Ctenosaura similis*) at Parque Nacional Palo Verde, Costa Rica, with comments on the conservation of the genus *Ctenosaura*. pp. 716-733. *In:* Wilson, L.D., J.H. Townsend & J.D. Johnson (eds.): Conservation of Mesoamerican amphibians and reptiles. Eagle Mountain, Utah (Eagle Mountain Publishing, LC): 812 pp.

Mora, J.M., F.H.G. Rodrigues, I. López & L.D. Alfaro (2015): Nature notes: *Ctenosaura similis*. Cannibalism. Mesoamerican Herpetology **2**(1): 107-109.

Morales-Mávil, J.E. & E.A. Suárez-Domínguez (2010): Registro de géneros de vertebrados pormunicipio. pp. 53-65. *In:* Mendoza-Cantú, A. (ed.): Atlas Regional de Impactos Derivados de la Actividades Petroleras en Coatzacoalcos, Veracruz. Mexico City (SEMARNAT and Universidad Nacional Autónoma de México).

Morales-Mávil, J.E., E.A. Suárez-Domínguez & C.R. Corona-López (2016): Biology and Conservation of the Gulf Spiny-Tailed Iguanas (*Ctenosaura acanthura*). Herpetological Conservation and Biology **11** (Monograph 6): 177-186.

Mundo-Hernández, V., M. Martínez-Haro, M.A. Balderas-Plata, X.A. Némiga & J. Manjarrez (2017): A new locality for *Ctenosaura pectinata* (Wiegmann, 1834) (Squamata: Iguanidae) in central Mexico, with implications for its conservation. Mesoamerican Herpetology **4**(1): 222-224.

Naccarato, A.M., J.B. Dejarnette & P. Allman (2015): Successful Establishment of a Non-Native Species after an Apparent Single Introduction Event: Investigating ND4 Variability in Introduced Black Spiny-Tailed Iguanas (*Ctenosaura similis*) in Southwestern Florida. Journal of Herpetology **49**(2): 230–236.

Oelrich, T.M. (1956): The anatomy of the head of *Ctenosaura pectinata* (Iguanidae). Miscellaneous Publications, Museum of Zoology, University of Michigan **94**: 1-122.

Olson, C.A., G.S. Klowden & M.L. Christie (2007): Geographic distribution: *Ctenosaurus similis* (Spiny-tailed Iguana). USA: Florida. Herpetological Review **38**(2): 217.

Ortiz-Lachica, F., S. Moreno-López, E. García-Padilla, V. Mata-Silva & L. D. Wilson (2017): *Ctenosaura similis* (Gray, 1830). Predation. Mesoamerican Herpetology **4**(3): 630–631.

Palacios-Aguilar, R. & O. Flores-Villela (2018): An updated checklist of the herpetofauna from Guerrero, Mexico. Zootaxa **4422**(1): 1-24.

Pasachnik, S.A. & D. Ariano-Sánchez (2010): CITES Appendix II listing for the *Ctenosaura palearis* clade: Developing conservation policies in Central America. IRCF Reptiles & Amphibians **17**(3): 137-139.

Pasachnik, S.A., J.A. Danoff-Burg, E.E. Antunez & J.P. Corneil (2014): Local knowledge and use of the Valle de Aguan Spiny-tailed Iguana, *Ctenosaura melanosterna*, in Honduras. Herpetological Conservation and Biology **9**(2): 436-447.

Pasachnik, S.A., A.C. Echternacht & B.M. Fitzpatrick (2010): Gene trees, species and species trees in the *Ctenosaura palearis* clade. Conservation Genetics **11**(5): 1767-1781.

Pasachnik S.A., A.C. Echternacht & B.M. Fitzpatrick (2011): Population genetics of the Honduran spiny-tailed iguana *Ctenosaura melanosterna*: implications for conservation and management. Endangered Species Research **14**: 113-126.

Pasachnik, S.A. & Corneil, J.P. (2011): Natural history notes: *Ctenosaura similis* (Black Spiny-tailed Iguana). Diet. Herpetological Review **42**(4): 601-602.

Pasachnik, S.A., B.M. Fitzpatrick, T.J. Near & A.C. Echternacht (2009): Gene flow between and endangered endemic iguana, and its wide spread relative, on the island of Utila, Honduras: when is hybridization a threat? Does hybridization threaten an endangered iguana? Conservation Genetics **10**(5): 1247-1254.

Pasachnik, S.A., C.E. Montgomery, L.E. Ruyle, J.P. Corneil & E.E. Antunez (2012): Morphological and Demographic Analyses of the Blackchested Spiny-tailed Iguana, *Ctenosaura melanosterna*, Across their Range: Implications for Population Level Management. Herpetological Conservation and Biology **7**(3): 399-406.

Penilla-Juárez, Á., D. Cruz-Sáenz & D. Lazcano (2013): Notes on the Herpetofauna of Western Mexico 9: Current status of Green Iguanas (*Iguana iguana*) and Western Spiny-tailed Iguanas (*Ctenosaura pectinata*) in the Natural Protected Area “Estero El Salado” in Puerto Vallarta, Jalisco, Mexico. Bulletin of the Chicago Herpetologial Society **48**(7):92-96.

Powell, R. (2004): Black Iguanas (*Ctenosaura similis*) in Guanacaste, Costa Rica. Iguana (West Hartford) **11**(1): 16-19.

Quintero-Díaz, G.E., R. Reyes-Ardit, Ch. M. García-Balderas, D. Valdéz-Jiménez, C. Chávez-Floriano, M. Muñíz-Salas & C. Sosa-Vargas (2013): Geographic Distribution: *Ctenosaura pectinata* (western spiny-tailed iguana). Herpetological Review **44**(2): 273.

Reed, R.N., S. Green, S.M. Boback & C.E. Montgomery (2006): Natural history notes: *Ctenosaura melanosterna* (Black-chested Ctenosaur). Predation. Herpetological Review **37**(1): 84.

Reynoso, V.H., E. Zarra-Franco, W. Medina Mantecon & P. Rueda Zozaya (2007): Black Iguana Project 2006 Update: Genetics, Demography, and Feeding. Iguana: Journal of the International Iguana Society, **14**(4): 249-250.

Reynoso, V.H., M. Vázquez-Cruz, R.C. Rivera-Arroyo, E. Zarza-Franco & T.D. Grant (2020): *Ctenosaura pectinata*. The IUCN Red List of Threatened Species 2020: e.T174478A1414553.

Reynoso, V.H., M. Vázquez-Cruz, R.C. Rivera-Arroyo, E. Zarza-Franco & T.D. Grant (2020): *Ctenosaura acanthura*. The IUCN Red List of Threatened Species 2020: e.T174473A1414410.

Rodriguez-Juarez, C. & J.L. Osorno Cepeda (1998): *Ctenosaura pectinata* (Brown iguana) Diet. Herpetological Review **29**(2): 100.

Rodríguez-Canseco, J.M., K.L. González-Estupiñan, E.S.G. Mata, J. Villarreal-Méndez &

A.B. Cruz (2016): *Ctenosaura pectinata* (Western Spiny-tailed Iguana) Predation. Herpetological Review **47**(1): 135.

Rogner, M. (1996): Schwarzer Leguan. Zur Biologie von *Ctenosaura similis*. Aquarium (Bornheim) **324**: 42-45.

Rogner, M. (2019): Die Schwarzen Leguane (*Ctenosaura similis*) von Chichén Itzá und Tulum (Yucatán, Mexiko). Reptilia (Münster) **24**(136): 58-62.

Rorabaugh, J.C. (2008): An introduction to the herpetofauna of mainland Sonora, México, with comments on conservation and management. Journal of the Arizona-Nevada Academy of Science **40**: 20–65.

Rorabaugh, J.C., S.L. Minter, T.R. Van Devender, T.R. Jones & J.D. Bygott (2015): Northernmost populations of spiny-tailed iguanas (*Ctenosaura*). Mesoamerican Herpetology **2**(1): 127-130.

Rueda-Zozaya P., G.D. Mendoza, M.M. Crosby, G. González & V.H. Reynoso (2010): Effect of feed type and sex on digestibility and feed efficiency utilization in black spiny-tailed iguana (*Ctenosaura pectinata*). Zoo Biology **29**: 1-6.

Sánchez-Hernández, A.S., V.C. Rosas-Espinoza & F.A. Rodríguez Zaragoza (2017): Canibalismo en *Ctenosaura pectinata* (Squamata: Iguanidae) en el parque nacional Isla Isabel, Nayarit, México. Acta Zoologica Mexicana Nueva Serie **33**(2): 386-388.

Schardt, M. (1995): Zur Maximalgrösse des Schwarzleguans *Ctenosaura palearis* Stejneger 1899. Iguana Rundschreiben **8**(1) (14): 18-19.

Schardt, M. (1997): Zur Zucht von *Ctenosaura palearis* aus Honduras, mit Erkenntnissen zur Fortpflanzungsbiologie. Herpetofauna (Weinstadt) **19**(106): 26-34.

Schulte, U. (2007): Beobachtungen zur Hybridisierung zwischen *Ctenosaura similis* (Gray 1831) und *Ctenosaura bakeri* Stejneger 1901 auf Utila, Honduras. Elaphe **15**(1): 55-59.

SEMARNAT (2010): Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Diario Oficial de la Federación. Ciudad de México, Mexico.

SEMARNAT (2014): Acuerdo por el que se da a conocer la lista de especies y poblaciones prioritarias para la conservación. Diario Oficial de la Federación. Ciudad de México, Mexico.

Sheetz, K.H., J.A. Lemos-Espinal & G.R. Smith (2007): Natural history notes: *Ctenosaura macrolopha* (Mainland Spinytail Iguana). Diet. Herpetological Review **38**(1): 77-78.

Smith, H.M. (1972): The sonoran subspecies of the lizard *Ctenosaura hemilopha*. Great Basin Naturalist **32**(2): 104-111.

Stejneger, L.H. (1898): Description of a new species of spiny-tailed iguana from Guatemala. Proceedings of the United States National Museum **21**: 381-383.

Stroud, J.T. & K.L. Krysko (2013): *Ctenosaura similis* (Gray's spiny-tailed iguana) non-native diet. Herpetological Review **44**(2): 322.

Suárez-Domínguez, E.A., A. González-Romero, J.E. Morales-Mávil & G. Aguirre-Léon (2004): Tamaño del ámbito hogareño y uso de hábitat de hembras de iguana negra (*Ctenosaura acanthura*, Shaw, 1802) en la zona de la Mancha, Veracruz. Memorias. Manejo de Fauna Silvestre en Amazonia y Latinoamérica: 300–319.

Suarez-Domínguez, E.A., J.E. Morales-Mavil, R. Chavira & L. Boeck (2011): Effects of habitat perturbation on the daily activity pattern and physiological stress of the spiny tailed iguana (*Ctenosaura acanthura*). Amphibia-Reptilia **32**(3): 315-322.

Suazo, I., & J. Alvarado (1994): Iguana negra. Notas sobre su historia natural. Universidad

Michoacana de San Nicolás de Hidalgo, U.S. Fish and Wildlife Service.

Teohtli, Z.R., A.D. Javier & O.E. de Valdivia (1999): Cría y Conservación de Iguana Verde en la Costa Michoacana: El Caso Maruata. Universidad Autónoma de Chapingo. 91 pp.

Templeton, J.R. (1967): Nasal salt gland excretion and adjustment to sodium loading in the lizard, *Ctenosaura pectinata*. Copeia **1967**(1): 136-140.

Townsend, J.H., K.L. Krysko & K.M. Enge (2003): The identity of spiny-tailed iguanas, *Ctenosaura*, introduced to Florida, USA (Squamata: Sauria: Iguanidae). Herpetozoa **16**(1/2): 67-72.

Traveset, A. (1990): *Ctenosaura similis* Gray (Iguanidae) as a seed disperser in a Central American deciduous forest. American Midland Naturalist **123**(2): 402-404.

Tuns, J. (2007): De Zwarte Leguaan, *Ctenosaura similis*. Lacerta **65**(1): 32-39.

Unger, S.D., C. Hickman & K. Murray (2018): The use of a hand-held smartphone device for non-invasive thermal observations of the Black Spiny-tailed Iguana (*Ctenosaura similis*) in Panama. IRCF Reptiles & Amphibians **25**(1): 86-88.

Urbansky, D. (2015): Leben in Ruinen. Iguana **28**(2): 28-32.

Van Devender, R.W. (1982): Growth and ecology of spiny-tailed and green Iguanas in Costa Rica, with comments on the evolution of herbivory and large bodysize. Pp. 162-163. *In:* Burghardt, G.M. & A.S. Rand (Hrsg.): Iguanas of the World. Park Ridge, New Jersey (Noyes Publications).

Valenzuela-López, G. (1981): Contribución al conocimiento de la biología y ecología de *Ctenosaura pectinata* e *Iguana iguana* (Reptilia: Iguanidae) en la costa de Jalisco. Tesis de Licenciatura. Universidad Autónoma de México. México, D.F.

Vásquez-Contreras, A. & D. Ariano-Sánchez (2016): Endozoochory by the Guatemalan Black Iguana, *Ctenosaura palearis* (Iguanidae), as a germination trigger for the Organ Pipe Cactus *Stenocereus pruinosus* (Cactaceae). Mesoamerican Herpetology **3**(3): 662-667.

Villa, J.D. & N.J. Scott (1967): The iguanid lizard *Enyaliosaurus* in Nicaragua. Copeia **1967**(**2**): 474-476.

Villegas Zurita, F. & D.B. Vazquez-Perez (2001): *Ctenosaura pectinata*. The black iguana, biology, research, and conservation of a species endemic to Mexico. Reptilia (GB) **18**: 33-38.

Warncke, G., I. Giel & F.W. Klussmann (1988): Die Bedeutung der motorischen Aktivität für die Wärmebildung beim Schwarzen Leguan (*Ctenosaura similis*). Verhandlungen der Deutschen Zoologischen Gesellschaft **81**: 333.

Wartenberg, L. (2013): Bedrohung und Schutz der Schwarzleguane (*Ctenosaura*). Iguana **26**(2): 20–33.

Wilson, L.D. (1979): New departmental records for reptiles and amphibians from Honduras. Herpetological Review 1**0**(1): 25.

Wisenden, B.D. (1998): Natural history notes: *Ctenosaura similis* (Ctenosaur, Garrobo, Iguana Negra). Behavior. Herpetological Review **29**(3): 168.

Wright, A.S. (1987): *Ctenosaura acanthura*, the Mexican Spiny-tailed Iguana. pp. 45-47. *In:* Welch, K.R.: Handbook on the maintenance of reptiles in captivity. Malabar, Florida (Robert E. Kreiger): 156 pp.

Zarza E., V.H. Reynoso, C.M.A. Faria & B.C. Emerson (2019): Introgressive hybridization in a Spiny-Tailed Iguana, *Ctenosaura pectinata*, and its implications for taxonomy and conservation. PeerJ **7**: e6744.

Zarza E., V.H. Reynoso & B. C. Emerson (2008): Diversification in the northern neotropics: mitochondrial and nuclear DNA phylogeography of the iguana *Ctenosaura pectinata* and related species. Molecular Ecology **17**: 3259-3275.

Zarza E., V.H. Reynoso & B.C. Emerson (2009): Isolation and characterization of polymorphic microsatellite markers in the black spiny tailed iguana (*Ctenosaura pectinata*) and their cross-utility in other *Ctenosaura*. Molecular Ecology Resources **9**: 117-119.

Zarza, E., V.H. Reynoso & B.C. Emerson (2016): Genetic Tools for Assisting Sustainable Management and Conservation of the Spiny-Tailed Iguana *Ctenosaura pectinata*. Herpetological Conservation and Biology **11** (Monograph 6): 255-264.

Zurita-Carmona, M.E. (1999): Situación actual de la iguana negra (*Ctenosaura pectinata*) en el Municipio de Santos Reyes Nopala, Oaxaca. Licentiate thesis. Departamento de Suelos, Universidad Autónoma Chapingo, Montecillos, Estado de México. 105 pp.

Zurita-Carmona, M.E., B. Aguilar, A. González, G.D. Mendoza & J.L. Arcos-García (2009): Composición de la dieta, consumo de proteína y energía en iguana negra, *Ctenosaura pectinata*. Universidad y Ciencia **25**:103-109.

Christian Langner (04.04.2021)

Ctenosaura – Island group

Species	Description author and date	Common name English	Common name German/ Spanish	Known in the trade
Ctenosaura bakeri	Stejneger, 1901	Utila spiny-tailed iguana	Utila-Schwarz-leguan	yes
Ctenosaura conspicuosa	Dickerson, 1919	San Esteban spiny-tailed iguana	San Esteban-Schwarzleguan/ Garrobo de Isla San Esteban	?
Ctenosaura hemilopha	Cope, 1863	Baja California spiny-tailed iguana, Cape spiny-tailed iguana	Baja California-Schwarzleguan/ Garrobo del Cabo	yes
Ctenosaura nolascensis	Smith, 1972	Nolasco spiny-tailed iguana	Nolasco-Schwarz-leguan/ Garrobo de Isla San Pedro Nolasco	?
Ctenosaura oedirhina	de Queiroz, 1990	Roatán Island spiny-tailed iguana	Roatán-Schwarz-leguan	yes

The five species of large spiny-tailed iguanas are grouped together in this species group because almost all of them are endemic to islands. Only the species *Ctenosaura hemilopha* also occurs in Baja California. Baja California is a peninsula, but due to its extremely narrow and elongated geography and the resulting high rate of endemic species, it has a special biogeographical position.

All five species are large and robust iguanas with a total length between 80 cm and over a meter. Until recently the species *C. conspicuosa* and *C. nolascensis* were considered subspecies of *C. hemilopha,* before they received species rank by Grismer (1999).

The species status of these geographically isolated morphs is currently accepted among taxonomists. The subspecies *C. hemilopha insulana* of the Jacques-Cousteau-Island (Isla Cerralvo) in the Gulf of California, is currently considered as synonym of *C. hemilopha.*

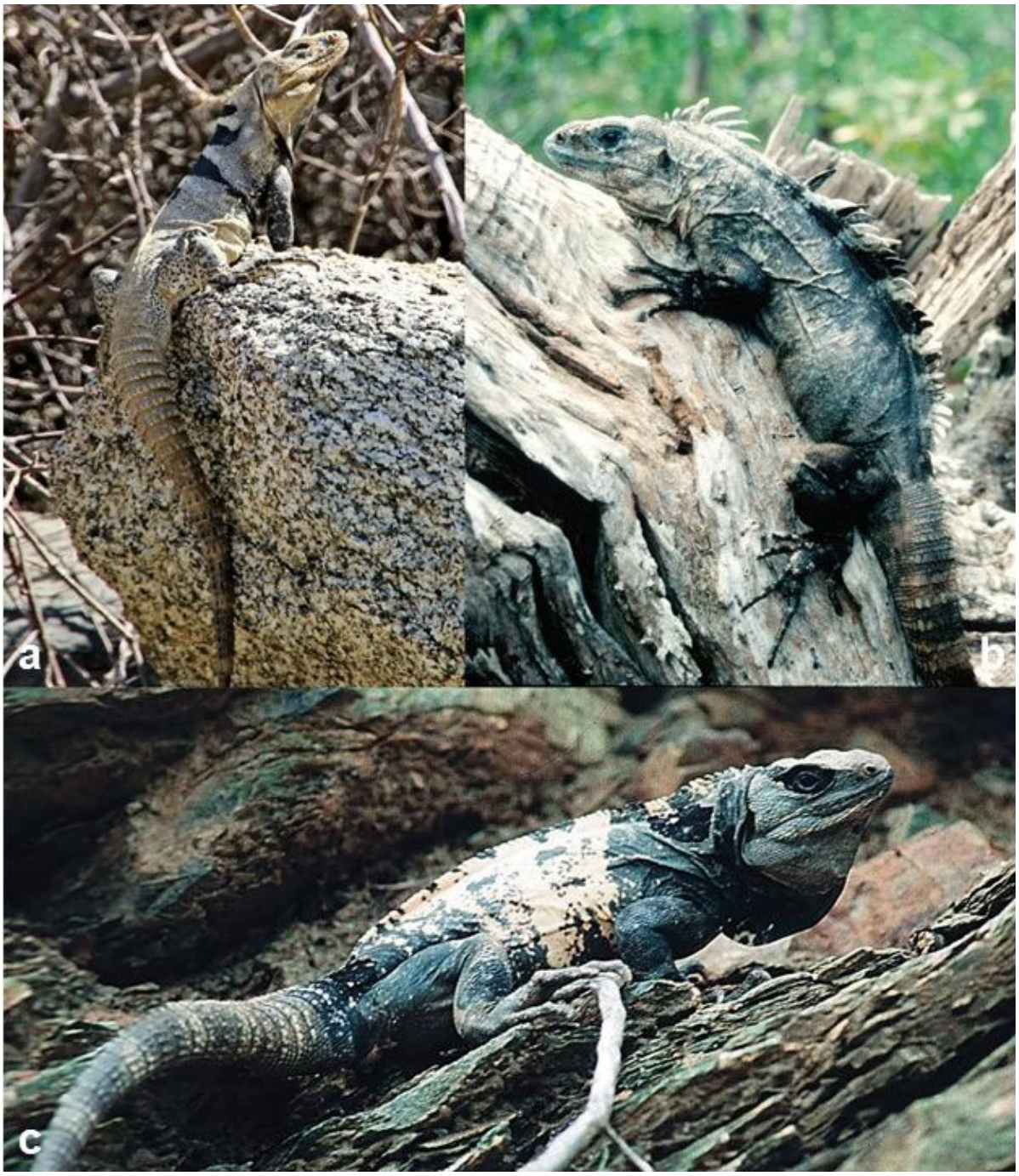

Fig. 9a: *Ctenosaura hemilopha*, south of La Paz, Baja California Sur, Mexico (Ch. Langner);
b: *Ctenosaura bakeri* ♂ (G. Köhler);
c: *Ctenosaura oedirhina* ♂ (G. Köhler).

Morphology and Taxonomy

The species of this group can be identified by the following characters:

Ctenosaura bakeri – the iguanas can reach up to 80 cm (SVL ca. 31 cm) in length, and in weight up to 900 g. Females are ca. 30 % smaller in size. The Utila spiny-tailed iguana is the smallest of all five species of this species group. Adult males have a conspicuous throat fold and a dorsal crest which is very subtle in females. Two rows of intercalaria of large spiny scales are present between the whorls from the seventh to the seventeenth tail vertebra. The ground color is grey-brown to turquois-blue with some dark spots. The tail has dark cross

bands. The dorsal spines are alternately colored black and white, with two to three equally colored scales. Contrary to other large Spiny-tailed iguanas, the juveniles are not green colored but have a grey brown ground color with darker cross bands instead. This has been attributed to the fact that this species inhabits mangrove forests which have predominantly grey tone ground coloration (Köhler 2000, 2002). Fertile hybrids of *Ctenosaura bakeri* with *C. similis* have been reported (Gutsche & Köhler 2004, Gutsche & Köhler 2008, Köhler & Blinn 2000).

Ctenosaura conspicuosa – total length up to 100 cm (SVL ca. 30.4 cm); females are ca 30% smaller in size. Contrary to adult females, adult males have a prominent dorsal crest which doesn't reach the pelvic region. The dorsum of hindlimbs has cross bands which are formed by dots. The body color is noticeable bright, almost white. Fine dark dots can be scattered over the body. Especially males can be colored jet-black in the shoulder and throat area as well as on the forelimbs, in a striking contrast to the rest of the much lighter body color. The typical bright cross bands of *C. hemilopha* are missing at the back side of the dorsum. There are no black dots on the venter of the body and tail. In contrast to the juveniles of the sister species *C. hemilopha*, the juveniles are not green colored (Köhler 2000, 2002).

Ctenosaura hemilopha – total length over 100 cm (SVL ca. 40 cm); females are ca. 30 % smaller in size. Contrary to adult females, adult males have a prominent dorsal crest which does not reach the pelvic region. Irregular dots are on the dorsal side of the hindlimbs. Three black cross bands, sometimes faded, appear around the neck. The forelimbs, particularly in males, can be uniformly jet-black colored and in females banded or spotted grey. There are no black dots on the venter of the body and tail. The juveniles are grass-green (Köhler 2000, 2002).

Ctenosaura nolascensis – total length just 100 cm (SVL ca. 285 mm); females are ca. 30 % smaller in size. Contrary to adult females, adult males have a prominent dorsal crest. The venter of body and tail has several black dots. On the posterior half of the body cross bands are lacking. The ground color is usually grey-brown and, in some specimens, it can be almost white. The shoulders, throat area and the forelimbs are black in both sexes. Males have cross bands on the neck area. The juveniles are green on the head and body (Köhler 2000, 2002).

Ctenosaura oedirhina – total length just 100 cm (SVL ca. 27 cm; Köhler (2000) estimates a maximum SVL of 35 cm). Contrary to adult females, adult males have a prominent dorsal crest, which never gets as large as in *C. similis.* In comparison to *Ctenosaura similis,* this species has a more compact body shape. The shape of the head appears blunt and the snout distended. Adult Roatán Island Spiny-tailed iguanas have four to five white cross bands on the back which can merge together. These cross bands can appear yellowish or orange due to a rub off effect of different substrates in the habitat. The tail is also with cross bands. In juveniles, the back limbs and tail are brown and the rest of the body is green. They also have dark dots scattered over their body (Köhler 2000, 2002, Rittman 2007).

Distribution and Habitat

Distribution

***Ctenosaura bakeri*:** Utilla Island, Honduras. Type locality: Utilla, Honduras

***Ctenosaura conspicuosa*:** Endemic to the Island San Esteban (Isla Turón), Sonora, Mexico in the Gulf of California. Type locality: San Esteban Island (Isla Turón), Sonora, Mexico

***Ctenosaura hemilopha*:** South of Baja California Sur, Mexico; Jacques-Cousteau-Island (Isla Cerralvo). The species occurs from near Loreto along Sierra la Giganta up to the West

Coast near Arroyo Seco. Directly near the coast along the East Coast there is a noticeable distribution gap. They also occur in the region south of La Paz (Grismer 2002). Type locality: Cabo San Lucas, near “Soria Ranch”, Baja California [Sur], Mexico.

***Ctenosaura nolascensis*:** Endemic to the Island San Pedro Nolasco, Sonora, Mexico in the Golf of California. Type locality: San Pedro Nolasco on the Gulf of California.

***Ctenosaura oedirhina*:** Endemic to the Island Roatán, Santa Elena, Barbareta and Big Pigeon Cay north of Honduras coast. Type locality: Roatán Island, ca. 4.8 km west of Roatán on a trail to Flower Bay, Islas de la Bahía, Honduras.

Habitat

Ctenosaura bakeri has more specific habitat requirements compared to the other species of the genus *Ctenosaura*. Contrary to all other species described here*, C. bakeri* does not inhabit dry and hot places, but the dense, moist and umbrageous mangroves of the Honduran Utila Island. The species is tree dwelling and inhabits primarily white mangrove (*Laguncularia racemosa).* Dead and hollow branches are used as retreat places. Specimens feed on leaves and buds of the mangroves, and sometimes also on insects or crabs. The species has a small home range (Köhler 2002).

Ctenosaura conspicuosa is primarily a tree dwelling species which is often found on large trees, rocks or columnar cacti (*Pachycereus pringlei*). The species prefers dry river valleys (Grismer 2002). Further endemic and strictly protected species of this UNESCO World Heritage Island are the Spiny chuckwalla species *Sauromalus hispidus* and *S. varius*. Sylber (1988) reports that an adult *C. conspicuosa* fed on a juvenile *S. varius.* A bat was found in a fecal examination of *C. conspicuosa* on the island of Cholludo (Grismer 2002). Felger & Moser (1985) report that the iguanas were used by the Seri Indians as a food resource.

Ctenosaura hemilopha inhabits the dry and hot regions of Sierra de la Giganta, the Cape region and the Jacques-Cousteau-Island. The species occurs at elevations lower than 1,000 m asl (Alvarez *et al.* 1988). They inhabit large rock accumulations and trees. Blázquez *et al.* (1997) and Blázquez & Rodríguez-Estrella (1997) report on iguanas basking in a height of more than six meters on Cardón cacti (*Pachycereus pringlei*). These large cacti usually provide woodpecker holes which are used as hiding places. Banks & Farmer (1963) report similar behaviors by the specimens on the Jacques-Cousteau-Island. Alvarez *et al.* (1988) report that in remote areas, *C. hemilopha* are consumed by the locals and used as remedy against pertussis.

Ctenosaura nolascensis is usually found on the ground, rocks, cacti and trees and considered not be very shy. Individuals bask preferably on large rock ledges and flagstones and have been observed at heights of three meters on an organ pipe cactus (*Stenocereus thurberi*), feeding on its fruit. Fruits from prickly pears and flowers from different plants (not specified) have been reported as further diet items. Juveniles have been observed feeding on grasshoppers and leaves in April (Grismer 2002).

Ctenosaura oedirhina occurs in dry forest with sandy-loamy soil (Köhler 2002). These iguanas apparently prefer slopes but can also be found directly on the beach near the sea. They are saxicolous and only climb into trees to flee from predators in exceptional occasions. Adult specimens have small home ranges and dig burrows, where they live solitarily. Juveniles shelter themselves in hollow branches.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 31).

Regulation (EG) Nr. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List Status

Ctenosaura bakeri: Critically Endangered (B1ab (i,ii,iii,v), assessed February 04, 2018);

Ctenosaura conspicuosa: Vulnerable (D2, assessed June 04, 2018);

Ctenosaura hemilopha: Least Concern (assessed January 17, 2020);

Ctenosaura nolascensis: Vulnerable (D2, assessed February 26, 2012);

Ctenosaura oedirhina: Endangered (B1ab(v)+2ab(v), assessed June 05, 2018).

Threats

All species dealt with in this species group are threatened by rapid habitat destruction and the associated loss of habitat. Climate change and the associated increase in drought in the islands of the golf of California, as well as tourism, degradation of mangroves, and hunting on Utila, Roatán and the islands of the Gulf of Mexico, pose further threats to the species.

Spiny-tailed iguanas are collected locally and at national level for food consumption and for traditional medicine. Specimens are still sold on the streets and markets. Animals are often brutally treated and have been observed to be tied up with their own tendons, which were pulled out of the toes alive. Often also the snout is sewed shut with the tendons and claws (Langner, pers. observation). In addition, specimens are also hunted, because they can cause damage to the crops (Köhler 2002).

Sometimes, smuggled specimens from this species group appear in the international trade. Offspring of some species raised in the USA have occasionally been imported to Europe. *C. oedirhina* and *C. bakeri* were imported to Germany with permission, and were kept both privately and in zoological institutions, where they successfully reproduced. A breeding station was built on Utila for the endangered species *C. bakeri*, where the iguanas have been successfully bred in captivity (Dirksen *et al.* 2004), Köhler 1998a, b, 1995b, Rittmann 2007).

Reproduction

Topic	Data
Secondary sexual traits	There is sexual dimorphism and dichromatism in all species described in this fact sheet. Males of all five species are larger and more robust in body constitution than females. The femoral pores are much more conspicuous in males than in females. The hemipenis bulges are also conspicuous. Neck crests are mostly only partially recognizable in ♀♀ but very pronounced in males. Males are often more colorful and show higher contrast in color.
Reproduction	Oviparous.
Mating/ nesting season	*Ctenosaura bakeri* – mating begins with the end of the rainy season, from middle January to March. *Ctenosaura oedirhina* – mating begun 20th May (recorded in captivity); nesting March, April, July, November, December (Rittmann 2007).
Number of eggs/ clutches per season	*Ctenosaura bakeri* – 5–9 eggs per clutch. *Ctenosaura oedirhina* – 7–12 eggs; one clutch per season (Rittmann 2007).

Egg size/ hatchling size	*Ctenosaura bakeri* – egg size: 33.2–36.2 mm x 19–20 mm; weight: 7.2–8.3 g; hatchling size: ca. 56–59 mm (SVL); 99–115 mm (SL) (Köhler 2002). *Ctenosaura oedirhina* – egg size: 35.0–40.0 mm x 20–23 mm; weight: 9–11.5 g; hatchling size: 60–62 mm (SVL); 120–130 mm (SL) (Rittmann 2007).
Incubation and hatching	*Ctenosaura bakeri* – at 29.5 °C between 89 to 92 days; incubation substrate is slightly moistened vermiculite (Köhler 1989). *Ctenosaura oedirhina* – at 31 °C and 90 % air humidity between 66 and 109 days; incubation substrate is foam or vermiculite (Rittmann 2007).

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Breeding is stimulated with the simulation of rainy and dry season. In Central Europe during summer months between June and October it should be extensively sprayed and from November to May the animals should be kept significantly drier.
Husbandry requirements	The large Spiny-tailed iguanas described in this fact sheet are challenging to keep, due to their requirements on sufficiently sized terraria, and energy for heating and lighting. When purchasing a juvenile, it should be considered that adults will require an enclosure of the size of a room. Also, the life span of these species should be considered, since they can live more than 20 years. Due to their space requirements, they are difficult to reallocate if keeping difficulties arise. The minimum space requirements for the keeping of reptiles in Germany (Federal Ministry for Food Agriculture and Forestry 1997) is 5 x 4 x 4 (L x W x H) the size of snout-vent-length. This results in a minimum terrarium size of 500 x 400 x 400 cm. A terrarium height of four meters is almost impossible to provide in normal house conditions, and even in zoological institutions difficult to implement. A terrarium height of 2–2.2 m is considered sufficient. Terraria should be adequately structured, and provide robust branches to climb on. Cork tubes or nest boxes are used as retreat places. Due to their herbivorous diet, planting of the enclosure with living plants should be avoided. Plastic plants could be used instead. As substrate, a soil- sand mixture or pine bark can be used. The substrate should be kept slightly moist to avoid dust formation. The diet should be varied and contain the usual, commercially available food insects (locusts, crickets, cockroaches, *Zophobas* larvae, etc.) and occasionally small mammals such mice. The herbivore diet should contain various herbs, leaves and fruits (e.g., dandelion, broad leaf plantain, clover, milk thistle, chicory, endive, cucumber, tomatoes, eventually also leaves of fruit trees etc.). The diet should be supplemented with minerals and vitamins. Fresh water should always be available. Fluorescent or LED light should be used. A common spotlight can be used as a heat and UV source as well also floor and central heating to achieve a day temperature between 28 and 32 °C. Under the spotlight, a temperature of 45 °C should be achieved. An additional daily irradiation with an Ultra Vitalux Lamp, for example, of about 20-30 minutes duration, will be necessary to provide the required UV radiation. During night time, the temperature can decrease to room temperature. Air humidity should be between 50 and 60 % during the day and around 70–80 % during the night. To simulate the rainy season in summer, an automatic sprinkler system can be installed.
General characteristics, difficulties with keeping and breeding	During the reproductive season, a substrate layer of sufficient depth should be provided, otherwise the egg clusters may be dropped by the female (Köhler 2002).

Topic	Data
	It is recommended to use vermiculite, foam, or sand and peat mixture as incubation substrate. The temperature should be constant at about 29 and 31 °C and a humidity of 90 to 100 %. The substrate should be only slightly moist (Köhler 2002).
Care of the young, technical and time effort	The juveniles should be kept in medium sized terraria of 100 x 60 x 80 cm (L x W x H). They require a similar diet as described for the adults. However, juveniles are mainly insectivore during the first weeks. The proportion of plants in the diet should increase with age. The leaves should be cut and offered only in small pieces, since juveniles frequently die by suffocation when eating long plant pieces. The diet should also be supplemented with minerals and vitamins. Sufficient UV light should be provided for the juveniles, with an Ultra Vitalux lamp (with a minimum distance of 50 to 60 cm), for example. The care of the young requires about 15–30 minutes daily.
Frequency of breeding in captivity	Rare, since only few keepers keep these species.
Breeding difficulty evaluation	Successful breeding is possible, but some experience in husbandry of large lizards is needed. Spiny-tailed iguanas are not suitable for unexperienced keepers.
Interviews/ Surveys/ Consultations	Several private breeders and 1 zoological institution.

References

Abraham, G. (1978): Schwarze Leguane aus dem Brutkasten. Zeitigung der Eier und Aufzucht der Jungen. Aquarien Magazin **12**(10): 484-486.

Alberts, A.C., R.L. Carter, W.K. Hayes & E.P. Martins (eds.; 2004): Iguanas: Biology and Conservation. Berkeley, California (University of California Press): 373 pp.

Alvarez-Cárdenas, S., P. Galina-Tessaro, A. González-Romero & A. Ortega-Rubio (1988): Herpetofauna. *In:* Arriaga, L. & A. Ortega (eds.): La Sierra de la Laguna de Baja California Sur, 167-184. La Paz, Baja California Sur: Centro de Investigaciones Biológicas de Baja California Sur A.C.

Bailey, J.W. (1928): A revision of the lizards of the genus *Ctenosaura*. Proceedings of the United States National Museum **73**(2733): 1-58.

Banks, R.C. & W.M. Farmer (1963): Observations on reptiles of Cerralvo Island, Mexico. Herpetologica **18**(4): 246-250.

Binn, E. (2014): Utila - Neues vom Swamper bzw. einer Swampine. Iguana **27**(2): 29-32.

Blázquez, M.C., R. Rodríguez Estrella & A. Munguía Vega (2006): Characterization of 10 microsatellite loci in the spiny-tailed iguana *Ctenosaura hemilopha*. Molecular Ecology Notes **6**(3): 753-755.

Blázquez, M.C. & R. Rodríguez Estrella (1997): Factors influencing the selection of basking perches on cardon cacti by spiny-tailed iguanas (*Ctenosaura hemilopha*). Biotropica **29**: 244-348.

Blázquez, M.C., R. Rodríguez Estrella & M. Delibes (1997): Escape behaviour and predation risk of mainland and island spiny-tailed iguanas (*Ctenosaura hemilopha*). Ethology **103**(12): 990–998.

Buckley, L.J., K. de Queiroz, T.D. Grant, B.D. Hollingsworth, J.B. Iverson, S.A. Pasachnik & C.L. Stephen (2016): A Checklist of the Iguanas of the World (Iguanidae; Iguaninae): 4-46. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph

6).

Castañeda-Hernández, C., L. Canseco-Márquez & M.E. Vargas-Orrego (2015): Distribution Notes: Additional distributional records for the state of Oaxaca, Mexico. Mesoamerican Herpetology **2**(3): 368-370.

de Queiroz, K. (1987): A new spiny-tailed iguana from Honduras, with comments on relationships within *Ctenosaura* (Squamata: Iguania). Copeia **1987**(4): 892-902.

de Queiroz K. (1990a): *Ctenosaura bakeri* Stejneger. Utila Island spiny-tailed iguana. Catalogue of American Amphibians and Reptiles **465**: 1-2.

de Queiroz K (1990b): *Ctenosaura oedirhina* de Queiroz. Roatán Island spiny-tailed iguana. Catalogue of American Amphibians and Reptiles **466**: 1-2.

de Queiroz K. (1995): Checklist and key to the extant species of Mexican iguanas (Reptilia: Iguaninae). Publicationes Especiales del Museo de Zoologia, Universidad Nacional Autonoma de Mexico **9**: 1-48.

Cook, D.G. & D. Haussler (2013): *Ctenosaura hemilopha* (Baja California spiny-tailed iguana) dispersal phenomenon. Herpetological Review **44**(2): 321-322.

Cope, E.D. (1863): Descriptions of New American Squamata, in the Museum of the Smithsonian Institution, Washington. Proceedings of the Academy of Natural Sciences of Philadelphia **15**(1863): 100–106.

Cryder, M.R. (1999): Molecular systematics and evolution of the *Ctenosaura hemilopha* complex (Squamata: Iguanidae). M.S. thesis, Loma Linda-University, 64 pp.

Dirksen, L. (2004): Beobachtung eines Paarungsversuchs zwischen einem Hybrid-Männchen (*Ctenosaura bakeri* x *similis*) mit einem *Iguana iguana*-Weibchen. Iguana Rundschreiben **17**(2): 15-17.

Dirksen, L. & A. Gutsche (2006): Beobachtungen zur Saurophagie bei *Ctenosaura bakeri* (Squamata: Iguanidae). Elaphe **14**(3): 51-52.

Dirksen, L. T. Blome, H. Pérez & G. Köhler (2004): Zur Nachzucht des Utila-Schwarzleguans (*Ctenosaura bakeri*) bei unterschiedlichen Inkubationstemperaturen in der Iguana Research and Breeding Station im Jahr 2004. Iguana Rundschreiben **17**(2): 7-13.

Duellman, W.E. (1961): The amphibians and reptiles of Michoacán, Mexico. University of Kansas Publications, Museum of Natural History **15**(1): 1-148.

Faulkner, S., N. Belal, S.A. Pasachnik, C.R. Bursey & S.R. Goldberg (2012): *Ctenosaura bakeri* (Utila spiny-tailed iguana). Endoparasites. Herpetological Review **43**(2): 332.

Felger R.S. & M.B. Moser (1985): People of the desert and sea: Ethnobotany of the Seri Indians. Tucson: University of Arizona Press, 435 pp.

Gandola, R. & C. Hendry (2011): *Ctenosaura oedirhina* (Roatán spiny-tailed iguana). Diet. Herpetological Review **42**(3): 428-429.

Goode, A.B.C. & S.A. Pasachnik (2016): Piebaldism in Roatán Spiny-tailed Iguanas, *Ctenosaura oedirhina*. Herpetological Bulletin **136:** 23-28.

Goode, A.B.C. & S.A. Pasachnik (2019): *Ctenosaura oedirhina* - Roatán Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2019: e.T44191A122558520.

Goode, A.B.C., S.A. Pasachnik & T.L. Maple (2016): Habitat Utilization of Roatán Spiny-Tailed Iguanas (*Ctenosaura oedirhina*) and its Implications for Conservation: 79-89. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology 11 (Monograph 6).

García-Padilla E., D.L. DeSantis, A. Rocha, V. Mata-Silva, J.D. Johnson & L.D. Wilson (2020): Conserving the Mesoamerican herpetofauna: the most critical case of the priority

level one endemic species. Amphibian & Reptile Conservation **14(**2): 73-132.

Grismer, L.L. (1999): An evolutionary classification of reptiles on islands in the Gulf of California, México. Herpetologica **55**(4): 446-469.

Grismer, L.L. (2002): Amphibians and Reptiles of Baja California, Including Its Pacific Islands and the Islands in the Sea of Cortes. Berkeley (University of California Press): 399 pp.

Gutsche, A. (2003): Utila Island Swampers. Iguana **10**(2): 28-29.

Gutsche, A. (2005): *Ctenosaura bakeri* (Utila Spiny-tailed Iguana). Predation. Herpetological Review **36**(3): 317.

Gutsche, A. (2005): Distribution and habitat utilization of *Ctenosaura bakeri* on Utila. Iguana **12(**3): 142-151.

Gutsche, A. (2006): Population structure and reproduction in *Ctenosaura bakeri* on Isla de Utila. Iguana **13**(2): 109-115.

Gutsche, A. (2010): Mehrere Amphibien- und Reptilienarten neu in das Washingtoner Artenschutzabkommen (CITES) aufgenommen. Reptilia (Münster) **15**(83): 3-8.

Gutsche, A. & G. Köhler (2004): A fertile hybrid between *Ctenosaura similis* (Gray 1831) and *C. bakeri* Stejneger 1901 (Squamata: Iguanidae) on Isla de Utila, Honduras. Salamandra **40**(3-4): 201-206.

Gutsche, A. & W.J. Streich (2009): Demography and Endangerment of the Utila Island Spiny-Tailed Iguana, *Ctenosaura bakeri*. Journal of Herpetology **43**(1): 105-113.

Gutsche, A. & F. Köhler (2008): Phylogeography and hybridization in *Ctenosaura* species (Sauria, Iguanidae) from Caribbean Honduras: insights from mitochondrial and nuclear DNA. Zoosystematics and Evolution **84**(2): 245-253.

Gutsche, A., F. Mutschmann, W.J. Streich & H. Kampen (2012): Ectoparasites in the endangered Utila spiny-tailed iguana (*Ctenosaura bakeri*). Herpetological Journal **22**(3): 157-161.

Hallmen, M. & S. Hallmen (2011): Notiz über eine Beobachtung zur Saurophagie beim Utila-Schwarzleguan *Ctenosaura bakeri*. Elaphe **19**(3): 11-13.

Hallmen, S. (2011): Neues aus Utila - reloaded. Iguana Rundschreiben **24**(2): 5-16.

Hedges, S.B., R. Powell, R.W Henderson, S Hanson & J.C. Murphy (2019): Definition of the Caribbean Islands biogeographic region, with checklist and recommendations for standardized common names of amphibians and reptiles. Caribbean Herpetology **67**: 1-53.

Jones, L.L. & R.E. Lovich (2009): Lizards of the American Southwest. A photographic field guide. Tucson, Arizona (Rio Nuevo Publishers): 568 pp.

Köhler, G. (1998a): Schutz- und Forschungprojekt Utila-Schwarzleguan: Die Nachzucht von *Ctenosaura bakeri* Stejneger 1901 im ex-situ-Zuchtprogramm. Salamandra **34**(3): 227-238.

Köhler, G. (1998b): *Ctenosaura bakeri* Stejneger, 1901. Sauria **20** Suppl.: 417-420.

Köhler, G. (1995a): Zur Systematik und Ökologie der Schwarzleguane (Gattung *Ctenosaura*) Dissertation Universität Frankfurt, 118 pp.

Köhler, G. (1995b): Freilanduntersuchungen zur Morphologie und Ökologie von *Ctenosaura bakeri* und *C. oedirhina* auf den Islas de la Bahia, Honduras, mit Bemerkungen zur Schutzproblematik. Salamandra **31**(2): 93-106.

Köhler, G. (2000): Reptilien und Amphibien Mittelamerikas, Bd. 1: Krokodile, Schildkröten, Echsen. Offenbach (Herpeton Verlag): 158 pp.

Köhler, G. (2002): Schwarzleguane - Lebensweise, Pflege und Zucht. Offenbach (Herpeton

Verlag): 144 S.

Köhler, G. (2008): Reptiles of Central America. 2nd Ed. Offenbach (Herpeton Verlag): 400 pp.

Köhler, G. & E. Blinn (2000): Natürliche Bastardierung zwischen *Ctenosaura bakeri* und *Ctenosaura similis* auf Ultila, Honduras. Salamandra **36**(1): 77-79.

Köhler, G., W. Schroth & B. Streit (2000): Systematics of the *Ctenosaura* group of lizards (Reptilia: Sauria: Iguanidae). Amphibia-Reptilia **21**(2): 177-191.

Lemos-Espinal J.A., G.R. Smith & J.C. Rorabaugh (2019): A conservation checklist of the amphibians and reptiles of Sonora, Mexico, with updated species lists. ZooKeys **829**: 131-160.

Lemos-Espinal, J.A. & H.M. Smith (2007): Amphibians and reptiles of the state of Chihuahua, Mexico. Universidad Nacional Autonoma de Mexico, 613 pp.

Lovich, R.E., L.L. Grismer & G. Danemann (2009): Conservation status of the Herpetofauna of Baja California, México and associated Islands in the Sea of Cortez and Pacific Ocean. Herpetological Conservation and Biology **4**(3): 358-378.

Lowe, C.H. & K.S. Norris (1955): Analysis of the herpetofauna of Baja California, Mexico. III. New and Revived Reptilian Subspecies of Isla de san Esteban, Gulf of California, Sonora, Mexico, with Notes on Other Satellite Islands of Isla Tiburon. Herpetologica **11**(2): 89-96.

Maryon, D., D. Ardon, A. Martinez, S. Clayson & S.A. Pasachnik (2018): *Ctenosaura bakeri* - Utila Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2018: e.T44181A125203850.

Maryon, D., T.W. Brown & D.C. Lee (2020): Love thy neighbor: Predation of a Utila Spiny-tailed Iguana (*Ctenosaura bakeri*) by a Common Spiny-tailed Iguana (*C. similis*) on Utila Island, Honduras. IRCF Reptiles & Amphibians **27**(1): 84-86.

Maryon, D., T.W. Brown & D.C. Lee (2020): Predation of a Utila Spiny-tailed Iguana, *Ctenosaura bakeri* (Iguanidae), by a Central American Boa, *Boa imperator* (Boidae), on Utila, Isla de la Bahia, Honduras. IRCF Reptiles & Amphibians **27**(2): 265-266.

McCranie, J.R, L.D. Wilson & G. Köhler (2005): Amphibians & Reptiles of the Bay Islands and Cayos Cochinos, Honduras. Salt Lake City (Bibliomania): 210 pp.

McCranie, J.R. (2015): A checklist of the amphibians and reptiles of Honduras, with additions, comments on taxonomy, some recent taxonomic decisions, and areas of further studies needed. Zootaxa **3931**(3): 352-386.

McCranie, JR. (2018): The Lizards, Crocodiles, and Turtles of Honduras. Systematics, Distribution, and Conservation. Bulletin of the Museum of Comparative Zoology, Special Publication Series **2**: 1-666.

McDiarmid, R.W., J.F. Copp & D.E. Breedlove (1976): Notes on the herpetofauna of western Mexico: new records from Sinaloa and the Tres Marias Islands. Contributions in Science, Los Angeles **275**: 1-17.

Otero Ortuño, C. & C. Mendoza Galán (2011): Altitudinal distribution of *Ctenosaura quinquecarinata* subpopulations in western municipalities of Nicaragua. Mesoamericana **15**(1): 77-82.

Palacios-Aguilar, R. & O. Flores-Villela (2018): An updated checklist of the herpetofauna from Guerrero, Mexico. Zootaxa **4422**(1): 1-24.

Pasachnik, S.A., C.E. Montgomery, A. Martinez, N. Belal, S. Clayson & S. Faulkner (2012): Body Size, Demography, and Body Condition in Utila Spiny-tailed Iguanas, *Ctenosaura bakeri*. Herpetological Conservation and Biology **7**(3): 391-398.

Pasachnik, S.A. & S. Hudman (2016): Conservation Genetics of Roatán Spiny-Tailed Iguanas, *Ctenosaura oedirhina*. 187-196. *In*: Iverson, J.B., T.D. Grant, C.R. Knapp & S.A. Pasachnik (eds.): Iguanas: Biology, Systematics, and Conservation. Herpetological Conservation and Biology **11** (Monograph 6).

Pasachnik, S.A. & C. Zeiller (2011): *Ctenosaura oedirhina* (Roatán's spiny-tailed iguana). Diet. Herpetological Review **42**(3): 429.

Reynoso, V.H., A. González Hernández & W. López Forment (2012): Geographic distribution: *Ctenosaura hemilopha* (Cape spiny-tailed iguana). Herpetological Review **43**(2): 305.

Reynoso, V.H., N. Pacheco-Hoyos, W. Moral-Uribina, H. Salinas Matus & S.A. Pasachnik (2019): *Ctenosaura conspicuosa* - San Esteban Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2019: e.T174474A1414432.

Reynoso, V.H. & S.A. Pasachnik (2012): *Ctenosaura nolascensis* - Nolasco Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2012: e.T174477A1414514.

Reynoso, V.H., M. Vázquez-Cruz, R.C. Rivera-Arroyo, M.C. Blázquez & T.D. Grant (2020): *Ctenosaura hemilopha* - Baja California Spiny-tailed Iguana. The IUCN Red List of Threatened Species 2020: e.T174475A1414471.

Rittmann, D. (2007): Langjährige Haltung, Pflege und Nachzucht des Roatán-Schwarzleguans *Ctenosaura oedirhina* De Queiroz, 1987, sowie Beobachtungen in dessen Lebensraum. Elaphe **15**(3): 33-40.

Ruiz-Campos, G. & J.H. Valdez-Villavicencio (2011): Geographic Distribution: *Ctenosaura hemilopha* (Baja California spiny-tailed iguana). Herpetological Review **42**(3): 391.

Schulte, U. (2007): Beobachtungen zur Hybridisierung zwischen *Ctenosaura similis* (Gray 1831) und *Ctenosaura bakeri* Stejneger 1901 auf Utila, Honduras. Elaphe **15**(1): 55-59.

Schulte, U. & G. Köhler (2010): Microhabitat selection in the spiny-tailed iguana *Ctenosaura bakeri* on Utila Island, Honduras. Salamandra **46**(3): 141-146.

Solís, J.M., L.D. Wilson & J.H. Townsend (2014): An updated list of the amphibians and reptiles of Honduras, with comments on their nomenclature. Mesoamerican Herpetology **1**: 123-144.

Smith, H.M. (1972): The Sonoran subspecies of the lizard *Ctenosaura hemilopha*. Great Basin Naturalist **32**(2): 104-111.

Wartenberg, L. (2013): Bedrohung und Schutz der Schwarzleguane (*Ctenosaura*). Iguana **26**(2): 20–33.

Wilson, L.D. & D.E. HAHN (1973): The herpetofauna of the Islas de la Bahía, Honduras. Bulletin of the Florida State Museum **17**(2): 93-150.

Christian Langner (10.03.2021)

Eublepharidae

Goniurosaurus lichtenfelderi group				
Species	**Description author and date**	**Common name English**	**Common name German / Chinese**	**Known in the trade**
Goniurosaurus bawanglingensis	Grismer, Haitao, Orlov & Ananjeva, 2002	Bawangling tiger gecko	Bawangling Tiger gecko / 王岭睑虎	yes
Goniurosaurus hainanensis	Barbour, 1908	Hainan tiger Gecko	Hainan Tigergecko / 南睑虎	yes
Goniurosaurus kwanghua	Zhu, Shen, Liu, Chen, Li & He, 2020	Kwanghua tiger Gecko Kwanghua cave gecko	Kwanghua Tigergecko	yes
Goniurosaurus lichtenfelderi	(Moquard, 1897)	Lichtenfelder's gecko	Lichtenfelders Tigergecko	yes
Goniurosaurus zhoui	Zhou, Wang, Chen & Liang, 2018	Zhou's tiger gecko	Zhous Tigergecko	possibly

Until recently, the *Goniurosaurus lichtenfelderi* group was considered to consist of *G. hainanensis* and *G. lichtenfelderi* only, while *G. bawanglingensis* and *G. zhoui* were placed in the *G. luii* group (Grismer *et al.* 2002, Yang & Chang 2015, Zhou *et al.* 2018). However, recent studies concluded that both species should be placed in the *G. lichtenfelderi* group (Liang *et al.* 2018). With the description of *G. kwanghua*, this clade was enlarged to five species (Zhu *et al.* 2020).

In literature, "clawed gecko" or "leopard gecko" was often used as a trivial name for the genus (Seufer *et al.* 2005, Grismer *et al.* 1999, Grismer *et al.* 2002, Chen *et al.* 2014). Initially, the only known species "*lichtenfelderi*" was placed in the genus *Eublepharis* (Moquard 1897). With the discovery of *G. hainanensis* the new genus *Goniurosaurus* was established (Barbour 1908). In this context, we propose to use the common name "leopard gecko" exclusively for the genus *Eublepharis* and to use the trivial name tiger geckos for representatives of the genus *Goniurosaurus*, as has been done in more recent literature (Dickhoff 2004; Ngo *et al.* 2021).

While most species of the genus *Goniurosaurus* have usually five cross bands, (one nuchal band, three around the midbody and one at the tail base), there are species in this group that only have two dorsal bands around the midbody, namely *G. kwanghua*, *G. lichtenfelderi* and *G. hainanensis,* whereas *G. bawanglingensis* and *G. zhoui* have three dorsal midbody bands.

Fig. 10a: *Goniurosaurus lichtenfelderi*, northwestern Viet Nam (N. Orlov);
b: *Goniurosaurus lichtenfelderi,* Typus locality (N. Orlov);
c: *Goniurosaurus hainanensis*, Typus locality (N. Orlov);
d: *Goniurosaurus lichtenfelderi*, Quang Ninh, Viet Nam (M. van Schingen-Khan);
e: *Goniurosaurus bawanglingensis*, Typus locality (N. Orlov);
f: *Goniurosaurus zhoui* ♀ (B. Liang).

Morphology and Taxonomy

The species of this group are characterized by a somewhat more compact body than the thin and slender species of the *Goniurosaurus luii group.*

The two longest known *Goniurosaurus species*, namely *G. hainanensis* and *G. lichtenfelderi*, which were already scientifically described more than hundred years ago, belong to this species group (Moquard 1897, Barbour 1908). Almost 100 years later, further species from China and Vietnam were described (Grismer *et al.* 1999). Until that time, no color photos were allegedly known and the knowledge on the species biology was also deficient. Museum collec-

tions only consisted of two specimens of *G. lichtenfelderi* and seven specimens of *G. hainanensis* (Grismer 1997). The first color picture of *G. hainanensis* can be found in Zhao & Adler (1993).

For a morphological identification key of the genus Goniurosaurus, see Ngo *et al.* (2021).

Goniurosaurus bawanglingensis – the snout-vent length is ca. 10.7 cm, TL ca. 18 cm. The original tail is shorter than the SVL. Regenerated tails are shorter and usually do not reach the length of the original tail. Regenerated tails do not have the typical cross bands, but have a marbled pattern instead. A clear diagnostic character for this species is the high number of precloacal pores. With 37–46 pores *G. bawanglingensis* has the highest amount of precloacal pores within the entire genus (Ngo *et al.* 2021). The species can also be differentiated from others by the row of overlapping scales on the mediolateral area of the wrist (Grismer *et al.* 2002). The iris is bright orange to orange-brown. The dorsal ground color is partly intense red brown, with age it turns bright to a purple-brown tone. *G. bawanglingensis* is the most colorful species within the Hainan clade. It has five orange transversal bands from the neck to the tail base. Juveniles lack spots, but show distinct bands. The cross bands on the dark tail are bright white with some light blue elements. The dorsal color of hatchlings is dark brown with bright orange cross bands. The top of the head is orange-brown. With increasing age, the dorsal bands and coloration is fading; transversal bands are wide and composed of dots and spots.

Goniurosaurus hainanensis – this a medium-sized, compact-appearing species which rarely exceeds a SVL of 10.5 cm and a total length of 17.7 cm (Seufer *et al.* 2005).

The species *G. hainanensis, G. kwanghua* and *G. lichtenfelderi* are phenotypically very similar. The two frequently kept species *G. hainanensis* and *G. lichtenfelderi* can be easily distinguished as hatchlings, which is well documented on the homepage of Markus Schröter (http://www.ms-goniurosaurus.de/). While the nuchal band in *G. hainanensis* extends to the mouth, it is only clearly noticeable on the neck and fades towards the mouth in *G. lichtenfelderi*. The ground color of hatchlings is very dark. The difference in color between the bands on the tail and those on the body is less pronounced than in other species. The bands initially appear very bright with only a slight tinge of yellow ground color. With age the bands become more yellow. *G. hainanensis* and *G. lichtenfelderi* have a darker ground color than the other species. Adults have a typical mottled pattern on the head, which also appears on the rest of the body, particularly on the flanks in the transition areas to the bright venter. The iris is red to red-brown. Characteristic for the species is a “U”- shaped nuchal band, three instead of four dorsal bands, 55–70 edge scales over the eyelids and the lack of an enlarged row of supraorbital tubercles (Ngo *et al.* 2021).

Goniurosaurus kwanghua –the iris is bright red. The SVL is 9.3 cm by a total length of 16 cm. *G. kwanghua* is phenotypically very similar to *G. hainanensis,* but has wider cross bands. The first cross band is narrowest at the middle of the dorsum, extending towards the venter and splits up in some cases. The nuchal band is also somewhat wider and only tapers very slightly towards the gap of the mouth. Overall, the species appears a bit more contrasting in pattern. In adults, the spots on the head and dorsum are more prominent and the ground color is brighter. In the terrarium hobby, it is differentiated between a lowland and a highland morph of *G. hainanensis*. The lowland morph, showed similar diagnostic characters as described by Zhu & He (2020) for *G. kwanghua*, such as a yellow spot on the top of forelimbs which is in contact with the first cross band, and the yellow spot on the back limbs (http://www.ms-goniurosaurus.de/). This indicates that *G. kwanghua* was already kept and bred as the so called “lowland morph” of *G. hainanensis* in the terrarium hobby, long before

the first description of the species appeared (Schröter, pers. communication). This also emphasizes the cryptic diversity in this genus. As diagnostic character to distinguish *G. kwanghua* from the similar species *G. hainanensis,* Ngo *et al.* (2021) mentioned 47–49 edge scales above the eyelid (versus 55–70 in *G. hainanensis*), and an enlarged row of supraorbital tubercles. *G. kwanghua* can bis differentiated from *G. lichtenfelderi* by the low number of scales around the midbody (109–118 in *G. kwanghua* versus 117–130 in *G. lichtenfelderi*). *G. kwanghua* was scientifically described in 2020. The species described by Zhou *et al.* (2019), *G. sinensis,* is regarded as a synonym of *G. kwanghua* by Ngo *et al.* (2021).

Goniurosaurus lichtenfelderi – this is the only species of the *G. lichtenfelderi* group that does not inhabit Hainan Island. This species was initially described as *Eublepharis lichtenfelderi* by Moquard (1897) and is the longest-known species of the genus *Goniurosaurus* in the scientific literature. With the description of *Goniurosaurus murphyi* by Orlov & Darevsky (1999), which was later considered as a synonym of *G. lichtenfelderi* by Grismer (2000), the sparse level of knowledge of this species expanded. First experiences on husbandry date back to that time (Kaverkin 2000). The species reaches 11.35 cm SVL and ca. 19 cm TL. Initially, *G. lichtenfelderi* was considered a very small species (Kaverkin 2000). New studies in Vietnam have shown that the species can reach a SVL of > 11 cm (Ngo *et al.* 2021). *G. lichtenfelderi* is in appearance very similar to *G. hainanensis* and *G. kwanghua. G. lichtenfelderi* also has four cross bands, whereby the nuchal band and the last body band at the tail base is similar in all species. These three species have two bands between the forelimbs and hindlimbs instead of three. In juveniles, the ground color is black shortly after hatching. The four dorsal cross bands at the midbody are pale yellow. With age the dorsal cross bands become more yellow-orange and the dark ground color becomes brown to grey-purple. A characteristic marbled pattern develops, which is less intense than in the related species *G. bawanglingensis* and *G. zhoui*. The presence of a row of enlarged supraorbital tubercles and the, on average lower number (47–58) of scales on the margin of the eyelids, differentiates *G. lichtenfelderi* from *G. hainanensis* (Ngo *et al.* 2021). Grismer (1987) already draws attention to the lack of prenasal scales in *G lichtenfelderi.*

Goniurosaurus zhoui – this species has a medium size of 9.3–9.7 cm SVL. The dorsal ground color of head, body and limbs is bright purple-brown, mottled with irregularly shaped dark brown spots in adults. The nuchal band is V-shaped and tapers towards the rear. Four weakly pronounced, purple-gray dorsal bands with dark spots between the nuchal band and the base of the tail are present, which are each bordered by wide dark bands. The indistinct edges of the dorsal bands have dark spots. The iris is brown. Eight nasal scales border the nostrils, one internasal scale is present. 49–62 tubercles on the margin of the upper lid have the same size as the tubercles on top of the head. Species specific pholidosis characters are: the lack of a row of slightly enlarged supraorbital tubercles; eight or nine supralabial scales; seven to nine infralabialia; 130–140 midbody-scales; 19–22 dorsal tubercle rows around midbody and 24–32 paravertebral tubercles between the limb bases. The dorsal scales are surrounded by eleven tubercle scales. Males have 36–38 precloacal pores and two postcloacal tubercles. The claws are covered by four scales, from which the two lateral ones are large and curved. According to Ngo *et al.* (2021), *G. zhoui* can be differentiated from the other species of the *G. lichtenfelderi* group by the following characteristics: the nuchal band is V-shaped and four dorsal bands are present on the tail (including the band at the tail-base).

Distribution and Habitat

Distribution

With exception of the eponymous species *Goniurosaurus lichtenfelderi,* all other species of the *G. lichtenfelderi* group are endemic to the island Hainan, China. *G. lichtenfelderi* is the only species of the group that also occurs in Vietnam and has an overall wider distribution than the other representatives of the group.

Goniurosaurus bawanglingensis: Type locality 5.6 km northeast from Bawangling, in Hainan Bawangling National Reserve, Hainan Province, China.

Goniurosaurus hainanensis: Endemic to the southeast island Hainan and was found by Blair *et al.* (2009) in the Bao Ting district, Haikou, Ling Shui and Giong Zhong (81-765 m asl). Type locality: Wuzhi Shan Bergen (five finger mountain) in Nanling National Nature Reserve Yangshan (ca. 560 m asl), near Chengjia Yao, Yangshan district, Guangdong province, China.

Goniurosaurus kwanghua: West of Hainan Island, China, at 750 m asl**.** Type locality: The exact location is not mentioned in the first description for reasons of species protection and it will only be disclosed to qualified researchers upon request.

Goniurosaurus lichtenfelderi: This species occurs on mainland China in the province of Guangxi, where it is known from Chongzuo. It also occurs in the north of Vietnam in the provinces of Hai Duong, Bac Giang, Quang Ninh and Ha Noi (usually at 200–300 m asl). Type locality: [*G. murphyi*]: Dang Chăm, Hoàng Hoa Thám, Chí Linh, Hải Hưng, Vietnam (21° 12'48"N, 106° 28'38"E), 250 m asl.

Goniurosaurus zhoui: The species occurs on Hainan Island, China. Type locality: Karst regions at 220–300 m asl, central Hainan Island, China. The exact location is not given in the publication due to the risk of poaching and will only be disclosed to qualified researchers upon request.

Habitat

The species of the *Goniurosaurus lichtenfelderi* group inhabit evergreen moist forests, as the other Vietnamese and Chinese *Goniurosaurus* species. Specimens of the genus *Goniurosaurus* are found in karst regions (limestone and granite). *G. bawanglingensis* has been mainly found in primary and secondary forests near the ground (Grismer *et al.* 2002, Zhai *et al.* 2019). *G. kwanghua* has been found mainly on limestone rocks (Zhu *et al.* 2002). All species of the *G. lichtenfelderi* group are nocturnal and predominantly active during summer.

Goniurosaurus lichtenfelderi is the species with the largest distribution range of the genus, and doesn't seem to be very closely associated with karst caves or karst formations as are the other species. Instead, this species has been usually found on large stones or rocks along narrow and densely vegetated streams in granitic forests in several protected areas (Ngo *et al.* 2021, Nguyen & Nguyen 2009, van Schingen-Khan pers. obs.). Thus, it seems that this is the only species of the genus that predominantly inhabits streams edges. This species is generally found in low densities.

Conservation Status and Main Threats

CITES Appendix II since 2019 (CoP18 Proposal 27).

Council Regulation (EC) No. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List Status

Goniurosaurus bawanglingensis: Endangered (B1ab(iii,v), assessed May 8, 2018);

Goniurosaurus hainanensis: Near Threatened (A2cd, assessed January 14, 2019);

Goniurosaurus lichtenfelderi: Vulnerable (B1ab(iii,v), assessed May 25, 2017);

Goniurosaurus zhoui: Data Deficient (assessed May 8, 2018).

The species *Goniurosaurus kwanghua,* which was only described in the end of 2020 has not yet been assessed by IUCN. It is expected that, due to its very small distribution range, it would meet the criteria for being classified as Critically Endangered. The conservation status of *G. hainanensis,* a species that has been known for a longer time, isn't evaluated yet, as well.

It has to be noted that the CITES listing proposal did not only include the species known up to that date, but explicitly lists all *Goniurosaurus* species from China and Vietnam. This was a precautionary measure since the discovery of new cryptic species was expected (CITES 2019).

Threats

Results from several studies from China (Luo *et al.* 2016, Qi *et al.* 202) and Malaysia (Grismer *et al.* 2016) show that karst habitats are not only hotspots of biodiversity and endemism, but are also at particular risk. At the same time, they are among the least protected areas on earth (Day & Urich 2000). The discovery of further species in the karst landscape of northern Guangdong highlighted the importance of protecting this unique habitat (Qi *et al.* 2020). In addition, the effects of climate change in these special habitats are important. Above all, they are crucial for the very sensitive and important water balance in this region. The resulting consequences of climate change cannot yet be assessed. A recently published niche modeling by Ngo *et al.* (2021b) predicts a significant reduction in suitable habitats for *G. lichtenfelderi*, depending on the scenario chosen, by 2050 or 2070, as a result of climate change. Additionally, Ngo *et al.* (2021b) assume that the species are threatened due to overexploitation (Grismer *et al.* 2002, Ngo *et al.* 2021a, b). Illegal collection of *G. bawanglingensis* in the habitat has been observed during field work (Zhu *et al.* 2020).

Reproduction

Topic	Data
Secondary sexual traits	There is no sexual dichromatism in any of the five species. Both sexes show the same color pattern and variations, but a clear sexual dimorphism is noticeable. In ♂♂, the postcloacal region (hemipenis bulges) is swollen, ♀♀ just have a slight swelling. Furthermore, only ♂♂ have precloacal pores: *Goniurosaurus bawanglingensis*: ♂♂ 37–46 precloacal pores; *Goniurosaurus hainanensis*: ♂♂ 24–31 precloacal pores; *Goniurosaurus kwanghua*: ♂♂ 28 precloacal pores; *Goniurosaurus lichtenfelderi*: ♂♂ 24–33 precloacal pores;

Topic	Data
	Goniurosaurus zhoui: ♂♂ 36–38 precloacal pores.
Reproduction	Oviparous. The eggshell is soft and the eggs are buried in the substrate.
Sexual maturity	*Goniurosaurus hainanensis*: 12–18 months; *Goniurosaurus lichtenfelderi*: 1.5–2 years, sometimes also later (Kaverkin 2000).
Mating/ hatching season	*Goniurosaurus bawanglingensis*: April–August; *Goniurosaurus hainanensis*: April–August.
Number of eggs/ clutches per season	*Goniurosaurus bawanglingensis*: 2 eggs per clutch; up to 6 clutches per season; *Goniurosaurus hainanensis*: 2 eggs per clutch; up to 5 clutches per season; *Goniurosaurus lichtenfelderi*: 1-2 eggs per clutch; minimum 4 clutches per season; *Goniurosaurus zhoui*: 2 eggs per clutch (Zhou *et al.* 2018).
Egg size/ hatchling size	*Goniurosaurus bawanglingensis*: 20 x 12 mm/ 72–75 mm; *Goniurosaurus hainanensis*: 20 x 11–13 mm, 1.4 g/ 75–85 mm; *Goniurosaurus lichtenfelderi*: 20 x 12 mm, 1.5 g (Kratochvil & Frynta 2006); *Goniurosaurus zhoui*: 22.5 x 13 mm, 2.25 g (Zhou *et al.* 2018). *Goniurosaurus bawanglingensis*: 20 x 12 mm/ 72–75 mm; *Goniurosaurus hainanensis*: 20 x 11–13 mm, 1.4 g/ 75–85 mm; *Goniurosaurus lichtenfelderi*: 20 x 12 mm, 1.5 g (Kratochvil & Frynta 2006); *Goniurosaurus zhoui*: 22.5 x 13 mm, 2.25 g (Zhou *et al.* 2018).
Incubation and hatching	*Goniurosaurus bawanglingensis*: 58–70 days (no data on temperature); *Goniurosaurus hainanensis*: 53–76 days, 53–54 days at 29 °C.
Temperature dependent sex determination	No data available, but likely.
Sperm storage	Yes.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	A reduction in temperature and humidity during the winter months has a positive influence on the reproduction behavior. A reduction in the lighting duration from 12 hours during the summer months to 8–10 hours during the winter months also has a stimulating effect on reproduction.
Husbandry requirements	The minimum space requirements for the keeping of reptiles (Federal Ministry for Food, Agriculture and Forestry 1997) are for ground-dwelling gecko species 4 x 3 x 2 (L x W x H) the size of snout-vent-length, which should be urgently revised. This would result in a minimum size of approx. 40 x 30 x 20 cm for the species dealt with here. If at all, a terrarium of this size is only recommended as a quarantine or rearing terrarium for juveniles. Terrariums of 80 x 50 x 50 cm are of acceptable dimensions. The terrarium should be moist and densely planted according to the natural habitat of these animals. A forest soil and sand mixture, partially covered with leaf-litter is recommended as substrate. Branches and rocks, which should be fixed to avoid slipping, can be used for climbing. Cork bark pieces and unglazed clay bowls can be used to provide hiding places. For egg laying, and to avoid difficulties during shedding, a “wet box”, filled with moist Sphagnum is recommended. Plants and additional sprinkling are important for the microclimate. Temperature during summer months should be 26–28 °C.

Topic	Data
	During winter, from October to March, the animals can be kept at cooler temperatures, which corresponds to their distribution range in southern China and northern Vietnam. A gradual reduction of lighting up to eight hours, and the reduction of the ambient temperature to ca. 16–18 °C, are the essential husbandry requirements for continuous breeding success. Artificial rocks have been proven to suit as backwall and provide extra space for the nocturnal activity. Specimens are strictly nocturnal and only emerge from their hiding places after sunset. Specimens prefer elevated places to scan the surroundings for insects which are captured with a targeted short sprint (Einsfelder 2016). Various invertebrates, such as crickets, grasshoppers, cockroaches, Zophobas larvae, mealworms, wax moth caterpillars, and woodlice, serve as food. The food should be supplemented with the commercially available mineral and vitamin powder. Fresh water in a bowl should always be available, as well as a bowl with grated cuttlefish bone.
General characteristics, difficulties with keeping and breeding	If the climatic requirements are fulfilled, tiger geckos of the genus *Goniurosaurus* are relatively easy to keep and breed.
Care of the young, technical and time effort	Hatchlings and juveniles should initially be kept separately, or together with their siblings, in small terrariums or plastic boxes. The setup of the terrariums can be purposefully designed, but must comply with the climatic requirements. Juveniles tend to dehydrate, and caves of baked clay have proven to be suitable hiding places since they provide a stable microclimate (Einsfelder 2016). Ground substrate should be a mixture of forest soil and sand, as for the adults. Epipremnum or Scindapsus shoots serve well as plants since they do not require much care. Juveniles should be fed 3 times a week with correspondingly smaller insects which should always be supplemented with mineral and vitamin powder.
Frequency of breeding in captivity	*Goniurosaurus bawanglingensis,* and presumably also *G. kwanghua* (as "*hainanensis* lowland morph") are relatively rare, but regularly being bred and offered. There are small breeding groups distributed among some successful breeders in Europe and the US, so that it can be assumed that these species will be established in captivity. *G. hainanensis* and *G. lichtenfelderi* have been regularly bred in the past, but less often in recent years due to a reduced demand.
Breeding difficulty evaluation	If the climatic requirements are met, the breeding is unproblematic.
F2 generation bred	*Goniurosaurus bawanglingensis, G. hainanensis, G. lichtenfelderi.*
Interviews/ Surveys/ Consultations	Several private breeders and 2 zoological institutions.

References

Internet Resources

https://www.goniurosaurus.net

http://www.ms-goniurosaurus.de

Animals of China: *Goniurosaurus* species in Hainan Island https://www.beautyofscience.com/goniurosaurus-species-in-hainan

Animals of China: *Goniurosaurus* species in China https://www.beautyofscience.com/goniurosaurus-species-in-china

References

Barbour, T. (1908): Some new reptiles and amphibians. Bulletin of the Museum of Comparative Zoology at Harvard College **51**(12): 315-325.

Blair C., N.L. Orlov, H.T. Shi & R.W. Murphy (2009): A taxonomic re-evaluation of *Goniurosaurus hainanensis* (Squamata: Eublepharidae) from Hainan Island, China. Russian Journal of Herpetology 1**6**: 35-44.

Chambers, G. & E.S. MacAvoy (1999): Molecular Genetic Analysis of Hybridization. Department of Conservation, Wellington, 29 pp.

Chen, T.-B., Y.-J. Meng, K. Jiang, P.-P. Li, B.-H. Wen, W. Lu, J. Lazell & M. Hou (2014): New Record of the Leopard Gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) for China and habitat partitioning between geographically and phylogenetically close Leopard Geckos. IRCF Reptiles & Amphibians **21**(1): 16-27.

CITES (2019): CoP18 Proposal 27: The inclusion of all species of the genus *Goniurosaurus* from People's Republic of China and the Socialist Republic of Viet Nam, namely the *G. lichtenfelderi* group, the *G. luii* group, and the *G. yingdeensis* group in Appendix II of CITES. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 14.08.2021).

Day, M.J. & P.B. Urich (2000): An assessment of protected karst landscapes in Southeast Asia. Cave and Karst Science **27**: 61-70.

Dickhoff, A. (2004): Ein Tiger im Terrarium - Haltung und Nachzucht von *Goniurosaurus araneus* (Grismer, Viets & Boyle, 1999). Draco **5**(18): 76-81.

Einsfelder, L. (2016): Haltung und Nachzucht von *Goniurosaurus yingdeensis* (Sauria: Gekkota: Eublepharidae) im Terrarium. Sauria **38**(4): 19-26.

Golinski, A., L. Kubicka, H. John-Alder & L. Kratochvil (2015): Androgenic control of male-typical behavior, morphology and sex recognition is independent of the mode of sex determination: A case study on Lichterfelder's gecko (Eublepharidae: *Goniurosaurus lichtenfelderi*). Hormones and Behavior **72**: 49-59.

Grismer, L.L. (1987): Evidence for the resurrection of *Goniurosaurus* Barbour (Reptilia: Eublepharidae) with a discussion on geographic variation in *Goniurosaurus lichtenfelderi*. Acta Herpetologica Sinica **6**(1): 43-47.

Grismer, L.L. (1997): Euplepharid Geckos. Living Relicts of Gekkotan Evolution. Fauna **1**(1): 26-33.

Grismer, L.L., B.E. Viets & L.J. Boyle (1999): Two new continental species of *Goniurosaurus* (Squamata: Eublepharidae) with a phylogeny and evolutionary classification of the genus. Journal of Herpetology **33**(3): 382-393.

Grismer, L.L. H.T. Shi, N.L. Orlov & N.B. Ananjeva (2002): A new species of *Goniurosaurus* (Squamata: Eublepharidae) from Hainan Island, China. Journal of Herpetology **36**(2): 217-225.

Grismer L.L., P.L. Wood, S. Anuar, H.R. Davis, A.J. Cobos & M.L. Murdoch (2016): A new species of karst forest Bent-toed Gecko (genus *Cyrtodactylus* Gray) not yet threatened by foreign cement companies and a summary of Peninsular Malaysia's endemic karst forest herpetofauna and the need for its conservation. Zootaxa **4061**: 1-17.

Honda, M., T. Kurita, M. Toda & H. Ota (2014): Phylogenetic relationships, genetic divergence, historical biogeography and conservation of an endangered gecko, *Goniurosaurus kuroiwae* (Squamata: Eublepharidae), from the central Ryukyus, Japan. Zoological Science **31**: 309-320.

Huelsenbeck J.P., F. Ronquist, R. Nielsen & J.P. Bollback (2001): Bayesian Inference of Phylogeny and Its Impact on Evolutionary Biology. Science **294**: 2310–2314.

Johann, H. (2006): Pflege und Nachzucht von *Goniurosaurus hainanensis* Barbour, 1908. Elaphe **14**(4): 27-31.

Jonniaux, P. & Y. Kumazawa (2008): Molecular Phylogenetic and Dating Analyses Using Mitochondrial DNA Sequences of Eyelid Geckos (Squamata: Eublepharidae). Gene **407**(1-2): 102-115.

Kaverkin, Y. (2000): Eublepharoide Geckos der Gattung *Goniurosaurus* Barbour, 1908 - Haltung und Zucht im Terrarium. Sauria **22**(4): 17-22.

Kratochvil, L. & D. Frynta (2006): Body-size effect on egg size in eublepharid geckos (Squamata: Eublepharidae), lizards with invariant clutch size: negative allometry for egg size in ectotherms is not universal. Biological Journal of the Linnean Society **88**(4): 527-532.

Liang, B., R.B. Zhou, Y.L. Liu, B. Chen, L.L. Grismer & N. Wang (2018): Renewed classification within *Goniurosaurus* (Squamata: Eublepharidae) uncovers the dual roles of a continental island (Hainan) in species evolution. Molecular Phylogenetics and Evolution **127**: 646-654.

Luo, Z.H., S.H. Tang, Z.G. Jiang, J. Chen, H.X. Fang & C.W. Li (2016): Conservation of terrestrial vertebrates in a global hotspot of karst in southwestern China. Scientific Reports **6**: 25717.

Ngo, H.N., H.Q. Nguyen, M.H. Tran, H.T. Ngo, M.D. Le, L.R. Gewiss, M. van Schingen-Khan, T.Q. Nguyen & T. Ziegler (2021a): A morphological and molecular review of the genus *Goniurosaurus*, including an identification key. European Journal of Taxonomy **751**: 38-67.

Ngo, H.N., N.Q. Nguyen, T.Q. Phan, T.Q. Nguyen, L.R. Gewiss, D. Rödder & T. Ziegler (2021b): Modeling the environmental refugia of the endangered Lichtenfelder's Tiger Gecko (*Goniurosaurus lichtenfelderi*) towards implementation of transboundary conservation. Frontiers of Biogeography **13**(4): e51167.

Nguyen, S.V., C.T. Ho & T.Q. Nguyen (2009): Herpetofauna of Vietnam. Frankfurt (Edition Chimaira): 768 pp.

Orlow, N.L. & I.S. Darevsky (1999): Description of a New Mainland Species of *Goniurosaurus* Genus, from the North-Eastern Vietnam. Russian Journal of Herpetology **6**(1): 72-78.

Orlov, N.L., S.A. Ryabov, N.T. Tao, N.Q. Truong & H.T. Cuc (2008): A new species of *Goniurosaurus* (Sauria: Gekkota: Eublepharidae) from North Vietnam. Russian Journal of Herpetology **15**: 229-244.

Palumbi, S., A. Martin, S. Romano, W.O. McMillan, L. Stice & G. Grabowski (1991): The Simple Fool's Guide to PCR. Version 2.0. Honolulu (University of Hawaii): 24 pp.

Qi, S., L.L. Grismer, Z.-T. Lyu, L. Zhang, P.-P. Li & Y.-Y. Wang (2020): A definition of the *Goniurosaurus yingdeensis* group (Squamata, Eublepharidae) with the description of a new species. ZooKeys **986**: 127-155.

Qi, S., J. Wang, L.L. Grismer, H.-H. Chen, Z.-T. Lyu & Y.-Y. Wang (2020): The Stoor Hobbit of Guangdong: *Goniurosaurus gollum* sp. nov., a cave-dwelling Leopard Gecko (Squamata, Eublepharidae) from South China. ZooKeys **991**: 137-153.

Ronquist, F., M. Teslenko, P. Van Der Mark, D.L. Ayres, A. Darling, S. Höhna, B. Larget, L. Liu, M.A. Suchard & J.P. Huelsenbeck (2012): MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. Systematic Biology **61**: 539-542.

Seufer, H., Y. Kaverkin & A. Kirschner [eds.] (2005): Die Lidgeckos. Rheinstetten (Kirschner und Seufer Verlag): 238 pp.

Yang, J. & Y. Wang (2019): *Goniurosaurus zhelongi*. The IUCN Red List of Threatened Species 2019: e.T98393682A98393729.

Wang, K., J. Ren, H. Chen, Z. Lyu, X. G. K. Jiang, J. Chen, J. Li, P. Guo, Y. Wang & J. Che (2020): The updated checklists of amphibians and reptiles of China. Biodiversity Science **28** (2): 189-218.

Wang, Y.-Y., J.-H. Yang, & L.L. Grismer (2013): A New Species of *Goniurosaurus* (Squamata: Eublepharidae) from Libo, Guizhou Province, China. Herpetologica **69**(2): 214-226.

Wang, Y.-Y., M.J. Jin, Y.L. Li & L.L. Grismer (2014): Description of a new species of *Goniurosaurus* (Squamata: Eublepharidae) from the Guangdong Province, China, based on molecular and morphological data. Herpetologica **70**(3): 309-322.

Wang, Y.-Y., J.-H. Yang, & R.-F. Cui (2010): A new species of *Goniurosaurus* (Squamata: Eublepharidae) from Yingde, Guangdong Province, China. Herpetologica **66**(2): 229-240.

Wang, Y.-Y., M.-J. Jin, Y.-L. Li, & L.L. Grismer (2014): Description of a New Species of *Goniurosaurus* (Squamata: Eublepharidae) from the Guangdong Province, China, Based on Molecular and Morphological Data. Herpetologica **70**(3): 309-322.

Wang, Y. (2019): *Goniurosaurus yingdeensis*. The IUCN Red List of Threatened Species 2019: e.T18917797A18917801.

Yang, J.H. & B.P.L. Chan (2015): Two new species of the genus *Goniurosaurus* (Squamata: Sauria: Eublepharidae) from southern China. Zootaxa **3980**(1): 67-80.

Zhai, X., Y. Chen, T. Wang & J. Wang (2019): Complete mitochondrial genome of *Goniurosaurus bawanglingensis* (Squamata: Sauria: Eublepharidae). Mitochondrial DNA Part B: Resources **4**(1): 844-845.

Zhao, E. & K. Adler (1993): Herpetology of China. Oxford/Ohio (SSAR): 522 pp.

Zhou, R.B., N. Wang, B. Chen & B. Liang (2018): Morphological evidence uncovers a new species of *Goniurosaurus* (Squamata: Eublepharidae) from the Hainan Island, China. Zootaxa **4369**(2): 281-291.

Zhou, R., X. Peng, M. Hou & F. Yuan (2019): A new species of genus *Goniurosaurus* - *G. sinensis* [in Chinese]. Journal of Shihezi University (Natural Science) **37**(5): 549-556.

Zhu, X.Y., C.Z. Shen, Y.F. Liu, L. Chen, Z. Li & Z.Q. He (2020): A new species of *Goniurosaurus* from Hainan Island, China based on molecular and morphological data (Squamata: Sauria: Eublepharidae). Zootaxa **4772**(2): 349-360.

Ziegler, T., N.Q. Truong, A. Schmitz, R. Stenke & H. Rösler (2008): A new species of *Goniurosaurus* from Cat Ba Island, Hai Phong, northern Vietnam (Squamata: Eublepharidae). Zootaxa **1771**(1): 16-30.

Felix Hulbert & Christian Langner (26.07.2021)

Goniurosaurus luii group

Species	Description author and date	Common name English	Common name German / Chinese	Known in the trade
Goniurosaurus araneus	Grismer, Viets & Boyle, 1999	Vietnamese tiger Gecko	Vietnamesischer Tigergecko/ 越南睑虎	yes
Goniurosaurus catbaensis	Ziegler, Trong, Schmitz, Stenke & Rösler, 2008	Cat Ba tiger Gecko	Cat Ba Tigergecko	yes
Goniurosaurus gezhi	Zhu, Chen, Roman-Palacios, Li & He, 2020	Gezhi cave gecko Research cave gecko	Gezhi Höhlengecko	probably not
Goniurosaurus huuliensis	Orlov, Ryabov, Nguyen, Nguyen & Ho, 2008	Huu Lien tiger gecko	Huu Lien Tigergecko	yes
Goniurosaurus kadoorieorum	Yang & Chan, 2015	Kadoories' cave gecko	Kadoorie Tigergecko	probably not
Goniurosaurus kwangsiensis	Yang & Chan, 2015	Guangxi cave gecko	Guangxi Höhlen-gecko/ 广西睑虎	probably not
Goniurosaurus liboensis	Wang, Yang & Grismer, 2013	Libo tiger gecko	Libo Tigergecko / 荔波睑虎	yes
Goniurosaurus luii	Grismer, Viets & Boyle, 1999	Chinese tiger gecko	Chinesischer Tigergecko/ 凭祥睑虎	yes

After the text of this script had been completed, a new species of the *G. luii* group, *Goniurosaurus chengzheng*, has been described (Zhu *et al.* 2021).

The distinction of the different species from the *Goniurosaurus luii* group by morphological characters is not easy due to an intraspecific phenotypic variation, particularly in color pattern. For a precise species identification, a DNA analysis is needed (Shuo Qi, pers. comm. 2021).

In members of the *G. luii group* and the *G. lichtenfelderi* group, the base of the claws is surrounded by four scales. Thereof, the two lateral scales are long and curved, the dorsal scale is smaller than the lateral ones, but longer than the ventral scale. Species of the *G. luii* group have 16–33 precloacal pores, which are completely missing in the *G. kuroiwae* group (Qi *et al.* 2020).

Fig. 11a: *Goniurosaurus luii*, southern China (N. Orlov);
b: *Goniurosaurus luii*, southern China (N. Orlov);
c: *Goniurosaurus luii*, Cao Bang, Viet Nam (M. van Schingen-Khan);
d: *Goniurosaurus luii*, Cao Bang, Viet Nam (M. van Schingen-Khan);
e: *Goniurosaurus huuliensis*, Typus locality (N. Orlov);
f: *Goniurosaurus huuliensis*, Typus locality (N. Orlov);
g: *Goniurosaurus catbaensis* (M. van Schingen-Khan);
h: *Goniurosaurus catbaensis* (N. Orlov).

Morphology and Taxonomy

For a morphological identification key of the genus Goniurosaurus, see Ngo *et al.* (2021).

Goniurosaurus araneus – this is a medium sized species of the family Eublepharidae. This species reaches an SVL of 11.5–13 cm. With a total length of 24 cm, it belongs to the larger representatives of the genus *Goniurosaurus.* Eponymous is the spider-like body shape.

The species is characterized by the combination of the following characters (Grismer *et al.* 1999, Nguyen 2011, Chen *et al.* 2014, Ngo *et al.* 2021): The external nostrils are surrounded by 6–8 nasal scales; the supraorbital region exhibits a row of large tubercles; the internasal is undivided; 8–10 supralabial and 8 or 9 infralabial scales; 13–18 preorbital scales, 4–6 post-mental scales and 52–67 scales on the margin of the eyelid; the dorsal scales are noticeable elongated; 29–38 paravertebral tubercles; 129–147 midbody scales; 10–14 scales surround-ing the dorsal tubercles; 23–25 sub digital lamellae under the fourth toe; 18–23 precloacal pores in males.

The iris is dark brown to rust red, the dorsal ground color of head, body and limbs is uniform dull grey-yellow. Caudally, the nuchal band tapers in a V-shape. Three light transverse bands bordered in dark brown run across the dorsum. Another cross band is present at the base of the tail. The ground color of the tail is velvet black. The five white cross bands on the tail extend to the ventral side. The venter, head and the limbs are frosted white and patternless. Juveniles have narrow, cream or white bands on a black background. Adjacent to the neck band are two dorsal bands and one band across the tail base. The tail has four continuous, also narrow, snow-white bands. *G. araneus* juveniles are very similar to *G. luii* juveniles.

Goniurosaurus catbaensis – this species has a SVL of 8.9–12.5 cm. Ziegler *et al.* (2008), Nguyen (2011) and Ngo *et al.* (2021) describe the following diagnostic char-acters: The nostrils are surrounded by 6–8 dorsalia. The supraorbital region contains some enlarged tubercles. The outer margin of the upper eyelid consists of granular scales which reach the same size as the head scales, but have a row of 6–10 en-larged humps. An internasal scale is missing. The species has 8–11 supralabial scales, 7–10 infralabial scales and 45–56 scales on the margin of the eyelid and 2–5 postmental scales. There are no enlarged tubercles in the anterior area of the lower jaw in the gular region. *G. catbaensis* has also 31–38 paravertebral tubercles, 112–127 midbody scale rows and eight to ten granular scales which surround the tuber-cles. The fourth toe has 22–25 subdigital lamellae. Males have 16–23 precloacal pores.

The iris is orange to brown. The dorsal ground color of head, body and limbs is grey brown to pale brown with dark brown mottled spots. A narrow neck band caudally tapers into a long “V” shape; 3–4 yellow, narrow dorsal cross bands are present which lack dark spots at the base of the limbs. The bright band across the base of the tail is 8–9 scales wide. The ground color of the tail is black, and the five continuous narrow tail bands are white. The venter of the head, body and limbs is unspotted matte white. The gular region is brown-spotted.

Goniurosaurus gezhi – this species can be distinguished from other species of the genus *Goniurosaurus* by the combination of the following characters (Zhu *et al.* 2020): a relative body size of 7.1–8.4 cm SVL; a neck band, three dorsal bands and a postsacral band. The head is covered by uniform granular scales interspersed with tubercles on the dorsal side. The species has a conspicuous row of enlarged supraorbital tubercles. The rostral is wider than high. The nostrils are limited to 6–7 nasalia. The 9–8 infralabialia appear rectangular.

The neck is narrower than the body and covered with uniform granulated scales, interspersed with tubercles. The dorsal tubercles are surrounded by 11–12 granulated scales; 21 longitudinal rows of tubercles around the midbody and 32 paravertebral tubercles are present between the limbs. A noticeable row of vertebral scales is missing.

The body appears thin and covered with granulated scales which turn into flattened subimbricate scales on the venter. The species has 142–151 scales around the midbody. Males have 20 precloacal pores and two enlarged postcloacal tubercles at the lateral tail base. The hindlimbs are longer than the forelimbs. The fourth finger has 20 broad subdigital lamellae. The claws are covered by four scales from which the two lateral ones are large and curved, the dorsal one is smaller than the lateral ones, but longer than the ventral one. The dorsal ground color of head, body and limbs is grey with irregular small black spots. Closely spaced black spots are present on top of the head. The iris is brown, the neck band is pale yellow and rounded posteriorly, not pointed. The three dorsal bands between the limbs as well as the postsacral band on the tail base is pale yellow. The venter of the head, body and limbs are matte white. The ground color of the tail is black with irregular distributed white marks.

Goniurosaurus huuliensis – with 9.7–13.5 cm SVL, G. *huuliensis* is the largest species of the genus *Goniurosaurus* (Ngo *et al.* 2021). The species is characterized by the following combination of characters (Orlov *et al.* 2008, Nguyen 2011, Ngo *et al.* 2021): The nostrils are bordered by 6–8 nasal scales and the supraorbital region has a row of enlarged tubercles. Enlarged tubercle scales are missing. Usually, one or two internasalia are present (rarely completely missing); 9–12 supralabial scales, 9–12 infralabial scales, 14–20 preorbital scales, 51–59 scales on the margin of the eyelid and two to four postmental scales. The species has enlarged tubercles in the anterior area of the lower jaw in the gular region. Furthermore, it has 118–130 scales rows around the midbody. The number of subdigital lamellae under the fourth toe varies between 21–25. Males have 25–30 precloacal pores.

The iris is red brown. The dorsal ground color of head, body and limbs is dark brown without small dark brown spots (it has dark spots on the lower part of the flanks). A narrow neck band caudally extends in a long “V” shape. The narrow dorsal cross bands between the limbs are yellow to orange brown without spots and bordered by a thin dark line. The black tail has 3–6 unspotted white bands.

The venter of the head, body and limbs is frosted and uniformly white, except some few spots on the edge of the gular region and limbs.

Goniurosaurus kadoorieorum – this species can be distinguished from other species of the genus by a combination of features. This species reaches a relatively large SVL of 11.2–11.8 cm. The neck band is wide and extends caudally. There are three broad, almost spotless, dorsal bands between the limb insertions. *G. kadoorieorum* has a marbled pattern. Dark brown spots extend laterally along the venter. The mental scale has a dark spot. The iris is blood red in juveniles, orange-red in subadults and remarkably olive-green in adults. Supraorbital tubercles are enlarged. Two internasal scales and 8–9 nasal scales surround the nostrils. 47–55 scales form the upper margin of the eyelid. The species is further characterized by 9–1 supralabialia, 9 infralabial scales and 124–132 midbody scales. Males have 26–28 precloacal pores and one or two postcloacal tubercles. The claws are covered by four scales from which the two lateral ones are large and curved.

The most important diagnostic character for *G. kadoorieorum* is the olive-green iris in adult

geckos, instead of ivory color, yellow, orange or blood red of the other species. Recent studies suggest that *G. kadoorieorum* is a junior synonym of *G. luii* (Ngo *et al.* 2021). *G. kadoorieorum* is only known from five type specimens and has not yet been genetically compared with the other species (Meiri *et al.* 2017).

Goniurosaurus kadoorieorum can be distinguished from all other species of the genus by its olive-green iris (Yang & Chan 2015). Subadult geckos have an orange red iris and juveniles have a blood red iris. However, recent studies suggest that *G. kadoorieorum* is a synonym for *Goniurosaurus luii* (Ngo *et al.* 2021, Zhu *et al.* 2020).

Goniurosaurus kwangsiensis – this species can be distinguished from the other species of the genus by a combination of the following characters (Yang & Chan 2015): this medium sized gecko reaches a body size of 9.8–10.9 cm SVL. The supraorbital is slightly enlarged. One to two internasalia and 8–9 nasals surround the nostrils. The eyelid margin is formed by 52–58 scales. The species has 8–10 supralabialia, 7–9 infralabialia and 122–128 midbody scale rows. In males, 31–33 conspicuous precloacal pores and one or two postcloacal tubercles are present. Claws are covered by four scales from which the two lateral ones are larger and curved.

The dorsal ground color of the head, body and limbs is yellowish-brown to pale grey-beige with several large, dark brown interspersed spots, which sometimes are fused together. The iris is orange-yellow. The narrow nuchal band is posteriorly slightly extended and anteriorly reaches the corner of the mouth. The nuchal band is dorsally and ventrally surrounded with a wide dark brown stripe. Four narrow, almost unmarked light dorsal bands, three between the limb insertions and another one at the tail base are edged towards the front and dorsally bordered by broad, dark bands. The nuchal band as well as the four dorsal bands are bright yellow, the infralabial and supralabial scales are frosted white with few dark brown spots. Ventral surfaces of the head, body and limbs are pale white and without marks, except for the few dark brown spots on the limbs and gular region. The mental has no spots. The ground color of the original tail is dark brown. The tail has five white bands without marks, which completely enclose the tail and ends with a white tip (Yang & Chan 2015).

Goniurosaurus liboensis – this species can be distinguished from the other species of the genus by the following combination of characters (Wang *et al.* 2013): a medium sized species, reaching 10.3–11 cm SVL. The nuchal band has a width of six to seven tubercle scale rows, is very thin and caudally slightly extended. The nostrils are surrounded by 8–9 nuchal scales, two or three internasals and a row of enlarged supraorbital tubercles. The tubercle scales of the upper margin of the eyelid are approximately of the same size as the tubercles on top of the head. Males have 23 precloacal pores, arranged in a transverse, continuous row. The claws are covered by four dorsal scales and two long and curved lateral ones.

The dorsal ground color of head, body and limbs is yellow brown. The top of the head has irregular large dark brown spots. The dorsal side of neck, body and limbs are covered with small dark spots. The nuchal band is pale yellow and bordered dorsally and ventrally by broad dark brown bands. The four narrow, unmarked, pale yellow dorsal bands, three running across the body between the extremities, and another at the base of the tail, are also bordered with broad dark brown bands. The infralabial is cream and has dark brown spots. The pupil is vertical and black, the iris grey and changing to pale orange near the pupil. Chin, throat, chest and ventral parts of body and limbs are pale white without dark spots. The ground color of the tail is black with white unmarked, circumferential tail bands as well as further irregularly distributed white markings.

Goniurosaurus luii – the SVL in this species is 8.7–12.7 cm. The following combination of characters is distinctive (Grismer *et al.* 1999, Vu *et al.* 2006, Nguyen 2011, Ngo *et al.* 2021): The nostrils are surrounded by 5–8 nasal scales. The supraorbital region has a row of enlarged tubercles. The margin of the upper eyelid is composed of granulated scales, which are half of the size of the tubercles on top of the head. Enlarged tubercles at the margin of the eyelid are missing. The species has one or two internasal scales, 8–12 supralabial scales, 8–11 infralabial scales, 13–16 preorbital scales, 2–6 postmental scales and 46–61 scales on the margin of the eyelid. The gular region has enlarged tubercles in the anterior region of the lower jaw. *G. luii* has 119–144 midbody scale rows and 29–38 paravertebral tubercles, 20–26 subdigital lamellae are present below the fourth toe. Males have 23–32 precloacal pores.

The iris is brown to bright orange. The dorsal ground color of head, body and limbs is pale brown to grey-brown, mottled with small dark brown round spots, which are missing in juveniles. The narrow nuchal band caudally extends in a “V” shape. The three narrow bands between the limb insertions are yellow to orange without dark spots. In juveniles, the spots are bright cream. The gular region, the venter and the ventral side of limbs, is brown spotted. The ground color of the tail is black almost throughout and grey brown on the base of the tail and has 3–6 narrow, white cross bands.

Distribution and habitat

Distribution

Goniurosaurus araneus: the hills on Cao Bằng Province, northern Vietnam are given as type locality. After two decades of intensive surveys, the species could not be found in Vietnam anymore (Ngo *et al.* 2021). Chen (2014), described the occurrence of the species for the first time for the national protected area Nonggang, in the Chongzuo prefecture of the autonomous region of Guangxi Province, southern China. Type locality: 40 km southeast from Cao Bằng, Cao Bằng Province, Vietnam.

Goniurosaurus catbaensis**:** the species was described in 2008 from the island Cat Ba in Cat Ba Archipelago, northern Vietnam. Recently, the species was also recorded by Ngo *et al.* (2019a) from small offshore islands near the coast in the Ha Long Bay Archipelago, which is bordering the Cat Ba Archipelago. Type locality: Cat Ba Island, Quang Ninh Province, North Vietnam.

Goniurosaurus gezhi: the species is only known from the southwest of the autonomic region of Guangxi Province in southern China. Type locality: Southwest Guangxi Province, China at 100–200 m elevation. The exact location is not mentioned in the publication to prevent poaching and it will only be disclosed to qualified researchers upon request.

Goniurosaurus huuliensis**:** Lang Son Province, Northeast Vietnam. Type locality: in Hữu Liên Nature Reserve, Hữu Lũng district, Lạng Sơn Province, Northeast Vietnam, (21°41’ 55.2’’ N 106°22’ 43.8’’ E) at 370 m asl.

Goniurosaurus kadoorieorum: this species is up to date only known from Guangxi Province, China. Type locality: Guangxi Province, China. The exact location is not published and will only be disclosed to qualified researchers upon request.

Goniurosaurus kwangsiensis: the species is only known from the southwest autonomic region of Guangxi Province in southern China. Type locality: autonomic region of Guangxi Province, southern China. The exact location is not published and will only be disclosed to qualified researchers upon request.

***Goniurosaurus liboensis*:** China (Guizhou). Type locality: this species is currently only known from the Nature Reserve in Maolan, Libo County (Lìbō Xiàn), autonomous district of Qiannan, Guizhou Province, China. At 660 m asl (25°15'37.73''N, 108°5'45.74''E).

Goniurosaurus luii: this species is known from the rural areas in Longzhou and Pingxiang, China, as well as from Cao Bằng Province, in northern Vietnam at about 770 m asl (Ngo *et al.* 2016; Thanh *et al.* 2006). Type locality: Pingxiang, Guangxi Province, China.

Habitat

The species of the *G. luii* group inhabit limestone karst forests where they usually occur in or in front of karst caves or associated with other karst formations and rocks. They hide in narrow crevices in case of danger. *G. luii* and *G. catbaensis* have been found at vertical karst rock walls during the night in approx. 1 m (up to 3 m) above the ground (Ngo *et al.* 2019a; pers. obs. van Schingen-Khan). Karst caves in northern Vietnam, where *G. luii* have been found, are up to 100 m long (often smaller) and often only few meters wide. It has also been observed that *G. luii* feeds on cave crickets (family Rhaphidophoridae) (pers. obs. van Schingen-Khan). *G. gezhi* has been found in limestone crevices and also some specimens on a street (Zhu *et al.* 2020). Egg remnants of *G. kwangsiensis* have also been found in crevices (Yan & Chan 2015). These species are nocturnal as are all species of the genus. During the active season in summer, an average temperature of 26 °C (22–28 °C) and 85 % humidity has been recorded in microhabitats of *G. catbaensis* (Ngo *et al.* 2019). In *G. luii* microhabitats, temperatures between 22–25 °C have been measured during the active season (pers. obs. van Schingen-Khan).

Conservation Status and Main Threats

CITES Appendix II since 2019 (CoP18 Proposal 27).

Council Regulation (EC) No. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List Status:

Goniurosaurus araneus: Endangered (B1ab(iii,v), assessed May 24, 2017);

Goniurosaurus catbaensis: Endangered (B1ab(ii,iii)+2ab(ii,iii), assessed June 15, 2016);

Goniurosaurus huuliensis: Critically Endangered (B1ab(iii), assessed May 25, 2017);

Goniurosaurus kadoorieorum: Endangered (B1ab(iii), assessed June 20, 2019);

Goniurosaurus kwangsiensis: Endangered (B1ab(iii,v), assessed June 20, 2019);

Goniurosaurus liboensis: Endangered (B1ab(iii,v), assessed May 8, 2018);

Goniurosaurus luii: Vulnerable (B1ab(v)), assessed May 23, 2017).

Goniurosaurus gezhi has not yet been evaluated for the IUCN-Red List.

The species *G. kadoorieorum* und *G. luii* were nationally classified as "Endangered" during a workshop in May 2018 in China. *G. gezhi* would presumably be classified as "Critically Endangered" due to the small distribution range and the currently low level of knowledge.

It has to be noted that the CITES listing proposal does not only include the species described until the time of listing, but explicitly includes all *Goniurosaurus* species from China and Vietnam. This was anticipatory since the discovery of new cryptic species has been expected (CITES 2019).

Threats

Results from several studies from China (Luo *et al.* 2016; Qi *et al.* 202) and Malaysia (Grismer *et al.* 2016) show that karst habitats are not only biodiversity hotspots which harbor numerous endemics, but also are at particular risk. At the same time, they belong to the least protected areas of the world (Day & Urich 2000). The recent discovery of several further species with a particularly small distribution in the karst region of north Guangdong and Guangxi emphasized the importance to protect this unique habitat (Qi *et al.* 2020). Furthermore, the potential devastating effects of climate change on these special habitats, which are crucial for the water balance of this region, cannot yet be assessed here at all.

Goniurosaurus araneus and *G. luii* have been collected in very high numbers for the pet market and for Chinese traditional medicine (Janssen & Indenbaum 2019, Lindenmayer & Scheele 2017).

One year after the species description, Kaverkin (2000) pointed out that high numbers of *G. luii und G. araneus* already had been harvested for commercial purposes. He also suggested that the populations would suffer massive reductions without a quota system, which appears to have been confirmed by more recent studies.

Meanwhile, the pressure from collection for the pet trade may have decreased for some species. Through continuous breeding in captivity, the initial price of 1,000 $/ € per wild caught specimen has been reduced to 40 $/ € per captive-bred specimen in *Goniurosaurus araneus* and *G. luii* (Kratochvil 2006). Species that are kept less frequently in captivity, or are relatively new to science, such as *G. catbaensis,* are however still collected from the wild and offered for higher prices (e.g., Ngo *et al.* 2019 a, b).

The same author also concluded that the captive breeding reduced the demand for the pet trade, but not for the Chinese traditional medicine. Additionally, he points out that the continuous breeding can be a chance for a captive “backup-population”, in case the population status in the wild worsens for the species with its small range.

Reproduction

Topic	Data
Secondary sexual traits	No sexual dichromatism was found in any of the species of this group. Both sexes show the same color pattern and variations, but a clear sexual dimorphism is noticeable. In ♂♂, the postcloacal region/ the hemipenis bulges are swollen, ♀♀ just have a slight swelling. Furthermore, only ♂♂ have precloacal pores (see “morphology and taxonomy”).
Reproduction	Oviparous. The eggs have a soft shell and are often burrowed in the substrate. Occasionally, the eggs are laid on the substrate on a hidden place or under the vegetation instead of being burrowed (observed in four clutches of *G. catbaensis).*
Sexual maturity	*Goniurosaurus catbaensis*, *G. huuliensis* and *G. luii*: 24 months
Number of eggs/ clutches per season	2 eggs (exceptionally only 1 egg) per clutch (*G. catbaensis, G. huuliensis, G. luii, G. araneus*); *G. araneus:* 1 clutch (3–4 clutches per season probably possible, egg laying in June); *G. catbaensis*: 2–3 clutches (up to 4 clutches per season probably possible, egg laying in May–August); 5–6 weeks between two clutch ca. 5–6; *G. huuliensis*: 2 clutches (up to 4 clutches probably possible, egg laying June to July)

Topic	Data
	G. luii: 2–3 clutches (up to 4 clutches per season probably possible, egg laying April to September).
Incubation and hatching	*G. araneus*: 72–73 days at 23.5–25.5 °C; *G. catbaensis:* 65–85 days at 23.5–25.3 °C; *G. huuliensis*: ca. 69 days (not exactly known)/ 23.5–25.3 °C (in terrarium conditions); *G. luii*: 65 days at 28 °C and ca. 84 days at 24 °C.
Hatching rate	*G. araneus & G. huuliensis* 100 %; *G. catbaensis*: 62.5 %; *G. luii*: ca. 80 % (33–100 %).
Sex ratio of hatchlings	*G. luii*: ca. 1:1; Holfert (2006) hatched mainly males (incubation temperature 24 °C and 28 °C).

Husbandry and Captive Breeding

Husbandry data is only available for the species *Goniurosaurus araneus, G. catbaensis, G. huuliensis* and *G. luii.* Since all species of this group have a similar ecology, it is assumed that the husbandry requirements are similar and all species can be successfully bred under the correct conditions.

Topic	Data
Trigger for reproduction	A reduction of the temperature and humidity during the winter months has a positive effect on reproduction. Also, a reduction of the lighting time from 12 hours during summer time, to 8–10 hours during winter, stimulates reproduction. It has been observed that *G. catbaensis* laid eggs after a temporary increase of humidity.
Husbandry requirements	The minimum space requirements for keeping reptiles (Federal Ministry for Food, Agriculture and Forestry 1997) are for ground-dwelling gecko species 4 x 3 x 2 (L x W x H) the size of SVL which should be urgently revised. This results in a minimum terrarium size of ca. 40 x 30 x 20 cm. A terrarium with such a small size is to be used as quarantine or for rearing juveniles, only. Terraria of 80 x 50 x 50 cm are considered acceptable for these geckos. The terrarium should be moist and densely planted according to the natural habitats. Forest soil and sand mixture, partially covered with leaf-litter, is recommended as substrate. Branches and rocks, which should be fixed to avoid slipping, can be used for climbing. Cork bark pieces and unglazed clay bowls can be used as hiding places. Plants and additional sprinkling are important for a stable microclimate. Temperature during summer months should be 26–28°C and during winter, from October to March, the animals can be kept in cooler temperatures, which corresponds to their distribution range in southern China and northern Vietnam. A gradual reduction of the lightning to eight hours and the reduction of the temperature to ca. 16–18 °C as well as a high humidity are the husbandry requirements that to date are considered as the most successful for a continuous breeding. Artificial rocks have been proven as suitable back wall which provide extra space for their nocturnal activity. Specimens are strictly nocturnal and only come out of their hiding place in the dark. Specimens prefer elevated places to scan the surroundings for insects which are captured with a targeted short sprint (Einsfelder 2016). Various invertebrates such as crickets, grasshoppers, cockroaches, *Zophobas*

Topic	Data
	larvae, mealworms, wax moth caterpillars, and woodlice serve as food. The food should be supplemented with commercially available mineral and vitamin supplements. Fresh water in a bowl should always be available, as well as a bowl with grated cuttlefish.
General characteristics, difficulties with keeping and breeding	If the climatic requirements – particularly a high humidity – are fulfilled, tiger geckos of the genus *Goniurosaurus* are relatively easy to keep and breed.
Care of the young, technical and time effort	Hatchlings and juveniles should initially be kept separately or together with their siblings in glass terrariums or plastic boxes The setup of the terrariums can be purposefully designed, but it has to comply with the required climatic conditions. Juveniles tend to dehydrate, and caves of baked clay have proven to be good hiding places since they provide a good microclimate (Einsfelder 2016). Ground substrate should be a mixture of forest soil and sand, as for the adults. *Epipremnum* or *Scindapsus* shoots serve well as plants since they do not require much care. Juveniles should be fed 3 times a week with correspondingly smaller insects which should always be supplemented with mineral and vitamin powder.
Life expectancy in captivity	*Goniurosaurus araneus, G. catbaensis, G. huuliensis* and *G. luii* minimum 5 years in captivity (the maximum life expectancy is estimated to be 15–20 years). A currently living pair of *G. catbaensis* is at least 10 years old and still reproducing.
Frequency of breeding in captivity	*Goniurosaurus araneus* and *G. luii* are frequently bred and offered in Europe and USA. There are small breeding groups distributed among some successful breeders in Europe and the US, so it can be assumed that this species can be preserved for terrarium keeping. For *G. catbaensis* and *G. huuliensis* there is up to date only little experience with husbandry. However, these wo species seem to have similar husbandry requirements to those of the well-established two other species.
Breeding difficulty evaluation	If the climatic requirements are met, the breeding of *Goniurosaurus* is unproblematic.
F2 generation bred	*Goniurosaurus araneus* und *Goniurosaurus luii*
Interviews/ Surveys/ Consultations	Several private breeders and 6 zoological institutions.

References

Barbour, T. (1908): Some new reptiles and amphibians. Bulletin of the Museum of Comparative Zoology at Harvard **51**: 313-325.

Blair, C., N.L. Orlov, H. Shi, & R.W. Murphy (2009): A Taxonomic Re-Evaluation of *Goniurosaurus hainanensis* (Squamata: Eublepharidae) from Hainan Island, China. Russian Journal of Herpetology **16** (1): 35-40.

Blake, P. (2000): Keeping and breeding Chinese leopard geckoes *Goniurosaurus luii* and *G. araneus.* Herptile **25**(3): 130–132.

Chen, T.-B., Y.-J. Meng, K. Jiang, P.-P. Li, B.-H. Wen, W. Lu, J. Lazell, & M. Hou (2014): New Record of the Leopard Gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) for China and habitat partitioning between geographically and phylogenetically close Leopard Geckos. IRCF Reptiles & Amphibians **21**(1): 16-27.

CITES (2019): CoP18 Proposal 27: The inclusion of all species of the genus *Goniurosaurus* from People's Republic of China and the Socialist Republic of Viet Nam, namely the *G.*

lichtenfelderi group, the *G. luii* group, and the *G. yingdeensis* group in Appendix II of CITES. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 14.08.2021).

Cooper, W.E. & J.J. Habegger (2000): Lingual and biting responses to food chemicals by some eublepharid and gekkonid geckos. Journal of Herpetology **34**(3): 360–368.

da Nóbrega Alves, R.R., W.L. da Silva Vieira & G.G. Santana (2008): Reptiles used in traditional folk medicine: conservation implications. Biodiversity and Conservation **17**: 2037e2049.

Dickhoff, A. (2004): Ein Tiger im Terrarium - die Haltung und Nachzucht von *Goniurosaurus araneus* (Grismer, Viets & Boyle, 1999). Draco **5**(2) (18): 76-81.

Einsfelder, L. (2016): Haltung und Nachzucht von *Goniurosaurus yingdeensis* (Sauria: Gekkota: Eublepharidae) im Terrarium. Sauria **38**(4): 19-26.

Gamble, T. (2010): Review of Sex Determining Mechanisms in Geckos (Gekkota: Squamata). Sexual Development **4**: 88-103.

Grismer, L.L. (1987): Evidence for the resurrection of *Goniurosaurus* Barbour (Reptilia: Eublepharidae) with a discussion on geographic variation in *Goniurosaurus lichtenfelderi*. Acta Herpetologica Sinica **6**(1): 43-47.

Grismer, L.L. (1988): The phylogeny, taxonomy, classification and biogeography of eublepharid geckos (Reptilia, Squamata). *In:* Estes R. & G. Pregil (eds.): Phylogenetic Relationships of the lizard families, Stanford (Stanford University Press): 369-469.

Grismer, L.L. (2002): *Goniurosaurus*: ancient gekkos of the Far East. Gekko **3**(1): 22-28.

Grismer, L.L., B.E. Viets & L.J. Boyle (1999): Two new continental species of *Goniurosaurus* (Squamata: Eublepharidae) with a phylogeny and evolutionary classification of the genus. Journal of Herpetology **33**(3): 382-393.

Grismer, L.L., S. Haitao, N.L. Orlov & N.B. Ananjeva (2002): A new species of *Goniurosaurus* (Squamata: Eublepharidae) from Hainan Island, China. Journal of Herpetology **36**(2): 217-224.

Holfert, T. (2006): Zeichnungsvariationen bei *Goniurosaurus luii* [Variations in the colour pattern of *Goniurosaurus luii*]. Sauria **28**(2): 55-56.

Janssen, J. & R.A. Indenbaum (2019): Endemic Vietnamese Reptiles in Commercial Trade. Journal of Asia-Pacific Biodiversity **12**(2019): 45e48.

Jonniaux, P. & Y. Kumazawa (2008): Molecular phylogenetic and dating analyses using mitochondrial DNA sequences of eyelid geckos (Squamata: Eublepharidae). Gene **407**(1-2): 105-115.

Kaverkin, Y. (2000): Eublepharoide Geckos der Gattung *Goniurosaurus* Barbour, 1908 - Haltung und Zucht im Terrarium. Sauria **22**(4): 17-22.

Kratochvil, L. (2006): Captive breeding and a threatened gecko. Science **313**(5789): 915.

Lindenmayer, D & B. Scheele (2017): Do not publish. Science **356**(6340): 800–801.

Lyons, J.A. & D.J. Natusch (2013): Effects of consumer preferences for rarity on the harvest of wild populations within a species. Ecological Economics **93**: 278-283.

Meiri, S., A.M. Bauer, A. Allison, F. Castro-Herrera, L. Chirio, G. Colli, I. Das, T.M. Doan, F. Glaw, L.L. Grismer, M. Hoogmoed, F. Kraus, M. LeBreton, D. Meirte, Z.T. Nagy, C. de C. Nogueira, P. Oliver, O.S. G. Pauwels, D. Pincheira-Donoso, G. Shea, R. Sindaco, O.J.S. Tallowin, O. Torres-Carvajal, J.-F Trape, P. Uetz, P. Wagner, Y. Wang, T. Ziegler & U. Roll (2017): Extinct, obscure or imaginary: the lizard species with the smallest ranges. Diversity and Distributions **24**(2): 262-273.

Ngo, H.N., T. Ziegler, T.Q. Nguyen, C.T. Pham, T.T. Nguyen, M.D. Le & M. van Schingen

(2016): First population assessment of two cryptic Tiger Geckos (*Goniurosaurus*) from northern Vietnam: implications for conservation. Amphibian and Reptile Conservation **10**(1): 34-45.

Ngo, H.N., T.Q. Le, M.L. Pham, T.Q. Nguyen, M.D. Le, M. van Schingen & T. Ziegler (2019a): First record of the Cat Ba Tiger Gecko, *Goniurosaurus catbaensis*, from Ha Long Bay, Quang Ninh Province, Vietnam: microhabitat selection, potential distribution, and evidence of threats. Amphibian & Reptile Conservation **13**(2): 1-13.

Ngo, H.N., T.Q. Nguyen, T.Q. Pham, M. van Schingen & T. Ziegler (2019b): A case study on trade in threatened Tiger Geckos (*Goniurosaurus*) in Vietnam including updated information on the abundance of the Endangered *G. catbaensis*. Nature Conservation **33**: 1–19.

Ngo, H.N., H.Q. Nguyen, H.M. Tran, H.T. Ngo, M.D. Le, L.R. Gewiss, M. van Schingen-Khan, T.Q. Nguyen & T. Ziegler (2021): A morphological and molecular review of the genus *Goniurosaurus*, including an identification key. European Journal of Taxonomy **751**: 38-67.

Nguyen, S.V., C.T. Ho & T.Q. Nguyen (2009): Herpetofauna of Vietnam. Frankfurt (Edition Chimaira): 768 pp.

Nguyen, T.Q. (2018): *Goniurosaurus huuliensis*. The IUCN Red List of Threatened Species 2018: e.T18917702A18917704.

Nguyen, T.Q., H. Ngo, M. van Schingen & T. Ziegler (2016): *Goniurosaurus catbaensis*. The IUCN Red List of Threatened Species 2016: e.T18917684A18917688.

Nguyen, T.Q., L.L. Grismer & J. Yang (2021): *Goniurosaurus araneus*, Vietnamese Leopard GeckoThe IUCN Red List of Threatened Species 2021: e.T18917624A18917668.

Nguyen, T.Q., J. Yang & Y. Wang (2021): *Goniurosaurus luii*, Chinese Leopard Gecko. The IUCN Red List of Threatened Species 2021: e.T18917749A18917751

Orlov, N.L., S.A. Ryabov, T.T. Nguyen, Q.T. Nguyen & T.C. Ho (2008): A new species of *Goniurosaurus* (Sauria: Gekkota: Eublepharidae) from north Vietnam. Russian Journal of Herpetology **15**(3): 229-244.

Robinson, J.E., R.A. Griffiths, F.A.S. John & D. L. Roberts (2015): Dynamics of the global trade in live reptiles: Shifting trends in production and consequences for sustainability. Biological Conservation **184**: 42-50.

Rösler, H. (2000): Kommentierte Liste der rezent, subrezent und fossil bekannten Geckotaxa (Reptilia: Gekkonomorpha). Gekkota **2**: 28-153.

Rösler, H. (2019): Vergleichende Untersuchungen zur extrakorporalen Entwicklung weich- und hartschaliger Eier von Geckos (Squamata: Gekkota): 4. *Goniurosaurus luii* Grismer, Viets & Boyle, 1999 (Eublepharidae). Sauria **41**(4): 57-61.

Russell, M. & R. Hartdegen (1998): A note on the husbandry and captive reproduction of the eublepharid gecko *Goniurosaurus* sp. Bulletin of the Chicago Herpetological Society **33**(7): 151-152.

Seufer, H., Y. Kaverkin & A. Kirschner (eds.) (2005): Die Lidgeckos. Karlsruhe (Kirschner und Seufer): 238 pp.

Stuart, B.L. & L.L. Grismer (2006): Captive breeding and a threatened gecko - response. Science **313**(5789): 915.

Vu, N.T., T.Q. Nguyen, L.L. Grismer & T. Ziegler (2006): First record of the Chinese leopard gecko, *Goniurosaurus luii* (Reptilia: Eublepharidae) from Vietnam. Current Herpetology **25**(2): 93-95.

Wang, Y.-Y., J.-H. Yang, & R.-F. Cui (2010): A New Species of *Goniurosaurus* (Squamata:

Eublepharidae) from Yingde, Guangdong Province, China. Herpetologica **66**(2): 229-240.

Wang, Y.Y., J.H. Yang & L.L. Grismer (2013): A new species of *Goniurosaurus* (Squamata: Eublepharidae) from Libo, Guizhou Province, China. Herpetologica **69**(2): 214-226.

Wang, Y.-Y., M.-J. Jin, Y.-L. Li, & L.L. Grismer (2014): Description of a New Species of *Goniurosaurus* (Squamata: Eublepharidae) from the Guangdong Province, China, Based on Molecular and Morphological Data. Herpetologica **70**(3): 309-322.

Wang, K., J. Ren, H. Chen, Z. Lyu, X.G.K. Jiang, J. Chen, J. Li, P. Guo, Y. Wang & J. Che (2020): The updated checklists of amphibians and reptiles of China. Biodiversity Science **28**(2): 189-218.

Yang, J.H. & B.P.L. Chan (2015): Two new species of the genus *Goniurosaurus* (Squamata: Sauria: Eublepharidae) from southern China. Zootaxa **3980**(1): 67-80.

Yang, J. & Y. Wang (2019): *Goniurosaurus liboensis*. The IUCN Red List of Threatened Species 2019: e.T98392722A98392725.

Zhu, X.-Y., G.-Y. Chen, C. Román-Palacios, Z. LiI & Z.-Q. He (2020): *Goniurosaurus* gezhi sp. nov., a new gecko species from Guangxi, China (Squamata: Eublepharidae). Zootaxa **4852**(2): 211-222.

Zhu, X.Y., Y.-J. Liu, Y. Bai, C. Román-Palacios, Z. Li & Z.-Q. He (2021): *Goniurosaurus chengzheng* sp. nov., A New Species of Leopard Gecko from Guangxi, China (Squamata: Eublepharidae). Zootaxa **4996**(3): 540–554.

Ziegler T, H. Rösler, H.W. Herrmann & V.N. Tanh (2002): *Cyrtodactylus phongnhakebangensis* sp. n., ein neuer Bogenfingergecko aus dem annamitischen Karstwaldmassiv, Vietnam. Herpetofauna **24**:11-25.

Ziegler, T. (2012): Erforschung und Erhalt der Artenvielfalt: Neue Wege des Kölner Zoos in Südostasien. Zeitschrift des Kölner Zoos **55**(3): 111-130.

Ziegler, T. & T.Q. Nguyen (2019): Herpetological Research and Conservation in Vietnam and Laos in compliance with the One Plan Approach. Proceedings of the 4th national scientific conference on amphibians and reptiles in Vietnam. Thanh Hoa: Hong Duc University, Hanoi: Institute of Ecology and Biological Resources: 17-26.

Ziegler, T., Q.T. Nguyen, A. Schmitz, R. Stenke & H. Rösler (2008): A new species of *Goniurosaurus* from Cat Ba Island, Hai Phong, northern Vietnam (Squamata: Eublepharidae). Zootaxa **1771**(1): 16-30.

Christian Langner & Felix Hulbert (26.07.2021)

***Goniurosaurus yingdeensis* group**				
Species	**Description author and date**	**Common name English**	**Common name German/ Chinese/ Vietnamese**	**Known in the trade**
Goniurosaurus gollum	Qi, Wang, Grismer, Chen, Lyu & Wang, 2020	Gollum tiger gecko	Gollum Tigergecko / 广东睑虎 guǎng dōng jiǎn hǔ”	No
Goniurosaurus varius	Qi, Grismer, Lyu, Zhang, Li & Wang, 2020	Nanling tiger gecko	Nanling Tigergecko / 南岭睑虎	No
Goniurosaurus yingdeensis	Wang, Yang & Cui, 2010	Yingde tiger gecko	Yingde Tigergecko / 英德睑虎	Yes
Goniurosaurus zhelongi	Wang, Jin, Li & Grismer, 2014	Zhe-Long’s tiger gecko	Zhe-Longs Tigergecko / 蒲氏睑虎	Likely

The *Goniurosaurus yingdeensis* group is the latest described of the four monophyletic groups within the genus *Goniurosaurus* (Yang & Chan 2015). Two new species, *Goniurosaurus varius* and *Goniurosaurus gollum,* have been scientifically described in November 2020 as members of this group (Qi *et al.* 2020a & Qi *et al.* 2020b), which was after the inclusion of *Goniurosaurus* spp. from China and Vietnam in CITES Appendix II.

The CITES listing covers all (also future) species occurring in China and Vietnam as defined in the listing proposal. This reference was made in anticipation of the fact that the taxonomy of closely related species within the genus is ongoing and that the discovery of additional cryptic species is to be expected (CITES 2019).

The identification of each species by means of morphological features is not easy due to the intraspecific phenotypic variability. Therefore, the DNA analysis is the most secure way to identify species (Shuo Qi, pers. comm. 2021).

Fig. 12a: *Goniurosaurus yingdeensis* (S. Qi);
b: *Goniurosaurus yingdeensis* juvenile (S. Qi);
c: *Goniurosaurus zhelongi* (S. Qi);
d: *Goniurosaurus zhelongi* juvenile (S. Qi);
e: *Goniurosaurus varius* without the nuchal stripe (S. Qi);
f: *Goniurosaurus varius* stripeless variant (S. Qi);
g: *Goniurosaurus gollum* holotype (S. Qi);
h: *Goniurosaurus gollum* (S. Qi).

Morphology and Taxonomy

The *Goniurosaurus yingdeensis* group can be distinguished from the other mainland group *inter alia* by the claw base which is covered by four scales from which the two lateral ones are shorter and cupped. In the G. *lichtenfelderi* group and the *G. luii* group the claw base is

also covered by four scales but the two lateral scales are long and curved. In the *G. yingdeensis* group the number of precloacal pores in ♂♂ is lower than 15 and the pores do not extend into the femoralia, the *G. lichtenfelderi* group has 17–46 precloacal pores and the *G. luii* group has 16–33. In contrary, there are no precloacal pores in the Japanese *G. kuroiwae* group (Qi *et al.* 2020a).

The species *G. yingdeensis* and *G. zhelongi* share strong phenotypic similarities, but can be differentiated by the following features (Ngo *et al.* 2021):

Goniurosaurus yingdeensis – tubercle scales between the orbitals are present, 2–4 gular scales which border the postmental scale, 5–7 preorbital scales.

Goniurosaurus zhelongi – there are no tubercles between the orbitals, 4–6 gular scales which border the postmental, 7–9 preorbital scales.

Goniurosaurus gollum – this species can reach a total length of ca. 18 cm. The ratio between snout-vent to tail length is balanced. The original tail is usually slightly shorter than the SVL. Regenerated tails are usually shorter than the original tail. The species has 121–128 mid-body scales, 16–17 dorsal tubercle rows in the middle of the body. In ♂♂ 10–12 precloacal pores, in ♀♀ is missing.

The iris is orange, becoming noticeably darker to the side. The nuchal band and transverse dorsal bands lack dark spots. The development of the transverse bands is reduced, partially broken up and converging. Only the neck band and the first midbody band at armpit level are clearly visible. The one or two bands around midbody are sometimes indistinct or converge. The color of these bands does not deviate very much from the pinkish-brownish ground color, but presumably is more contrasty in the expected juvenile coloration. The species has large dark brown spots on the top of the head and dorsum. The dorsal side of the limbs are bright grey-brown with dark brown dots and beige tubercles. Also, the lateral tubercle tips are beige. The venter and the throat are pink. The tail has 9-10 white, sometimes faded, cross bands. The regenerated tail is shorter and with a marbling pattern. The species is only known from three specimens.

Goniurosaurus varius – the total length in this species is up to ca. 17 cm. This species has 101–110 mid-body scales, 21–24 dorsal tubercle rows in the middle of the body. The ♂♂ have 10 precloacal pores, in ♀♀ these are missing.

The iris is orange red with reduced net pattern. The dorsal bands and patterns are very variable, ranging from a clear banding pattern of five dorsal bands extending from the nuchal region to the pelvic region, to lack of the nuchal band or cross bands. There are even morphs, completely missing cross bands, resulting in a marbled pattern. If nuchal bands are present, they are interspersed with black spots. The other three species of the *G. yingdeensis* group have unmarbled cross bands. The bands are washed out of beige color. The ground color of the body, head and limbs is a reddish brown, which can vary in intensity. The tips of the flank's tubercles are beige, and some dorsal tubercle tips are also beige. The venter and the throat are pinkish.

Goniurosaurus yingdeensis – in this species the total length is up to ca. 19 cm. The species has 101–116 mid-body scales and 20–25 dorsal tubercle rows in the middle of the body. The ♂♂ have 10–13 precloacal pores which are distinctly less pronounced in ♀♀.

The iris is orange to grey, with a more distinct orange color towards the pupil. Sometimes the iris can be completely grey. The nuchal and dorsal bands do not have dark spots. The cross bands are also in adult specimens clearly recognizable since they are surrounded by a dark brown fringe which is usually wider than the beige transversal bands. The juveniles show

more contrast in color than adults. Hatchlings have, after the first shedding, an orange head and limbs and a dark brown dorsum. The nuchal band is white, and the dorsal bands are orange. The tail is black grey in ground color with washed bands (Einsfelder 2016). Similar to other species of the family Eublepharidae, hatchlings lack a pattern, with exception of the bands, and develop the patterns with age. The dots develop into larger dark brown spots which are distributed over the head and back. The ground color of adults is bright grey to grey brown with dark brown spots and beige tubercle tips, which are contrasty at the flanks and on the limbs. The original tail has 9–10 white partly fading cross bands. Regenerated tails are significantly shorter and have a marbled pattern. The venter is grey with reduced, but visible spots.

Goniurosaurus zhelongi – this species can attain a total length of 18 cm. The species has 99–109 midbody scales and 23–28 dorsal tubercle rows in the middle of the body. In ♂♂ 9–12 precloacal pores are present, which are missing in ♀♀.

The iris is orange to greyish with a pronounced net pattern. The dorsal bands are well recognizable, as in *G. yingdeensis*, since they are surrounded by a dark brown fringe which is usually wider than the yellow beige cross band. The ground color of adults is bright grey to grey brown with dark brown spots and beige to grey white tubercle tips. The venter is pale grey with less spots. Juveniles have a brighter color. The head and limbs of juveniles are initially without spots and are colored bright orange. Cross bands yellowish-orange, lined with black on both sides. The basic dorsal color is initially darker (see Wang *et al.* 2014). With reaching maturity, the color between the bands brightens and appears more orange. Dorsal spots on the head and neck, spreading down the back and legs are present. It is assumed that with age the pattern and contrast in color decreases and specimens get a darker appearance.

Distribution and Habitat

Distribution

All representatives of the *Goniurosaurus yingdeensis* group originate from the Guangdong province in China.

***Goniurosaurus gollum*:** type locality: Near Zhaoqing, Huaiji region, Guangdong Province, China. Due to the conservation status of the species, no exact locality data was provided.

Goniurosaurus varius: type locality in Nanling National Nature Reserve Yangshan (ca. 560 m asl) near the city of Chengjia Yao, Yangshan region, Guangdong Province, China.

Goniurosaurus yingdeensis: type locality at 137 m asl near the village of Guoshanyao near Yingde city, Guangdong province, China.

Goniurosaurus zhelongi: type locality in Shimentai National Nature Reserve (184 m asl) Yingde, Guangdong Province, China.

Habitat

Both, *G. varius* and *G. gollum* have been only found in limestone karst regions, whereas *G. yingdeensis* and *G. zhelongi* have been also found in granite stone. The habitats are situated in primary forests or old secondary forests.

The microhabitats of many *Goniurosaurus* species are characterized by rock cuts, crevices, caves, or sinkholes and sometimes are located near streambeds (Grismer *et al.* 1999, Nguyen *et al.* 2009, Orlov *et al.* 2008, Wang *et al.* 2010, Zhou *et al.* 2018, Ziegler *et al.* 2008).

Despite the few knowledges available on *Goniurosaurus gollum*, from which only three specimens are known to the science, it is assumed that is a cave dwelling species since specimens were found 50 m deep from the entrance of a cave (Qi *et al.* 2020b). The other species of this group were also found in cave entrances, but also in rocky habitats which met the microhabitat requirements. A specimen of the type series of *G. varius* was found run over as a road casualty (Qi *et al.* 2020a).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 27).

EU Council Regulation (EC) No. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Goniurosaurus zhelongi: Endangered (B1ab(v), assessed May 10, 2018);

Goniurosaurus yingdeensis: Critically Endangered (B1ab(iii), assessed May 08, 2018);

Goniurosaurus gollum and *Goniurosaurus varius*, which were at the end of 2020 first described, have not yet been evaluated in the IUCN Red List. However, it is expected that due to their very small distribution range and the few data available, they would meet the criteria of being critically endangered.

Threats

The results of numerous studies from China (Luo *et al.* 2016, Qi *et al.* 2020), but also from other regions such as Malaysia (Grismer *et al.* 2016) have shown that karst habitats are not only hotspots of diversity and endemic species, but that these habitats are also endangered to a particularly high degree themselves. At the same time, they belong to the less protected regions of the earth (Day & Urich 2000). The discovery of further species in the karst region of northern Guangdong highlighted the importance of protecting this unique habitat (Qi *et al.* 2020).

It has been found that *G. yingdeensis* was excessively collected for the pet trade and that the species' habitat was destroyed due to the construction of a dam for drinking water (Wang 2019). It is predicted that *G. zhelongi* will become threatened by the collection for the pet trade (Yang & Wang 2019) which is also expected for the other two representatives of this group.

Reproduction

Topic	Data
Secondary sexual traits	No sex dichromatism was found in any of the four species in this group. Both

Topic	Data
	sexes show the same coloring pattern and variations, but a clear sexual dimorphism is noticeable. In ♂♂ the postcloacal region, where the hemipenis bulges are, is swollen, ♀♀ just have a slight swelling. *Goniurosaurus gollum*: ♂♂ 10–12 precloacal pores; ♀♀ none; *Goniurosaurus varius*: ♂♂ 10 precloacal pores; ♀♀ none; *Goniurosaurus yingdeensis*: ♂♂ 10–13 precloacal pores; ♀♀ can have less pronounced precloacal pores; *Goniurosaurus zhelongi*: ♂♂ 9–12 precloacal pores; ♀♀ none.
Reproduction	Oviparous, the eggs have a soft shell and are buried in the substrate.
Sexual maturity	From 18 months old.
Nesting season	*Goniurosaurus yingdeensis*: April–June.
Number of eggs/ clutches per season	*Goniurosaurus yingdeensis*: 2 eggs per clutch; minimum 3 clutches per season.
Egg size/ hatchling size	*Goniurosaurus yingdeensis*: egg size 22 x 12 mm. Directly after hatching 22 x 18 mm and 3.8 g, hatchling size 76–77 mm.
Incubation	55–65 days.
Temperature dependent sex determination	No data available, but likely.
Sperm storage	Yes.

Husbandry and Captive Breeding

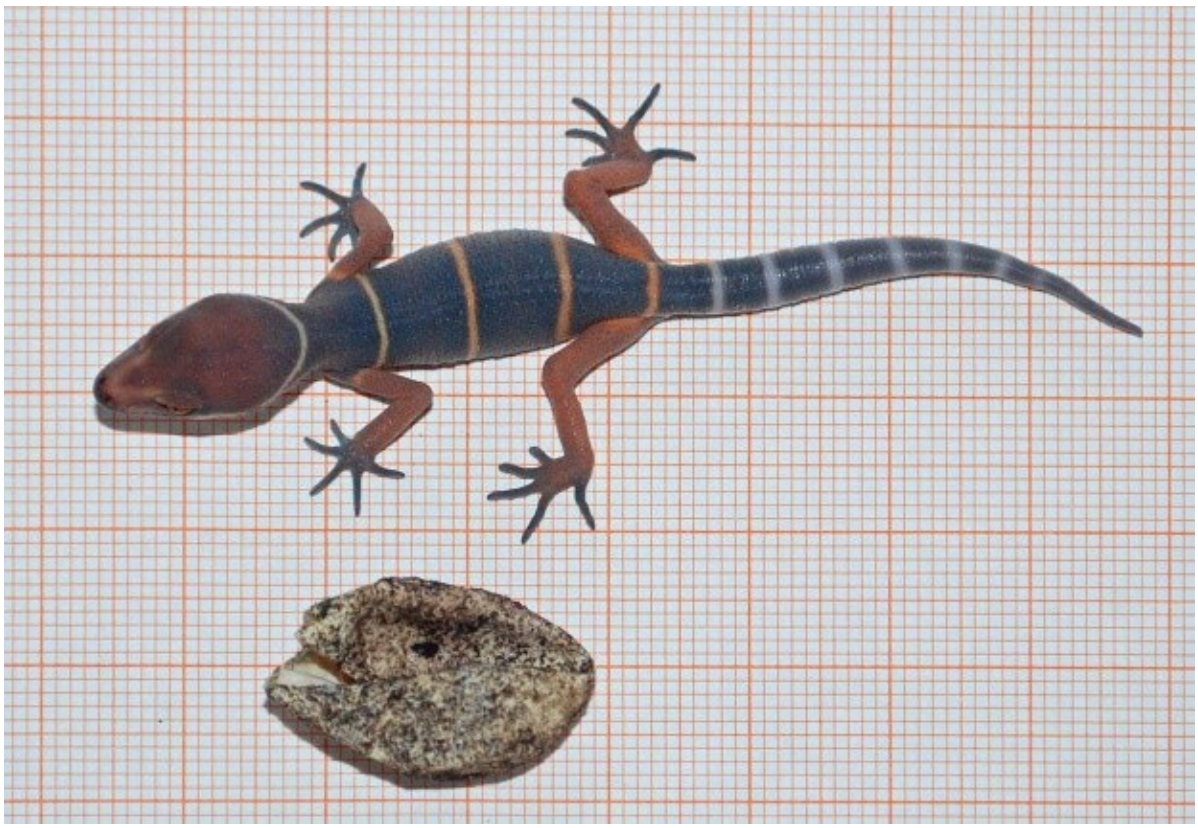

Fig. 13 *Goniurosaurus yingdeensis* hatchling before first shedding of the skin (L. Einsfelder).

Regarding husbandry and captive breeding of the species of this group, there is only data available for *G. yingdeensis.* Although it has been reported that *G. zhelongi* is often collected (Yang & Wang 2019), the presence of the species European and American market could not be proven. Probably the species is mainly collected for local national use or only exported in low numbers. However, it cannot be ruled out that morphologically similar species have been imported under a wrong name. The species of this group have similar habitat requirements; thus, it is assumed that husbandry requirements are similar as well, and therefore all species of this group are considered to breed well in captivity under the respective conditions.

Topic	**Data for *Goniurosaurus yingdeensis***
Trigger for reproduction	A reduction in temperature and humidity during the winter months has a positive influence on the reproduction behavior. A reduction of the duration of lighting from 12 hours during the summer months to 8–10 hours during the winter months also stimulates reproduction.
Husbandry requirements	The minimum space requirements for keeping reptiles (Federal Ministry for Food, Agriculture and Forestry 1997) are for ground-dwelling gecko species 4 x 3 x 2 (L x W x H) the size of snout-vent-length, which should be urgently revised. This results in a minimum terrarium size of 40 x 30 x 20cm. A terrarium with such a small size is to be used as quarantine or for rearing juveniles, only. Terrariums of 80 x 50 x 50 cm are considered to be of acceptable dimensions. The terrarium should be moist and dense in plants according to natural habitats. Forest soil and sand, partially covered with leaf-litter is recommended as substrate. Branches and rocks, which should be fixed to avoid slipping, can be used for climbing. As hiding places, cork pieces and unglazed clay bowls can be used. For egg laying and to avoid difficulties when shedding, a wetbox filled with moist Sphagnum is recommended. Plants and additional sprinkling are important for the necessary microclimate. Temperature during summer months should be 26–28°C and during winter, from October to March, the animals can be kept in cooler temperatures, which corresponds to natural temperature fluctuations in their distribution range. Artificial rocks have been proven to suit as back wall which provide extra space for their nocturnal activity. Specimens are strictly nocturnal and only come out of their hiding place in the dark. They prefer elevated places to scan the surroundings for insects which are captured with a targeted short sprint (Einsfelder 2016). Various invertebrates such as crickets, grasshoppers, cockroaches, *Zophobas* larvae, mealworms, wax moth caterpillars and woodlice serve as food. The food should be supplemented with the commercially available mineral and vitamin supplements. Fresh water in a bowl should always be available, as well as a bowl with grated cuttlefish.
General characteristics, difficulties with keeping and breeding	If the climatic requirements are fulfilled, tiger geckos of the genus *Goniurosaurus* can be kept and bred well in captivity.
Care of the young, technical and time effort	Hatchlings and juveniles should initially be kept separately or together with their siblings in glass terrariums or plastic boxes. The setup of the terrariums can be purposefully designed, but it has to comply with the climatic conditions. Juveniles tend to dehydrate, and caves of baked clay have proven to be good hiding places since they provide a good microclimate (Einsfelder 2016). Ground substrate should be a mixture of forest soil and sand, as for the adults. *Epipremnum* shoots serve well as plants since they do not require much care. Juveniles should be fed 3 times a week with correspondingly smaller insects, which should always be supplemented with mineral and vitamin powder.

Topic	Data for *Goniurosaurus yingdeensis*
Life expectancy in captivity	*G. yingdeensis*: at least 10 years. 2–3-year-old adults, acquired in 2015, reproduced in 2021 and still are in good health.
Frequency of breeding in captivity	*Goniurosaurus yingdeensis* is relatively frequently bred in captivity and offered for sale. There are small breeding groups distributed among some successful breeders in Europe and the USA, so it can be assumed that this species can be preserved for terrarium keeping.
Breeding difficulty evaluation	If the climatic requirements are met, the breeding of *Goniurosaurus yingdeensis* is unproblematic. It can be assumed that the husbandry requirements for the other species of this group are similar and thus, also unproblematic to breed and keep.
F2 generation bred	Yes.
Interviews/ Surveys/ Consultations	Several private breeders.

References

Chen, T.-B., Y.-J. Meng, K. Jiang, P.-P. Li, B.-H. Wen, W. Lu, J. Lazell & M. Hou (2014): New Record of the Leopard Gecko *Goniurosaurus araneus* (Squamata: Eublepharidae) for China and habitat partitioning between geographically and Phylogenetically Close Leopard Geckos. IRCF Reptiles & Amphibians **21**(1): 16-27.

Day, M.J. & P.B. Urich (2000): An assessment of protected karst landscapes in Southeast Asia. Cave and Karst Science **27**: 61-70.

Einsfelder, L. (2016): Haltung und Nachzucht von *Goniurosaurus yingdeensis* (Sauria: Gekkota: Eublepharidae) im Terrarium. Sauria **38**(4): 19-26.

Grismer, L.L., B.E. Viets & L.J. Boyle (1999): Two new continental species of *Goniurosaurus* (Squamata: Eublepharidae) with a phylogeny and evolutionary classification of the genus. Journal of Herpetology **33**(3): 382–393.

Grismer, L.L., P.L. Wood, S. Anuar, H.R. Davis, A.J. Cobos & M.L. Murdoch (2016): A new species of karst forest Bent-toed Gecko (genus *Cyrtodactylus* Gray) not yet threatened by foreign cement companies and a summary of Peninsular Malaysia's endemic karst forest herpetofauna and the need for its conservation. Zootaxa **4061**(1): 1-17.

Luo, Z.H., S.H. Tang, Z.G. Jiang, J. Chen, H.X. Fang & C.W. Li (2016): Conservation of terrestrial vertebrates in a global hotspot of karst in southwestern China. Scientific Reports **6**: 25717.

Nguyen, V.S., T.C. Ho & Q.T. Nguyen (2009): Herpetofauna of Vietnam. Frankfurt (Edition Chimaira): 768 pp.

Orlov, N.L., S.A. Ryabov, N.T. Tao, N.Q. Truong & H.T. Cuc (2008): A new species of *Goniurosaurus* (Sauria: Gekkota: Eublepharidae) from North Vietnam. Russian Journal of Herpetology **15**(3): 229-244.

Qi, S., L.L. Grismer, Z.-T. Lyu, L. Zhang, P.-P. Li & Y.-Y. Wang (2020): A definition of the *Goniurosaurus yingdeensis* group (Squamata, Eublepharidae) with the description of a new species. ZooKeys **986**: 127-155

Qi, S., Wang, L.L. Grismer, H.-H. Chen, Z.-T. Lyu & Y.-Y. Wang (2020): The Stoor Hobbit of Guangdong: *Goniurosaurus gollum* sp. nov., a cave-dwelling Leopard Gecko (Squamata, Eublepharidae) from South China. ZooKeys **991**: 137-153.

Yang, J. & Y. Wang (2019): *Goniurosaurus zhelongi*. The IUCN Red List of Threatened Species 2019: e.T98393682A98393729.

Wang, K., J. Ren, H. Chen, Z. Lyu, X. Guo, K. Jiang, J. Chen, J. Li, P. Guo, Y. Wang & J. Che (2020): The updated checklists of amphibians and reptiles of China. Biodiversity Science **28**(2): 189-218.

Wang, Y.-Y., J.-H. Yang & R.-F. Cui (2010): A new species of *Goniurosaurus* (Squamata: Eublepharidae) from Yingde, Guangdong Province, China. Herpetologica **66**(2): 229-240.

Wang, Y.-Y., J.-H. Yang & L.L. Grismer (2013): A New Species of *Goniurosaurus* (Squamata: Eublepharidae) from Libo, Guizhou Province, China. Herpetologica 69 (2): 214-226.

Wang, Y.-Y., M.-J. Jin, Y.-L. Li & L. L. Grismer (2014): Description of a New Species of *Goniurosaurus* (Squamata: Eublepharidae) from the Guangdong Province, China, based on Molecular and Morphological Data. Herpetologica **70**(3): 309-322.

Wang, Y. (2019): *Goniurosaurus yingdeensis*. The IUCN Red List of Threatened Species 2019: e.T18917797A18917801.

Yang, J.H. & Chan, B.P.L. (2015): Two new species of the genus *Goniurosaurus* (Squamata: Sauria: Eublepharidae) from southern China. Zootaxa **3980**(1): 67-80.

Yang, Z.H. & Y. Wang (2019): *Goniurosaurus zhelongi*. The IUCN Red List of Threatened Species 2019: e.T98393682A98393729.

Zhou, R. B., N. Wang, B. Chen & B. Liang (2018): Morphological evidence uncovers a new species of *Goniurosaurus* (Squamata: Eublepharidae) from the Hainan Island, China. Zootaxa **4369**(2): 281-291.

Ziegler, T., N. Q. Truong, A. Schmitz, R. Stenke & H. Rösler (2008): A new species of *Goniurosaurus* from Cat Ba Island, Hai Phong, northern Vietnam (Squamata: Eublepharidae). Zootaxa **1771**(1): 16-30.

Felix Hulbert & Christian Langner (02.05.2021)

Gekkonidae

Gekko gecko and *Gekko reevesii*				
Species	**First description, author, date**	**Common name English**	**Common name German**	**Known in trade**
Gekko gecko	(Linnaeus, 1758)	Tokay gecko, Tuctoo, Tokeh-tokeh	Tokeh, Panthergecko	yes
Gekko reevesii	Gray 1931	Reeves' Tokay gecko	Reeve‘s Tokeh	yes, but often not with the correct species name

Fig. 14a: *Gekko gecko*, Bago Yoma, Myanmar (F. Hulbert);
b: *Gekko gecko*, captive bred animal (F. Hulbert);
c: *Gekko gecko* ♂, Climate Campus, Allwetterzoo, Münster (Ch. Langner);
d: *Gekko gecko*, Bali, Indonesia (A. Kwet).

Adult tokays are impressive animals. ♂♂ can get 36.5 cm in total length and 18.5 cm in snout-vent length. The tail is 18 cm long in 200 g individuals. ♀♀ are smaller in size and get 15.5 cm snout-vent length in 130 g individuals. Since tokays are paid on by weight, in the Traditional Chinese medicine, they are commonly overfed, while some reports mention individuals that weigh 300 g (Caillabet 2013). Other reports on specimens with 400 g individuals (e.g., Koch 1964) could not be confirmed.

The most prominent characteristic of this species is its call, which can be defined as a growl followed by “To-Keh” several times (Brillet & Paillette 1991). The unique “To-Keh” call can be

used to confirm the presence of the species, even if the animal itself cannot be directly observed (Ling 2007). The call of *Gekko gecko* males can be easily distinguished from that of *G. reevesii,* however the authors are not aware of any published sound recordings or sonagrams of the territorial calls of males of *G. reevesii*.

Fig. 15a: *Gekko reevesii* (W. Grossmann);
b: *Gekko reevesii*, mating pair in the terrarium (W. Grossmann);
c: *Gekko reevesii*, Quang Ninh Province, northern Viet Nam (M. van Schingen-Khan);
d: *Gekko reevesii*, Quang Ninh Province, northern Viet Nam (M. van Schingen-Khan).

Gekko reevesii Gray 1831, from North Vietnam and South China had been synonymized with *G. gecko* by Mertens (1955) without any justification, but was considered as a separate species by Rösler *et al.* (2011). *G. reevesii* was explicitly included in the CITES listing proposal for *Gekko gecko* (CITES 2019).

Morphology and Taxonomy

Gekko gecko – the ground color of the dorsum varies individually and is also depending on the geographic origin. It ranges from bright to dark grey to bluish. Seven bright bands of dots cross the dorsum from the neck to the tail. The color of these dots can be white, grey, or greenish white. Yellow, orange blood-red or brownish-red spots are present between the bands. Usually, red dots are present on top of the head, frequently forming a Y-shape. The oral mucosa is black, the eyes are round with a vertical pupil and an amber colored iris, which sometimes is reddish-brown or brown. The venter is whitish, beige blue- or greenish white with yellowish, orange red or reddish-brown dots that partially or entirely cover the venter. The dorsum of the hatchlings is dark grey or blackish in color with white dotted bands. Hatchlings often show contrasting white and dark cross bands on the tail. The red dots become more prominent with age.

Tokay geckos are able of autotomy and can lose their tail when threatened. The new grown tail has a different color, is smooth and does not reach the original length. Significantly pronounced tubercle scales are characteristic for the tokay gecko. In other species of the *Gekko* genus, the tubercles are usually flatter and not that conspicuous.

The subspecies *G. g. azhari* (Mertens 1955) was described due to the presence of black instead of red dots. There are also monochromatic individuals which are bright blue (Grossmann 1987; Grossmann & Simon 2014), white, bright grey, yellow, beige, bright brown, brownish and black (Grossmann 2004). Some specimens change their coloration with age, and get irregularly scattered dark brown or white dots ("Calico") (Simon & Grossmann 2013). All the known color morphs have been initially found in wild specimens; unfortunately, no exact geographic data of origin were reported in such cases. Other color morphs, such as albinos are known from captive breeding, but are rarely offered.

Gekko verticillatus De Rooij 1915 (according to breeding reports from Tatzelt 1912) is considered as a synonym of *Gekko gecko*.

Gekko reevesii – in the original description, these geckos are characterized as being black with cross bands of white dots with dark and relatively large tubercle scales – the correct generic name Gekko is included elsewhere in the text, but not in the diagnosis. *Gekko reevesii* Gray 1831 from North Vietnam and South China was synonymized with *G. gecko* by Mertens (1955) and re-validated by Rösler *et al.* (2011). The species is slightly smaller and slimmer than the red dotted tokay (Zhang *et al.* 2014), however it is still a large gecko species with a snout vent length of 150 mm (adults) with a proportionately large head. The ground color is greyish brown to greenish and the dorsal dots are reddish brown to dark brown. The dots are usually arranged in rows or cross bands. The tail has prominent black and white cross bands. The species differs from *G. g. azhari* (which also lacks red spots) by having protruding tubercle scales and by being larger in size. The territorial calls are characteristic for *G. reveesii*. At the initial growl (gnarl) the pulses are separated by clearer pauses than in *G. gecko*. The voiced calls, i.e., the second phase of the calls, are frequency modulated, and the syllables are also separated by more distinct silent pauses (Yu *et al.* 2011). Neighboring males can be recognized by their calls, and as a response, they call more often.

Species complex

Genetic studies point out that *Gekko gecko* incl. *G. reevesii* probably form a species complex, i.e., consisting of more than the two yet described species mentioned above, however no detailed taxonomic analyses have been undertaken to date. It is necessary that the genetic differences of the local forms are considered for conservation measures to ensure the maintenance of the genetic diversity among different populations (Kongbutad *et al.* 2016).

A comprehensive revision of the phylogenetic relations of the two morphologically completely different genera *Ptychozoon* and *Luperosaurus* with *Gekko* showed close genetic relations between them. Thus, both genera *Ptychozoon* and *Luperosaurus,* are interpreted as synonyms of the genus *Gekko*, which currently includes more than 80 species (Wood *et al.* 2020).

Distribution and Habitat

Distribution

It is not possible to clearly define the natural distribution range of *Gekko gecko,* as this synanthrope species has also been spread by humans. Bangladesh, Bhutan, China, Democratic Republic of Laos, India, Indonesia, Cambodia, Malaysia, Myanmar, Nepal, Philippines, Thailand, Timor-Leste and Vietnam are considered countries of origin. It is not possible to clarify whether the populations on the Andaman Islands and Taiwan are actually autochthonous or introduced through human influence.

Introduced populations are known from Guadeloupe and other Central American countries, Hong Kong, Madagascar, Martinique, Singapore, and USA (Florida and Hawaii). Genetic studies revealed that the tokay geckos introduced into Florida originate from different countries (Fieldsend *et al.* 2021).

Terra typica: “habitat in Indiis” since the type is missing, the terra typica is restricted to the Island of Java, Indonesia, based on Linné’s work (Mertens 1963).

G. reevesii occurs in southern China (Fujian, Guangdong, Guangxi, and Yunnan provinces) and northern Vietnam (up to the Quang Binh province) (Zhang *et al.* 2014). The type locality is “China” (Rösler *et al.* 2011).

The potential distribution range for both species based on the Maxent-Modell was predicted by Zhang *et al.* (2014). Both species are allopatric, even though red dotted tokays that probably escaped from captivity have been found within the distribution range of the black dotted tokay.

Habitat

The original habitats of *G. gecko* are tropical lowland forests with karst cliffs near the coast (Yu *et al.* 2014). Tokay geckos are not found above 1,000 m of altitude. This species prefers vertical structures and thus, also inhabits rock walls. Due to their high adaptability, they are also found in big cities such as in Chiang Mai in northern Thailand (Grossmann 2004), where they forage for insects attracted by the city lights (Aowphol *et al.* 2006). Tokays may even sometimes feed on waste or juvenile rats (Bucol & Alcala 2013) and are hunted by cats (Bucol 2019).

Little is known about the habitat of *Gekko reevesii* since the species has often not been considered as a separate taxon from *G. gecko.* Yu *et al.* (2011) provides a similar habitat description as for *Gekko gecko.* Zhang *et al.* (2014) noted that *G. reevesii* inhabits areas with lower daily and seasonal temperature fluctuations than *G. gecko.* However, the distribution area of this species also corresponds to the so-called “cold tropics” of Asia (Wissmann 1939) where the boundaries of the tropical seasonal frost events occur. *G. reevesii* has been found in houses of remote villages situated in evergreen forests, but not in big cities.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 28). *Gekko reevesii* was considered as synonym of *Gekko gecko* for conservation purposes under CITES, and thus the following protection status is valid for both species.

Council Regulation (EC) No. 338/97 Annex: B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Gekko gecko: Least Concern (assessed May 24, 2017);

Gekko reevesii: Least Concern (assessed October 24, 2017).

Threats

The main threat to the species is harvest for human consumption. Tokay geckos are dried or soaked in alcohol (rice liquor) and used in the Traditional Chinese medicine (Altherr 2010, Wagner & Dittmann 2014).

Gekko reevesii also known as “blackspotted gecko”, is considered to be more effective than *Gekko gecko* in the Traditional Chinese medicine which makes it is more expensive and thus the threat of illegal hunting may be greater (Su *et al.* 2020).

The use of tokays in the Traditional Chinese medicine has led to high prices and increased imports of living specimens and their products (i.e., dried tokays) (Cunningham & Long 2019). Tokay geckos are not only locally consumed (Kasper *et al.* 2020), but are also of international interest. According to the CITES trade database 1.575.379 wild-caught specimens and 11.000 specimens with the source code “F” from Indonesia were exported to China and Hongkong in 2019 (UNEP-WCMC 2020). In the same year, 2010 living wild caught specimens were imported into the EU and 3741 into Japan and Korea. Ardiantoro & Kurniawan (2021) consider that these specimens that were exported from Indonesia before the CITES listing, were most likely wild caught.

In China there are attempts to domesticate and breed Tokay geckos (Liang *et al.* 1985), however this is still not working in practice which was confirmed by the reports of Nijman & Shepherd (2015) on the plausibility of breeding in Indonesia. The high density of specimens in such farms and the stress during transport frequently causes outbreaks and spreading of pathogens: Hence, imported animals are often infected upon arrival at the country of destination (Casey *et al.* 2015).

The wild populations are further threatened by habitat loss due to timber extraction (Lwin *et al.* 2019).

Reproduction

Topic	Data
Secondary sexual traits	Adult ♂♂ are larger and heavier than ♀♀. In sexual mature ♂♂ a row of 10–24 precloacal pores as well as the hemipenis bulges are present.
Reproduction	Oviparous. The eggshell is hard, and the two eggs are firmly adhered to the surface, and often they stick to each other, too.
Sexual maturity	In captivity, often after 1 year. Sometimes earlier if fed very well.
Nesting site/ season	A pair of eggs is adhered to vertical surfaces and preferably in crevices. Nesting sites are repeatedly used and often shared with related females (communal nesting), so that over time conspicuously large accumulations of empty eggshells can form. Oviposition takes place during the rainy season in natural habitats. In captivity, reproduction all year round, however a dry period is recommended to simulate a resting period.
Number of eggs/ clutches per season	Almost always two eggs per clutch, and up to five clutches per year are possible. When females are permanently kept with a male, they eventually try to lay more eggs. This should be avoided, since the reserves of the female may become depleted, which can lead to egg binding.
Egg size/ hatchling size	The eggs are of spherical in shape 35–19 x 19–23 mm; the hatchlings are 5–7.5 cm (including tail).
Incubation	95–200 days.
Sex determination	Genetic sex determination: XX/XY (Solleder & Schmidt 1984). It is likely that in G. *reevesii,* temperature dependent sex determination occurs, and that mainly females hatch when the clutch is placed at a cool site. However, this could not be verified in captivity.
Sperm storage	Females that were kept separated from males during some weeks could lay fertilized eggs.

Husbandry and Captive Breeding

The call of *Gekko gecko* is one of the loudest reptile vocalization and males can call persistently during the night. For this reason, males are often kept individually in a terrarium room or free in tropical houses in zoos, and therefore, few detailed data on husbandry and captive breeding was available.

The husbandry and captive breeding of *Gekko reevesii* has not been reported separately. This species is considered as “Tokays of the northern distribution range of Vietnam” in literature (Grossmann 2004, p.45). Husbandry and captive breeding requirements of *Gekko reevesii* are considered similar to that of *Gekko gecko.*

Topic	Data for *Gekko gecko* sensu lato
Trigger for reproduction	Increase in humidity. In captivity, a pause of one or two months with reduced light and humidity is recommended so that the females get a resting period.
Husbandry requirements	The minimum space requirements for keeping a pair (Federal Ministry for Food Agriculture and Forestry 1997) are 108 x 108 x 144 cm (L x W x H). However, Kober (2002) recommends 100 x 50 x 120 cm. Vertical structures that offer hiding places are required. Day temperature should be 25–32°C and lower during night, but not below 18°C. During night, a high humidity is required, thus it should be sprayed in the evenings. A “rain forest” terrarium setup with robust plants is recommended. Fresh water should always be available. It is possible to keep tokays in terrarium rooms, where they can freely move and forage. However, they should be fed a variety of food insects from tweezers additionally. This is a common practice in zoos. They can also be fed occasionally with baby mice, but this results in softer and smelly feces. There is no need of extra UV light for these geckos which are active during night. The water used for spraying should be complemented with vitamin and minerals. Some keepers feed low fat fruit yogurt, mixed with the food supplements, which tokays usually like to eat.

Topic	Data for *Gekko gecko* sensu lato
General characteristics, difficulties with keeping and breeding	Tokays can be kept in pairs or in groups of related females with one male. Males are aggressive towards each other, as are unrelated females often, too. Tokays have a very elaborated social behavior which should be considered. The eggs are guarded by females or by both parents. The young are also protected by both parents. Usually, related individuals stay together. Often a house is inhabited by one tokay family, where the territories overlap and where females often share the same nesting site (communal nesting).
Care of the young, technical and time effort	No special difficulties. The young hatch in the same terrarium as their parents and get their intestinal flora from the feces of adults. At the age of six months, the young should be separated from the adults to avoid that the adult male considers the young males as rivals and chases them.
Necessary safety measures	Tokays are very susceptible to stress and usually bite, thus any unnecessary handling should be avoided. Bites from adult males can result in wounds that eventually need medical attention and may have to be sewed (Grossmann 2004).
Life expectancy in captivity	Usually up to 20 years. The reported maximum is > 25 years.
Frequency of breeding in captivity	Very frequently.
Breeding difficulty evaluation	If the keeping requirements are met and the animals are adapted to their environment, breeding is easy. Adaptation of the individuals can take up to two years, and during this time no eggs are laid.
Mortality in the first years of life	Very low, if the young are separated from the adults at the right time.
F2 generation bred	Yes. The first breeding report was published in 1942 (Dathe 1942). It is not clear whether the offspring described by Senfft (1928) had already been bred in captivity.
Interviews/ Surveys/ Consultations	Several private breeders and 4 zoological institutions. Many breeders, who were contacted, did not fill in the questionnaire and instead referred to the publications. These data have been included.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Altherr, S. (2010): Traditionelle chinesische Medizin und internationaler Artenschutz. Chinesische Medizin/ Chinese Medicine **25**(4): 200–213.

Aowphol, A., K. Thirakhupt, J. Nabhitabhata & H.K. Voris (2006): Foraging ecology of the Tokay Gecko, *Gekko gecko* in a residential area in Thailand. Amphibia-Reptilia **27**(4): 491-503.

Ardiantoro, A., A. & N. Kurniawan (2021): Evaluation on the Legal Trade of Tokay gecko (Lacertidae; Gekkonidae; *Gekko gecko* Linnaeus, 1758) in Indonesia. Journal of Tropical Life Science **11**(1): 93-100.

Brillet, C. & M. Paillette (1991): Acoustic signals of the nocturnal lizard *Gekko gecko*; analysis of the "long complex sequence". Bioacoustics **3**(1): 33-44.

Brodský, O. (1969): Breeding the great house gecko *Gekko gecko* at Prague Zoo. International Zoo Yearbook **9**: 37-39.

Bucol, A. & A. Alcala (2013): Tokay gecko, *Gekko gecko* (Sauria: Gekkonidae) predation on juvenile house rats. Herpetolology Notes **6**: 307-308.

Bucol, L.A. (2019): Predation of Tokay Gecko (*Gekko gecko*) by domestic cat (*Felis catus*) in Siquijor Island, Philippines. SE Asia Vert Records (SEAVR 2019): 19-20.

Caillabet, O. (2013): The trade in Tokay Geckos in South-East Asia: with a case study on Novel Medicinal Claims in Peninsular Malaysia. TRAFFIC Malaysia, 44 pp.

Casey, C.L., S.M. Hernandez, M.J. Yabsley, K.F. Smith & S. Sanchez (2015): The carriage of antibiotic resistance by enteric bacteria from imported tokay geckos (*Gekko gecko*) destined for the pet trade. Science of the Total Environment 505: 299-305.

CITES (2019): CoP18 Proposal 28, *Gekko gecko*. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

Cunningham, A.B. & X. Long (2019): Linking resource supplies and price drivers: Lessons from Traditional Chinese Medicine (TCM) price volatility and change, 2002-2017. Journal of Ethnopharmacology 229: 205-214.

Dathe, H. (1942): Zur Geburt eines Panthergeckos (*Gekko gecko* L.). Der Zoologische Garten (N.F.) **14**: 211–212.

Fieldsend, T., K. Krysko, P. Sharp & T.M. Collins (2021): Provenance and genetic diversity of the non-native geckos *Phelsuma grandis* Gray 1870 and *Gekko gecko* (Linnaeus 1758) in southern Florida, USA. Biological Invasions (in press), https://doi.org/10.1007/s10530-021-02463-1.

Grossmann, W. (1987): Über einen ungewöhnlich gefärbten Tokeh aus Thailand - ein *Gekko gecko* (Linnaeus, 1758)? Sauria **9**(4): 19-20.

Grossmann, W. (2004): Der Tokeh, *Gekko gecko*. Münster (Natur und Tier Verlag): 64 pp.

Grossmann, W. & G. Simon (2014): Tokeh-Morphen, *Gekko gecko* (Linnaeus, 1758) sensu lato im Terrarium. Teil 2: Blauköpfige Grüne". Sauria **36**(2): 21-35.

Hemmer, H. & R. Schipp (1970): Zum Beutefangverhalten des Tokehs (*Gekko gecko* L.). Zeitschrift für Tierpsychologie **27**(5): 591-609.

Janssen, J. & S.L. Chng (2018): Biological parameters used in setting captive-breeding quotas for Indonesia's breeding facilities. Conservation Biology 18(1): 18-25.

Kaiser, H. & M. O'Shea (2020): Skyfall: an Extreme Case of Male-Male Aggression in Tokay Geckos (Gekkonidae: *Gekko gecko*) on Ataúro Island, Timor-Leste. Herpetology Notes **13**: 969-971.

Kasper, K., J. Schweikhard, M. Lehmann, C.L. Ebert, P. Erbe, S. Wayakone, T.Q. Nguyen, M.D. Le & T. Ziegler (2020): The extent of the illegal trade with terrestrial vertebrates in markets and households in Khammouane Province, Lao PDR. Nature Conservation **41**: 25-45.

Kober, I. (2002): Tokehs im Terrarium: besser als ihr Ruf. Reptilia **7**(36): 43-49.

Koch, H. (1964): Haltung und Zucht von Tokehs, *Gekko gecko*. Aquarien Terrarien, Leipzig, **11**(4): 111-113.

Kongbuntad, W., C. Tantrawatpan, W. Pilap, K. Jongsomchai, T. Chanaboon, P. Laotongsan, T.N. Petney & W. Saijuntha (2016): Genetic diversity of the red-spotted tokay gecko (*Gekko gecko* Linnaeus, 1758) (Squamata: Gekkonidae) in Southeast Asia determined with multilocus enzyme electrophoresis. Journal of Asia-Pacific Biodiversity 9: 63-68.

Liang, Q., D. Tang & S. Liu (1985): Studies on the growth of *Gekko gecko*. Acta Herpetologica Sinica **4**(4): 344-348.

Ling, R. (2007): File: Mating call of a male Tokay gecko (Gekko gecko) https://en.wikipedia.org/wiki/File:Mating_call_of_a_male_Tokay_gecko_(Gekko_gecko).ogg.

Lwin, K., T. Neang, S. Phimmachak, B. Stuart, W. Thaksintham, G. Wogan, P. Danaisawat, D. Iskandar, J. Yang & B. Cai (2019): *Gekko gecko*, Tokay gecko. The IUCN Red List of Threatened Species 2019: e.T195309A2378260.

Mertens, R. (1955): Über eine eigenartige Rasse des Tokehs (*Gekko gecko*) aus Ost-Pakistan. Senckenbergiana Biologica **36**: 21-24.

Nguyen, T.Q., B. Cai & J. Yang (2021): *Gekko reevesii*, Reeves' Tokay Gecko. The IUCN Red List of Threatened Species 2021: e.T104717831A104718941.

Nijman, V. & C.R. Shepherd (2015): Adding up the numbers: an investigation into commercial breeding of Tokay Geckos in Indonesia. TRAFFIC Malaysia, 9 pp.

Petzold, H.-G. (1963): Beobachtungen und Erfahrungen bei der Zucht des Tokehs (*Gekko gecko*) (L.). Der Zoologische Garten (N.F.) **27**: 194–202.

Rösler, H. (1995): Geckos der Welt - Alle Gattungen. Urania, Leipzig, 256 pp.

Rösler, H. (2001): Studien am Tokeh: 1. *Gekko gecko azhari* Mertens 1955 (Sauria: Gekkonidae). Gekkota **3**: 33-46.

Rösler, H. (2005): Studien am Tokeh: 2. Intraspezifische Variation der südostasiatischen Populationen von *Gekko gecko* (Linnaeus, 1758) (Sauria: Gekkonidae). Gekkota **5**: 65-149.

Rösler, H., A.M. Bauer, M.P. Heinicke, E. Greenbaum, T.R. Jackman, Q.T. Nguyen & T. Ziegler (2011): Phylogeny, taxonomy, and zoogeography of the genus *Gekko* Laurenti, 1768 with the revalidation of *G. reevesii* Gray, 1831 (Sauria: Gekkonidae). Zootaxa **2989**: 1-50.

Schmidt, A. (1954): Pflege und Zucht des Tokeh's *Gekko gecko*. Deutsche Aquarien- und Terrarienzeitung **7**(9): 243-246.

Senfft, W. (1928): Aufzucht von *Gekko gecko* Linné. Aquar. Charlottenburg. **1928**: 207-209.

Simon, G. & W. Grossmann (2013): Tokeh-Morphen, *Gekko gecko* (Linnaeus, 1758) sensu lato im Terrarium. Teil 1: "Calico"-Tokehs. Sauria **35**(4): 37-52.

Solleder, E. & M. Schmid (1984): XX/XY-Sex Chromosomes in Gekko gecko (Sauria, Reptilia). Amphibia-Reptilia 5 (3-4): 339-345

Su, Y., D. Ding, M. Yao, L. Wu, G. Dong, D. Zhang, S. Chen & L. Xiang (2020): Specific DNA mini-barcoding for identification of *Gekko gecko* and its products. Chinese Medicine **15**: Article No. 103.

Tatzelt, G. (1912): *Gecko verticillatus* Laur., ein ideales Terrarientier. Blätter für Aquarien- & Terrarienkunde 23: 288-290.

Treu, B. (2008): Gute Absichten bringen nicht immer erwünschte Resultate: ungewöhnliche Haltung einer Großfamilie des Tokehs. Sauria **30**(2): 45-46.

Ulber, T. & E. Ulber (1987): Auf der Mauer, auf der Lauer - Erfahrungen mit der Zimmerhaltung von verschiedenen Geckos. Sauria **9**(2): 7-12.

UNEP-WCMC (2020): CITES Trade Database. https://trade.cites.org/en/cites_trade/ (accessed 14.03.2021).

Wagner, P. & A. Dittmann (2014): Medicinal use of *Gekko gecko* (Squamata: Gekkonidae) has an impact on agamid lizards. Salamandra **50**(3): 185-186.

Whitaker, R. & Z. Whitaker (1978): Breeding of the Tokay gecko. Journal of the Bombay Natural History Society **75**(2): 499-500.

Wood, P.L., X. Guo, S.L. Travers, Y.-C. Su, K.V. Olson, A.M. Bauer, L.L. Grismer, C.D. Siler, R.G. Moyle, M.J. Andersen & R.M. Brown (2020): Parachute geckos free fall into synonymy: *Gekko* phylogeny, and a new subgeneric classification, inferred from thousands of ultraconserved elements. Molecular Phylogenetics and Evolution **146**: 106731.

Beate Pfau, Christian Langner & Felix Hulbert (31.03.2021)

Paroedura androyensis (Grandidier, 1867)

Grandidier's Madagascar ground gecko

German: Madagassischer Zwerg-Großkopfgecko

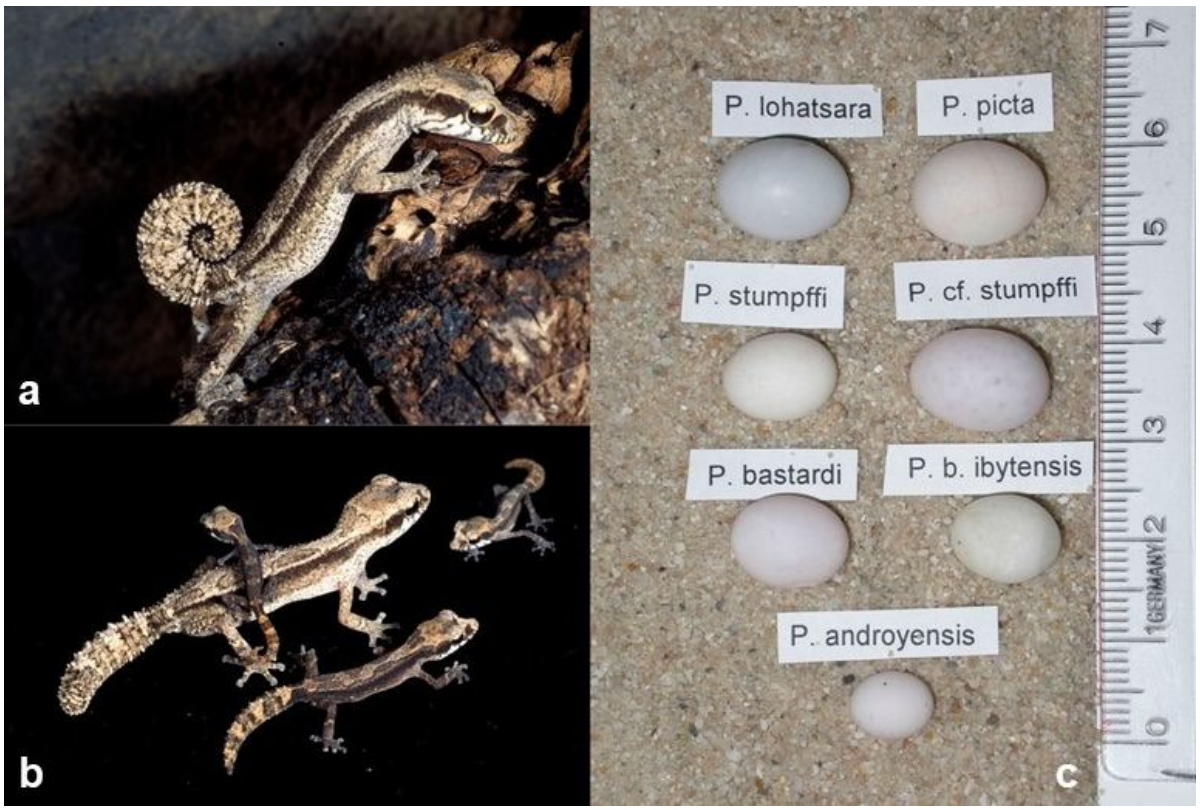

Fig. 16a: *Paroedura androyensis* showing tail curling with excitement (K. Glaw);
b: Captive bred *Paroedura androyensis* (K. Glaw);
c: Eggs of different *Paroedura* species for comparison (K. Glaw).

Morphology and Taxonomy

The species of the genus *Paroedura* Günther 1879 were for a long time placed in the genus *Phyllodactylus* Gray, 1828 before Dixon *et al.* (1974) transferred the Malagasy species to the genus *Paroedura*. According to current knowledge, the members of the genus *Phyllodactylus* belong to different families (this is not yet represented in CITES-nomenclature). For example, the European leaf-toed gecko (*Euleptes europaeus*), which was formerly also assigned to the genus *Phyllodactylus*, was not integrated into the family Phyllodactylidae (leaf-toed geckos), which was established in 2008, but is placed within the Sphaerodactylidae. *Paroedura* is a genus within the family Geckonidae, the common geckos.

Nussbaum & Raxworthy (2000) divide the genus *Paroedura* into two clades. One of them is the "*picta* group" (including *P. androyensis, P. bastardi, P. maingoka, P. picta* und *P. vahiny*). The main feature of this clade is that nostril and rostral scales are not in contact. The species belonging to this group are typical for the dry and hot regions of south and southwest Madagascar.

The second clade is the "*sanctijohannis* group" (includes *P. sanctijohannis, P. gracilis, P. homalorhina, P. oviceps, P. stumpffi, P. masobe, P. karstophila, P. tanjaka* and *P. vazimba*). In these species, the nostril and rostral scales are in contact.

The species belonging to this groups are distributed in moist habitats in western central and east Madagascar as well as in the Comoros.

Paroedura androyensis is together with *P. vahiny* the smallest species of the genus. The geckos reach a SVL of 47 mm and a TL of 80 mm. The dorsal tubercles are medium sized and give the geckos a rough-skinned appearance. The venter is smooth. The rounded and broad short tail has the appearance of a caterpillar. The dorsal color is beige to dark brown with four beige markings which extend from the neck to the pelvic region, but not extend into the ventral region. The lips are white with dark stripes. The throat is white with a grey-brown net-shaped pattern. The juveniles have a beige head which sets off from the darker dorsal coloration. The tail has noticeable orange and dark color bands.

Paroedura vahiny, described by Nussbaum & Raxworthy in 2000, is a species morphologically very similar to *P. androyensis*. It can be distinguished by pholidosis and by its clearly smooth appearance and small size dorsal scales. Of this species, which is evidently only distributed in a very small area, the first description was based only on the type specimen.

Distribution and Habitat

Distribution

Paroedura androyensis occurs in two regions in south and southwest of Madagascar and has been recorded from Andrahomana, Cap Sainte Marie Isaka-Ivondro, Malahelo, Miray, Petriki, Sarorano, Tolagnaro, Tsivanoa and in Zombitse forests. Type locality: Sancta Maria, Madagascar (Cap Sainte-Marie)

Habitat

This nocturnal gecko is predominantly saxicolous and inhabits deciduous dry forests and rocky coast biotopes.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 30).

Council Regulation (EC) Nr. 338/ 97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Vulnerable (assessed 26 January 2011).

Threats

The greatest threat to the species is the rapid habitat loss, which takes place in Madagascar as in all tropical regions. The last relicts of dry forest in the south of Madagascar are rapidly disappearing. The remaining forests, which are of great importance for the variety in specialized and endemic species, belong to the most endangered biotopes on earth. The few remaining forests are concentrated in small, protected areas. Logging and land grabbing for a rapidly increasing population are the main threats to remaining habitats. A further problem, which has become extreme in the past few years is the noticeable impact of climate change in the south of Madagascar. The region, which has a low rainfall anyway, has experienced increasingly extreme droughts in recent years. Due to its small distribution range and the rapid habitat loss, *Paroedura androyensis* is extremely threatened.

In the past, the collection for the pet trade was an additional threat. Like the only other species in the genus, *Paroedura masobe* is subject to international protection regulations.

Reproduction

Topic	Data
Secondary sexual traits	*Paroedura androyensis* has no visible sexual dimorphism. ♂♂ can be differentiated by the swollen tail basis (hemipenis bulges).
Reproduction	Oviparous.
Sexual maturity	From one year of age and 6–7 cm total length.
Mating season	All year round.
Number of eggs/ clutches per season	2 eggs; up to 3 clutches per year.
Hatchling size	Ca. 25 mm total length.
Incubation and hatching	Incubation 2–3 months at 25–27 °C; hatching rate 90 %; eggs were incubated between 25° and 27° C, dry with only light basic humidity. Both sexes were present.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	The animals lay eggs without special trigger all year round.
Husbandry requirements	Specimens can be kept in plastic boxes of 60 x 35cm area and 40cm high, the top should be covered with gauze. The terrarium should contain vertical cork pieces as well as a succulent plant, the substrate should be kept moist. Calcareous sand should be used as substrate. A part of the terrarium should be covered with forest earth and oak leaf litter. The terrarium should contain several branches, which are used by the geckos at night for climb. The terrarium should be kept dry with partially moist areas. The lighting and a temperature gradient can be achieved by using a 60 W spotlight. A calcareous supplementation is important during rearing of the young and for the gravid females.
General characteristics, difficulties with keeping and breeding	2 ♂♂ and 4 ♀♀ can be kept together due to the relatively large space in relation to the size of the geckos. In smaller terrarium only one male should be kept.
Care of the young, technical and time effort	Juveniles can be kept together in a terrarium with enough structures. Small food items such as micro-crickets, *Drosophila*, firebrats etc. should be supplied with high-quality food (gut-loading). When feeding, only the amount that is being fed on should be provided (better often feeding than too much at once). The food items should be supplemented with minerals and vitamins. The terrariums should be closed since juveniles are good climbers.
Life expectancy in captivity	Ca. 5 years.
Frequency of breeding in captivity	Rare, since the geckos are only kept by few keepers. First breeding in 2001; thereafter multiple times a year.
Breeding difficulty evaluation	Unproblematic, when the husbandry requirements are met. Breeding is in principle unproblematic, if dry conditions are met. High humidity can cause problems and result in juvenile mortality.
Mortality in the first years of life	No mortality in more than 20 captive-bred animals (according to the questionnaire survey).
F2 generation bred	Yes, since 2002.
Interviews	Several private breeders.

References

Angel, F. (1942): Les Lézards de Madagascar. Mémoires de l'Académie Malgache Fasc. 36. Tananarive (Pitot de la Beaujardière): 193 pp.

Aprea, G., F. Andreone, D. Fulgione, A. Petraccioli & G. Odierna (2013): Chromosomal rearrangements occurred repeatedly and independently during species diversification in Malagasy geckos, genus *Paroedura*. African Zoology **48**(1): 96-108.

Boulenger, G.A. (1896): Descriptions of new lizards from Madagascar. Annals and Magazine of Natural History **17**(102): 444-449.

Daoues, K. & F. Girard (2005): Note on a Malagasy shipment with geckos belonging to the genus *Paroedura* Günther. Gekko **4**(1): 6-7.

D'Cruze, N., A. Olsonn, D. Henson, S. Kumar & D. Emmett (2009): The Amphibians and Reptiles of the Lower Onilahy River Valley, a Temporary Protected Area in Southwest Madagascar. Herpetological Conservation and Biology **4**(1): 62-79.

Dixon, J.R. & J.C. Kroll (1974): Resurrection of the generic name *Paroedura* for the phyllodactyline geckos of Madagascar, and description of a new species. Copeia **1974**(1): 24-30.

Glaw, F., K. Schmidt & M. Vences (2003): Nachtgeckos aus Madagaskar. DATZ (Die Aquarien- und Terrarien-Zeitschrift) **56**(9): 6-11.

Glaw, F. & M. Vences (2007): A Fieldguide to the Amphibians and Reptiles of Madagascar (Third edition). Köln (Vences & Glaw Verlag): 496 pp.

Guibé, J. (1956): Revision des espèces malagaches du genre *Phyllodactylus* Gray. Mémoires de l'Institut Scientifique de Madagascar (Ser. A) **10**: 245-250.

Günther, A. (1879): On mammals and reptiles from Johanna, Comoro Islands. Annals and Magazine of Natural History (Ser. 5) **3**: 215-219.

Grandidier, A. (1867): Liste des reptiles nouveaux découverts, en 1866, sur la côte sud-ouest de Madagascar. Revue et Magazine de Zoologie (Paris), Sér. 2, **19**: 232-234.

Hawlitschek, O. & F. Glaw (2013): The complex colonization history of nocturnal geckos (*Paroedura*) in the Comoros Archipelago. Zoologica Scripta **42**(2): 135-150.

Jackman, T.R., A.M. Bauer, E. Greenbaum, F. Glaw, F. & M. Vences (2008): Molecular phylogenetic relationships among species of the Malagasy-Comoran gecko genus *Paroedura* (Squamata: Gekkonidae). Molecular Phylogenetics and Evolution **46**(1): 74-81.

Koubova, M., P.M. Johnson, M. Rovatsos, K. Farkacova, M. Altmanova & L. Kratochvil (2014): Sex determination in Madagascar geckos of the genus *Paroedura* (Squamata: Gekkonidae): are differentiated sex chromosomes indeed so evolutionary stable. Chromosome Research **22**(4): 441-452.

Liebel, K., M. Meyer & W. Schmidt (2004): Die Madagassischen Grosskopfgeckos (*Paroedura*). Draco **5**(2) (18): 28-39.

Main, H., D.P. Scantlebury, D. Zarkower & T. Gamble (2012): Karyotypes of two species of Malagasy ground gecko (*Paroedura*: Gekkonidae). African Journal of Herpetology **61**(1): 81-90.

Nussbaum, R.A. & C.J. Raxworthy (2000): Systematic revision of the genus *Paroedura* Gunther (Reptilia: Squamata: Gekkonidae), with the description of five new species. Miscellaneous Publications Museum of Zoology University of Michigan **189**: 1-26.

Rabibisoa, N., J. Rafanomezantsoa & N.A. Rakotondrazafy (2011): *Paroedura androyensis* - Grandidier's Madagascar Ground Gecko. The IUCN Red List of Threatened Species 2011: e.T172822A6924613.

Rösler, H. (2000): Kommentierte Liste der rezent, subrezent und fossil bekannten Geckotaxa (Reptilia: Gekkonomorpha). Gekkota **2**: 28-153.

Schönecker, P. (2008): Geckos of Madagascar, the Seychelles, Comoros and Mascarene Islands [Geckos Madagaskars, der Seychellen, Komoren und Maskarenen]. Terralog Vol. 12. Frankfurt (Edition Chimaira): 147 pp.

Schönecker, P. (2017): Die madagassischen Großkopfgeckos der Gattung *Paroedura*. Reptilia (Münster) **22**(125) 14-23.

Starostova, Z., L. Kubicka & L. Kratochvil (2010): Macroevolutionary pattern of sexual size dimorphism in geckos corresponds to intraspecific temperature-induced variation. Journal of Evolutionary Biology **23**(4): 670–677.

Christian Langner (27.06.2021)

Sphaerodactylidae

Gonatodes daudini Powell & Henderson, 2005

Union Island gecko, Grenadines clawed gecko

German: Daudins Zwerg-Gecko/ Union Island-Zwerggecko

Fig. 17a: *Gonatodes daudini* mating pair (L. Sotornik);
b: *Gonatodes daudini* in the terrarium (L. Sotornik);
c: *Gonatodes daudini* ♀ in the terrarium with a freshly laid egg (L. Sotornik);
d: *Gonatodes daudini* hatchling still in the incubator (L. Sotornik).

Morphology and Taxonomy

Gonatodes daudini is one of five *Gonatodes* species, endemic to the Caribbean and was only scientifically described in 2005. It is a very small *Gonatodes* species with a pointy snout and a noticeable bright orange-red iris. The species can be separated from other congeners of the genus by the low number of mid-dorsal scales, which are also much larger than in other *Gonatodes* species. *Gonatodes daudini* has 39-44 dorsalia (versus 70 or more in other *Gonatodes* species). The body pattern is remarkable and colorful. These geckos have three characteristic pairs of white dots on the flanks which are concentrically surrounded first by a black, then by a red ring. These ocelli are lacking in other species. The SVL of the type specimen is 29.9 mm and the total length 55.4 mm. For the scientific description, only male specimens were available at the time (Powell & Henderson 2005). Thus, it was not clear that there is no

evident sexual dimorphism in this species, contrary to what usually is the case in other species of this genus. ♂♂ und ♀♀ of *Gonatodes daudini* are identically colored, while ♂♂ in other *Gonatodes* species are more colorful, and which have a more noticeable pattern than the brown colored ♀♀.

When *Gonatodes daudini* was described, this gecko was considered the only endemic *Gonatodes* species in the West Indies. The authors of the first description only mentioned about 20 species for the entire genus (Powell & Henderson 2005). In the meantime, it has been shown that other Caribbean islands, especially the Lesser Antilles, also have endemic *Gonatodes* species and that the diversity of the genus is significantly larger than assumed. By 2021, already 41 species had been described, more than doubling the number of species in the past 16 years since the description of *G. daudini.* Like all species of this genus, *G. daudini* is diurnal. In the slopes of Chatham Bay, *G. daudini* was found to be sympatric and syntopic with pygmy geckos of the species *Sphaerodactylus kirbyi.* Research on intraspecific interactions of both species showed no significant differences in the behavior repertoire of each species. Important intraspecific identification characteristics are the visual and olfactory stimuli. The olfactory stimuli are perceived by the vomeronasal organ or Jacobson's organ (Rivera Rodríguez *et al.* 2011). The genus *Gonatodes* has been placed in the family Sphaerodactylidae Underwood 1954, however, this family is not yet represented in CITES-nomenclature. Therefore, in the CITES-nomenclature and in the Council Regulation (EC) No 338/97, the species is placed within the family Gekkonidae.

Distribution and Habitat

Distribution

Gonatodes daudini is endemic to the Caribbean island Union Island, which is one of the southernmost islands of the nation Saint Vincent and the Grenadines. The island belongs to the Grenadines.

Habitat

Union Island has a surface of 8.1 km² and has the highest elevation of the Grenadines with 305 m asl and an average annual precipitation of 1.025 mm (Daudin 2003).

Howard (1954) describes the habitat where *Gonatodes daudini* had been found as flat and relatively dry, with secondary vegetation. Forests are open, with low vegetation of four and a half to ten meters high.

Fiard (2003) describes the species' habitat in the Water Rock Forest Reserve as "surprisingly lush for a dry island" with tree heights of 15–18 m and *Bursera simaruba, Pisonia fragrans, Lonchocarpus violaceus, Albizia caribaea,* and *Spondias mombin* as dominant species.

The small-scale distribution range seems to be limited to the remnants of the original dry highland forest. Powell & Henderson (2005) found the geckos under rotting tree trunks with litter and rocks interspersed on the ground.

Conservation Status and Main Threats

CITES-Appendix I since 2019 (CoP18 Proposal 29).

Council Regulation (EC) No. 338/97: Annex A.

In Germany particularly and strictly protected under BNatSchG [BG] Status: s.

IUCN Red List status: Critically Endangered (B1ab(iii)+2ab(iii), assessed February 16, 2019).

Threats

In the Caribbean, as everywhere in the tropics, the rapid habitat loss poses the greatest threat to the species. Building projects for tourism and other infrastructure, as well as agriculture are the principal causes for habitat loss. A further threat, which has increased in recent years, are the consequences of climate change. In the Caribbean region, hurricanes are occurring more frequently and becoming increasingly violent in their effects, causing large scale damage, devastating complete islands.

The species is particularly susceptible to habitat loss, due to its very small distribution area and is therefore extremely endangered. Dangerous incidents like hurricanes and forest fires could eventually cause the extinction of the species in the wild.

The collection for the pet trade poses a further serious and existential threat to this species. Since these attractive geckos are apparently easy to breed in captivity, this problem could be alleviated by creating a stable ex situ breeding stock. The establishment of a coordinated and scientifically supported conservation breeding program on an institutional basis could contribute to the preservation of the acutely endangered species, in order to build up a reserve population for reintroduction or population reinforcement, if the necessity arises after such a catastrophic event on that island.

Reproduction

Topic	Data
Secondary sexual traits	*Gonatodes daudini* is the only species of the genus with barely visible sexual dimorphism. ♂♂ are only recognizable by the strikingly bright scales on the venter near the cloaca.
Reproduction	Oviparous.
Sexual maturity	With one and a half years old.
Mating season	All year round.
Number of eggs/ clutches per season	Only 1 egg per clutch; 6–10 clutches per year.
Incubation and hatching	Incubation 100–110 days at 27–28 °C with a nighttime decrease to 23 °C. Hatching rate 100 %, hatchling size ca. 28 mm total length.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Egg deposition occurs all year round without special trigger.
Husbandry requirements	The geckos can be kept in pairs in terraria with a surface of 25 x 30 x 30 cm. Proper ventilation in the front and top of the terrariums should be provided. For the setup of the terrarium cork pieces, roots and branches should be used. Plant density in the terrarium should not be too high, in order to facilitate observation, control and finding the eggs. As substrate, a mixture of sand and fine pine bark, with a slightly moist area, is recommended. A small water bowl with fresh water should be continuously provided. Day temperature should be between 26 and 28 °C and can drop during nighttime to room temperature. During summer month, the terrarium should be shortly sprinkled every day. It is however important, that the terrarium can completely dry up again. During the winter months, the interval between spraying can be larger. LED lighting or fluorescent lamps can be used. A calcareous supply is important during rearing of the young and for the gravid females.
General characteristics, difficulties with keeping and breeding	Adult geckos can be kept together all year round from one year of age. With one and a half years they reach sexual maturity, and egg deposition (often unfertile in the first few clutches) starts.
Care of the young, technical and time effort	The juveniles can be kept individually in cricket boxes up to five months old. Small food items should be supplied with high-quality food (gut-loaded) such as micro-crickets, *Drosophila*, *Thermobia*, small isopods etc. It is important to feed just the amount that the juveniles can feed on immediately. The food items should be supplemented with minerals and vitamins. The terrarium boxes should close properly in order to avoid that the juveniles escape through small gaps.
Frequency of breeding in captivity	Rare, since these geckos are only kept by few keepers.
Breeding difficulty evaluation	If the mentioned requirements are met, breeding is unproblematic.
Mortality in the first years of life	Almost 0 %, all animals can reach adulthood, if no accidents happen.
F2 generation bred	Yes.
Interviews/ Surveys/ Consultations	Several private breeders and 1 commercial breeding company.

References

Bentz, E.J., M.J. Rivera Rodríguez, R.R. John, R.W. Henderson & R. Powell (2011): Population Densities, Activity, Microhabitats, and Thermal Biology of a Unique Crevice- and Litter-dwelling Assemblage of Reptiles on Union Island, St. Vincent and the Grenadines. Herpetological Conservation and Biology **6**(1): 40–50.

Daltry, J.C., R. Adams, G. Gaymes, F. Providence & R. Sweeney (2016): Union Island Gecko: Conservation Action Plan, 2016e2021. Report to the Saint Vincent & the Grenadines Forestry. Department, Fauna & Flora International, Union Island Environmental Attackers and Virginia Zoo.

Daltry, J.C., R. Powell & R.W. Henderson (2019): *Gonatodes daudini* - Union Island Gecko. The IUCN Red List of Threatened Species 2019: e.T194258A71748321.

Daudin, J. & M. de Silva (2007): An annotated checklist of the amphibians and terrestrial reptiles of the Grenadines with notes on their local natural history and conservation. Applied Herpetology **4**(2): 163-175.

Fiard, J.-P. (2003): The phytosociologic and dynamic outline of the main forestry groups of Union Island. Pp. 47-53. *In:* Daudin, J. (ed.): A Natural History Monograph of Union Island. Martinique, French West Indies (Désormeaux).

Gamble, T., A.M. Simons, G.R. Colli & L.J. Vitt (2008): Tertiary climate change and the diversification of the Amazonian gecko genus *Gonatodes* (Sphaerodactylidae, Squamata). Molecular Phylogenetics and Evolution **46**(1): 269-277.

Hailey, A., J.A. Horrocks & B. Wilson (2006): Conservation of insular herpetofaunas in the West Indies. Applied Herpetology **3**(3): 181-195.

Hedges, S.B. (2006): An overview of the evolution and conservation of West Indian amphibians and reptiles. Applied Herpetology **3**(4):281-292.

Henderson, R.W., & R. Powell. (2009): Natural History of West Indian Reptiles and Amphibians. Gainesville, Florida, USA (University Press of Florida).

Higham, T.E., T. Gamble & A.P. Russell (2017): On the origin of frictional adhesion in geckos: small morphological changes lead to a major biomechanical transition in the genus Gonatodes. Biological Journal of the Linnean Society **120**(3): 503-517.

Hluschi, D. (2009): Gonatodes - die unbekannten Juwelen der Neotropis. Reptilia (Münster) **14**(78): 16-23.

Howard, R.A. (1952): The vegetation of The Grenadines, Windward Islands, British West Indies. Contribution from the Gray Herbarium of Harvard University (**174**):1-129.

John, R.R., M.J. Rivera Rodriguez, E.J. Bentz, R.W. Henderson & R. Powell (2012): *Gonatodes daudini*. Catalogue of American Amphibians and Reptiles **895**: 1-2.

Krintler, K. (1982): Die Geckos der Gattung *Gonatodes* auf Trinidad und Tabago. DATZ (Die Aquarien- und Terrarien-Zeitschrift) **35**(9): 349-350.

Meiri, S., A.M. Bauer, A. Allison, F. Castro-Herrera, L. Chirio, G. Colli, I. Das, T.M. Doan, F. Glaw, L.L. Grismer, M. Hoogmoed, F. Kraus, M. LeBreton, D. Meirte, Z.T. Nagy, C. de C. Nogueira, P. Oliver, O.S.G. Pauwels, D. Pincheira-Donoso, G. Shea, R. Sindaco, O.J.S. Tallowin, O. Torres-Carvajal, J.-F. Trape, P. Uetz, P. Wagner, Y. Wang, Y., T. Ziegler & U. Roll (2017): Extinct, obscure or imaginary: the lizard species with the smallest ranges. Diversity and Distributions **24**(2): 262-273.

McTaggart, A.L., D.P. Quinn, J.S. Parmerlee, R.W. Henderson & R. Powell (2011): A Rapid Assessment of Reptilian Diversity on Union Island, St. Vincent and the Grenadines.: South American Journal of Herpetology **6**(1): 59-65.

Murphy, J.C. (1996): Crossing Bond's Line: The herpetofaunal exchange between the eastern Caribbean and mainland South America. Pp. 207-216.*In:* Powell, R. & R.W. Henderson: Contributions to West Indian Herpetology: A Tribute to Albert Schwartz. Contributions to Herpetology **12**. Ithaca, New York (Society for the Study of Amphibians and Reptiles).

Noseworthy, J. (2017): Cold-blooded Conflict: Tackling the Illegal Trade in Endemic Caribbean Island Reptiles (MS thesis). University of Cambridge, Cambridge, UK.

Powell, R. & R.W. Henderson (2005): A new species of *Gonatodes* (Squamata: Gekkonidae) from the West Indies. Caribbean Journal of Science **41**(4): 709-715.

Powell, R. & R.W. Henderson (2011): *Gonatodes daudini* (errata version published in 2017). The IUCN Red List of Threatened Species 2011: e.T194258A115333400.

Quinn, D.P., A.L. McTaggart, T.A. Bellah, E.J. Bentz, L.G. Chambers, H.D. Hedman, R.R. John, D.N. Muñiz Pagan & M.J. Rivera Rodríguez (2010): An annotated checklist of the reptiles of Union Island, St. Vincent and the Grenadines. IRCF Reptiles and Amphibians **17**(4): 222-233.

Rivas, G.A., G.N. Ugueto, W.E. Schargel, T.R. Barros, P. Velozo, & L.E. Sánchez (2013): A Distinctive New Species of *Gonatodes* (Squamata: Sphaerodactylidae) from Isla La Blanquilla, Venezuela, with Remarks on the Distribution of Some Other Caribbean Sphaerodactylid Lizards. South American Journal of Herpetology **8**(1): 5-18.

Rivera Rodríguez, M.J., E.J. Bentz, R.R. John & R. Powell (2011): Intraspecific and intergeneric behavioural interactions of *Sphaerodactylus kirbyi* and *Gonatodes daudini* (Squamata: Sphaerodactylidae) on Union Island, St. Vincent and Grenadines. Salamandra **47**(1): 9-16.

Rivero-Blanco, C. (1980): The Neotropical lizard genus *Gonatodes* Fitzinger (Sauria: Sphaerodactylinae). Ph.D. dissertation, Texas A&M University, College Station, Texas.

Rogner, M. (2010): *Gonatodes* und *Sphaerodactylus*: Terrarienhaltung und Vermehrung von Zwerggeckos. DATZ (Die Aquarien- und Terrarien-Zeitschrift) **63(**2): 58-62.

Shepherd, C.R., J. Janssen & J. Noseworthy (2019): A case for listing the Union Island Gecko *Gonatodes daudini* in the Appendices of CITES. Global Ecology and Conservation **17:** e00549.

Vanzolini, P.E. & E.E. Williams (1962): Jamaican and Hispaniolan *Gonatodes* and allied forms (Sauria, Gekkonidae). Bulletin of the Museum of Comparative Zoology **127**: 479-498.

Christian Langner (30.06.2021)

Serpentes

Viperidae

Pseudocerastes urarachnoides
Bostanchi, Anderson, Kami & Papenfuss, 2006

Spider-tailed viper

German: Spinnenschwanzviper

Fig. 18: *Pseudocerastes urarachnoides*, Ilam Province, Iran (G. Martínez del Mármol).

Morphology and Taxonomy

Total length: maximum 87.5 cm, of which 8 cm is the length of the tail. This species can be easily distinguished from other *Pseudocerastes* species, due to its characteristic tail tip ornamentation, which resembles a spider.

In comparison with the other two species of the genus *Pseudocerastes,* and to the closely related monotypic genus *Eristicophis, P. urarachnoides* is rough scaled throughout the body. Thus, the species may be only confused with other species as hatchling, when the scales are still smooth and when the characteristic tail appendage is not yet completely developed.

The ground color is greyish brown with 4–6 rows of brown spots. The middle of the dorsum is partially bright cream colored. The two central rows of spots on dorsum sometimes merge together and form a transversal dorsal spot. These are partially surrounded with a dark line. Hatchlings can sometimes be reddish colored instead of the usual brownish ground color. Juveniles lack dorsal spots.

The appearance of this species is ragged, and it merges with the rugged calcareous rocky underground of their habitat in the Zagros mountains. This appearance is due to the strongly pronounced keels of the dorsal scales with tubercle shaped end, as well as due to their color. Compared to *P. fieldi* and *P. persicus*, the dorsal scales of *P. urarachnoides* are more sharply keeled. Another striking character are the scales with small horns above the eyes, as well as overall keeled or tubercle-like head scales. The most prominent characteristic is the spider-shaped tail end. The last pair of dorsal and ventral tail scales form a button-like thickening that resembles the posterior part of a spider (Opisthosoma), while the lateral and dorsolateral scales are elongated and mimic the spider legs.

Thanks to successful breeding as well as field and lab studies, this unique characteristic has been very well documented (Fathinia *et al.* 2015). Like in rattle snakes, hatchlings are born without this characteristic tail feature, which develops further with every shedding. By each shedding, the distal scales get thicker and the extended scales get longer. The button-like thickening of the tail tip reaches a length of approx. 12 mm and the individual elongated scales approx. 14 mm (Fathinia *et al.* 2015). These can be found up to halfway down the tail.

The unique tail of *Pseudocerastes urarachnoides* is used to lure their prey. By gently moving their tail, the attention of their prey is attracted. “Caudal luring” is a known hunting behavior, which may also be displayed by other snake species. However, none of the other snake species have such a uniquely developed tail and perfect mimicry. While the snake lays perfectly camouflaged with the ground color, it positions its tail close to the head. The snake gently moves its tail end, which usually has a different color, imitating a moving spider to lure birds. It strikes extremely fast on its prey which is quickly killed by the injected venom. This behavior has been extensively documented with video and photos (Fathinia *et al*. 2009, Fathinia *et al*. 2015). The venom of *Pseudocerastes* is cytotoxic and leads to edema and local necrosis. It is a similar venom to that of European vipers. Recent studies have shown that the venom of *Pseudocerastes fieldi* has a strong neurotoxic component and the venom of *Pseudocerastes urarachnoides* produces strong blood clotting disorder. These clear differences within the genus are thought to be due to ecological adaptations, triggered by the prey specialization of the spider-tailed horned viper. The venom of *Pseudocerastes urarachnoides* is very effective in birds and toads whereas the venom of *Pseudocerastes fieldi* and *Pseudocerastes persicus* has only a mild effect on birds. Further studies are needed to determine the paraspecificity of an antidote and to draw ecological conclusions on the effect of the diet (op den Brouw 2021).

Fig. 19a: *Pseudocerastes urarachnoides* hatchling, F2 generation (M. Egli);
b: Mating of *Pseudocerastes urarachnoides*, ♀ above, ♂ below (M. Egli).

Distribution and Habitat

Distribution

The distribution of *Pseudocerastes urarachnoides* is limited to the western foothills of the Zagros Mountains. Originally, the species was described from the Iranian provinces Ilam, Kermanshah and isolated areas in Khuzestan. Meanwhile, new distribution areas were found in the eastern Iraq provinces Diyala and Wasit (Al-Sheikhly *et al.* 2019; 2020). Recent ecological modelling studies suggest possible isolated distribution areas in the Kurdistan region north of Iraq (Fathinia *et al.* 2020). Other sites are expected in western Iran. Due to the political instability in the Kurdish part of Iraq and the border region between Iraq and Iran, few information on the local herpetofauna is available.

The closely related species *Pseudocerastes persicus* occurs partly syntopic with the spider-tailed viper (Fathinia & Rastegar-Pouyani 2010; Bok *et al.* 2017). However, contrary to *Pseudocerastes urarachnoides*, it inhabits a wider range of habitats.

Habitat

The species inhabits hilly and rocky regions, usually formed by calcareous or gypsum sediment. Due to erosion, the species habitat is characterized by many cracks and crevices and sparse vegetation. The snakes usually wait in ambush near a bush or small tree. Adults mainly feed on birds; whereby migratory birds are their main prey (Fathinia *et al.* 2015). Presumably, the juveniles feed on small lizards.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 32).

Council Regulation (EC) No. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN red List status: Data Deficient (assessed December 14, 2014).

DOE (Department of Environment, Tehran): Endangered (November 2018).

Threats

Due to the species' unclear distribution and the hidden way of life, it is not entirely possible to estimate the extend of threats to this species. The species has been classified as "Data Deficient" in the IUCN Red List (Anderson & Papenfuss 2009). The Department of Environment, Tehran, Iran, has classified the species as "Nationally Endangered Species" (DOE 2018). It has been pointed out that the pet market and the presence in herpetoculture could pose a threat to the species (Martínez del Mármol *et al.* 2016; CITES 2019).

It is assumed that *Pseudocerastes urarachnoides* has a larger distribution range than currently known (Bok *et al.* 2017), which is also supported by the recent findings in east Iraq (Al-Sheikhly *et al.* 2019; 2020). However, recent niche modeling by Fathinia *et al.* (2020) predict that the habitat in eastern Iraq and in the west of Iran could become dramatically threatened as a consequence of climate change. Potential future suitable habitats, eastwards of the known distribution range, do not yet appear to be populated by the species (Fathinia *et al.* 2020). This leads to a mismatch between the current and the predicted future suitable habitats (Fathinia *et al.* 2020). Due to the difficult access to the species habitat within its known range and the further east climatically suitable regions, the known distribution range may increase in the future, as well as the knowledge on this unique species.

Reproduction

Topic	Data
Secondary sexual traits	In ♂♂, the postcloacal region is slightly swollen due to the hemipenis pockets, leading to a smooth transition from the body to the tail. In contrast, ♀♀ have a thinner tail base, clearly differentiating the tail from the body. The tail of ♂♂ is slightly larger than that of ♀♀.
Reproduction	Oviparous.
Sexual maturity	At the age of 4 years, with a total length of ca. 70 cm.
Mating season	After hibernation.
Number of eggs/ clutches per season	8–10 eggs/ 1 clutch per year.
Gestation period	Currently unknown. 63–75 days in *Pseudocerastes fieldi* (Scholz *et al.* 2020).
Egg size/ hatchling size	No data on egg size available/ hatchlings < 20 cm (Fathinia *et al.* 2015).
Incubation and hatching	Incubation ca. 50 days at 30 °C, hatching rate 100 %.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	To trigger reproduction, a hibernation period is required. It should last 3 to 4 months, similar to the requirements of the other *Pseudocerastes* vipers (Scholz *et al.* (2020).
Husbandry requirements	According to the minimum requirements valid in Germany (Federal Ministry for Food Agriculture and Forestry 1997), the minimum size of the terrarium should be 1.25 x 0.75 x 0.75 (L x W x H) the size of total length. This results in minimum size of 110 x 65 x 65 cm for adults. This recommendation refers to the keeping of a pair. For each further individual, 20 % of the volume should be added. In principle, these requirements are to be considered as the absolute minimum size. As for other species, for the spider-tailed viper the setup of the terrarium with sufficient structure is very important. Specimens should be kept in a dry terrarium with similar setup to their natural habitat with large rocks. A coarse gravel-stone mixture is suitable as substrate. There is no need for plants, but dry branches and roots should be integrated to be used as ambush places by the snakes. Fluorescent tubes (T5 with an electronic ballast unit) are used for lighting, and a spotlight as heating source is necessary. Ambient temperatures should range between 24 °C to 28 °C, and 40 °C should be reached under the spotlight. Lower nighttime temperatures in spring and autumn should be provided. A hibernation period, lasting several months, is crucial for stimulating reproduction. Temperatures during hibernation should be 10–12 °C. For oviposition, but also to avoid possible shedding difficulties, the use of a so-called wetbox, which is a hiding place filled with slightly moistened sphagnum (peat) moss, is recommended. Mice and chicks are accepted as food. Commonly, juveniles refuse feeding as it is the case in other viper species. Force-feeding with baby mice can help in these situations. After a few forced-feeds, specimens start to accept baby mice. It has been reported in another *Pseudocerastes* species that the acceptance for

Topic	Data
	slightly hairy young mice is higher than for naked baby mice (Scholz *et al.* 2020). Specimens are easily irritable when handled, but otherwise are not sensitive to stress.
General characteristics, difficulties with keeping and breeding	No specific difficulties. It is not necessary, but if a second male is kept in the terrarium to stimulate mating, it should be removed after the ritualized fighting.
Safety requirements	The general safety requirements and the partially existing keeping restrictions in different German federal states, or in other countries, for the keeping of venomous snakes must be considered. There is no specific antiserum for the species. Due to the significant difference between the venom of *Pseudocerastes urarachnoides* and that of the closely related species *P. persicus* and *P. fieldi*, there are serious concerns on the use of existing polyvalent antiserums (op den Brouw 2021). A bite of this species should be considered dangerous. The bitten area should not be moved. No tourniquet should be applied, because it could create further damage. The patient should be brought to a hospital where the symptoms should be treated. The patient should stay under observation for at least 12 hours.
Care of the young, technical and time effort	Time requirements varies. Careful observation of the snake's accounts for the main time effort. The initial rejection of feed by the juveniles poses a difficulty. Security measures should be taken.
Frequency of breeding in captivity	Very rare
Breeding difficulty evaluation	Unproblematic. However, there is still not much experience with this species.
Number of individuals that reach maturity	Ca. 90 %.
Age and/ or size at first reproduction	Ca. 70 cm, at about 4 years old.
Life expectancy in captivity	Unknown, possibly 25–35 years.
F2 generation bred	Yes, but only recently. The F1 had probably been bred already in 2015 (unverified data), the F2 was bred in 2019 and 2020.
Interviews/ Surveys/ Consultations	Several private breeders. This species is also being kept in a European zoo. A further private breeder published the breeding success in social media only.

References

Al-Sheikhly, O.F., A.N. Al-Barazengy & M.L. Al-Haideri (2019): Erstnachweis der Iranischen Spinnenschwanzviper *Pseudocerastes urarachnoides* Bostanchi, Anderson, Kami & Papenfuss, 2006 (Serpentes: Viperidae) im Irak. Sauria **41** (3): 43-46.

Al-Sheikhly, O.F., M.K. Haba, H.O. Al-Rikabi & M.L. Al-Haideri (2020): Neue Fundorte der Iranischen Spinnenschwanzviper *Pseudocerastes urarachnoides* (Serpentes: Viperidae) im Irak. Sauria **42**(3): 73-76.

Anderson, S.C. & T. Papenfuss (2009): *Pseudocerastes urarachnoides*. The IUCN Red List of Threatened Species 2009: e.T164664A5916336.

Böhme, W. & T. Koppetsch (2020): Wann wurde das Seitenwinden wüstenbewohnender Vipern erstmals beschrieben? Und war die Spinnenschwanz-Viper (*Pseudocerastes*

urarachnoides Bostanchi *et al.*, 2006) vielleicht schon fast 2000 Jahre vorher bekannt? DGHT Sekretär 20: 81-89.

Bok, B., M. Berroneau, M. Yousefi, J. Nerz, F. Deschandol, M. Berroneau & L. Tiemann (2017): Sympatry of *Pseudocerastes persicus* and *P. urarachnoides* in the western Zagros Mountains, Iran. Herpetology Notes **10**: 323-325.

Bostanchi, H., S.C. Anderson, H.G. Kami, & T.J. Papenfuss (2006): A new species of *Pseudocerastes* with elaborate tail ornamentation from Western Iran (Squamata: Viperidae). Proceedings of the California Academy of Sciences **57**(14): 443-450.

Chefaoui, R. M., M. S. Hosseinzadeh, M. Mashayekhi, B. Safaei-Mahroo, & S. M. Kazemi (2018): Identifying suitable habitats and current conservation status of a rare and elusive reptile in Iran. Amphibia-Reptilia **39**(3): 355-362.

CITES (2019): CoP18 Proposal 32, *Pseudocerastes urarachnoides*. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

David, P. & G. Vogel (2010): Venomous Snakes of Europe, Northern, Central and Western Asia. Terralog Vol. 16. Frankfurt (Edition Chimaira): 164 pp.

DOE (2018): Spider-tailed horned viper was declared endangered by the DOE, Department of Environment Islamic Republic of Iran, in November 2018. Cited from: Anon. (2019): Illegal trade of unique Persian horned viper banned. TehranTimes August 27, 2019.

Fathinia, B. (2014): Taxonomic status of the genus *Pseudocerastes* Boulenger, 1896 (Ophidia: Viperidae) in Iran based on molecular and morphological characters. PhD. Thesis, Razi University, 195 pp.

Fathinia, B., S.C. Anderson, N. Rastegar-Pouyani, H. Jahani & H. Mohamadi (2009): Notes on the Natural History of *Pseudocerastes urarachnoides* (Squamata: Viperidae). Russian Journal of Herpetology **16**(2): 134-138.

Fathinia, B. & N. Rastegar-Pouyani (2010): On the Species of *Pseudocerastes* (Ophidia: Viperidae) in Iran. Russian Journal of Herpetology **17**(4): 275-279.

Fathinia, B., N. Rastegar Pouyani, H. Darvishnia & M. Rajabzadeh (2010): The snake fauna of Ilam Province, southwestern Iran. Iranian Journal of Animal Biosystematics **6**(1):9-23.

Fathinia, B., N. Rastegar-Pouyani, E. Rastegar-Pouyani, F. Todehdehghan & M. Rajabizadeh (2014): Molecular sytematics of the genus *Pseudocerastes* (Ophidia: Viperidae) based on the mitochondrial cytochrome *b* gene. Turkish Journal of Zoology **38**: 575-581.

Fathinia, B., N. Rastegar-Pouyani, E. Rastegar-Pouyani, F. Todehdehghan & F. Amiri (2015): Avian deception using an elaborate caudal lure in *Pseudocerastes urarachnoides* (Serpentes: Viperidae). Amphibia-Reptilia **36**(3): 223-231.

Fathinia, B., N. Rastegar-Pouyani, E. Rastegar-Pouyani, F. Todehdehghan & M. Mansouri (2016): Annual activity pattern of *Pseudocerastes urarachnoides* Bostanchi, Anderson, Kami & Papenfuss, 2006, with notes on its natural history (Squamata: Serpentes: Viperidae). Herpetozoa **29**(3/4): 135-142.

Fathinia, B., N. Rastegar-Pouyani & E. Rastegar-Pouyani (2018): Molecular phylogeny and historical biogeography of genera *Eristicophis* and *Pseudocerastes* (Ophidia, Viperidae). Zoologica Scripta **47**(6): 673-685.

Fathinia, B., D. Rödder, N. Rastegar-Pouyani, E. Rastegar-Pouyani, M.S. Hosseinzadeh & S.M. Kazemi (2020): The past, current and future habitat range of the Spider-tailed Viper, *Pseudocerastes urarachnoides* (Serpentes: Viperidae) in western Iran and eastern Iraq as revealed by habitat modelling. Zoology in the Middle East **66**(3): 197-205.

Gholamifard, A. (2011): Endemism in the reptile fauna of Iran. Iranian Journal of Animal Biosystematics 7(1): 13-29.

Gower, D., K. Garrett & P. Stafford (2012): Snakes. Firefly Books, Buffalo, NY, 144 p.

Kamali K. (2013): A Field Guide for Reptiles and Amphibians of Iran. Iranshenasi Publisher, Tehran, Iran. (in Farsi). 368 p.

Kamali, K. (2020) A Guide to the Reptiles and Amphibians of Iran. Frankfurt (Edition Chimaira): 574 pp.

Krautwald-Junghanns, M.E (2018): Haltung exotischer Tiere und Wildtiere in Privathand. Situationsanalyse, Bewertung und Handlungsbedarf insbesondere unter Tierschutzaspekten (EXOPET-Studie). Bundesanstalt für Landwirtschaft und Ernährung.

Martínez del Mármol, G., O. Mozaffari & J. Gállego (2016): *Pseudocerastes urarachnoides*: the ambush specialist. Boletín de la Asociación Herpetológica Española **27**(1): 36-42.

op den Brouw, B., F.C.P. Coimbra, L.A. Bourke, T.M. Huynh, D.H.W. Vlecken, P. Ghezellou, J.C. Visser, J.S. Dobson, M.A. Fernandez-Rojo, M.P. Ikonomopoulou, N.R. Casewell, S.A. Ali, B. Fathinia, W.C. Hodgson & B.G. Fry (2021): Extensive Variation in the Activities of *Pseudocerastes* and *Eristicophis* Viper Venoms Suggests Divergent Envenoming Strategies Are Used for Prey Capture. Toxins **13**: 112.

O'Shea, M. (2018): The Book of Snakes. Ivy Press/ Quarto Publishing, London, 656 pp.

Phelps, T. (2010): Old World Vipers. Frankfurt (Edition Chimaira): 558 pp.

Rajabizadeh, M. (2017): Snakes of Iran. Iranshenasi, Tehran (in Farsi): 496 pp.

Rastegar-Pouyani, N., A. Gholamifard, R. Karamiani, Z. Bahmani, A. Mobaraki, E. Abtin, H. Faizi, N. Heidari, M. Takesh, F. Sayyadi, N. Ahsani & R. Browne (2015): Sustainable Management of the Herpetofauna of the Iranian Plateau and Coastal Iran. Amphibian and Reptile Conservation **9**(1): 1-15.

Rastegar-Pouyani, N., H.G. Kami, M. Rajabzadeh, S. Shafiei & S.C. Anderson (2008): Annotated Checklist of Amphibians and Reptiles of Iran. Iranian Journal of Animal Biosystematics **4**(1): 7-30

Russel, F.E. & J.R. Campbell (2015): Venomous terrestrial Snakes of the Middle East. Frankfurt (Edition Chimaira): 186 pp.

Scholz, S., C. Radspieler & F. Siegenthaler (2020): Fields Trughornviper (*Pseudocerastes fieldi*) - Beobachtungen im Lebensraum und bei der Fortpflanzung im Terrarium. Elaphe **2020**(3): 68-77.

Wallach, V., K.L. Williams & J. Boundy (2014): Snakes of the World: A Catalogue of Living and Extinct Species. [type catalogue] Taylor and Francis, CRC Press, 1237 pp.

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Testudines

Geoemydidae

Cuora galbinifrons group

The Indochinese box turtles from the *Cuora galbinifrons* group (*Cuora galbinifrons*, *C. bourreti* and *C. picturata*) are morphologically very similar, have similar ecological requirements and are closely related. Therefore, they are presented as a species group.

Morphology and Taxonomy

Adult Indochinese box turtles from this group attain typically 20 cm in carapace length, and weigh up to 1 kg. They have a hinge in their plastron that allows it to be closed up against the carapace. Their carapace is domed and smooth.

The carapace color is highly variable, from beige to yellow, orange, brown or dark brown. They have a wide dark brown band along the middle of the carapace which covers the vertebral scutes and the upper quarter of the costal scutes.

Fig. 20: Hatchling of *Cuora galbinifrons* s.str. (B. Pfau).

The taxa mentioned in the species group can only be distinguished with difficulty, even by experts. This is why poachers' confiscated shipments often contain a mixture of these species that have been unknowingly thrown together. Under such stress conditions, the healthier specimens keep their plastrons tightly closed, hiding their heads and legs. This behavior, typical for the species, can be maintained for several days.

Fig. 21: Top: Species identification of smuggled Indochinese box turtles 2015;
middle: Lateral view of *Cuora picturata* (left), *C. bourreti* (middle) and *C. galbinifrons* (right);
bottom: Plastron patterns of the same animals (all photos by T. McCormack, ATP/IMC).

The three species can usually be differentiated by their head and plastral patterns. The carapace of hatchlings is rather pale. The coloration of the animals becomes darker, and they develop more contrasting patterns with increasing age.

The nomenclature of this group is still controversial. Initially, all the Indochinese box turtles were referred to as *Cuora galbinifrons*, even though different color variants were noticed early, and these were bred on as pure as possible.

The first described subspecies, *Cuora galbinifrons serrata,* from Hainan, later turned out to be a natural hybrid with *Cuora mouhotii*. This species occurs sympatric with all three species of the *C. galbinifrons* group, and meanwhile more hybrid individuals *of C. mouhotii* with all three species of the *C. galbinifrons* species group have been found.

The subspecies *Cuora galbinifrons bourreti* was described in 1994, and four years later *C. g. picturata*. In 2004, the two subspecies were categorized as full species, based on genetic studies, but this is still in debate. *Cuora galbinifrons* s.str. is closer related to *C. bourreti*, while *C. picturata* shows more differences in species-specific characteristics.

We will refer hereafter to the three species, as in the proposal to CITES CoP18, according to the taxonomy in Spinks *et al.* (2012).

Distribution and Habitat

Distribution

***Cuora galbinifrons* s.str.:** China (province Guangxi and Hainan Island), northern Laos and Vietnam, in the provinces Lao Cai, Yen Bai, Vinh Phuc, Son La, Dien Bien, Hoa Binh, Thanh Hoa, Quang Binh and Nghe An), usually between 500 and 1,000 m asl. Temperatures above 28 ºC are badly tolerated. Some well-known localities also experience light frost in winter.

Cuora bourreti: Vietnam, in the provinces Nghe An, Ha Tinh, Quang Binh, Thua Thien-Hue, Da Nang, Quang Nam and Kon Tum, as well as in the adjacent province Savannakhet in the People's Republic of Laos, usually between 300 und 700 m asl. In these regions, the climate is more tropical than in the natural habitats *of C. galbinifrons* s.str. and these turtles tolerate higher temperatures.

Cuora picturata: The natural distribution is limited to a small area within southern Vietnam, in the provinces Binh Dinh, Phu Yen, Dak Lac and Khanh Hoa. The species was described from animals found in the trade, and in 2011 nine individuals were found in a mountain forest with bamboo, between 346 and 561 m asl, on the eastern slopes of the Langbian Plateau, where temperatures rarely drop below 20 °C.

Habitat

All three species of the Indochinese box turtle complex inhabit moist, closed-canopy, evergreen forests in Indochina.

The turtles are predominantly terrestrial, but they can also swim, and they often sit in shallow water for quite some time. Due to their carapace coloration, they are well camouflaged in the foliage layer on the ground. Their limbs are relatively long and the turtles are good climbers. When threatened, the animals push themselves off and roll down the slope until they disappear in a pile of dead leaves.

Cuora galbinifrons Bourret 1940

Indochinese box turtle, Flowerback box turtle

German: Indochinesische Scharnierschildkröte

Vietnamese: Rua hop tran vang.

Fig. 22 Two females of *Cuora galbinifrons* with different head coloration (B. Pfau in IZS Münster).

Cuora galbinifrons s.str. shows rather variable markings. The plastron is mainly dark brown to black, sometimes with a light central area. The carapace is dark brown or tan overall, often the costal scutes are lighter brown below the dark median band. The various local populations differ in their pattern regarding the first costal scutes (Leprince pers. communication). Research on their genetics is in progress. The breeders try to keep the breeding groups of the different color varieties separately.

Indochinese box turtles often have yellow, orange and even red head patterns in both sexes, and these colors may be present on the scales on the forelimbs, too. The lower jaw is often bright yellow. In adult individuals, the head pattern remains almost constant, therefore a picture of one side of the head can be used for photo documentation.

The pupil is round and the iris is green, yellow or sometimes bright orange or red.

Cuora bourreti Obst & Reimann, 1994

Bourret's box turtle, Central Vietnamese Flowerback box turtle

German: Bourret Scharnierschildkröte, Zentralvietnamesische Scharnierschildkröte

Vietnamese: Rua hop bua-re.

Fig. 23: *Cuora bourreti* (B. Pfau in IZS Münster).

In *Cuora bourreti* the head is less brightly colored than in *C. galbinifrons* s.str., and it usually lacks the bright yellow and red markings. The iris is often green and the pupil is round. The middle band on the carapace is not as pronounced as in *C. galbinifrons* s.str., and the carapace is often orange-brown. The plastron is bright with black dots on the edge or with irregularly distributed black dots. In *C. bourreti* the carapace is proportionally higher (more domed) than in *C. galbinifrons*.

Cuora picturata Lehr, Fritz & Obst, 1998

Southern Viet Nam box turtle

German: Südvietnamesische Scharnierschildkröte

Vietnamese: Rua hop viet nam.

Fig. 24: *Cuora picturata* (B. Pfau in IZS Münster).

The most important identification characteristic of *Cuora picturata* is the star shaped pupil of the eye, surrounded by a greenish iris. The head of these turtles is often yellow, sometimes with small black dots or fine black lines. The plastron is beige, with large, angular or finger-shaped, serrated black dots on the outer side of the scutes. The carapace is almost round and relatively high so that the species can be morphometrically identified.

Many of these Indonesian box turtles had been legally imported into Europe as "*Cuora galbinifrons",* before *Cuora picturata* was described. Shortly after the first imports there were also reports on captive breeding. Even if there are no reports of this species in the CITES Trade Database (UNEP-WCMC 2020), the animals which are offered as captive bred in Europe don't necessarily need to be descendants of illegally sourced specimens (see Janssen & Indenbaum 2018), but can be descendants of the specimens mentioned above, which were back then labelled as *C. galbinifrons*.

Conservation Status and Main Threats

Cuora galbinifrons

CITES Appendix II since 2000 (CoP11 Proposal 33). At CITES CoP16, proposal 33 for transferring *C. galbinifrons* s.l. (including the other two species which were subspecies at that time) in Appendix I was declined due to rule 23.6, because the proposal 32 already related to that species and had a less restrictive effect on the trade (CITES 2013). A proposal to transfer *C. galbinifrons* to Appendix I at the CoP18 meeting had not been submitted in time (P.P. van Dijk pers. comm.).

Council Regulation (EC) No 338/97: Annex B

Cuora bourreti

CITES Appendix I since 2019 (CoP18 Proposal 33).

Council Regulation (EC) No 338/97: Annex A.

Cuora picturata

CITES Appendix I since 2019 (CoP18 Proposal 34).

Council Regulation (EC) No 338/97: Annex A.

In Germany, all three species are particularly protected under BNatSchG [BG] Status b, while *C. bourreti* and *C. picturata* are strictly protected as well, and thus have status s.

IUCN- Red List Status of all three species: Critically Endangered (A2bd+4bd, assessed July 1 2015).

Since the 90s, the market value of these species has sharply increased in China and thus the illegal catching and smuggling has increased accordingly. Specially trained dogs are used to find the well-hidden turtles. The wild population has probably decreased to only 10 %. All three species are particularly threatened by collection for consumptive use, especially in range countries.

Legal imports to supply the pet trade in the Europe has come to a complete standstill, which is documented by the lack of entries in all the available trade databases. There are also no recorded smuggling attempts to the EU in recent years.

In Vietnam, the turtle trade is now more tightly controlled, and open trade in the animal markets has come to a halt since 2006, when some turtle species became strictly protected there. Nevertheless, the illegal trade in wild caught animals continues, albeit in smaller numbers, as the animals have become rare, and since the two species were transferred to Appendix I, which makes the penalties imposed on arrested smugglers very noticeable (see for example the mails by D. Hendrie to the IUCN TFTSG mail group from November 2020 on, and the discussion in Anon. (2020)).

Another major threat factor in the natural habitat is the conversion of the forest into plantations, and thus the loss of habitat.

Reproduction

Topic	Data
Sexual traits	In adult ♂♂ the tail is longer and thicker at the basis than the one of ♀♀. This trait can be seen in subadults only just before reaching sexual maturity.
Reproduction	Oviparous.

Topic	Data
Sexual maturity	With 10 to 15 years. In both sexes from ca. 14 cm CL on.
Nesting site	Eggs are sometimes laid half-open or buried only relatively shallowly in very soft, moist substrate. Stressed females often drop their eggs in water. In captivity, laying mounds of soft forest soil or similar can help as an incentive to lay eggs.
Nesting season	The firs eggs are laid soon after hibernation in March. The timing of the following egg-laying varies. Last clutches were observed end of September.
Number of eggs/ clutches per season	In the Cuc Phuong breeding center in Vietnam 1 clutch per year. in captivity often 2 clutches per year, rarely 3 clutches per year. In *C. galbinifrons* s.str., 1–5 eggs per clutch, usually 2 eggs depending on the nutritional status. Max. 7 eggs in one year have been observed. *C. bourreti* and *C. picturata* lay max. 3 eggs per clutch.
Egg size/ hatchling size	Eggs of *C. galbinifrons* & *C. bourreti* ca. 55 x 30 mm and 20–30 g. In *C. bourreti* very large eggs > 35 g have been observed, but these are not capable of development. The size of the eggs of *C. picturata* is up to 60 x 35 mm. Hatchlings: *C. galbinifrons* s.str. ca. 50 mm CL and 25.5 g, *C. bourreti* 41–52 mm CL and 17.0–23.5 g and *C. picturata* 57–60 mm CL and 22.5–27 g.
Incubation and hatching	Incubation with high air humidity. With temperatures of 24–30.5 °C, the incubation period is 49–112 days. At constant temperature at 26–27 °C, *C. galbinifrons* s. str. hatches after 70–91 days, *C. bourreti* after 86–97 days, and *C. picturata* after 74–112 days. Eggs of the first clutch of the year hatch faster at the same incubation temperatures.
Sex determination	Whether this species have temperature-dependent sex determination is unknown. Research is underway.
Sperm storage	Yes, > 1 year

Husbandry and Captive Breeding

Already the first description by René Bourret (1940) contains a hint on the beauty of these turtles, and Europeans tried to acquire some animals for zoos. The first husbandry report from a German Zoo is from 1963. From about 1980, these turtles came to Europe in larger numbers, and later they also became known in the USA. The individuals were imported from Hong Kong, where they were offered for slaughtering, and could be acquired by traders for resale in Europe. These animals were then often in a deplorable condition, full of parasites, and many did not survive. Nevertheless, there were already first breeding successes at the end of the 80s.

All three species are often bred in Europe and USA, and there is also good breeding success in the rescue center in Cuc Phuong. Keeping them under stress-reducing conditions is crucial for the breeding success. Regular breeding success is usually only achieved when the animals are kept individually (mating under supervision), or in very spacious enclosures with plenty of cover. This excludes breeding them in large numbers in breeding farms, and the inspection of alleged breeding farms has also shown that actual breeding would not be possible in those farms.

In captivity, these turtles require a varied diet, including fruits and leaves (lettuce, etc.) in addition to crustaceans and snail or mussel meat. Sometimes, the addition of vitamin/mineral preparation is necessary, otherwise the egg quality will be low. Some animals also accept pellet food. The young animals are predominantly carnivorous and accept small earthworms or similar live food as first food. Poorly eating animals sometimes accept live earthworms. UV lighting is recommended.

Topic	Data
Trigger for reproduction	Egg laying begins soon after hibernation, females are often willing to mate in late summer and fall. Some breeders mate the animals in spring and autumn at equinox. For mating, place male with female, separate them immediately after mating or if the female is unwilling to mate. According to experiences in Vietnam, *C. picturata* tolerates only little cooling in winter. If the temperature falls below 15 °C, the eggs laid afterwards will not develop. In captivity, a temporarily cooler hibernation seems to be tolerated without influence on the development of the eggs.
Husbandry requirements	Strictly solitary in wet terrariums with soft substrate for burrowing and with cover structures (burrows of wood or cork, preferably with live plants), shallow water basin for immersion. Visual protection from other terrariums with turtles of the same species is required.
General characteristics, difficulties with keeping and breeding	Very stress susceptible. Avoid touching or moving. Sometimes they feed only when they are not watched.
Care of the young, technical and time effort	Keep the young individually if possible. Initially in shallow water with plants or other ways to hold on, and a small island.
Necessary safety measures	Secure the enclosure to prevent the animals from climbing out.
Life expectancy in captivity	Over 30 years.
Frequency of breeding in captivity	Rare.
Breeding difficulty evaluation	For specialists. Some individuals temporarily stop reproducing due to stressful experiences (e.g., new tank setup, or even visual contact with conspecifics in neighboring tanks).
Mortality in the first years of life	Juvenile mortality is low when the hatchlings are raised first in shallow water and afterwards in high air humidity conditions. However, underweight hatchlings usually die within the first two years.
F2 generation bred	Yes, but rarely.
Interviews/ Surveys/ Consultations	Several private breeders and 3 zoological institutions. Many breeders who were contacted did not fill in the questionnaire and instead referred to the publications.

The EAZA studbook for all three species is being kept at IZS Münster, the St. Louis Zoo is responsible for the AAZA studbook. Some private breeders are organized in the ESF, but many breeders have not joined any studbook at all.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Anon. (2016): Testudinate China [in both English and Chinese] 8th World Congress of Herpetology, Hangzhou, Testudinate Industry Branch of the China Fishery Association.

Anon. (2020): Laundering wildlife through farms. ENV Wildlife Crime Bulletin **2/2020**: 6-7.

Augustine, L. & N. Haislip (2019): Husbandry and reproduction of the Indochinese box turtle *Cuora galbinifrons*, Bourret's box turtle *Cuora bourreti* and Southern Vietnam box turtle *Cuora picturata* in North America International Zoo Yearbook **53**(1): 238-249.

Augustine, L. & R.W. Mendyk (2012): The *Cuora galbinifrons* studbook: A model for understanding studbook challenges. Animal Keepers' Forum **39**(7): 334-337.

Bartlett, R.D. (1984): An exquisite oriental (Initial observations on the Vietnamese box turtle, *Cuora galbinifrons*). Notes from NOAH **11**(10): 3-6.

Becker, H. (2019): Notes on the Husbandry and Propagation of the three Species of the former "*galbinifrons Complex*" *Cuora bourreti*, (Obst & Reimann, 1994), *Cuora galbinifrons* (Bourret, 1939), and *Cuora picturata* (Lehr, Fritz & Obst, 1998). Radiata **28**(1): 21-36.

Becker, H. & H.-D. Philippen (2008): Bemerkungen zur innerartlichen Variabilität von *Cuora galbinifrons*. Marginata **5**(1): 10–15.

Belcher, J. (1988): Vietnamese box turtles hatch at the Bronx Zoo. AAZPA newsletter 29.

Blanck, T. (2013): Zu Besuch bei *Cuora galbinifrons* auf Hainan, China. Reptilia (Münster) **18**(1): 100-109.

Borek, A., P. Miller, D. Yoshimi & J. Pramuk (2018): Husbandry of the Indochinese Box Turtle (*Cuora galbinifrons*: Geoemydidae) at Woodland Park Zoo. Herpetological Review **49**(2): 264-270.

Bour, R. (2005): The type specimens of *Cuora galbifrons* Bourret, 1939. Emys **12**(1): 33-36.

Bourret, R. (1939): Notes herpétologiques sur l'Indochine française, XVIII. Reptiles et batraciens reçus au Laboratoire des Sciences Naturelle de l'Université au cours de l'année 1939. Descriptions de quatre espèces et d'une variété nouvelles. Bulletin Général de l'Instruction Publique. Hanoi **19**(4): 5-39.

Buskirk, J.R. (1988): The Indochinese Box turtle: A perspective on captive management. The Vivarium **1**(1): 22-25.

Cao, X., K. Huang, B. Lu, J. Pan, J. Cao, Z. Zhang & C. Chen (2020): Study on the Reproduction Behaviors of Artificial Breeding *Cuora galbinifrons*. Sichuan Journal of Zoology **39**(2): 189-195.

CITES 2013: Final decisions on proposals to amend the appendices considered at CITES CoP16. https://cites.org/eng/meetings/cop (accessed 12.02.2021).

De Bruin, R. (1994): De Indochinese doosschildpad (*Cuora galbinifrons*) in het terrarium. Lacerta **52**(3): 58-66.

De Bruin, R. (2006). Breeding the Indochinese box turtle, *Cuora galbinifrons galbinifrons*. pp. 69-76. *In:* Artner, H., B. Farkas & V.T. Loehr (eds.): Turtles. Proceedings: International Turtle & Tortoise Symposium Vienna 2002. Frankfurt (Edition Chimaira): 618 pp.

De Bruin, R. & H.G. Artner (1999): On the turtles of Hainan Island, southern China. Chelonian Conservation & Biology **3**(3): 479-486.

Duc, L.D. & S. Broad (1995): Investigations into tortoise and freshwater turtle trade in Vietnam. IUCN Species Survival Programme. Frank Lambert. Gland, Switzerland and Cambridge, UK., IUCN Species Survival Commission: 34 pp.

Education for Nature Vietnam (ENV) (2020): Laundering wildlife through farms: Know a criminal when you see one. Crime Log. Wildlife Crime Bulletin **2020**(2).

Espenshade, W.H. & L.T. Duc (2002): Pu Mat turtle hunter interview. Turtle and Tortoise Newsletter **5**: 16-17.

Fiebig, J. & E. Lehr (2000): Haltung und Erstnachzucht der Bourret-Scharnierschildkröte *Cuora galbinifrons bourreti* Obst & Reimann, 1994, mit Anmerkungen zum Bedrohungsstatus. Salamandra **36**(3): 147-156.

Fritz, U., A. Petzold & M. Auer (2006): Osteology in the *Cuora galbinifrons* complex suggests conspecifity of *C. bourreti* and *C. galbinifrons*, with notes on shell osteology and phalangeal formulae within the Geoemydidae Amphibia-Reptilia **27**(2): 195-205.

Fritz, U., T. Ziegler, H.W. Herrmann & E. Lehr (2002): Intergradation between subspecies of *Cuora galbinifrons* Bourret, 1939 and *Pyxidea mouhotii* (Gray, 1862) in southern North Vietnam (Reptilia: Testudines: Geoemydidae). Faunistische Abhandlungen Dresden **23**(1): 29-74.

Fritzsche, D. & M. Fritzsche (2005): Erfahrungen mit der Hinterindischen Scharnierschildkröte *Cuora galbinifrons* Bourret, 1939. Radiata **14**(2): 48-49.

Gaillard, D., L. Lin, H. Shi & S. Luo (2017): Turtle Soup: Local Usage and Demand for Wild Caught Turtles in Qiongzhong County, Hainan Island. Herpetological Conservation and Biology **12**(1): 33-40.

Goetz, M. (2004): A brief report on the long-term rehabilitation of wild-caught *Cuora galbinifrons*. British Chelonia Group, Durrell Wildlife Conservation Trust.

Gong, S., A.T. Chow, J.J. Fong & H. Shi (2009): The chelonian trade in the largest pet market in China: scale, scope and impact on turtle conservation. Oryx **43**(2): 213-216.

Hennig, A. (2020): Inkubation von Schildkröteneiern. Frankfurt (Edition Chimaira): 253 pp.

Heuberger, W. & K. Heuberger (2008): Erfolgreiche Haltung und Nachzucht von *Cistoclemmys (galbinifrons) bourreti*, der hinterindischen Scharnierschildkröte. Reptilia **13**(4): 64-71.

Hiller, A. (2005): Beobachtungen bei der Haltung von *Cuora galbinifrons galbinifrons* Bourret, 1939. Radiata **14**(2): 44-47.

IUCN TFTSG (o.J.): IUCN/SSC Tortoise and Freshwater Turtle Specialist Group membership https://iucn-tftsg.org/membership/ (accessed 12.02.2021).

Iverson, J.B. & W.P. McCord (1992): A new subspecies of *Cuora galbinifrons* (Testudines: Batagurinae) from Hainan Island, China. Proceedings of the Biological Society of Washington **105**(3): 433-439.

Janßen, M. & J. Janßen (2008): Beobachtungen und Erfahrungen bei der Haltung und Nachzucht der Gelbkopf-Scharnierschildkröte *Cuora galbinifrons bourreti*. Marginata **5**(1): 22-27.

Jarvis, P. & L. Augustine (2018): *Cuora bourreti* (Bourret's Box turtle). Brumation, oviposition and incubation. Herpetological Review **49**(3): 486-487.

Lehr, E., U. Fritz & F.J. Obst (1998): *Cuora galbinifrons picturata* subsp. nov., eine neue Unterart der Hinterindischen Scharnierschildkröte. Herpetofauna **20**(113): 5-11.

Lehr, E., U. Fritz & F.J. Obst (1998): Die Unterarten von *Cuora galbinifrons* Bourret, 1939. Zoologische Abhandlungen (Dresden) **50**(6): 77-97.

Lehr, E. (2001): Zum Schildkrötenhandel in Asien. Elaphe N.F. **9**(1): 87-88.

Leprince, B. (2017): Du rêve à la réalité: observation de *Cuora bourreti* (Obst & Reimann, 1994) et *Cuora picturata* (Lehr *et al.*, 1998) dans leur habitat. Chéloniens **42**: 30-37.

Linh, T.T.K., T.V. Pham, L.D. Minh, T. McCormack, H.V. Ha, N.T. Thang & N.T. Hanh (2016): Illegal Turtle Trade in Bac Kan, Quang Ninh, Tuyen Quang Provinces and Online Illegal Turtle Trade. VNU Journal of Science: Earth and Environmental Sciences **32**(1S): 245-253.

Liu, X., W. Li, Z. Ye, Y. Zhu, X. Hong & X. Zhu (2019): Morphological characterization and phylogenetic relationships of Indochinese box turtles - The *Cuora galbinifrons* complex. Ecology and Evolution **9**(23): 13030-13042.

Malesky, E., S. Nillasithanukroh, E. Patel & E. Weinthal (2019): Scaling Back Wildlife Trade in the Mekong Delta: Applying a Political Economy Lens to the Farmer Loophole with a Focus on Vietnam and Laos, Research Technical Assistance Center, United States Agency for International Development (USAID): 65 pp.

McCord, W.P. & J.B. Iverson (1991): A new box turtle of the genus *Cuora* (Testudines: Emydidae) with taxonomic notes and a key to the species. Herpetologica **47**(4): 407-420.

McCormack, T. (2010): Training detection dogs for research and conservation of tortoises and freshwater turtles in Southeast Asia. Turtle Survival **2010**: 70-72.

McCormack, T., H Shi & B. Stuart (2016): *Cuora galbinifrons*, Indochinese Box Turtle (errata version published in 2017). IUCN Red List of Threatened Species. IUCN: 14 pp.

Nicol, E.B. (1984a): Feeding *Cuora galbinifrons*. Notes from NOAH **11**(9): 8.

Nicol, E.B. (1984b): Parasites in *Cuora galbinifrons* and *Cyclemys mouhoti*. Notes from NOAH **12**(3): 5-7.

Niessen, L. (2008): Haltung und Nachzucht der Südvietnamesischen Scharnierschildkröte, *Cuora galbinifrons picturata*. Marginata **5**(1): 28-30.

Obst, F.J. & M. Reimann (1994): Bemerkenswerte Variabilität bei *Cuora galbinifrons* Bourret, 1939, mit Beschreibung einer neuen geographischen Unterart: *Cuora galbinifrons bourretii* subsp. nov. (Reptilia: Testudines: Cryptodira: Bataguridae). Zoologische Abhandlungen (Dresden) **48**(7): 125-138.

Pauler, I. (1980): Die Schildkrötengattung *Cuora*. Herpetofauna **2**(6): 15-18.

Petzold, H.-G. (1963): Über einige Schildkröten aus Nord-Vietnam im Tierpark Berlin. Senckenbergiana Biologica **44**: 1-20.

Petzold, H.-G. (1965): *Cuora galbinifrons* und andere südostasiatische Schildkröten im Tierpark Berlin (Teil 1 und 2). DATZ **18**: 87-91; 119-121.

Pham, V.T., B. Leprince, H.L. Xuan, Q.N. Thu, O. Le Duc, C. Bordes, M.V. Tien & L. Luiselli (2019): Observations of threatened Asian box turtles (*Cuora* spp.) on trade in Vietnam. Herpetological Journal **29**(3): 173-178.

Shi, H., J.F. Parham, W.B. Simison, J. Wang, S. Gong & B Fu (2005): A report on the hybridization between two species of threatened Asian box turtles (Testudines: *Cuora*) in the wild on Hainan Island (China) with comments on the origin of 'serrata'-like turtles. Amphibia-Reptilia **26**(3): 333-381.

Spinks, P.Q., R.C. Thomson, Y. Zhang, J. Che, Y. Wu & H.B. Shaffer (2012): Species boundaries and phylogenetic relationships in the critically endangered Asian box turtle genus *Cuora*. Molecular Phylogenetics and Evolution **63**(3): 656-667.

Struijk, R.P.J.H. (2010): European studbooks: *Cuora bourreti*, *Cuora galbinifrons*, and *Cuora picturata*. Turtle Survival **2010**: 33-34.

Struijk, R.P.J.H. & T.E.G. Blanck (2016): A likely new natural hybrid form of "*Cuora serrata*" (*Cuora picturata* x *Cuora mouhotii obsti*) and its presence in the wild in Phu Yen province, Vietnam. Herpetology Notes **9**: 73-80.

Struijk, R.P.J.H. & J. Stumpel (2010): Studbook breeding programme *Cuora bourreti* (Bourrets' box turtle) Annual Report 2009. Studbook Overview, European Studbook Foundation.

Struijk, R.P.J.H. & J. Stumpel (2010): Studbook breeding programme *Cuora galbinifrons* (Indochinese box turtle) Annual Report 2009. Studbook Overview, European Studbook Foundation.

Struijk, R.P.J.H. & J. Stumpel (2010): Studbook breeding programme *Cuora picturata* (Vietnamese box turtle) Annual Report 2009. Studbook Overview, European Studbook Foundation.

Struijk, R.P.J.H. & L.A. Woldring (2005): Das *Cuora*-Zuchtprogramm - ein Überblick. Radiata **14**(2): 64-73.

Stuart, B.L. & J.F. Parham (2004): Molecular phylogeny of the critically endangered Indochinese box turtle, *Cuora galbinifrons*. Molecular Phylogenetics Evolution **31**(1): 164-177.

UNEP-WCMC (2020): CITES Trade Database. https://trade.cites.org/en/cites_trade/ (accessed 12.02.2021).

Van Dijk, P.P., B.L. Stuart & A.G.J. Rhodin (eds.) (2000): Asian turtle trade: Proceedings of a workshop on conservation and trade of freshwater turtles and tortoises in Asia. Chelonian Research Monographs **2**: 164 pp.

Vu, Q., R. Carvill, H. Bui, D. Hendrie & D. Orders (2017): An analysis of wildlife farming in Vietnam, 2017. Education for Nature - Vietnam (ENV), 31 pp.

Wagner, P. (2018): Die Gattung *Cuora* - eine akut bedrohte, einzigartige Kreation der Evolution Reptilia **23**(5): 16-21.

Wang, J., H. Shi, C. Xue, L. Wang & E. Zhao (2011): Population densities of *Cuora galbinifrons* at Diaoluoshan nature reserve, Hainan Island, China. Sichuan Journal of Zoology **30**: 471-474.

Yiming, L. & L. Dianmo (1998): The dynamics of trade in live wildlife across the Guangxi border between China and Vietnam during 1993-1996 and its control strategies Biodiversity and Conservation **7**(7): 895-914.

Beate Pfau (29.11.2020)

I wish to thank Timothy McCormack for reviewing this fact sheet.

Mauremys mutica group

Mauremys mutica and *Mauremys annamensis* are closely related. Genetic studies (Fong *et al.* 2007, Fong *et al.* 2019) suggest a complicated relationship between the two species; the two species can be clearly distinguished genetically, which indicates they are separate species, but the pattern is obscured likely due to historical (relatively short time since speciation) and modern (recent hybridization) factors. Morphologically, both species can be easily distinguished. However, genetic studies showed that some individuals, which would be visually identified as *M. annamensis*, were in fact hybrids of both species (Blanck & Braun 2013, Protiva 2015, Somerová *et al.* 2015).

Previously, *M. mutica* was improperly referred to as *M. nigricans*, and this incorrect practice may still be used in reference books. Therefore, we will include *Mauremys nigricans* in this fact sheet, despite clearly differing in appearance at all ages from the two aforementioned species.

All three species are bred in farms in their range countries, hybrids likely occur between these three species and with other Geoemydidae species. Thus, we outline the diagnostic characteristics for the three species.

Morphology and Taxonomy

Fig. 25a: *Mauremys annamensis* (B. Pfau);
b: *Mauremys mutica* (D. Guarnotta);
c: Hybrid *Mauremys annamensis X Cuora amboinensis* (B. Pfau);
d: *Mauremys nigricans* (B. Pfau]
The yellow arrows point to the characteristic stripe pattern on the head.

Adult turtles of this species group will grow up to 20 cm in carapace length (CL). In exceptional cases, ♀♀ of *M. nigricans* can reach 30 cm CL. The carapace is dark without a clear pattern.

The plastron has no transversal hinge, in contrast to *Cuora amboinensis,* with which *M. annamensis* is frequently confused with and sometimes sold in mixed shipments.

Within most wild populations, both ♂♂ and ♀♀ have similar CL, or ♂♂ are larger. In *M. nigricans*, of which there are currently no known wild populations, the ♀♀ can grow considerably larger than the ♂♂.

The juveniles of *M. annamensis* and *M. mutica* have the same color as the adults. However, hatchlings of *M. nigricans* have a bright red-orange plastron color with black blotches on plastron, and adult ♂♂ can have red-colored patterns on the head and neck.

Mauremys nigricans is easy to identify by its distinctive, foul-smelling musk odor, which is readily emitted when the turtles are molested. The musk of other Geoemydidae species does not smell as pungently.

♀♀ and juveniles of the three species can be differentiated by the coloration and pattern of head and neck.

All three species were described to science between 1834 and 1985. Their past taxonomy was problematic, with multiple names used as synonyms of different turtle species, and being placed in different, contradictory genera. Furthermore, natural or artificially farm-bred hybrids were described as full species and added to this species complex. This taxonomic tangle has been described and hopefully resolved by Iverson & McCord (1989) and Rhodin *et al.* (2017).

This taxonomic problem has been taken into account when reviewing published material for this fact sheet.

Mauremys annamensis has striking whitish to yellowish stripes on head and neck. Characteristic for this species is the stripe above the eye, which forms an arc above the eye orbit in uniform width.

Mauremys mutica has no stripe above the eye, but a conspicuous lateral stripe on the head, beginning at the nose, continuing behind the eye, and bending downwards before reaching the neck. In contrast to *M. annamensis* the stripes of both sides do not meet at the nose. The shape of the stripe behind the eye is extremely variable. Normally, *M. mutica* does not have a stripe above the eye, but usually has small stripes below the broad lateral stripe. The color of the stripes is usually beige, while the color of the carapace is brown to dark brown with no obvious pattern.

The *M. annamensis x C. amboinensis* hybrid possesses an intermediate head stripe morphology. In this hybrid individual, the stripe above the eye, forms an interrupted arc above the eye orbit (characteristic of *M. annamensis*. Pure *C. amboinensis* have a straight line on the top of the head. The presence of a plastral hinge, which is typical for adult *Cuora amboinensis*, has not yet developed in this young specimen (compare to Fritz & Mendau 2002).

The head of *M. nigricans* usually has pale grey to yellowish stripes with a spotted pattern. One stripe runs from the back of the eye to the neck, while the second stripe runs from the mouth to the neck. Adult ♀♀ are typically very dark and the stripes are difficult to see. ♂♂ approaching sexual maturity usually develop a red neck coloration (see below).

Distribution and Habitat

Mauremys annamensis is endemic to Vietnam. It is only found in the lowlands in Quang Nam, Da Nang, and Gia Lai Provinces in the catchment area of the Trà Bồng river. The species inhabits small lakes, ponds, and pools in marshes near the river. When the water level rises during the rainy season, animals can disperse to other water bodies. The turtles do not move far from the water, and during the day they often bask on wood logs above the water. The main activity time, at least in captivity, is during night.

Mauremys mutica occurs in northern Vietnam (where the habitat is separated from that of *M. annamensis* only by one mountain chain), in the neighboring parts of China to the north (including Hainan and Taiwan) and on the westernmost islands belonging to Japan. The only one accepted subspecies, *M. m. kami* is found in Ryukyu Island of Japan. In Hong Kong, *M. mutica* was probably introduced. Meanwhile, there is evidence that the species also occurs in several Asian countries such as Japan (mainland,) and Korea (Lin *et al.* 2015, Kim 2018). *Mauremys mutica* is ecologically similar to *M. annamensis*. One exception is that *M. mutica* has been also found in mountain lakes, although is not sure whether this is a natural or introduced habitat.

Mauremys nigricans has been found only in the catchment area of the Pearl River in Guangdong Province, China. The turtles lived at 300–400 m asl, with water temperatures around 16–17 °C. There are several older records of animals found outside this area (Anders & Iverson 2012), but these are probably based on released turtles or misidentifications. It is not possible to reconstruct the actual distribution range, because there are no wild animals left today. The ecology of this species is probably similar to *M. mutica* and *M. annamensis*.

Mauremys annamensis (Siebenrock, 1903)

Vietnamese pond turtle

German: Annam-Sumpfschildkröte

Vietnamese: Rùa Trung Bô.

Fig. 26: *Mauremys annamensis* at IZS Zoo Münster (B. Pfau).

Mauremys annamensis is a medium-sized turtle; ♀♀ have an approximate CL of 21 cm and weigh of 1.7 kg. The two largest known ♀♀ were 28.5 cm CL. ♂♂ are smaller in size with about 19 cm CL and slightly over 1 kg weight; the largest male recorded had 23.2 cm CL.

The coloration on head and neck is characteristic (see “Morphology”), carapace and rear limbs are dark.

The similarities and the distinguishing characters of these and other closely related species to *M. mutica* are presented in detail by the working group of Jonathan Fong and Timothy McCormack (Fong 2006, Fong *et al.* 2007, Fong & Chen 2010, McCormack *et al.* 2014, McCormack *et al.* 2020).

Mauremys mutica (Cantor, 1842)

Yellow pond turtle

German: Gelbe Sumpfschildkröte

In Chinese (translated): Stone turtle, fragrant turtle.

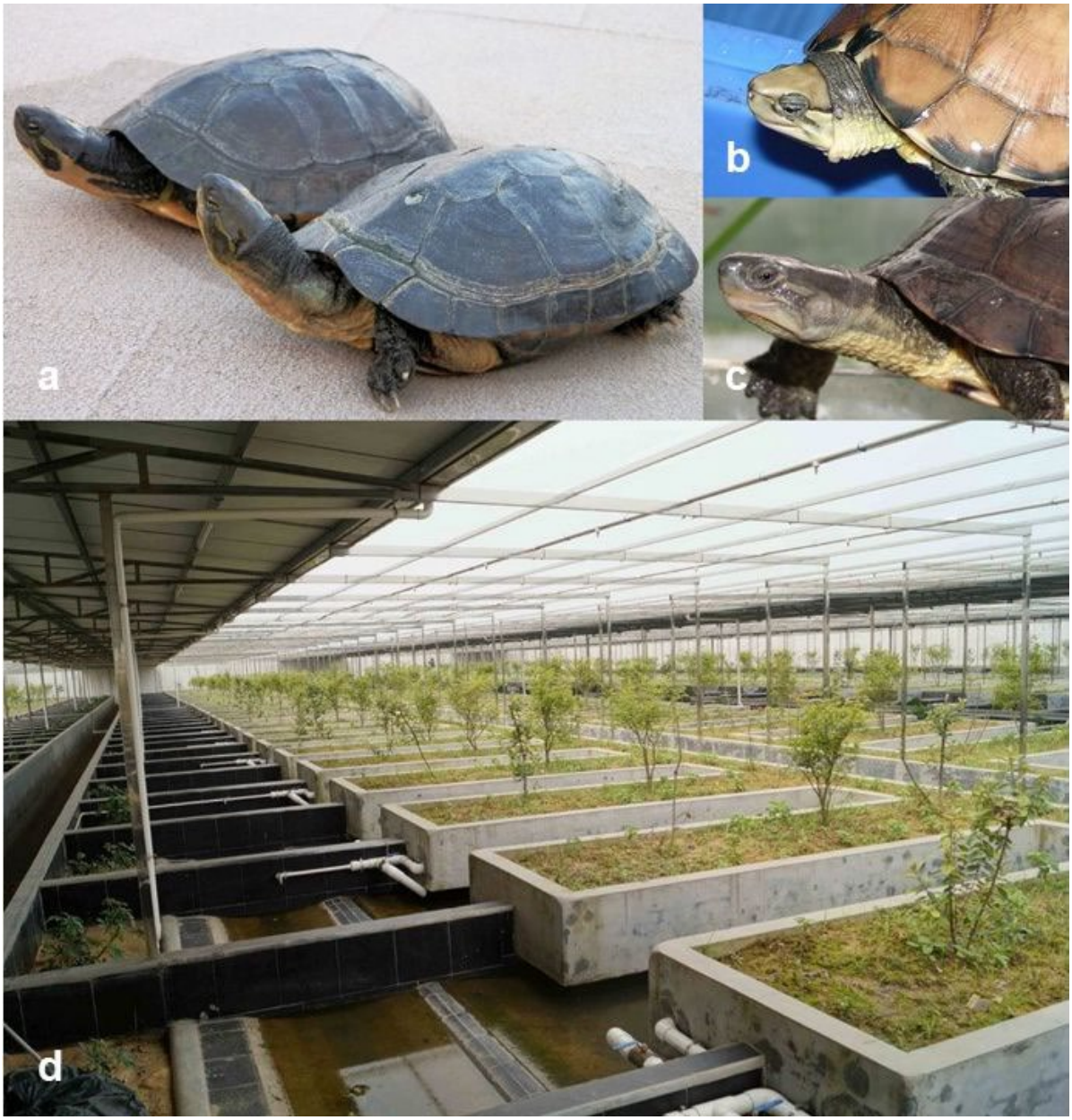

Fig. 27a: *Mauremys mutica*, northern China local form (front);
Vietnam/ southern China form (rear) (D. Guarnotta);
b: *Mauremys mutica*, an animal with a particularly contrasting color pattern of the Vietnam/ southern China local form, photographed at the Huadiwan market in Guangzhou (S. Nickl);
c: *Mauremys mutica kami* (S. Nickl);
d: *Mauremys mutica* breeding farm in China (P. Petrás).

Both local forms, from Vietnam and China, are currently not differentiated taxonomically, although captive breeding reports point to some differences in reproductive parameters.

The head pattern of the Vietnam/ southern China local form is more conspicuous and more similar to *M. annamensis* than the northern China local form from a bit farther north.

The individual depicted in Figure 27a (rear) is not a hybrid, it is a descendant of correctly determined wild caught specimens.

Adult ♂♂ from northern China are on average 16.8 cm CL, while in the southern form may grow to 21.6 cm CL. ♀♀ are on average 15.9 cm and 18.1 cm CL (northern and southern local form, respectively). There are also differences in the basic coloration of both carapace and head: the northern local form has a yellow to brown carapace and a greenish head, while the southern local form has a brown to dark brown carapace and head.

Breeding farms do distinguish the two local forms, since they have different temperature requirements. The southern local form is farmed in Guangdong, Guangxi, and Hainan Provinces, while the northern local form is farmed more frequently in Zhejiang, Jiangsu, and Anhui Provinces (Zhu 2018). At the World Herpetological Congress 2016 in China (Li *et al.* 2016), the two local forms were named with two different species names: The northern form was termed *M. mutica*, of which it is estimated that there are 20,000 wild individuals and 3 million in farms producing 1.2 million offspring per year. The southern form was termed *M. guangxiensis* (Uetz *et al.* 2020), with estimated 50,000 wild individuals, and 24 million adults in farms producing 8 million hatchlings per year. Some farms also produce albino turtles of this local form (Ren *et al.* 2021).

There are no detailed data available about breeding farms in Vietnam.

Mauremys mutica kami

Yasukawa, Ota & Iverson (1996) described the small sized, light-colored turtles from the Ryukyu Island as *M. mutica kami.* The natural range is on the islands of Ishigakijima (type locality), Iriomotejima, and Yonagunijima of the Yaeyama Island group. Individuals that occur elsewhere in Japan are imported from the Asian mainland as pets, and are often hybrids of the two *M. m. mutica* local forms or *M. m. mutica* x *M. m. kami*.

♂♂ of *M. m. kami* are larger than the ♀♀, the CL of ♂♂ is on average 15 cm (maximum 18.9 cm CL). ♀♀ usually grow to 14 cm CL (maximum 17.6 cm CL). The ground color of the head is olive-brown to grey-beige, and the bright stripe on the head is cream color. The color of the relatively flattened carapace is yellow or grey beige to bright brown.

Mauremys nigricans (Gray, 1834)

Chinese Red-necked turtle, Kwangtung River turtle

German: Chinesische Rothalsschildkröte.

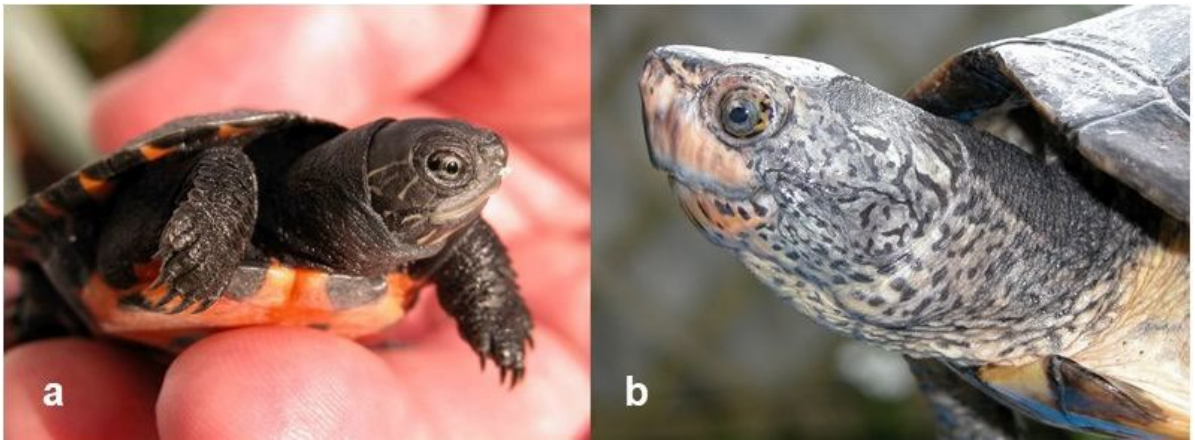

Fig. 28a: *Mauremys nigricans*, hatchling (B. Pfau);
b: adult ♂ (B. Pfau).

The hatchlings have bright coloration: their plastron is orange to red with irregular black dots. The intensity of the color depends on the content of carotenoids in the mother's diet.

At about two years, the bright colors fade and the carapace, head, and neck become grey to brown with irregular dots on the plastron. The coloration continues to darken with age.

♂♂ develop a reddish coloration or pattern on the neck when approaching sexual maturity, hence the common name "red neck turtles". Sometimes the red coloration extends to the head and beak, and the iris of the eyes develops a bluish hue. This sex specific coloration intensifies in the mating season.

♂♂ usually grow to 15 cm CL and ♀♀ to 20 cm CL, and the known maximum CL is > 28 cm.

Old, wild caught specimens often have enlarged heads. It is not known whether this is related to a diet based on hard prey items like crabs and crayfish. This head enlargement has not been observed in captive-raised individuals.

This species was previously placed in the genus *Chinemys*. *Mauremys nigricans* differs from the more common Chinese Three-keeled pond turtle (*M. reevesii*) by having only one carapacial keel.

Conservation Status and Main Threats

Conservation status

Mauremys annamensis

CITES Appendix I since 2019 (CoP18 Proposal 35).

Council Regulation (EC) No 338/97: Annex A.

In Germany particularly and strictly protected under BNatSchG [BG] Status: s.

IUCN Red List Status: Critically Endangered (A2bcd+4bcd; B2ab(i,ii,iii,iv,v); D, assessed March 14, 2018).

The transfer of *M. annamensis* from CITES II to CITES Appendix I was first proposed in 2013 at the CITES CoP16 meeting (Proposal 35). It was rejected and the species remained in Appendix II due to the overlap with Proposal No. 32 on the admission of other Geoemydidae, *inter alia* this species.

Mauremys mutica

CITES Appendix II since 2003 (CoP12 Proposal 26).

Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List Status: Endangered (A1cd+2cd, assessed June 30, 2000).

Mauremys nigricans

CITES Appendix II since 2013 (CoP16 Proposal 32).

Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List Status: Endangered (A1cd+2cd, assessed June 30, 2000).

Threats

Mauremys annamensis

This species is mainly threatened by the collection for the food and the pet market. In Vietnam, specimens are locally consumed and used in traditional medicine. Most animals are exported or smuggled to China, where they are considered a delicacy. Meanwhile, almost no individuals are found in the wild any more. The species lives in sympatry with *M. sinensis* and the remaining wild *M*. *annamensis* often do not find mating partners of their own species, causing hybridization (McCormack *et al.* 2020). At the 8th Herpetology World Congress, it was reported that this species was introduced into China before 1970 (Li *et al.* 2016). More than 300,000 turtles were reportedly being kept in farms, which produce about 120,000 juveniles per year for the food market.

In Vietnam, there are also farms that produce this species, however their breeding groups are likely supplied with wild caught turtles (Blanck & Braun 2013, McCormack *et al.* 2020). At the turtle center in Cuc Phuong National Park in northern Vietnam, a *M. annamensis* breeding group is being kept for reintroduction into natural habitats. However, the temperatures there are a bit lower than in their natural distribution range, which leads to a lower hatching rate (McCormack *et al.* 2014, McCormack 2015). It is not yet decided whether the new rescue center in Bach Ma National Park will become a breeding center, but at least turtles meant for reintroduction can be kept and acclimated there.

Mauremys mutica

Mauremys mutica animals and products command high prices in China. As a consequence, this species has been collected in high quantities for farms. The juveniles are kept as pets in private homes, the adults are considered a delicacy and also used as traditional medicine, and the shells are used to craft jewelry. Wild populations are threatened by hybridization ("genetic pollution") with released pets. In China, the release of turtles is a common religious ritual to bring good luck, and the turtles are released into natural water bodies regardless of their geographic origin. Natural populations of *M. m. kami* in Japan are also threatened by hybridization with other released Geoemydid species. *Mauremys mutica kami* is released outside its natural distribution range in Japan as well, and is therefore considered to be an invasive species (Shimadzu, & Kawauchi 2017). Since *M. mutica* is exported for the pet market and released outside its natural distribution range, it is classified as invasive species not only throughout southeast Asia, but also in many European countries (see for example GT IBMA 2017).

Mauremys nigricans

This species has been common in the wild and was frequently sold in pet markets for a low price. However, the size of the wild population is unknown since the distribution range is small and the species was often caught in traps installed for other turtle species (Anders & Iverson 2012, Artner & Hofer 2001). Threats to this species are the development of natural water bodies and the release of introduced Geoemydid pet turtles leading to hybridization.

A book released at the 8th World Congress of Herpetology estimates the wild population size to be 15,000 and the number of individuals in farms to be 250,000 (Li *et al.* 2016). However, this estimate cannot be substantiated. The husbandry conditions in these farms, described in this book are disputable, since typical skin diseases, due to the high density of individuals in the enclosures, are frequently reported.

Reproduction

Topic	Data
Secondary sexual traits	The tail in adult ♂♂ is longer and thicker at the basis than in ♀♀. *Mauremys nigricans*: ♂♂ develop reddish color markings on the neck and head, which get more intense during the mating season.
Reproduction	Oviparous.
Sexual maturity	*Mauremys annamensis*: 7–8 years; *Mauremys mutica:* in captivity ≥ 3 years, depending on temperature and feeding regime; *Mauremys nigricans*: ♂♂ at ca. 8 cm CL, ♀♀ at ca. 13 cm CL.
Nesting sites	*Mauremys annamensis*: ♀♀ sometimes lay eggs in two nests; *Mauremys mutica*: in captivity will use a simple box with a humid soil and sand mixture, the eggs are usually buried 6–8 cm deep; *Mauremys nigricans*: ♀♀ often lay eggs of one clutch in different nests at about 10 cm distance to each other. Depending on the size of the ♀♀ the eggs can be laid ca. 8–12 cm deep.
Nesting season	Starts at the beginning of the summer. In captivity in Central Europe, starts around mid may, depending on the temperatures. *Mauremys mutica kami* requires lower temperatures and starts nesting in mid-April.
Number of eggs/ clutches per season	*Mauremys annamensis*: in Vietnam, 1–2 clutches with 5–8 eggs per year. In Cuc Phuong Center, north of the natural distribution range, 1 clutch with up to 6 eggs. In captivity, with ample feeding, 4 clutches with 5–8 eggs per year are possible. *Mauremys mutica*: In breeding farms in China, 1–6 eggs per clutch, up to 10

Topic	Data
	clutches per year. *Mauremys mutica kami*: In captivity up to 3 eggs per clutch and 5 clutches per year. *Mauremys nigricans*: Depending on the nutritional status of the female, up to 5 clutches per year with > 30 eggs.
Egg size/ hatchling size	*Mauremys annamensis*: Eggs 38–41 x 20–21 mm, 10–13 g; hatchlings 34–37 mm CL, 7–8 g. *Mauremys mutica* (in a Chinese farm): Egg weight 8.3–24.4 g depending on the age of the female and the weather conditions. Northern local form: 3 eggs per clutch, 39.2 mm long and 9.8 g; hatchling 32.1 mm and 6.6 g. Southern local form: 6 eggs per clutch, egg length 45.3 mm and 15 g, hatchlings 38.2 mm and 10.5 g. (data from a farm that breeds both local forms separately, but under same conditions). *Mauremys nigricans*: 37–50 x 20–27 mm, hatchlings ca 3 cm long and 4 g without temperature control in a greenhouse; 3.5 cm long and 8 g after incubation with temperature control at 26.5–31.5 °C.
Incubation and hatching	*Mauremys annamensis*: 71–107 days at constant incubation temperatures of 25–30 °C and 72–99 days at constant 27–30.5 °C with a diapause of 3–4 weeks at room temperature after 1 month of incubation. The hatching rate of fertilized eggs without diapause is low, but with diapause it is about 100 %. *Mauremys mutica mutica*: 61–104 days at 25–31 °C, up to ca. 33 °C can be tolerated. *Mauremys mutica kami* 66–74 days at 26.5–30 °C, at > 30 °C the embryos die. No diapause is required. *Mauremys nigricans*: 51–90 days, the already developed embryos remain in the egg until the beginning of the rainy season. With temperatures between 26.5 and 31.5 °C the eggs will hatch after 51–75 days. Constant incubation temperatures above 31.5 °C will kill the embryos. A diapause is not required for this species.
Sex determination	Temperature dependent, pivotal temperature at 28.6 °C for *Mauremys annamensis,* 28.5 °C *for Mauremys nigricans* (see discussion in Hennig 2020).
Sperm storage	Yes, > 1 year.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	*Mauremys annamensis*: Mating begins directly after hibernation, which lasts 3–4 month at > 17 °C. *Mauremys mutica*: Mating after hibernation should be supervised since the female often is bitten on the neck by the male when she refuses to mate. *Mauremys nigricans*: Mating should be supervised; mating begins after hibernation at > 18 °C. Egg deposition in captivity occurs from the end of April to the beginning of July.
Husbandry requirements	These turtles require large basins with high oxygen content and filtered water. They usually rest between large rocks on the basin floor. Simple containers with sand can be used for the terrestrial part. The ladder to the terrestrial part can be designed for basking if the heating lamp is shining into to the shallow water.
General characteristics, difficulties with keeping and breeding	♂♂ of all three species are best kept solitarily. Female groups should be supervised, and aggressive individuals removed from the group. It is possible to keep ♀♀ of these species together and also with ♀♀ of other species. Hybridization is possible and should be avoided.
Care of the young, technical and time effort	Very low. Juveniles of all three species can be kept in groups with similar sized individuals in a small plastic box with plants (plastic plants) and a place to dry, such as a flat stone. Live food is necessary for persuading individuals to feed directly after hatching, but later they will accept dried food, pellets, or feeding gel.
Necessary safety measures	Terrariums for *Mauremys nigricans* should be secured against the escape of the animals by climbing out. The other two species are also good climbers.

Topic	Data
Life expectancy	*Mauremys annamensis*: > 50 years. *Mauremys mutica*: Ca. 23 years (Zoo data). *Mauremys nigricans*: There is a report of a 100-year-old individual (Ipser 2011).
Frequency of breeding in captivity	Frequent in all three species. Not all eggs are incubated since it is not easy to find a suitable, new home for these turtles.
Breeding difficulty evaluation	Very easy, if the species-specific requirements are met.
Mortality in the first years of life	The egg quality decreases, if ♀♀ are stressed by an aggressive male. This leads to decreased hatching rate and vitality of the hatchlings, as well as to egg binding. Generally, juveniles of all three species are easy to keep and no deaths have been reported.
F2 generation bred	*Mauremys mutica*: F3 generation in a zoo in Taipei. F5 generation of the albinotic turtles of the southern local form in the breeding farms. *Mauremys nigricans*: F1 offspring were already known in 2009. It is thus probable that F3 offspring are currently being bred.
Interviews/ Surveys/ Consultations	*Mauremys annamensis*: Several private breeders and 5 zoological institutions; *Mauremys mutica*: Several private breeders and 1 zoological institution; *Mauremys nigricans*: Several private breeders. Many breeders who were contacted did not fill in the questionnaire and referred to publications instead.

The coordinator of the European Association of Zoos and Aquaria is Thomas Maunders (Zoological Society London).

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Anders, B. & J.B. Iverson (2012): *Mauremys nigricans* (Gray 1834) - Red-Necked Pond Turtle, Chinese Red-Necked Turtle, Kwangtung River Turtle, Black-Necked Pond Turtle. Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. A.G.J. Rhodin, P.C.H. Pritchard, P.P. van Dijk, RA. Saumure, K.A. Buhlmann & J.B. Iverson, IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. **5**.

Artner, B. (1998): Eine neue Variante des Gelatinepuddings für Wasserschildkröten. Emys **5**(3): 20-22.

Artner, H. (2007): Chilling the eggs during incubation as the key to successful breeding of the Annam Leaf turtle *Mauremys annamensis* (Siebenrock, 1903). Emys **14**(1): 19-32.

Artner, H. (2009): Successful breeding of the Chinese Red-necked Pond Turtle *Mauremys [Chinemys] nigricans* (Gray, 1834). Emys **16**(2): 4-24.

Artner, H. & A. Hofer (2001): Observations on the Qing Ping Free Market, Guangzhou, China, November 2000. Turtle and Tortoise Newsletter **3**: 14.

Asian Turtle Trade Working Group (2000): *Mauremys mutica*, Yellow Pond Turtle. The IUCN Red List of Threatened Species 2000: e.T39613A97371342.

Asian Turtle Trade Working Group (2000): *Mauremys nigricans*, Chinese Red-necked Turtle. The IUCN Red List of Threatened Species 2000: e.T4656A97372062.

Becker, H., E. Meier, M. Raffel & H. Zwartepoorte (2015): Haltung, Vermehrung und Aufzucht der Annam-Sumpfschildkröte, *Mauremys annamensis.* Marginata **11**(3): 10-21.

Blanck, T. & S. Braun (2013): Zentral-Vietnam: Ostasiatischen "Bachschildkröten" und Hybriden auf der Spur. Marginata **10**(2): 18-30.

Chen, Y., B. Zhao, B.-J. Sun, Y. Wang & W.-G. Du (2011): Between-population variation in body size and growth rate of hatchling Asian yellow pond turtles, *Mauremys mutica*. Herpetological Journal **21**(2): 113-116.

De Bruin, R. (1992): De Kwangtung-moerasschildpad (*Chinemys nigricans*), kweek en ontwikkeling in het terrarium. Lacerta **51**(2): 42-46.

Fong, J.J. (2006): Systematics of the endangered *Mauremys mutica* and *Mauremys annamensis*. MS thesis, Loma Linda University.

Fong, J.J. & T.-H. Chen (2010): DNA evidence for the hybridization of wild turtles in Taiwan: possible genetic pollution from trade animals Conservation Genetics **11:** 2061-2066.

Fong, J.J., J.F. Parham, H. Shi, B.L. Stuart & R.L. Carter (2007): A genetic survey of heavily exploited, endangered turtles: caveats on the conservation value of trade animals. Animal Conservation: 10(4): 1-9.

Fong, J.J., B.L. Stuart, T. McCormack & J.F. Parham (2019): First Genetic Data of the Critically Endangered Vietnamese Pond Turtle (*Mauremys annamensis*) from Known-locality Specimens. Current Herpetology **38**(2): 140-152.

Fong, J.J., H. Hoang, P. Li, T. McCormack, D.-Q. Rao & L. Wang (2021): *Mauremys mutica*, Yellow Pond turtle. The IUCN Red List of Threatened Species 2021: e.T39613A2930788.

Fritz, U. & D. Mendau (2002): Ein Gattungsbastard zweier südostasiatischer Schildkröten: *Cuora amboinensis kamaroma* Rummler & Fritz, 1991 x *Mauremys annamensis* (Siebenrock, 1903). Salamandra **38**(3): 129-134.

GT IBMA (2017): *Mauremys mutica*. Base d'information sur les invasions biologiques en milieux aquatiques. Groupe de travail national Invasions biologiques en milieux aquatiques. UICN France et Agence française pour la biodiversité.

Hennig, A. (2020): Inkubation von Schildkröteneiern. Frankfurt (Edition Chimaira): 253 pp.

Hofstra, J. (1995): Kweken met de moerasschildpad, *Mauremys mutica*. Lacerta **53**(6): 187-191.

Ipser, T. (2011): Anmerkungen zu *Mauremys nigricans* (Chinesische Rothalsschildkröte). Sacalia **9**(31): 6-56.

Iverson, J.B. & W.P. McCord (1989): The proper taxonomic allocations of *Emys nigricans* Gray, *Emys muticus* Cantor, and *Geoclemys kwangtungensis* Pope. Amphibia-Reptilia **10**(1): 23-33.

Jenkins, M. (1995): Tortoises and Freshwater Turtles: The Trade in Southeast Asia. TRAFFIC Southeast Asia, Petaling Jaya, Selangor, Malaysia, 47 pp.

Kim, D.E. (2018): Management System of Invasive Alien Species Threating Biodiversity in Korea and Suggestions for the Improvement. Journal of Environmental Impact Assessment **27**(1): 33-55.

Li, T., X.-K. Han, W. Chen, H.-B. Zhou & Y.-P. Zhang (2018): Phenotypic Consequences of Embryonic Responses to Developmental Temperatures in Two Latitudinally Separated Populations of Asian Yellow Pond Turtles. Journal of Herpetology **52**(4): 454-458.

Li, Y., Y. Tian, B. Gu, Y. Gao & T. Zhou (eds) (2016): Testudinate China [in both English and Chinese]. Testudinate Industry Branch of the China Fishery Association, published on occasion of WCH8, 54 pp.

Lin, S.-M., Y. Lee, T.-H. Chen & J.-W. Lin (2015): Habitat Preference and Management of a Chinese Pond Turtle Population Protected by the Demilitarized Kinmen Islands. Journal

of Herpetology **49**(3): 399-404.

McCormack, T. (2015): Cuc Phuong National Park breeding success for the Vietnamese Pond Turtle in 2015. Asian Turtle Program. https://asianturtleprogram.org/mauremys-project/ (accessed 02.03.2021).

McCormack, T., P.P. van Dijk, S. Roberton & J.S. Dawson (2020): *Mauremys annamensis*, Vietnamese Pond Turtle. The IUCN Red List of Threatened Species 2020: e.T12876A182354172.

McCormack, T., J.E. Dawson, D.B. Hendrie, M.A. Ewert, J.B. Iverson, R.E. Hatcher & J.M. Goode (2014): *Mauremys annamensis* (Siebenrock 1903) - Vietnamese Pond Turtle, Annam Pond Turtle, Rùa Trung Bộ. Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. A.G.J. Rhodin, P.C.H. Pritchard, P.P. van Dijk, RA. Saumure, K.A. Buhlmann & J.B. Iverson, IUCN/SSC Tortoise and Freshwater Turtle Specialist Group: **5**.

Pham, V.T. (2021): Das Bach Ma Herpetology Rescue Center: Planung für eine neue Amphibien- und Reptilienauffangstation in Zentralvietnam. Elaphe **2021**(1): 7-9.

Prokop, H. & P. Petras (2008): Zucht und Aufzucht der Ryukyu Dreikiel-Bachschildkröte *Mauremys mutica kami* (Yasukawa, Ota & Iverson, 1996). Sacalia **20**(6): 5-22.

Protiva, T. (2015): Genetische und Panzerform-Variabilität bei *Mauremys annamensis*. Marginata **11**(3): 22-25.

Ren, Z. K. Ren, S. Ren, B. Liu & Y. Zhao (2021): Successful Cultivation of Albino Mauremys mutica for the First Time. Asian Agricultural Research 12(8): 65-68.

Rhodin, A.G.J., J.B. Iverson, R. Bour, U. Fritz, A. Georges, H.B. Shaffer & P.P. van Dijk (2017): Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (8th Ed.). *In:* Rhodin, A.G.J., J.B. Iverson, P.P. van Dijk, R.A. Saumure, K.A., Buhlmann, P.C.H. Pritchard & R.A. Mittermeier (Eds.): Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs **7**:1-292.

Schilde, M. (2003): Beitrag zur Kenntnis und Erstbericht zur Nachzucht der Vietnamesischen Sumpfschildkröte, *Mauremys annamensis* (Siebenrock, 1903). Reptilia (Münster) **8**(1): 62-64.

Shimadzu, N. & N. Kawauchi (2017): A report on the establishment and distribution of an introduced population of the Yaeyama yellow pond turtle, *Mauremys mutica kami*, on Tarama Island. Fauna Ryukyuana **36**: 13-17.

Sigouin, A., M. Pinedo-Vasquez, R. Nasi, C. Poole, B. Horne & T.M. Lee (2017): Priorities for the trade of less charismatic freshwater turtle and tortoise species. Journal of Applied Ecology **54**(2): 345-350.

Somerová, B., I. Rehák, P. Velenský, K. Palupčíková, T. Protiva & D. Frynta (2015): Haplotype variation in founders of the *Mauremys annamensis* population kept in European Zoos. Acta Herpetologica **10**(1): 7-15.

Uetz, P., P. Freed & J. Hošek (eds.) (2020): The Reptile Database, http://www.reptile-database.org, accessed 13.05.2021

Uhrig, D. & D.S. Lee (2006): Pflege und Nachzucht der hochgradig gefährdeten Vietnamesischen Sumpfschildkröte, *Mauremys annamensis* (Siebenrock, 1903). Radiata **15**(1): 3-10.

Wang, Y., J. Zhao, X. Liu, W. Li, S. Ouyang & X. Zhu (2019): Identification of SNPs and copy number variations in mitochondrial genes related to the reproductive capacity of the cultured Asian yellow pond turtle (*Mauremys mutica*). Animal Reproduction Science **205**: 78-

87.

Wen, P., J. Zhao, W. Li, X.-Y. Hong & X.-P. Zhu (2015): The parentage assignment of *Mauremys mutica* using multiplex PCR of microsatellites. Acta Hydrobiologica Sinica **39**(6): 1134-1141.

Wermuth, H. & R. Mertens (1977): Liste der rezenten Amphibien und Reptilien: Testudines, Crocodylia, Rhynchocephalia. Berlin (De Gruyter), 174 pp.

Yasukawa, Y., H. Ota & J.B. Iverson (1996): Geographic variation and sexual size dimorphism in *Mauremys mutica* (Cantor, 1842) (Reptilia: Bataguridae), with description of a new subspecies from the southern Ryukyus, Japan. Zoological Science, Tokyo **13**(2): 303-317.

Zhao, B., Y. Chen, H.-L. Lu, Z.-G. Zeng & W.-G. Du (2015): Latitudinal differences in temperature effects on the embryonic development and hatchling phenotypes of the Asian yellow pond turtle, *Mauremys mutica*. Biological Journal of the Linnean Society **114**: 35-43.

Zhao, J., W.-L. Li, P. Wen, D. Zhang & X. Zhu (2015): Genetic diversity and relationship of *Mauremys mutica* and *M. annamensis* assessed by DNA barcoding sequences. Mitochondrial DNA Part A: DNA Mapping, Sequencing, and Analysis **27**(5): 3507-3510.

Zhou, T., C. Huang, W.P. McCord & T. Blanck (2008): Gewerbliche Zuchten von Sumpf- und Wasserschildkröten in China. Reptilia (Münster) **13**(6): 27-33.

Zhu, X.-P., Y.-L. Chen, C.-G. Wei, Y.-H. Liu, X.D. Lu & G.-M. Zheng (2001): Reproduction of Yellow Pond turtle, *Mauremys mutica*. Acta Hydrobiologica Sinica **25**(5): 449-454.

Zhu, X.-P., C.-Q. Wei, W.-H. Zhao, H.-J. Du, Y.-L. Chen & J.-F. Gu (2006): Effects of incubation temperatures on embryonic development in the Asian yellow pond turtle. Aquaculture **259**(1-4): 243-248.

Zhu, X.-P., Y.-L. Chen, C.-Q. Wei, Y.-H. Liu & J.-F. Giu (2006): Temperature effects on sex determination in yellow pond turtle (*Mauremys mutica* Cantor). Acta Ecologica Sinica **26**(2): 620-625.

Zhu, X.-P. & J. Zhao: (2018): Hard-Shelled Turtle Culture. Pp. 353-361. *In:* Gui, J.-F., Q. Tang, Z. Li, J. Liu & S.S. de Silva (eds.): Aquaculture in China: Success Stories and Modern Trends. Hoboken (Wiley-Blackwell) 720 pp.

Zwartepoorte, H., H. Becker, E. Meier, M. Raffel & T. McCormack (2015): Die stark bedrohte Annam-Sumpfschildkröte (*Mauremys annamensis*) - Nachzucht in menschlicher Obhut als Beitrag für den Artenschutz. Marginata **11(**3): 26-32.

Beate Pfau (29.11.2020)

Thanks to Jonathan Fong for the review.

Testudinidae

Geochelone spp.

The two species of Indian star tortoise's genus *Geochelone* Fitzinger, 1835, namely *G. elegans* and *G. platynota,* look superficially similar.

They used to be imported in mixed shipments (usually labelled as "*Geochelone elegans*", because for this species the international trade restrictions were lower).

Even today, Indian star tortoises are frequently kept in large breeding groups of mixed-species, where hybridization may occur accidentally or even intentionally. Therefore, both species will be presented here.

Morphology and Taxonomy

Fig. 29: *Geochelone elegans* (left) and *G. platynota* (right), both two years old (H.-J. Bidmon).

Generally, male star tortoises are smaller than females, which can reach 30 cm CL depending on their geographical origin and the local form to which they belong. Some giant females, which were larger than 40 cm in CL, have been found in both species, but they were obviously no longer fertile.

Both species have yellowish stripes in a radiating pattern on a brown background color on the carapace. The areole of the scutes is yellow. In *Geochelone elegans*, usually one of the bright rays on the vertebral shield, either continuous or reduced to a single point, runs in the midline above the vertebral column, whereas in *G. platynota* the rays radiate to the sides of the scutes without the interrupted bright line along the vertebral column. Furthermore, the downward-radiating rays of the first costal scutes of *G. platynota* form a diamond-shaped pattern together with the upward-radiating rays of the first three marginal shields, which is not present in *G. elegans*. The costal scutes in *G. platynota*, as a rule, have 6 bright rays, whereas those in *G. elegans* have more than 8 rays.

Geochelone platynota was regarded as a subspecies of *G. elegans* by Obst (1985) in the inventory of chelonian species of the world. Meanwhile is widely accepted that both taxa are different species.

Hybrids of these two species show intermediate patterns, i.e., the middle ray is not continuous or widened towards the side. The number of rays varies, sometimes differs at each flank and the diamond shape pattern is irregular.

The two species can be easily differentiated by their plastron pattern (see below in the species portrays). However, photos of confiscated animals are often only showing the carapace patterns.

The missing nuchal is a good identification trait to differentiate this species from tortoises with similar “star tortoise” carapace patterns.

In wild animals of both species (particularly frequently in *G. elegans* females of the South India local form) the carapace can be conspicuously pyramided. The reasons for this are not yet fully understood. This means that in both these species it is not always a sign of incorrect husbandry conditions. Captive bred offspring from these animals, raised under correct husbandry conditions, may have smooth, thus not pyramided, carapace surfaces.

Distribution and Habitat

Distribution

Geochelone platynota inhabits dry zones in Myanmar between 50 and 500 m asl. The species was thought to be extinct and was reintroduced in protected areas.

G. elegans is found in India, Pakistan and in Sri Lanka. They inhabit low lands, often near the coast (below 200 m asl), with a warm and moist climate. But they also occur at higher elevations, up to ca. 900 m asl, and in desert like areas with dry seasons and cold periods. Escaped animals have established a small reproducing population in Florida, USA.

Habitat

Both species inhabit scrubland and dry grassland. They can also be found in agricultural landscapes.

Geochelone elegans (Schoepff, 1795)

Indian Star tortoise

German: Indische Sternschildkröte.

Adult Indian star tortoises have a carapace length between 15 and 38 cm and weigh 1–6.6 kg. Their carapace is domed. Contrary to *G. platynota,* the plastron of *G. elegans* has a radiating pattern which appears when the development of the hatchling advances. In some old individuals the radiating pattern is abraded and the plastron is uniform yellow.

The species occurs in Sri Lanka and on the Indian subcontinent in two disjunct areas. Genetic studies can differentiate the three local forms, but since confiscated or pet animals have often been released close to natural populations and integrated into them, a consistent genetic identification is difficult, and the suggested differentiation of three genetically defined subspecies (Gaur *et al.* 2016) has become almost impossible (Vamberger *et al.* 2020).

Fig. 30a: *Geochelone elegans* ♀ North India;
b: *Geochelone elegans* ♀ South India;
c: *Geochelone elegans* Sri Lanka (near Batticaloa);
♀ in foreground ♂ in background (H.-J. Bidmon).

The Indian star tortoises of Sri Lanka are very large, females can reach 3–5 kg. Usually, they have a contrasting carapace pattern with wide, straight and often yellow rays. The South Indian tortoises are much smaller. Adult males reach 700 g and females often between 1500–2500 g with a carapace length below 25 cm. The background color of the carapace is very dark with narrow bright rays which often do not run straight, but in an arc from the areole to the shield edge. The tortoises of north India are particularly large and often tan colored between the light rays. Bidmon (2001) mentions a very small local morph from Pakistan (adult females 1.2–2 kg, ca. 500–800 g). Apparently, a group of this morph is kept in California, but this could not be verified by the author.

Geochelone platynota (Blyth, 1863)

Burmese Star tortoise

German: Burma-Sternschildkröte.

Fig. 31a: *Geochelone platynota, 2* ♂♂ compete for a ♀ (H.-J. Bidmon);
b: Plastron patterns (B. Pfau).

In female Burma star tortoises, the carapace length is often > 30 cm whereas the males are often < 25 cm. The carapace in individuals without humpy scutes is flattened, which was eponymous for the scientific name.

The carapace is very dark, sometimes even black, which makes it very conspicuous with the bright radiation pattern (usually 6 rays per scute) on it.

The plastron is yellow with dark triangular (pointing inwards) marks. In individuals with abraded plastron, these dark marks are practically gone and thus the plastron is rather yellow.

Conservation Status and Main Threats

Geochelone elegans

CITES-Appendix I since 2019 (CoP18 Proposal 36).

Council Regulation (EC) No 338/97: Annex A.

IUCN Red List status: Vulnerable (A4cd, assessed March 13, 2018).

Geochelone platynota

CITES-Appendix I since 2013 (CoP16 Proposal 37).

Council Regulation (EC) No 338/97: Annex A.

IUCN Red List status: Critically Endangered (A1cd, assessed March 14, 2018).

In Germany, both species are particularly and strictly protected under BNatSchG [BG] Status: s.

Threats

Both species are threatened due to collection for local consumption and mainly for the international pet market. Habitat loss is another main threat. *Geochelone elegans* is the most smuggled tortoise species worldwide, even after being uplisted in CITES Appendix I. Already before 2000, *Geochelone platynota* was extinct in their natural habitats. Only in recent years this species has been reintroduced in protected areas in Myanmar, thanks to captive breeding programs.

Reproduction

Topic	Data
Secondary sexual traits	Mature males have larger tails and the root of the tail is thicker than in females. In both species females are larger than males.
Reproduction	Oviparous, the eggs are hard-shelled.
Sexual maturity	*G. elegans* males at 6–8 years, females at 8–12 years. In south India both sexes at 6–7 years. In captivity often at only 3–5 years in both sexes. Females often lay their first viable eggs at the age of 7 years. *In G. elegans* the sex can be identified at the age of 2 years. G. *platynota* at 6–15 years.
Nesting site	The eggs are buried in the soil in the afternoon and evening. The females usually choose sites with covering vegetation. In captivity, moist and workable substrate of about 20 cm deep substrate is often used.
Nesting season	There are local differences in *G. elegans*, however nesting always occurs during the monsoon season, and embryo development occurs during the dry season. In *G. platynota*, nesting occurs from October to February, during the first half of the dry season. Eggs of the first clutch normally go through a diapause. The eggs of both species are able to remain fully developed during a period of time without hatching. A considerable increase in the soil moisture triggers hatching.
Number eggs/ clutches per season	In nature, *G elegans* lays 2 clutches with 2–10 eggs a year, maximum 24 eggs have been observed. In captivity often 10 eggs per clutch and up to 9 clutches a year. The first clutches of the year have more eggs than the following ones. In nature*, G. platynota* lays up to 6 clutches with 4–5 eggs (generally 16 eggs a year). In captivity, 4–8 eggs per clutch and 14 clutches a year are possible. Clutches with 16 eggs have been observed, and large females can lay > 50 eggs per year.
Egg size/ hatchling size	Females of *G. elegans* produce eggs which may be different in shape (rounder or more elongated) from those of other females of the same species. Egg diameters range between 35 and 52 mm and the weight between 12–38 g. Hatchlings of the Sri Lanka local form often weigh ca. 17 g. Hatchlings of the South India local form are smaller and lighter. The eggs of *G. platynota* are 40 x 55 mm long and the hatchlings weigh 23 g.
Incubation and hatching	In *G. elegans* 90–170 days (min. 47, max. 180 days). During the incubation period the soil moisture should be reduced and the increase in moisture will trigger hatching. In *G. platynota,* 172–251 days. An initial, cool, diapause of ca. 4 weeks is recommended to increase hatching success. Afterwards, incubation should take place at 29–32 °C and > 60 % air moisture.
Sex determination	In *G. elegans* the pivotal temperature is 30 °C. In *G. platynota* the pivotal temperature is probably between 31 and 32 °C, but when breeding them in captivity the offspring is predominantly male. The number of females increases when the diapause temperatures are >20 °C and fluctuating, whereas the number of males remains high when the diapause temperature is kept constantly at 18 °C.
Sperm storage	Yes, in both species > 1 year.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Annual rhythms of temperature should correspond to the area of origin. When kept under constant temperature regime year-round, the egg fertilization rate decreases.
Husbandry requirements	*G. elegans* should be kept in high humidity and >10–15 °C all year round. *G. platynota* tolerates lower temperatures. It is recommended to keep them outdoors during summer in middle Europe, and during winter in a spacious enclosure to allow enough movement for active individuals. The substrate should be moist enough to avoid dust formation.
General characteristics, difficulties with keeping and breeding	Both species can be kept in groups (of the same species). The fertilization rate seems to increase when several males are present in the group. There is evidence that removing the males at the beginning of the egg deposition is of advantage since they can disturb females while laying eggs. Females have a strong hierarchy system. It has been observed that some lower rank females vomit when a higher rank female approaches them. *G. platynota* males have a very pointed horny end nail on the tail which can lead to poorly healing mating injuries in females of other species such as *G. elegans*. Therefore, and also to avoid any hybridization, it is recommended to keep tortoise species separated. Both species are susceptible to infections (especially *Mycoplasma*) and thus should be kept separate from other tortoises. Nevertheless, *G. platynota* is less susceptible and mostly gets infected when kept together with *G. elegans*. A high? humidity according to conditions in natural habitats is required, otherwise cold and swollen eyes may occur.
Care of the young, technical and time effort	Hatchlings of both species still have the yolk sac when hatching in the incubator, and should be kept sterile until the umbilicus is closed. The hatchlings from undetected nests in large terrariums are fully developed and start feeding immediately. During the first weeks they only feed a little, and after six weeks start feeding larger amounts of food, which leads to rapid growth. Humidity has to be kept high enough to avoid too much pyramiding of the carapace scutes.
Necessary safety measures	Placing of structures like wood on the ground to help tortoises to turn around in case they fall. Avoid heating cables on the ground.
Life expectancy in captivity	High (> 50 years). Many of the *G. elegans* individuals which were imported, mostly from Sri Lanka since 1980, are still alive, yet they show some signs of senility, and *G. platynota* of about the same age (about 40 years) are also known.
Frequency of breeding in captivity	Both species are commonly/ frequently bred in captivity.
Breeding difficulty evaluation	Easy, but with high space requirements. Furthermore, to simulate the annual seasons and to achieve the adequate lighting in indoor enclosures a sophisticated technical equipment is needed.
Mortality in the first years of life	Very low, even if given to unexperienced keepers < 10 %.
F2 generation bred	Yes, first reports published in 1964.
Interviews/ Surveys/ Consultations	*G. elegans*: Several private breeders, 3 zoological institutions and 2 commercial breeding companies; *G. platynota*: Several private breeders. Many breeders who were contacted did not fill in the questionnaire and instead referred to the publications.

G. elegans is commonly bred in Europe, USA and in Southeast Asia. In USA there are companies that offer new born hatchlings and even eggs ready to hatch. Breeding of *G. elegans* in farms in India or Sri Lanka on a larger scale is rather unlikely since the published data show that neither local keepers nor veterinarians there really know how to keep and breed the species in captivity. No data could be found on the breeding conditions in the Arabian countries that have exported a considerable amount of Indian star tortoises according to the CITES Trade Database.

G. platynota is meanwhile being bred in Europe and USA so frequently that many breeders only hatch young on advance order. Large scale breeding farms are being built in Asia.

References

These references are a selection. For a more complete bibliography please contact the author of this fact sheet.

Arathi, M. (2020): Illegal Trade in Star Tortoise Thrives. WCS India Blog.

Bidmon, H.-J. (2001): Die Indische Sternschildkröte *Geochelone elegans* (Schoepff, 1795), eine problematische tropische Landschildkröte? Mehrjährige Haltung und Vermehrung in Deutschland. Teil 1: Aussehen, Verbreitung und Lokalrassen, Eingewöhnung, Vorstellung der Zuchtgruppe. Reptilia (Münster) **6**(6): 56-64.

Bidmon, H.-J. (2002): Die Indische Sternschildkröte *Geochelone elegans* (Schoepff, 1795), eine problematische tropische Landschildkröte? Mehrjährige Haltung und Vermehrung in Deutschland. Teil 2: Haltung. Reptilia (Münster) **7**(1): 56-63.

Bidmon, H.-J. (2002): Die Indische Sternschildkröte *Geochelone elegans* (Schoepff, 1795), eine problematische tropische Landschildkröte? Mehrjährige Haltung und Vermehrung in Deutschland. Teil 3: Nachzucht. Reptilia (Münster) **7**(2): 56-62.

Bidmon, H.-J. (2002): Die Indische Sternschildkröte *Geochelone elegans* (Schoepff, 1795), eine problematische tropische Landschildkröte? Mehrjährige Haltung und Vermehrung in Deutschland. Teil 4: Schlupf, Aufzucht und Krankheiten. Reptilia (Münster) **7**(3): 56-63.

Bidmon, H.-J. (2002): Eine "laufende Nase" oder das Runny Nose Syndrom (RNS)? Praktische Erfahrungen mit Indischen Sternschildkröten. Radiata **11**(3): 41-43.

Bidmon, H.-J. (2003): Indische Sternschildkröten *Geochelone elegans* (Schoepff, 1795): Ihre Terrarien- und Freilandhaltung und Nachzucht. Emys **10**(1): 4-42.

Bidmon, H.-J. (2006): *Geochelone elegans* (Schoepff, 1795), the Indian star tortoise: is it really a "difficult" tropical tortoise? Several years of indoor and outdoor husbandry and breeding in Germany. pp. 18-49. *In:* Artner, H., B. Farkas & V.T. Loehr (eds.): Turtles. Proceedings: International Turtle & Tortoise Symposium Vienna 2002. Frankfurt (Edition Chimaira): 618 pp.

Choudhury, B.C., A. de Silva & C. Shepherd (2020): *Geochelone elegans*, Indian Star Tortoise. IUCN Red List of Threatened Species. IUCN, IUCN: 20 pp.

CITES (2019): CoP18 Proposal 36, *Geochelone elegans*. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021)

D'Cruze, N., A. Mookerjee, R. Vyas, D.W. Macdonald & A. de Silva (2018): *Geochelone elegans* (Schoepff 1795) - Indian Star Tortoise, Star Tortoise. *In:* Rhodin, A.G.J., J.B. Iverson, P.P. van Dijk, C.B. Stanford, E.V. Goode, K.A. Buhlmann, P.C.H. Pritchard & R.A. Mittermeier (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs **5**(106):1-13. doi: 10.3854/crm.5.106.elegans.v1.2018; iucn-tftsg.org/cbftt/.

de Silva, A., R. Wijneratne, K. Rodrigo, H.A.H.R. Hettiarachichi & G.A.T. Prasad (2017): The giant Star tortoise (*Geochelone elegans*) of Lunguhamwehera National Park, Sri Lanka. Wildlanka **5**(1): 31-35.

de Silva, A., M. Gunawardena, P. Wijenayake, D. Malsinghe & T. Prasad (2019): Star tortoises (*Geochelone elegans*): World's number one tortoise in the illegal pet trade. Wildlanka **7**(2): 51-58.

Draper, C. (2010): Husbandry Guidelines For Indian Star Tortoise *Geochelone elegans* (Reptilia: Emydidae). Western Sydney Institute of TAFE, Richmond: 189 pp.

Fife, J.D. (2007): Star Tortoises: The Natural History, Captive Care, and Breeding of *Geochelone elegans* and *Geochelone platynota*. Living Art Publishing, 116 pp.

Gaur, A., A. Reddy, S. Annapoorni, B. Satyarebala & S. Shivaji (2006): The origin of Indian Star tortoises (*Geochelone elegans*) based on nuclear and mitochondrial DNA analysis: A story of rescue and repatriation Conservation Genetics **7**(2): 231-240.

Hennig, A. (2020): Inkubation von Schildkröteneiern. Frankfurt (Edition Chimaira): 253 pp.

Hoekstra, R. & H.-J. Bidmon (2006): The secret tortoise: *Geochelone platynota*, die Burmesische Sternschildkröte -eine noch weit gehend unbekannte Landschildkröte. Schildkröten im Fokus **3**(3): 3-22.

Jasser-Häger, I. & H.-D. Philippen (2006): Burmesische Sternschildkröte *Geochelone platynota* (Blyth, 1869). Marginata **3**(3): 31-34.

Kuchling, G., E. Goode & P. Praschag (2011): Endoscopic Imaging of Gonads, Sex Ratio and Temperature Dependent Sex Determination in Captive Bred Juvenile Burmese Star Tortoises *Geochelone platynota*. Asiatic Herpetological Research 2(4): 240–244.

Langford, M. (2020): Care-sheet for baby and juvenile Indian Star tortoises bred by Marcus Langford here in the UK. 19 pp. www.marcus-langford-reptiles.co.uk (accessed Oktober 2020).

Le Berre, F. & G. Ceccarelli (2010): Farming *Geochelone platynota*. Testudo Magazine **5**(16): 14-22.

McCloud, K. (2008): A Photographic Identification Guide to Star-Patterned Tortoises. Identification Guides for Wildlife Law Enforcement. Ashland, OR, USFWS, National Fish and Wildlife Forensics Laboratory. 12: 17 pp.

Neizhko, I. & O. Marushchak (2019): Indian star tortoise (*Geochelone elegans* Schoepff, 1795): keeping and breeding at BION Terrarium Center. Breeding & Keeping Info. BION Terrarium Center is reptile`s operation located in Kyiv, Ukraine, BION Terrarium Center: 4 pp.

Obst, F.J. (1985): Die Welt der Schildkröten. Zürich (Rüschlikon) 235 pp.

Philippen, H.-D. (2007): Hinter den Kulissen einer slowenischen Schildkrötenfarm. Draco 32: 79-86.

Platt, S.G., S. Thanda, K.K. Win, K. Platt, M.M. Khin, T.R. Rainwater & D. Emmett (2011): *Geochelone platynota* (Blyth 1863) - Burmese Star Tortoise, Kye Leik. *In:* Rhodin, A.G.J., J.B. Iverson, P.P. van Dijk, C.B. Stanford, E.V. Goode, K.A. Buhlmann, P.C.H. Pritchard & R.A. Mittermeier (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs **5**(57): 1-9.

Platt, S.G., T. Lwin, K. Platt, R.M. Elsey & T.R. Rainwater (2019): *Geochelone platynota* (Burmese Star Tortoise). Maximum body size and gigantism. Herpetological Review **50**(1): 121-123.

Platt, S.G. & K. Platt (2020): The Road to Recovery: Restoring the Burmese Star Tortoise as

a Functional Member of Dry Zone Ecosystems in Myanmar. Radiata **29**(3): 4-25.

Praschag, P., K. Platt & B.D. Horne (2020): *Geochelone platynota*, Burmese Star Tortoise. IUCN Red List of Threatened Species. IUCN, IUCN: 12 pp.

Raphael, B.L., S.K. Macey, S.G. Platt, T. Seimon, R.J. Ossiboff, B. Horne, A.L. Gamarra, M.G. Barrera, T. Lwin, M.M. Soe, S.H. Aung, S.S. New, L.L. Khaing & K. Platt (2019): Health Screening of Burmese Star Tortoises (*Geochelone platynota*) Prior to Introduction to the Wild. Chelonian Conservation & Biology **18**(2): 153-162.

Rauhaus, A., C. Niggemann, J. Nicolaudius & T. Ziegler (2021): Haltung und Nachzucht der vom Aussterben bedrohten Burmesischen Sternschildkröte *Geochelone platynota* im Kölner Zoo, Deutschland. Sauria **43**(2): 13-26.

Scholdei, J. (2011): Ein nicht-alltäglicher Doppelschlupf von Zwillingen bei der Sternschildkröte (*Geochelone elegans*) im Allwetterzoo Münster - weitere Daten über die Gewichts- und Wachstumsentwicklung. Marginata **8**(1): 56-58.

Sharun, K., A. Satheesh & J. Alexander (2020): Diagnosis and therapeutic management of gastrointestinal parasitism among the captive population of Indian star tortoise (*Geochelone elegans* Schoepff, 1795) at Zoological Garden, Thiruvananthapuram, Kerala, India. Journal of Parasitic Diseases **44**: 453-456.

Squires, M.A., M.R. Rochford & F.J. Mazzotti (2018): The Indian Star Tortoise, *Geochelone elegans* (Schoepff 1795) (Testudinidae), a New Introduced Species in Florida. IRCF Reptiles & Amphibians **25**(1): 128-131.

Storms, G. & H.-D. Philippen (2004): Langjährige Zucht der Indischen Sternschildkröte, *Geochelone elegans* (Schoepff, 1794). Marginata **1**(4): 22-30.

Vamberger, M., C. Spitzweg, A. de Silva, R. Masroor, P. Praschag & U. Fritz (2020): Already too late? Massive trade in Indian star tortoises (*Geochelone elegans*) might have wiped out its phylogeographic differentiation. Amphibia-Reptilia **41**(1): 133-138.

Vyas, R. (2005): Captive breeding of the Indian Star Tortoise (*Geochelone elegans*). Zoos' Print Journal **20**(5): 1859-1864.

Beate Pfau (29.11.2020)

I wish to thank Hans-Jürgen Bidmon for the photos and his critical review.

Malacochersus tornieri (Siebenrock, 1903)

Pancake tortoise, Crevice tortoise

German: Spaltenschildkröte.

Fig. 32: *Malacochersus tornieri* in Tanzania
top: Adult tortoise in its rock crevice, bottom a juvenile (R. Mittermeier).

Morphology and Taxonomy

Adult pancake tortoises have a relatively soft, long and flattened carapace. Their limbs are very mobile and allow them a rapid locomotion similar to lizards. They are good climbers, which is unusual in tortoises. When feeling threatened, they run to a rock crevice where they clamp themselves by inhaling and pressing the carapace tightly to the crevice wall so that they cannot be caught. This is a species-specific strategy, and the reason for the common name “crevice tortoise” (Mertens 1942).

Young individuals have a domed carapace as other tortoise species have. The carapace flattens when growing. The color of the carapace is variable, often with a pattern, and provides a good camouflage on the granite rocks inhabited by the species.

Pancake tortoises can be individually identified very easily by photo documentation (Bender & Henle 2001). Currently, genetic markers are being developed, and phylogeographic studies are under way (Michael Tuma, pers. comm 2020), in order to identify the origin of the imported specimens in trade.

Distribution and Habitat

Distribution

Pancake tortoises occur in East Africa, mostly in Kenia and Tanzania. A small population also occurs in the North of the United Republic of Zambia.

Habitat

The species inhabits rock crevices in the “Kopjes”, small inselbergs of granite rocks, found in the savanna of East Africa. The tortoises only come out of their crevice to feed.

Conservation Status and Main Threats

CITES-Appendix I since 2019 (CoP18 Proposal 37).

Council Regulation (EC) No 338/97: Annex A.

In Germany particularly and strictly protected under BNatSchG [BG] Status: s.

IUCN Red List status: Critically Endangered (A4abcd, assessed October 25, 2018).

Threats

The population density in the wild is very low and many wild populations have already gone extinct due to illegal collection for the pet trade. Poachers sometimes destroy the whole “Kopje” to catch the animals, which causes habitat loss not only for this species, but also for other species that inhabit and use these Kopjes. A further threat is the mining of the Kopjes for building material and material for charcoal piles. Fires, either intentional or unintentional, burning down the vegetation layers, pose a further threat.

Reproduction

Topic	Data
Secondary sexual traits	The tail of adult ♂♂ is longer and thicker at the basis than the one of ♀♀. This trait can be seen already in juveniles at 3 months of age.
Reproduction	Oviparous.
Sexual maturity	Males reach maturity at 9–10 cm CL and ca. 380 g. Females at 13–14 cm CL. In captivity sexual maturity can be reached in 5–8 years depending on feeding.
Nesting site	The eggs are often laid at the back of a crevice and sometimes lie open on the ground there. Laying eggs in the ground as other tortoises do is rare in this species and if it happens, the females usually nest close to the nearest big rock. In terrariums the eggs are often not found, and then the young tortoises are discovered unexpectedly next to the adults. If females do not find an appropriate site to lay their eggs, they can get egg bound.
Nesting season	In the wild, the nesting season takes place during the rainy season and the hatchlings come out at the beginning of the following rainy season. In captivity, females nest during the simulated rainy season.
Number eggs/ clutches per season	Normally one egg and very rarely two eggs per clutch. Three, then much smaller eggs per clutch have already been observed. However, in such a case it is not clear whether the eggs are able to develop. In wild populations, normally one clutch per year. In captivity, often ca. four clutches per year at intervals of ca. 3 weeks. A maximum of 6 clutches a year has already been observed. Three young per female and year is a good breeding result.
Egg size/ hatchling size	Data on wild conditions is missing. In captivity, eggs are on average 46.6 x 28.9 mm and weigh 23.4 g (Shaw 1970). The hatchlings are on average 40.7 mm (35–45 mm) long and weigh 12–15 g.

Topic	Data
Incubation and hatching	75–340 days at 27–33 °C. It is recommended lowering the temperature during night time. If after 6 weeks there are no signs of development, a cool diapause of about 15 days could help. It is important that the incubation occurs in dry conditions at 50–70 % humidity. Increasing the substrate moisture to 80 % usually triggers hatching within the next 4 weeks.
Sex determination	Temperature dependent. The pivotal temperature is 29.8 °C. Males hatch at <= 28 °C and females hatch at >= 30.5 °C.
Sperm storage	Yes, probably > 2 years.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Annual fluctuations: mating occurs at the beginning of the rainy season and at least 3 weeks later the eggs are laid. During the dry season, no eggs are laid. A prolonged rainy season and plentiful feeding can increase the number of clutches per year. Males are more willing to mate when a male from a different group is present. However, males should only be put together under supervision, to avoid overly aggression.
Husbandry requirements	The tortoises can be kept outdoors during summer if climate conditions are adequate. When kept indoors, ensure sufficient lighting (UV-Index 1 to 5) and control the temperature regime. Replicating a sufficient number of rock crevices with adequate air moisture is recommended. The temperature during the rainy season should be between 25–35 °C, up to 40 °C during daytime with lowering the temperatures during night time. Since the species is sensitive to too much moisture, spray only moderately even during the rainy season. During the dry season 20–30 °C during day time, and restricted feeding is recommended. Food: high in fiber, diverse with wild herbs and maybe herb hay. The amount of feed should be limited to avoid overweight. Ensure appropriate Ca/P ratio of 1.4/1. If needed, add calcium (cuttlebone or seaweed lime) but no forced administration of lime preparations.
General characteristics, difficulties with keeping and breeding	These tortoises should be kept pairwise or in a harem with only one male per group. The social structure should be observed because even females can be aggressive towards each other. Each individual has its own crevice, thus the terrarium set up should be transferred to the outdoor enclosure.
Care of the young, technical and time effort	No special difficulties. Sometimes the young can remain to grow up in the terrarium with their progenitors.
Necessary safety measures	They are very nimble and are good climbers. Therefore, the enclosure or terrarium should be secured and without possible escape ways.
Life expectancy in captivity	Over 45 years.
Frequency of breeding in captivity	Very often. In the meantime, some breeders have a new melanistic morph.
Breeding difficulty evaluation	Easy. In established breeding groups reproduction occurs regularly.
Mortality in the first years of life	Under appropriate incubation conditions the hatching rate is > 80 %. Mortality of the young is very low given that humidity and feeding conditions are appropriate.
F2 generation bred	Yes. Detailed breeding reports have been published since 1960. Since 2000 F2 generation and following generations have been reported.
Interviews/ Surveys/ Consultations	Several private breeders, 6 zoological institutions and 2 commercial breeding companies. Many breeders who were contacted did not fill in the questionnaire and referred to the publications instead.

Pancake tortoises are kept and bred both in Europe and in the USA. In online trading platforms, the demand is larger than the offer. These nimble tortoises are very popular in Zoos. The EAZA-studbook is kept at Bristol Zoo.

Reports from breeding farms in Kenia and Zambia mention that pancake tortoises are kept with other species such as leopard tortoises (*Stigmochelys pardalis*) in flat enclosures that do not offer the necessary rock habitat with crevices and where the young can allegedly just be collected. Such reports are not very credible, due to the species-specific husbandry requirements (Chomba *et al.* 2014; Mutua 2019). Furthermore, field research on the surroundings of a well-known Kenyan farm, where a large wild population of this species had been known from, found that the former population has almost disappeared after the establishment of the breeding farm (Jacob Ngwava, pers. comm. 2020, see also in Mwaya *et al.* 2018).

Mwaya (2008) reports on a breeding farm in Tanzania that recreated the “Kopjes” and had true breeding success. However, this farm closed when Tanzania set the export quota to zero.

There is still a problem with smuggled individuals. Due to their flexible carapaces, turtles are able to breathe even when they are taped (to avoid scratching noises) and they fit perfectly into book shipping cartons.

References

These references are a selection. For a more complete bibliography please contact the author(s) of this fact sheet.

Allainguillaume, J., A. Campbell, Z. McLean, J.R. Santos, S.T. Evans, J. Leslie, A. Croxford, T. Skelton & G. McCabe (2017): Ex-situ conservation of the pancake tortoise (*Malacochersus tornieri*) - novel DNA markers for the genetic characterisation of captive breeding populations. BCG Testudo **8**(4): 1-11.

Bender, C. (2001): Fotodokumentation von geschützten Reptilien. Mannheim (DGHT), 28 pp.

Bender, C. & K. Henle (2001): Individuelle fotografische Identifizierung von Landschildkröten-Arten (Testudinidae) des Anhangs A der europäischen Artenschutzverordnung. Salamandra **37**(4): 193-204.

Chomba, C., C. Obias & V. Nyirenda (2014): Game Ranching: A Sustainable Land Use Option and Economic Incentive for Biodiversity Conservation in Zambia. Open Journal of Ecology **4**(9): 571-581.

Ettmar, S. (2019): Workshop-Protokoll *Malacochersus tornieri*. ISV Jahrestagung 2018. Sacalia **17**(2): 8-13.

Ewert, M.A., R.E. Hatcher & J.M. Goode (2004): Sex Determination and Ontogeny in *Malacochersus tornieri*, the Pancake Tortoise. Journal of Herpetology 38(2): 291-295.

Goode, M.J., W.C. Horrace, M.J. Sredl & J.M. Howland (2005): Habitat destruction by collectors associated with decreased abundance of rock-dwelling lizards. Biological Conservation **125**(1): 47-54.

Hennig, A. (2020): Inkubation von Schildkröteneiern. Frankfurt (Edition Chimaira): 253 pp.

Hufer, H. (2006): Zur Haltung und Vermehrung der Spaltenschildkröte - *Malacochersus tornieri* (Siebenrock, 1903). Schildkröten im Fokus **3**(1): 3-16.

Kisingo, A., J. Raycraft & B. Mboya (2021): Community awareness of critically endangered pancake tortoises (*Malacochersus tornieri*) in a village near Tarangire National Park, Tanzania: A pilot study. African Journal of Ecology (early view). DOI: 10.1111/aje.12912.

Kyalo, S. (2008): Conservation, management and control of trade in Pancake tortoise *Malacochersus tornieri* (Siebenrock, 1903) in Kenya: The non-detriment finding studies case study. International Expert Workshop on CITES Non-Detriment Findings. Cancun, Mexico, November 17th to 22nd, 2008.

Malonza, P.K. (2003): Ecology and Distribution of the Pancake Tortoise*, Malacochersus tornieri* in Kenya. Journal of East African Natural History **92**(1): 81-96.

Mertens, R. (1942): Über das Verhalten der Spaltenschildkröte *Malacochersus tornieri* (Siebenrock). Der Zoologische Garten **14**: 245-251.

Mwaya, R.T. (2008): Observation of the Pancake Tortoise, *Malacochersus tornieri* (Testudinidae), in Captive Breeding Facilities in Tanzania, College of African Wildlife Management, Mweka, P.O Box 3031, Moshi, Tanzania: 16 pp.

Mwaya, R.T., D. Moll, P.K. Malonza & J.M. Ngwava (2018): *Malacochersus tornieri* (Siebenrock 1903) - Pancake Tortoise, Tornier's Tortoise, Soft-shelled Tortoise, Crevice Tortoise, Kobe Ya Mawe, Kobe Kama Chapati. *In:* Rhodin, A.G.J., J.B. Iverson, P.P. van Dijk, C.B. Stanford, E.V. Goode, K.A. Buhlmann, P.C.H. Pritchard & R.A. Mittermeier (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs **5**(107):1-15. doi: 10.3854/crm.5.107.tornieri.v1.2018; iucn-tftsg.org/cbftt/

Mwaya, R.T., P.K. Malonza, J.M. Ngwava, D. Moll, F.A.C. Schmidt & A.G.J. Rhodin (2019): *Malacochersus tornieri*, Pancake Tortoise. The IUCN Red List of Threatened Species 2019: e.T12696A508210.

Schmidt, F.A.C. (2006). Some observations on pancake tortoises (*Malacochersus tornieri*) in Ruaha National Park, Tanzania. pp. 393-408. *In:* Artner, H., B. Farkas & V.T. Loehr (eds.): Turtles. Proceedings: International Turtle & Tortoise Symposium Vienna 2002. Frankfurt (Edition Chimaira): 618 pp.

Beate Pfau (08.03.2021)

Caudata

Salamandridae

***Echinotriton* spp.**				
Species	**Description author and date**	**Common name English**	**Common name German**	**Known in the trade**
Echinotriton chinhaiensis	Chang, 1932	Chinhai spiny crocodile newt	Chinhai-Stachel-molch	no
Echinotriton maxiquadratus	Hou, Wu, Yang, Zheng, Yuan & Li, 2014	Mountain spiny crocodile newt	Berg-Stachelmolch	no

Fig. 33a: *Echinotriton chinhaiensis* female, Chengwan (A. Hernandez);
b: *Echinotriton maxiquadratus*, subadult at the new breeding site (A. Hernandez);
c: *Echinotriton maxiquadratus* adult (A. Hernandez).

Morphology and Taxonomy

Echinotriton are unique animals that are characterized by having a relative flat head that is wider than the body, a rough skin, elongated and oblique ribs (Hernandez 2016a). *Echinotriton* is most similar to *Tylototriton*, but differs in a number of significant morphological and life history features (Nussbaum & Brodie 1982). *Echinotriton* has a stockier body than *Tylototriton*, shorter limbs, digits and tail. The adults are completely terrestrial.

The genus includes three species, namely *E. chinhaiensis*, *E. maxiquadratus* and *E. andersoni*, whose ecology is poorly understood, and exhibit fragmented distributional pattern (Hernandez 2016a). Only the two Chinese species, *E. chinhaiensis* and *E. maxiquadratus* were listed in CITES Appendix II, while *E. andersoni* endemic to Japan was listed in CITES Appendix III on 14.02.2021. The present guidance only focuses on the two Appendix II listed species, while the biology of *E. andersoni* is considered similar. The two species described in this factsheet have never been in husbandry outside China. The export of these species from China is illegal and poaching is rigorously punished.

The species of this genus can be identified by the following combination of characters, based on Hernandez (2016a) and Sparreboom (2014):

Echinotriton chinhaiensis – a median sized newt (TL ca. 11–15 cm) with a large, depressed head. The median cephalic ridge is in front of another V-shaped ridge that continues through the low, wide vertebral ridge. The parotoid glands are prominent. Two rows of 12 small square glandular costal nodes extend to the sides of the tail. The skin is rough except for the snout, lips, fingers and toes, palms and soles, and the lower keel of the tail. The species has a normally developed fifth toe and is generally black to dark brown in color, gray-orange on the palms and soles of the feet, and on the lower caudal keel. The tail is shorter than the body.

Echinotriton maxiquadratus – this species was discovered in 2014 and described based only on a single female measuring 13 cm TL. It is a fairly large species that can reach 16 cm TL. The species differs from other taxa by having a cephalic crest in front of the parotoid, which is very pronounced and trapezoidal. The species has ca. 12 prominent dorsolateral rib nodules at the end of the ribs they pierce. The 5th toe is usually developed as in *E. chinhaiensis*. The body and head are flattened, the vertebral crest is wide, the skin is very grainy, and the general color is black. The ends of the lateral cephalic ridge, fingers and toes, and tail are orange-yellow to light yellow or even whitish (Hernandez 2016a) in old adult specimens.

Distribution and Habitat

***Echinotriton chinhaiensis*:** Only known from the type locality and two nearby valleys east of the city of Ningbo (respectively, Chengwan, Ruiyansi and Qiushan, Beilun District, Zhejiang Province, China), where it inhabits a forest area at 100–200 m elevation (Cai & Fei 1984; Chang 1932).

***Echinotriton maxiquadratus*:** Microendemic species which exact localities have not been published beyond "a mountain in southern China" in an attempt to prevent commercial collecting and the extinction of the population (Hou *et al.* 2014). Just recently, a second population has been found, but its locality has also not been disclosed (Hernandez 2016b).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 39).

EU Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Echinotriton chinhaiensis – Critically Endangered (B1ab[iii,iv]+2ab[iii,iv], assessed April 30, 2004);

Echinotriton maxiquadratus – Critically Endangered (B2ab[iii], assessed June 18, 2019).

Threats

Echinotriton chinhaiensis – the one population that has been followed over the years occurs in Ruiyansi Forest Park, near the city of Ningbo in Zhejiang Province. Suitable habitats featuring a combination of characteristics such as sufficient cover for the eggs and appropriate water bodies for the development of larvae, are rare. Road construction and deforestation contribute to fragmentation of the scarce habitats and to a decrease in populations and number of individuals, and pollution of the breeding habitat is also a serious threat (Xie *et al.* 2000; Xie & Gu 2004). Cai and Fei (1984) and Fei (1992) signaled that the natural habitat in the valley was rapidly decreasing, being replaced by tea plantations, orange orchards and small-scale agriculture.

Echinotriton maxiquadratus – has a very small population size and its current area of occupancy (AOO) is estimated to be 8 km^2. The habitat of *E. maxiquadratus* is suffering continuing decline in its extent and quality due to increased agriculture, pollution, forest industry and tourism. The species is likely also threatened by climate change and illegal hunting. The distribution of *E. maxiquadratus* has not been made public due to concerns of extinction through illegal collection (Hou *et al.* 2014; IUCN 2020).

Reproduction

Topic	**Data for *E. chinhaiensis***
Secondary sexual traits	Sexual dimorphism is poorly expressed, ♀♀ are larger, heavier and present a puncture like cloacal orifice, while ♂♂ are smaller, slender, and present an elongated opened slit. In ♀♀ the cloaca is smooth inside, while in ♂♂ cloaca is more rugose. ♂♂ have a swollen tail-base in the breeding season (Sparreboom *et al.* 2011).
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	3–4 years.
Mating and oviposition sites	Terrestrial oviposition; Courtship on land.
Breeding season	In nature, it depends on the beginning of the monsoon season, which is always slightly variable, but usually mating starts in February and egg laying in March/April.
Number of eggs/ clutches per season	Ca. 69±21 eggs/clutch. ♀♀ can lay one clutch a year. The eggs are laid singly in one clutch. Egg deposition takes up to two days (Xie *et al.* 2000).
Average egg diameter and hatchling size	Average egg diameter (with gelatinous layer) ca. 6.5 mm. Larvae hatch with ca. 20 mm. At water temperatures of 25 °C the larvae finish metamorphosis with a TL of 41.6 mm.
Development duration egg to metamorphosis	Egg phase lasts between 58–88 days at 25 °C. The duration of the larval phase depends on water temperature and last around two months at similar temperatures.
Sperm storage	Unknown, but likely.

Husbandry and Captive Breeding

Echinotriton chinhaiensis △

Echinotriton maxiquadratus X

Topic	Data for *E. chinhaiensis*
Trigger for reproduction	Short period of higher temperatures followed by subsequent cooling and humidity increase by rain. ♀♀ usually deposit eggs during thunderstorms in spring, which apparently supports in addition the effect of air pressure change.
Husbandry requirements	Terrarium size depends on group size, sex-ratio, size of animals and behavior. Adults need a terrestrial setup with moderate humidity and appropriate hiding places for most of the year. During the breeding season an additional aquatic part (water depth 5–10 cm) and a thick leaf litter are to be included, as females deposit eggs under the litter along the bank of the water body. Eggs develop on land, so humidity needs to increase to sustain embryonic development. Larvae develop in water and post metamorphs are terrestrial. Animals are kept at room temperature (Chengdu, China). The humidity is more than 70 %.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis, the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General characteristics, difficulties with keeping and breeding	Adults need a large terrarium. Animals do not show signs of intra-specific aggression, with the exception of animals during egg laying. Larvae and juveniles need to be fed regularly.
Care of the young, technical and time effort	Eggs can be incubated either on moist tissue or in water. Incubation on moist tissue makes it easier to remove eggs with mold. Larvae develop in water at around 25° C. Close to finishing metamorphosis additional stone material or wood must be added to the enclosure to prevent metamorphs from drowning and to help them reaching land. Rearing post-metamorphs requires a high level of hygiene, and special attention regarding humidity requirements. It is recommended to cover the enclosure to prevent young salamanders from escaping.
Life expectancy in captivity	At least 8 years recorded, but likely more.
Frequency of breeding in captivity	Very rare. Current knowledge of a single breeding success in Chengdu, China.
Breeding difficulty evaluation	Only suitable for experienced breeders, because it is very difficult to combine the right breeding triggers. Therefore, successful breeding is very challenging.
Mortality in the first years of life	The percentage of viable eggs is about 95 %, mortality in larvae is about 10 %, and mortality in juveniles is about 20 %.
F2 generation bred	No.
Interviews/ Surveys/ Consultations	None. The information was obtained through the experience of the authors and from literature.

References

Cai, C. & L. Fei (1984): Description of neotype of *Echinotriton chinhaiensis* (Chang) and its ecology and habitat. Acta Herpetologica Sinica **3**(1): 71-72.

Chang, M.L.Y. (1932): Notes on two salamanders from Chekiang, *Tylototriton chinhaiensis* sp. n., and *Triturus sinensis* (Gray). Contributions from the Biological Laboratory of the Science Society of China. Zoological Series **8**(7): 201-212.

Fei, L. (1992): "*Echinotriton chinhaiensis* (Chang) and its endangered status." Chinese Journal of Zoology **27**(4): 39-41.

Hernandez, A. (2016a): Crocodile Newts - the Primitive Salamandridae from Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition Chimaira): 416 pp.

Hernandez, A. (2016b): Le genre relicte *Echinotriton* Nussbaum & Brodie, 1982: Histoire naturelle, écologie, biogéographie et perspectives conservatoires. Revue Francophone d'Herpétoculture, Situla **29**: 18-31.

Hou M, Y. Wu, K. Yang, S. Zheng, Z. Yuan & P. Li (2014): A missing geographic link in the distribution of the genus *Echinotriton* (Caudata: Salamandridae) with description of a new species from southern China. Zootaxa **3895**(1): 89-102.

IUCN SSC Amphibian Specialist Group (2020): *Echinotriton maxiquadratus*. *The IUCN Red List of Threatened Species* 2020: e.T78494566A122172217.

Nussbaum, R.A. & E.D. Brodie Jr. (1982): Partitioning of the salamandrid genus *Tylototriton* Anderson (Amphibia: Caudata) with a description of a new genus. Herpetologica **38**(2): 320–332.

Xie, F., L. Fei, C.Y. Ye, C.M. Cai, Z.W. Wang & M. Sparreboom (2000): Breeding migration and oviposition of the Chinhai salamander, *Echinotriton chinhaiensis* (Caudata: Salamandridae). Herpetological Journal **10**(3): 111-118.

Xie, F., H. Gu (2004): *Echinotriton chinhaiensis*. The IUCN Red List of Threatened Species 2004: e.T59447A11942842.

Sparreboom, M., F. Xie & L. Fei (2001): Reproductive behaviour of the Chinhai Salamander (*Echinotriton chinhaiensis*) (Caudata: Salamandridae) Amphibia-Reptilia **22**(3): 309-320.

Yang W, C. Liu, J. Jiang, C. Li & F. Xie (2011): Age structure of females in a breeding population of *Echinotriton chinhaiensis* (Caudata: Salamandridae) and its conservation implication. Asian Herpetological Research **2**(2): 91-96.

Authors: Feng Xie, Axel Hernandez, Marta Bernardes, Uwe Gerlach (26.04.2021)

Paramesotriton spp.

Species	Description author and date	Common name English	Common name German	Known in the trade
Paramesotriton aurantius	Yuan, Wu, Zhou & Che, 2016	Golden warty newt	Fujian-Warzenmolch	yes
Paramesotriton caudopunctatus	(Liu & Hu, 1973)	Spot-tailed warty newt	Schwarzpunkt-Warzenmolch	yes
Paramesotriton chinensis	(Gray, 1859)	Chinese warty newt	Chinesischer Warzenmolch	yes
Paramesotriton deloustali	(Bourret, 1934)	Tam Dao/ Vietnamese warty newt/ salamander	Vietnamesischer Warzenmolch	yes
Paramesotriton fuzhongensis	Wen, 1989	Fuzhong/ Wanggao warty newt	Fuzhong-Warzenmolch	yes
Paramesotriton guangxiensis	(Huang, Tang & Tang, 1983)	Guangxi warty newt	Guangxi-Warzenmolch	yes
Paramesotriton hongkongensis	(Myers & Leviton, 1962)	Hong Kong warty newt	Hongkong-Warzenmolch	yes
Paramesotriton labiatus	(Unterstein, 1930)	Spotless Smooth/ Ermi Zhao warty newt	Glatthäutiger Warzenmolch	yes
Paramesotriton longliensis	Li, Tian, Gu & Xiong, 2008	Longli warty newt	Longli-Warzenmolch	yes
Paramesotriton maolanensis	Gu, Chen, Tian, Li & Ran, 2012	Maolan warty newt	Maolan-Warzenmolch	no info/ not expected
Paramesotriton qixilingensis	Yuan, Zhao, Jiang, Hou, He, Murphy & Che, 2014	Qixiling warty newt	Qixiling-Warzenmolch	no info/ not expected
Paramesotriton wulingensis	Wang, Tian & Gu, 2013	Wuling warty newt	Wuling-Warzenmolch	no info/ not expected
Paramesotriton yunwuensis	Wu, Jiang & Hanken, 2010	Yunwu warty newt	Yunwu-Warzenmolch	yes
Paramesotriton zhijinensis	Li, Tian & Gu, 2008	Zhijin warty newt	Zhijin-Warzenmolch	no info/ not expected

The species included in this genus are described according to Sparreboom (2014) and Yuan *et al.* (2016). Newts in this genus are medium to large sized. The dorsum is generally dark green to dark brown and shows dorsal and dorsolateral ridges. The skin is usually warty. The species are not easily distinguishable without locality information or genetic analyses, especially as some trade consignments may contain a mixture of species.

Fig. 34a: *Paramesotriton hongkongensis* (F. Pasmans);
b: *Paramesotriton aurantius* Pair (M. Römhild);
c: *Paramesotriton caudopunctatus* (A. Jamin);
d: *Paramesotriton chinensis* (H. Janssen/ C. Michaels);
e: *Paramesotriton deloustali* (U. Gerlach);
f: *Paramesotriton yunwuensis* (G. Decome);
g: *Paramesotriton fuzhongensis* (J. Nerz);
h: *Paramesotriton guangxiensis* ♀ (A. Jamin);
i: *Paramesotriton guangxiensis* ♂ (A. Jamin).

Morphology and Taxonomy

The species of this genus can be identified by the following combination of characters, based on Yuan *et al*. (2014) and Sparreboom (2014) **(although molecular identification is recommended for definitive species identification)**:

Paramesotriton aurantius – a robust newt (11–15 cm) with very rough skin. Dorsal and lateral color of head, body, limbs, and tail dark brown. Vertebral ridge brown, conspicuous, and intermittent. Presence of irregular yellow spots on cheek, lateral sides of dorsum, lateral sides of tail, base of limbs. Numerous small irregular orange-red or yellow spots on the chin, venter, underside of axillae, and cloaca.

Differentiation from *P. chinensis* by examination of vomerine tooth morphology (Yuan *et al.* 2016).

Paramesotriton caudopunctatus – small body size (12–15 cm) with an elongated snout and a prominent orange ridge. Belly color variable from grey brown to orange. Tail of male animals with conspicuous orange to pink spots.

Paramesotriton chinensis – a robust newt (average size 13–15 cm, with a maximum size up to 18 cm) with very rough skin. Belly bluish-black with small irregular yellow-orange spots. No cranial ridges and less prominent dorsolateral ridges.

Paramesotriton deloustali – a large (16–20 cm) newt with warty skin and a large head. Bright orange coloration on belly, throat and skin, covered with a network of black lines.

Paramesotriton fuzhongensis – a large, stout newt (13–17 cm) skin densely covered with warts. Very similar to *P. chinensis* but larger and covered with more and larger warts. Color of dorsal side dark to olive-brown, medium sized irregular orange-red spots on dark belly.

Paramesotriton guangxiensis – a moderately sized (12–14 cm) warty newt. Flat-triangular head, longer than wide. Doral side dark brown, belly black with irregular yellow to orange spots.

Paramesotriton hongkongensis –a medium-sized (11–14 cm) stocky newt with a dorsal ridge and dorsolateral ridges consisting of glandular warts. The transverse section of the trunk is pentagonal. Dorsal color uniform dark olive to dark brown, ventral coloration bluish-black with irregular orange spots.

Paramesotriton labiatus –a slender flat-bodied newt of small to medium size (9–14 cm). Skin relatively smooth, granular warts absent on head and body. Head depressed, nearly flat. Dorsal color olive-brown with irregular small black spots. Ventral side paler brown with irregularly shaped orange blotches.

Paramesotriton longliensis – a robust (10–14 cm) newt with granular skin and prominent vertebral ridges. Head flattened, longer than wide. Dorsal color light brown, ventral side black with scattered, irregular orange-red spots, including one on the underside of the base of each leg.

Paramesotriton maolanensis –a large-bodied (18–21 cm) newt with smooth skin without granular warts. Head longer than wide, elongated snout. Eyes degenerated. Prominent mid-dorsal ridge. Color brown-black, venter and chin with irregular orange-red spots.

Paramesotriton qixilingensis –a robust newt (13–15 cm) with very rough skin, large clusters of conical dark brown warts covering the dorsum of head, lateral surface of body and dorsolateral ridges, and small, irregular and orange-red spots present on ventral surface, chin, underside of axillae, and cloaca.

Paramesotriton wulingensis – a slender medium sized (11–14 cm) warty newt. Body color is a deeper dark-brown, ventral side yellowish with small black spots.

Paramesotriton yunwuensis – a large (15–19 cm), robust newt. Head longer than broad, wider than neck. Parotoids prominent. Dorsal coloration ranges from reddish-brown to olive-brown. Ventral color pattern varies from black background with a few orange blotches to orange background with numerous black flecks.

Paramesotriton zhijinensis – a medium sized (10–13 cm) robust newt. Eyes relatively large and round. Dorsal color is brown-black. Dorsal stripes are variable, sometimes indistinct with tiny little yellow spots. Large, irregular orange-red spots on venter, chin, cloacae and tail. Neoteny is common with most adult specimen having vestigial gills and gill filaments.

Distribution and Habitat

Paramesotriton aurantius**:** From Jiulongjin, and near Longxi reservoir, Zherong County, Feiluan, Luoyuan Country, and near Dongzheng reservoir, Putian County, Fujian Province (southeastern coast of mainland China). Altitude around 590–830 m asl (Yuan *et al.* 2016).

Paramesotriton caudopunctatus: Populations are found in southwestern Hunan and northeastern Guangxi provinces in central China (500–1,800 m asl) (Sparreboom 2014).

Paramesotriton chinensis**:** Zhejiang and West and South into Anhui to northeastern Jiangxi and northern Fujian, China, at ca. 200–1,200 m asl. The species distribution falls into two discrete blocks (Sparreboom 2014).

Paramesotriton deloustali**:** Known from Bac Kan, Ha Giang, Yen Bai, Tuyen Quang, Tay Nguyen and Lao Cai provinces, in Vietnam around, 200–1,300 m elevation (Van Sang *et al.* 2003) and southern Yunnan Province, China (Zhang *et al.* 2018).

Paramesotriton fuzhongensis**:** Northeastern area of Guangxi Province, China between 400–1,200 m asl (Zhao & Yuan 2004).

Paramesotriton guangxiensis**:** Ningming County, Guangxi Province, China, and Cao Bang Province, northeastern Vietnam from elevations around 470 m asl (Rafaëlli 2013).

Paramesotriton hongkongensis: Coastal region of Guangdong Province and Hong Kong area (300–940 m asl) (Wu *et al.* 2010).

Paramesotriton labiatus**:** Type locality is Mount Dayao (Guangxi Province, China). Distribution not fully clear as animals may be misidentified as *P. chinensis* (Sparreboom 2014).

Paramesotriton longliensis**:** China, known from central Guizhou Province, Longli County, Shuichang village at 1,142 m altitude (Li *et al.* 2008), from western Hubei Province, Xianfeng County, Shizilu village at 787 m elevation and from southeastern Chongqing Province (Wu *et al.* 2010).

Paramesotriton maolanensis**:** Known only from Maolan National Nature Reserve, Libo County, Guizhou Province, China (Gu *et al.* 2012).

Paramesotriton qixilingensis**:** Known only from Qixiling Nature Reserve, Yongxin County, Jiangxi Province, southeastern China (Yuan *et al.* 2014).

Paramesotriton wulingensis**:** Wuling Mountains, in southern Chongqing and northeastern Guizhou provinces, China, at elevations between 500 to 1,800 m asl (Sparreboom 2014).

Paramesotriton yunwuensis**:** Known only from a scenic park near Luoding City, Guangdong Province, China at about 525 m asl (Wu *et al.* 2010).

***Paramesotriton zhijinensis*:** Zhijin County, Guizhou Province, China at about 1,310 m asl (Zhao *et al.* 2008).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 40).

EU Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Paramesotriton aurantius – Vulnerable (B1ab[iii], assessed June 19, 2019);

Paramesotriton caudopunctatus – Near Threatened (A2cd, assessed December 19, 2019);

Paramesotriton chinensis – Least Concern (assessed April 30, 2004);

Paramesotriton deloustali – Least Concern (assessed April 6, 2017);

Paramesotriton fuzhongensis – Vulnerable (C2a[i], assessed June 19, 2019);

Paramesotriton guangxiensis – Endangered (B1ab[iii]+2ab[iii], April 30, 2004);

Paramesotriton hongkongensis – Near Threatened (B1ab[iii], assessed June 19, 2019);

Paramesotriton labiatus – not yet assessed;

Paramesotriton longliensis – Vulnerable (B1ab[iii,v], assessed June 21, 2019);

Paramesotriton maolanensis – Data Deficient (assessed June 20, 2019);

Paramesotriton qixilingensis – Vulnerable (D1, assessed June 19, 2019);

Paramesotriton wulingensis – Least Concern (assessed June 20, 2019);

Paramesotriton yunwuensis – Endangered (B1ab[iii,v], assessed June 19, 2019);

Paramesotriton zhijinensis – Endangered (B1ab[iii,v], assessed June 19, 2019).

Threats

Main threats to the genus *Paramesotriton* are related with habitat loss and degradation, especially around the breeding habitats (Sodhi *et al.* 2009) as well as harvesting for the domestic and international trade and usage in traditional medicine. Below is a list of specific reported threats to and available information on the population status on each of these species:

Paramesotriton aurantius – increasing infrastructure development (roads) throughout most of its range, apart from in Dongzhen in Fujian Province, is thought to be a threat to the species through road mortalities. The development of dams has occurred within several of the localities that this species is known from, but it is unknown whether this has impacted the species. It is also found in the international pet trade, but this is not considered to be a major threat to the species (Z. Yuan pers. comm. June 2019; IUCN 2020a).

Paramesotriton caudopunctatus – although reportedly a very common species, it is affected by habitat degradation and harvesting for use in traditional Chinese medicine and the international pet trade (Sparreboom 2014);

Paramesotriton chinensis – although it is suggested as abundant, the effect of harvesting for the Chinese pet market is unknown (Sparreboom 2014);

Paramesotriton deloustali – in some localities (e.g., Van Ban, Lao Cai Province) the habitat

is severely threatened by the selective logging of large and valuable timber species, as well as by the unsustainable harvest of non-timber forest products like bamboo, fungi, medicinal plants, and rattan. The clearance of large tracts of riparian forest (often by fire) for the cultivation of cardamom, and the degradation by continued grazing of domesticated buffalo are also major threats to the habitat of *P. deloustali* (Swan & O'Reilly 2004). The species is additionally collected from the wild for use in traditional medicine and the national and international pet trade (CITES 2019; Sparreboom 2014; Swan & O'Reilly 2004);

Paramesotriton fuzhongensis – in view of the small population size and continuing population decline caused by harvesting for Traditional Chinese Medicine. The total number of mature individuals in the population is thought to be less than 10,000 (around 2,000), the number of subpopulations being less than 10, and each subpopulation thought to contain fewer than 1,000 mature individuals (IUCN 2020b);

Paramesotriton guangxiensis – vulnerable habitat and limited extent of currently known occurrence (Sparreboom 2014);

Paramesotriton hongkongensis – extent of occurrence (EOO) is probably not much greater than 20,000 km^2 and the species might be in decline because it is being collected for the pet trade, thus making the species close to qualifying for Vulnerable (IUCN 2021b);

Paramesotriton labiatus – no published information;

Paramesotriton longliensis – EOO is 12,326 km^2, it occurs in three locations that are severely fragmented, and there is continuing decline in the area and quality of its habitat, as well as, continuing decline in the number of mature individuals due to incidental by-catch and harvesting for the pet trade (IUCN 2020c);

Paramesotriton maolanensis – no published information;

P. qixilingensis – the number of mature individuals in the entire population of this species is believed to be no more than 1,000, and it is restricted to one protected area (IUCN 2020e);

Paramesotriton wulingensis – no published information;

Paramesotriton yunwuensis – EOO of 1,099 km^2, it occurs in five or fewer threat-defined locations, and there is ongoing decline in the extent and quality of its habitat and in the number of mature individuals due to harvesting (IUCN 2020f);

Paramesotriton zhijinensis – EOO is estimated to be no greater than 358 km^2, it occurs in a single threat-defined location, and there is a continuing decline in the area and quality of its habitat (IUCN 2020g).

Reproduction

Topic	Data
Secondary sexual traits	Sexual dimorphism is poorly expressed, especially outside of breeding season. ♂♂ are usually smaller, with higher tail, and present an elongated slit-shaped cloaca. ♀♀ are usually larger, with narrower tail and a puncture like cloaca. *P. aurantius* – ♂♂ have bright black or blue colors on the tail, especially intense during breeding season ♀♀ lack that coloration; *P. caudopunctatus* – ♂♂ have a light, round or elongated, pink spot on each side of the tail end, surrounded by black lines. ♀♀ lack of spots on the tail (Sparreboom 1983); *P. chinensis* – ♂♂ usually with darker coloration and a blue stripe along center of tail, especially intense during breeding season. ♀♀ usually lighter in coloration and lacking blue stripe; *P. deloustali* – ♂♂ presence of a broad silver-white, iridescent stripe on tail. In

Topic	Data
	♀♀ a silver-white stripe may only faintly be present; *P. fuzhongensis* – ♂♂ presence of a silver-blue sheen along the tail. ♀♀ lack of sheen on tail; *P. guangxiensis* – ♂♂ presence of a silver-white stripe on tail. ♀♀ lack of stripe on tail; *P. hongkongensis* – ♂♂ presence of a greyish-white stripe on tail. ♀♀ lack of stripe on tail; *P. labiatus* – ♂♂ white dots or spots in the rear third of the tail. ♀♀ lack of spots on tail; *P. yunwuensis* – ♂♂ have a bluish-white caudal stripe on the posterior half of the tail during breeding season. ♀♀ lack of stripe on tail (Sparreboom 2014).
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	*P. aurantius* – in captivity: 4–5 years; *P. chinensis* – in captivity: ♂♂ 4 years, ♀♀ 5–7 years. Maturation may be reached sooner if juveniles are forced to be aquatic, but this is difficult and may result in mortality and other problems; *P. deloustali* – in captivity: ♂♂ 3–4 years, ♀♀ 5–6 years; *P. guangxiensis* – in captivity: 4–5 years; *P. hongkongensis* – 2–3 years (Kong & Tong 1996), although more likely between 3–7 years (Pasmans *et al.* 2014); *P. yunwuensis* – in captivity: 4–8 years.
Breeding places	Aquatic, from courtship to oviposition. Eggs are laid singly or in small series between the leaves of underwater vegetation. *P. caudopunctatus* – eggs are normally placed in stone crevices, between stones and in fissures, either singly or as small clutches.
Breeding season	*P. aurantius* – after a cold period of several months at temperatures between 6–10 °C egg deposition starts in March/April at temperatures above 14 °C; *P. caudopunctatus* – egg deposition from mid-February to mid-April at water temperatures around 14 °C; *P. chinensis* – courtship begins in autumn, is paused over the coldest months, and resumed in spring. Oviposition starts in February at water temperatures of 10–13 °C and continues until late April, with maximal oviposition rates at 15–16 °C in the middle of this period (Michaels 2016); *P. deloustali* – eggs and larvae are found in nature in February and March at water temperatures above 16 °C (Martens 2003); *P. fuzhongensis* – courtship begins in autumn; first eggs are laid in February until April at water temperatures around 13–18 °C; *P. guangxiensis* – courtship begins in autumn (October), first eggs are laid in February until April at water temperatures around 15 °C; *P. hongkongensis* – main reproductive season from November–April (Fu *et al.* 2013), after a cold period of several months at temperatures between 5–10 °C egg deposition starts in March/April at temperatures above 15/16 °C; *P. labiatus* – after a cold period of several months at temperatures between 2–10 °C egg deposition starts in March/April at temperatures above 9 °C; *P. yunwuensis* – after a cold period of several months at temperatures between 6–10 °C egg deposition starts in March/April at temperatures above 14 °C.
Number of eggs/ clutches per season	*P. aurantius* – around 40 eggs per female; *P. caudopunctatus* – around 40–65 eggs per female; *P. chinensis* – one clutch is laid more or less continuously over an extended period (66–79 days) each year. Oviposition depends on the external temperature influencing females to lay between 0 and 7 eggs per day. A large female may lay up to 100 eggs during this time (Michaels 2016); *P. deloustali* – one clutch is laid over an extended time period (January–April). One female may lay more than 200 eggs a year (Bachhausen 2018); *P. fuzhongensis* – one clutch is laid more or less continuously over an extended period (30–60 days). A large female may lay up to 100 eggs; *P. guangxiensis* – one clutch is laid over an extended time period (February–April). One female may lay approximately 100 eggs per season;

Topic	Data
	P. hongkongensis – In literature, clutch sizes of up to 115 eggs are reported (Romer 1951). Although long time experience from captivity accounts for average clutch sizes of around 40 eggs per female a year; *P. labiatus* around 30 eggs per female. Female monitors and shows brood care by being in the immediate vicinity of the eggs with the tail; *P. yunwuensis* – around 50 eggs per female.
Egg size/ Hatchling size	*P. aurantius* – hatchling size ca. 9–10 mm; *P. caudopunctatus* – eggs: Total diameter of ca. 4 x 3 mm and 5 x 3.5 mm including the jelly capsule; larvae hatch after 17–40 days and measure 9–11 mm (Sparreboom 1983); *P. chinensis* – eggs: Total diameter of ca. 3 x 4 mm, nucleus diameter app. 2 mm; hatchlings: 5–9 mm depending on stage of development at hatching (Michaels 2016); *P. deloustali* – eggs: Total diameter of app. 5–6 x 7–8 mm, nucleus diameter app. 3 mm (Rehák1981); hatchlings: ca. 15 mm TL; *P. fuzhongensis* – eggs: Total diameter of app. 5 x 6 mm, nucleus diameter app. 2.5–3 mm; *P. hongkongensis* – eggs: Total diameter of app. 4.5 x 6 mm, nucleus diameter ca. 2.9 mm (Kong & Tong 1996); Hatchlings: app. 10–14 mm TL (Romer 1951); *P. labiatus*– eggs: Total diameter of app. 4–5 mm; *P. yunwuensis* - eggs: Total diameter of ca. 5–5.5 mm; Hatchlings: ca. 12 mm TL.
Development duration egg to metamorphosis	Development time depends on temperature. *P. aurantius* – egg stage 4–5 weeks and from larva to young animal ca. 3 months; *P. caudopunctatus* – slow development of larvae takes around 6 or 7 months in fresh, well oxygenated water with a temperature of 15–18 °C; *P. chinensis* – ca. 4 months from oviposition to metamorphosis at 16–18 °C (Michaels 2016); *P. deloustali* – in egg stage 4–6 weeks at 16–20 °C and from larva to young animal app. 3–6 months; P. *fuzhongensis* – larvae hatch after 3–5 weeks depending on the water temperature with a size of 10–12mm. Time to metamorphosis between 3–4 months. Size of young animal 40 mm; *P. guangxiensis* – first metamorphosis about 6 months after egg deposition at water temperatures of 16–18 °C. Higher water temperatures (20–22 °C) decrease the time to metamorphosis; *P. hongkongensis* – in egg stage ca. 3–4 weeks at 20 °C and from hatchling to young animal ca. 6–10 weeks; *P. labiatus* – eggs hatch after 52–58 days at 9–12 °C. Time from egg to metamorphosis between 3–4 months. Size of young animal 32 mm; *P. yunwuensis* – egg stage 4–5 weeks and from larva to young animal ca. 3 months.
Sperm storage	Unknown, but likely.

Husbandry and Captive Breeding

Paramesotriton aurantius 

Paramesotriton caudopunctatus 

Paramesotriton chinensis 

Paramesotriton deloustali 

Paramesotriton fuzhongensis 

Paramesotriton guangxiensis 

Paramesotriton hongkongensis 

Paramesotriton labiatus 

Paramesotriton longliensis X

Paramesotriton maolanensis X

Paramesotriton qixilingensis X

Paramesotriton wulingensis X

Paramesotriton yunwuensis 

Paramesotriton zhijinensis X

The current available knowledge on the husbandry and captive breeding conditions for the species of this group are all very similar. A general description is given in Pasmans *et al.* (2014).

Topic	**Data**
Trigger for reproduction	Adults of *Paramesotriton* require several months of temperatures consistently below 10 °C followed by a slow increase in temperature during spring time (reflecting annual variation in temperature in their natural range) (Michaels 2016; Pasmans *et al.* 2014; Bachhausen 2018).
Husbandry requirements	Adults may be housed in permanently aquatic conditions year-round, or may be kept on land for the summer, which reflects the case in nature. Aquaria with at least a size of 90 x 40 cm floor size and 20–40 cm water depth are recommended for a pair. As the animals are sometimes aggressive or territorial larger size aquaria like 120 x 50 cm are preferred. The water should be aerated and circulated using an internal water filter. Temperatures should be between 15 and 20 °C and may not exceed 24 °C in the summer. During hibernation a lowering of the temperature to 7–10 °C will trigger the breeding. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. Animals should be fed in order to maintain good body condition, but weekly feeds of as much as the animal will consume is a reasonable estimate of required frequency.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis the juveniles can be fed on small invertebrate prey includ-

Topic	Data
	ing hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General characteristics, difficulties with keeping and breeding	The main difficulties with caring for this species group surround aggression between adults. Only one adult male should be maintained per tank. Lowering the temperature is necessary to ensure breeding
Care of the young, technical and time effort	**Eggs** The eggs are laid individually or in small clusters and usually on submerged vegetation. *P. caudopunctatus* exceptionally lays its eggs on the bottom of the water body or between stones. Eggs will be consumed by adults so they should be removed from the aquarium as soon as possible. Eggs should preferably be separated from the plant material on which they are laid, washed with clean water and placed in a smaller aquarium containing mature water and some live plants. The water should be kept at around 18–20 °C and should be oxygenated with minimal turbulence. Eggs should not be disturbed once they are in this setup as moving them may cause premature hatching. **Larvae** The stage of development at which larvae hatch can vary considerably. Larvae may hatch earlier in the development and lie motionless in the water to complete development outside of the egg. However, under good conditions they will hatch fully pigmented with black skin and white gill tips, and already with front limbs. Larvae should be raised under conditions similar to housing the eggs, with regular small water changes to remove waste. Air-driven sponge filters are excellent to provide biological filtration and aeration. Larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. Excellent water quality is necessary and fungal/oomycete infections will rapidly kill whole batches of larvae if water quality declines or fluctuates. **Metamorphs** When larvae approach metamorphosis they should be moved to a container of shallow water with easily accessible islands. As soon as they climb out the water, they should be moved to another container with damp kitchen towel substrate and a relatively humid atmosphere. Once they gill stubs have been absorbed and the skin changed to a hydrophobic form, they should be transferred to juvenile setups. **Juveniles** Small juveniles should be housed on moist but not wet paper towel with a pile of dead oak leaves taking up ½ the floor area. The leaves provide areas of different dampness for the newts to regulate themselves. The enclosure should be moderately ventilated, ideally at substrate level. A box of 30 x 20 cm footprint can accommodate ca. 10 juveniles. The paper towel should be exchanged approximately weekly and the leaves as they begin to break down. Juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders when possible. When juveniles have stabilized in feeding, they can be moved onto more natural substrate, which will reduce the frequency of required cleaning. This change is not necessary and animals may be maintained on paper towel until adult. Natural substrate should comprise a mixture of decomposed leaf litter humus, topsoil and potting compost, which should be dampened and compressed to form a compact substrate that absorbs moisture but is not loose. On top of this oak leaf litter is arranged as for the paper towel setup. In both sorts of housing set-ups, it is critical to avoid wet conditions; dry surfaces with high ambient humidity are required. Wet conditions will rapidly lead to skin infections and deaths. Once some animals begin to succumb, developing sticky, shiny skins and becoming emaciated, it is difficult to prevent all animals in the container from eventually dying in the same way even if conditions are rectified.

Topic	Data
Life expectancy in captivity	Estimations are that animals can reach more than 30 years under good conditions.
Frequency of breeding in captivity evaluation	Yearly reproduction possible.
Breeding difficulty evaluation	Captive breeding is easy and consistent given good general care and correct annual temperature curves. Several F2-breedings are reported (e.g., *P. deloustali* - Bachhausen 2014). Rearing larvae and juveniles is more difficult, as slightly suboptimal conditions may result quickly in death for the described cases.
Mortality in the first years of life	Elevated, if husbandry requirements are not met (Pasmans *et al.* 2014), otherwise with optimal housing conditions, it can be negligible to none.
F2 generation bred	Breeding of up to F3 or more has been achieved at least for the species *P. deloustali* and *P. hongkongensis*. The long generation time implies that higher filial generations bred in captivity take a rather long time to achieve.
Interviews/ Surveys/ Consultations	*P. aurantius, P. caudopunctatus, P. chinensis, P. deloustali, P. fuzhongensis, P. guangxiensis, P. labiatus* and *P. yunwuensis* – the information was obtained through the experience of the authors and from literature; *P. hongkongensis* – several private breeders answered to the questionnaires, additional information was obtained through the experience of the authors and from literature; *P. longliensis, P. maolanensis, P. qixilingensis, P. wulingensis* and *P. zhijinensis* – none.

References

Bachhausen, P. (2014): F2-Nachzucht des Vietnamesischen Warzenmolches (*Paramesotriton deloustali*) nach sechsjähriger Aufzucht. Elaphe/Terraria **49**: 38-42.

Bachhausen, P. (2018): *Paramesotriton deloustali* (Bourret, 1934) - Vietnamesischer Warzenmolch, pp. 134-147. *In:* Grosse, W.-R. (ed.): Gefährdete Molch- und Salamanderarten - Richtlinien für Erhaltungszuchten. Band 2. Mertensiella **26**, Mannheim, Germany: 292 pp.

CITES (2019): CoP18 Proposal 41, *Tylototriton* spp. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

Fu, V.W.K., N.E. Karraker & D. Dudgeon (2013): Breeding dynamics, diet, and body condition of the Hong Kong newt (*Paramesotriton hongkongensis*). Herpetological Monographs 27: 1-22.

Gu, X., R. Chen, Y. Tian, S. Li & J. Ran (2012): A new species of *Paramesotriton* (Caudata: Salamandridae) from Guizhou. Zootaxa **3510**(1): 41-52.

Gu, H., B. Geng & Z. Yuan (2004): *Paramesotriton chinensis*. The IUCN Red List of Threatened Species 2004: e.T59457A11945154.

IUCN SSC Amphibian Specialist Group (2017): *Paramesotriton deloustali*. The IUCN Red List of Threatened Species 2017: e.T16129A113959728.

IUCN SSC Amphibian Specialist Group (2020a): *Paramesotriton aurantius*. The IUCN Red List of Threatened Species 2020: e.T112688544A112688609.

IUCN SSC Amphibian Specialist Group (2020b): *Paramesotriton fuzhongensis*. The IUCN Red List of Threatened Species 2020: e.T59458A63873307.

IUCN SSC Amphibian Specialist Group (2020c): *Paramesotriton longliensis*. The IUCN Red List of Threatened Species 2020: e.T195407A2382229.

IUCN SSC Amphibian Specialist Group (2020d): *Paramesotriton maolanensis*. The IUCN Red List of Threatened Species 2020: e.T78529967A122172322.

IUCN SSC Amphibian Specialist Group (2020e): *Paramesotriton qixilingensis*. The IUCN Red List of Threatened Species 2020: e.T78531031A122172327.

IUCN SSC Amphibian Specialist Group (2020f): *Paramesotriton yunwuensis*. The IUCN Red List of Threatened Species 2020: e.T78531041A122172332.

IUCN SSC Amphibian Specialist Group (2020g): *Paramesotriton zhijinensis*. The IUCN Red List of Threatened Species 2020: e.T78532178A122172337.

IUCN SSC Amphibian Specialist Group (2021a): *Paramesotriton caudopunctatus*. The IUCN Red List of Threatened Species 2021: e.T79101514A63867899.

IUCN SSC Amphibian Specialist Group (2021b): *Paramesotriton hongkongensis*. The IUCN Red List of Threatened Species 2021: e.T59460A63873529.

IUCN SSC Amphibian Specialist Group (2021c): *Paramesotriton wulingensis*. The IUCN Red List of Threatened Species 2021: e.T79101500A122172417.

Li, S., Y.-Z. Tian, X.-M. Gu & R.-C. Xiong. (2008): A new species of *Paramesotriton* - *Paramesotriton longliensis* (Caudata: Salamandridae). Zoological Research **29**(3): 313-317.

Martens, H. (2003): Am Typus Fundpunkt von *Paramesotriton deloustali*. Elaphe N.F. **11**(1): 55-59.

Michaels, C.J. (2016): Successful reproduction in *Paramesotriton chinensis* after more than a decade of reproductive inactivity, with observation of parental care. Herpetological Bulletin **137**: 24-27.

Pasmans, F., S. Bogaerts, H. Janssen & M. Sparreboom (2014): Molche und Salamander: halten und züchten. Münster (Natur und Tier Verlag): 248 pp.

Raffaëlli J. (2013): Les Urodèles du Monde. Deuxième édition. Plumelec (Penclén édition): 472 pp.

Rehák, I. (1981): První rozmnožování vietnamského mloka v zajetí. Živa **6**: 231-233.

Romer, J.D. (1951): Observations on the habits and life-history of the Chinese Newt, *Cynops chinensis* Gray. Copeia **1951**(3): 213-219.

Sodhi, N.S., T.M. Lee, L.P. Koh, & B.W. Brook (2009): A meta-analysis of the impact of anthropogenic forest disturbance on Southeast Asias biotas. *Biotropica* **41**(1): 103-109.

Sparreboom, M. (1983): On the sexual behaviour of *Paramesotriton caudopunctatus* (Liu & Hu) (Amphibia: Caudata: Salamandridae). Amphibia-Reptilia **4**(1): 25-33.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Swan, S.R. & S.M.G. O'Reilly (2004): Van Ban: a priority site for conservation in the Hoang Lien Mountains. Community-based conservation in the Hoang Lien Mountains, technical report No. 1. Fauna & Flora International Vietnam Programme, Hanoi, Vietnam.

Van Sang, D.N., H.T. Cuc, N.Q. Truong, T.V. Cuong, N.X. Tuong, L.T. Hai & N. Van Cong (2003): Feasibility study for a programme to conserve the Vietnamese salamander *Paramesotriton deloustali* in Ba Be and Cho Don districts, Bac Kan Province, PARC Project VIE/95/G31&031, Government of Viet Nam (FPD) UNOPS/UNDP/Scott Wilson Asia-Pacific Ltd., Ha Noi.

Wu, Y., K. Jiang & J. Hanken (2010): A new species of newt of the genus *Paramesotriton* (Salamandridae) from southwestern Guangdong, China, with a new northern record of *P. longliensis* from western Hubei. Zootaxa **2494**(1): 45-58.

Yuan, Z., E. Zhao & L. Shunqing (2004): *Paramesotriton guangxiensis*. The IUCN Red List of Threatened Species 2004: e.T59459A11945437.

Yuan, Z., Y. Wu, J. Zhou & J. Che (2016): A new species of the genus *Paramesotriton* (Caudata, Salamandridae) from Fujian, southeastern China. Zootaxa **4205**(6): 549-563.

Yuan, Z., H. Zhao, K. Jiang, M. Hou, L. He, R.W. Murph & J. Che (2014): Phylogenetic relationships of the genus *Paramesotriton* (Caudata: Salamandridae) with the description of a new species from Qixiling Nature Reserve, Jiangxi, Southeastern China, and a key to the species. Asian Herpetological Research **5**(2): 67-79.

Zhang, M., F. Han, J. Ye, Q. Ni, Y. Li, Y. Yao & H. Xu (2018): The entire mitochondrial genome of Vietnam Warty Newt *Paramesotriton deloustali* (Salamandridae: *Paramesotriton*) with a new distribution record from China. Conservation Genetics Resources **10**: 551-554.

Zhao, E. & Z. Yuan (2004): *Paramesotriton fuzhongensis*. The IUCN Red List of Threatened Species 2004: e.T59458A11945297.

Zhao, H., J. Che, W. Zhou, Y. Chen, H. Zhao & Y.-P. Zhang (2008): A new species of *Paramesotriton* (Caudata: Salamandridae) from Guizhou Province, China. Zootaxa **1775**(1), 51-60.

Authors: Uwe Gerlach & Marta Bernardes (01.04.2021)

Following Authorships:

P. aurantius – Georges Decome

P. caudopunctatus – Arnoud Jamin

P. chinensis – Christopher J. Michaels

P. deloustali – Paul Bachhausen

P. fuzhongensis – Christopher J. Michaels

P. guangxiensis – Arnoud Jamin

P. hongkongensis – Uwe Gerlach – Acknowledgement to Paul Bachhausen and Georges Decome

P. labiatus – Martin Schenk

P. yunwuensis – Georges Decome

Tylototriton asperrimus group				
Species	**Description author and date**	**Common name English**	**Common name German**	**Known in the trade**
Tylototriton asperrimus	Unterstein, 1930	Black knobby/ crocodile newt	Schwarzer Krokodilmolch	yes
Tylototriton hainanensis	Fei, Ye & Yang, 1984	Hainan knobby/ crocodile newt	Hainan Krokodilmolch	no info/ not expected
Tylototriton notialis	Stuart, Phimmachak, Sivongxay & Robichaud, 2010	Khammouan/ Laos knobby/ crocodile newt	Laos Krokodilmolch	no info/ not expected
Tylototriton panhai	Nishikawa, Khonsue, Pomchote, & Matsui, 2013	Panha's knobby newt/ Loei crocodile newt	Panhas Krokodilmolch	yes
Tylototriton pasmansi pasmansi *Tylototriton pasmansi obsti*	Bernardes, Le, Nguyen, Pham, Pham, Nguyen, & Ziegler, 2020	Pasmans' crocodile newt Obst's crocodile newt	Pasmans Krokodilmolch Obsts Krokodilmolch	no info/ not expected
Tylototriton sparreboomi	Bernardes, Le, Nguyen, Pham, Pham, Nguyen, & Ziegler, 2020	Sparreboom's crocodile newt	Sparrebooms Krokodilmolch	no info/ not expected
Tylototriton vietnamensis	Böhme, Schöttler, Nguyen & Köhler, 2005	Vietnam crocodile newt	Vietnam Krokodilmolch	yes
Tylototriton ziegleri	Nishikawa, Matsui & Nguyen, 2013	Ziegler's crocodile newt	Zieglers Krokodilmolch	yes

The species included in this group present a very conservative morphology (Bernardes *et al.* 2020, Stuart *et al.* 2010), making species identification very difficult, without locality information or genetic analyses. Additionally, new species are continuously being described from within the historical *Tylototriton asperrimus* species complex, making it impossible to know which species entered the trade under a potentially wrong identification. In an attempt to acknowledge the degree of uncertainty associated to some of the data presented below, questionable species names will be presented with quotation marks (e.g., "*T. asperrimus*"). *Tylototriton panhai* is the most easily recognizable species from within this group. This species shares morphological similarities with the *T. verrucosus* species group, and it seems to have been sporadically sold under a false name in the pet trade prior to its original scientific description (Hernandez 2016a). However, phylogenetically *T. panhai* is more similar to *T. vietnamensis* (Nishikawa *et al.* 2013a).

Fig. 35a: *Tylototriton asperrimus* male topotype (A. Hernandez);
b: *Tylototriton vietnamensis* male topotype (M. Bernardes);
c: *Tylototriton hainanensis* male topotype (A. Hernandez);
d: *Tylototriton hainanensis* male topotype (A. Hernandez);
e: *Tylototriton panhai* male, Phitsanulok, Thailand (A. Hernandez);
f: *Tylototriton ziegleri* male topotype (M. Bernardes).

Fig. 36a: *Tylototriton pasmansi pasmansi* dorsal view (C.T. Pham);
b: *Tylototriton p. pasmansi* ventral view (C.T. Pham);
c: *Tylototriton p. obsti* dorsal view (A.V. Pham);
d: *Tylototriton p. obsti* ventral view (A.V. Pham);
e: *Tylototriton sparreboomi* dorsal view (A.V. Pham);
f: *Tylototriton sparreboomi* ventral view (A.V. Pham).

Morphology and Taxonomy

This group is characterized by medium-sized newts with total lengths from 100 to 150 mm (Stuart *et al.* 2010; Ziegler *et al.* 2018), rough skin covered with small warts and glands, differentiated roundish rib nodules on both sides of the body, dark ground color except for palms, soles, finger and toe tips, vent region and ventral ridge of tail, which is usually yellow to bright orange in color (Bernardes *et al.* 2020, Fei *et al.* 1984, Nishikawa *et al.* 2014).

The coloration on the rib nodules and posterior parotoids doesn't seem to be a valid diagnostic characteristic, as evidence keeps on showing exceptional variation within each species (M. Bernardes pers. obs.).

The species of this group can be identified by the following combination of characters (although molecular identification is recommended for definitive species identification):

Tylototriton asperrimus – moderately large body (max TL ca. 13.8 cm; Hernandez 2016a) head slightly wider than long, tips of fingers reaching the nostril when laid forward, low dorsal tail fin-fold (Fei *et al.* 1984), short distance between the eyes, prominent bony ridges on head (Bernardes *et al.* 2020).

Tylototriton hainanensis – large body (TL up to 14.8 cm; Hernandez 2016a), head much wider than long, tips of fingers reaching the eye when foreleg laid forward, dorsal tail fin-fold high (Fei *et al.* 1984), brownish-black dorsal color (Ziegler *et al.* 2008).

Tylototriton notialis – knob-like rib nodules (Stuart *et al.* 2010), short distance between the eyes, skin with small glandular warts, long limbs (Bernardes *et al.* 2020), relatively thin and short tail (Nishikawa *et al.* 2013b).

Tylototriton panhai –yellow, orange, or reddish-brown markings on dorsal head, upper and lower lips, parotoids, vertebral ridge, rib nodules, tips of fingers and toes, margin of vent slit, and dorsal and ventral edges of tail, black limbs, large and prominent knob-like rib nodules, wide and moderately protruding dorsolateral bony ridges on head, spine not quadrate, vertebral ridge distinct and not segmented (Nishikawa *et al.* 2013a).

Tylototriton pasmansi – TL ca. 12 cm, head slightly longer than wide, distinct mid-dorsal ridge, relatively wide distance between the eyes, tips of fingers reaching the eye when foreleg is laid forward, rib nodules distinct and varying from pointy to more rounded, vertebral ridge high, slightly rough and segmented, dorsal skin more granulose than ventral skin, and skin in middle of abdomen with smooth tubercles shaped like transverse wrinkles, labial and gular folds present (Bernardes *et al.* 2020).

Tylototriton sparreboomi – TL ca. 12 cm, moderately stout habitus, head clearly longer than wide, wide distance between the eyes, tips of fingers reaching nostril when foreleg adpressed along head, rib nodules distinct, round and relatively enlarged, vertebral ridge segmented, high and relatively wide, skin tubercles on ventral side shaped like transverse wrinkles, gular fold present, labial fold slightly evident (Bernardes *et al.* 2020).

Tylototriton vietnamensis – TL ca. 12 cm, skin with fine and sparse glandular warts, slightly flattened and only moderately developed rib nodules, gular fold absent, low vertebral ridge, color uniformly greyish or brownish (Böhme *et al.* 2005), tip of forelimb reaching to nostril (Nguyen *et al.* 2009).

Tylototriton ziegleri – moderately large body, skin distinctly rough, large eyes, vertebral ridge prominent and segmented, tail long and thin, knob-like rib nodules, limbs long and thin, tips of fore- and hind-limbs greatly overlapping when adpressed along body, dorsum usually dark brown or blackish (Nishikawa *et al.* 2013b), rib nodules prominent to very prominent, bony ridges on head prominent to very prominent (Ziegler *et al.* 2018).

Distribution and Habitat

Distribution

Tylototriton asperrimus**:** Endemic to Guangxi Province, China. Known from Jinxiu County: Mount (Mt.) Dayao (=Yao Shan; type locality), including in the Dayaoshan Nature Reserve, Bainiu, and Mt. Xianglu; from Longsheng County; from Ziyuan County: Mt. Miao'er; from Huanjiang County: Mulun Nature Reserve; and from Tian'e County (Bernardes *et al.* 2020; Hernandez 2016a, 2018; Qin *et al.* 2012; Shen *et al.* 2012; Yang *et al.* 2014). Inhabits bamboo and primary forest (Sparreboom 2014).

Tylototriton hainanensis**:** Endemic to Hainan Province, China. Known from: Mt. Wuzhi (type locality), Diaoluoshan National Forest Park, Jianfengling National Nature Reserve; Bawangling National Nature Reserve, and Yinggeling National Nature Reserve (Hernandez 2016a, Zhao *et al.* 2008).

Tylototriton notialis**:** Known from Laos, Khammouan Province, Boualapha District, Nakai-Nam Theun National Protected Area (type locality); and from Vietnam, Nghe An Province, Que Phong District, Dong Van Commune, Pu Hoat Nature Reserve (Nishikawa *et al.* 2013b; Stuart *et al.* 2010). In Laos, this species is found in semi-evergreen forest mixed with pine forest (Stuart *et al.* 2010).

***Tylototriton panhai*:** Known from Thailand, Loei Province, in Phu Luang Wildlife Sanctuary (type locality), and Phu Suan Sai National Park; Phitsanulok Province, in Phu Hin Rong Kla National Park and Mt. Phu Soi Dao; Uttaradit Province, continuation of Mt. Phu Soi Dao; and Phetchabun Province, Phu Thap Boek. Also recorded from Laos, Xaignabouli (Sainyabuli) Province, Botene District, Mt. Phou Samrium. Historical populations that were not recently re-discovered include: Phu Ruea National Park and Phu Kradueng in Loei P., Thung Salaeng Luang National Park in Phitsanulok P., and Nam Nao National Park in Phetchabun P. Additional populations from Phu Khe, Doi Phu Wae, and Doi Phi Pan Nam, all from the same mountain range in Thailand are likely to belong to this species, although support from genetic analysis awaits confirmation (Hernandez 2017, 2016a, 2016b; Hernandez *et al.* 2019; Khonsue *et al.* 2010; Nishikawa *et al.* 2013a; Phimmachak *et al.* 2015; Pomchote *et al.* 2008).

***Tylototriton pasmansi*:** Endemic to Vietnam, from Phu Tho Province, Tan Son District, Xuan Son National Park (type locality); and from Hoa Binh Province: Lac Son District, Thuong Tien Nature Reserve and Da Bac District, Phu Canh Nature Reserve (Bernardes *et al.* 2020).

***Tylototriton sparreboomi*:** Currently only known from Vietnam, Lai Chau Province, Sin Ho District, Sa De Phin Commune (Bernardes *et al.* 2020).

***Tylototriton vietnamensis*:** Endemic to Vietnam, known from Bac Giang Province, Son Dong and Luc Nam Districts, Tay Yen Tu Nature Reserve (type locality); from Quang Ninh Province, Hoanh Bo District, Dong Son – Ky Thuong Nature Reserve and Uong Bi District, Yen Tu Nature Reserve; and from Lang Son Province, Loc Binh District, Mau Son Mt. (Bernardes *et al.* 2020, 2013). This species is found in secondary evergreen lowland forest mixed with hardwood, bamboo and shrubs on granite parental rock material (Bernardes *et al.* 2017a).

***Tylototriton ziegleri*:** Known from Vietnam, Ha Giang Province, Quan Ba District, Mt. Ta Boc (Type locality), and Bac Quang District; and from Cao Bang Province, Bao Lac District, and Nguyen Binh District, Mt. Pia Oac; and from China, Yunnan Province, Malipo County (Jiang *et al.* 2017; Nishikawa *et al.* 2013b). This species occurs in primary forests on limestone parent rock material characterized mainly by bamboo vegetation (Bernardes *et al.* 2017b; Nishikawa *et al.* 2013b).

Habitat

In general, *Tylototriton* species inhabit forests in mountain regions with a high amount of annual precipitation during the summer monsoon, to support the creation of water bodies with a long hydroperiod for breeding success (Bernardes *et al.* 2013, Bernardes *et al.* 2017a). These species usually reproduce in small temporal pools (e.g. *T. vietnamensis* [Bernardes *et al.* 2013]), but can also breed in permanent ponds of variable size (e.g. *T. ziegleri* [Nishikawa *et al. 2*013b]) or small streams with slow current (e.g. *T. notialis* [Stuart *et al.* 2010] and *T. ziegleri* [Nishikawa *et al.* 2013b]).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

EU Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Tylototriton asperrimus – Near Threatened (assessed January 1st, 2008);

Tylototriton hainanensis – Endangered (B1ab[iii]+2ab[iii], assessed January 1st, 2008);

Tylototriton notialis – Vulnerable (B1ab[iii], assessed January 28, 2014);

Tylototriton panhai – Data Deficient;

Tylototriton pasmansi – Data Deficient;

Tylototriton sparreboomi – Data Deficient;

Tylototriton vietnamensis – Endangered (B1ab[iii], assessed January 29, 2016);

Tylototriton ziegleri – Vulnerable (B1ab[iii], assessed July 17, 2015).

Threats

Main threats to *Tylototriton* are related with habitat loss and degradation especially around the breeding habitats (Nishikawa *et al.* 2013b) as well as harvesting for the domestic and international trade (CITES 2019; Rowley *et al.* 2016). Below is a list of specifically reported threats to each of these species:

Tylototriton asperrimus – exploitation for traditional medicine, used both locally and nationally (van Dijk *et al.* 2008), habitat loss and degradation, poaching for the international trade, increased tourism and infrastructure developments, and electro-fishing (Hernandez 2016a);

Tylototriton hainanensis – habitat loss and degradation, climate change (Hernandez 2016a), infrastructure development for tourism (Sparreboom 2014);

Tylototriton notialis – habitat loss and degradation, poaching (Hernandez 2016a), used nationally in traditional medicine (IUCN 2015);

Tylototriton panhai – deforestation, tourism, global warming, persecuted as bad omen, collection for traditional medicine and the international pet trade (Hernandez 2016a);

Tylototriton pasmansi – as all the other species in this group it is affected at least by habitat loss and degradation;

Tylototriton sparreboomi – as all the other species in this group it is affected at least by habitat loss and degradation;

Tylototriton vietnamensis – coal extraction extending to the buffer area of Tay Yen Tu Nature Reserve, increased forest fragmentation, evidence of breeding habitats used by cattle, harvest for use in traditional medicine, or for local and international pet trade (Bernardes *et al.* 2017a), intentional forest fires to clear land for agriculture development, increased tourism and infrastructure developments, and re-forestation based on monocultures to be exploited by the paper industry (M. Bernardes, pers. obs.).

Tylototriton ziegleri – habitat loss and degradation (Nishikawa *et al.* 2013b), distribution not included within any protected area, has been in demand for the international pet trade (Bernardes *et al.* 2017b).

Reproduction

Topic	Data for this group
Secondary sexual traits	Sexual dimorphism is poorly expressed. ♀♀ are larger, heavier and present a puncture like cloacal orifice, while ♂♂ are smaller, slender, and present an elongated opened slit. During the breeding season, mature adults will present a more evidently bulbously and inflated cloacal region (Hernandez 2016). *T. vietnamensis* and *T. ziegleri* – ♂♂ show lighter coloration during aquatic phase.
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	*T. panhai* – sexual maturity is reached at an age of 4 years in the wild in both sexes (Khonsue *et al.* 2010); *T. vietnamensis* – 1.5–5 years in captivity (Rauhaus & Ziegler, submitted); *T. ziegleri* – 3–6 years in captivity.
Mating and oviposition sites	Aquatic: courtship, and spermatophore transfer; terrestrial: oviposition.
Breeding season	In nature depends on the beginning of the monsoon season, which is always slightly variable. "*T. asperrimus*" – starts in April/ May (Fleck & Schultschik 2013); *T. hainanensis* and *T. notialis* – starts in April/ May (Hernandez 2016a); *T. panhai* – usually starts in early May (Hernandez 2016a); *T. vietnamensis* and *T. ziegleri* – April to July (Bernardes *et al.* 2017b). In captivity starts with the right triggers. In the Cologne Zoo, egg depositions both in *T. vietnamensis* and *T. ziegleri* occurred from January to August (in *T. vietnamensis* mostly between March and July) (A. Rauhaus, pers. comm.).
Number of eggs/ clutches per season	"*T. asperrimus*" – ca. 30–52 eggs per clutch (Fleck & Schultschik 2013); *T. hainanensis* – ca. 58–90 eggs per clutch (Hernandez 2016a); T. *panhai* – ca. 15–20 eggs (at least) per clutch (Hernandez 2016a); *T. vietnamensis* – in natural habitat ca. 5–85 eggs per clutch (Bernardes *et al.* 2017b), in captivity up to 178 eggs per clutch; 1–2 clutches per year; *T. ziegleri* – ca. 11(at least)–134 eggs per clutch (Bernardes *et al.* 2017b); 1–3 clutches per year.
Average egg diameter and hatchling size	"*T. asperrimus*" – eggs ca. 7–10 mm; hatchlings ca. 22 mm (Fleck 2010); *T. vietnamensis* – in natural habitat eggs ca. 6–13.6 mm; hatchlings ca. 15.6–17.9 mm (Bernardes *et al.* 2017b); in captivity hatchlings 18–22 mm; *T. ziegleri* – eggs ca. 7.2–11.2 mm; hatchlings ca. 15–22 mm (Bernardes *et al.* 2017b).
Development duration egg to metamorphosis	*T. panhai* – at ca. 22 °C metamorphose is completed after 3 to 6 months after oviposition; *T. vietnamensis* – most larvae hatch around 3–4 weeks after egg deposition (at temperatures of 20–24 °C). Depending on temperatures, hatching can take place after 9 days up to almost 4 months. Metamorphosis usually takes place 2–3 months after hatching but depending on feeding regime, group size, temperature etc., the larval phase can last between 8 weeks and 6 months. Total lengths at metamorphosis between 53.1 and 74.7 mm; *T. ziegleri* – larvae hatch after ca. 20 days (Bernardes *et al.* 2017b), and metamorphosis is completed in between 8 to 16 weeks at TL between 42 and 65 mm. At the Cologne Zoo larvae hatched 22–36 days after egg deposition and metamorphosis took place 12–19 weeks after egg deposition. TL at metamorphosis between 49 and 57.7 mm (A. Rauhaus, pers. comm.).
Sperm storage	Possible, but not known.

Husbandry and Captive Breeding

Tylototriton asperrimus 

Tylototriton hainanensis X

Tylototriton notialis X

Tylototriton panhai 

Tylototriton pasmansi X

Tylototriton sparreboomi X

Tylototriton vietnamensis 

Tylototriton ziegleri 

Topic	Data for this group
Trigger for reproduction	*T. asperrimus* – unknown. Possibly a short period of higher temperatures followed by subsequent cooling by rain. *T. vietnamensis* – increased temperatures, water level and humidity after a drier and cooler period during winter. Egg depositions often occurred during thunderstorms, so air pressure might be an additional trigger. *T. ziegleri* – some report that simply elevating temperatures in spring (above approx. 18 °C) after a drier and cooler period (with temperatures around 15 °C) during winter, causes the males to enter the water. Others combine increased temperature with raised humidity, changes in air pressure, and raised water level.
Husbandry requirements	Adults need a terrestrial setup with moderate humidity and appropriate hiding places for most of the year. During the breeding season an additional aquatic part needs to be included, as males become strictly aquatic. Larvae develop in water and post metamorphs are terrestrial until reaching sexual maturity. Terrarium size depends on group size, sex-ratio, size of animals and behavior, but usually ca. 120 x 40 x 40 cm for a pair or a small group with 2/3 land and 1/3 water. *"T. asperrimus"* – yearly temperatures ranging in average between 10 °C and 25 °C, with min. and max. values able to exceed this range during short periods. From March onward, adults are kept in aquaterraria with water depths of about 10 cm (Fleck & Schultschik 2013); *T. hainanensis* – following information obtained by Hernandez (2016) from other sources, temperatures below 15 °C and excess moisture are life threatening for this species. A terrarium size of 120 x 40 x 40 cm is suitable for three to four adults and should be kept relatively dry during winter; *T. panhai* – requires a large aquaterrarium (120 x 40 x 40 cm for a pair), temperatures between 18 to 24 °C during February–October, and between 10 to 14 °C during November–January and high humidity requirements (ca. 70–80 %) throughout the year. Therefore, it is recommended to always keep water inside the aquatic section of the enclosure. However, a dry part should always be accessible, especially during cold season, when excessive moisture can be fatal for adults; *T. vietnamensis* – temperatures March–October 22–25 °C, November–February 18–20 °C (although cooler winters are also possible), can tolerate high temperatures of around 30 °C for short periods during summer as long as there are suffi-

Topic	Data for this group
	cient cooler hiding places. Dry keeping during winter; increased spraying and water level in early March, maximum water depth around 5 cm; *T. ziegleri* – yearly temperatures ranging between 10 °C and 28 °C. Juveniles (up to 3 years old) are kept in a terrestrial setup with a shallow water basin to ensure humidity requirements. Adults are kept either with constant water level throughout the year of around 5 cm, or with water level fluctuations: lower depths (ca. 2 cm) during dry season and higher depths (ca. 10 cm) during breeding season.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General particularities, difficulties with keeping and breeding	Adults need to be separated from eggs and larvae. Larvae and juveniles need to be fed regularly. High requirements of hygiene (depending on setup and group size), moisture availability and sometimes supplements. *T. hainanensis* – high sensitivity to environmental inadequacies (Hernandez 2016a); *T. panhai* –cannibalism is not uncommon between larvae with 15 to 25 mm, but will subside beyond this size range (Hernandez 2016a); *T. ziegleri* – their secretive behavior may lead to delayed detection of social distress. Especially larvae should be observed regularly due to intraspecific aggression. Need for clean and dry surfaces/ substrate in hides to avoid skin related complications. Short interval-based cleaning routines during the first 2 years of terrestrial nursing.
Care of the young, technical and time effort	Eggs and larvae should be separated from the adult's enclosure. Eggs can be incubated either on moist tissue or in water. Incubating on moist tissue makes it easier to remove eggs with mold. Rearing post metamorphs requires a high level of hygiene, the availability of different moisture ranges, and powdering prey animals (e.g., micro crickets) with mineral and vitamin supplements. *"T. asperrimus"* – rearing of the larvae is problem-free under appropriate hygienic conditions, and sufficient food availability, given the tendency to cannibalism; *T. panhai* – larvae are best kept individually in containers with Java moss and a small bubbler to oxygenate the water (Hernandez 2016a); *T. vietnamensis* – best incubation results on moist tissue over a water surface. Once larvae start to hatch, the incubation box can be flooded. Larvae can be reared in small groups (5–10 larvae) in plastic containers (ca. 10 l water) with

Topic	Data for this group
	plants, cooked oak leaves, hiding opportunities and snails, temperatures 21–23 °C. The authors did not observe cannibalism but it is recommendable to sort individuals according to body sizes. Larvae are fed several times a day, partial water exchanges are performed twice a day in order to remove feces and food remains. Another less work-intense method is rearing larger groups of larvae in larger aquaria with numerous plants and leaves, where occasional water exchanges are sufficient but mortality rate is much higher. Metamorphlings are kept in small groups in boxes with gravel, a small shallow water part, moss pieces, leaves and cork bark as hiding places; boxes are checked every day to control health state on animals and to remove feces, once a week the gravel is flushed out and the leaves are exchanged. Another alternative substrate to gravel is the use of slightly moist tissue, in which case it should be changed daily. Juveniles are fed daily with micro crickets, firebrats, *Tubifex* worms, small earthworms or *Drosophila*, food is supplemented. *T. ziegleri* – larvae are best kept separate and in small numbers with many hiding possibilities, due to cannibalism behavior. Larvae have the ability to leap out of the water when disturbed, so appropriate high enclosures should be used. It is essential that a partial water change is conducted every second day, as well as clean live food is presented every two days. Metamorphlings can be kept in the same way as *T. vietnamensis*. Gut loading of prey or supplements necessary. Juveniles up to approx. 8 cm TL and/or 1.5 to 2 years of age are active nocturnal hunters and present limited activity radius, so they can be kept in bigger groups in smaller enclosures.
Life expectancy in captivity	*T vietnamensis* – at least 11 years; *T. ziegleri* – at least between 23 and 28 years old (Ziegler *et al.* 2018), but likely more.
Frequency of breeding in captivity evaluation	*T. asperrimus* – difficult to breed in captivity. Likely completely disappeared from the terraristics in Europe; *T. vietnamensis* – at Cologne Zoo annually since 2018 (meanwhile F2 generation), offspring of Cologne Zoo has also reproduced at some private keepers and in Melinh station for Biodiversity, Vietnam; *T. ziegleri* – successful and frequent breeding by experienced breeders.
Breeding difficulty evaluation	*"T. asperrimus"* – breeding is possibly more difficult than with other *Tylototriton* species (Fleck & Schultschik 2013); *T. hainanensis* – likely very hard, given that it was described over three decades ago, and contrary to most *Tylototriton* species there are no reports of it ever entering the international pet trade; *T. vietnamensis* – requires a considerable investment of time to keep high hygiene standards, but not particularly difficult once larvae have overcome the first critical weeks after hatching. Well-fed adults reproduce regularly; *T. ziegleri* – requires a considerable investment of time to keep high hygiene standards for raising the young and the aggressive behavior among the larvae involve special care. Adults present secretive habits but are quite robust, and not particularly difficult to breed.
Mortality in the first years of life	*T. vietnamensis* – at Cologne Zoo highest mortality in early larval stages, only few losses in advanced stages or after metamorphosis; *T. ziegleri* – 25–50 % (average over several years), including cannibalistic behavior, resulting in the loss of extremities (very few successfully regenerated limbs). Similar experience at the Cologne Zoo with cannibalism resulting also in death of some individuals and high mortality after metamorphosis (so far around 35–40 %). Metamorphlings are smaller than in T. vietnamensis and seem to be

Topic	Data for this group
	more sensitive e.g., towards bacterial infections (A. Rauhaus, pers. comm.).
F2 generation bred	*T. asperrimus* – no, not known; *T. hainanensis* – no, not known; *T. notialis* – no, not known; *T. pasmansi* – no, not known; *T. sparreboomi* – no, not known; *T. vietnamensis* – yes, documented; *T. ziegleri* – yes, documented.
Interviews/ Surveys/ Consultations	*T. asperrimus* – several private breeders and the authors contributed; *T. vietnamensis* – the authors contributed; *T. ziegleri* – one zoological institution and the authors contributed; *T. hainanensis, T. notialis, T. pasmansi* and *T. sparreboomi* – none.

References

Bernardes, M., M.D. Le, T.Q. Nguyen, C.T. Pham, A.V. Pham, T.T. Nguyen, D. Rödder, M. Bonkowski & T. Ziegler (2020): Integrative taxonomy reveals three new taxa within the *Tylototriton asperrimus* complex (Caudata, Salamandridae) from Vietnam. Zookeys **935**(2020): 121-164.

Bernardes, M., C.T. Pham, T.Q Nguyen, M.D. Le, M.D., M. Bonkowski & T. Ziegler (2017a): Comparative morphometrics and ecology of a newly discovered population of *Tylototriton vietnamensis* from northeastern Vietnam including remarks on species conservation. Salamandra **53**(3): 451-457.

Bernardes, M., A. Rauhaus, C. Michel, C.T. Pham, T.Q. Nguyen, M.D. Le, F. Pasmans, M. Bonkowski & T. Ziegler (2017b): Larval development and breeding ecology of Ziegler' s crocodile newt, *Tylototriton ziegleri* Nishikawa, Matsui and Nguyen, 2013 (Caudata: Salamandridae), compared to other *Tylototriton* representatives. Amphibian & Reptile Conservation **11**(1): 72-87.

Bernardes, M., D. Rödder, T.T. Nguyen, C.T. Pham, T.Q. Nguyen & T. Ziegler (2013): Habitat characterization and potential distribution of *Tylototriton vietnamensis* in northern Vietnam. Journal of Natural History **47**(17-18): 1161-1175.

Böhme, W., T. Schöttler, T.Q. Nguyen & J. Köhler (2005): A new species of salamander, genus *Tylototriton* (Urodela: Salamandridae), from northern Vietnam. Salamandra **41**(4): 215-220.

CITES (2019): CoP18 Proposal 41, *Tylototriton spp*. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

Fei, L., C. Ye & R. Yang (1984): A new species and a new subspecies of the genus *Tylototriton* (Caudata: Salamandridae). Acta Zooogica Sinica **30**(1): 85-91.

Fleck J. (2010): Die Krokodilmolche der Gattung *Tylototriton* Anderson, 1871 (Teil 1). Elaphe **18**(1): 38-45.

Fleck, J. & G. Schultschik (2013): *Tylototriton asperrimus* Unterstein, 1930 - Black alligator newt, pp. 131-136. *In:* Schultschik G. W.-R. Grosse (eds.): Threatened Newts and Salamanders of the World - Captive Care Management/ Gefährdete Molch- und Salamanderarten der Welt - Richtlinien für Erhaltungszuchten. Vol. 1. Mertensiella **20**, Mannheim, Germany: 189 pp.

Hernandez, A. (2016a): Crocodile Newts - the Primitive Salamandridae of Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition Chimaira): 416 pp.

Hernandez, A. (2016b): *Tylototriton* Anderson, 1871. Observation du genre en Thaïlande et éléments de réflexion sur la diversité des sous-genres *Tylototriton* et *Yaotriton*. Situla Revue de l'Association française de terrariophilie **28**: 12-25.

Hernandez, A. (2017): New localities for *Tylototriton panhai* and *Tylototriton uyenoi* Nishikawa, Khonsue, Pomchote & Matsui 2013 in northern Thailand. Bulletin de la Société Herpétologique de France **162**(2017): 110-112.

Hernandez, A. (2018): Ecological affinities of *Tylototriton asperrimus* Unterstein, 1930 (Amphibia, Caudata: Salamandridae) at Bainiu, Dayaoshan, Guangxi province, China with an emphasis on its cryptic diversity. Bulletin de la Société Herpétologique de France **166**(2018): 79-82.

Hernandez, A., D. Escoriza, P. Pomchote & M. Hou (2019): New localities for *Tylototriton uyenoi*, *T. panhai* and *T. anguliceps* in Thailand with remarks on the southernmost distribution of the genus. Herpetological Bulletin **147**(2019): 15-18.

IUCN SSC Amphibian Specialist Group (2015). *Tylototriton notialis*. The IUCN Red List of Threatened Species 2015: e.T47144426A47144432.

IUCN SSC Amphibian Specialist Group (2017): *Tylototriton ziegleri*. The IUCN Red List of Threatened Species 2017: e.T47144899A47144905.

Jiang, Y., Z. Wei, F. Han, Q. Ni, Y. Yao, H. Xu, Y. Li, D. Rao & M. Zhang (2017): The complete mitogenome sequence of *Tylototriton ziegleri* (Amphibia: Caudata). Conservation Genetics Resources **9**(3): 503-506.

Khonsue, W., T. Chaiananporn & P. Pomchote (2010): Skeletochronological assessment of age in the Himalayan crocodile newt, *Tylototriton verrucosus* (Anderson, 1871) from Thailand. Tropical Natural History **10**(2): 181-188.

Nguyen, T.Q., V.S. Nguyen, T.L. Ho, K.Q. Le & T.T. Nguyen (2009): Phylogenetic relationships and taxonomic review of the family Salamandridae (Amphibia: Caudata) from Vietnam (in Vietnamese). Vietnam Journal of Biotechnology **7**(3): 325-333.

Nishikawa, K., W. Khonsue, P. Pomchote & M. Matsui (2013a): Two new species of *Tylototriton* from Thailand (Amphibia: Urodela: Salamandridae). Zootaxa **3737**(3): 261-279.

Nishikawa, K., M. Matsui & T.T. Nguyen (2013b): A new species of *Tylototriton* from Northern Vietnam (Amphibia: Urodela: Salamandridae). Current Herpetology **32**(1): 34-49.

Nishikawa, K., M. Matsui & D. Rao (2014): A new species of *Tylototriton* (Amphibia: Urodela: Salamandridae) from Central Myanmar. Natural History Bulletin of the Siam Society **60**(1): 9-22.

Phimmachak, S., A. Aowphol & B.L. Stuart (2015): Morphological and molecular variation in *Tylototriton* (Caudata: Salamandridae) in Laos, with description of a new species. Zootaxa **4006**(2): 285-310.

Pomchote, P., P. Pariyanonth & W. Khonsue (2008): Two distinctive color patterns of the Himalayan Newt *Tylototriton verrucosus* (Urodela: Salamandridae) found in Thailand and its implication on geographic segregation. Natural History Journal of Chulalongkorn University **8**(1): 35-43.

Qin, W., X. Tang, G. Qin & L. Wie (2012): Preliminary survey of *Tylototriton asperrimus* habitat in Mulun Nature Reserve, Guangxi (in Chinese). Sichuan Journal of Zoology **31**(2): 303-306.

Rauhaus, A. & T. Ziegler (submitted): *Tylototriton vietnamensis* Böhme, Schöttler, Nguyen and Köhler, 2005 - Vietnamesischer Krokodilmolch. *In:* Schultschik G. W.-R. Grosse (eds.): Threatened Newts and Salamanders of the World - Captive Care Management/ Gefährdete Molch- und Salamanderarten der Welt - Richtlinien für Erhaltungszuchten. Vol. 3. Mertensiella, Mannheim, Germany.

Rowley, J.J.L., C.R. Shepherd, B.L. Stuart, T.Q. Nguyen, H.D. Hoang, T.P. Cutajar, G.O.U. Wogan & S. Phimmachak (2016): Estimating the global trade in Southeast Asian newts. Biological Conservation **199**(2016): 96-100.

Shen, Y., J. Jiang & X. Mo (2012): A new species of the genus *Tylototriton* (Amphibia, Salamandridae) from Hunan, China. Asian Herpetological Research **3**(1): 21-30.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Stuart, B.L., S. Phimmachak, N. Sivongxay & W.G. Robichaud (2010): A new species in the *Tylototriton asperrimus* group (Caudata: Salamandridae) from central Laos. Zootaxa **2650**(1): 19-32.

van Dijk, P.P., N. Truong, N.L. Wai, Z. Ermi & L. Shunqing (2008): *Tylototriton asperrimus* - Black Knobby Newt. The IUCN Red List of Threatened Species 2008: e.T59482A11932895.

Yang, D., J. Jiang, Y. Shen & D. Fei (2014): A new species of the genus *Tylototriton* (Urodela: Salamandridae) from Northeastern Hunan Province, China. Asian Herpetological Research **5**(1): 1-11.

Zhao, H., J. Che, W. Zhou, Y. Chen, H. Zhao & Y.-P. Zhang (2008): A new species of *Paramesotriton* (Caudata: Salamandridae) from Guizhou Province, China. Zootaxa 1**775**(1): 51-60.

Ziegler, T., T. Hartmann, K. van der Straeten, D. Karbe & W. Böhme (2008): Captive breeding and larval morphology of *Tylototriton shanjing* Nussbaum, Brodie & Yang, 1995, with an updated key of the genus *Tylototriton* (Amphibia: Salamandridae). Der Zoologische Garten **77**(4): 246-260.

Ziegler, T., R. Marcec, D. Vardukyan, T.Q. Nguyen, M.D. Le & M. Bernardes (2018): First record of longevity in *Tylototriton ziegleri* Nishikawa, Matsui & Nguyen, 2013 (Urodela, Salamandridae). Alytes **36**(1-4): 328-338.

Marta Bernardes (01.03.2021)

Following Authorships:

T. asperrimus – Marta Bernardes & Uwe Gerlach – acknowledgement to Jürgen Fleck

T. vietnamensis – Marta Bernardes & Anna Rauhaus

T. ziegleri – Marta Bernardes, Philipp Grundtner, Frank Pasmans

Tylototriton kweichowensis Fang & Chang, 1932

Kweichow crocodile Newt, Red-tailed knobby newt, Guizhou crocodile newt

German: Kweichow Krokodilmolch

Fig. 37a: *Tylototriton kweichowensis* ♀ (K. Neubauer);
b: *Tylototriton kweichowensis* ♀, Yunnan (A. Hernandez);
c: *Tylototriton kweichowensis* ♀ laying eggs (K. Neubauer);
d: *Tylototriton kweichowensis* courtship circle dance (K. Neubauer).

Morphology and Taxonomy

Large, robust salamander with total lengths up to 21 cm, head with distinct bony ridges in the frontal and interorbital areas, granular skin, prominent glandular vertebral ridge, dorsolateral warts indistinct and almost fused, dark dorsal color with three longitudinal reddish brown to yellowish stripes including colored tail, parotoids, and tips of fingers and toes (Fang & Chang 1932; Freytag 1936; Hernandez 2016; Sparreboom 2014). This species might be misidentified with *T. yangi* by an inexperienced observer.

Distribution and Habitat

The species is known from Guizhou P., Bijie City, Dafang (=Dading) County, Kungchishan (type locality); Hezhang County; Nayong County; Weining Yi County; Zhijin County; Liupanshui City, Shuicheng County; and Yunnan P., Zhaotong City, Yiliang and Yongshan Counties and Kunming City, Panlong County (Hernandez 2016; Liu 1950; Raffaëlli 2013; Sparreboom 2014; Yang *et al.* 2004; Zhang *et al.* 2013; Zhao & Adler 1993; Zhao *et al.* 1988).

The species inhabits grasslands around their breeding ponds in mountain regions at elevations between 1,400 and 2,400 m asl, characterized by humid subtropical climate (Hernandez 2016; Sparreboom 2014).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

EU Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Vulnerable (A4acd, assessed June 20, 2019).

Threats

Main threats to *Tylototriton* in general are related with habitat loss and degradation especially around the breeding habitats (Nishikawa *et al.* 2013) as well as harvesting for the domestic and international trade (CITES 2019; Rowley *et al.* 2016). In particular, the habitat of *T. kweichowensis* is threatened by industrial activities, coal mining, agriculture and urbanization. The species is used locally in traditional medicine and it was very attractive for the international pet trade due to its unique coloration (Hernandez 2016; IUCN 2020). Large imports of wild caught specimens in the past showed infections with *Ranavirus* which can seriously threaten the Urodelan fauna outside of its native range (Pasmans *et al.* 2008).

Reproduction

Topic	Data
Secondary sexual traits	Sexual dimorphism is poorly expressed, unless it is a large, mature individual, in which case they present a more evidently bulbously round inflated cloacal region during the breeding season. ♀♀ are larger, heavier and present a puncture like cloacal orifice, while ♂♂are smaller, slender, and present an elongated opened slit (Hernandez 2016; Fang & Chang 1932; Fleck 1992, 2013).
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	3 to 6 years in captivity.
Mating and oviposition sites	Aquatic: mating ritual with circular dancing and spermatophore transfer; terrestrial: oviposition (only a few cm above the water level, which may cause some eggs to roll inside the water).
Breeding season	In natural habitat from May to early July (Tian *et al.* 1997). In captivity it is variable, but usually from March until May (sometimes even until November/December).
Number eggs/ clutches per season	Ca. 37 to 160 eggs per clutch, with averages of around 122 eggs (Tian *et al.* 1997; Fleck 1992, 2013; Hernandez 2016) and 1–2 clutches per female a year.
Average egg diameter and hatchling size	Eggs ca. 5.5 to 12 mm; hatchlings ca. 12–15 mm (sometimes even smaller sizes, if larvae hatch early) (Tian *et al.* 1997; Fleck 1992, 2013).
Development duration egg to metamorphosis	Larvae hatch ca. 11–21 days after egg deposition (at temperatures of 16–22 °C); metamorphosis usually occurs in ca. 70–105 days (at temperatures of 20–25 °C) with TL between 38 and 65 mm (average 55 mm), although some larvae can overwinter and take up to 7 months.
Temperature dependent sex determination	Not known. In captivity, a higher ratio of females was observed at temperatures of at least 20 °C.

Husbandry and Captive Breeding

Topic	Data
Trigger for reproduction	Terrestrial period between 8 to 13 °C (short periods as low as 3 °C can be tolerated) for at least 3 months during winter. In spring a sudden increase of temperatures (to approx. 20 °C), followed by increased humidity (i.e., artificial rain) and transfer to an aquaterrarium.

Topic	Data
Husbandry requirements	Terrarium sizes depend on group size, sex-ratio, size of animals and behavior. Outside of the breeding season (November–February) a solely terrestrial setup is possible. Between March and October, the animals must be moved to an aquaterrarium with at least 45 x 24 cm part water (25 x 80 cm is more recommended) and 4–6 cm deep for one breeding pair. During the breeding season temperatures range between 13–25 °C (can tolerate slightly higher temperatures of around 30 °C for short periods during summer as long as there are sufficient cooler hiding places) and humidity increases. It is essential to provide a variety of hides both dry and humid year-round.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis, the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General particularities, difficulties with keeping and breeding	Adults need to be separated from eggs and larvae. Larvae and juveniles need to be feed regularly. Moderate requirements of hygiene, moisture availability and sometimes supplements.
Care of the young, technical and time effort	Larvae are best kept in small numbers with many hiding possibilities (leaves, plants). It is essential that a partial water change is conducted every 3 to 7 days. No filtration is needed but helpful. Setups for metamorphlings should be cleaned regularly, depending on substrate, size and number of animals. Gut loading of feeders or supplements are necessary. Juveniles are active nocturnal hunters and can be kept in bigger groups for the first year.
Life expectancy in captivity	F1 animals have bred successfully at least until getting 22 years old. Reports in captivity note animals living until at least 25 years old (Fleck 2010).
Breeding difficulty evaluation	Require a considerable investment of time to keep high hygiene standards, but not particularly difficult once larvae have overcome the first critical weeks after hatching. Well-fed adults reproduce regularly.
Frequency of breeding in captivity evaluation	Frequently bred since the 1990s. For example, F1 CB 1997 from a WC pair reproduced 13 times between 2004 and 2018. F2 CB 2015 produced fertile eggs in 2020.
Mortality in the first years of life	In captivity 15 to 30 % of the eggs in a clutch are infertile. Losses in early larval stages and in the first three years after metamorphosis as susceptible to disease. Cannibalism is uncommon, but if the density of larvae is high, sometimes bites can occur.
F2 generation bred	Yes. Up to F3.
Interviews/ Surveys/ Consultations	None.

References

CITES (2019): CoP18 Proposal 41, *Tylototriton* spp. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

Fang, P.W & M.L.Y. Chang (1932): Notes on *Tylototriton kweichowensis*, sp. nov. and *asperrimus* Unterstein with synopsis to species. Sinensia **2**(9): 111-122.

Fleck, J. (1992): Haltung und Nachzucht von *Tylototriton kweichowensis* (Fang & Chang, 1932). Salamandra **28**(2): 97-105.

Fleck J. (2010): Die Krokodilmolche der Gattung *Tylototriton* Anderson, 1871 (Teil 1). Elaphe **18**(1): 38-45.

Fleck, J. (2013): *Tylototriton kweichowensis* Fang & Chang, 1932 - Kweichow-Krokodilmolch, pp. 139-142. *In:* Schultschik G. W.-R. Grosse (eds.): Gefährdete Molch- und Salamanderarten der Welt. Richtlinien für Erhaltungszuchten. Vol. 1. Mertensiella **20**, Mannheim, Germany: 189 pp.

Freytag, G.E. (1936): Über die systematische Stellung des *Tylototriton kweichowensis* Fang and Chang. Blätter für Aquarien- und Terrarienkunde **47**:30-32.

Hernandez, A. (2016): Crocodile Newts - the Primitive Salamandridae of Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition Chimaira): 416 pp.

IUCN SSC Amphibian Specialist Group (2020): *Tylototriton kweichowensis*. The IUCN Red List of Threatened Species 2020: e.T59484A63870946.

Liu, C.C. (1950): Amphibians of Western China. Fieldiana, Zoology Memoirs **2**: 400 pp.

Pasmans, F., S. Blahak, A. Martel, N. Pantchev, & P. Zwart (2008): *Ranavirus*-associated mass mortality in imported red tailed knobby newts (*Tylototriton kweichowensis*): a case report. Veterinary Journal **176**(2): 257-259.

Raffaëlli J. (2013): Les Urodèles du Monde. Deuxième édition. Plumelec (Penclén édition): 472 pp.

Rowley, J.J.L., C.R. Shepherd, B.L. Stuart, T.Q. Nguyen, H.D. Hoang, T.P. Cutajar, G.O.U. Wogan & S. Phimmachak (2016): Estimating the global trade in Southeast Asian newts. Biological Conservation **199**: 96-100.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Tian, Y.Z., A.Q Shun & S. Li (1997): Observation on the reproductive habit of the salamander, *Tylototriton kweichowensis*. Chinese Journal of Zoology **32**: 20-23.

Wang, S. & E. Zhao (1998): China red data book of endangered animals. Amphibia and Reptilia. National Environmental Protection Agency, Endangered Species Scientific Commission, Beijing Science Press: 334 pp.

Yang, D., S. Lu & G. Wu (2004): *Tylototriton kweichowensis*. The IUCN Red List of Threatened Species 2004: e.T59484A11933654.

Zhang, M., G. Yu, M. Yang, Y. Li, J. Wei, H. Xu, Y. Yao, L. Wang, X. Zhang, D. Rao & J. Yang (2013): Mitochondrial phylogeography of the red-tailed knobby newt (*Tylototriton kweichowensis*). Biochemical Systematics and Ecology **51**: 195-202.

Zhao, E. & K. Adler (1993): Herpetology of China. Society for the study of amphibians and reptiles. St. Louis University. 521 pp.

Zhao, E.-m., Q.-x. Hu, Y.-m. Jiang, & Y.-h. Yang (1988): Studies on Chinese Salamanders. Society for the study of amphibians and reptiles. Oxford, Ohio. 44 pp.

Karl Neubauer, Philipp Grundtner, Marta Bernardes (11.04.2021)

Tylototriton verrucosus group

Species	Description author and date	Common name English	Common name German	Known in the trade
Tylototriton anguliceps	Le, Nguyen, Nishikawa, Nguyen, Pham, Matsui, Bernardes, & Nguyen, 2015	Angular-headed newt	Schmalkopf-Krokodilmolch	likely yes/ no info
Tylototriton himalayanus	Khatiwada, Wang, Ghimire, Vasudevan, Paudel, & Jiang, 2015	Eastern Himalayan crocodile newt	Östlicher Himalaya-Krokodilmolch	likely yes/ no info
Tylototriton kachinorum	Zaw, Lay, Pawangkhanant, Gorin, & Poyarkov, 2019	Kachin crocodile newt	Kachin-Krokodilmolch	likely yes
Tylototriton ngarsuensis	Grismer, Wood, Quah, Thura, Espinoza, Grismer, Murdoch, & Lin, 2018	Ywangan crocodile newt	Ywangan-Krokodilmolch	likely yes
Tylototriton panwaensis	Grismer, Wood, Quah, Thura, Espinoza, & Murdoch, 2019		Panwa-Krokodilmolch	likely yes
Tylototriton phukhaensis	Pomchote, Khonsue, Thammachoti, Hernandez, Peerachidacho, Suwannapoom, Onishi, & Nishikawa, 2020	Doi Phu Kha newt	Phu-Kha-Krokodilmolch	no info/ not expected
Tylototriton podichthys	Phimmachak, Aowphol, & Stuart, 2015			no info/ not expected
Tylototriton pseudoverrucosus	Hou, Gu, Zhang, Zeng, and Lu, 2012	Southern Sichuan/ Chuannan crocodile/ knobby newt	Südlicher Geknöpfter Birma-Krokodilmolch	no info/ not expected
Tylototriton pulcherrimus	Hou, Zhang, Li, & Lu, 2012	Hoanglien Mountain crocodile newt/ Huanglienshan knobby newt	Hoanglien-Krokodilmolch	yes
Tylototriton shanjing	Nussbaum, Brodie, & Datong, 1995	Red knobby newt/ Yunnan newt/ Mandarin salamander/ Yellow (or Mandarin) alligator newt	Mandarin-Krokodilmolch	yes
Tylototriton shanorum	Nishikawa, Matsui, & Rao, 2014	Taunggyi crocodile newt	Taunggyi-Krokodilmolch	yes
Tylototriton uyenoi	Nishikawa, Khonsue, Pomchote, & Matsui, 2013	Uéno's knobby newt Phuping newt	Uénos Krokodilmolch	likely yes/ no info
Tylototriton verrucosus	Anderson, 1871	Inthanon salamander/ crocodile newt	Geknöpfter Birma-Krokodilmolch	likely yes

Tylototriton yangi	Hou, Zhang, Zhou, Li, & Lu, 2012	Tiannan/ Yang's crocodile/ knobby newt	Tiannan-Krokodilmolch	yes

Fig. 38a: *Tylototriton shanjing* ♂, Menghai (A. Hernandez);
b: *Tylototriton shanjing* adult ♀, Kaiyuan (A. Hernandez);
c: *Tylototriton* cf. *verrucosus*, Doi Chang, Thailand (A. Hernandez);
d: *Tylototriton phukaensis* (P. Pomchote);
e: *Tylototriton pulcherrimus* adult ♂ in captivity sold on a Chinese market (A. Hernandez);
f: *Tylototriton pseudoverrucosus* adult ♀ (A. Hernandez).

Fig. 39a: *Tylototriton yangi* ♀ topotype Gejiu (A. Hernandez);
b: *Tylototriton yangi* (F. Braux);
c: *Tylototriton uyenoi* (U. Gerlach);
d: *Tylototriton shanorum* (U. Gerlach);
e: *Tylototriton anguliceps* (A. Hernandez).

Photos of the remaining species can be found in literature, under the respective description.

The species included in this group present a very conservative morphology (Hernandez 2016). Some morphological characteristics can direct species identification; however genetic analyzes are necessary for definitive distinction.

Animals from this group have been exported from Asia to Europe and the USA in large numbers. It has to be assumed that these consignments of wild caught newts were mixtures of species under the current taxonomic status. This is especially true for the group of species previously attributed to *T. verrucosus* before taxonomic separation of species originating from Myanmar and of more western distributions (e.g. *T. shanorum* [Nishikawa *et al.* 2014], *T. ngarsuensis* [Grismer *et al.* 2018], *T. himalayanus* [Khatiwada *et al.* 2015], *T. uyenoi* [Nishikawa *et al.* 2013a]). Given the vast presence of *T. shanorum* and similar species in the trade, it has to be considered that all the species originating from Myanmar have entered the international trade (under erroneous identification) due to the historical exports of "*T. verrucosus*"

from this country. Similarly, *T. yangi* has been confused with *T. verrucosus* and *T. kweichowensis* and it was the most traded species in the USA (Sparreboom 2014; Wang *et al.* 2017); *T. shanjing* has been traded as "lighter *T. verrucosus*"; *T. pulcherrimus* as *T. shanjing*, and so on. With these taxonomic confusions, it is understandable that there is some uncertainty around the presence of *T verrucosus sensu stricto* in the trade.

Furthermore, *Tylototriton* species are known to hybridize in captivity and species of the *T. verrucosus* group, being some of the most common and longer available in the trade, are very likely to present hybrids. A genetic screening of specimens in the trade is recommended at this point to identify species and pure lineages.

Given this inherent degree of taxonomic uncertainty, the following data should be regarded with caution. Questionable species names will be presented below with quotation marks (e.g., "*T. verrucosus*").

Wild caught animals can have serious health issues that can be very problematic to solve (even on the long term), furthermore they have great potential to be vectors of disease such as *Bsal* and *Ranavirus,* which can seriously threaten the urodelan fauna outside of its native range.

Morphology and Taxonomy

This group is characterized by medium to large newts with adults presenting total lengths from ca. 12 to 20 cm usually with some sort of bright dorsal marking (darker taxa include the most western geographic distributions: *T. himalayanus, T. shanorum, T. kachinorum*, *T. verrucosus*). Their skull bones and parotoids are less distinct than in *T. asperrimus* group (Hernandez 2016).

The species of this group can be identified by the following combination of characters (although molecular identification is recommended for definitive species identification):

Tylototriton anguliceps – moderately large species with max. TL at 15.8 cm. The species is characterized by a more prominent dorsal granules than both *T. shanjing* and *T. uyenoi*, a prominent middorsal ridge and steep and narrow lateral bony edges of the head (vs. less prominent middorsal ridge and gentle and wide lateral bony edges on the head in *T. shanjing* and *T. uyenoi*, and no middorsal ridge and nearly flat lateral bony edges on head in *T. shanorum*), a skeletal connection (quadrate) between maxillary and pterygoid, a vertebral ridge distinct and slightly segmented (Le *et al.* 2015, Hernandez 2016). Ground color black, bright to dark orange markings on head, vertebral ridge, rib nodules, limbs, vent region, part of ventral trunk and whole tail (Le *et al.* 2015; Nishikawa *et al.* 2013a);

Tylototriton himalayanus – average TL of 15.4 cm in ♂♂ and 17.5 cm in ♀♀ (Sparreboom 2014). The species is diagnosable by having a flat and blunt snout (vs. truncate snout in *T. shanorum*), head is longer than wide (vs. head wider than long in *T. shanorum*), greatly separated dorsolateral bony ridges on head (vs. poorly separated dorsolateral bony ridges in *T. shanorum*, *T. verrucosus* and *T. shanjing*), 16 dorsal warts (vs. 14 dorsal warts in T*. shanorum*), distinct grooves on either sides of tail base (vs. absent grooves in *T. verrucosus*, and poorly developed grooves in *T. shanjing*), being uniformly blackish, dark brown coloration in dorsal region, with lighter tone in dorsolateral region and creamy coloration in ventral surface (Khatiwada *et al.* 2015);

Tylototriton kachinorum – average TL of 14.8 cm for ♂♂ and 16.3 cm ♀♀, medium body size, tail length longer than SVL in both sexes (vs. comparably shorter tail in *T. shanorum*)

and lacking lateral grooves (vs. very distinct lateral groves in *T. himalayanus*), truncate snout (vs. rounded snout in *T. ngarsuensis*), wide and protruding supratemporal bony ridges on head, beginning at anterior corner of orbit (vs. beginning at loreal region in *T. shanorum*; beginning posterior to orbit in *T. ngarsuensis*), weak and almost indistinct sagittal ridge on head, long, thin limbs, broadly overlapping when adpressed along body, distinct, wide, and non-segmented vertebral ridge (vs. well-segmented in *T. verrucosus*; narrow and weakly segmented in *T. shanorum*; weakly segmented in *T. ngarsuensis*), 13 or 14 weakly distinct rib nodules (vs. 15 well-distinct rib nodules in *T. ngarsuensis*; 16 large and prominent rib nodules in *T. himalayanus*), and brown to dark-brown background coloration with dull orange-brown to yellowish-brown markings on labial regions, parotoids, rib nodules, whole limbs, vent, and ventral tail ridge (vs. no ventral markings on body and tail in *T. verrucosus*) (Zaw *et al*. 2019);

Tylototriton ngarsuensis – this species is characterized by its large size, relatively short head, absence of glandular ridge on the midline of the crown (vs. presence of a ridge on the crown in *T. verrucosus*), large, rounded rib nodules with diameters equivalent to or greater than eye (vs. small and slightly elongated rib nodules with diameters smaller than eye in *T. shanorum*), thick, glandular, vertebral tubercular ridge (vs. narrow and less glandular ridge in *T. shanorum*), 15 rib nodules (vs. 14 in *T. shanorum*), parotoid ridge beginning posterior to the orbits (vs. beginning in the loreal region in *T. shanorum*), top of head, vertebral ridge, rib nodules, limbs, and side of tail nearly black (vs. red-brown in *T. shanorum*), labial regions, palms, soles, and subcaudal region dark-brown (vs. dull-yellow in *T. shanorum*), and venter and underside of limbs being dark-gray (vs. dull-yellow in *T. shanorum*) (Grismer *et al.* 2018);

Tylototriton panwaensis – is a medium size species, with a relatively short axilla-groin length (vs. longer axilla-groin distance in *T. shanorum*), head relatively short (vs. longer in *T. shanjing*, *T. verrucosus* and *T. shanorum*) and narrow (vs. wider in *T. ngarsuensis*, *T. shanjing*, *T. verrucosus* and *T. shanorum*), relatively shorter forelimb length than *T. shanorum*, longer hind limb length than *T. shanjing* and *T. verrucosus*, indistinct gular fold (vs. prominent in *T. shanorum* and *T. ngarsuensis*), supraorbital ridge beginning in the loreal region (vs. beginning in the postorbital region in *T. ngarsuensis*), presence of glandular ridge on the crown of the head (vs. absence *T. shanorum* and *T. ngarsuensis*), raised vertebral ridge (vs. flat in *T. ngarsuensis*), overlapping adpressed limbs (vs. not overlapping in *T. ngarsuensis*), top of head dark brown; vertebral ridge, rib nodules, side of tail, labial regions, palms and soles, vent and subcaudal region varying shades of dull orange and dull yellow (probably orange in life) (Grismer *et al.* 2019);

Tylototriton phukhaensis – dorsolateral bony ridges on head narrow (vs. wide in *T. uyenoi*), and rough looking (vs. smooth looking in *T.* cf. *verrucosus* from Thailand), vertebral ridge narrow and weakly segmented (vs. narrow and segmented in *T.* cf. *verrucosus* from Thailand, and wide and segmented in *T. uyenoi*), dorsolateral skin with small and sparse granules (vs. large and dense granules in *T. anguliceps* and *T. uyenoi*), dorsal and ventral head, parotoids, vertebral ridge, rib nodules, limbs, vent, and tail of dull reddish-orange to light brown color (vs. bright to dark orange color in *T. anguliceps* particularly on the ventral trunk) (Pomchote *et al.* 2020b);

Tylototriton podichthys – average TL of 12–13 cm for ♂♂ and ca. 16.5 cm for ♀♀ (Hernandez 2016). The species is characterized by presenting an indistinct glandular ridge on midline of crown (vs. distinct ridge on midline of crown in *T. verrucosus*, *T. shanjing*, *T. uyenoi* and *T. anguliceps*), distinct rib nodules with diameter equivalent to or greater than that of eye (vs. small, slightly elongated rib nodules in *T. shanorum*), parotoid oriented parallel to body axis in lateral view (vs. parotoid oriented obliquely downward relative to body axis in lateral

view in *T. verrucosus* and *T. uyenoi*), thick, glandular vertebral ridge (vs. distinctly narrower and less glandular in *T. shanorum*), rough, glandular skin on cranial crest (vs. smoother in *T. verrucosus*), orange markings separated between rib nodules and dark coloration on ventral surfaces of limbs and finger tips (Phimmachak *et al.* 2015);

Tylototriton pseudoverrucosus – max TL of 18.7 cm for ♂♂ and 20.0 cm for ♀♀ (Hou *et al.* 2012). The species exhibits the following characteristics: connected color markings on rib nodules, forming dorsolateral lines (Nishikawa *et al.* 2013a), head depressed and longer than wide, snout square, 12 to 15 indistinct glandular warts, black ground color with exception of orange to red coloration on cephalic and vertebral ridges, most of head, dorsolateral lines, whole tail and limbs (Hernandez 2016);

Tylototriton pulcherrimus – is a medium size species with tail size corresponding to 70 to 100 % of snout-vent distance. TL in ♂♂ has been reported as larger than those of ♀♀ (14.5 cm in ♂♂ vs. 13.9 cm in ♀♀). It resembles *T. verrucosus* or *T. shanjing*, but more vividly colored, with reddish brown to dark brown or black on upper side with yellow to orange markings on head edges, vertebral ridge, glandular warts, limbs, whole tail and ventral parts (Hernandez 2016);

Tylototriton shanjing – TL 13.6–15.0 cm in ♂♂ and 14.7–17.0 cm in ♀♀ (Sparreboom 2014). Dark-brown to black dorsal ground color (likely up to red as reported by Rehberg 1986), with color markings in yellowish orange to bright yellow in bony edges of the head, vertebral ridge, dorsolateral glandular warts, limbs, tail and most of ventral side (Nussbaum *et al.* 1995). The posterior ends of the dorsolateral head crests reach the exo-occipital in *T. shanjing* (vs. do not reach in *T. anguliceps* and *T. uyenoi*) (Le *et al.* 2015);

Tylototriton shanorum – it is one of the largest species (TL ca. and 18.7 cm in ♂♂ and 17.6 cm in ♀♀). Head wide, truncate snout, dorsolateral bony ridges on head not very steep or narrow, presenting a rough-like surface, rib nodules moderately prominent, vertebral ridge narrow and weakly segmented, dorsal ground color dark brown to black, anterior head, parotoid, vertebral ridge, rib nodules, limbs, and lateral side of tail dull reddish brown, upper and lower lips, palm and sole, vent region, and ventral side of tail dark yellow (Nishikawa *et al.* 2014);

Tylototriton uyenoi – characterized by its large size (TL ca. 15 cm in ♂♂ and 17.5 cm in ♀♀), rounded snout, dorsolateral bony ridges on head prominent but narrow, vertebral ridge distinct and slightly segmented, dorsolateral glandular warts distinct and prominent, shallow vomerine tooth series. Ground color dark brown, orange to reddish brown color markings on anterior half of head, vertebral ridge, rib nodules, limbs, vent region, and whole tail (Hernandez 2016; Nishikawa *et al.* 2013a; Nishikawa *et al.* 2014). Differs from *T. shanjing* by having darker markings, wider head, longer and higher tail, wider and longer vomerine teeth series (vs. narrower head, shorter and lower tail, and narrower and shorter vomerine teeth series in *T. shanjing*) (Nishikawa *et al.* 2013a);

Tylototriton verrucosus – this species has an all-brown ground color, with tail and soles of feet slightly lighter than dorsum, pale coloration restricted to ventral ridge of tail, with strongly developed cranial crests (vs. weakly developed cranial crests in *T. asperrimus*) (Nussbaum *et al.* 1995).

Tylototriton yangi – max TL of 15.8 cm for ♂♂ and 17.2 cm for ♀♀ (Hernandez & Hou 2018a) this species shows distinctively warty skin, laterally protruding quadrate regions, rounded snout, prominent vertebral ridge, isolated dorsolateral glandular warts, reddish-orange markings on posterior half of parotoids, middorsal ridge, dorsolateral knobs on body,

ventrolateral sides of trunk, jaw angle, cloacal region, tail, fingers and toes, but lack of markings on the limbs or on the anterior half of head (Hernandez 2016; Nishikawa *et al.* 2013a; Nishikawa *et al.* 2015). The species presents an intermediary coloration between *T. kweichowensis* and *T. shanjing* (Raffaëlli 2013).

Distribution and Habitat

Distribution

***Tylototriton anguliceps*:** Known from Vietnam, Dien Bien Province, Muong Nhe District, Muong Nhe Nature Reserve (type locality), and from Son La Province, Thuan Chau District, Nong Vai Village and Copia Nature Reserve and Song Ma District, Tup Pha B Village and Sop Cop Nature Reserve. The species is also known from northern Thailand, Chiang Rai Province, Doi Lahnga and Khun Chae National Park, and Chiang Mai Province, Chai Prakan District, Si Dong Yen and Doi Wiang Pha, and from northern Laos, Luang Namtha Province, Viengphoukha District, Phou Ya Kaho Village. Its vertical distribution ranges from 1,443–1,778 m asl (Hernandez *et al.* 2019; IUCN 2016; Le *et al.* 2015; Phimmachak *et al.* 2015; Pomchote *et al.* 2008). The species is associated with streams and ponds and their vicinity in evergreen forest (Le *et al.* 2015).

***Tylototriton himalayanus*:** Currently confirmed from Nepal, Mechi Zone, Illam District, May Pokhari 1 (type locality), May Pokhari 2, and Bagh Khor, and from India, Darjeeling District, West Bengal. The species inhabits subtropical hill forest dominated by scattered vegetation at elevations of 900–2,317 m asl (Khatiwada *et al.* 2015). The populations from western Bhutan (Toebisa, Kabjisa, Kazh districts) (Wangyal & Gurung 2012) still await taxonomic confirmation.

***Tylototriton kachinorum*:** Only known from Myanmar, Kachin State, Mohnyin Township, Indawgyi Lake area in Ingyin Taung Mountain. The species is found on a forest swamp surrounded by montane evergreen tropical forest at elevations from 900 to 1,050 m asl (Zaw *et al.* 2019).

***Tylototriton ngarsuensis*:** Only known from Myanmar, Shan State, Taunggyi District, Ywangan Township, Ngar Su Village, Baw Hto Chang (type locality) at 1,212 m asl (Grismer *et al.* 2018).

***Tylototriton panwaensis*:** Only known from Myanmar, Kachin State, Myitkyina District, Panwa Township, in the vicinity of Panwa Town (type locality) at elevations of 2,225–2,256 m asl. A second population from Sagaing Region, Khandi District, Lahe Township, was cautiously described as *T.* cf. *panwaensis* as morphological differences were only supported by 1 % of genetic divergences (Grismer *et al.* 2019).

***Tylototriton phukhaensis*:** Only known from a temporary swamp in northern Thailand, Nan Province, Doi Dong Ya Wai Mountain, Doi Phu Kha National Park at an elevation of 1,795 m asl (Pomchote *et al.* 2020b).

***Tylototriton podichthys*:** Endemic to Laos in Luang Phabang Province, Phoukhoun District, Nam Madao Village (type localiy), Xieng Khouang Province, Kham District, Yord Lieng Village and Houaphanh Province, Viengthong District, Phou Louey National Protected Area, and Xam Neua District between 1,189 and 1,493 m elevation asl. The species inhabits a variety of natural and disturbed habitats in subtropical forest (Hernandez 2016; IUCN 2017; Phimmachak *et al.* 2015).

***Tylototriton pseudoverrucosus*:** Endemic to the Daliang Mts. (=Da Liang Shan), Ningnan County, Sichuan Province, China, at 2,300–2,800 m elevation asl. It is currently only known

from two large permanent ponds surrounded by grassland and shrub forest (Hernandez 2016).

***Tylototriton pulcherrimus*:** China, Yunnan P., Lüchun County (type locality) in Huanglian Mts., including the Huanglianshan National Nature Reserve and Jinping Miao County in Fenshui Mts., inlcuding the Fengshuilin National Nature Reserve at elevations between 1,450–1,550 m asl (Hernandez 2016; Hernandez *et al.* 2018). Phylogenetic analyzes by Yu *et al.* (2013) cluster the population from Zhangba County together with the ones above, likely identifying a third population of this taxa.

***Tylototriton shanjing*:** The taxonomic status and biogeographical separation of this species from *T. verrucosus*, especially in potential hybridization zones is unclear. The localities below attempt to summarize the distribution of the "light colored morphotype" previously identified as *T. verrucosus* although until further clarifications, some distributions remain problematic. *T. shanjing* is endemic to China and Yunnan Province. Known from Pu'er City: Jingdong (type locality), Mojiang, and Menglian Counties; Lincan City: Yongde, and Yun Counties; Baoshan City; Nujiang Lisu Prefecture, Lushui County, Pianma Township, Gangfang; Lijiang City: Lijiang County and Yulong County, Peiliang; Dali Bai Prefecture, Nanjian County; Chuxiong Prefecture: Dayao, and Shuangbai Counties; Yuxi City: Yuanjiang, and Xinping Counties; Honghe Prefecture: Jianshui, and Lüchun Counties; Xishuangbanna Prefecture: Menghai, and Jinghong Counties (Hernandez 2016; Hernandez & Hou 2017; Nussbaum *et al.* 1995; Yu *et al.* 2013). The species occurs at elevations between 1,000–2,500 m asl in primary and secondary forests, but also in disturbed habitats like tea plantations and rice paddies (Raffaëlli 2013, Hernandez & Hou 2017).

***Tylototriton shanorum*:** Endemic to Myanmar, Shan State, Taunggyi Township (type locality), Kalaw, Pindaya, and Pinlaung townships. The species inhabits wetlands near highland lakes at elevations of 1,393–1,457 m asl (Nishikawa *et al.* 2014; Onishi *et al.* 2020).

***Tylototriton uyenoi*:** Occurs in Thailand, in Chiang Mai Province: in Doi Suthep (type locality) (including Doi Suthep-Pui National Park), Doi Ang Khang, Doi Chang Kien, Doi Inthanon (including Doi Inthanon National Park), Doi Pui, Doi Mak Lang, Doi Pha Hom Pok, Doi Khun Chang Khian, Doi Chiang Dao (including Chiang Dao Wildlife Sanctuary); in Tak Province: Doi Soi Malai, Umphang, Doi Mon Jong; Mae Hong Son Province, Namtok Mae Surin National Park; and Kanchanaburi Province, Khao Laem National Park, at elevations between 1,200 and 1,900 m asl (Gerlach 2012; Hernandez 2016; Hernandez 2017; Hernandez *et al.* 2019; Hernandez & Pomchote 2020; Michaels 2014; Nishikawa *et al.* 2013a).

***Tylototriton verrucosus*:** The taxonomic and biogeographical separation of this species from *T. shanjing* remains problematic. *T. verrucosus* occurs in China, southwestern Yunnan Province: along the western reaches of the Gaoligong Mountains, from Nujiang Prefecture (Lushui County), via the western parts of Baoshan Prefecture (Baoshan and Tengchong Counties, including in the Gaoligong Mountain National Nature Reserve), to south Dehong Prefecture (Longchuan [including Husa and Gongwa Townships] and Yingjiang Counties) (Hernandez 2016; Hernandez & Hou 2018b; Nussbaum *et al.* 1995). Some authors defend an even more cautious habitat' projection, based only on the occurrence of the dark morphotype distributed in the southwestern parts of the above-mentioned range in Longchuan County (Hernandez 2016). Pomchote *et al.* (2020a) choosing not to distinguish between color morphs, treat *T. verrucosus* and *T. shanjing* as conspecific, and describe a new population of *T.* cf. *verrucosus* from Thailand, Chiang Rai Province, Doi Chang. Due to the border proximity, this species is also expected to occur in Myanmar (Hernandez 2016).

***Tylototriton yangi*:** Only known from China, Yunnan Province. It is distributed in Honghe

Prefecture: Gejiu City, Dawei Moutains (including Daweishan National Forest Park), Pingbian Miao, Honghe and Hekou Counties and Mengzi City; and in Wenshan Prefecture: Wenshan County, Laojunshan Mts., and in Wenshan National Nature Reserve (Hernandez 2016; Hou *et al.* 2012; Sparreboom 2014; Wang *et al.* 2017; Zhao *et al.* 2012). The species inhabits karstic mountains of secondary mixed forests and plantation patches at elevations between 1,600 and 2,200 m asl within humid sub-tropical climate (Hernandez & Hou 2018a).

Habitat

In general, *Tylototriton* species inhabit forests in mountain regions with a high amount of annual precipitation during the summer monsoon, to support the creation of water bodies with a long hydroperiod for larval development (Bernardes *et al.* 2013; Bernardes *et al.* 2017a). These species usually reproduce in small temporal ponds, but also in permanent ponds of variable size, as well as small streams with slow current, swamps, and artificial water bodies (Hernandez 2016).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

Council Regulation (EC) No 338/97Annex: B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Tylototriton anguliceps – Least Concern (assessed January 19, 2016);

Tylototriton himalayanus – Data Deficient;

Tylototriton kachinorum – Data Deficient;

Tylototriton ngarsuensis – Data Deficient;

Tylototriton panwaensis – Data Deficient;

Tylototriton phukhaensis – Data Deficient;

Tylototriton podichthys – Least Concern (assessed January 20, 2016);

Tylototriton pseudoverrucosus – Endangered (B1ab[iii] assessed June 20, 2019);

Tylototriton pulcherrimus – Data Deficient;

Tylototriton shanjing – Vulnerable (A4acde, assessed June 20, 2019);

Tylototriton shanorum – Vulnerable (B1ab[iii], assessed January 15, 2016);

Tylototriton uyenoi – Data Deficient;

Tylototriton verrucosus – Least Concern (assessed April 30, 2004);

Tylototriton yangi – Endangered (A4acd, assessed June 20, 2019).

Threats

Main threats to *Tylototriton* are related with habitat loss and degradation especially around the breeding habitats (Nishikawa *et al.* 2013b) as well as overharvesting (Stuart *et al*. 2004) for food, traditional medicine, and the domestic and international trade (CITES 2019; Rowley *et al.* 2016). Below is a list of specific reported threats to each of these species:

Tylototriton anguliceps – the habitat of this species is likely declining due to infrastructure

development and expanding agriculture, and the species is likely to have entered the international in the past under a wrong name (IUCN 2016);

Tylototriton himalayanus – breeding ponds are threatened by the necessity of land conversion into agricultural areas (Seglie *et al.* 2003), pollution associated with agrochemicals (van Dijk *et al.* 2009), and introduction of exotic species (like carp farming practices) (Kuzmin *et al*. 1994). There are further reports of intentional collection for human consumption, as well as for use in biological and scientific studies, especially in universities and college museums throughout India, as it is the only known representative of the order Caudata in the country (Das & Dutta 2014);

Tylototriton kachinorum – it is likely affected by the growing anthropogenic pressure and forest destruction observed throughout its distribution range (Zaw *et al.* 2019). The species has likely been collected for the international trade as other relative species from Myanmar;

Tylototriton ngarsuensis – used locally in traditional medicine, collected for the national and international pet trade (Grismer *et al.* 2018);

Tylototriton panwaensis – likely suffers from habitat loss, which is identified as the highest threat to amphibian diversity in Myanmar (Wogan 2014), as well as collection for the international trade as with other relative species from the country;

Tylototriton phukhaensis – the habitat is declining due to increased deforestation inflicted by exploration of forest resources, and feral cattle grazing. The animals are collected even within protected area (Pomchote *et al.* 2020b);

Tylototriton podichthys – is threatened by slash and burn agriculture and pollution from agrochemicals, as well as intentional collection for the pet market and use in traditional medicine (Phimmachak *et al.* 2015b);

Tylototriton pseudoverrucosus – the habitat of this species is degraded due to increased development, like tourism and road construction (Hernandez 2016);

Tylototriton pulcherrimus – the habitat of this species is threatened by the development of hydroelectric dams and ongoing deforestation. The species is collected for the international pet trade (Hernandez 2016);

Tylototriton shanjing – the habitat of *T. shanjing* is threatened by increased agricultural practices, exploration of goat farms (Hernandez 2016), small-scale wood collection, pollution, and expanding human settlements. *T. shanjing* is also predated by the invasive crayfish as well as used in the traditional medicine, both locally and nationally, and in the national and international pet trade (IUCN 2020);

Tylototriton shanorum – the habitat of the species is declining due to infrastructure development and expanding agriculture. *T. shanorum* are harvested for use in traditional medicine, both nationally and internationally, and the national and international pet trade. The species is known to have been persecuted and killed for being associated with bad omen (IUCN 2017b), harvested to be used as bait for fishing (Sparreboom 2014), and is consumed locally as food (Hernandez 2016);

Tylototriton uyenoi – is currently threatened by extensive deforestation for agricultural activity, shifting cultivation, pollution from human settlement (Dowwiangkan *et al.* 2018);

Tylototriton verrucosus – the habitat of the species is declining due to infrastructure development, expanding agriculture, slash and burn techniques, pollution and exploitation of natural reserves, like logging. The species is collected for medicine purposes, locally, nationally, and internationally, as well as sold to the national and international pet market (van Dijk *et al.*

2009);

Tylototriton yangi – the distribution range of this species greatly overlaps with major tin-mining sites in China. Furthermore there is evidence of the species being harvested every year from May to July (when it gathers in breeding ponds and it is easier to collect), dried and sold for traditional medicine (Wang *et al.* 2017) both locally and nationally. The species is also collected for the national and international pet trade (IUCN 2020b).

Reproduction

Topic	Data for this group
Secondary sexual traits	Sexual dimorphism is poorly expressed. ♀♀ are larger, heavier and present a puncture like cloacal orifice, while ♂♂ are smaller, slender, and present an elongated opened slit. During the breeding season, mature adults will present a more evidently bulbously and inflated cloacal region (Hernandez 2016). *T. himalayanus* – ♂♂ have smaller heads, shorter limbs and higher tails than ♀♀ (Seglie *et al.* 2010). During the breeding season, since ♂♂ spend longer periods inside the water, their skin is more shiny and smooth than that of ♀♀ (Roy & Mushahidunnabi 2001); "*T. shanjing*" – ♂♂ have longer tails than ♀♀ (Pasmans *et al.* 2014); *T. shanorum* – ♂♂ have a more robust body, longer tail, and longer vent slit than the ♀♀ (Nishikawa *et al.* 2014); *T. uyenoi* – ♀♀ are larger, heavier, while ♂♂ are smaller, slender. Cloacae of ♂♂ adult newts are longer than those of ♀♀, which have a round and swollen cloacae. (Dowwiangkan *et al.* 2018); "*T. verrucosus*" – ♂♂ have longer tails than ♀♀ (Pasmans *et al.* 2014); *T. yangi* – ♂♂ may develop nuptial pads absent in ♀♀ (Hernandez 2016) like *T. vietnamensis* and *T. taliangensis*.
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	T. *himalayanus* – two studies based on skeletochronology of wild populations in Darjeeling, India, support sexual maturity between 3 and 5 (mostly 4) years old (Kuzmin *et al.* 1994), and around 2.5 years in ♂♂ and 3.2 years in ♀♀ (Seglie *et al.* 2010); *T. shanjing* – in captivity between 3–4 years (Mudrack 2005); "*T. shanorum*" – in captivity, usually 2.5–3 years (Hernandez 2016), and around 5–6 when raised terrestrial with cooler period in winter; "*T. verrucosus*" – in captivity between 1.5 (Ziegler *et al.* 2008) and 2 years old (Pasmans *et al.* 2014); T. *yangi* – in captivity 3.5–4 years old (Hernandez 2016) or later.
Mating and oviposition sites	*T. himalayanus* – aquatic courtship (extensive nose rubbing and tail fanning), ventral amplexus, spermatophore transfer and oviposition (Roy & Mushahidunnabi 2001); *T. phukhaensis* – oviposition occurs on land; eggs are deposited in single, double and triple formations attached to the tip of grasses and on rocks covered with vegetation ca. 3–82 cm above the water (Pomchote *et al.* 2020b); *T. shanjing* – Mudrack (2005) with WC animals originally from Garfong, Jingdong, described courtship occurring both outside and inside of the water, and eggs being glued to the vegetation directly above the water. Courtship ("circling" and tail fanning) but also oviposition can occur both in land as well as inside the water. And although the substrate for egg deposition is very unspecific (Pasmans *et al.* 2014), there seems to be a preference for egg laying in shallow water or on the wet bank (Hernandez 2016). Eggs present an adhesive layer that allows them to attach to different substrates like aquatic plants (Wang *et al.* 2017). No

Topic	Data for this group
	amplexus has yet been observed in *T. shanjing* sensu stricto (Schultschik *et al.* 2013); "*T. shanorum*" – aquatic amplexus and oviposition. Eggs are individually attached to plants or other structures (Hernandez 2016). ♀♀ of some groups deposit their eggs exclusively aquatic, even when a small land setup is available, while others may also deposit their eggs on water saturated substrate; *T. uyenoi* – Hernandez (2016) reported ventral amplexus for what now is considered as *T. uyenoi* instead of *T. verrucosus* sensu stricto (Wang *et al.* 2017); "*T. verrucosus*" – aquatic courtship (nose-rubbing and tail fanning), but apparently amplexus has not yet been observed in topotypic individuals (Wang *et al.* 2017), only on "*T. verrucosus*" from unknown (likely Chinese) origin (Sparreboom 1999). Oviposition occurs mostly on submerged vegetation and at the bottom of the water body (Hernandez 2016), and rarely on land (Sparreboom 1999). Eggs present an adhesive layer that allows them to attach to different substrates (Sparreboom 1999) and are deposited in small and bigger groups; *T. yangi* – courtship (kind of circular nuptial dance like in *T. kweichowensis* [Hernandez and Hou 2018], and extensive nose rubbing and sniffing prior to tail fanning [Wang *et al.* 2017]), and spermatophore transfer occurring within the water. Currently it is not clear if ventral amplexus occurs (Wang *et al.* 2017). Eggs are laid individually and do not present an adhesive layer (contrary to *T. shanjing*) (Wang *et al.* 2017). Oviposition occurs on the saturated substrate directly at the water or at the vicinity.
Breeding season	In natural habitat, the breeding season begins around spring with the onset of the monsoon, which is always slightly variable. In captivity, breeding starts when triggered by the respective climate parameters. *T. himalayanus* – in Darjeeling, India, from late March throughout September (Kuzmin *et al.* 1994); *T. ngarsuensis* – at the type locality from May until end October (Grismer *et al.* 2018); *T. shanjing* – May to August (Sparreboom 2014) when temperatures and humidity rise (Pasmans *et al.* 2014); *T. shanorum* – in May the with the onset of raining season newts move from terrestrial hiding places to breeding ponds where they reproduce until October (Gerlach & Gerlach 2018; Pe 2018). In captivity "*T. shanorum*" reproduces usually in the spring, but if for some reason that does not occur, repeating the breeding triggers in the fall might start reproduction; *T. uyenoi* – in the rainy season (Mai to September), and eggs are laid from June to August (Gerlach 2012; Dowwiangkan *et al.* 2018); *T. verrucosus* – monsoons last from March to September (Hernandez 2016); *T. yangi* – in natural habitat from end of April up to September (Hernandez & Hou 2018a), in captivity, breeding generally starts in May/June (Hernandez 2016).
Number eggs/ clutches per season	*T. himalayanus* – mean clutch sizes of 117 ± 45 eggs (range between 47 and 196 eggs) depending on the size of the female. Females lay only one clutch a year (Roy & Mushahidunnabi 2001); *T. shanjing* – in natural habitat, clutch sizes of 126±18 eggs are reported (Li *et al.* 2010 in Hernandez 2016). In captivity clutch sizes in literature vary between 30–80 eggs (Hernandez 2016), to ca. 100 eggs (Pasmans *et al.* 2014). Historical sums of 291 eggs in captivity (Rehberg 1986) cannot be confirmed by current captivity practices. Females lay one clutch a year; *T. shanorum* – unknown in nature. In captivity the average clutch size for "*T.*

Topic	Data for this group
	shanorum" is of ca. 65 eggs per female (ranges between 60 to 80 eggs) are reported. Females lay one clutch a year; *T. uyenoi* – the total number of eggs per female is unknown, but a female releases 15–31 eggs per night (Dowwiangkan *et al.* 2018); "*T. verrucosus*" – references report up to 400 eggs in one clutch (Pasmans *et al.* 2014), ca. 300 eggs deposited by 2 ♀♀ several times during the course of 4 months (Sparreboom 1999), while others report an average of only ca. 30 eggs, with large ♀♀ depositing up to 100 eggs (Hernandez 2016). One keeper reported that ♀♀ can lay 1–3 clutches a year; *T. yangi* – 60–80 eggs per female (Hernandez 2016). One main clutch per female and sometimes few eggs still deposited later. Eggs laid individually, close together and without adhesive outer layer.
Average egg diameter and hatchling size	TL of metamorphlings depends on temperature. *T. himalayanus* – egg size 6–10 mm (Khatiwada *et al.* 2015); in natural habitat larvae hatch with mean TL of 11 mm and finish metamorphosis at average TL of 13.5 cm (Kuzmin *et al.* 1994); *T. phukhaensis* – in the wild the average egg diameter is around 7.8 mm (range between 5.7–12.3 mm) (Pomchote *et al.* 2020b); "*T. shanjing*" – egg diameter 7 mm (Rehberg 1986). At temperatures of 18–20 °C, larvae hatch in 3–4 weeks with TL of 10–15 mm (Hernandez 2016). Metamorphosis is completed at TL of 4–6 cm (Pasmans *et al.* 2014); "*T. shanorum*" – small eggs with ca. 2–3 mm in diameter. At water temperature above 19 °C TL hatchling is ca. 10–11 mm, and TL at metamorphosis is ca. 5 cm; *T. uyenoi* – small eggs with averages of 2.5 ± 0.4 mm in diameter (Dowwiangkan *et al.* 2018); "*T. verrucosus*" – eggs with ca. 5–7 mm diameter and larvae hatch with TL of 13–15mm (Ziegler *et al.* 2008). Sparreboom (1999) with a small group of "*T. verrucosus*" likely original from China reports that at water temperatures between 20–25 °C larvae hatch with 12 mm (after 10–20 days) and complete metamorphosis with average TL between 6–7 cm, but also a few exceptionally small (ca. 3 cm) or exceptionally large (ca. 13–16 cm); *T. yangi* – eggs ca. 8–10.7 (Hernandez pers. comm.); hatchling size ca. 17 mm.
Development duration egg to metamorphosis	*T. himalayanus* – larvae can overwinter (Nag & Vasudevan 2014); *T. shanjing* – at air temperatures of 25 °C the larvae hatched after 15–40 days, and at water temperatures of 20–22 °C metamorphosis was completed in ca. 8 weeks with TL between 40–45 mm (Mudrack 2005). At slightly higher water temperatures of 26–27 °C the metamorphosis of "*T. shanjing*" (n=8 animals) was completed after 9–13 weeks (Ziegler *et al.* 2008); *T. shanorum* – in nature, development time of egg is unknown, but larvae can still be found in water up to January (Pe 2018). For "*T. shanorum*" in captivity at water temperatures above 19 °C the egg phase lasts approximately 30 days and the larval phase between 3–4 months; *T. uyenoi* – development time of egg in nature is unknown. In permanent water bodies year-round larvae could be found (Dowwiangkan *et al.* 2018). In the same location larvae of different development stage could be found, giving hint to twice egg-laying per season (Gerlach 2021); "*T. verrucosus*" – at temperatures of ca. 17–20 °C larvae hatch after 3–4 weeks (Hernandez 2016). Pasmans *et al.* (2014) with a group of "*T. verrucosus*" whose juveniles could be raised fully aquatic (note: which is not the case of the terrestrial habits seen in the juveniles of "*T. shanorum*"), observed that at temperatures

Topic	Data for this group
	between 20–25 °C larvae completed metamorphosis after 2–4 months after egg deposition at TL of 5–7.5 cm. Sparreboom (1999) with the same kind of aquatic juveniles (and at water temperatures between 20–25 °C), observed that larvae kept individually or in small groups usually took longer to complete metamorphosis, sometimes up to 1 year or longer. In these cases, some larvae developed into extraordinarily enormous sizes (ca. 13–16 cm); *T. yangi* – in captivity at 20–25 °C larvae hatch after 15 days measuring between 10–12 mm in TL, and completed metamorphosis in approx. 4 months (Wang *et al.* 2017); at slightly lower temperatures of 18 °C larvae hatch after 22–30 days and at 25 °C temperatures during the day and lower during the night metamorphosis is completed after 4 to 5 months with TL of ca. 5 cm.
Temperature dependent sex determination	Not known.
Sperm storage	Possible, but not known.

Differences in courtship behavior, like for example occurrence of ventral amplexus may be a characteristic behavioral pattern that differentiates *T. himalayanus* and *T. shanorum* from *T. verrucosus sensu stricto* (Wang *et al.* 2017).

Husbandry and Captive Breeding

Tylototriton anguliceps X

Tylototriton himalayanus X

Tylototriton kachinorum X

Tylototriton ngarsuensis X

Tylototriton panwaensis X

Tylototriton phukhaensis X

Tylototriton podichthys X

Tylototriton pseudoverrucosus X

Tylototriton pulcherrimus X

Tylototriton shanjing ●

Tylototriton shanorum ●

Tylototriton uyenoi X

Tylototriton verrucosus ●

Tylototriton yangi ▲

Topic	Data for this group
Trigger for reproduction	"*T. shanjing*" – increased air temperature (to ca. 25 °C) in association with increased humidity (Pasmans *et al.* 2014) after a natural yearly temperature fluctuation, with relatively dry and colder (ca. 15–18 °C) winter period; *"T. shanorum"* – the general experience with captive animals is that most adults (with few exceptions) will choose to stay inside the water year-round, despite that in nature animals are terrestrial outside of the breeding season (Gerlach & Gerlach 2018; Pe 2018). However, it is advisable that a small terrestrial part is always provided, so that the few exceptions can have a choice. To trigger reproduction, if the animals are kept aquatic, it is necessary to drop water temperature to about 16 °C for a few weeks in winter. In spring with water temperatures of ca. 20 °C and changing about 1/3 of the water volume of the aquarium for fresh colder water (ca. 12–15 °C) can trigger reproduction (Hernandez 2016). However, if the animals are kept terrestrial during winter, it is necessary to provide colder winters (of around 12–14 °C) during 3 months so that the animals can have a terrestrial resting phase (although it seems that max. lower temperatures of 18 °C in winter are enough to trigger reproduction next spring). In this case, increased temperatures (ca. 20 °C), humidity, and total water change (cold water ca. 16 °C) will stimulate reproduction. It seems like the cold period is not really necessary for triggering reproduction, but mostly hot temperatures and new and colder water in the tank; "*T. verrucosus*"- like with "*T. shanorum*", with that the species was historically confused, most keepers maintain "*T. verrucosus*" aquatic year-round (nevertheless see "*T. shanorum*" above for general recommendations, especially given the uncertainty surrounding species identification). It seems that juveniles can be raised fully aquatic until sexual maturity and beyond (Pasmans *et al.* 2014; Sparreboom 1999). Sparreboom (1999) observed aquatic and not yet fully metamorphosed juveniles (with 1.5 years of age, and TL of 15 cm) depositing eggs without any specific breeding trigger initiated from his part, besides the usual yearly temperature oscillations. Pasmans *et al.* (2014) write for terrestrial kept animals that increasing temperatures above 20 °C in spring and providing an aquatic setup after a colder (around 15 °C) and drier winter will trigger reproduction. It seems that the slight increase of temperature in spring, and the presence of an aquatic part is enough to trigger reproduction in "*T. verrucosus*". Additionally, 30–50 % of regular water changes might help, if increasing temperatures alone was not enough; *T. yangi* – cold and dry winters of 3–4.5 months (December to mid. April) followed by raising temperatures and simulating heavy rains with humidity around 90 %. Good results are attained by bringing well-fed adults to an outside aquaterrarium during heavy rains in late spring with temperatures not below 18 °C.
Husbandry requirements	Terrarium sizes depend on group size, sex-ratio, size of animals and behavior. Environmental conditions depend on each species-specific requirement. *T. himalayanus* – in Darjeeling, India, the species experience three main seasons: cold season from October to February (mean temperatures around 6 °C), warm season from March to June (maximum temperatures of ca. 27 °C), and rainy season from July to September. The species has aquatic habits during the breeding season, and terrestrial habits outside of the breeding season. During the coldest months the species goes through a period of inactivity and even hibernation (Seglie *et al.* 2010) of about 4 to 5 months (Kuzmin *et al.* 1994). The only husbandry information that can be traced back to this taxon without doubt (being based on the Indian population) supports the following: an aquaterrarium with 134 x 60 x 75 cm dimension, providing one half terrestrial, and the other half aquatic, properly enriched with hides and vegetation. The aquatic part should

Topic	Data for this group
	provide a water depth between 8 and 20 cm. The data on husbandry temperatures are kept mostly without amplitude changes throughout the year, with air temperature between 25–26 °C, and water temperature between 18–20 °C. Basking spots can be added with UV lights providing temperatures of ca. 27 °C in the summer and a max. of 22 °C in the winter, as well as a water filter. Larvae should be raised separate from adults in small groups. Metamorphs can be raised at the same temperatures as the adults (Hernandez 2016). However, the authors have to note that the husbandry requirements mentioned above do not consider the species natural history, namely a colder phase during winter and the opportunity for the species to have a period of inactivity. While the species can be kept and possibly even reproduced under these conditions, a lack of temperature oscillations is not reflecting conditions in nature, and might have detrimental effects on the animals' well-being and longevity; "*T. shanjing*" – the species can be kept at "living-room" temperature (Pasmans *et al.* 2014; Rehberg 1986; Ziegler *et al.* 2008). During the winter season, the setup is kept relatively dry and air temperatures may drop to ca. 15 °C (Pasmans *et al.* 2014) or down to 8 °C (Mudrack 2005). Animals are mostly terrestrial year-round, so it is necessary to provide a proper terrestrial setup with many hides (Pasmans *et al.* 2014). In case of an aquaterrarium, the aquatic section during this season can contain only some water (Hernandez 2016). During the breeding season, humidity and air temperature increase to 15–25 °C, although temperatures up to 30 °C are also good tolerated (Pasmans *et al.* 2014). Water temperatures during this season should be around 20–22 °C and water depths of about 15 cm (Mudrack 2005). Minimum terrarium size of 60 x 30 x 30 cm for a group of 3–5 animals with a relatively large aquatic part (Pasmans *et al.* 2014). Although one male and two ♀♀ is the right ratio for one group (Hernandez 2016). The water must be stagnant (no water filter or aerator) (Hernandez 2016); *"T. shanorum"* – in captivity, adults can be kept fully aquatic without any obvious negative effects, despite the fact that in nature, they are terrestrial outside of the breeding season (Gerlach & Gerlach 2018; Pe 2018). Nevertheless, it is still advisable to offer a small terrestrial setup, so that the animals can have a choice. The water temperature can vary between 15–17 °C in winter (at around 12–14 °C or lower the species hibernates on land) and around 20 °C in the summer (25 °C is tolerated for short periods). Water depth should present a minimum of 15 cm (or lower in winter if temperatures move the animals into land). It is recommended to add a water filter and enrich the environment with aquarium plants (Hernandez 2016). However, in the natural habitat the species experiences temperature' oscillations throughout the seasons: temperatures of air and water do not exceed 30 °C and 27 °C, respectively in the summer, and may go as low as 5 °C and 9 °C, respectively in the winter. During the coldest months the animals hibernate buried in their terrestrial hides (Hernandez 2016); "*T. verrucosus*" – in captivity, adults may be kept fully aquatic without any obvious negative effects, despite the fact that in nature, they are terrestrial outside of the breeding season. In spring, with increasing temperatures, the animals need to be accommodated in an aquaterrarium, if they are not already being kept aquatic. Temperatures during breeding season should be around 20–25 °C (Pasmans *et al.* 2014). It is recommended to always provide a terrestrial setup with enough hides. If the animals are kept terrestrial during winter period a larger terrestrial part is necessary the setup should be kept relatively dry with temperatures around 10–15 °C. Aquatic part ca. 7 cm deep in breeding phase and less outside; *T. yangi* – a pair of adults requires an aquaterrarium of at least 80 x 40 cm with several hiding places. The species requires a large aquatic section (ca. 40 %),

Topic	Data for this group
	with ca. 15 cm water depth. Air temperatures between November–February 8–10 °C (and lower) and between March–October 18–22 °C, with abundant watering during this time (Hernandez 2016; Raffaëlli 2013). Adults will switch daily between land and water. In alternative, there is higher breeding success reported when two aquaterraria are used: one inside for the winter, and one outside for the active/ breeding phase. In this case the winter enclosure should have 1/4 of water and water depths between 1–4 cm, and the breeding enclosure should have 2/3 of water with depths around 10–12 cm. Adults hibernate at temperatures of 10 °C.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General particularities, difficulties with keeping and breeding	"*T. shanjing*" – adults don't show signs of intra-specific aggression (Pasmans *et al.* 2014), but larvae are better raised separate in small groups by size (Ziegler *et al.* 2008); *"T. shanorum"* – more aquatic than other related species, however juveniles are under risk of drowning if kept exclusively aquatic. It is advisable to always include a dry, terrestrial part with hiding places (mimicking nature) so that the animals can move in and out of the water as necessary, especially given the degree of uncertainty around species identification. Very voracious species that will predate on smaller cohorts (large larvae on small larvae, adults on eggs, larvae and juveniles); "*T. verrucosus*" – more aquatic than other related species, some juveniles will not leave the water. Since the origin of most animals in the trade is unknown, it is advisable to always include a dry, terrestrial part with hiding places so that the animals can move in and out of the water as necessary; *T. yangi* – some keepers seem to experience eggs with susceptibility to fungal infections, in which case it is recommendable that they are left untouched until right before hatching (Hernandez 2016). But usually fertile and viable eggs do not have fungal growth, contrary to unfertile or dead eggs. It is recommended to be attentive and remove moldy eggs as soon as possible. Animals are a lot more active during heavy rains and thunderstorms.
Care of the young, technical and time	*T. himalayanus* – in nature larvae develop in stagnant waters where they can

Topic	Data for this group
effort	even overwinter, likely producing larger and stronger juveniles (Nag & Vasudevan 2014); *"T. shanjing"* – larvae should be well fed and kept by size classes to avoid cannibalistic tendencies (Ziegler *et al.* 2008) *"T. shanorum"* – eggs and larvae should be raised separately from the adults but in the similar environmental conditions. Larvae should be well fed and kept by size classes (with 4 to 5 larvae maximum) to avoid cannibalistic tendencies. The larva setup should have ca. 5 cm water depth, and it is recommended to add Java moss, small round pebbles to the bottom and a small bubbler. Juveniles are not aquatic; "*T. verrucosus*" – eggs and larvae should be raised separated from the adults but in the similar environmental conditions. Larvae should be kept in small groups of 4 to 6 larvae and should be offered sufficient food to avoid cannibalism. The larva setup should have ca. 5 cm water depth, and it is recommended to add Java moss and small round pebbles to the bottom. The water temperatures should be kept low at around 17–18 °C to give time for the larvae to grow, which may influence survival later on. Metamorphlings spend their time in the transition zone between land and water (Hernandez 2016); *T. yangi* – before hatching, the eggs should be carefully moved to a hatching setup. Larvae develop well with oxygenated water, Java moss and some fallen leaves (Hernandez 2016). The hatching setup is a box with moss or tissue, high humidity, and water level around 5 mm. No need for extra oxygenation in outside setups, the rain drops seem to be sufficient;
Life expectancy in captivity	Under good conditions in captivity these species can live long. At least 21 years for *T. shanorum*, 15 for *T. yangi*, but likely even more, as for example *T. ziegleri* with ca. 28 years (Ziegler *et al.* 2018).
Breeding difficulty evaluation	*"T. shanjing"* – easy to keep and breed (although not as easy as with *"T. verrucosus"*), nevertheless requires seriousness and cleanliness. Without locality data or genetic analysis, it is impossible to correctly identify *T. shanjing sensu stricto*; *"T. shanorum"* – very easy to keep and reproduce. However, requires seriousness and cleanliness. Although without locality data or genetic analysis it is impossible to correctly identify *T. shanorum* sensu stricto; *"T. verrucosus"* – very easy to keep and reproduce. However, requires seriousness and cleanliness. Although without locality data or genetic analysis it is impossible to correctly identify *T. verrucosus sensu stricto*; *T. yangi* – difficult inside even with hibernation and artificial rains during spring. Easier outside (it has worked every time the authors tried it). Seems harder to keep in optimal conditions as well.
Frequency of breeding in captivity evaluation	"*T. shanjing*" – very frequent, species breeds every year; *"T. shanorum"* – very frequent, species breeds every year; *"T. verrucosus"* – very frequent, species breeds every year. *T. yangi* – not frequent. It is hard to combine the correct breeding triggers.
Mortality in the first years of life	"*T. shanorum*" – ca. 15 % of the eggs are unviable, but afterward the mortality is very low; "*T. verrucosus*" – high percentage of unfertilized eggs (Hernandez 2016); *T. yangi* – hatching rate above 75 %, low larvae mortality, but hard to bring to adulthood.
F2 generation bred	*T. anguliceps* – no; *T. himalayanus* – unknown; *T. kachinorum* – unknown;

Topic	Data for this group
	T. ngarsuensis – unknown; *T. panwaensis* – unknown; *T. phukhaensis* – no; *T. podichthys* – no; *T. pseudoverrucosus* – no; *T. pulcherrimus* – unknown; *T. shanjing* – yes; *T. shanorum* – yes; *T. uyenoi* – unknown; *T. verrucosus* – yes; *T. yangi* – only known from Russia.
Interviews/ Surveys/ Consultations	*T. verrucosus* – several private breeders and the authors contributed; *T. shanjing, T. shanorum* and *T. yangi* – the authors contributed; *T. anguliceps, T. himalayanus, T. kachinorum, T. ngarsuensis, T. panwaensis, T. phukhaensis, T. podichthys, T. pseudoverrucosus T. pulcherrimus* and *T. uyenoi* – none.

References

Bernardes, M., M.D. Le, T.Q. Nguyen, C.T. Pham, A.V. Pham, T.T. Nguyen, D. Rödder, M. Bonkowski & T. Ziegler (2020): Integrative taxonomy reveals three new taxa within the *Tylototriton asperrimus* complex (Caudata, Salamandridae) from Vietnam. Zookeys **935**: 121-164.

CITES (2019): CoP18 Proposal 41, *Tylototriton* spp. https://cites.org/eng/cop/18/proposals_for_amendment (accessed 09.08.2021).

Das, I. & S.K. Dutta (2014): Status and declines of amphibians of India. *In:* Heatwole H. & I. Das (Eds). Conservation Biology of Amphibians of Asia - status of conservation and decline of amphibians: Eastern hemisphere. Volume 11, part 1 of Amphibian Biology. Borneo, Malaysia (Natural History Publications): 382 pp.

Dowwiangkan, T., Y. Ponpituk, C. Chuaynkern, Y. Chuaynkern & P. Duengkae (2018): Population and habitat selection of the *Tylototriton uyenoi* in the Maesa-Kogma Biosphere Reserve, Chiang Mai Province, northern Thailand. Alytes **36**(1-4): 300-313.

Dowwiangkan, T., C. Chuaynkern, P. Dumrongrojwattana & P. Duengkae (2020): Diet composition and neighboring prey community of the Phuping newt (*Tylototriton uyenoi*) in Maesa–Kogma Biosphere Reserve, Chiang Mai Province, northern Thailand. Biodiversitas **21**(10): 4515-4523.

Gerlach, U. (2012): Im Habitat des Birma-Krokodilmolches *Tylototriton verrucosus* in Thailand. Amphibia **11**(1): 13-15.

Gerlach, U. (2021): Vergleich der Krokodilmolche *Tylototriton uyenoi* und *Tylototriton shanorum* in ihrer jeweiligen Terra typica. Amphibia **20**(1): 24-32.

Gerlach, D. & U. Gerlach (2018): Im Habitat von *Tylototriton shanorum*. Amphibia **17**(2): 25-30.

Grismer, L.L., P.L.W. Junior, E.S.H. Quah, M.K. Thura, R.E. Espinoza, M.S. Grismer, M.L. Murdoch & A. Lin (2018): A new species of Crocodile Newt *Tylototriton* (Caudata: Salamandridae) from Shan State, Myanmar (Burma). Zootaxa **4500**(4): 553-573.

Grismer, L.L., P.L. Wood, E.S.H. Quah, M.K. Thura, R.E. Espinoza & M.L. Murdoch (2019): A new species of crocodile newt *Tylototriton* (Caudata: Salamandridae) from northern

Myanmar (Burma). Journal of Natural History **53**(7-8): 475-495.

Hernandez, A. (2016): Crocodile Newts - the Primitive Salamandridae of Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition Chimaira): 416 pp.

Hernandez, A. (2017): New localities for *Tylototriton panhai* and *Tylototriton uyenoi* Nishikawa, Khonsue, Pomchote & Matsui 2013 in northern Thailand. Bulletin de la Société Herpétologique de France **2017**(162): 110-112.

Hernandez, A., D. Escoriza, P. Pomchote & M. Hou (2019): New localities for *Tylototriton uyenoi, T. panhai* and *T. anguliceps* in Thailand with remarks on the southernmost distribution of the genus. Herpetological Bulletin **147**(2019): 15-18.

Hernandez, A., & M. Hou (2017): New localities of *Tylototriton shanjing* Nussbaum, Brodie & Yang 1995 at its southern limit of distribution in Yunnan province, China. Bulletin de la Société Herpétologique de France **163**(2017): 103-105.

Hernandez, A. & M. Hou (2018a): Natural history and biology of the Tiannan Crocodile Newt, *Tylototriton yangi* (Urodela: Salamandridae) at Gejiu, Yunnan Province, China with its conservation implications. Nature Conservation Research **3**(1): 277-281.

Hernandez, A. & M. Hou (2018b): Notes on the biogeography and ecology of *Tylototriton pulcherrimus* Hou, Zhang, Li & Lü 2012 with its conservation implications in the Yunnan province, China. Bulletin de la Société Herpétologique de France **165**(2018): 15-18.

Hernandez, A., & P. Pomchote (2020): New southernmost record for the genus *Tylototriton* in Asia: *Tylototriton uyenoi* Nishikawa, Khonsue, Pomchote & Matsui 2013, discovered in Khao Laem National Park, Kanchanaburi province, western Thailand. Bulletin de la Société Herpétologique de France **175**(2020): 64-67.

Hou, M., P. Li, & S. Lu (2012): Morphological research development of genus *Tylototriton* and primary confirmation of the status of four cryptic populations. Journal of Huangshan Univeristy **14**(3): 61-65. [Chinese with short English abstract]

IUCN SSC Amphibian Specialist Group. (2020a): *Tylototriton shanjing*. The IUCN Red List of Threatened Species 2020: e.T59485A63871498.

IUCN SSC Amphibian Specialist Group. (2020b): *Tylototriton yangi*. The IUCN Red List of Threatened Species 2020: e.T78587030A122172387.

IUCN SSC Amphibian Specialist Group (2016): *Tylototriton anguliceps*. The IUCN Red List of Threatened Species 2016: e.T79427218A88441865.

IUCN SSC Amphibian Specialist Group (2017a): *Tylototriton podichthys*. The IUCN Red List of Threatened Species 2017: e.T84335689A88444689.

IUCN SSC Amphibian Specialist Group (2017b): *Tylototriton shanorum*. The IUCN Red List of Threatened Species 2017: e.T73736309A73736329.

Khatiwada, J.R., B. Wang, S. Ghimire, K. Vasudevan, S. Paudel & J. Jiang (2015): A new species of the genus *Tylototriton* (Amphibia: Urodela: Salamandridae) from Eastern Himalaya. Asian Herpetological Research **6**(4): 245-256.

Kuzmin, S.L., R. Dasgupta & É.M. Smirina (1994): Ecology of the Himalayan newt (*Tylototriton verrucosus*) in Darjeeling Himalayas, India. Russian Journal of Herpetology **1**(1): 69-76.

Le, D.T., T.T. Nguyen, K. Nishikawa, S.L.H Nguyen, A.V. Pham, M. Matsui, M. Bernardes & T.Q. Nguyen (2015): A new species of *Tylototriton* Anderson, 1871 (Amphibia: Salamandridae) from Northern Indochina. Current Herpetology **34**(1): 38-50.

Michaels, C.J. (2014): Field observations, morphometrics and a new locality for *Tylototriton uyenoi* in Chiang Mai Province, Thailand. Herpetological Bulletin **130**(2014): 26-27.

Mudrack, W. (2005): Nachzucht von Krokodilmolchen, *Tylototriton shanjing*. Amphibia **4**(1): 23-25.

Nag, S., & K. Vasudevan (2014): Observations on overwintering larvae of *Tylototriton verrucosus* (Caudata: Salamandridae) in Darjeeling, Himalaya, India. Salamandra **50**(4): 245-248.

Nishikawa, K., W. Khonsue, P. Pomchote & M. Matsui (2013a): Two new species of *Tylototriton* from Thailand (Amphibia: Urodela: Salamandridae). Zootaxa **3737**(3): 261-279.

Nishikawa, K., M. Matsui, & T.T. Nguyen (2013b): A new species of *Tylototriton* from northern Vietnam (Amphibia: Urodela: Salamandridae). Current Herpetology **32**(1): 34-49.

Nishikawa, K., M. Matsui & D. Rao (2014): A new species of *Tylototriton* (Amphibia: Urodela: Salamandridae) from Central Myanmar. Natural History Bulletin Siam Society **60**(1): 9-22.

Nishikawa, K., D. Rao, M. Matsui & K. Eto (2015): Taxonomic relationship between *Tylototriton daweishanensis* Zhao, Rao, Liu, Li and Yuan, 2012 and *T. yangi* Hou, Li and Lu, 2012 (Amphibia: Urodela: Salamandridae). Current Herpetology **34**(1): 67-74.

Nussbaum, R.A., E.D. Brodie & Y. Datong (1995): A taxonomic review of *Tylototriton verrucosus* Anderson (Amphibia: Caudata: Salamandridae). Herpetologica **51**(3): 257-268.

Onishi, Y., P.T. Kyaw, S. Zay, Y. Aung, K. Myint, T.L. Thwe & K. Nishikawa (2020): Range expansion of *Tylototriton shanorum* (Salamandridae, Urodela) in Shan State, Myanmar, with reference to its relict and circum-highland lake distribution. Natural History Bulletin Siam Society **64**(1): 47-50.

Pe, T.K. (2018): Distribution of *Tylototriton shanorum* in southern Shan State. Taunggyi University Research Journal **9**: 1-11.

Phimmachak, S., A. Aowphol & B.L. Stuart (2015): Morphological and molecular variation in *Tylototriton* (Caudata: Salamandridae) in Laos, with description of a new species. *Zootaxa **4006***(2): 285-310.

Phimmachak, S., B.L. Stuart & A. Aowphol (2015): Ecology and natural history of the knobby newt *Tylototriton podichthys* (Caudata: Salamandridae) in Laos. Raffles Bulletin of Zoology **63**: 389-400.

Pomchote, P., W. Khonsue, P. Sapewisut, K. Eto & K. Nishikawa (2020): Discovering a Population of *Tylototriton verrucosus* (Caudata: Salamandridae) from Thailand: Implications for Conservation. Tropical Natural History **20**(1): 1-15.

Pomchote, P., W. Khonsue, P. Thammachoti, A. Hernandez, P. Peerachidacho, C. Suwannapoom, Y. Onishi & K. Nishikawa (2020): A New Species of *Tylototriton* (Urodela: Salamandridae) from Nan Province, Northern Thailand. Tropical Natural History **20**(2): 144-161.

Pomchote, P., P. Pariyanonth & W. Khonsue (2008): Two distinctive color patterns of the Himalayan Newt *Tylototriton verrucosus* (Urodela: Salamandridae) found in Thailand and its implication on geographic segregation. The Natural History Journal of Chulalongkorn University **8**(1): 35–43.

Raffaëlli J. (2013): Les Urodèles du Monde. Deuxième édition. Plumelec (Penclén édition): 472 pp.

Rehberg, F. (1986): Haltung und Zucht des Krokodilmolches *Tylototriton verrucosus* Anderson, 1871. Herpetofauna **8**(45): 11-17.

Rowley, J.J.L., C.R. Shepherd, B.L. Stuart, T.Q. Nguyen, H.D. Hoang, T.P. Cutajar, G.O.U. Wogan & S. Phimmachak (2016): Estimating the global trade in Southeast Asian newts. Biological Conservation **199**(2016): 96-100.

Roy, D. & M. Mushahidunnabi (2001): Courtship, mating and egg-laying in *Tylototriton verrucosus* from the Darjeeling district of the Eastern Himalaya. Current Science **81**(6): 693-695.

Schultschik G., W.-R. Grosse & J. Fleck (2013): *Tylototriton shanjing* (Nussbaum, Brodie, & Datong, 1995) - Yellow (or Mandarin) alligator newt. *In:* Schultschik G. W.-R. Grosse (eds.): Threatened Newts and Salamanders of the World - Captive Care Management/ Gefährdete Molch- und Salamanderarten der Welt - Richtlinien für Erhaltungszuchten. Vol. 1. Mannheim (Mertensiella **20)**: 189 pp.

Seglie, D, D. Roy, C. Giacoma & M. Mushahiddunnabi (2003): Distribution and conservation of the Himalayan newt (*Tylototriton verrucosus*, Urodela, Salamandridae) in the Darjeeling District, West Bengal (India). Russian Journal of Herpetology **10**(2): 157-162.

Seglie, D., D. Roy & C. Giacoma (2010): Sexual dimorphism and age structure in a population of *Tylototriton verrucosus* (Amphibian: Salamandridae) from the Himalayan region. Copeia **4**(4): 600-608.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Stuart, B.L., S. Phimmachak, N. Sivongxay & W.G. Robichaud (2010): A new species in the *Tylototriton asperrimus* group (Caudata: Salamandridae) from central Laos. Zootaxa **2650**(2010): 19-32.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fischman & R.W. Waller (2004): Status and trends of amphibian declines and extinctions worldwide. Science **306**(5702): 1783-1786.

van Dijk, P.P., G. Wogan, M.W.N. Lau, S. Dutta, T.K. Shrestha, D. Roy & T.Q. Nguyen (2009): *Tylototriton verrucosus*. The IUCN Red List of Threatened Species 2009: e.T59487A11934912.

Wang, K., Z. Yuan, G. Zhong, G.L. Li & P.A. Verrell (2017): Reproductive biology of *Tylototriton yangi* (Urodela: Salamandridae), with suggestions on its conservation. Amphibian and Reptile Conservation **11**(2): 33-43.

Wangyal, J.T. & D.B. Gurung (2012): The distribution of Himalayan Newts, *Tylototriton verrucosus* in the Punakha-Wangdue Valley, Bhutan. Journal of Threatened Taxa **4**(13): 3218-3222.

Wogan, G.O.U. (2014): Amphibian conservation: Myanmar. *In:* Heatwole H. & I. Das (eds.). Conservation Biology of Amphibians of Asia - status of conservation and decline of amphibians: Eastern hemisphere. Volume 11, part 1 of Amphibian Biology. Borneo, Malaysia (Natural History Publications): 382 pp.

Yu, G., M. Zhang, D. Rao & J. Yang (2013): Effect of Pleistocene climatic oscillations on the phylogeography and demography of red knobby newt (*Tylototriton shanjing*) from southwestern China. PloS One **8**(2): e56066.

Zaw, T., P. Lay, P. Pawangkhanant, V.A. Gorin & N.A. Poyarkov (2019): A new species of Crocodile Newt, genus *Tylototriton* (Amphibia, Caudata, Salamandridae) from the mountains of Kachin State, northern Myanmar. Zoological Research **40**(3): 151-174.

Zhao, T., D. Rao, N. Liu, S. Yuan & Z. Tao (2012): Molecular Phylogeny Analysis of *Tylototriton verrucosus* Group and Description of New Species. Journal of West China Forestry Science **41**(5): 85-89.

Ziegler, T., T. Hartmann, K. Van der Straeten, D. Karbe & W. Böhme (2008): Captive breeding and larval morphology of *Tylototriton shanjing* Nussbaum, Brodie & Yang, 1995, with an updated key of the genus *Tylototriton* (Amphibia: Salamandridae). Der Zoologische Garten **77**(4): 246-260.

Ziegler, T., R. Marcec, D. Vardukyan, T.Q. Nguyen, M.D. Le & M. Bernardes (2018): First record of longevity in *Tylototriton ziegleri* Nishikawa, Matsui & Nguyen, 2013 (Urodela, Salamandridae). Alytes **36**(1-4): 328-338.

Authors: Marta Bernardes & Uwe Gerlach (30.04.2021)

Following Authorships:

T. shanjing – Marta Bernardes, Frank Pasmans & Philipp Grundtner;

T. shanorum – Marta Bernardes, Georges Decome, Uwe Gerlach & Philipp Grundtner;

T. uyenoi – Marta Bernardes& Uwe Gerlach;

T. verrucosus – Marta Bernardes, Frank Pasmans & Philipp Grundtner;

T. yangi – Axel Hernandez, Frédéric Braux, Philipp Grundtner & Marta Bernardes.

Tylototriton taliangensis Liu, 1950

Taliang knobby newt, Pusakang crocodile newt

Common name German: Rotohr-Krokodilmolch, Taliang Krokodilmolch

Synonym: *Liangshantriton taliangensis* (Liu, 1950).

Fig. 40a: *Tylototriton taliangensis* adult ♀ in situ (A. Hernandez);
b: *Tylototriton taliangensis* (F. Braux).

Morphology and Taxonomy

One of the largest species of the genus (TL up to 22 cm in ♀♀ and 23 cm in ♂♂) with tail longer than snout-vent length. Ground color black with exception of red-orange coloration on edges of parotoids, tips of fingers and toes, cloaca and underside of tail. Cranial ridges clearly visible, but less prominent than in *T. kweichowensis* and *T. verrucosus,* head longer than wide, distinct dorsal ridge, dorsolateral glandular ridges inconspicuous with glandular warts of various sizes, very rough skin (Fleck 2013, Hernandez 2016, Sparreboom 2014).

Distribution and Habitat

The species is endemic from Sichuan Province, China. Type locality Fulinhsien, Pusakang. Known from Liangshan Prefecture: Zhaojue, Mianning and Meigu Counties; Ya'an Prefecture: Shimian and Hanyuan Counties; Leshan Prefecture: E'bian and Mabian Counties; and Chengdu Prefecture: Dujiangyan County, Daguan Town at elevations between 1,300 and 3,300 m asl (Fei & Xie 2004; Fei & Ye 2001; Hernandez 2016; Liu 1950; Raffaëlli 2013; Sparreboom 2014; Wang & Zhao 1998; Zhao & Adler 1993; Zhao *et al.* 1988). *T. taliangensis* inhabits densely vegetated valleys on mountain ranges in the vicinity of breeding ponds (Kabisch *et al.* 1994; Kühnel 1993; 2006; Sparreboom 2014).

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

EU Council Regulation (EC) No 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status: Vulnerable (A2acde, assessed June 18, 2019)

Threats

Habitat loss and degradation as a result of wetland conversion for aquaculture, introduction of economically more profitable species to their habitat (like the Asian carp), increased tourism, and pollution. This species also suffers from over-collection for the traditional Chinese medicine, and the international trade. Some local extinctions have already been recorded (IUCN 2020; Fei & Xie 2004; Rowley *et al.* 2016; Wang & Zhao1998).

Reproduction

Topic	Data for this species
Secondary sexual traits	Sexual dimorphism is poorly expressed. ♀♀ are larger, heavier and present a puncture like cloacal orifice, while ♂♂ are smaller, slender, and present an elongated opened slit. During the breeding season, mature adults will present a more evidently bulbously and inflated cloacal region (Hernandez 2016). ♂♂ develop orange to reddish nuptial pads on the forearms (also seen outside of breeding season), absent in ♀♀ (Fleck 2013; Kabisch *et al.* 1994).
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	In captivity, at least 6 years. Males may reach maturity earlier.
Mating and oviposition sites	Courtship, tail-fanning, ventral amplexus and sperm transfer occur inside the water. Eggs are deposited singly and close to each other on the saturated substrate more or less directly at the water level and also in water (Fleck 1997, 2013; Gong *et al.* 2018; Hernandez 2016).

Topic	Data for this species
Breeding season	In nature, breeding depends on the beginning of the monsoon season, which is always slightly variable, but around June to August (Sparreboom 2014). Hernandez (2016) observed newts entering the water in natural habitat at temperatures between 13–15 °C. In captivity, under the right breeding triggers.
Number eggs/ clutches per season	In literature, clutch sizes of up to 280 eggs are reported (Fei & Ye 2001; Fleck 1997; Sparreboom 2014). Although long time experience from captivity accounts for maximum clutch sizes of 80 eggs, with averages around 40 eggs or less per female a year.
Average egg diameter and hatchling size	Eggs relatively small ca. 4 to 6 mm and hatchlings ca. 15 mm. TL of metamorphlings depends on temperature: 6 cm (25 °C by day and lower at night), 4 cm (18 °C by day and lower at night), 5 cm (between 12–16 °C).
Development duration egg to metamorphosis	Egg phase lasts between 20 to 25 days at 20 °C. The duration of the larval phase depends on temperature: 4 months (25 °C by day and lower at night), 6 months (18 °C by day and lower at night), 10 months (between 12–16 °C). Temperatures as low as 5 °C can be tolerated, resulting in even slower developmental rates. Slower development seems to produce more resistant larvae, in comparison to fast growing larvae at higher temperatures.
Sperm storage	Possible, but not known.

Husbandry and Captive Breeding

Topic	Data for this species
Trigger for reproduction	In captivity, increased air pressure and humidity seem to be particularly important triggers for reproduction when temperatures gradually rise, after a long and cold winter period (between 2 and 10 °C). Adults start entering the water when temperatures are around 15 °C (although occasionally amplexus has been observed with temperatures as low as 12 °C). A cold-water change at this time might help to start reproduction. Some keepers report difficulties in triggering reproduction in indoor setups, even after providing hibernation phase and rain chamber. In this case it might work to move the animals to an outdoor aquaterrarium (from ca. April to July) during heavy rains/thunderstorm in late spring under adequate mild temperatures. Egg deposition often occurs during thunderstorms (when temperatures are around 18 °C), seemingly supporting the effect of air pressure. The right combination of all these parameters will initiate reproduction (Fleck 1997, 2010, 2013; Hernandez 2016; Raffaëlli 2013; Sparreboom 2014).
Husbandry requirements	The species should be kept in an aquaterrarium year-round with appropriate hides. The dimensions of the aquaterrarium should be based on group size, sex-ratio, size of animals and behavior. One can either use the same aquaterrarium setup year-round (e.g., 60 x 30 x 30 cm for 2 pairs) with an aquatic part covering 1/2 to 2/3 of total size and water level between ca. 3 to 15 cm depending on the season, or constantly at 15 cm depth (for the latter it is recommended to add a water filter). Or one can setup a keeping terrarium (indoors) with 75 x 50 x 30 cm for two pairs with at least 1/4 with permanent water depth of 3 cm water, and a breeding setup (outside) with same dimensions but 2/3 water and water depths of 10–12 cm. Outside of the breeding season, air temperatures of ca. 10 °C that can go as low as 2 °C, in which case animals hibernate. During breeding season, raised temperatures up to 23 °C, and increased humidity. Some keepers report only breeding

Topic	Data for this species
	success when aquaterraria are set outdoors. Larvae are aquatic and post metamorphs are terrestrial and should be kept in small groups with 1 cm water depth available. Animals accept a variety of invertebrate prey.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. Tubifex should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose. **Juveniles** After metamorphosis the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General particularities, difficulties with keeping and breeding	Tylototriton taliangensis is a highland species that requires long and cold winters, during which it shows terrestrial habits, reduced activity and mostly ceases feeding. During the breeding season and with increased temperatures, adults become more aquatic (males showing more aquatic habits than females) and active. Peaks of activity are also observed during heavy rains and thunderstorms. Some expert keepers are only able to reproduce the species outdoors with the aid of spring rainy weather. Usually, the best setups will provide oscillations in the daily temperature (with temperature drops occurring during the night). These are often more a result of the keeping conditions (e.g., outdoor setups, and indoor setups influenced by outside temperatures). Adults might sporadically feed on single eggs, but not on larvae and juveniles. Larvae can stay in the water during the winter until becoming terrestrial next spring. This kind of slower development seems to produce more resistant larvae, in comparison to fast growing larvae at higher temperatures. Long period until reaching sexual maturity.
Care of the young, technical and time effort	As a precaution eggs and adults should not co-exist in the same setup. It is recommended to either carefully remove the eggs to an appropriate nursing setup (avoiding depositing them under direct sun light), or removing the adults to a replicated aquaterrarium. Although larvae are able to grow in the tank of the adults without being predated. Some authors report that it is a good option to add a filter and aerator to the aquarium.
Life expectancy in captivity	More than 20 years, at least.
Frequency of breeding in captivity	Experts on this species can successfully reproduce it every year. However, captive breeding is not frequent, even by long time keepers.

Topic	Data for this species
Breeding difficulty evaluation	Sexual maturity takes a long time. It is very difficult to combine the right breading triggers. The offspring is not very numerous, grows slowly and it is difficult to bring to adulthood. It seems that clutches and egg numbers might depend on the intensity of winter and whether a dry spring occurs or not.
Mortality in the first years of life	Hatching rate above 75 %. Larvae and juvenile mortality between 25 and 50 %, but mistakes can lead to total loss of the offspring.
F2 generation bred	Very uncommon.
Interviews/ Surveys/ Consultations	Several private breeders.

References

Fei, L. & F. Xie (2004): *Liangshantriton taliangensis*. The IUCN Red List of Threatened Species 2004 e.T59486A11934491.

Fei, L., & C. Ye (2001): The colour handbook of the amphibians of Sichuan. - Chengdu, Sichuan, China: Sichuan Forestry Department, Sichuan Association of Wildlife Conservation, and Chengdu Institute of Biology. Chinese Academy of Sciences, 262 pp.

Fleck, J. (1997): Nachzucht von *Tylototriton taliangensis.* Elaphe **5**(2): 86.

Fleck, J. (2010): Die Krokodilmolche der Gattung *Tylototriton* Anderson, 1871 (Teil 1). Elaphe **18**(1): 38-45.

Fleck, J. (2013): *Tylototriton kweichowensis* Fang & Chang, 1932 - Kweichow-Krokodilmolch, pp. 139-142. *In:* Schultschik G. W.-R. Grosse (eds.): Threatened Newts and Salamanders of the World - Captive Care Management/ Gefährdete Molch- und Salamanderarten der Welt - Richtlinien für Erhaltungszuchten. Vol. 1. Mertensiella **20**, Mannheim, Germany: 189 pp.

Gong, Y., G. Shu, F. Huang, L. He, C. Li, & F. Xie (2018): Courtship behaviour and male sexual competition of the Taliang crocodile newt, *Liangshantriton taliangensis*. Amphibia-Reptilia, **39**(3): 275-288.

Hernandez, A. (2016): Crocodile Newts - the Primitive Salamandridae from Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition (Edition Chimaira): 416 pp.

IUCN SSC Amphibian Specialist Group (2020): *Tylototriton taliangensis*. The IUCN Red List of Threatened Species 2020: e.T59486A63871228.

Kabisch, K., H.J. Hermann, & K.D. Kühnel (1994): Zur Faunistik, Ökologie und Morphologie von *Tylototriton taliangensis* Liu, 1950 aus Süd-Sichuan (SW-China). Abhandlungen und Berichte für Naturkunde **17**:109-118.

Kühnel, K.D. (1993): *Tylototriton taliangensis* - Freilandbeobachtungen und erste Haltungserfahrungen. Elaphe **1**(1): 26.

Kühnel, K.D. (2006): Riesenunken und Co im Hochland Südwest-Chinas. Draco **27**(7): 32-35.

Liu, C.C. (1950): Amphibians of Western China. Fieldiana, Zoological Memoirs **2**: 400 pp.

Raffaëlli J. (2013): Les Urodèles du Monde. Deuxième édition. Plumelec (Penclén édition): 472 pp.

Rowley, J.J.L., C.R. Shepherd, B.L. Stuart, T.Q. Nguyen, H.D. Hoang, T.P. Cutajar, G.O.U. Wogan & S. Phimmachak (2016): Estimating the global trade in Southeast Asian newts. Biological Conservation **199**: 96-100.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Wang, S. & E. Zhao (1998): China red data book of endangered animals. Amphibia and Reptilia. National Environmental Protection Agency, Endangered Species Scientific Commission, Beijing Science Press, P.R.C.: 334 pp.

Zhao, E. & K. Adler (1993): Herpetology of China. Society for the study of amphibians and reptiles. St. Louis University: 521 pp.

Zhao, E., Q. Hu, Y. Jiang, & Y Yang (1988): Studies on Chinese Salamanders. Society for the study of amphibians and reptiles. Oxford, Ohio: 44 pp.

Philipp Grundtner, Georges Decome, Frédéric Braux, Marta Bernardes (10.04.2021)

***Tylototriton wenxianensis* group**				
Species	**Description author and date**	**Common name English**	**Common name German**	**Known in the trade**
Tylototriton anhuiensis	Qian, Sun, Li, Guo, Pan, Kang, Wang, Jiang, Wu & Zhang, 2017	Anhui crocodile newt	Anhui-Krokodilmolch	no info/ not expected
Tylototriton broadoridgus	Shen, Jiang & Mo, 2012	Sangzhi knobby newt	Sangzhi-Krokodilmolch	likely yes
Tylototriton dabienicus	Chen, Wang & Tao, 2010	Dabie knobby newt	Dabie-Krokodilmolch	likely yes
Tylototriton liuyangensis	Yang, Jiang, Shen, & Fei, 2014	Liuyang crocodile newt	Liuyang-Krokodilmolch	no info/ not expected
Tylototriton lizhenchangi	Hou, Zhang, Jiang, Li & Lu, 2012	Mangshan crocodile newt	Mangshan-Krokodilmolch	yes
Tylototriton maolanensis	Li, Wei, Cheng, Zhang, and Wang, 2020	Maolan knobby newt	Maolan-Krokodilmolch	no info/ not expected
Tylototriton wenxianensis	Fei, Ye & Yang, 1984	Wenxian knobby salaman-der/ newt	Wenxian-Krokodilmolch	yes

Fig. 41a: *Tylototriton lizhenchangi,* captive bred animal 2 years old (A. Hernandez);
b: *Tylototriton lizhenchangi* pair (G. Decome);
c: *Tylototriton wenxianensis* male (F. Pasmans);
d: *Tylototriton wenxianensis* ♀ (F. Pasmans).

Photos of the remaining species of this group can be found in literature, under the respective description.

The species included in this group present a very conservative morphology (Hernandez 2016; Yang *et al.* 2014). A genetic screening of specimens in the trade is recommended at this point to identify species and pure lineages. Some morphological characteristics can direct species identification however genetic analyses are indicated for definitive distinction. As new species are continuously being described from within the historical *T. wenxianensis* group (and sometimes even the *T. asperrimus* species complex, from which *T. wenxianensis* was originally split), it is currently unclear which species have entered the trade under a potentially misidentification. For example, *T. dabienicus* was first described as a subspecies of *T. wenxianensis* (Shen *et al.* 2012), *T. anhuiensis* (Qian *et al.* 2017), and *T. liuyangensis* (Hernandez 2016) were previously confused with *T. wenxianensis, T. lizhenchangi* probably entered the trade as *T. asperrimus* (Sparreboom 2014), and *T maolanensis* was confused with *T. asperrimus* (Weisrock *et al.* 2006) and *T. wenxianensis* (Yuan *et al.* 2011).

Given the inherent degree of taxonomic uncertainty present within the trade, the following data regarding husbandry and captive breeding should be regarded with caution.

Wild caught animals can have serious health issues that can be very problematic to solve (even in the long term). Furthermore, they have great potential to be vectors of disease such as *Bsal* and *Ranavirus,* which can seriously threaten the Urodelan fauna outside of its native range.

Morphology and Taxonomy

This group is characterized by medium to moderately large newts with total lengths from ca. 11–17.3 cm (Sparreboom 2014; Yang *et al.* 2014), mostly indistinct rib nodules (or dorsolateral glandular warts), forming two dorsolateral ridges (Hernandez 2016), rough skin covered with small warts and glands (Shen *et al.* 2012), dorsal body blackish brown except for palms, soles, finger and toe tips, vent region and ventral ridge of tail, which is usually yellow to bright orange in color (Hernandez 2016).

The species of this group can be identified by the following combination of characters (although molecular identification is recommended for definitive species identification):

Tylototriton anhuiensis – TL ca. 13 cm in males and females, head length greater than width, bony ridges on head prominent and necked-in, width of the dorsal ridge smaller than eye diameter, tail height larger than width at the base of tail, orange coloration on the digit ends, peripheral area of the cloaca and the lower edge of tail (Qian *et al.* 2017);

Tylototriton broadoridgus – TL ca. 13 cm in males and 15 cm in females, dorsal ridge broad and thick, with width approximately equal to eye diameter, tail height larger than width at the base of tail (due to more developed upper caudal keel), no villous genital papilla found inside the male anal fissure during reproductive season, projecting tubercles around anal fissure and mostly colored in orange, slightly differentiated nodule-like warts, along lateral margin of the trunk, bulge and forming tubercles, and thin and transverse striae present between the tubercles (Shen *et al.* 2012);

Tylototriton dabienicus – TL ca. 14.5 cm in females (Qian *et al.* 2017), head length much greater than width, limbs short, tips of fore- and hind-limbs do not touch when adpressed along the body, tips of fingers reaching orbital anterior region when stretched forward, margin of cloacal opening orange (Chen *et al.* 2010);

Tylototriton liuyangensis – TL ca. 11–15 cm in males and 14–16 cm in females, rough skin with ventral tubercles looking more flat than dorsal tubercles and presenting many transverse

striae between them, small and indistinct dorsolateral ridge of glandular warts, comparatively wide interorbital space, bony ridges on the dorsal side of the head going through the upper eyelids, a comparatively large space between axilla and groin, a small genital armature inside the cloacal opening on the anterior side in male during the breeding season, coloration varies from black to dark brown on dorsum and lighter on ventral side, the lower edge of the tail, cloacal region, and ends of fingers and toes are yellowish orange (Yang *et al.* 2014);

Tylototriton lizhenchangi – TL ca. 15–17 cm in males and 15–16 in females (Sparreboom 2014), head longer than wide, tail longer than the snout-vent length, finely granular and relatively smooth skin, dorsolateral glandular warts indistinct forming two sharp-edged, distinctly raised dorsolateral ridges, ground color mostly black with the exception of the tips of the fingers and toes, the cloacal region, and the underside of the tail being yellowish to reddish, the rear parts of the parotoids may be orange to red (in both sexes), but this character is not always present (Hernandez 2016);

Tylototriton maolanensis – TL ca. 16 cm in males and females, head longer than wide, snout truncate in dorsal view, relative length of toes III > IV > II > I > V, the distal tips of the limbs greatly overlapping when the fore- and hind-limbs are pressed along the trunk, fingertips reaching beyond the snout when the forelimbs are stretched forward, orange coloration on distal digit ends, ventral digits, peripheral area of cloaca and the lower margin of tail (Li *et al.* 2020);

Tylototriton wenxianensis – TL ca. 14 cm (Hernandez 2016), lateral glands clearly undifferentiated from each other, tubercles on both dorsal and ventral side rather uniform in size and no transverse wrinkles on the latter, margin of cloacal region colored black in most specimens (Fei *et al.* 1984), projecting tubercles around anal fissure, villous genital papilla found inside the male anal fissure during reproductive season, tail width larger than height at the base of tail, head length equal to head width (Shen *et al.* 2012).

Distribution and Habitat

Distribution

***Tylototriton anhuiensis*:** Dabie Mountains, including the Yaoluoping National Nature Reserve, Yuexi County, Anhui Province, China, at elevations of 1,000–1,200 m. The species inhabits subtropical mountain forest of bamboo groves with high amount of fallen vegetation (Qian *et al.* 2017).

***Tylototriton broadoridgus*:** Tianping Mountains in Liaoyewan, Sangzhi County, Hunan Province, China, at 1,000–1,600 m elevation. The species lives in bamboo groves with high amount of fallen vegetation (Shen *et al.* 2012).

***Tylototriton dabienicus*:** Dabie Mountains, including parts of the Huangbaishan National Forest Park, Shangcheng County, Henan Province, China at 698–767 m elevation (Chen *et al.* 2010). This species inhabits coniferous forests (Hernandez 2016).

***Tylototriton liuyangensis*:** Only known from two localities within the Hunan Liuyang Daweishan Provincial Nature Reserve, Hunan Province, China, at elevations between 600–1386 m. This species inhabits marshy areas in subtropical moist forests (IUCN 2020c).

***Tylototriton lizhenchangi*:** Currently only known from the vicinity of the type locality in the Mangshan National Nature Reserve, Yizhang County, southern Hunan Province, China, at 952–1200 m elevation. Its presence in neighboring Ruyuan County, Guangdong Province (Hernandez 2016) stills awaits taxonomic confirmation. This species inhabits subtropical moist montane forests of limestone (IUCN 2020d).

***Tylototriton maolanensis*:** Only known from the Maolan National Nature Reserve, Libo County, Guizhou Province, China, at elevations of about 750 m (Li *et al.* 2020).

***Tylototriton wenxianensis*:** Wenxian County, including Baishuijiang National Nature Reserve from 950–1280 m elevation, Gansu Province; Pingwu (or Pingure) County, Qingchuan County, Wangcang County, including the population from Longmen Mountain, Sichuan Province, China (Hernandez 2016; Liang & Changyuan 2004; Shen *et al.* 2012; Wang *et al.* 2018; Zaw *et al.* 2019). The populations from central Guizhou, Chongqing and Hubei provinces, are most likely to belong to undescribed species complexes (Bernardes *et al.* 2020; Hernandez 2016).

Habitat

In general, *Tylototriton* species inhabit forests in mountain regions with a high amount of annual precipitation during the summer monsoon, to support the creation of ponds with a long hydroperiod used for reproduction (Bernardes *et al.* 2013). Exceptionally *T. liuyangensis* and *T. lizhenchangi* (Hernandez 2016) can also reproduce in shallow streams.

Conservation Status and Main Threats

CITES-Appendix II since 2019 (CoP18 Proposal 41).

Council Regulation (EC) No. 338/97: Annex B.

In Germany particularly protected under BNatSchG [BG] Status: b.

IUCN Red List status

Tylototriton anhuiensis – Critically Endangered (B1ab[iii], assessed June 21, 2019);

Tylototriton broadoridgus – Data Deficient;

Tylototriton dabienicus – Endangered (B1ab[iii], assessed June 21, 2019);

Tylototriton liuyangensis – Endangered (D, assessed June 19, 2019);

Tylototriton lizhenchangi – Critically Endangered (B1ab[v], assessed June 21, 2019)*;*

Tylototriton maolanensis – Data Deficient;

Tylototriton wenxianensis – Vulnerable (A2cd, assessed June 19, 2019).

Threats

Main threats to species of *Tylototriton* are related with habitat loss and degradation especially around the breeding habitats (Nishikawa *et al.* 2013) as well as harvesting for the domestic and international trade (Rowley *et al.* 2016). Below is a list of specifically reported threats to each of these species:

Tylototriton anhuiensis – small range species experiencing continuing decline in the extent and quality of its habitat, mostly due to infrastructure development (IUCN 2020a);

Tylototriton broadoridgus – small range species experiencing ongoing habitat loss (Hernandez 2016);

Tylototriton dabienicus – small range species experiencing decrease in habitat quality and extent mostly due to agricultural expansion, tourism development and pollution (Hernandez 2016; IUCN 2020b);

Tylototriton liuyangensis – the region surrounding the protected area where the species occurs is famously known for its prominent "black" peanut farming (Hernandez 2016). Although

there are currently no major threats known to this species, the small population size itself is of concern, as it is more prone to the effects of stochastic events. Tourism development might also be a threat (IUCN 2020c);

Tylototriton lizhenchangi – nationally the species is used in traditional medicine. Since its description, an intensive overharvesting for the international pet trade is causing alarming population declines (Hernandez 2016; IUCN 2020d; Sparreboom 2014).

Tylototriton maolanensis – small range species likely experiencing population decline due to increased human activities and climate change (Li *et al.* 2020)*;*

Tylototriton wenxianensis – uncommon species experiencing ongoing population declines (of more than 30 % over the last twelve years) due to habitat loss, namely agricultural expansion, wood collection, infrastructure development, and pollution as well as overexploitation for food, use in traditional Chinese medicine, and the international pet trade (IUCN 2020e).

Reproduction

Topic	Data for this group
Secondary sexual traits	Sexual dimorphism is poorly expressed. ♀♀ are usually larger, heavier and present a puncture like cloacal orifice, while ♂♂ are usually smaller, slender, and present an elongated opened slit. During the breeding season, mature adults will present a more evidently bulbously and inflated cloacal region (Hernandez 2016). *T. maolanensis* – in ♂♂ tail length is longer than the snout-vent length and presence of papilla in the inner cloacal wall, in ♀♀ tail length is shorter than the snout-vent length and absence of papilla in the inner cloacal wall; *T. wenxianensis* – ♂♂ develop more pronounced tail fins in the aquatic phase.
Reproduction	Oviparous, with internal fertilization.
Sexual maturity	*T. lizhenchangi* – age at first reproduction 4–5 years; *T. wenxianensis* – age at first reproduction 4–5 years (Pasmans *et al.* 2014).
Mating and oviposition sites	*T. lizhenchangi* – in captivity “circling” courtship and ventral amplexus have been observed inside the water. Eggs are deposited on land in the transition zone to water; *T. wenxianensis* – notes on natural conditions reported mating behavior on land and spawning in water (Gong & Mu 2008), although long captive breeding experience supports that if given the choice, animals lay eggs on land (Pasmans *et al.* 2014). Tail fanning and “circling” have been observed (Gong & Mu 2008; Pasmans *et al.* 2014) with ventral amplexus occurring very rarely (Pasmans *et al.* 2014). However, the complete pairing has not yet been described.
Breeding season	In nature, breeding starts with the beginning of the monsoon season when it becomes relatively warm and humid. *T. broadoridgus* – starts in early May (Shen *et al.* 2012); *T. dabienicus* – expected to start in late April or early May (Hernandez 2016); *T. liuyangensis* – early May to end June (Hernandez 2016); *T. lizhenchangi* – starts in early May (Hernandez 2016). In captivity has occurred as early as February, but usually in March, until July; *T. wenxianensis* – from early April (Gong & Mu 2008) to June (Sparreboom 2014).
Number eggs/ clutches per season	*T. lizhenchangi* – reports from captivity point to a rather small number of eggs in a clutch (between 25 and 49 eggs). Females can lay two clutches a year, but often only one clutch is produced;

Topic	Data for this group
	T. wenxianensis – 53–80 eggs (Pasmans *et al.* 2014).
Average egg diameter and hatchling size	*T. broadoridgus* – in nature, larvae with ca. 34 mm TL were estimated to be 1–1.5 months old, and at 62 mm TL the gills started to atrophy indicating the last stage of metamorphosis (Shen *et al.* 2012); *T. liuyangensis* – eggs ca. 7.8–8.1 mm (Hernandez 2016); *T. lizhenchangi* – eggs ca. 8–10 mm in diameter and hatchlings ca. 6 mm; *T. wenxianensis* – eggs ca. 7–8 mm (Fleck 2013). Average hatchling length 19 +/- 1 mm (Pasmans, pers. obs.).
Development duration egg to metamorphosis	*T. broadoridgus* – larvae can overwinter (Shen *et al.* 2012); *T. lizhenchangi* – at air temperatures of 15 to 20 °C, larvae hatch after 20–25 days and at water temperatures of 22 °C larvae complete metamorphosis after 2 months, during a period of 10 days (n = 40 larvae) with a TL of 4.5 cm. At lower temperatures (ca. 10 to 12 °C, or probably lower) larvae can overwinter; *T. wenxianensis* – at temperatures between 18–22 °C, larvae hatched in between 28 and 65 days. Hatching time also depends on incubation method. Eggs incubated on wet tissue hatch earlier (median at 33 days) than eggs incubated in water (median at 37 days). At water temperature of 18–25 °C metamorphosis is completed in 2–4 months with a TL of 5 cm (Pasmans *et al.* 2014).
Sperm storage	Possible, but not known.

Note: The obvious difference in egg appearance between *T. lizhenchangi* and *T. wenxianensis* is that in *T. lizhenchangi* eggs are small and very sticky (laid scattered at the water/land interface, resembling *T. taliangensis* and *T. shanjing*), while in *T. wenxianensis* eggs are large, and non-adherent (laid in "nests" on land like in the *T. asperrimus* group).

Husbandry and Captive Breeding

Tylototriton anhuiensis X

Tylototriton broadoridgus X

Tylototriton dabienicus X

Tylototriton liuyangensis X

Tylototriton lizhenchangi 

Tylototriton maolanensis X

Tylototriton wenxianensis 

Topic	Data for this group
Trigger for reproduction	Increased air temperature combined with increased humidity. *T. broadoridgus* – reproduction starts when temperatures reach 19 °C (Hernandez 2016); *T. lizhenchangi* – aquatic courtship starts when air temperatures reach 13.0–14.5 °C. However, it is necessary to provide a cold period before; *T. wenxianensis* – in April an increase of temperature to 18–22 °C is sufficient to initiate breeding (Pasmans, pers. com.), however, others recommend increasing

Topic	Data for this group
	the humidity at the same time by spraying with warm water (ca. 18 °C) (Hernandez 2016).
Husbandry requirements	Adults need a terrestrial, relatively dry setup with appropriate hiding places for most of the year; during reproduction period an increased humidity and an additional aquatic part is needed. Larvae develop in water and post metamorphs are terrestrial until reaching sexual maturity. Animals accept a variety of invertebrate prey and quickly learn to accept food from tweezers. Terrarium size depends on group size, sex-ratio, size of animals and behavior. *T. broadoridgus* – likely to have similar requirements to *T. wenxianensis* (Hernandez 2016); *T. dabienicus* – likely to have similar requirements to *T. wenxianensis* (Hernandez 2016); *T. liuyangensis* – likely to have similar requirements to *T. wenxianensis*. In the natural habitat the average air temperature does not exceed 11.4 °C between October and April, and reaches a maximum of 20.0–23.9 °C between May and September. Air humidity is ca. 85 % year-round (Hernandez 2016); *T. lizhenchangi* – winter temperatures between 5–10 °C and spring–summer temperatures between 18–27 °C. The terrarium should have a minimal size of 80 x 40 x 30 cm for two pairs. The setup should resemble a marshy habitat where humidity prevails. The terrestrial part should be highly vegetated with moss and large herbs, and include bark and vaulted roof tile, offering numerous hiding places. The aquatic part should offer between 7 and 15 cm of water depth. Some animals show preference for terrestrial habitat, visiting the water only during breeding season, while others stay beyond that period, either inside the water, or in the transition zone given the existence of sufficient hides. Nevertheless, all animals show both a terrestrial and aquatic phases, only their duration can be very variable. The reason for this wide range of experience in the husbandry is still unknown, but requires an equally flexible approach regarding the size between land and water. *T. wenxianensis* – yearly temperatures ranging between 15 °C and 25 °C. In winter temperatures should decrease to 10–15 °C, and during this period the animals will mostly cease to feed. Above 15 °C, animals increase feeding. The terrarium should have a minimal size of 80 x 40 x 30 cm for a group of 3–5 animals (Pasmans *et al.* 2014). Although ideally the terrarium size for a breeding pair is 110 x 60 x 40 cm and has an aquatic setup with at least 10 cm water depth (Hernandez 2016). During breeding season (throughout spring and most part of the summer) males are aquatic, while females will mostly stay on land.
Feeding	**Adults** Terrestrial animals will accept crickets, earthworms, caterpillars, slow-moving cockroaches and other similar fare. Individuals may learn to tong feed. Food items should be supplemented using supplement powders sold for use with reptiles and amphibians; calcium is particularly important in this regard. Aquatic newts will eat earthworms, small pieces of fish, bloodworms, blackworms, shrimp and most other prey items available for aquatic newts. *Tubifex* should be used with care due to its potential to introduce harmful bacteria to the aquarium. **Larvae** Urodelan larvae may be fed on most cultured worms, especially bloodworms and whiteworms. Food must be benthic as the larvae will not swim into the water column. It is important to rear larvae as large as possible before they metamorphose.

Topic	Data for this group
	Juveniles After metamorphosis the juveniles can be fed on small invertebrate prey including hatchling crickets, fruit flies, whiteworms, which can be scattered in the enclosure. Live bloodworms can be placed directly on the paper towel substrate, contained within a suitable dish or rubber gasket ring, and left overnight for newts to feed. Food should be dusted with supplement powders where possible.
General particularities, difficulties with keeping and breeding	As for any salamander/newt, high requirements of hygiene, moisture availability and sometimes supplements are necessary. Larvae and juveniles need to be fed regularly. Adults need to be separated from eggs and larvae. *T. lizhenchangi* – some experiences with fungal growth on the eggs. Intraspecific aggression can occur between larvae. Juveniles are sensitive to fungal infections and other skin problems. Adults enter the water at the beginning of the breeding season at air temperatures of 13.0–14.5 °C, thus at lower temperatures than the other species. Animals are secretive. It is difficult to combine the right humidity and temperature; *T. wenxianensis* – some authors report susceptibility to microbial contaminations, which can be avoided by frequently replacing stagnant water, removing eggs with fungal growth and improving the ventilation of the terrarium (Hernandez 2016). On the contrary others keepers do not experience these difficulties, regarding this species as very resistant, reporting that eggs occasionally showing fungal growth are removed, and the only problems regard nematode parasites.
Care of the young, technical and time effort	Eggs and larvae should be separated from the adult's enclosure. Eggs can be incubated either on moist tissue or in water. Incubating on moist tissue makes it easier to remove eggs with mold. Rearing post metamorphs requires a high level of hygiene, the availability of different moisture ranges, and powdering prey animals (e.g., micro crickets) with mineral and vitamin supplements. *T. lizhenchangi* – hiding possibilities (at least some leaves) should be provided to the larvae enclosures. At 15 °C, larvae feed well and grow quickly; *T. wenxianensis* – reports from keepers experiencing egg sensitivity recommend that eggs be left untouched, and hatched larvae be scooped up and in groups of 10–15 placed in separated aquariums of 40 x 20 cm size (Hernandez 2016). Others have long experience with handling the eggs and transferring them without any obvious negative effects out of the parent tank to an incubation setup composed either of wet tissue or in a thin layer of water. Larvae can be raised in acidic (pH 5.2–6), oxygenated water (by use of an aerator), and set up with Java moss and dead oak leaves as substrate (Hernandez 2016), or in neutral water (pH ca. 7) with Java moss. Larvae feed 2–3 times a week. Small groups of juveniles (4–5) should be kept in 40 x 20 cm terrariums set up mostly with a terrestrial part, but also a small aquatic area to assure high humidity. Air temperatures should be kept at 18–22 °C (Hernandez 2016). Juveniles can also be raised on moist tissue (weekly replaced) and several layers of bark that provide a moisture gradient. Crickets are accepted as food.
Life expectancy in captivity	*T. wenxianensis* – at least 15 years, but likely more. Old animals seem to experience a kind of depigmentation, turning on a yellowish color.
Frequency of breeding in captivity evaluation	*T. lizhenchangi* – successful and frequent breeding only by experienced breeders; *T. wenxianensis* – yearly reproduction.
Breeding difficulty evaluation	*T. lizhenchangi* – both eggs and juveniles are very sensitive to fungal infections; *T. wenxianensis* – easy.
Mortality in the first	*T. lizhenchangi* – ca. 20 % until reaching metamorphosis. Very susceptible to

Topic	Data for this group
years of life	disease and difficult to raise to adulthood.
F2 generation bred	*T. lizhenchangi* – yes; *T. wenxianensis* – yes.
Interviews/ Surveys/ Consultations	*T. lizhenchangi* and *T. wenxianensis* – the authors contributed; *T. anhuiensis, T. broadoridgus, T. dabienicus, T. liuyangensis* and *T. maolanensis* – none.

References

Bernardes, M., M.D. Le, T.Q. Nguyen, C.T. Pham, A.V. Pham, T.T. Nguyen, D. Rödder, M. Bonkowski & T. Ziegler (2020): Integrative taxonomy reveals three new taxa within the *Tylototriton asperrimus* complex (Caudata, Salamandridae) from Vietnam. Zookeys **935**(2020): 121–164.

Chen, X.H., X.W. Wang & J. Tao (2010): A new subspecies of genus *Tylototriton* from China (Caudata, Salamandridae). Acta Zootaxonomica Sinica **35**(3): 666–670 (In Chinese with English abstract).

Fei, L., C. Ye & R. Yang (1984): A new species and a new subspecies of the genus *Tylototriton* (Caudata: Salamandridae). Acta Zoologica Sinica **30**(1): 85–91.

Gong, D.J. & M. Mu (2008): Behavioral observations and descriptions of the endangered Knobby Newt *Tylototriton wenxianensis* and their application in conservation. Asiatic Herpetological Research **11**(2008): 31–38.

Hernandez, A. (2016): Crocodile Newts - the Primitive Salamandridae from Asia (genera *Echinotriton* and *Tylototriton*). Frankfurt (Edition Chimaira): 416 pp.

IUCN SSC Amphibian Specialist Group (2020a): *Tylototriton anhuiensis*. The IUCN Red List of Threatened Species 2020: e.T145401474A151007958.

IUCN SSC Amphibian Specialist Group (2020b): *Tylototriton dabienicus*. The IUCN Red List of Threatened Species 2020: e.T78586683A122172367.

IUCN SSC Amphibian Specialist Group (2020c): *Tylototriton liuyangensis*. The IUCN Red List of Threatened Species 2020: e.T78586709A122172372.

IUCN SSC Amphibian Specialist Group (2020d): *Tylototriton lizhenchangi*. The IUCN Red List of Threatened Species 2020: e.T78586743A122172377.

IUCN SSC Amphibian Specialist Group (2020e): *Tylototriton wenxianensis*. The IUCN Red List of Threatened Species 2020c: e.T145401116A63871774.

Li, S., G. Wei, Y. Cheng, B. Zhang & B. Wang (2020): Description of a new species of the Asian newt genus *Tylototriton* sensu lato (Amphibia: Urodela: Salamandridae) from Southwest China. Asian Herpetological Research **11**(4): 282–296.

Liang, F. & Y. Changyuan (2004): *Tylototriton wenxianensis* The IUCN Red List of Threatened Species 2004 e.T59488A11935450.

Nishikawa, K., M. Matsui & T.T. Nguyen (2013): A new species of *Tylototriton* from northern Vietnam (Amphibia: Urodela: Salamandridae). Current Herpetology **32**(1): 34–49.

Pasmans, F., S. Bogaerts, H. Janssen & M. Sparreboom. (2014): Molche und Salamander: halten und züchten. Münster (Natur und Tier Verlag): 247 pp.

Qian, L., X. Sun, J. Li, W. Guo, T. Pan, X. Kang, J. Jiang, J. Wu & B. Zhang (2017): A new species of the genus *Tylototriton* (Amphibia: Urodela: Salamandridae) from the southern Dabie Mountains in Anhui Province. Asian Herpetological Research **8**(3)**:** 151–164.

Rowley, J.J.L., C.R. Shepherd, B.L. Stuart, T.Q. Nguyen, H.D. Hoang, T.P. Cutajar, G.O.U. Wogan & S. Phimmachak (2016): Estimating the global trade in Southeast Asian newts. Biological Conservation **199**: 96–100.

Shen, Y., J. Jiang & X. Mo (2012): A new species of the genus *Tylototriton* (Amphibia, Salamandridae) from Hunan, China. Asian Herpetological Research **3**(1): 21–30.

Sparreboom, M. (2014): Salamanders of the Old World: the salamanders of Europe, Asia and northern Africa. Zeist, Netherlands (Knnv Publishing) 385 pp.

Stuart, B.L., S. Phimmachak, N. Sivongxay & W.G. Robichaud (2010): A new species in the *Tylototriton asperrimus* group (Caudata: Salamandridae) from central Laos. Zootaxa **2650**(1): 19–32.

Wang, B., K. Nishikawa, M. Matsui, T.Q. Nguyen, F. Xie, C. Li, J.R. Khatiwada, B. Zhang, D. Gong, Y. Mo, G. Wei, X. Chen, Y. Shen, D. Yang, R. Xiong & J. Jiang (2018): Phylogenetic surveys on the newt genus *Tylototriton* sensu lato (Salamandridae, Caudata) reveal cryptic diversity and novel diversification promoted by historical climatic shifts. PeerJ **6**: e4384.

Weisrock, D.W., T.J. Papenfuss, J.R. Macey, S.N. Litvinchuk, R. Polymeni, I.H. Ugurtas, E. Zhao, H. Jowkar & A. Larson (2006): A molecular assessment of phylogenetic relationships and lineage accumulation rates within the family Salamandridae (Amphibia, Caudata). Molecular Phylogenetics and Evolution **41**(2): 368–383.

Yang, D., J. Jiang, Y. Shen & D. Fei (2014): A new species of the genus *Tylototriton* (Urodela: Salamandridae) from Northeastern Hunan Province, China. Asian Herpetological Research **5**(1): 1–11.

Yuan, Z.-Y., K. Jiang, S.-Q. Lü, J.-X. Yang, T.Q. Nguyen, T.T. Nguyen, J.-Q. Jin & J. Che (2011): A phylogeny of the *Tylototriton asperrimus* group (Caudata: Salamandridae) based on a mitochondrial study: suggestions for a taxonomic revision. Zoological Research **32**(6): 577–584.

Zaw, T., P. Lay, P. Pawangkhanant, V.A. Gorin & N.A. Poyarkov (2019): A new species of Crocodile Newt, genus *Tylototriton* (Amphibia, Caudata, Salamandridae) from the mountains of Kachin State, northern Myanmar. Zoological Research **40**(3): 151–174.

Author Marta Bernardes (09.04.2021)

Following Authorships:

T. lizhenchangi – Marta Bernardes, Frank Pasmans, Philipp Grundtner and Georges Decome

T. wenxianensis – Marta Bernardes and Frank Pasmans

Glossary

Symbols Evaluating the Captive Breeding Potential

These symbols provide a quick first impression of the level of difficulty in keeping and breeding the species, but they are not an indicative of the frequency of keeping them in captivity.

This species is easily maintained and bred in captivity, but not necessarily a species for beginners.

This species is easy to maintain and breed by an expert keeper, if the required conditions are given. Not for beginners or laity persons.

This species can be kept and bred in captivity, but its requirements are solely achievable by specialized and experienced keepers. The species is estimated as impossible to be bred commercially in large numbers.

X As far as known, no keeping and breeding experience for this species is established.

Relevant CITES Source Codes

CITES Source Code	Explanation
C	"Captive bred" (UNEP-WCMC 2020): Animals bred in captivity in accordance with Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof. This labeling should not get mixed up with the German term NZ (Nachzucht).
F	"Captive born": Specimens born or hatched in controlled environment, but do not meet the requirements for "C" (see above) according to CITES Res. Conf. 10.16.
I	Confiscated or seized specimens.
O	Pre-convention; the specimen was obtained before the CITES listing of the species.
R	"Ranched"; eggs, larvae or juveniles that were taken from the wild and were raised under controlled captive conditions. Usually, some part of the raised adults is released back to the habitat.
W	Wild caught animals.

Technical Terms

Technical term	Explanation
♂; ♂♂	One male; several males
♀; ♀♀	One female; several females
1,2,3	Group composition; first position: number of males, second position: number of females, third position: number of juveniles of unknown sex
Adult	Full grown resp. sexually mature specimen(s)
Allochthonous species	Alien, non-native, species which had been introduced by humans.
allopatric	Biological populations that have become geographically isolated from each other.
amplexus	A form of copulation, found chiefly in amphibians, in which the male grasps the female with his front legs as part of the mating process.
Antivenin, antivenom	Specific treatment for envenomation. It is composed of antibodies and used to treat certain venomous bites and stings.

Technical term	Explanation
aquatic	Living in water (semi-aquatic: spending parts of their time or life-cycle in water).
arboricolous	Arboreal; living in trees.
areola	Central plate of the shield in tortoises, the remainder of the hatchling's first shield. The growth rings are deposited around this areola.
autochthonous species	An autochthonous, or a native, species is indigenous to a given region or ecosystem if its presence in that region is the result of only local natural evolution (though often popularized as "with no human intervention.
autopsy	An autopsy or post-mortem examination is a surgical procedure that consists of a thorough examination of a corpse by dissection to determine the cause, mode and manner of death or to evaluate any disease or injury that may be present for research or educational purposes.
biotope preference	Preference for a certain habitat (and environmental conditions).
blackworm	The name blackworm is given to at least three distinct *Lumbriculus* species that are identical in appearance and were once considered a single species.
bloodworm	The larvae of a non-biting midge (Family Chironomidae) containing hemoglobin.
Bsal, *Bd*	*Batrachochytrium salamandrivorans* (*Bsal*) is a pathogenic chytrid fungus that infects amphibian species, *Batrachochytrium dendrobatidis* is a fungus that causes the disease chytridiomycosis in amphibians. In order to prevent further spread, if possible, it is essential to follow the measures described in the two Citizen Conservation/ DGHT (2020) documents when handling live animals.
captive breeding	(Continuous) reproduction of a species in captivity.
carapace	Dorsal part of the shell of turtles and tortoises.
carnivorous	is an animal whose food and energy requirements derive mainly or solely from animal products through hunting or carrion-eating.
clade	A group of organisms that are monophyletic – that is, composed of a common ancestor and all its lineal descendants.
cloaca	A cloaca is the posterior orifice that serves as the only opening for the digestive, reproductive, and urinary tracts of many vertebrate animals (all amphibians and reptiles). The opening at the vent.
conspecific	Belonging to the same species.
coralline	The origin of this material is corals.
costal node	Distinctly protruding, often deviantly colored, glandular elevations on the ribs of certain newt species.
dorsal	Anatomical term of location referring to the back or upper side of an organism.
dorsoanterior	Anterior part of the dorsal side of the animal.
endoscopy	The endoscopy procedure uses an endoscope to examine the interior of a hollow organ or cavity of the body with the help of an optical probe head.
epiphyte	An epiphyte is an organism that grows on the surface of a plant and derives its moisture and nutrients from the air and rain or from debris accumulating around it.
exo-occipital	Bone besides the great foramen.
Firebrat	*Thermobia domestica*, a primitive insect used as food for small amphibians and reptiles.
follicle	An ovarian follicle is a roughly spheroid cellular aggregation set found in the ovaries. The term is often used for eggs in the oviducts prior to shelling.

Technical term	Explanation
Frontline®	Treatment agent for snake mites *Ophionyssus natricis.* Active substance is Fipronil; discuss treatment with a vet or experienced keepers.
gestation	Pregnancy. Period from fertilization to egg laying/ birth.
gonads	Internal sexual organs.
gulars, gular scales	Scales in the central or throat region.
gular fold	A granular fold found on the ventral throat, located immediately in front of the forelegs, in lizards (Iguanidae) and some other reptiles.
gut loading	Food animals are often fed with special vitamin- and mineral-rich foods, with the intention of passing those nutrients to the animal for which the prey animal is intended.
hatchling	Freshly hatched juvenile reptile.
hemipenis	A hemipenis (plural hemipenes) is one of a pair of intromittent sexual organ of male squamates (snakes, lizards).
herbivore	An herbivore is an animal anatomically and physiologically adapted to eating plant material.
heterospecific	Two individuals are heterospecific if they are considered to belong to different biological species.
humidity	Short for: Relative atmospheric humidity. It is important for the incubation of reptile eggs.
incubation media	For captive breeding reptile eggs are often incubated in special incubators, and buried in incubation media to provide a constant humidity. Popular industrially produced incubation media are vermiculite, perlite, seramis or orchid chips, or simply sand, sometimes mixed with peat or soil (see also Köhler 2004).
infralabialia	Scales on the lower jaw.
intercalaria	Rows of smaller scales between the rows of large tail scales in lizards.
interorbital	Between the eye cavities.
Jacobson’s organ	The vomeronasal organ or Jacobson's organ, is the paired auxiliary olfactory sense organ located just above the roof of the mouth.
lecithotrophy	A form of development in which the embryo receives no nutrition other than the yolk originally contained within its egg. Some reptile species give birth to live offspring, which were not provided with nutrients via a placenta but via the egg yolk. Offspring hatches out of the permeable egg at birth.
loreal region	The region between the eyes and nostrils.
maxilla	In vertebrates the upper bone of the jaw.
mechanoreceptor	Sensory receptor that responds to mechanical pressure or distortion.
median	In the middle.
meristic characters	Meristic characters are the countable structures occurring in series (for example number of scales, pores or vertebrae). Their variability is used in scientific taxonomy.
metamorphosis	The young amphibians generally undergo metamorphosis from larva with gills to an adult air-breathing form with lungs. A metamorph of an amphibian is an animal which has undergone metamorphosis.
mimesis	The resemblance or similarity of an animal species to a feature of its natural surroundings, developed in order to gain some advantage from predators.

Technical term	Explanation
monotypic	A monotypic taxon is a taxonomic group (taxon) that contains only one immediately subordinate taxon.
morphometrics	Quantitative analysis. Morphometrics can be used to quantify a trait of evolutionary significance.
mosquito larvae	Larvae and pupae of different mosquito (Culicidae) genera, often called “wigglers” make a good food source for water-living amphibians as well as for small reptiles that take food from the water. If feeding them alive be sure to use them up quickly, before they turn into adult mosquitoes. Many terrarium animals also feed on them when frozen and carefully thawed.
necrosis	A form of cell injury which results in the premature death of cells in living tissue by autolysis.
neoteny	The retention of larval traits in sexually mature individuals, as sometimes seen in newts and salamanders.
neurotoxic	Neurotoxicity is a form of toxicity in which a biological, chemical, or physical agent produces an adverse effect on the structure or function of the central and/or peripheral nervous system.
nuchal	In the neck region. Nuchal scute: At the anterior of the tortoise or turtle shell there may be a single nuchal scute.
oedema	Or edema, also known as fluid retention, dropsy, hydrops and swelling, is the build-up of fluid in the body's tissue.
olfactory	The sense of smell, or olfaction, is the special sense through which smells (or odors) are perceived.
omnivorous	Including both animal and vegetable tissue in the diet.
oomycetes	The oomycetes are also often referred to as water molds, although the water-preferring nature which led to that name is not true of most species, which are terrestrial pathogens.
orchid chips	Styrofoam chips as an addition to orchid potting soil. Often used as an incubation medium for reptile eggs.
osteoderm	Osteoderms are bony deposits forming scales, plates, or other structures based in the skin.
oviparous, ovoviviparous	Laying eggs. In ovoviviparous species the eggs develop within the mother’s body, and the eggs hatch directly at, or shortly after, laying.
Oxytocine	A peptide hormone and neuropeptide normally produced in the hypothalamus. In veterinary medicine Oxytocine preparations are sometimes used for the induction of laying in egg bound reptiles.
paraspecific	A polyvalent snakebite antivenin that includes a paraspecific antibody that protects against bites from this and other closely related snake species.
parotoids	The parotoid gland is an external skin gland on the back, neck, and shoulder of salamanders. In frogs and toads, the similar glands should be called parotoids, and the often-used term “parotid glands” should be restricted to the salivary glands of mammals (Tyler *et al.* 2001).
paravertebral scales	Scales besides of the vertebral column.
parietal eye	Also known as a third eye or pineal eye, is a part of the epithalamus present in some species of fish, amphibians and reptiles.
Perlite	An amorphous volcanic glass, that has a relatively high water content, typically formed by the hydration of obsidian. Often used as an incubation substrate.

Technical term	Explanation
pholidosis	The layout or disposition of the scales of reptiles.
pivotal temperature	In reptiles with temperature-dependent sex determination this is the constant incubation temperature yielding a 1:1 hatchling gender ratio. In many chelonians a higher incubation temperature will yield more female than male hatchlings, while in many geckos and in most crocodiles and alligators the reverse is true.
plastron	Ventral part of the turtle shell.
postorbital scale	A scale behind the eye.
pressure immobilization technique	The pressure immobilization technique is a first aid treatment used for treating spider bites, snake bites, or bee, wasp and ant stings in allergic individuals, blue ringed Octopus stings, cone shell stings, etc. The object of pressure immobilization is to contain venom within a bitten limb and prevent it from moving through the lymphatic system to the vital organs. This therapy has two components: pressure to prevent lymphatic drainage, and immobilization of the bitten limb to prevent the pumping action of the skeletal muscles. This method is not undisputed.
probing	Probing a snake or lizard involves inserting a thin metal rod (called a snake probe) into the vent (cloacal opening) for sexing.
procoagulant	Promoting blood clotting (coagulation)
pterygoid	A bone of the palate of many vertebrates.
pyramiding	Pyramiding is a shell deformity of captive tortoises, in which the shell grows unevenly resulting in a pyramid shape underlying each scute. Factors which may contribute to pyramiding include inadequate water supply; the consumption of excessive animal or vegetable protein; inadequate calcium, UVB and/or vitamin D3; poor nutrition, see also in Stärk *et al.* (2019).
quadrate	The quadrate bone forms the upper part of the jaw joint.
Ranavirus	*Ranaviruses* can infect many vertebrate classes including fish, amphibians and reptiles, but for the most part, research has been focused on non-reptilian hosts, amphibians in particular. More recently, reports of ranaviral infections of reptiles are increasing. To prevent further spread, it is essential to follow the measures described in the two Citizen Conservation/ DGHT (2020) documents when handling live animals.
rearing	To care for young animals under captive conditions until they reach maturity (rearing cannot be equated with captive breeding; see there)
revalidated	A genus or species name has been declared valid again.
rostral scale	The median scale on the tip of the snout that borders the mouth opening.
rudiment	In biology, a rudiment is a feature that has become partially or completely nonfunctional during phylogenetic development, but is still present.
saxicolous	Living on rocks.
Seramis	Clay granules used for potting plants, also a popular reptile egg incubation medium.
sexual dichromatism	Special form of sexual dimorphism where coloration of sexes is different
solitary	an animal that does not live with others in its species, ♂ and ♀ meet only for mating.
species group, species complex	A group of closely related organisms that are so similar in appearance that the boundaries between them are often unclear.
spermatophore	A capsule or mass containing spermatozoa created by males of many salamanders, which is transferred in entirety to the female's ovipore during reproduction.

Technical term	Explanation
sperm storage/ amphigonia retardata	“Amphigonia retardata" is a term synonymous with "delayed fertilization" involving the storage of viable sperm by a female. More specifically, it may be defined as the union of egg and sperm after the male gametes have been retained in the genital tract for a considerable period after copulation. It occurs in testudines and squamates.
squamates	Squamata is the largest order of reptiles, comprising lizards and snakes, which are known as squamates or scaled reptiles.
striae	Some salamanders are characterized by dense tubercles on the lateral trunk that form continuous nodule like warts, with thin transverse striae present between these warts.
subadult	Half grown. The term is sometimes used for young animals where the secondary sexual characters are already discernible.
sublabialia	Scales on the lower lip.
supplementation	Adding of vitamins and minerals to the food. Insects, for example, are dusted with a vitamin/mineral powder to upgrade the nutritional value. See also “gut loading”.
superciliary scales	The scales directly above the eye, much like eyebrows.
sympatric	The species existing in the same geographic area.
syntopy	Syntopy is a special case of sympatry. It means the joint occurrence of two species in the same habitat at the same time.
taxon	A group of one or more populations of an organism or organisms seen by taxonomists to form a unit. Plural: Taxa
taxonomy	Taxonomy is the practice and science of categorization or classification
terra typica	the area from which the type of a species originates. A terra typica restricta is designated when the nomenclature has to be refined and the originally given type localities are unclear.
trigger	Stimulation.
tubercle	Any round nodule, small eminence, or warty outgrowth of the skin.
Tubifex	*Tubifex* worms are often used as a live food for amphibians during their aquatic phase. They may come from polluted water bodies, and they may be infected with various diseases. This risk can be partially solved by keeping the worms under brisk running water until they have voided the contents of their digestive systems.
tympanum	Eardrum.
type specimen	Individual in biological nomenclature that serves to define the features of a particular taxon.
type locality	The place where a type specimen was found.
valid	In taxonomy: Current scientific name of a genus/ species.
ventral	Anatomical term of location referring to the abdominal or lower side of an organism.
Vermiculite	Vermiculite is a sheet silicate of varied composition, and a proven and popular medium for the incubation of reptile eggs.
viviparous	Live bearing.
vomerine teeth	The vomer is one of the bones in the roof of the mouth. In urodeles it carries teeth, and their morphology and arrangement can be used as a distinguishing character for species identification.

Technical term	Explanation
whiteworms	Mostly *Enchytraeus albidus* and *Enchytraeus buchhholzi* – these small oligochaete worms can be easily cultured as food for urodele larvae.
zoochory	Plant seed dispersal by animals.
Zophobas	*Zophobas morio* is a darkling beetle (Tenebrionidae) whose larvae are robust mealworms sold as food for pets.

References used for the Glossary

BfN (2021) Legal basis: Commission Regulation (EC) No 865/2006. https://www.bfn.de/en/activities/cites/regulationslegalbases/legal-basis.html (accessed 19.10.2021).

BMEL (1997): Mindesthaltungsrichtlinien Reptilien. Gutachten über Mindestanforderungen an die Haltung von Reptilien vom 10. Januar 1997.

CITES (1997): Conf. 10.16 (Rev.) Specimens of animal species bred in captivity. https://cites.org/eng/res/10/10-16C15.php (accessed 16.10.2021).

Citizen Conservation/ DGHT (2020): Empfehlungen zum Import lebender Amphibien in die EU unter besonderer Berücksichtigung von veterinärmedizinischen und epidemiologischen Aspekten. Berlin: 6pp, Empfehlungen zum Import lebender Amphibien in die EU. Salzhemmendorf: 16 pp.

Köhler, G. (2004): Inkubation von Reptilieneiern: Grundlagen, Anleitungen und Erfahrungen. Offenbach (Herpeton): 254 pp.

Pieau, C. (1996): Temperature variation and sex determination in reptiles. BioEssays **18**(1): 19-26.

Stärk, J., A.R. da Silva, L. Jouvet, P.P. van Dijk, B. Pfau, I. Alexiadou & D. Condé (2019): Manual for the differentiation of captive-produced and wild-caught turtles and tortoises (Testudines). Species360 under contract for the CITES Secretariat, 24 pp.

Tyler, M.J., T. Burton & A.M. Bauer (2001): Parotoid or Parotid: On the Nomenclature of an Amphibian Skin Gland. Herpetological Review **32**(2): 79-81.

Resources

BfN-Skripten (2021): Evaluation of the Captive Breeding Potential of selected Reptile Taxa included in Appendices I and II at CITES CoP17. BfN-Script 609. https://www.bfn.de/infothek/veroeffentlichungen/bfn-skripten.html (accessed 02.09.2021).

CITES (2019): Proposals for amendment of Appendices I and II - Eighteenth meeting of the Conference of the Parties. https://cites.org/eng/cop/18/prop/index.php (accessed 02.06.2021).

CITES (2019): Conf. 12.11 (Rev. CoP18) -Standard nomenclature. Resolutions of the Conference of the Parties in effect after the 18th meeting. https://cites.org/eng/res/index.php (accessed 02.06.2021).

UNEP (2021): The Species+ Website. Nairobi, Kenya. Compiled by UNEP-WCMC, Cambridge, UK. Available at: www.speciesplus.net (accessed 02.06.2021).

UNEP-WCMC (2020): CITES Trade Database. https://trade.cites.org/en/cites_trade/ (accessed 14.03.2021).

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