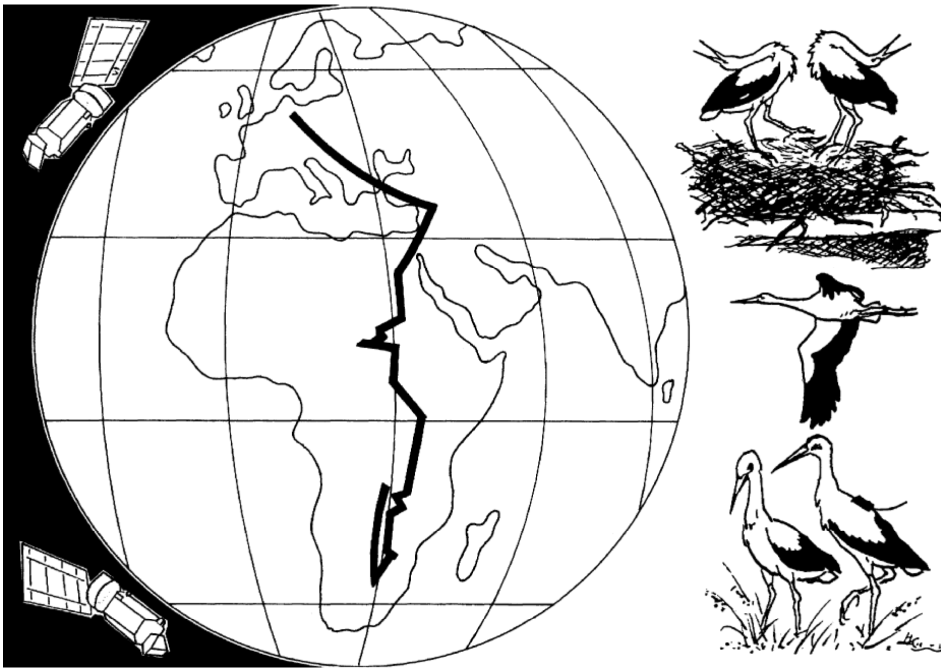
Willem Van den Bossche
in collaboration with
Peter Berthold, Michael Kaatz,
Eugeniusz Nowak & Ulrich Querner

Eastern European White Stork Populations: Migration Studies and Elaboration of Conservation Measures



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Final Report of the F+E-Project

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German Federal Agency for Nature Conservation 2002

Authors' addresses
W. Van den Bossche: BirdLife Belgium – Natuurpunt vzw, Kardinaal Mercierplein 1, B-2800 Mechelen, Brussels (wim.vandenbossche@natuurpunt.be)

P. Berthold, U. Querner: Max Planck Research Centre for Ornithology, Vogelwarte Radolfzell, Schlossallee 2, D-78315 Radolfzell

M. Kaatz: Universität Halle, Landwirtschaftliche Fakultät

E. Nowak: Langenbergweg 77, D-53179 Bonn-2

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1. Preface

In 1990 we in Europe were able for the first time to employ a new, highly promising method: satellite tracking. It allowed us to investigate the migratory and staging behaviour of endangered large bird species such as the White Stork *Ciconia ciconia*, relatively rapidly obtaining such extensive data that we could contemplate using it to work out targeted conservation programmes. Once pilot experiments had proved successful (Berthold et al. 1997), the German Federal Ministry for Environmental Affairs accepted our applications for support and towards this end approved two F+E-(Research and Development-) Projects, which made it possible to conduct more comprehensive studies. The first, carried out in the period 1994-1997, was entitled "Investigation of Migratory Birds as Basis for the Conservation of Migratory Species within the Scope of the Bonn Convention – a Model Study of the White Stork based on Satellite Tracking – a joint German-Israeli Project (short title: German-Israeli White Stork Project; Z1.2-534 11-1/94). A Final Report on that project was produced in 1997 and sent to the Ministry. The second undertaking was a direct continuation of the first, carried out from 1997 through 2000 with a subject as stated in the title of the present Final Report (short title: Conservation Concept for Eastern European White Stork Populations; Z1.2- 534 11-1/97). In preparing this report we have necessarily referred to many results from the first project, most especially in describing the migration events on the basis of data from satellite tracking, in the treatment of staging areas, and the like. Because the two projects constitute a unit with respect to the objectives of the research and our approach to them, Section I.2 includes detailed statements of the problem areas to which both projects were addressed.

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We would like to thank all people who made this project successful. In particular we want to thank Dr. Cristoph and Mechthild Kaatz from Staatliche Vogelschutzwarte, Storchenhof Loburg, Germany and Dr. Yossi Leshem and Mr. Dan Alon of the Society for the Protection of Nature in Israel for their enormous work to make the international cooperation in this project a success. Thanks to the effort of Dr. Michael von Websky, Deputy Director of the Ministry for the Environment, Nuclear Safety and Nature Conservation of the Federal

Republic of Germany, Dr. Yossi Leshem and Prof. Peter Berthold it was possible to organize the workshop 'migrating birds know no boundaries' in September 1997 in Israel, an important result of the international cooperation. Finally we are especially grateful to docent Dr. Horst Korn, Bundesamt für Naturschutz, Internationale Naturschutz Akademie Insel Vilm, for his excellent supervision of the project, his permanent advice and valuable support, including this report.

2. Detailed statement of objectives

The main objective in the first of the two projects mentioned above was to use satellite tracking in order to monitor the progress of outward and homeward migration of central and eastern European storks systematically and with minimal gaps, including the resting ecology in staging areas as far as possible. To achieve this goal, the following 10 individual questions were formulated:

1) Into what regions can a stork departing from Central Europe continue to migrate undisturbed: as far as Slovakia, to the Balkans or into Turkey and beyond?

2) What kinds of disturbances are encountered?

3) In which sections of the migration route are they encountered?

4) When storks finish their day's flight, do they regularly find places to rest undisturbed, where they can also look for food in peace the next morning before taking off again?

5) What happens when disturbances do occur — for instance, are family groups easily broken apart?

6) When migrating flocks of storks are disrupted by disturbances, can the individuals continue to migrate normally in differently composed flocks?

7) Can 1st-winter storks, for example, while migrating alone or in a grouping other than the original one, maintain the normal daily stages with orientation typical of the species, or is the further progress of their migration as a whole at risk?

8) Does the main mass of the storks within a migration corridor travel so closely bundled together, visiting particular staging areas so regularly, that specific conservation measures can very easily protect a large proportion of the individual populations?

9) Must storks that stop to rest in areas of intensive agriculture stay longer than usual, because the feeding conditions are more difficult, before they can start out on the next stage of migration?

10) It is known that storks differ in the distance they can cover per stage; are these differences best explained by different endogenous programming of the birds or rather primarily by a diversity of more or less pronounced environmental change and/or deterioration? What influence is exerted by normal and unusual climate and weather factors, for example on the migration routes and the daily stages?

The main objective of the second project, which is the primary subject of the present report, was to investigate ecophysiological questions pertaining to conservation and, having clarified these, to formulate guidelines for a "Conservation Plan for the White Stork" migrating along the eastern route. Specifically, the work was to concentrate on the following 13 questions:

1) Can it be definitely established that the eastern storks, on their way from eastern Germany to the Mediterranean region, at present find conditions for flight and rest so favourable that they can generally pass through Israel in a few days and without feeding, on the basis of reserves accumulated during the preceding journey?
2) Do these reserves take the form of fat stores and if so, to what extent?
3) Can it be reliably documented that the storks on migration to the Mediterranean region feed mainly in agricultural areas?
4) What supplementary role is played by large wetlands, protected or requiring protection, as resting sites and sources of food?
5) Are mice the primary source of food during stopovers? What other kinds of food also contribute?
6) To what extent can the current conditions for resting and feeding as far as the Mediterranean region be regarded as stable and ensured for the future, or what needs to be protected now or in future?
7) What are the reasons for the starved state of storks found in Israel in the spring, while returning from their winter quarters? Are they suffering from fat and/or protein deficiency?
8) If it is a matter of protein deficiency, is this so severe that it could impair breeding success in the breeding grounds (by reducing the clutch size)?
9) In the case of protein deficiency, which could result in smaller clutches, reduced breeding success and hence a more or less rapid decline of the population, it would surely be essentially impossible to take countermeasures in the winter quarters (e.g., by reducing local efforts to suppress migratory locusts). But one possibility is in theory available: might it be possible to supply the adult storks with high-quality protein food for a brief period after they have

returned to the breeding grounds, so that they become capable of laying clutches of optimal size? Tests relevant to this highly promising possibility should be conducted without delay.

10) In our previous studies on migrating storks of the eastern population, most of the disturbances (some with lethal consequences) and most of the birds falling victim to collisions, oil contamination etc. have been recorded in Israel, though it should be noted that the highest concentrations of storks altogether are also found here. This situation needs to be quantified, with the aim of answering the question: do such casualties have long-term repercussions with respect to population decline, or are they within tolerable limits?

11) Will it be possible, by equipping many more storks with transmitters and tracking them, to pinpoint the most commonly used wintering areas within what we now know to be the enormously extensive (from Yemen to South Africa and Nigeria) winter quarters?

12) If wintering centres can be specified as in Point 11, what are the local ecological conditions for the storks? Are special studies needed? Are protective measures necessary and practicable?

13) Is it possible to assess whether hunting of storks in Africa by the indigenous population is so intensive as to put the stocks at risk?

Finally, an opportunity arose to examine a relatively large set of White Stork tissue samples for the presence of biocides (Chapter V.4).

3. Research aims

Surviving and acquiring a breeding site and mate depend on the social status of an individual (Krebs 1971, Ekman 1988). For long-distance migrants such as storks; migration pattern, stopover ecology and the choice of wintering site are important activities that determine survival and breeding success and are subject to selection pressure (Alerstam 1981, Bairlein 1981). Migratory behaviour is influenced by genetic and environmental factors (Berthold 2000). Early arriving individuals might have better chances in the competition for territories, mates, nest sites and food (von Haartman 1968). Storks arriving late in the breeding area have no chance to breed successfully and arrival time depends on latitude, the migration route followed and the weather conditions in the wintering area and along the migration route (Cramp and Simmons 1977, Dallinga and Schoenmakers 1989, Goriup and Schulz 1991).

The White Stork *Ciconia ciconia* has always been an important element in the European culture. As a messenger of prosperity, storks are welcome over most of their range. The flocking behaviour during migration makes it one of the most spectacular migrants of the Western Palaearctic. Its size, migratory behaviour and presence in the vicinity of humans made storks very popular birds for ringing and observation.
Most studies were concentrated on aspects of the species' breeding biology, from behaviour at the nest to continental population dynamics. Most data on the migratory behaviour and wintering ecology were gathered from ring data and from occasional observations. Studies on the occurrence of the White Stork in Israel were concentrated on migration and yielded important data on numbers, origin and migratory habits. Most of the research was carried out to prevent bird-strikes with airplanes (Leshem 1991).

The stork's popularity in Europe doesn't protect it from the negative effects of habitat loss and habitat impoverishment (Schulz 1988). The former huge decline within the western population and its spectacular recovery partly on the Iberian peninsula and France prove that even large populations of this long-distance migrant are at risk.

If we want to manage the stopover sites of migrating White Storks we have to know details on their habitat-use. We will have to determine important elements in their behaviour to be able to manage the habitats in their favour and in compatibility with the economic needs of people living in the area.

The main aim of the White Stork tracking programme is to study the migratory behaviour of this long-distance migrant as an adaptation to resource scarcity (1). We also study which factors influence the choice of summering (2) and wintering areas (3). All these data provide us with crucial data for the protection of the species.

(1) Migratory behaviour

Objective : to explain variation in migration pattern, migratory behaviour and use of stopover sites by White Storks as an adaptation to weather, social and food conditions on autumn and spring migration.

Approach : which is the migration pattern of White Storks and how do age, seasonal and yearly differences affect this pattern ? The migration pattern is the way how a stork tries to safely reach its destination and under conditions where it is possible to carry out its intended activities. Do storks maximize migration speed as time minimizer, do storks minimize energy expenditure as an adaptation to patchy food distribution along the migration route or are there other adaptations to prevent risks influencing the migration pattern ? How are flight path and flying behaviour influenced by weather conditions and by social factors ? The composition and activity of flocks is discussed in chapter II.4.

What are the location and importance of stopover sites and are stopover sites revisited ?
A staging site may serve as a safe sleeping place or a rich feeding site for thousands of individuals. The meaning of stopover sites for different age-groups and seasons is described in chapter II.5. Determining the meaning is important to discuss the migration pattern because time minimizers will skip potential stopover sites, while energy minimizers will fly short distances (Alerstam 1979). Following other experienced birds to a good stopover site might also be one of the factors determining flocking behaviour.

(2) Summering

Objective : to explain variation in summering location of White Storks.

Approach : How do non-breeding storks behave during the migration season?
Only very few storks breed for the first time as 2nd-summer birds, so migration stress in 1st-summer storks is most likely not triggered by breeding unrest. When young and adult storks winter in mixed flocks at the same areas (Schulz 1988), how do young birds react when adults start their spring migration ?
Which factors affect its choice of a summering site ?
1st-summer storks show the tendency to migrate towards their place of birth but not all birds complete this migration. The fishponds in Israel are a rich feeding area along the major flyway of the non-breeding storks. We discuss their behaviour at this potential summering site in chapter III.

(3) Wintering

Objective : to explain variation in behaviour at and the choice of wintering sites of White Storks.

Approach : <u>Where are wintering sites located and which factors influence the first choice and repeated use of this wintering location ?</u>
The choice of the wintering site by an individual can be determined by genetic as well as environmental factors such as social influences, habitat quality and weather conditions.
<u>What is the composition and the behaviour of the wintering population in Israel</u> ? The age-structure and composition of a wintering flock is affected by habitat quality and by the accessibility of food resources to different age-groups.

To find a site to study the migratory behaviour was not so difficult because stork species avoid crossing large expanses of water. This takes the storks to the Middle East on their autumn migration from Europe to Africa and on the return migration in spring. Israel is thus the most important migration bottleneck area for soaring birds in the old world (Bijlsma 1987, Leshem 1991). Previous studies proved the importance of the Jordan Valley in northern Israel as a flyway for large numbers of White Storks (Schulz 1988, Arieli 1993). This characteristic alone however is not unique because large concentrations of storks are also observed in Turkey and Egypt (Porter and Willis 1968, Bijlsma 1987, Schulz 1988). What makes the study area so special is the presence of hundreds of fishponds right on the migration route of the storks. These ponds are intensively used stopover sites, thus creating a unique opportunity to observe and compare the behaviour of stork species. Extremely convenient was the fact that the fishponds were easily accessible thanks to good roads and friendly owners. The fish farms are extremely important for Black Storks, the farming techniques responsible for these rich food conditions are discussed in chapter I.4.2.

The Middle East and especially Israel is named as an important area for summering storks (Libbert 1954). Israel is furthermore the most northern wintering area for the eastern European population of the White Stork (Mendelssohn 1975, Cramp and Simmons 1977).

We had the unique opportunity to use data from satellite telemetry to study the migratory behaviour and wintering movements in Africa of individual storks. Combining these data with simultaneous field observations proved to be a unique and useful approach.

4. Study species : White Stork

Breeding, distribution, population trends and dynamics. The White Stork *Ciconia ciconia* is a polytypic species. The nominate race *ciconia* (Linnaeus, 1758) occurs in Europe, North Africa and in the Middle East. In central Asia *asiatica* (Severtzov, 1872) is found breeding. *Ciconia boyciana* (Swinhoe, 1873) occuring in east Asia is now considered as a separate species (Hancock et al. 1992). The nominate race is divided in two sub-populations. Storks from the western population breed in West and Southwest Europe and in northern Africa. The birds from Europe migrate southwest to Gibraltar in Spain and, mixed with the African birds, they winter in West Africa (Cramp and Simmons 1977). Birds from the eastern population migrate through the Middle East and winter in East Africa (Cramp and Simmons 1977).

White Storks in Europe breed near open natural or extensively cultivated lowland, wet grassland or farmland. High breeding densities are found near rivers, with regularly flooded grassland (Cramp and Simmons 1977, Goriup and Schulz 1991). The breeding behaviour and regional population trends of the White Stork are well documented. Since the beginning of the 20th century, storks have been ringed and information is gathered on arrival time, brood size, number of young and nest occupation. The White Stork basically is a gregarious species, often breeding in solitary pairs but commonly feeding in small parties and also nesting colonially in part of its range (Cramp and Simmons 1977, Haverschmidt 1949). White Storks typically use man-made structures for nest construction, such as roofs, poles and strawstacks. Storks have one brood a year and the 2 to 6 eggs are incubated for 33 to 34 days. The fledging period varies between 58 and 64 days (Haverschmidt 1949).

The number of White Stork breeding pairs is followed-up since the beginning of the 20th century. This population census has become a large scale monitoring project and covers the whole range of the species. Data were collected in 1934, 1958, 1974, 1984 and 1994/95 (Schulz 1994, 1999, Schüz 1936, 1940b, 1979, Schüz and Szijj 1962). The most recent population figures per country are summarized in Table I.1.

Table I.1. ***Number of White Stork breeding pairs.***

Country	Breeding pairs	Year	Reference
Eastern population			
Albania	2	1995	(22)
Armenia	668	1984	(28)
Austria	350	1994	(13)
Bosnia	50	1984	(28)
Bulgaria	4227	1994/95	(24)
Croatia	ca. 1500	1994/95	(19)
Czech Republic	800	1995	(25)
Denmark	6	1994-96	(30)
Estonia	ca. 2650	1994/95	(20)
Georgia	ca. 60	1996	(7)
Germany	4063	1995	(12)
Greece	ca. 1500	1990s	(10)
Hungary	ca. 4850	1994	(14)
Israel	13	1994/95	(28)
Iran	2209	1995	(16)
Latvia	10600	1994/95	(11)
Lithuania	11124	1994/95	(15)
Macedonia	500	1984	(28)
Moldova	491	1994	(34)
Poland	ca. 40900	1995	(9)
Romania	ca. 5000	1994/95	(33)
Russia	ca. 8400	1994/95	(2)
Slovakia	1127	1995	(6)
Slovenia	138	1984	(28)
Sweden	11	1995	(1)
Syria	'few 100s'	1994/95	(31)
Turkey	1200- 3200	1993	(21)
Ukraine	ca. 17500	1994/95	(8)
White Russia	11807	1994/95	(27)
Yugoslavia	872	1996	(23)
Central Asia	ca. 1450	1994	(29)(*Ciconia c. asiatica*)
Western population			
Algeria	2394	1995	(18)
Belgium	43	1998	(32)
France	315	1995	(3)
Italy	29	1994/95	(28)
Morocco	ca. 5000	1995	(4)
Netherlands	266	1995	(31)
Portugal	3302	1994	(26)
Spain	18000	1996	(17)
Switzerland	167	1995	(5)
Tunisia	ca. 350	1984	(28)

(1) Cavallin 1999, (2) Cherevicko et al. 1999, (3) Duquet 1999, (4) El Agbani and Dakki 1999, (5) Enggist 1999, (6) Fulin 1999, (7) Gavashelishvili 1999, (8) Grischtschenko 1999, (9) Guziak and Jakubiec 1999, (10) Heckenroth 1999, (11) Janaus and Stipniece 1999, (12) Kaatz 1999, (13) Karner and Ranner 1999, (14) Lovaszi 1999, (15) Malinauskas and Zurba 1999, (16) Mansoori 1999, (17) Marti 1999, (18) Moali et al. 1999, (19) Muzinic (1999), (20) Ots (1999), (21) Parr et al. 1997, (22) Peja and Bego 1999, (23) Pelle 1999, (24) Petrov et al. 1999, (25) Rejman 1999, (26) Rosa et al. 1999, (27) Samusenko 1999, (28) Schulz 1999, (29) Shernazarov 1999, (30) Skov 1999, (31) Skov and Strehle 1999, (31) van der Have et al. 1999, (32) Van den Bossche : pers. obs., (33) Weber 1999, (34) Zubcov et al. 1999.

The eastern White Stork population is estimated at 132718 to 134718 pairs (Table I.1). Only about 29866 pairs belong to the western population. The German population is counted with the eastern group, although storks breeding west of the Elbe migrate Southwest. About 1450 pairs of the subspecies *asiatica* breed in Central Asia.

The western population is estimated at 112000 individuals and the eastern at circa 552000 birds (Schulz 1999). While since the beginning of the century and even in 1984 populations were still declining, an important positive trend in the population development was noted in 1994/95 (Schulz 1999). The strong increase of the western population was clearly observed at observation stations at the Strait of Gibraltar. From 50281 storks in autumn 1976 (Bernis 1980), numbers decreased to 27414 in autumn 1985 (Lazaro and Fernandez-Cruz 1989) and increased recently to 91416 in 1996 and 113006 in 1998 (Szabo 1997, Fernandez-Cruz 1999).

Schulz (1988) made an excellent analysis of the population dynamics of the White Stork.
Both, conditions in the breeding area and on the wintering grounds are triggering the population changes. The White Stork is in most of its range a typical farmland species depending for its food on worms, mice, frogs and large insects. The cutting of forest and expansion of wetlands for cattle and agriculture first led to an increase of the population. Intensification of agricultural land-use and activities, such as the conversion of grassland to arable land and the intensive use of herbicides and pesticides have diminished the abundance of prey species (Schulz 1988). The loss of habitats by destruction and draining of wetlands, industrialization and the extension of residential areas have destroyed former breeding areas on an important scale, especially in western Europe. The recent increase in the core breeding area in eastern Europe is believed to be an adaptation to better breeding conditions due to an agricultural crisis in many of those countries (Schulz 1999). In the winter area, the storks largely depend on the amount of yearly rainfall. The amount of precipitation influences the vegetation cover and thus densities of insects and small mammals, the potential prey species for the White Stork. The population of the White Stork of central Europe and probably in the rest of

Europe is directly dependent on the amount of rainfall and thus the availability of locust in Africa (Dallinga and Schoenmakers 1989). The amount of yearly rainfall in the African winter quarters affects the food abundance and thus survival and spring departure time. In years with a high rainfall in the wintering area, storks arrived earlier in the breeding area, and a higher proportion of the pairs produced fledged young. Some new habitats however, such as the alfalfa fields in southern Africa and reservoirs can be beneficial for storks and could make the population less dependent on locusts.

In Israel, the breeding population and the majority of the migrating and wintering storks belong to the nominate race. Some individuals caught on passage had large wings and bills, approaching in size those of *asiatica* (Mendelssohn 1975). Around 10 pairs of White Storks breed since the 1980s near human settlements on the Golan Heights. Single pairs breed irregularly on the Coastal Plain (Suarez 1991).

Ageing White Storks. Ageing of 2nd-winter storks does not get much attention in works on plumage description (Cramp and Simmons 1977, Schröder and Burmeister 1974). However, in most cases it is possible to identify an individual stork as 1st-winter, 2nd-winter or adult, based on plumage, bare parts and moult-pattern. For this study it was important to determine the age of unmarked individuals in the field and special attention was given to the moult-pattern. We omit the first down plumage that the birds have in the nest. The *juvenile* plumage is the plumage in which the young leaves the nest (July). The *1st-winter* White Storks have no post-juvenile moult of wing feathers, but bill length as well as colour of the bill and legs are changing. Wing coverts are moulted in winter. The Bill is red or orange with a black point, the legs are orange or dull red. All primaries and secondaries show a white shine on the outer web. The inner median and humeral coverts are black, and are visible as a spot after a partial moult of the coverts. The *1st-summer and 2nd-winter* storks have a red bill and legs. Some individuals keep the black parts in their bills. The moulted primaries show a white shine as a mirror in the brown not moulted primaries. Some black inner median coverts might remain until October/November. White Storks obtain their *adult* plumage from their 2nd-summer. The bills and legs are red. The wing shows several moulting centres, visible by new primaries and secondaries with a white shine and old black feathers in between. Storks have 11 primaries (here numbered outwards from the innermost), 19 secondaries (here numbered inwards from the outermost), and 3 tertials (s20-s22 numbered inwards). Excellent information on White Stork wing moult was gathered by Bloesch et al. (1977), who checked the moult pattern of 5 captive storks in Switzerland. The same information can be found in Sutter (1984).

Population and migration routes. On the basis of their migration routes and wintering regions, the European White Stork population can be divided into a western and eastern sub-population.

The numbers and the behaviour of migrating storks has been intensively studied at Gibraltar (Bernis 1980), Bulgaria (Michev and Profirov 1989) and Turkey (Heckenroth 1968, Porter and Willis 1968, Kasparek and Kilic 1989). In Israel, information on White Storks was collected from ring recoveries and irregular field observations (Safriel 1968, Paz 1987, Raviv 1989). On impulse of Yossi Leshem of the Society for the Protection of Nature in Israel and Tel Aviv University, intensive surveys by field observers, radar and motorgliders were started in the 1980s (Leshem 1991, Shirihai 1996). Our study of the migration of White Storks in Israel is a continuation of this work. We collaborated with volunteers of the Israel Ornithological Centre, who count migrating birds in a project of the Israel Airforce to prevent bird-strikes with airplanes. We combined the results of earlier surveys in the Bet She'an Valley (Horin and Adar 1986, Tsovel and Alon 1991) with our observations in 1993 until 1997. Besides our observations in the Bet She'an Valley, we analyzed the data from the tagged storks and ring recoveries (IBRC).

The general route of the western population through Spain to western Africa and of the eastern population through the Middle East to eastern Africa is being studied since the beginning of the 20th century by ringing nestlings in the breeding area and collecting information through recoveries (Cramp and Simmons 1977). As an example we have to mention the important data set built up by the ringing activities of co-workers of Vogelwarte Hiddensee in northern Germany. Between 1964 and 1993, 31626 storks were individually marked and these birds reappeared 6107 times during this interval (Köppen 1996). Details of the migration routes have been published for parts of the Middle East : Turkey (Heckenroth 1968, Kasparek and Kilic 1989, Porter and Willis 1968), Israel (Leshem 1991), Sinai and north eastern Egypt (Koch et al. 1966). The –mostly scattered- data existing from the routes and migration times of the White Stork were compiled by Schulz (1988). Thanks to the method of satellite-tracking we gathered from tens to thousands of locations of individual storks. In this study it was possible for the first time to gather data on the repeated use of routes by the same individual.

Migration direction and migration routes of White Storks seem to be influenced by genetic, as well as by social factors and by topography, potential feeding sites and weather (Heckenroth 1968, Liechti et al. 1996, Reed and Lovejoy 1969, Steiof 1987). The migration direction that young storks take on autumn migration seems to be fixed (Jenni et al. 1991). Western storks fly southwest, eastern storks fly southeast or south and Maghreb storks fly south. Topographic and social factors can change the endogenous migratory direction (Schüz 1949, Schüz 1964, Jenni et al. 1991, Meybohm 1993).

Storks breeding west of a line from the Harz to Osnabruck in northern Germany and west of 11°E in southern Germany, migrate southwest. Some storks breeding in the Netherlands used to migrate east, but birds from the re-established population fly southwest (Cramp and Simmons 1977, Schulz 1988). They fly through France and Spain, are joined by French and Iberian storks and cross the Mediterranean Sea at the Strait of Gibraltar. From there they fly to their wintering areas in western and central Sahel.

Storks breeding east from the 'migration divide' fly southeast or south towards Burgos in Bulgaria (Cramp and Simmons 1977, Schulz 1988). They avoid the Black Sea and the Mediterranean Sea and cross the Bosphorus at Istanbul or fly across the west shore of the Sea of Marmara near the Dardanelles. Small numbers of storks round the Black Sea along the eastern coast (Bijlsma 1987). White Storks cross water bodies by gliding from high altitudes and flapping low above the water (Koch et al. 1966, Heckenroth 1968).

From the Bosphorus, most storks migrate southeast and reach the Mediterranean Sea at the Göksu Delta. From there the birds follow the shore line (Kasparek and Kilic 1989). At the northeastern point of the Mediterranean, storks turn south at the Gulf of Iskenderum and follow as guidelines the Orontes, Litani and Jordan Valley towards the southern point of the Dead Sea (Schulz 1988). A few storks pass through Lebanon (Kumerloeve 1961). This could mean that in normal autumns, about 50 % of all storks migrating through Israel can actually be seen in the Bet She'an Valley. This was also observed during two synchronized surveys along the eastern migration axis from 2 to 7 September 1990. One survey covered the Bet She'an Valley and a second survey was done more in the south in the eastern Negev and Arava Valley, near Dimona. During this period, 143572 White Storks were counted in the south and only 96112 in the north

(Leshem 1991). Only small numbers or loose flocks are observed in the southern Arava Valley (Safriel 1968). The majority migrate through the Jordan Valley to the Dead Sea and cross the central Negev to northern Sinai. Some storks leave the Jordan Valley near Bet She'an and migrate parallel with the Jordan Valley close to Jerusalem to Be'er Sheva. In Eilat, storks are rarely seen on autumn migration from August to early November (Safriel 1968). Almost no storks enter Africa through Suez (Schüz 1955), but they cross the southern part of the Gulf of Suez near El Tor (Koch et al. 1966, Safriel 1968). Small numbers cross the Gulf of Suez south of El Tor at Ras Mohammed, the southern point of Sinai. At this point there are islands that could attract the migrating flocks (Koch et al. 1966).

In the Middle East, small numbers of storks migrate east of the Rift Valley. In Azraq (Jordan) only very small numbers occur (Cameron and Cornwallis 1966). At the Arabian Gulf States, the White Storks appear in very small numbers from August to October (Bundy and Warr 1980). In Oman, the first storks arrive in late August, with a peak passage of up to several thousand birds in September. On 16 September 1984, an exceptional large flock of 3000 storks landed at Abu Dhabi airport (Gallagher 1989). There is a small number of recoveries from 1st-winter and older storks from Arabia, east of the Rift Valley (Heckenroth and Schüz 1970). A high proportion of these storks were ringed in Bulgaria and Greece.

In Africa, White Storks continue their migration west of the Rift Valley, through the Lake Victoria basin. This route is also followed by the Abdim's Stork *Ciconia abdimii* (Pomeroy 1989).

From northern Sudan is the spring migration route the same as the autumn route. In Sudan, storks might follow the Nile near Khartoum, but cross the Nubian desert near Abu Hamed towards Korosko, avoiding the Dongola bend (Schüz 1959, Reed and Lovejoy 1969).

Only very few storks fly through the Libyan Desert to the north (Moreau 1934). In Egypt, most storks follow the Nile from Abu Simbel (now Lake Nasser) until Qena (Reed and Lovejoy 1969). From there they fly northeast to the Red Sea and cross it near El Tor (Schüz 1955, Reed and Lovejoy 1969). Small numbers of storks passing at the end of spring migration keep following the Nile until the delta and cross it near Suez. These storks are mainly 1st-winter, immature and weak adult storks (Schüz 1955). Schüz (1955) calls the Nile Delta the 'stork hospital'.

During the spring passage, White Storks enter Israel in a broad front from Eilat in the east, to the Mediterranean coast at the Gaza strip (Leshem 1991, Shirihai 1996). This is a migration front of about 130 km width. Flocks entering Israel through the central Negev and further east (eastern axis) continue to migrate along the western slopes of the Arava Valley and the Jordan Valley towards the Sea of Galilee and the Hula Valley (Leshem 1991). White Storks entering Israel in the northwest Negev (western axis) continue their north northeasterly migration along Be'er Sheva, west of Jerusalem towards the western Bet She'an Valley. Some flocks keep following the coastline until Lebanon. The proportion of birds following the western or eastern axis depends on weather conditions and timing. Easterly winds push flocks westwards to the Coastal Plain and even over the Mediterranean Sea. Radar-tracking revealed a flock of 30000 storks drifted over the sea, to 45 km off the coastline, on 22 and 24 March 1989 (Leshem 1991). The northwest Negev seems to attract more flocks during the later part of the migration period. Large flocks appear in Eilat in March and not in April (Safriel 1968). Migration close to the Mediterranean coast through the western Negev and west of Be'er Sheva only occurs in spring (Schüz 1955). In Eilat, spring migration takes place in April and May (Safriel 1968). Migrating storks appear rarely in Eilat during the peak period in the second half of March (Safriel 1968). In 1994, only 3121 White Storks were counted from 15 February to 19 May (Yosef 1995). More to the east also very few storks are observed migrating east of the Rift Valley in Jordan and Syrian Desert (Wallace 1982, Steiof 1987).

The route is fixed because of the location of the Mediterranean Sea and the birds' orientation by valleys (Koch et al. 1966). Besides these geographical guidelines, the Nile attracts migrating birds. In Egypt and northern Sudan, there is only a small zone with vegetation close to the river, which the storks follow (Mathiasson 1963).

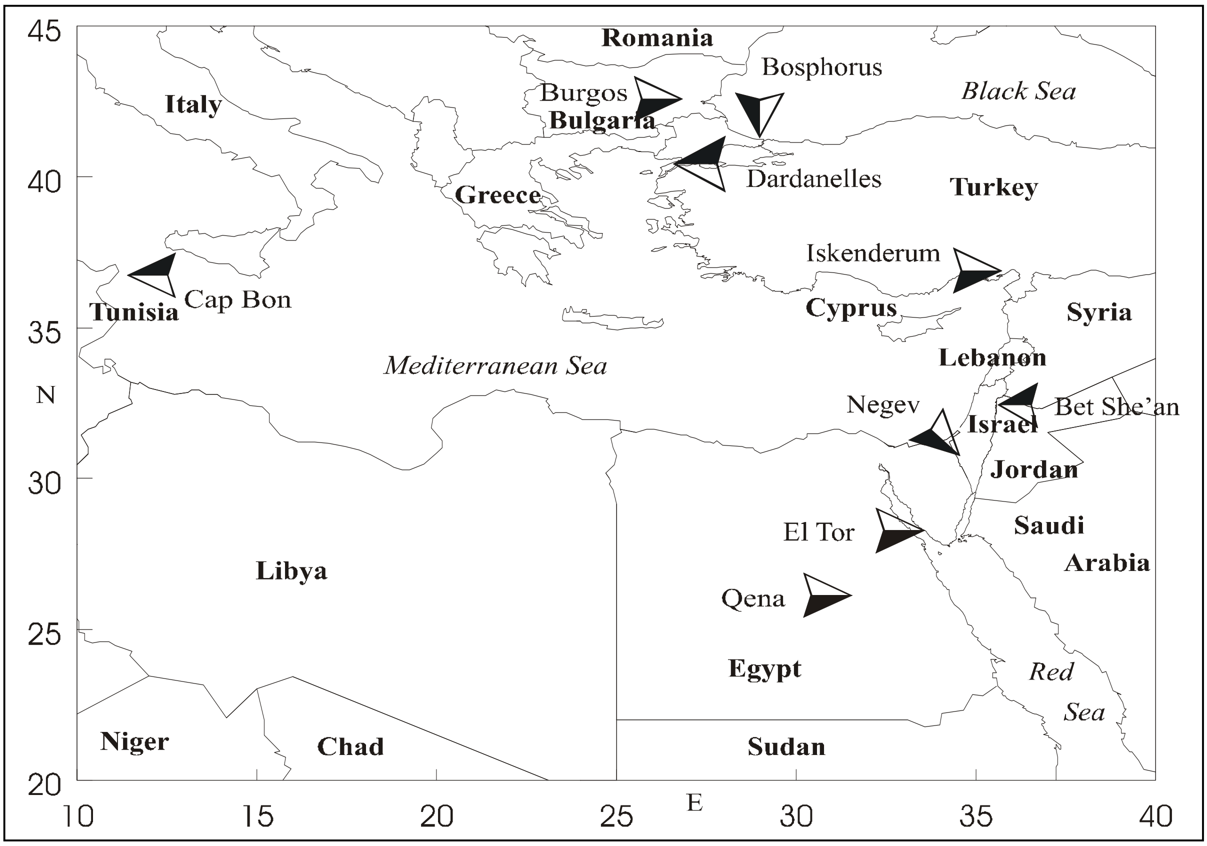


Figure I.1 : migration bottleneck areas in the eastern Mediterranean.

Migration pattern. White Storks are long-distance migrants using long-term soaring flight to cover large distances with low expenditures of metabolic energy. To locate lift they seem to rely on their social behaviour. The species often soars in thermals on rigid wings, in particular during migration and has limited capacities for persistent flapping flight (Pennycuick 1972). The energy gained from raising air in thermals is consumed while the birds are gliding in the migratory direction. Storks reduce their energy requirements more than 30 times by soaring (Pennycuick 1975), but are forced to stay above land and rest during the night and prolong the journey. Storks try to find powerful thermals to fly up to 3836 m above ground level (Liechti et al. 1996). In southern Israel storks flew between 500 and 1060 m above ground in spring and 670 to 1640 m above ground in autumn (Liechti et al. 1996). In good thermal conditions storks might form larger flocks, which have better glide ratios than single birds. Large flocks can compensate drift better than individual birds and directional deviations are minimized (Liechti et al. 1996).

During the migration season and in the wintering quarters the species typically occurs in large flocks. Storks are migrating in disorganised flocks. There seems to be no pair-bond outside the breeding season, males and females do not seem to winter in pairs, or associate in pairs on spring and autumn migration (Cramp and Simmons 1977, Haverschmidt 1949).

The migration pattern of White Storks is clearly described by the use of satellite-tracking in chapter II.3 of this study. Previous estimates were based on ring recoveries, counts at migration bottleneck areas and by tracking stork flocks with radar and gliders. Estimates were made on the number of days storks are migrating and their daily migration speed was estimated between 200 and 400 km (Bauer and Glutz 1966, Leshem 1991, Michev and Profirov 1989). Cross-country speed relative to the ground of migrating storks is around 33 km/h to 39 km/h in Israel and 44 km/h in Tanzania (Liechti et al. 1996, Leshem 1991, Pennycuick 1972). Spring passage was believed to be almost twice as rapid than the autumn exodus (Bauer and Glutz 1966, Cramp and Simmons 1977).

It is very difficult under normal observation conditions to identify the age of a significant number of storks in flight. At bottleneck areas it was therefore not possible to describe the migration pattern for different age-groups (Porter and Willis 1968, Schulz 1988). In the Bet She'an Valley the conditions were perfect to identify the age of large numbers of White Storks during all seasons. Storks are mainly ringed on the nest and thus identifying ringed storks is a good method to study their origin.

There is a substantial difference in the arriving time of westerly and easterly migrating storks. In general, storks of the western population start to breed in March to April, while the eastern birds start to breed 10 to 20 days later from April to May (Cramp and Simmons 1977). This makes it difficult to compare the spring migration timing of adult, 1st-summer and 2nd-summer storks.

New in this study is the information on the stopover behaviour of a large number of birds and different age groups along the major migration route. Previous observations on the behaviour of storks at staging sites along the eastern migration corridor are scarse (Horin and Adar 1986, Reed and Lovejoy 1969). The use of satellite telemetry to detect the stopover sites of storks is the only reliable method to identify all sites used by an individual bird. Observers are concentrated near the bottleneck areas to see as many birds as possible on a day, rather than observing single birds or small groups in sometimes difficult conditions. Ring recoveries can be biased to areas where more people are concentrated and thus the chance is higher that a ringed bird will be found, for instance, in Eilat (Israel) and Sharm el Sheikh (Egypt). The description of the plumage characteristics of 1st, 2nd-winter and 1st-summer storks in this study was an important factor in determining the age-composition of migrating as well as wintering flocks.

Summering locations. The analyses of ring recoveries show different results with up to 65 % of the 1st-summer storks remaining more than 1000 km south of their place of birth (Libbert 1954, Cramp and Simmons 1977, Creutz 1988), while other authors state that the majority of 1st-summer storks reach the breeding area up to a few hundred kilometres or less (Hornberger 1954, Bairlein 1981, Jenni et al. 1991, Fiedler 2000).

In Africa, single White Storks are recorded from many places. In Kenya, storks summer in small numbers at altitudes above 1500 m, west of the Rift Valley (Pomeroy 1989). In Zambia, storks summer in groups up to ten individuals (Benson 1967). Observations of larger groups are more exceptional and might occur only in specific years. From May to July 1959, 500 to 2200 White Storks were present in an area of 400 km² in the Rukwa Valley, Tanzania (Dean 1964). This was about 50 % of the number present in this savannah area in winter. In July 1973, 200 White Storks were still present in Natal (South Africa) (Maclean et al. 1973). Based on ring recoveries, Libbert (1954) described the Middle East as a main summering area of 1st-summer storks. Observations are scarcer, at the end of May and in June, nevertheless 400 to 700 storks were present both at Amik Gölü and near Cardak Gölü in central Turkey (Kumerloeve 1966). Two White Storks summered in the Azraq wetland in Jordan in June 1995 (Khoury 1997). In Israel, small numbers summered since the middle of the 20th century (Schüz 1955). Not much attention was given to these birds. Mendelssohn (1975) mentions that probably immature storks occur in summer in agricultural areas, irrigated fields, near fishponds and water reservoirs. There are only few observations of large summering flocks in northern Europe. In 1989 and 1990, about 200 storks summered in NW Germany in different flocks in areas with many rodents (Meybohm 1993).

In this study, our observations on different age-groups during autumn and spring migration give more detailed information on the migratory behaviour and locations of the summering grounds of 1st-summer storks.

Wintering locations and behaviour. The majority of storks migrate to Africa and smaller numbers to Iran and the Indian subcontinent (Bauer and Glutz 1966, Haversmidt 1949, Moreau 1972, Schulz 1988). The western population of the White Stork winters mainly in the Sahel and

northern Sudan zones, between 18°N and 11°N (Bauer and Glutz 1966, Brown et al. 1982, Schulz 1988, Jenni et al. 1991). This area is situated from Senegal, through Mali, Burkina Faso, Benin and Niger to the Chad lake in northeast Nigeria, Cameroon and Chad. Keysites for the wintering population are found in the Inner Delta of the river Niger in Mali (Schulz 1988) and numerous small temporary and permanent lakes in the eastern and central Sahel (Mullié et al. 1995). This means that winter quarters of the western and eastern European population are largely separated because White Storks from eastern Europe winter from 14°N in Chad and Sudan and southwards to South Africa (Bauer and Glutz 1966, Moreau 1972, Schulz 1988). The largest concentrations are found in Tanzania, Zimbabwe and South Africa.
Storks arrive in September and October in Sudan and stay there for several weeks or months before migrating further south (Schulz 1988). In these vast areas ground observations are difficult to be carried out on a large scale and ring recoveries are scarce. The results of satellite-tracking in this study reveal the importance of particular pre-wintering areas and give evidence for the fidelity of individuals to previously used sites.

The factors limiting White Stork winter distribution are rainfall and vegetation type and height. Outside the migration season, storks rarely occur in regions with less than 200 mm annual rainfall and avoid forest zones (Schulz 1988, Mullié et al. 1995).

Few White Storks winter in continental Europe, mainly on the Iberian peninsula (Schulz 1988). In eastern Europe, Turkey and Egypt, White Storks winter irregularly and mainly individually (Kasparek and Kilic 1989, Grischtschenko 1991, Atta et al. 1994).
The fishpond areas in Israel are the most northern wintering sites where White Storks of the eastern population occur yearly and in large groups (Paz 1987).

Feeding behaviour. The White Stork feeds on animal matter of a wide variety. Small mammals, reptiles, amphibians, fish, eggs, fledglings, small birds and invertebrates are part of its diet (Cramp and Simmons 1977). The species is an opportunist that feeds on plague species as voles *Microtus spp.* and locusts, while aggregations of White Storks are also observed feeding at garbage dumps.

5. Material and methods

5.1 Introduction

As pointed out in the general introduction we choose Israel as study site because of the large numbers of storks that gather in this bottleneck area.

This part describes the importance of the study area as wetland area in Israel. Most aspects of the impact for birds of the fish culture in Israel are described, with special attention to the backgrounds of the techniques and changes in those techniques.

Our observations of migrating flocks were combined with data from the team of the Israel Ornithological Centre (IOC). We caught and marked 84 storks and observed them and other migrating and wintering storks from the ground. Thanks to the method of satellite-tracking it was for the first time possible to track individual storks along the whole length of their migratory route, logging exactly departure, stopover and arrival times and locations. Recoveries of storks ringed with metal rings give the researcher in most cases only two locations, where the bird is ringed and where it is controlled. Using colour rings can give already better results because more rings can be positively identified and read from a larger distance.

Gathering information by satellite-tracking on the migratory behaviour of individual 1st-summer storks on their way to the summering grounds proved to be very difficult because of the high mortality in their first autumn. Because of the high costs of the transmitters and the satellite-time we could only use a limited number of transmitters. We made the choice to study the behaviour of young storks on the route from their breeding site to the wintering quarters, rather than to catch 1st-winter storks of unknown origin but that had survived the high autumn mortality. To study the summering behaviour we relied on field observations in the Middle East, which was mentioned by Libbert (1954) as the most commonly used summering site.

In the framework of this study it was not possible to study the composition of wintering flocks in the winter quarters in Africa. To study the choice of the pre-wintering and wintering areas of individual White Storks we relied on the tagged storks and on ring data published in the literature. The number of birds we could catch during the real winter period were with 28 individuals relatively small, also the number of wintering birds ringed elsewhere was low.

5.2 Study area in Israel

Wetlands in Israel

In Israel only a few permanent fresh water habitats are found, among which Sea of Galilee, Hula nature reserve and Ma'agan Barukh are the largest. The marshes of the northern valleys and the Coastal Plain were drained during the 1950s. Ma'agan Barukh, near Afula, was drained in autumn 1996. Most springs, pools and rivers in the Coastal Plain and Galilee are captured and polluted with sewage water. On the Golan Heights, Jordan and Bet She'an Valley, there are many pools and small rivers, which partially dry up in summer and early autumn. The majority of wetlands are artificial and consist of reservoirs and fishpond areas. They are concentrated in former marshland areas. Sewage ponds serve as water habitats in desert areas. In the western Negev rain capturing reservoirs supply fresh water.
At the Mediterranean Sea, Red Sea and Dead Sea there are salt pans. The Dead Sea, however, is too saline to support any form of life, suitable as food for migrating storks.

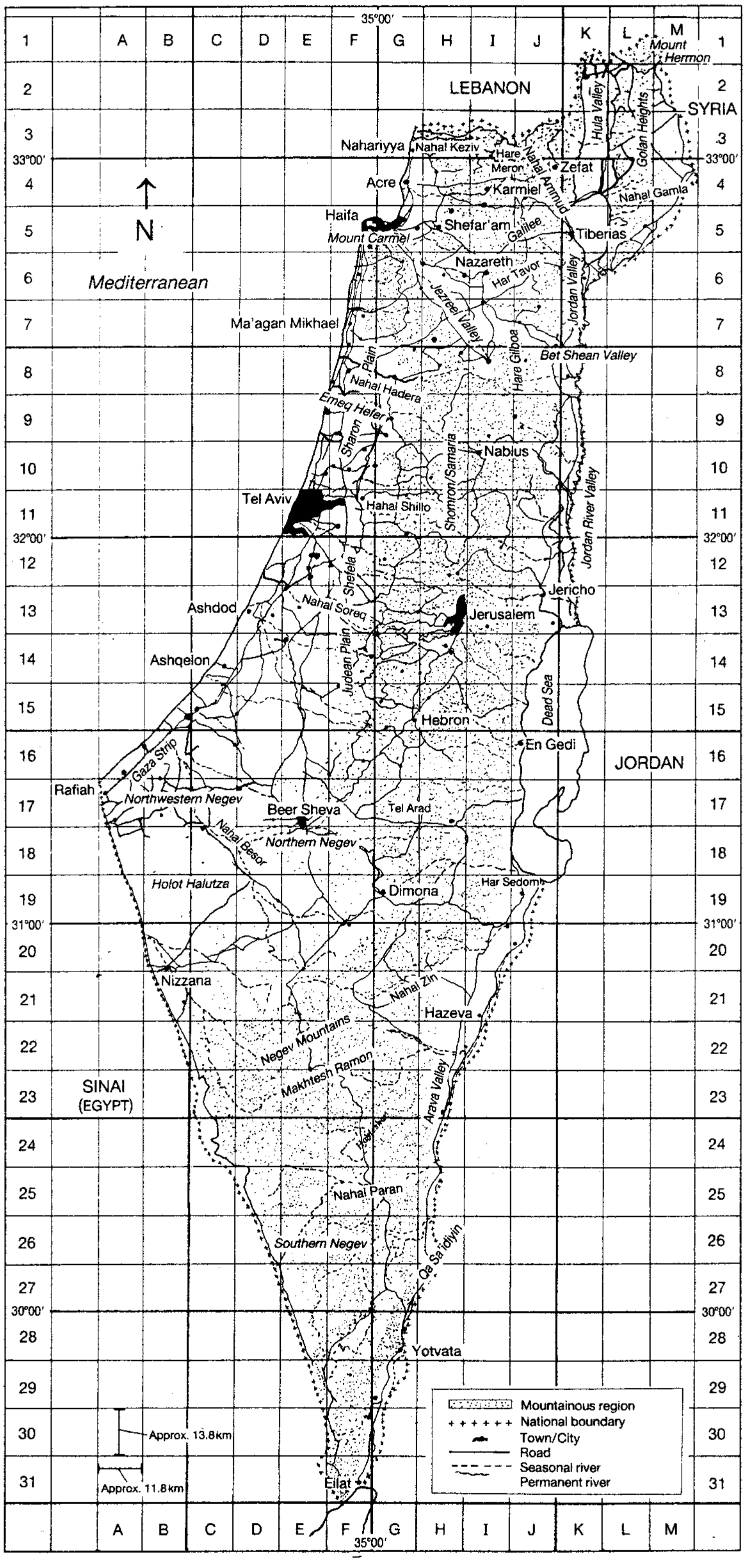


Figure I.2. ***Israel, including occupied territories (Shirihai 1996).***

Fishpond areas

The first fishponds were constructed in the 1940s. The maximal surface of ponds and reservoirs was reached in 1965 with 5095 ha (Figure I.3, Sarig 1997). In the following years the fishpond area decreased and stabilized to 3000 ha in the period from 1983 to 1995. Not only the area but also the number of fish farms decreased from 96 farms in 1965 to 55 farms in 1995. The majority of the fishponds are privately run by kibbutzim. In contrast to the decrease in surface, the fish farm yield increased strongly from 0.1 ton per ha in 1946, to 5 tons per ha in the period from 1987 to 1995 (Figure I.3).

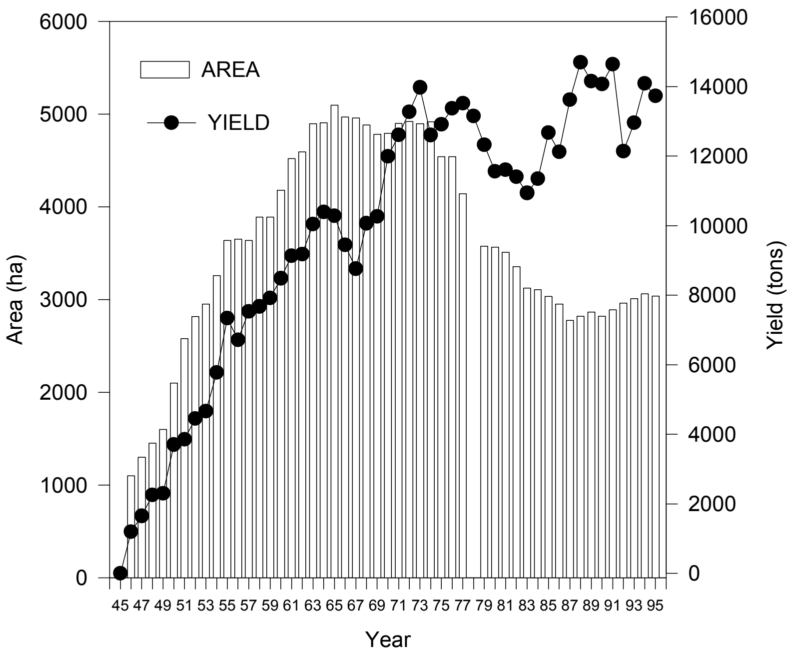


Figure I.3. ***Fishpond area in ha and yield in tons.***

In Israel, there are currently four large fishpond areas with reservoirs and ponds covering 3037 ha (Sarig 1997).

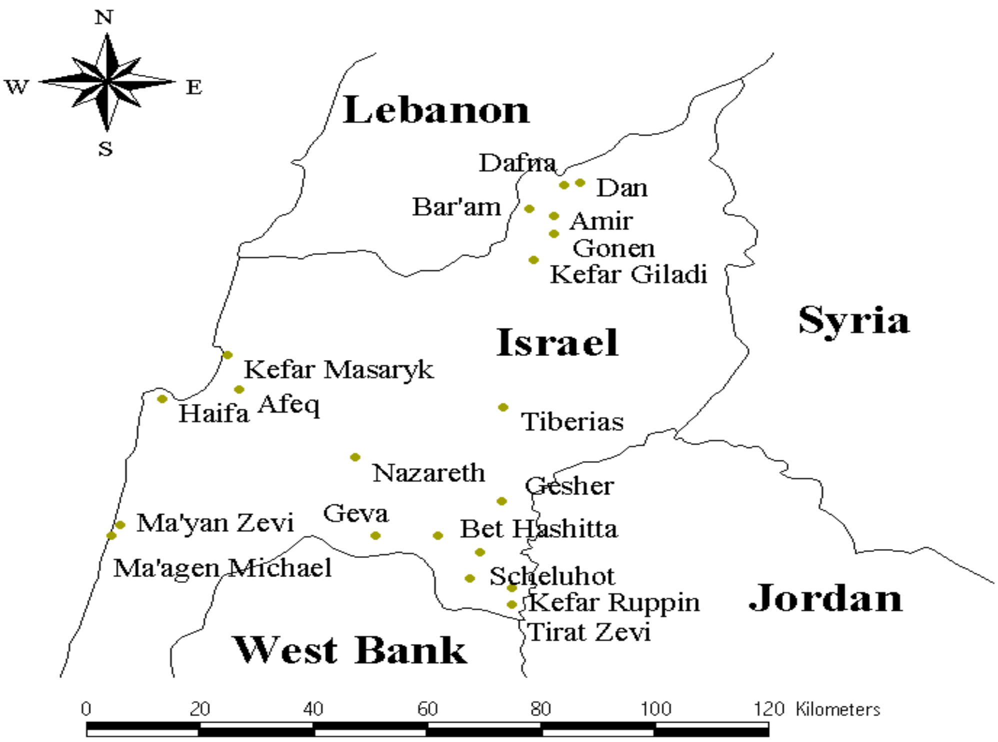


Figure I.4. ***Fishpond areas in Israel.***

The largest concentration of fishponds is found in the Bet She'an and Jezreel Valley, between Tirat Zevi, Gesher and Geva (Figure I.4, I.5). Including the smaller ponds of the Jordan Valley they cover 1695 ha. They are situated east of Afula to the border with Jordan. Further ponds are situated in the Jordan Valley, from Bet She'an to the southern corner of the Sea of Galilee. The ponds of the Bet She'an, Jezreel and Jordan Valley were the main study area. In this work, we will refer to these three areas as Bet She'an Valley. Comprising 24 fishpond complexes, which are run by several kibbutzim : Ma'ale Gilboa, Tirat Zevi, Sede Eliyyahu, Kefar Ruppin, En Hanaziv, Ma'oz Hayyim, Newe Etan, Hamadya, Newe Ur, Gesher, Afiqim, Scheluhot, Mesillot, Reshafim, Nir David, Bet HaShitta, Bet Alfa, Hefzi Bah, Tel Yosef and Geva. The 580 ha of fishponds in the Coastal Plain are concentrated between Mount Carmel, Ma'agan Mikha'el and Nahal Hadera. Only the fishponds of Ma'agan Mikha'el and Ma'yan Zevi were controlled. We had no access to the ponds between Nasholim and Atlit. The third region is the Zevulon Valley, south of Acre (Akko) and west of Afula, with 320 ha of fishponds. In this area, the fishponds of En Hamifraz, Kefar Masaryk and Afeq were controlled. The reservoirs between Yagur and Acre were not checked systematically. In Upper-Galilee, mainly the Hula Valley, there are 442 ha of fishponds and reservoirs. In the Hula Valley, we controlled fishponds of Kefar Giladi, Dan, Dafna, Amir, Gonen, Lahavot Habashan, Shamir and Bar'am. The area of the lake north of the Hula Nature reserve and the canals, both in the centre of the Hula Valley, were also checked for storks. The reservoirs on the Golan Heights were not counted.

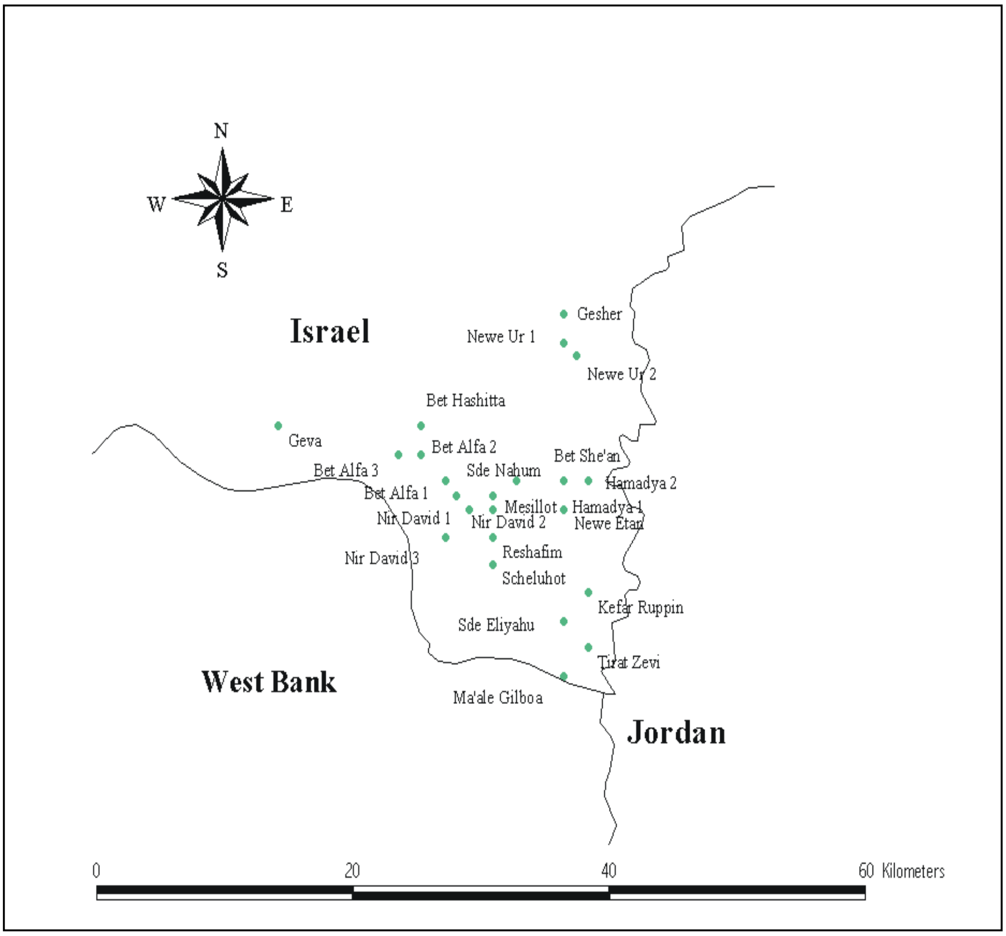


Figure I.5. ***Fishpond complexes in the Bet She’an Valley.***

Fishculture

General characteristics. There are three main types of fishponds : reservoirs, grow-out and storage ponds. The ponds are rectangular and the bottom consists of sand, which becomes covered with mud. At every larger pond, a food elevator is placed, the fish are fed automatically at regular times.

The reservoirs collect water during winter and serve for irrigation and growing fish at the same time. The reservoirs are used for fishculture during 200 to 250 days per year and for irrigation of crops during summer and early autumn. These ponds have a size of 8 to 20 ha and a water depth of 3 to 12 m. They are drained once a year in the period from July to December and have a significantly higher yield per ha than the shallow ponds. The grow-out ponds are shallow with a water depth of 0.5 to 3 m and are smaller than 3 ha. They are normally drained at least twice a year. The small ponds are used as a storage place for living fish, taken from the reservoirs and grow-out ponds. They are drained several times a year. The total area of different types of ponds for each region is listed in Table I.2 (Sarig 1997). Reservoirs and grow-out ponds cover the largest area. The ponds are filled with water from rivers, springs and rainfall in winter and spring. Many ponds in the Bet She’an Valley are filled with water from warm springs. In the Coastal Plain, Upper-Galilee and Zevulon Valley, there are no warm springs. In winter, the water is too cold for fish to grow and therefore the majority of the ponds are emptied in the period from September to the beginning of December. In these regions, some ponds are partially refilled with water but contain no fish. In the Bet She'an Valley, most fishponds remain populated with fish throughout the winter period. Many ponds are irrigated with warm water from Sachne, a spring near kibbutz Nir David, thus allowing the cultivated Tilapias to survive the winter period.

Table I.2. ***Area (ha) of different types of fishponds in 1995.***

	Reservoirs	Grow-out	Storage	Total
Upper-Galilee	210	190	42	442
Bet She'an Valley	968	577	150	1695
Zevulon Valley	121	179	20	320
Coastal Plain	97	449	34	580
Total area	1396	1395	246	3037

Fish fry are produced by hatcheries in autumn and stocked in nursery ponds in April and May when they weigh 0.1 g. When the fish weigh 15 to 50 g they are transferred to grow-out ponds and reservoirs to remain there until they are ready to be marketed. 12 to 18 months after hatching, when a Carp weighs 600 g and Tilapia 250 g, they come onto the market. The fish are harvested by draining the pond and are taken to the factory or stored in small ponds at a temperature of 16 to 18°C.

The handling time of a small pond is only a few hours, in this time the pond is drained and all the fish is taken out. The pond is normally refilled shortly afterwards. In the ponds fish are kept in polyculture and the different species and sizes are separated by a machine on the spot. It takes about 3 to 7 days to drain a grow-out pond completely due to the processing of the fish. The draining of a reservoir can last 3 to 4 weeks. Recent techniques of taking out all fish at once have drastically diminished the handling time of a pond.
Not all the ponds can be drained at the same time because there would be too much fish on the market. Due to the large number of ponds in the Bet She'an Valley 10 or more ponds were drained at any day in autumn (Figure I.6).

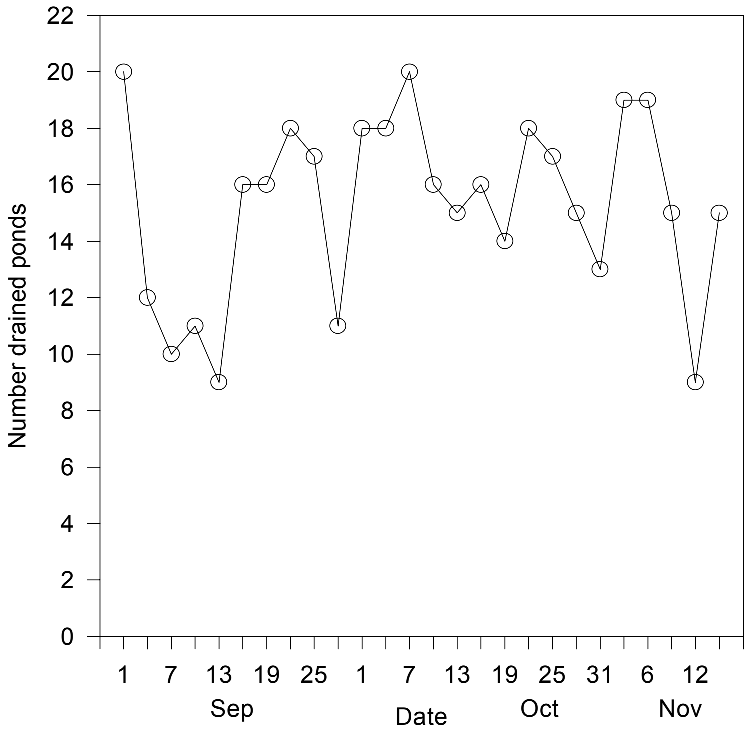


Figure I.6. ***Number of drained ponds in the Bet She'an Valley in autumn 1996.***

The ponds are drained through an opening with a filter with mazes small enough to keep the cultivated fish inside. The water is led to canals. The fish concentrate in the lowest corner of the pond, where the water stays the longest. They are taken out with nets and selected on size and species. The small fish also concentrate in large quantities in the corner of the pond or get into the canals near the pond, escaping through the filtering system. The small fish in the pond that are not eaten by birds, die from lack of oxygen or are killed with chemicals that burn the gills. The fishermen try to eliminate all remaining fishes before refilling the pond with water and bringing in new fish. This method reduces the risk of having unwanted 'wild' fish in the pond.

At some kibbutzim all fish are taken out from the ponds at the same time, without selecting them at the pond on size and species. The fish are selected in the kibbutz factory and small fish are thrown on waste dumps or released in the canals near the river Jordan. This method leaves fewer living fishes for birds and cuts short the processing time of the pond.

The cultivated fish species are : Common Carp *Cyprinus carpio*, Tilapia hybrids *Oreochromis niloticus (female) x O. aureus (male)*, Mugilidae *Mugil cephalus* and *Liza ramada*, Silver Carp *Hypothalmicthys malitrix* (Table I.3). At some kibbutzim Goldfish *Carassius australis* are bred to sell as pet-fish.
In 1995, 13723 tons of fish grown on fishpond were marketed (Sarig 1997).

Table I.3. ***Quantity of fish marketed from fishponds in 1995.***

Fish species	Yield in tons	% of total
Common carp	7120	51.9
Tilapia	5040	36.7
Silver carp	576	3.8
Grey mullet	1047	7.6
Total	13723	

Between the fishponds, there are unpaved roads, bordered by weeds. On the water edge, plants as Reed *Phragmites australis*, Bullrush *Scirpus lacustris* and Tamarisk *Tamarisk spp.* are growing. The border vegetation of many fishponds is destroyed by cutting, burning and spraying of herbicides. All newly built reservoirs and ponds lack high vegetation such as Reeds.

Tilapia hybrids. Tilapia is a very important food source for Black and White storks in the Bet She'an Valley and understanding the lifecycle of this species is important to explain variation in stork numbers and behaviour. The Tilapia hybrids do not grow at a temperature below 20°C and die when the water is colder than 15°C. Therefore some of the storage ponds are heated to eliminate the possibility of high mortality of the fish. In the Bet She'an Valley, many of the ponds are supplied with water from the spring Sachne, near kibbutz Nir David. This water has a temperature of 24°C, which enables Tilapia species to survive throughout the winter. For this reason, the production of Tilapia hybrids in the Bet She'an Valley is the most important of Israel with 69 % (Sarig 1997). Here Tilapia can grow for 200 days in a year. Uncontrolled proliferation is seen as one of the biggest problems in Tilapia fish cultures. In a warm climate, the Tilapias start over-reproducing when they reach a weight of more than 100 g. To prevent this proliferation the fisherman try to grow only male Tilapias. To get only males, the small Tilapias formerly used to be selected on sight and females were thrown away. Approximately 250 tons of female fish were yearly thrown on the waste dumps. In later years, hormones were used to determine the sex at an early stage of growth. Currently, males are selected by crossbreeding. 90 to 100 % of the hybrids of the two Tilapia species *Oreochromis niloticus* and *O. aureus* are males (Ben Tuvia 1981). This hybridisation method minimizes uncontrolled proliferation of the Tilapias, but substantial proliferation still exists (Shelton et al. 1978 *in Ashkenazi and Yom-Tov 1996*). The exact quantity of this uncontrolled fry is not known. The uncontrolled fry in a grow-out pond in the Hula Valley was estimated at 2 million fish, each weighing 5 g (Ashkenazi and Yom-Tov 1996). These small Tilapias are an enormously important food resource, especially for the Black Storks in Israel.

Besides the cultivated hybrid Tilapia there are several native Tilapia species. *Tilapia zillii, Sarotherodon galieus, Oreochromis aureus, Tristramela spp.* and *Aplochomis spp.* occur in the Lake of Galilee, in some canals and in the river Jordan. Especially the small size *Tilapia zillii* has a strong proliferation and contributes to the increase of fish density (Ashkenazi and Yom-Tov 1996). The high temperatures are causing a strong evaporation. To keep the water at a sufficient level, the ponds are constantly irrigated with water from the river Jordan, springs and canals. Males and females of the local Tilapia species can unwantedly enter the majority of the fishponds through the insufficiently protected water inlets.

Protective measures against birds. The fishpond clusters attract many bird species. Shorebirds are attracted by the muddy bottom of the drained ponds. Other species, such as ducks, gulls and Coots are feeding on the food given to the fish. Gulls, herons, kingfishers, Spoonbills *Platalea leucorodia*, cormorants, White Pelicans *Pelicanus onocrotalus* and storks feed on small fish, mainly on ponds that are being drained. Most predation by birds is harmless for the economic fish yield because most birds feed on the uncontrolled fry (Ashkenazi and Yom-Tov 1996). Although the impact of birds on the overall yield is small some storage ponds are covered with plastic or nets to avoid predation by birds. In the Bet She'an Valley in spring 1997, 27 White Storks and 3 Black Storks were killed in these nets (K.Meyrom and J.Szabo, pers.com.). Most of the kibbutzim have one or more guards to chase Cormorants *Phalacrocorax carbo* and White Pelicans from the ponds. Most guards use bombing bullets to scare the birds away, but at some places, live ammunition is used to kill birds.

Gas-cannons are placed to disturb birds from grow-out ponds and reservoirs, especially when they are drained. Flocks of migrants are easily disturbed by this method. Local birds are getting used to gas-cannons. At some kibbutzim, fishermen use all the scaring methods at the same time and chase all birds, migrants as well as residents. The large numbers of wintering Cormorants and thousands of White Pelicans staying for weeks in the area have increased the aggression of fishermen against birds. In 1993, gas-cannons against birds were placed in 7 out of 24 fishpond areas. In 1996, fishermen used gas-cannons in 20 out of 24 fishpond complexes.

Garbage dumps

Almost every kibbutz, farm and army camp have their own garbage dump. Besides these small dumps, there are larger dumps near cities. These dumps are visited by large numbers of gulls, Cattle Egrets *Bubulcus ibis*, Black Kites *Milvus migrans* and White Storks. The refuse dumps near Tel Aviv and Hadera in the Coastal Plain and Kefar Masaryk in the Zevulon Valley were checked during visits at the neighbouring fishponds. The dumps of Hadera and Kefar Masaryk, where many White Stork had been observed, were closed in 1996. Adjacent to the fishponds of Newe Etan, there are three ponds where the waste and sewage water from the chicken and turkey factory of Bet She'an is collected. This place is an important feeding site for the White Storks during winter and spring.

Bet She'an Valley

Topography. The Jordan Valley is the northern part of the Syrian-African Rift. The Bet She'an Valley is part of the Jordan Valley, with the river Jordan in the eastern part of the valley. Near Kefar Ruppin, the bottom of the Valley is about 12 km wide and is on an average 200 m below sea-level. The lowest point is the meandering river Jordan at 290 m below sea-level. The hills and cliffs in the valley of the river Jordan are 30 to 50 m above ground level. The valley of the river Jordan is the border between Israel and Jordan and is a closed military area. To the west, the slopes of Mt. Gilboa (500 m) are steep. The eastside of the Bet She'an Valley is rising slowly from the river Jordan to the Gilead mountains (1000 m).

Meteorological data. The average temperature in August is 30°C in the western part of the Bet She'an Valley and 35°C in the Jordan Valley. The temperature drops to about 20°C in October (Horin and Adar 1986). There is normally no rainfall in autumn before the second half of October.
Especially in August and September, there is a daily pattern in the wind regime in the Bet She'an Valley. From 9.00 to 10.00 h a northwesterly wind starts to blow in the valley and increases to a strength of 4 to 5 Beaufort in the afternoon. It is the difference in temperature between the Mediterranean Sea and the Jordan Valley that causes this daily wind regime (Leshem 1991).

Agriculture. All open areas in the Bet She'an Valley have been exploited for agriculture. In the lower, central part of the Bet She'an Valley there are large grain fields, which are harvested and ploughed in May. These fields are empty in autumn. The large cotton fields are sprayed and harvested from the end of August until the beginning of November. The fields are sprayed with small airplanes. These planes disturb especially the large flocks of migrating storks. In the Bet She'an Valley most fields are used to cultivate grains, which are empty and ploughed in autumn. There are around 600 ha Luzerne fields. These fields are continuously irrigated and harvested every two to three weeks. An increasing proportion of the area is being used for the intensive growth of vegetables.

5.3 Study methods

5.3.1 Satellite-tracking

Number of tagged birds. From 1991 to 1999, 75 White Storks were captured in Germany (54), Poland (11) and Israel (10). They were tagged with satellite-transmitters to follow their migratory flight and movements on the wintering grounds. Out of 75 tagged storks, 5 transmitters failed before the onset of migration, 3 storks did not migrate and 4 storks migrated southwest. In this study we analyzed the data of the remaining 63 tagged storks (Table I.4).
All Polish and Israeli storks were wild birds. Out of 31 German 1st-winter storks that we tagged, 20 were kept in a cage for a short time, 9 transmitters were put on young just before fledging and 2 on recently fledged storks. Out of 11 adult German Storks, 4 were kept in a cage for a short period.

Some individuals were given a name. All transmitters had an identification number of five or six digits. The first two digits referred to the year, the three or four following digits were the ARGOS platform number. Some individuals were tracked during several years : *'Polsky'* was tracked from 1996/97, 1997/98, 1998/99, 1999/2000, *'Prinzessin'* in 1994/95, 1997/98 and 1998/99, *'Prinz'* in 1994/95 and 1996, No *96992* in 1996/97 and 1997, No 98552 in 1998 and 1999, No 98555 in 1998 and 1999, No 981979 in 1998 and 1999. Table VIII.1 gives the complete list of all tagged storks.

Table I.4. Tagged storks 1991 to 1999 : country of capture, age, origin, number (treated = kept in cage).

Country	Age	Origin	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Germ.	1w	treated	3	6	1	0	5	2	2	0	1	20
		pullus	0	0	0	2	0	0	0	3	4	9
		wild	0	0	0	1	0	1	0	0	0	2
Germ.	Ad	treated	0	0	1	2	0	0	1	0	0	4
		wild	0	0	2	3	1	1	0	0	0	7
Pol.	Ad	wild	0	0	0	0	0	4	3	4	0	11
Israel	1w	wild	0	0	0	0	1	0	0	0	0	1
Israel	Ad	wild	0	0	2	3	2	1	1	0	0	9
Total			3	6	6	11	9	9	7	7	5	63

Transmitter types. During the course of the study we constantly changed to the use of technically improved models. We changed from battery powered to solar-powered models because of their longer life time which produced significantly more locations per individual (*see number of locations*). When types with a comparable performance were available we used transmitters with the lowest weight to avoid possible effects of overweight. The transmitters were PTT-100 (platform transmitter terminal) from Microwave Telemetry (USA) of 30, 35, 45, 60 and 90 g. The 45 g and 90 g transmitters had a battery and were transmitting every day or every second day. One 90 g transmitter had a solar-panel and was transmitting every day. The 60 g transmitters had a solar-panel and were transmitting every day for about 16 h. From 1997 all transmitter had a weight of 35 g and had a solar panel. The two 30 g transmitters that were used were transmitting for 8 h every 4th day.

Attachment. The transmitter was attached to the storks back by a continuous strip of Teflon-rope on two storks and on the others by a 3.5 mm nylon rope. The transmitters with solar-panels were placed as a backpack as high as possible on the storks back, to avoid that feathers would cover the panels. The 30g transmitters were placed low on the back. The rope was passed through the forward holes in the transmitter box and the left and right part were tightened in front of the box. The rope was placed in front of the wings and left and right part were fixed at each other at the sternum. Both parts were passed under the wing and the right rope was put through the rear hole and fixed to the left rope at both sides of the transmitter.

The solar transmitter should work in theory for several years, so to prevent that the transmitter could be lost, both ends of the rope were tightened with metal clips. The 30g transmitters had a battery with a short life time, so there was no use to leave the transmitter with empty battery on the stork. Therefore the 30g transmitters were fixed with a Teflon-rope of which the ends were fixed on the height of the birds breast with nylon wires. As intended, at least one of the transmitters had fallen off by the next winter. The larger transmitters were always well visible and not covered with feathers by the bird. This way the solar-panel remained free. The antenna was always well visible.

Number of locations. The PTTs were transmitting with an impulse of 53 sec. The length of one impulse was about 300 msec. Every impulse contained information in code regarding identification number, battery level, temperature, activity and on some transmitters, height. The signals were captured at 850 km above the earth by NASA-satellites of the TIROS-series.

These satellites needed 102 min to round the globe and passed about 14 times a day at a certain location. When they crossed a point they picked up signals from an area as large as 5000 km. This means that theoretically a transmitter could be in contact with a satellite for 15 minutes. With an impulse of 53 sec, the satellite could capture a maximum of 17 impulses. The information was signalled from the transmitter to the ground-station of ARGOS in Toulouse, France. ARGOS then provided the PTT-locations. ARGOS used Doppler shift data and their own algorithms to locate the transmitter. Because of the speed of the satellite, the frequency of the transmitter was captured differently while the satellite was passing the transmitter location. This change in frequency made it possible to locate the transmitter. The impulse of the transmitter must be always the same, because otherwise the satellite interprets the frequency changes as movements. Furthermore, to find a transmitter the satellite has to receive at least two impulses. The number of impulses the satellite can pick up is influenced by the battery power, weather conditions and position of the antenna.

Two examples may show the difference in data quantity collected from tagged storks. An adult male was captured in Germany and tagged with a 90 g transmitter on solar energy (*No 94555*) and was sending signals every day. Between 5 August 1994 and 4 May 1995, this individual flew to Chad and Egypt and the transmitter produced 1845 reliable locations. An adult was captured in Israel and tagged with a 30 g transmitter (*No 93554*) with battery and was sending signals every 4th day. Between 29 September 1993 and 31 March 1994, this individual flew to Poland and the transmitter produced 87 reliable locations.

Data interpretation. The data from the transmitter were captured by satellite and sent to the groundstation in Toulouse, France. The signals were sent to the user in a format as shown in Table I.5.

The locations obtained by the satellite were different in reliability. Data were processed in the groundstation and locations were classified by ARGOS in classes with a different range of accuracy : from LC of Z with the lowest accuracy to B, A, 0, 1, 2 or 3 with the highest accuracy. With LC in class 1 the location is reliable up to 1 km, LC 2 to 350 m, LC 3 to 150 m and with LC 0 and A the reliability depends on the number of measurements and the overall time that the satellite picked up transmitter signals (CLS/ARGOS 1996). Bad weather conditions and battery problems made the reception of the signal difficult and therefore positioning of the bird at certain times unreliable. Therefore we did not use the Z and B locations.

Table I.5. ***Information sheet of Stork with platform number 14544, which is 'Prinzessin' on 25 February 1999.***

14544 Date : 25.02.99	16:53:34 LC : 2	IQ : 56	
Lat1 : 34.035 S	Lon1 : 24.179 E	Lat2 : 35.997 S	Lon2 : 14.437 E
Nb mes : 007	Nb mes>-120dB : 000 Best level : -126 dB		
Pass duration : 432s	NOPC : 3		
Calcul freq : 401 652886.1 Hz	Altitude : 80 m		
170 154 49	126		

Line one : platform number (14544), date (25.02.99), hour GMT (16.53h 34sec), accuracy of the location (2 = 0 to 350 m), transmission quality (IQ).
Line two : two locations.
Line three : number of signals captured by the satellite, number of measurements more than –120 dB, best reception in dB.
Line four : number of seconds that transmitter and satellite had contact. Number of successful test (NOPC).
Line five : measured transmitter frequency in Hz. Altitude of the transmitter in meters.
Line six : sensor data : temperature (170), battery voltage (154), counter (49), activity counter (126).

Thanks to the activity counter we could determine if a bird was dead or if there was a transmitter problem. As long as a bird is moving around the activity counter adds up. When a bird was dead the transmitter still gave locations but the activity counter transmitted the same number for days or weeks. When the satellite picked up a signal but the signal was too weak to calculate a location, the sensor data, including the activity counter, were still logged. We learned that when we suddenly lost all contact with a transmitter and no locations or data came in, this was caused by a technical problem with the transmitter rather than that the bird was dead. These incidents were not used to calculate the mortality rate.

Calculation of daily distance. The daily distance covered by a tagged stork is the distance between successive night locations. The night location was measured by calculating the mean of all locations between 18.00 h and 4.00 h GMT. If there were no locations during this timeframe, the location logged 2 hours before 18.00 h or after 4.00 h was considered. This daily distance is probably an underestimation because most storks probably did not fly in a straight line between the two night locations. However, not all tagged individuals were located during the day and therefore intermediate locations could not be used in the calculation.

5.3.2 Trapping and marking

Trapping.

Europe. We captured storks in northeast Germany (54) and in northeast (10) and northwest (1) Poland. We trapped the free-living Polish adults with a machine-gun that fired a net. When the storks were following a mowing tractor at a distance of maximal 5m, they came close enough to be captured one by one. Previous experiments to catch feeding storks in recently cut Alfalfa fields with a 30x60m canon-net were unsuccessful.

In northeast Germany we captured free-living adults and 1st-winters storks in a cage. The storks were fed for several weeks to adjust them to the presence of the cage and then captured. We also tagged storks that were treated in the Storchenhof Loburg. These were mainly young birds that had fallen out of their nests which needed care for some short time and slightly wounded or weakened adults.

Israel. In Israel, we captured storks by hand in fishponds, high vegetation and nets covering ponds. On hot days in August and September and some days in October, storks washed themselves at midday. Storks made themselves very wet and walked afterwards to the edge of a fishpond to dry their feathers. When we spotted such a very wet stork, we tried to flush the stork in such a way that it had to cross the pond. If the stork was heavy enough, it fell into the pond and we could catch it by swimming. Only birds out of small flocks were chosen because we did not want to disturb large migrating flocks. We caught up to 4 storks at the same time. We noticed that even when it was raining heavily, the storks could still fly very well, only when they were wetting also the small breast feathers were they heavy enough to be caught. In the Western Negev, Kobi Meyrom and Willem Van den Bossche were able to chase some White Stork in the high vegetation of a Paprika field, where we caught 5 birds. We captured another 5 storks in nets covering fishponds. We captured 84 White Storks from 1993 to 1997. Since most storks were trapped between 11.00 and 12.30 h, most of these birds were summering birds and individuals that stayed for a longer period. Migrating birds were flying at this time of the day. Only one 1st-winter stork of a migrating flock was captured after the main group had taken off.

Measurements. Wing, bill and tarsus were measured with a ruler to the nearest 1 mm (Svensson 1970). The wing was straightened and slightly flattened, but not pushed down on the ruler. Body mass was measured to the nearest 50 g using a Pesola balance.

White Storks were sexed by the length of the bill, measured from the tip of the bill to the head feathers. Witherby et al. (1939) did not find females with a bill larger than 170 mm. Post et al. (1991) measured storks of a reintroduction project in the Netherlands and found for females a mean bill length of 160.3 mm (s.d = 7.8) and a range of 140 - 175 mm (n=61). 74 males had a mean bill length of 178.9 mm (s.d.= 8.8), with a range of 160 - 198 mm. . In the Dutch population, only 10 % of the females had a bill larger than 170 mm (Post et al. 1991). Based on these literature data and the frequency distribution of 94 measurements on Israeli storks we classified storks with a bill shorter than 168 mm as females and longer than 172 mm as males. Storks with a bill of 168 to 172 mm were noted as “sex unknown”.

All birds were controlled for possible moulting and we counted the number of old and new flight feathers and the presence of black inner median and humeral coverts.

Marking. Birds that were caught in the water were taken to a cage in the kibbutz and were completely dry after 2 to 3 hours. After drying we ringed the birds with a metal ring from Tel Aviv University and took the measurements. From February 1995, the birds were marked with one or two plastic colour-rings, in combination with the metal ring. All White Storks were individually marked with colour on the greater wing-coverts. For the coloration we used a marker suitable for animals. The colour stayed on the feathers for several months if these feathers were not moulted. However, most storks moulted their wing-coverts in October and lost the colour pattern gradually.

We combined our observations and readings of ringed birds with previously collected recoveries. The list of recovered White Storks in Israel with ringing and recovery places and dates was compiled in a report by Menachem Raviv, Yakov Langer for the Israel Bird Ringing Centre in Tel Aviv (IBRC, Raviv 1989, 1995). In this study, we analysed recoveries from storks in Israel, including the occupied West Bank, Gaza and Golan Heights. Data from Sinai were not included in the analysis.

Some storks were individually recognizable by characteristics of plumage, beak or other features.

5.3.3 Ground observations

Tracking tagged birds on the ground. From 1995 to 1999, Michael Kaatz and his co-workers followed tagged storks on their migration route in autumn and spring in Europe and Turkey. Table I.6 gives an overview of the expeditions and the number of observations. Relying on the satellite data they were able to locate the tagged storks with the help of antennas and receivers on a jeep and minibus. When a bird was in sight data on behaviour, habitat choice and flock composition was collected.

Table I.6. ***Number of observations of tagged storks during expeditions 1995-99.***

Period	Bird ID number	Observations
Autumn 1995	95543	2
	95549	3
	95550	1
	95558	1
Autumn 1996	96554	8
	96555	2
	96991 (=94550)	3
	96992	2
	96993b	4
Spring 1997	96552	11
Autumn 1997	97544	2
	97553	10
	978883	2
	978885	1
	97543 (=94552)	3
Spring 1998	96551	9
Autumn 1998	981979	3
	981980	7
	981981	8
	981982	4
	98544 (=94552)	1
	98555	4
Spring 1999	98544 (=94552)	2
Total		93

Observations on fishponds. We studied the storks in the fishpond areas during the observation periods listed in Table I.7. In autumn 1993, we visited the fishponds of Newe Etan and Ma'oz Hayyim daily in the morning and late afternoon. When appropriate, also other interesting complexes were counted. During 15 days in autumn 1993, a complete count of all fishponds in the Bet She'an Valley was carried out. On other days, we manned an observation post in the Jordan Valley from 7.30 till 16.00 h. In August 1994, Dan Alon from the Israel Ornithological Centre and Willem Van den Bossche used a radar in Tirat Zevi to locate groups of White Storks arriving from Jordan. In the morning and late afternoon, interesting fishponds were checked for landing storks. In autumn 1995, spring 1996, autumn 1996 and 1997, all fishponds in the Bet She'an Valley were checked almost daily, including the weekends (Table I.7).

Table I.7. ***Number of observation days during 1993-97.***

Period	Observation days
02.08 - 06.11.93	97
02.08 - 20.12.94	130
17.01 - 29.05.95	105
06.08 - 14.12.95	112
29.02 - 15.03.96	16
28.03 - 26.04.96	29
23.08 - 19.11.96	88
18.08 - 11.10.97	54
27.11 - 07.12.97	11

The fishponds in the Coastal Plain and Zevulon Valley were checked once a month. The fishponds and canals of the Hula Valley (Upper-Galilee) were checked every fortnight. While controlling the fishponds and fields we looked especially for dead or wounded storks. When we found a stork I took measurements and made notes on the possible cause of death. We classified dead birds as “electrocuted, in bad condition, stuck in mud, killed by raptor, choked in fish, killed on road, caught in tree, killed in net” or “cause of death unknown”. Wounded birds were classified as birds with “broken wing, broken leg, broken beak, swollen leg, shot, in bad condition” or “stuck in mud”. Wounded birds were taken to the animal parks of several kibbutzim. The location of the bird or the type of injuries such as burn marks or severe wounds made it possible to identify victims of electrocution. When a stork with a low weight was found in an open area it was classified as a bird in "bad condition". In many cases these storks stayed behind in the open field when the rest of the migrant flock took off. We only noted a death as "killed by raptor" when we actually observed the killing. Especially in spring, many of the dead birds disappeared quickly because they were eaten by Mongoose *Herpestes ichneumon*, Jackal *Canis aureus* or domestic cats. For example on 13 March 1996, 3500 White Storks were disturbed by fishermen at Ma'ale Gilboa ponds and 5 adult storks out of this flock were killed by hitting powerlines. Only 5 minutes later, all the birds were pulled under bushes by Mongoose and domestic cats.

Multi-station migration survey. From 1988, a survey of migrating soaring birds was organised by Israel Raptor Information Centre and Israel Ornithological Centre in the northern valleys (Tsovel and Alon 1991). Both organisations are part of the Society for the Protection of Nature in Israel. The aim of this survey is to map the migration routes, timing and numbers of soaring birds and to give real time bird warnings to the Israeli Air Force. From the coastal area (Yagur, 12 km from the coast) to the Jordan Valley (Kefar Ruppin, 62 km from the coast), observation posts were placed at a distance of 2 to 4 km apart. The posts were manned by one or two observers from about 2 h after sunrise till sunset or 1 h before sunset. The total survey was manned by 10 to 15 observers, so it was impossible to open all 25 stations every day. In the middle of September, the main migration route of raptors shifted west. To save manpower, the posts east from Geva (43 km) were closed. In 1993, 1994 and 1995 we manned the eastern observation post in the centre of the Jordan Valley to cover the migration of the Black Stork until 16 October. We were always in radio contact with the other observers and could react immediately to observe their behaviour when large flocks approached the area. Besides observing, our role in the team was to collect the papers of all stations and control and eliminate the possible double counts. In 1996 and 1997, we concentrated on controlling storks on the ground.

As Table I.8 shows we counted every autumn in a comparable number of stations and similar intensity.

Table I.8. ***Number of stations manned and number of hours counted during autumn migration surveys in the Bet She'an Valley.***

Period	Stations	Hours counted
14.08-17.10.93	25	3600 h
12.08-13.10.94	23	3836 h
12.08-15.10.95	24	4184 h
07.08-12.10.96	23	4099 h
03.08-22.09.97	18	2428 h

It proved possible to see large flocks of migrating storks from several posts. To eliminate these double counts, time, flock size and location were carefully registered. As most stations were in contact by radio, details on the size and the behaviour of the flocks were exchanged by the observers, when the observers agreed on their double count this was noted on the paper. We eliminated these identified double counts together with the flocks observed in the same period of 5 to 10 minutes near the same location by two or more stations. For example in autumn 1993, we eliminated out of the total 120670 White Storks as double counts. As “resident” birds, 9708 White Storks were eliminated additionally. Storks were identified as “resident” birds when they were flying in small groups and not in the migration direction, or at a low height between ponds or fields. These double counts were eliminated during all surveys.

Migration survey of one station. From 28 February to 18 May 1995, we observed during 60 days from 7.30 to 16.30 h the migration of storks from the edge of a reservoir, 1 km west from Kefar Ruppin. The excellent visibility in spring made it possible to spot and count flocks of storks up to a distance of 25 km. From the middle of April the observation conditions worsened and we moved the station 200 m to the east in the shadow of a tree.

Numbers of wintering storks. Since 1965 the Israel Nature Reserve Authority (INRA) organized yearly waterfowl counts in January. Volunteers counted the numbers of birds present on fishponds and reservoirs. The results of these counts were published in yearly summary reports (Zuaretz 1987, Shy 1992 to 1996). Unfortunately, not all fishponds areas and fields were covered during these surveys. We use these data to compare trends in wintering numbers with changes in the fishculture.

Migratory behaviour. We noted time, species, number, height, direction of migrating flocks and controlled whether they landed in the area. Large flocks of migrating White Storks were followed by car. Birds in flight were not aged.

Feeding and resting behaviour. During the controls of fishponds we took notes on the water level of every fishpond and the presence of storks. When we spotted a flock we first counted all storks, aged and checked for rings and abnormalities. Their behaviour was only classified as "feeding, drinking" or "resting". White Storks in flocks with less than 500 individuals were also individually aged. Out of larger flocks mostly only some hundreds of storks could be aged, but from both the periphery and the centre of the groups. The age-characteristics that we used to identify the different age groups are listed in chapter I.5.

Age- and plumage-terminology. The age-terminology used in this work is based on plumage-terminology (Grant 1982, Johnsson 1992). The categories are starting from juvenile to 1st-winter, 1st-summer, 2nd-winter, 2nd-summer, …, adult. This method avoids the use of terms as "immature" or "sub-adult". To prevent confusion, we sometimes refer to calendar-year terminology. The calendar method is only based on the period from 1 January till 31 December and does not consider plumage changes. Storks do not moult several adjacent flight feathers at one time but change feathers at different points in the wing. These points are called moulting centres. The period between loosing the first old feather in a moulting centre and the last flight feather being replaced is called a moulting cycle. Partial moult is when only body feathers and parts of the wing-coverts are changed.

Optical material. For the observations, a Swarowski 10x42 binocular and an Optolyth telescope with zoom lens (20-60x) were used.

Time. All times of observations in Israel are expressed in local winter time, this is Greenwich Mean Time plus two hours.

5.3.4 Calculating distances

In the analysis of the ring recoveries, we did not calculate the distance as a straight line between the ringing and observation site. Instead, we calculated the distance between the ringing site and points along the main migration route; from the ringing or observation area to the Bosphorus (41°00'N 28°30'E), from the Bosphorus to Iskenderum (37°00'N 36°00'E) and from Iskenderum to Israel. In all cases, this distance is longer than a straight line between ringing and observation site and reflects better the really migrated distance.

5.3.5 Using satellite data to determine take off and landing times

During our investigations, M. Kaatz improved his method to use sensor data of the transmitter to determine the take off and landing time of tagged storks, we shortly describe this method.
To determine the take off and landing time we used data from temperature, battery voltage and counter sensors.
The first clue is the temperature which is lower when the bird is in the air. When the bird is flying, the battery voltage of the solar transmitter increases sharply. In addition is the repetition period of the transmitter signal shorter when the bird is flying. The counter sensor is logging the number of signals of the transmitter and by using this counter data and hour, the moment that the repetition period changed can be calculated. This moment is the take off or landing time. An example of such a calculation is given in Table I.9.

Tab.I.9. Example of a calculation of take off time on 27 August 1997.

Date	GMT	Temperature	Voltage	Counter	repetition period
First satellite track					
27.08.97	6:31:58	31,6° C	3,84 V	75	
					1min 16sec
27.08.97	6:33:14	31,6° C	3,86 V	76	
					1min 17sec
27.08.97	6:34:31	31,9° C	3,85 V	77	
Second satellite track					
27.08.97	8:14:57	24,6° C	4,03 V	159	
					1min 10,5sec
27.08.97	8:17:18	24,3° C	4,03 V	161	

When we look at the hour, counter and repetition period in Table I.9 we see that the transmitter gave a signal 41 times between 6:34:31 and 7:26:35 h GMT with a repetition period of 1min 16,5sec before it changed to a shorter period. For the change from one to the other period we have to take into account a delay. In this case, the system delay is about 5 minutes which means that the stork took off at 7.22 h.

In order to determine this moment, the satellite data may not be further apart than 2 hours because the repetition period is not stable during several hours. Field observations learned that there is an error of 8 minutes in the calculated take off and landing time.

5.3.6 Magnetic resonance imaging and spectroscopy (MRI, MRS)

MRI is a novel tomography method that provides sharp, high-contrast images of the interior of the body. With this non-invasive method it is possible to investigate the same individuals repeatedly and to monitor, e.g., aspects of annual cycles. As part of this project, we have used it in a pilot study to demonstrate the annual cycle of fat deposition in captive White Storks for comparison to wild conspecifics, in order to clarify the energy metabolism of this migratory species. Altogether 12 test birds (young storks) were monitored systematically for 15 months, to follow seasonal changes in the internal organs (mainly breast muscles) and tissues (mainly fat depots). At each monthly examination 22 high-contrast pixel images representing serial dorsoventral sections through the body were generated with the computer program MatLab, after which the pixels per section image were converted to tissue components in cm^2 and the distances between consecutive sections were used to calculate the tissue volumes in cm^3. To measure the fat in the breast muscle spectroscopy was used to determine the fat:water ratio, from which changes in fat content could be derived. The study revealed pronounced seasonal changes in the visceral and cutaneous/subcutaneous fat depots, which precisely paralleled the annual variation in body weight of the birds. For results see Chapter II.7, for technical details Berthold et al. 2001.

5.3.7 Tests of blood and tissue samples for environmental chemicals

During the period 1994-2000 we were able to collect and examine blood and tissue samples from a total of 66 White Storks. These were obtained in Israel (40), eastern Germany (18) and Egypt (8) and were subjected to tests for organochorine compounds and the heavy metal mercury. The tests were carried out by Prof. Dr. P. Becker, Dr. D. Behrends, U. Pijanowska and T. Dittmann, Wilhelmshaven. The contaminants concerned here are presented in Chapter V.4, and the test methods have been described in detail by Becker (1998).

6. Morphometrics and moult

6.1 Introduction

We collected a lot of information on ageing and moulting characteristics of storks because this was an important method to determine the behaviour of the different age-groups. Because of the small number of marked birds of known age we had to rely on information we could gather by ageing storks on moult and plumage characteristics. By measuring storks of different ages during the migration and wintering seasons we tried to check for different body conditions of 1st-winter and adult storks.

6.2 Ageing and moult

1st-winter. *Bare parts* In juveniles, the bill and legs are initially black, but gradually change through orange to red. This colour change starts while they are still in the nest and, for most individuals, is completed before their 1st-summer. In August, about one third of the bill is dark at the point and the length of the bill is less than 80 % of the adult bill length.
Wings The fresh primaries and secondaries are black but have a white shine on all the outer web. The tertials are black. The white shine is also well visible on a closed wing. The white fades off and has largely disappeared in spring. Just the parts of the flight feathers under the greater coverts might retain the white shine. The greater secondary and primary coverts are brownish black. Because 1st-winters do not moult any primaries or secondaries their flight feathers show no contrast in spring and are all dull brownish-black.
The inner median coverts and some humeral coverts of 1st-winters are black. These, together with the secondary coverts, form a black area on the inner wing. 1st-winters moult their body feathers, tail coverts and some lesser coverts during late winter and spring, and the inner median coverts moult from black to white feathers. In spring, 1st-winters retain the black inner median coverts which contrast clearly with the adjacent white median and lesser coverts.

1st-summer/2nd-winter. *Bare parts* Some individuals retain small dark areas on their bill. Legs are orange or red.
Wings During their 1st-summer (=2nd-calendar year) White Storks can moult primaries, from p1 to p7, starting in May or June (Cramp and Simmons 1977, Sterbetz 1968). Some individuals

however change no primaries. By the end of September, only very few adult birds showed active moult while controlled in flight.

Captive 1st-summer storks moulted primaries and secondaries from March/April to November (Bloesch et al. 1977, Hall et al. 1987). They started in late March by moulting from p1 outwards to p6 or p7, which they changed by October. The primary cycle was completed in the next year (2nd-summer). The moult of the secondaries was initiated at 3 centres : s1, s5 and tertial s20 and only completed in the next year. Bloesch et al. (1977) found large individual differences in the numbers of wing feathers that captive storks moulted (Table I.10). Between 7 August and 6 September (1994 to 1997), we checked the moulting pattern of 35 1st-summer storks. They were aged on the combination of beak colour, condition of primaries and secondaries and presence of black inner median coverts. One was ringed and its exact age was known. From these individuals, 20 were actively moulting. In contrast to captive storks, only 5 storks had 3 and none showed 4 moult-centres. The majority showed moult of primaries and tertials but no moult of s1 or s5. They also moulted fewer feathers than captive storks (Table I.10). From the 35 1st-summer birds : 1 moulted 6 primaries, 6 moulted 5, 5 moulted 4, 12 moulted 3, 6 moulted 2, 3 moulted 1 and 2 birds moulted no primaries. The difference between the number of moulted primaries and secondaries for captive and wild males and females respectively, was after a sequential Bonferoni correction highly significant (males primaries t_{11}=10.3, $P<0.001$; males secondaries t_{19}=12.3, $P<0.001$; females primaries t_{22}=7.4, $P<0.001$; females secondaries t_{22}=11.1, $P<0.001$; Rice 1989). In the hand, newly moulted feathers are longer, broader and at the tip more rounded. Because most 1st-summers have moulted only a few primaries, their fresh ‘white shine’ primaries look like contrasting ‘mirrors’ amongst the brown of their other not moulted flight feathers. These colour differences can be observed in wings of flying as well as sitting storks.

From August onwards, the wing moult is continued with the change of lesser and median coverts. The black inner median coverts are replaced by white. In the period before this moult, the 2nd-winter birds can still be aged by the few black inner coverts that are left. In early autumn, 33 out of 35 storks we controlled still had 1 to 5 black inner coverts. After November, some 2nd-winter birds can still be identified by the white outer webs of the moulted primaries.

Table I.10. ***Number of primaries and secondaries moulted on one wing of White Storks.***

	Captive males (n= 5) (Hall et al. 1987)	Males Israel (n= 16) (this study)
Primaries	9.2 (s.d.= 0.7)	2.9 (s.d.= 1.3)
Secondaries	11.0 (s.d.= 1.6)	1.9 (s.d.= 1.4)
	Captive females (n= 5)	Females Israel (n= 19)
Primaries	8.2 (s.d.= 0.4)	3.1 (s.d.= 1.5)
Secondaries	8.8 (s.d.= 0.8)	1.5 (s.d.= 1.4)

Adult. *Bare parts* Bill and legs bright red.

Wings Adult birds have a primary and secondary moult with different moult-centres. In addition, adults moult tertials and most of their coverts during summer and early autumn. From August, lesser and median coverts are moulted and are all replaced by December. During their second summer, the first moulting cycle is continued and shortly afterwards a new cycle starts at p1 and s1, s2 and s20/22. This pattern then continues year after year, but with the cycles tending to become slower and taking more time to be completed (Bloesch et al. 1977). From their 4th summer (5th calendar year), captive storks started to moult from mid May to November. 2nd to 3rd-summer storks moulted like 1st-summer birds from March/April to November (Bloesch et al. 1977). Some individuals are changing feathers from December to February (Witherby et al. 1939, Bloesch et al. 1977). In December 1997, we found that only 6 % of 210 wintering adult storks in Israel showed active moult of flight feathers.

On an average 6 out of 11 primaries and 12.7 of 22 secondaries are moulted each year and 4 to 8 moulting centres are present simultaneously (Bloesch et al. 1977). The final pattern with 3 to 4 active cycles in the hand and up to 8 centres in the forearm is not achieved until the 4th or 5th summer. The completion of the first cycle lasts 2 to 3 years and the following up to 5 years for secondaries and 6 years for primaries (Bloesch et al. 1977). In contrast to 2nd-winters, adults have thus from 4 to 8 centres, which are easily visible on the spread wing.

6.3 Measurements

Bill length : 150 - 198 mm, n = 87 (2nd-winter and adults), wing length : 522 - 592 mm, n = 87 (2nd-winter and adults), tarsus : 178 - 248 mm, n = 143. The mean bill depth at the base was 33.97 mm (s.d.: 2.02, n=132). The mean tarsus length was 220.30 mm (s.d.: 12.87, n=143). We made a distinction between birds captured in autumn : 1 August – 15 September, winter : 16 September – 31 January and spring : 1 March – 31 May.

Migrating adults in autumn had a mean weight of 3523 g (s.d.=378, n=44), while exhausted adults had a mean weight of 2517 g (s.d.=189, n=3). Migrating 1st-winters in autumn had a mean weight of 2988 g (s.d.=391, n=28), while exhausted 1st-winters had a mean weight of 2173 g (s.d.=391, n=11). Migrating adults in spring had a mean weight of 3340 g (s.d.=307, n=5), while migrating 1st-winters in spring had a mean weight of 2878 g (s.d.=363, n=16).

Table I.11. ***Condition as residuals from the regression of log body mass and log tarsus of White Storks found in the Bet She'an Valley (1994-96). Five data are of spring 1995 in the western Negev.***

Period	Status	Age	n	Mean condition	s.d.
Autumn	Captured	1st-winter	26	1.48	0.02
	Bad condition	1st-winter	9	1.42	0.03
	Captured	>1st-winter	35	1.51	0.02
	Bad condition	>1st-winter	3	1.45	0.00
Winter	Captured	1st-winter	8	1.50	0.03
	Bad condition	1st-winter	1	1.41	
	Captured	>1st-winter	14	1.51	0.02
	Bad condition	>1st-winter	2	1.48	0.02
Spring	Captured	1st-winter	16	1.47	0.02
	Bad condition	1st-winter	3	1.44	0.02
	Captured	>1st-winter	5	1.51	0.02
	Bad condition	>1st-winter	1	1.46	

The total weight gives a good indication on the weight a stork can loose on migration but to check the condition of 1st-winter and adult storks during different seasons we have to use a more accurate method. We measured condition as residuals from the regression of log body mass and log tarsus. We analyzed data from captured storks separately from those of storks found in bad condition, which were wounded, sick or exhausted. The condition of captured 1st-winter White Storks was inferior to that of captured adults in spring (t_{19}=-3.84, P<0.01) and autumn (t_{59}=-7.23, P=0.00). In winter, there was no difference in condition between captured young and adult birds ($t_{9.7}$=-0.75, P=0.47).

Chapter II : Migration

1. Introduction

The chapter on migratory behaviour is divided in these sections : the autumn migration from the breeding area to the wintering quarters, the return migration in spring and the choice of and behaviour at stopover sites. The individual migration routes, pattern and choice of stopover sites were studied by observing the behaviour of tagged storks and comparing these data with the behaviour of migrants in Israel.

Migration should be a phenomenon subject to strong selective pressure (Alerstam 1981). Type of flight, flight speed and stopover ecology are components of bird migration that determine the migration pattern. Birds in general store energy reserves as fat or proteins. We expect that the migration pattern that evolved in a species is a result of natural selection during migratory flights, when energy reserves are consumed, and during stopover periods, when new energy reserves should be built up or economized, depending on migration or local feeding conditions. The migration pattern chosen by a species or an individual must permit the bird to arrive at its destination safely and to arrive at a time and in a condition which enable it to carry out the intended activity successfully. The quality of stopover sites could influence the chances for birds to complete their migration.

The migration journey is carried out in a variety of ways, depending on species and season. Migratory birds can build up small fat reserves and fly only short distances at a time, or they can store and use large fat depots and migrate in long or intermediate flights (Piersma 1987). When energy -food- is scarce along the route, it might be beneficial for a bird to minimize energy expenditure. For actively flying birds, the value of stored fat decreases with increasing fat load (Pennycuick 1975). Flying for short stretches with small fat loads (Alerstam 1979) is one way to tackle this problem. Another way is to use the benefit of thermals. High migration speed will minimize the time spent on migration. Early arrival might be beneficial because it increases the chances of getting access to limited resources as territories, mates, nest sites and food.

During stopover, birds may look intensively for food or rest. Resting birds will wait for migratory conditions to improve as, for example, soaring birds wait for the build-up of thermals.

On the site, they may defend short-term individual territories (Rappole and Warner 1976), stay in dense flocks or wander around. The availability of food and the rate at which migrants can deposit fat, will determine stopover time and behaviour (Lindström 1990). When arriving on a potential stopover site, there is normally a period of time of fat loss before a bird can start fat deposition (Mascher 1966, Hansson and Pettersson 1989). However, the replenishment of proteins and water in a short time can be an important positive factor for the condition of a migrant bird.

Some long-distance migrating species have to stop several times along the migration route in order to finish the voyage successfully. According to Moreau (1972), White Storks migrate slowly in autumn, which allows them to feed at various locations along the route. In spring, storks migrate relatively quickly (Moreau 1972). In this chapter, we analyze the autumn and spring migration pattern of tagged White Storks. 23 out of 48 German and Polish tagged storks reached their pre-wintering grounds in eastern Africa. In addition, 2 storks tagged in Israel also migrated to Sudan. The restricted lifetime of the batteries and mortality caused that we collected data only from 7 storks on their spring migration. Observations on one of the most important potential stopover sites in Israel provide the necessary data to interpret the migration pattern of tagged storks.

2. Individual migration pattern

2.1 Autumn

Migration and stopover. 23 tagged White Storks tracked from 1991 to 1999 reached their pre-wintering grounds in Sudan and Chad. To reach northern Sudan, the storks covered a distance of about 4600 km from Germany and about 4400 km from Poland.

The number of days that the storks needed to reach Sudan is listed in Table II.1. The first day that the birds flew 50 km or more in the general migration direction was taken as starting date. During stopover days, the distance between the two night locations was smaller than 50 km. The tagged storks did not show any migratory behaviour during the night nor did they fly large distances to return to the starting point.

Table II.1. ***Migration pattern of White Storks followed with satellite-transmitters on autumn migration from the breeding area to northern Sudan (19°N ca. 32°E).***

Number of migration (>50 km) and stopover days :

Origin	Age	Range	n
Germany	Adult	18 – 31	7
	1st-winter	17 – 66	7
Poland	Adult	14 – 57	9

Number of migration days (>50 km, stopover days excluded)

Origin	Age	Range	Mean	s.d.	n
Germany	Adult	16 – 22	19.3	2.2	7
	1st-winter	16 – 24	18.6	2.9	7
Poland	Adult	14 – 25	19.2	3.5	9

As Table II.1 and Figure II.1 and 2 are showing, 6 1st-winter and 14 adult storks covered the distance from the breeding area to northern Sudan quickly in a period of 18 to 19 days. There was no difference in migration period between adult or 1st-winter German storks (t_{12}=0.51, P=0.62).

There were 3 individuals that made long stopovers in the Middle East. One adult flew from Germany to Sudan in 31 days and a 1st-winter stork in 66 days. One adult flew from Poland to Sudan in 57 days.

Five individuals were tracked during more than one autumn migration. In Table II.1 only the data from the first migration season are used to keep the data unbiased.

The female *'Prinzessin'* migrated in 1994, 1997 and 1998 from Germany to Sudan in 19 (19), 24 (20) and 16 (15) days respectively. The number in brackets is without stopover days. The male *'Prinz'* migrated in 1994 and 1996 from Germany to Sudan in 18 (18) and 22 (19) days respectively. *'Polsky'* migrated in 1996, 1997, 1998 and 1999 from Poland to Sudan in 18 (18), 19 (18), 18 (18) and 14 (14) days respectively. No 98552 migrated 14 (14) and 16 (16) days in autumn 1998 and 1999. No 981979 migrated 17 (22) and 15 (16) days in 1998 and 1999.

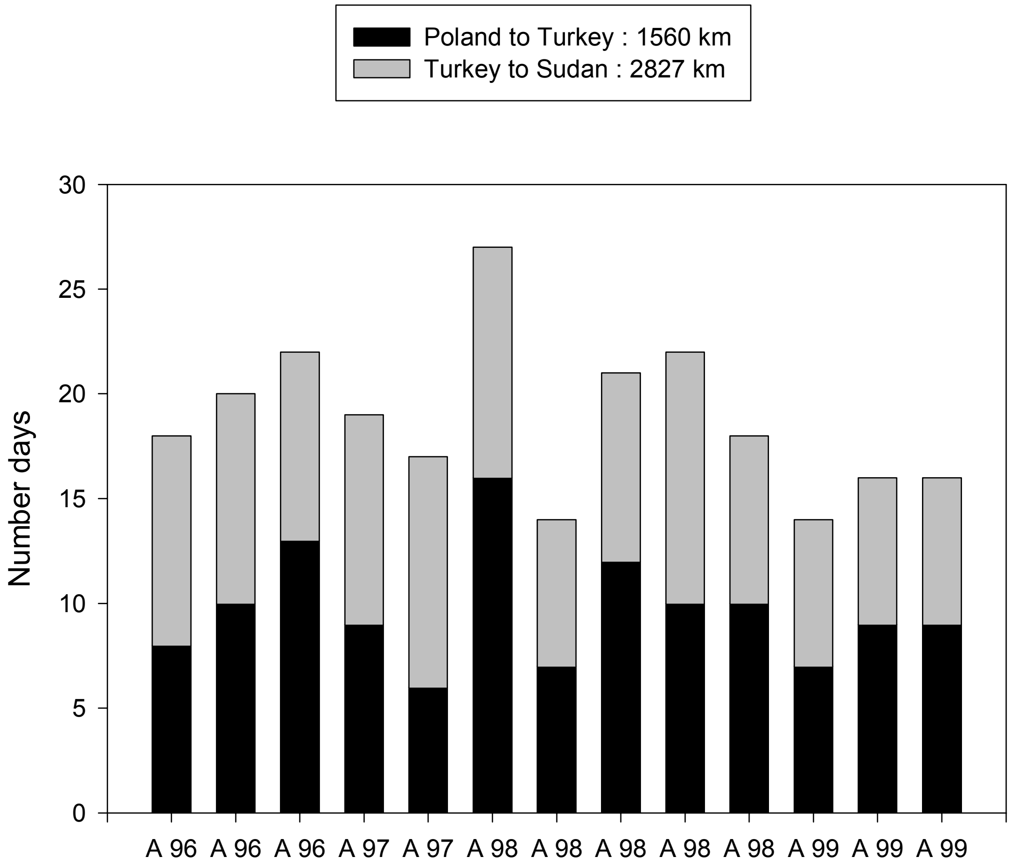


Figure II.1. ***Migration pattern of satellite-tracked White Storks migrating between their breeding area in Poland and northern Sudan (19°N)(1992-99). All days considered. Not included one adult migrating for 57 days.***

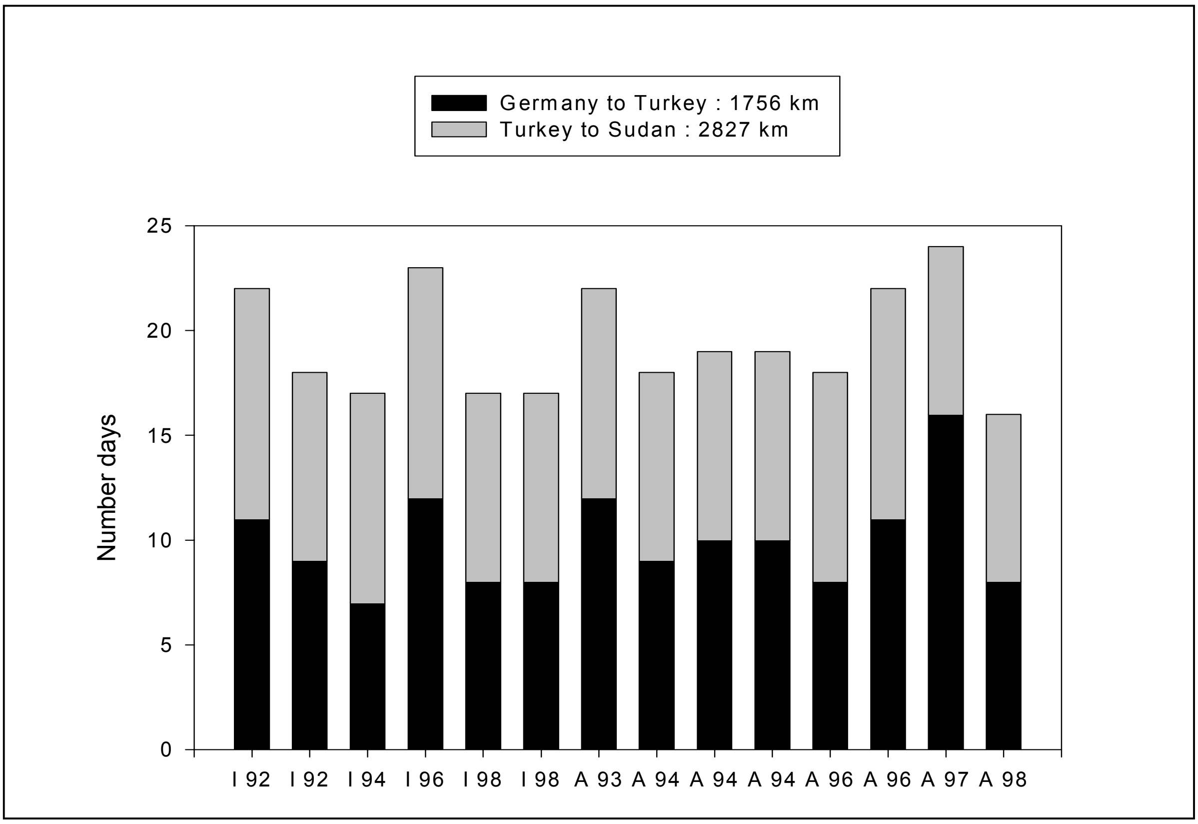


Figure II.2. ***Migration pattern of satellite-tracked White Storks migrating between their breeding area in Germany and northern Sudan (19°N, 1992-99). All days considered. Not included an adult stork migrating for 31 days and a 1st-winter stork for 66 days.***

As an example for the route of tagged storks, we will look at the migration pattern of two adult storks from northern Germany, the fast migrating '*Caesar*' and stork No 94549 which stopped for a longer period (Figure II.3 and 4). '*Caesar*' started its migration on 26 August 1994 and reached northern Bulgaria on night 7 (Figure II.3). During its 10th migration day it crossed the Bosphorus and needed 3 days to fly through Turkey. This male flew fast across Syria, Jordan and Israel and slept already on the Egyptian mainland on night 15. It reached northern Sudan on day 18.

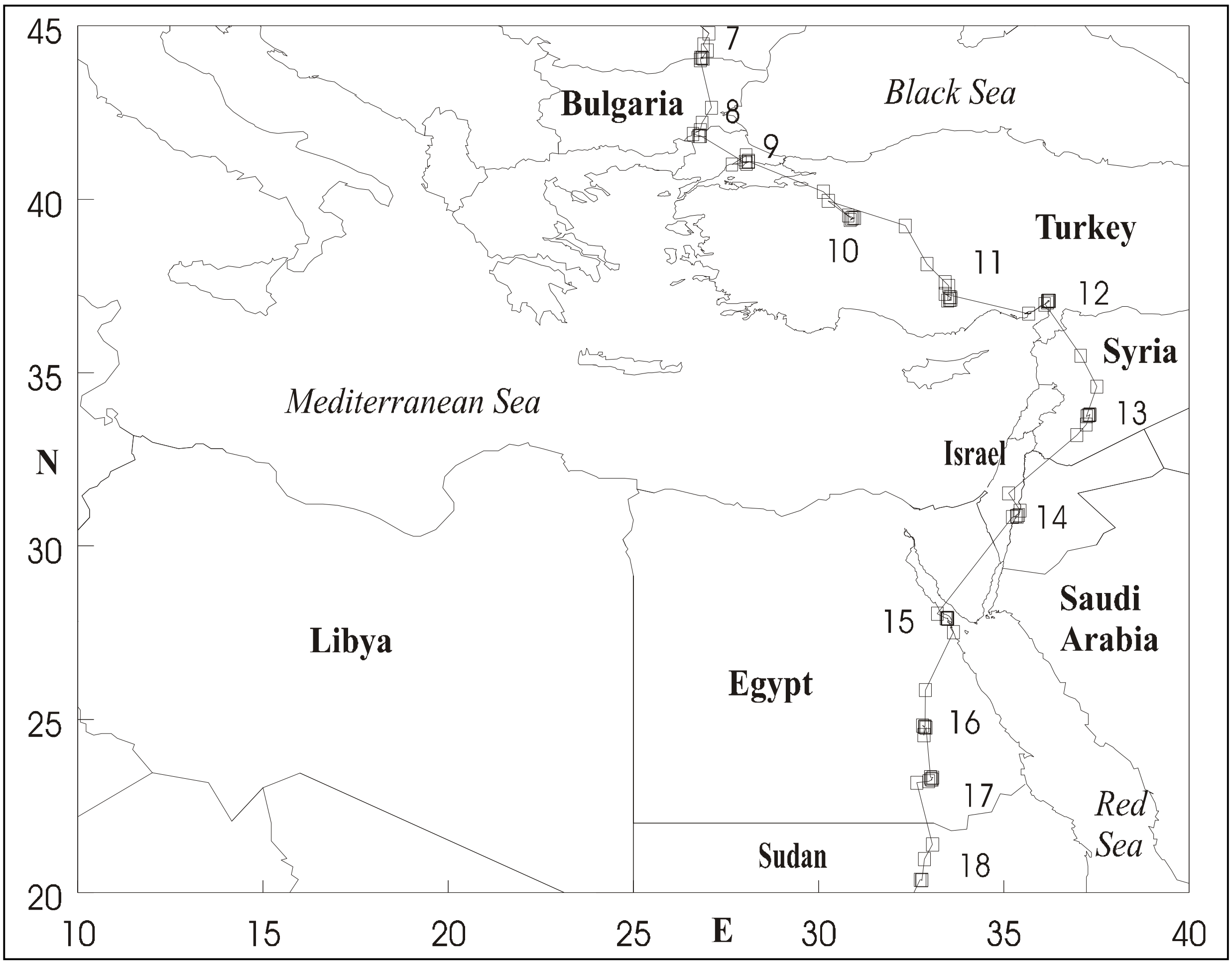


Figure II.3. ***Migration pattern of 'Caesar', No 94555 from Bulgaria to Sudan. The night locations are numbered.***

No *94549* started its migration on 1 September 1994, but stopped 55 km east of its starting point for one day (Figure II.4). On 3 September, it flew 342 km southeast and continued its migration towards the Bosphorus covering a long distance of 504 km on 6 September. It slowed down when it reached the Bosphorus and crossed on 8 September. It arrived at Iskenderum on 11 September and flew through Syria to arrive in the Bet She'an Valley in Israel on 14 September. It stayed in this valley for 12 nights and continued its migration to the south, crossing the Red Sea near El Tor on 27 September. When it reached the northern point of Lake Nasser it migrated only 70 km on 29 September, but later continued its migration to central Sudan.

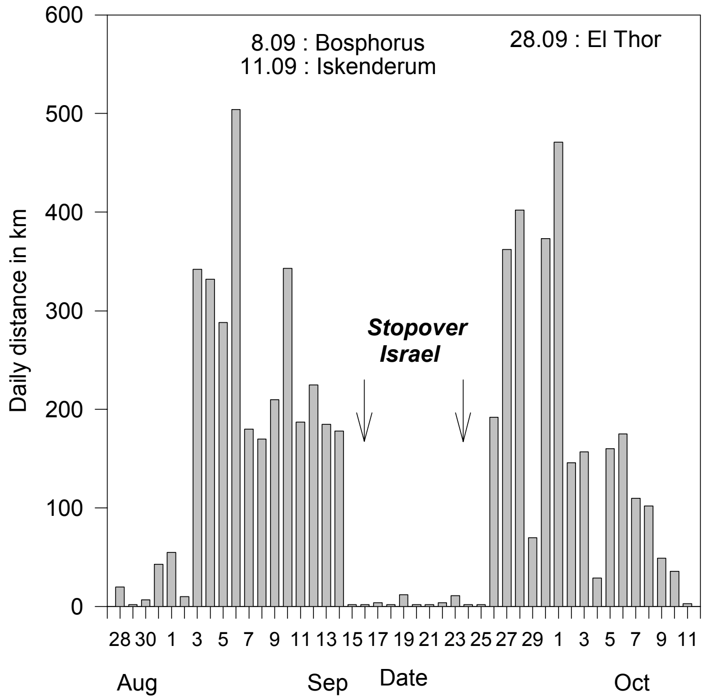


Figure II.4. ***Migration pattern of No 94549 an adult stork from northern Germany.***

The stopover behaviour of tagged migrants is summarized in Table II.2. We used only data from individuals that were located daily.

In Europe, 9 out of 14 1st-winters and 13 out of 21 adults stopped at least once for more than one night at a location. Some storks stopped already for more than one night after only one or two migration days in Europe. Two storks stopped for a longer period of 5 and 22 nights near the Bosphorus. Overall, the stopover time in Europe was short, 3.6 nights for 1st-winters and 2.4 nights for adults (Table II.2). This difference between the age-groups is significant (N_1=13, N_2=27, U=144.5, P<0.02).

Most migrants flew fast through the Middle East, only 1 out of 7 1st-winters and 4 out of 16 adults stopped for more than one night. When the storks stopped they rested long, adults stopped for 9.2 nights and 1st-winters for 21 nights (Table II.2). The longest stopover period was of a 1st-winter stork stopping for 37 nights near Iskenderum in southeast Turkey.

While most storks stopped only for a short period and mostly only once, some individuals (No *95550*, *95554, 96992*) stopped several times during one season, even for longer periods. This could be a reflection of the poor condition these birds had. We have no data on the condition of these birds prior to their departure.

Table II.2. ***Mean number of stopover nights of satellite-tracked White Storks for birds stopping more than one night (1991-98).***

Age	nights stopover	s.d.	n
Europe			
1st-winter	3.6	3.1	13
Adult	2.4	0.6	27
Middle East			
1st-winter	21	22.6	2
Adult	9.2	8.3	5

Storks tracked during several years showed slight differences between seasons. '*Prinz*' stopped no more than 1 night in 1994, compared to twice for 2 nights in Europe and once for 2 nights in the Middle East in 1996. '*Polsky*' had no long stops in 1996 and 1998, while in 1997 it stopped 2 nights in Europe. '*Prinzessin*' stopped no longer than 1 night in 1994, stopped for 2, 2 and 3 nights in Europe in 1997 and once for 2 nights in 1998.

The majority of marked storks that were captured in the Bet She'an Valley stayed for longer than one night (Table II.3). This is why we captured these birds during the middle of the day, when, in general, only summering birds and storks that interrupted their migration were present. 44 % of the 1st-winter storks stayed for one night, which is almost twice the proportion of adults.

Table II.3. ***Bet She'an Valley, percentage of marked White Storks with one night stops.***

Age	n	one night stop	%
1st-winter	9	4	44
2nd-winter	11	4	36
Adult	24	6	25

For those storks that stayed longer than one night in the Bet She'an Valley most 2nd-winters might have been summering locally (Table II.4). The minimum stopover length for 1st-winters and adults might be a better reflection of the behaviour of migrants.

Table II.4. ***Bet She'an Valley : minimum length of autumn stopover period for different age-groups of marked White Storks, with a stopover period longer than one night.***

Age	Range	Mean >1 night	s.d.	n
1st-winter	2 – 32	11.8	10.7	5
2nd-winter	3 – 43	19.7	12.5	7
Adult	2 – 33	13.3	7.3	18

Daily distance. The mean daily migration distance was calculated of tagged individuals that were tracked all over the following regions : Europe, from Germany and Poland to Bosphorus (Turkey), Middle East from Bosphorus to El Tor (Sinai, Egypt) and Africa from El Tor to 19°N (Sudan).

Table II.5. ***Daily migration distance of White Storks tracked with satellite-transmitters on autumn migration (1991-98).***

Region	Mean daily distance (km)	s.d.	Number individ.
Europe	227	56	33
Middle East	278	48	26
Africa	292	50	25

Inside Europe, the tagged storks covered a mean daily distance of 227 km for adult and 1st-winter birds (Table II.5). This is short compared to the mean daily distance of 278 km and 292 km in the Middle East and Africa.

In a model which tests for year, region, age and transmitter weight; only region significantly affected variation in daily migration distance (REPEATED ANOVA : Region $F_{2,72}$=11.40, P<0.001; Year $F_{5,72}$=0.47, P=0.80; Age $F_{1,72}$=2.08, P=0.15; transmitter weight $F_{1,72}$=0.07, P=0.80). The mean migrated daily distance was not influenced by transmitter weight (Table II.6).

Table II.6. ***Mean daily distance across all regions for storks with a different transmitter type.***

Transmitter	Mean daily distance	s.d.	Individuals
35 g	273	63	28
45 g	210	61	2
60 g	256	60	28
90 g	260	53	26

'*Prinz*', '*Prinzessin*' and '*Polsky*' were tracked during different seasons. The mean daily distances per region can differ considerably between years (Table II.7).

Table II.7. ***Mean daily migration distance 'Prinz', 'Prinzessin' and 'Polsky'.***

	Year	Europe	Middle East	Africa
'*Prinz*'	1994	213	310	305
	1996	231	303	223
'*Prinzessin*'	1994	209	267	240
	1997	175	318	329
	1998	269	323	288
'*Polsky*'	1996	228	305	374
	1997	237	249	352
	1998	218	362	339

The range of daily migration distance in autumn for all individuals is listed in Table II.8. In this table, we used also data from White Storks that were tracked through part of the region, but data from the winter period are not included.

White Storks migrated up to a maximum of 620 km a day and flew often more than 500 km a day in Europe as well as in the Middle East and Africa.

Table II.8. ***Range of daily migration distance of White Storks tracked with satellite-transmitters in autumn.***

Region	Age	Range (km)	Days
Europe	Adult	52 – 621	179
	1st-winter	51 – 549	94
Middle East	Adult	51 – 490	139
	1st-winter	55 – 495	42
Africa	Adult	70 – 542	94
	1st-winter	108 – 456	29

We collected also detailed information at some important bottleneck areas. The daily distance of 28 tagged White Storks crossing on autumn migration near Burgas in Bulgaria (42°30'N 27°25'E) was 324 km (s.d.= 101, 1991-98). For 27 tagged storks on autumn passage through Israel near the Dead Sea (31°00’N 25°20’E) we measured a daily distance of 317 km (s.d.= 78, 1992-98).

2.2 Spring

Migration and stopover. Daily locations on the spring migration were gathered for 4 different tagged storks. In addition, ‘*Polsky*’ was followed during 3 consecutive springs and ‘*Prinzessin*’ during 2 springs (Table II.9).

Two out of 4 interrupted their return migration for a longer period. ‘*Prinzessin*’ stopped in central Sudan (10 days) and Israel (6 days) in 1995 and southern Turkey in 1999 (7 days). ‘*Polsky*’ stopped in central (6 days) and northern Syria (9 days) in 1997, in Bulgaria (5 days) in 1998 and in northwest Turkey (7 days) in 1999.

The number of days these 3 Polish and one German stork needed for the return migration depended on the migrated distance, but from Sudan to the breeding site they migrated for 19 to 49 days (Table II.9). These birds that were tracked during several seasons showed yearly differences of more than 30 %.

Tabel II.9. ***Migration pattern of tagged White Storks to the breeding site.***

Stork	Start	Days	Migration days (>50 km)	Km	Stops
'*Polsky*' 1997	Kenya	56	33	6544	6
'*Polsky*' 1998	Kenya	43	33	6242	3
'*Polsky*' 1999	Sudan	37	25	4979	4
'*Prinzessin*' 1995	Tanzania	70	47	6944	7
'*Prinzessin*' 1999	South Africa	64	53	10540	5
No 98552 (1999)	Botswana	56	51	8866	4
No 981979 (1999)	Sudan	21	20	4744	1

Three adult tagged storks started but did not finish their spring migration. Male No *94555* started in Chad on 27 February and arrived in Egypt, near Suez, on 31 March 1995. It stopped shortly 7 times for a total of 8 days. No *96552* started in Botswana on 26 February and arrived in the Bosphorus region in Turkey on 21 April 1997. It stopped 6 times for a total of 17 days, the longest for 10 days in southeast Turkey in the Iskenderum region. No *96992* started on 30 March in Sudan and arrived on 29 May 1997 in southeast Turkey. It stopped 5 times for all together 35 days particulary in Israel and Syria. No 981982 started on 6 April in Zambia and stopped 2 times for a total of 9 days until it reached the desert area at 26°28'N 27°43'E. No 981981 started on 30 March at Mozambique and stopped once for 2 nights in Sudan until it stopped along the Nile in central Egypt.

Marked storks stopped only for a short period in the Bet She'an Valley during spring migration, 7 out of 8 1st-winters and 5 out of 8 adults stopped only for one night. From these birds that stayed longer than one night, one 1st-winter stayed at least 5 nights and 3 adults stayed between 2, 5 and 7 nights.

Daily distance. The four storks that were tracked along the whole spring migration route covered a mean daily distance of 242 km (s.d.=56) in northern Africa, 211 km (s.d.=88) in the Middle East and 201 km (s.d.=96) in Europe. In Africa, tagged storks migrated up to 550 km a day, in the Middle East up to 390 km a day and in Europe up to 454 km a day (Table II.10).

Table II.10. ***Daily distance covered by tagged White Storks on migration days (>50 km) in spring 1991-98.***

Region	Range (km)	n	Number of routes (number of individuals)
Africa	52 – 550	276	15 (12)
Middle East	52 – 390	95	10 (7)
Europe	52 – 454	68	7 (4)

Four marked storks were controlled in Israel and in the same spring on their nest in Germany and Denmark and 2 tagged storks were followed from Israel to Poland and White Russia (Table II.11). Five storks migrated at least about 100 km a day, but one stork flew at least 213 km a day.

Table II.11. ***Calculation of minimal daily migration distance of ringed and tagged White Storks from Israel to the breeding area.***

Code	Year	Start	Breeding	Km	Days	Daily distance
Helgoland 2969	1985	Israel	Germany	3210	28	115
Helgoland 4799	1985	Israel	Germany	3305	46	72
Hiddensee A1640	1985	Israel	Germany	3304	25	132
Copenhagen 7966	1990	Israel	Denmark	3415	16	213
Tel Aviv tagged *93554*	1994	Israel	White Russia	2557	31	82
Tel Aviv tagged *94557*	1995	Israel	Poland	2728	27	101

3. Routes

We followed the autumn migration route of 52 tagged storks breeding in Germany (41) and Poland (11) and 2 storks captured in Israel. Four out of 41 tagged White Storks captured in Germany, followed the western route towards Gibraltar. These birds did not reach Africa and are therefore not discussed in this study. The other German and all Polish storks followed the eastern route through Turkey and Egypt. Over the entire study period, 12 tagged White Storks could be tracked during parts of their spring migration. Two individuals were tracked in more than one season, '*Prinzessin*' in spring 1995 and 1999 and '*Polsky*' in spring 1997, 1998 and 1999. Tagged storks returned in spring along the eastern migration route and followed in general the same route in Africa and Middle East as in autumn.

3.1 Europe

Autumn The German birds flew southeast of the region of Berlin, through the Czech Republic, central Slovakia or east Austria, west Hungary, west Romania and through Bulgaria towards the Bosphorus region in Turkey. Some birds flew a more eastern route through southwest Poland, Slovakia and central Romania.

The Polish birds flew from Masuria, south through east Poland, west Ukraine, east Romania and along the west coast of the Black Sea through Bulgaria on their way to the Bosphorus region in Turkey. All 9 Polish birds crossed the Sea of Marmara near the Bosphorus.

Spring

In spring, storks were avoiding sea crossings and entered Europe from Turkey at the Bosphorus and the Dardanelles. We tracked only very few birds on spring migration what makes it difficult to draw reliable conclusions. In spring 1997 and 1998, '*Polsky'* followed almost exactly the same route as in autumn. In spring 1995 and 1998, *'Prinzessin'* followed a route about 300 km more to the east compared to autumn. It flew first north to Bulgaria and eastern Romania to complete a loop migration in westerly direction through southwest Ukraine and southern Poland.

3.2 Middle East

Autumn 30 (91%) out of 34 tagged storks, crossed the Sea of Marmara in the eastern sector in the Bosphorus region in autumn (Table II.12). Two 1st-winter storks flew through the Dardanelles in the western sector of the Sea of Marmara. The female '*Prinzessin*' was followed during both migration periods. In autumn of 1994 it flew through the Bosphorus region and in spring through the Dardanelles.

Table II.12. ***Route of 34 tagged White Storks crossing the Sea of Marmara (Turkey) in 1991-99.***

	Age	Bosphorus region (east)	Dardanelles (west)
Autumn	1st-winter	12	2
	Adult	19	1

The White Storks flew southeast through Turkey towards the Gulf of Iskenderum, through western Syria and the Jordan Valley to Sinai (Egypt), where most birds crossed the Red Sea at El Tor. Only a few birds passed Sharm El Sheikh, which is more south. The storks reached the Nile near Qena and continued southward to Sudan. The route to the pre-wintering areas and the further route through eastern Africa is described in II.5.3.

Israel. Most White Storks on autumn migration enter Israel not from the north, but from the northeast and east. The majority enters Israel between the southern part of the Golan Heights and the southern edge of the Dead Sea. The flocks fly into the Jordan Valley and reach the western mountain ridge of the valley. At this point, they change their migration direction and fly south to south southwest. During the first migration wave in August 1993, most storks passed east of Newe Etan in the centre of the Jordan Valley at about 58 to 63 km from the coast (Figure II.5).

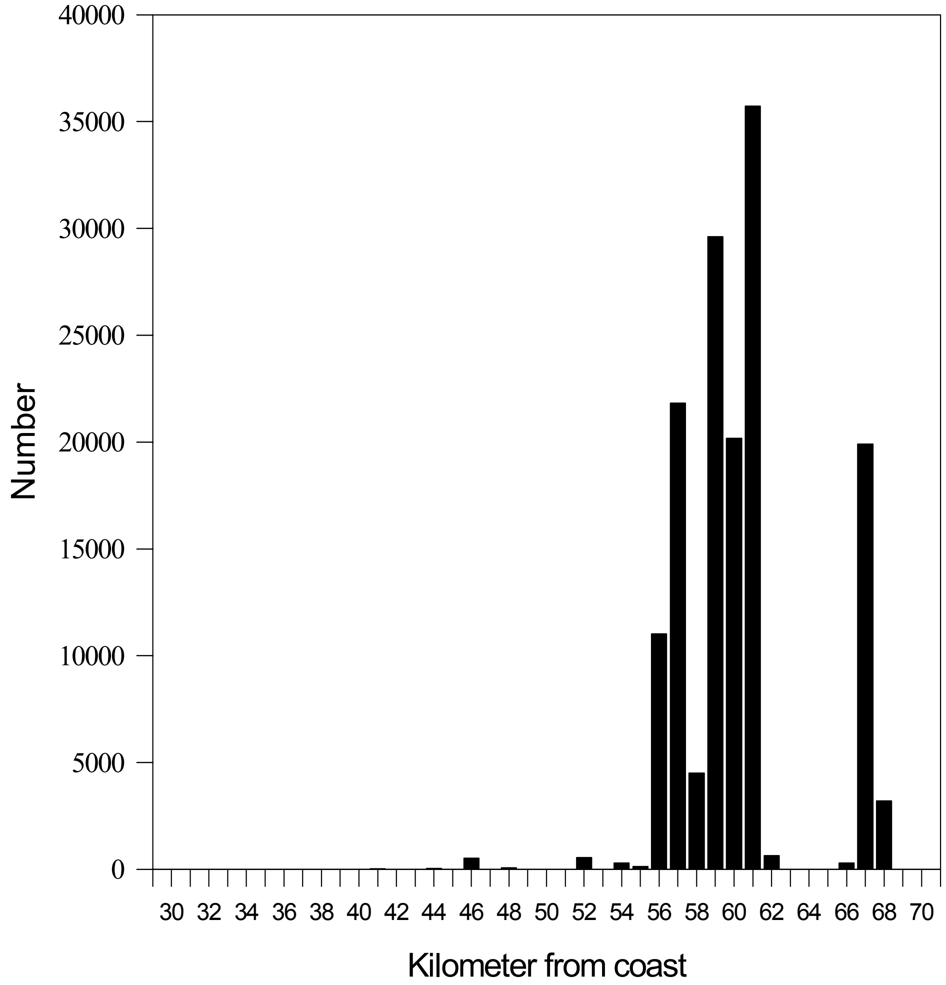


Figure II.5. ***Numbers of White Storks passing through the Jordan Valley in August 1993.***

During the second wave in September, there was a western shift of the migration axis, with high numbers in the centre of the Jordan Valley and along the western mountain ridge. During all autumns, large flocks were only seen west of Bet Hashitta, 48 km from the coast, during days with strong easterly winds.

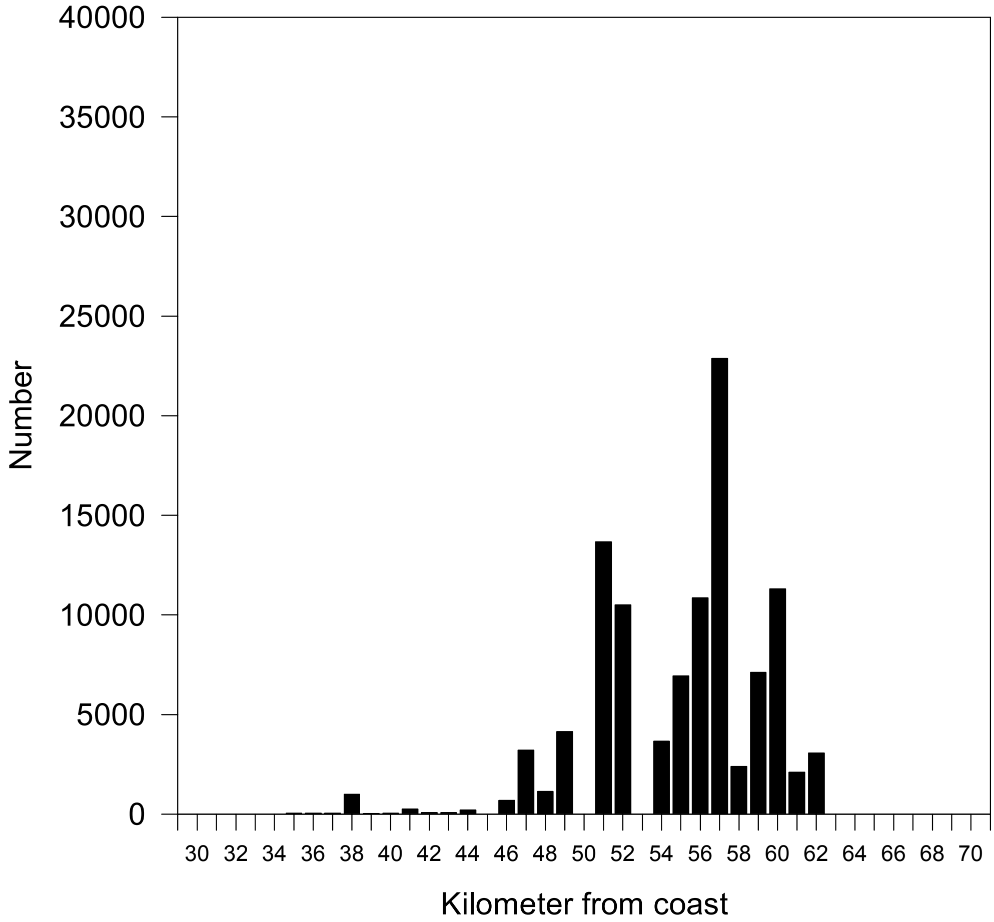


Figure II.6. ***Numbers of White Storks passing through the Jordan Valley in September 1993.***

South of Bet She'an, the flocks continued their migration along the western mountain range of the Jordan Valley towards the Dead Sea area and crossed the central Negev mountains in the area of Mizpe Ramon and Sede Boquer.

16 out of 24 tagged storks, entered Israel north from the Dead Sea and 8 south from the Dead Sea (Arava Valley). From the 16 storks that entered Israel north from the Dead Sea, 8 passed through the Bet She'an Valley and continued along the Jordan Valley and 8 flew through Jordan, east of the Bet She'an Valley.

Spring '*Prinzessin*' crossed the Sea of Marmara at the Dardanelles, instead of the Bosphorus as in autumn. To reach its breeding area near Berlin, it flew through Ukraine and Poland which was more easterly than in autumn.
6 tagged storks could be tracked during their migration through Israel. On 15 April 1995 '*Prinzessin*', rested near Qiriat Gat about 25 km from the coast along the western migration route. In 1999, '*Prinzessin*' followed a more eastern route close to the east side of the Dead Sea, followed the Jordan Valley northwards on 2 April 1999 and flew through the Hula Valley. In 1997 '*Polsky*' migrated through the Arava Valley on the Jordanian side, but reached the southern Dead Sea on the western side. It crossed the southern Dead Sea area and continued migrating through Jordan. In 1998 and 1999, it flew along the coast and in 1999, it was tracked close to Nahariya in the north of Israel. No *96552* migrated through the Negev west of Revivim, crossed Be'er Sheva and flew to a location north of Jericho on the western side of the Jordan Valley. No *96992* entered Israel and stayed for a few days in the western Negev near kibbutz Magen (ca. 31°15'N 34°27'E, western axis) and continued to Bet She'an. No *98552* and *981979* migrated through the coastal region. No *981979* reached Bet She'an on 15 March 1999 and continued north to the Hula Valley. From these 9 mapped routes, 7 times one stork flew west of the Dead Sea through the coastal region. Only on one of these 9 occasions a stork left Israel south from Bet She'an and continued north through Jordan. In the Bet She'an Valley, we observed only a few flocks following the eastern mountain ridge of the Jordan Valley.

3.3 Africa

Autumn The pre-wintering areas of tagged storks were spread over a vast area of more than 2500 km from 11°00'N 13°00'E to 15°00'N 37°00'E. Those storks that left their pre-wintering area for a wintering site south of the equator or in northern Kenya moved towards Uganda. In northern Uganda and Kenya (4°00'N), all tagged storks were funnelled into a 350 km front. Further south, the migration front narrowed to a 100 to 150 km front east of Lake Victoria (1°00' N 35°14'E). On their passage through northern Tanzania, the front of 100 km widened to 500 km. From central Tanzania (5°00'S) to eastern Zambia (13°00'S), the storks followed a narrow corridor of 50 to 150 km. Reaching northern Zimbabwe (15°00'S), the tagged storks started following different routes from northwest Zimbabwe (29°13'E) to western Mozambique (33°32'E).

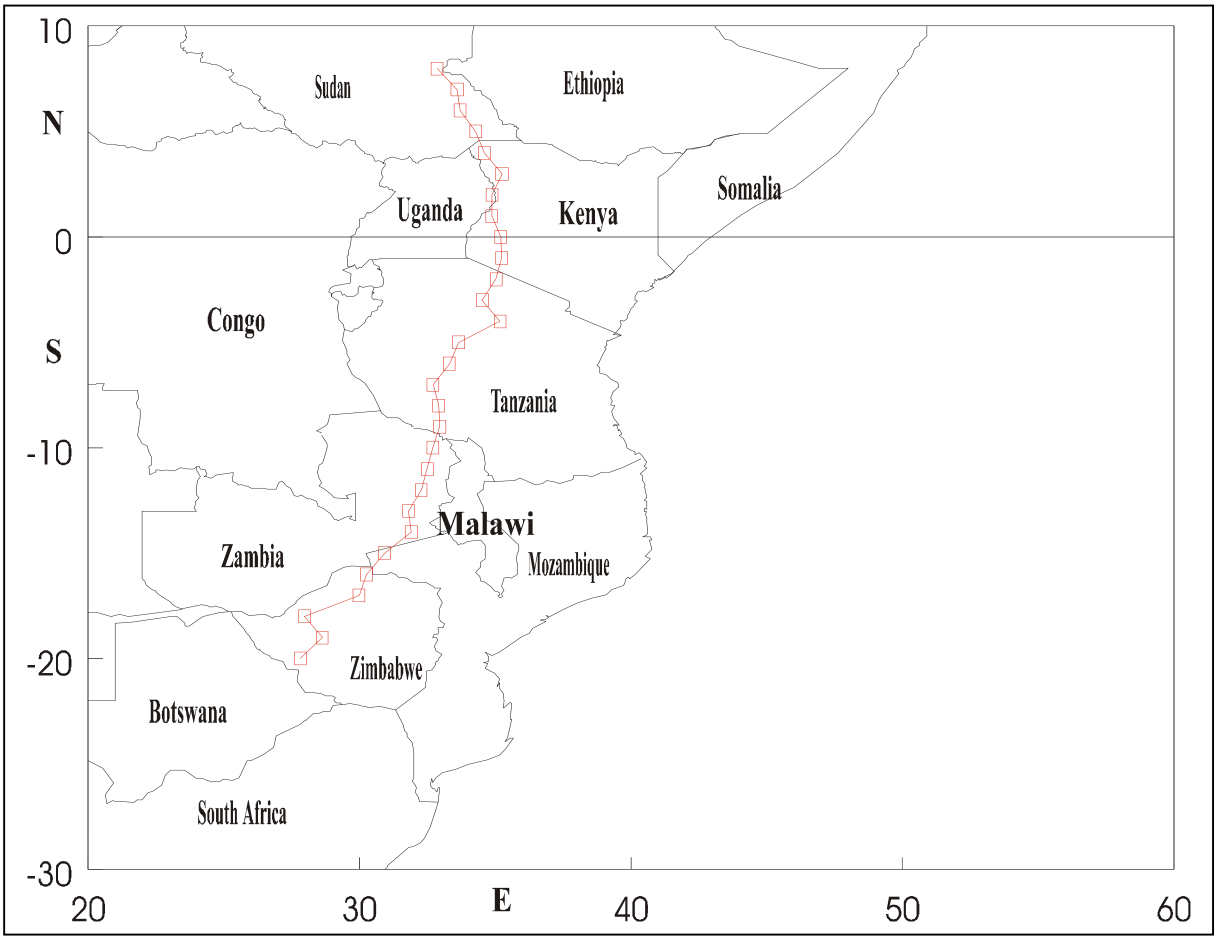


Figure II.7. ***Mean migration route of tagged White Storks through eastern Africa.***

Spring '*Caesar*' started on 27 February 1995 and flew along its autumn migration route through Chad, but flew in northwest Sudan about 100 km north of its autumn route. In north Sudan, the stork flew more to the north and passed 550 km north of its autumn route. It reached the Nile at 20°N and continued slowly along the Nile until Suez. The storks that had a pre-wintering area in east Chad or west Sudan didn't return to these western areas but flew north from central and southern Africa through the Rift Valley in Kenya along the White Nile. Further north in Sudan, all 11 tagged storks arriving from the south avoided the Dongola bend in the Nile, but left the river and crossed the desert towards the east side of Lake Nasser. Only one bird (No *981982*) followed the Nile to the Dongola bend and than took a remarkable western course to the desert area along the Libyan-Egyptian border. It flew north through the desert and ended up in the Nile Delta where it died. 10 out of 11 tagged storks flew to El Tor to cross the Red Sea, while only one avoided the Red Sea by flying to Suez.

4. Migration pattern in Israel

4.1 Autumn

4.1.1 Total number and flock size

Total number. During autumn counts in 1988-96, between 73153 and 313108 White Storks were counted on migration, passing through the Bet She'an Valley (Table II.13). The high number of 538000 birds in 1997 was very exceptional.

Table II.13. ***Numbers of migrating White Storks observed during autumn counts in the Bet She'an Valley.***

Period	Year	Number
16.08 - 16.10	1988	73153 (IOC)
10.08 - 16.10	1989	122851 (IOC)
12.08 - 13.10	1990	188259 (IOC)
21.08 - 15.10	1991	235906 (IOC)
21.08 - 16.10	1992	173677 (IOC)
1.08 - 17.10	1993	274405
12.08 - 13.10	1994	313108
3.08 - 12.10	1995	249670
7.08 - 12.10	1996	278916
3.08 - 20.09	1997	538272

On peak days, a high percentage of the autumn total passed. In 1993, these peak days were 14, 19, 22 and 23 August and 11, 15, 16 and 17 September. On each of these days, more than 10000 storks were passing. During these eight peak days, 74 % of the total number of migrating storks were counted (Table II.14).

The autumn migration of White Storks in 1997 was exceptional. On 6 September, 162856 storks passed the Bet She'an Valley, which is 30 % of the total number in autumn and also about 30 % of the total eastern White Stork population (Table I.1). On peak days with more than 10000 storks passed 89 % out of the total. This is the highest value in 10 observation years.

Table II.14. ***Peak migration days of White Storks in the Bet She'an Valley.***

Year	Number	Date	Percentage of total	Days >10000	Percentage of total
1988	11931	31.08	16 %	1	16 %
1989	20001	25.08	16 %	3	44 %
1990	48378	2.09	26 %	5	66 %
1991	54128	5.09	23 %	6	76 %
1992	59089	26.08	34 %	5	81 %
1993	66229	23.08	24 %	8	74 %
1994	44608	30.08	14 %	10	78 %
1995	55835	28.08	22 %	7	70 %
1996	39720	30.08	14 %	9	72 %
1997	162856	6.09	30 %	10	89 %

Flock size. We looked at the flock size during August, September and October and distinguished between small flocks of 1 to 10, 11 to 100 birds, large flocks of 101-1000 birds and very large flocks of more than 1000 birds.

Table II.15. ***Number of flocks of different size of migrating White Storks in autumn 1993-97 and proportion of total number.***

Month	Flock size	1993	1994	1995	1996	1997
Aug	1 - 10	108 (.3)	133 (.3)	170 (.4)	98 (.3)	39 (.3)
	11 - 100	96 (3)	227 (5)	240 (5)	218 (5)	206 (13)
	101 – 1000	81 (21)	151 (23)	163 (33)	118 (27)	79 (36)
	>1000	30 (76)	41 (71)	45 (62)	29 (67)	14 (51)
Sep	1 - 10	287 (1)	192 (1)	172 (1)	54 (.2)	54 (.1)
	11 - 100	238 (7)	216 (8)	162 (6)	171 (5)	205 (2)
	101 – 1000	100 (33)	83 (27)	72 (28)	117 (29)	176 (15)
	>1000	21 (59)	20 (64)	20 (64)	34 (66)	102 (83)
Oct	1 - 10	12 (21)	4 (11)	39 (18)	3 (14)	
	11 - 100	9 (79)	2 (89)	14 (51)	3 (86)	
	101 – 1000	0 (0)	0 (0)	2 (31)	0 (0)	
	>1000	0 (0)	0 (0)	0 (0)	0 (0)	

White Storks present in a certain area and with the same migration intention might try to form a flock. Only a few individuals migrate alone or in flocks of less than 100 birds. During August and September stork migration is at its peak and most storks pass in flocks of more than 100 birds (Table II.15). In October, the total number of migrants is small and then more birds fly alone or in small flocks. In September 1997, 83 % of the storks passed in flocks larger than 1000 birds, this is a high percentage compared to 59 to 66 % in 1993-96.

Table II.16. ***Mean flock size of migrating White Storks in autumn 1993-97.***

	Period	Mean flock size	Range	n
Aug	1993	471 (s.d.= 1583)	1-19500	315
	1994	402 (s.d.= 1302)	1-13500	552
	1995	310 (s.d.= 926)	1-12000	618
	1996	325 (s.d.= 1304)	1-22252	463
	1997	198 (s.d.= 622)	1- 8000	340
Sep	1993	165 (s.d.= 764)	1-13500	646
	1994	178 (s.d.= 647)	1- 7200	511
	1995	205 (s.d.= 708)	1- 7000	426
	1996	359 (s.d.= 892)	1- 7000	376
	1997	878 (s.d.= 2300)	1-34800	539
Oct	1993	11 (s.d.= 11)	1- 44	21
	1994	10 (s.d.= 12)	1- 27	6
	1995	15 (s.d.= 27)	1-133	55
	1996	16 (s.d.= 12)	1- 35	6

The mean flock size of 11 to 16 birds in October was small (Table II.16). Mean flock size was larger in August 1993-96 (310 to 471) than in September 1993-96 (165 to 359), but groups varied between 1 to 22252 birds. Autumn 1997 was exceptional with a mean flock size of 198 birds in August, which is half the number of 1993-96. In September 1997, mean flock size was more than twice as large as in September 1993-96. The largest flock we observed on autumn migration consisted of 34800 storks taking off at Tirat Zevi on 6 September 1997.

The variation in flock size was significantly affected by the total number of migrants on a day (ANOVA : $F_{1,2867}$=362.13, P<0.001), hour ($F_{1,2867}$=11.67, P<0.001) and km from the coast ($F_{1,2867}$=27.45, P<0.001, autumn 1995-97). On days with many migrating storks, they formed larger groups (Figure II.8). Flock size increased in the same way as the number of groups. This means that although they formed larger flocks, the storks did not wait for others to form a few very large flocks. Between 7 and 8 h, large flocks took off (Figure II.9). Later in the day, storks passed regularly and mean flock size remained stable between 10 and 16 h. In the late afternoon between 16 and 18 h, smaller flocks landed and very large flocks were formed which continued their migration.

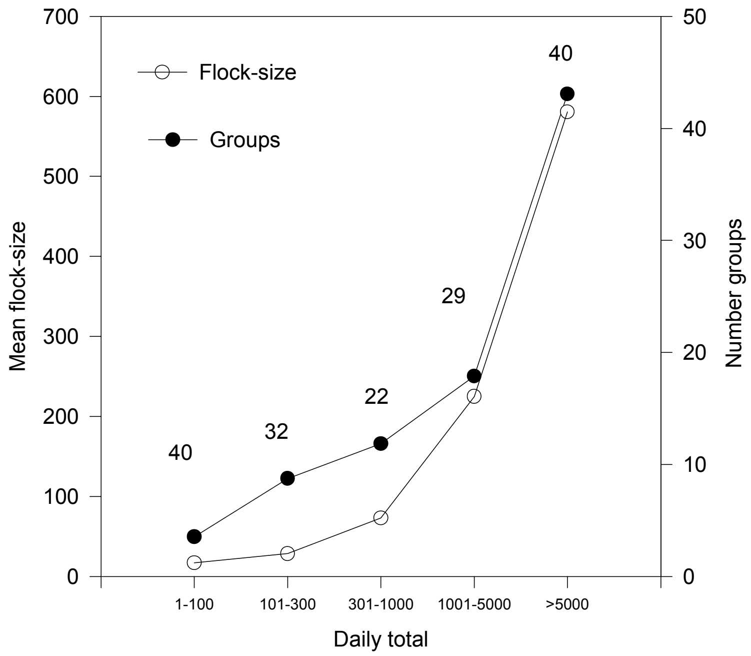


Figure II.8. ***Mean flock size and number of groups on migration days of different magnitude (Autumn 1995-97).***

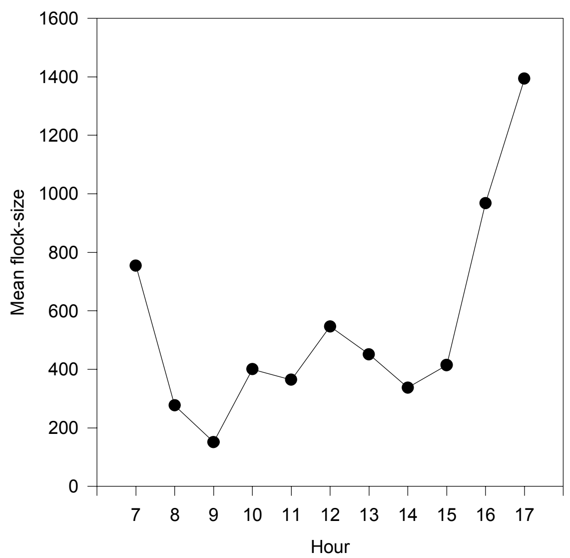


Figure II.9. ***Mean flock size per hour of migrating storks in the Bet She'an Valley (Autumn 1995-97).***

Daily pattern. In the Bet She'an Valley we gathered information on the number of hours migrated per day. White Storks started to leave the area from 7.00 h in August and 6.15 h in September. At this time of the day, the thermal activity is weak and migrating storks have to use flapping flight. These early flocks were not moving between fields or ponds but were really migrating.

The majority of migrating storks waited until 8.00 to 9.00 h to take off (Table II.17). Sunrise is at 4.01 h at 20 August and 4.16 h at 10 September. The mean take-off time was 8.42 h in August and 8.50 h in September, which is about 4,5 hours after sunrise. At this time, thermals are so strong that the storks only have to flap their wings for a few minutes to gain height.

Table II.17. ***Timing of take-off of migrating flocks in the Bet She'an Valley in autumn.***

Period	Take-off	s.d.	Number of groups
Aug 1993	8.32 h	0.20 h	86
Aug 1994	8.45 h	0.33 h	149
Aug 1995	8.51 h	0.28 h	262
Aug 1996	8.38 h	0.30 h	142
Mean 1993-96	8.42 h	0.29 h	
Sep 1993	8.37 h	0.28 h	203
Sep 1994	9.03 h	0.45 h	140
Sep 1995	8.39 h	0.29 h	92
Sep 1996	8.50 h	0.29 h	84
Mean 1993-96	8.50 h	0.38 h	
Range take-off :	August : 7.04 h - 11.06 h September : 6.15 h - 10.50 h		

Migrating storks started to land after midday, but the majority landed between 15 and 17 h (Table II.18). The mean landing time was 15.54 h in August and 16.19 h in September. Sunset is at 17.17 h on 20 August and at 16.53 h on 10 September.

After sunset, some large flocks were still passing at high altitudes. These birds probably did not continue during the night, but landed out of sight of the observation posts.

Table II.18. ***Timing of landing of migrating flocks in the Bet She'an Valley in autumn.***

Period	Landing	s.d.	Number of groups
Aug 1993	15.56 h	1.00 h	20
Aug 1994	16.20 h	1.07 h	33
Aug 1995	15.30 h	1.05 h	54
Aug 1996	15.54 h	1.11 h	27
Mean 1993-96	15.54 h	1.09 h	
Sep 1993	16.19 h	0.53 h	18
Sep 1994	16.24 h	1.14 h	11
Sep 1995	16.26 h	0.38 h	13
Sep 1996	16.08 h	0.39 h	17
Mean 1993-96	16.19 h	0.56 h	
Range landing :	August : 12.48 h - 18.00 h September : 14.10 h - 18.00 h		

The take-off time in August (1993-96) was negatively correlated with flock size (df=637, r^2=0.025, P<0.0001). Large flocks took off between 7.30 h and 8.30 h, groups taking off after 8.30 h were small.

In September (1993-96), take-off time was not correlated with flock size (df=517, r^2=0.0003, P=0.70). On 15 September 1993, large flocks of White Storks took off very late from arable fields near Hamadya. Between 10.15 h and 10.50 h, most of the 7620 storks took off in large flocks of 3500, 700, 1260 and 1170 birds. We have no data that can explain the late departure of these flocks. If we ignore the exceptional data of 15 September 1993, then take-off time is negatively correlated with flock size (df=509, r^2=0.011, P<0.05).

Large groups were landing later than small groups. Flock size was positively correlated with landing time in August (df=132, r^2=0.058, P<0.01), and in September (df=57, r^2=0.152, P<0.01).

4.1.2 Timing

4.1.2.1 Origin

White Storks breeding in a vast area from western Europe to the east side of the Black Sea pass through Israel. The most eastern stork was ringed at Lugow (51°44'N 35°14'E) in Russia on the border with Ukraine. Two storks breeding in western Europe were found in the Bet She'an Valley, one was ringed in 1951 in Rijperkerk (53°12'N 5°54'E) in the Netherlands and one was ringed in Mulhouse (47°45'N 7°20'E) in France. One exceptional finding was a stork ringed in Tunisia in June 1955 and found in Israel on 24 April 1958. The origin of 317 marked storks recovered from 1932 to 1996 in Israel are plotted in Figure II.10. In addition, we included the breeding locations of 35 storks found in Sinai in 1932-82, 2 tagged storks and a French stork that we observed in 1997.

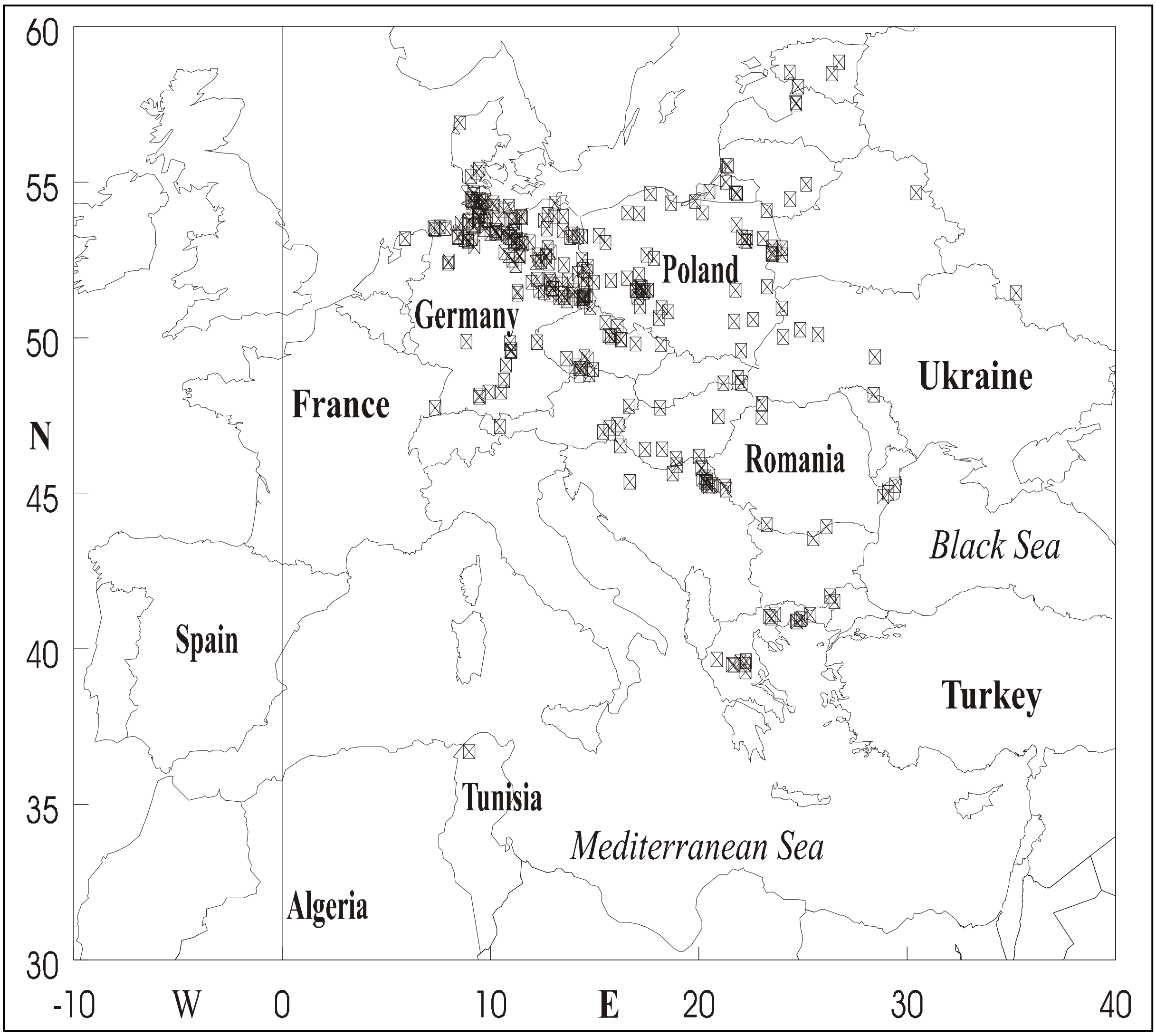


Figure II.10. ***Ringing sites of White Storks recovered in Israel.***

In the period 1960-96, 29 marked 1st-winter White Storks were controlled in Israel. Their arrival time in Israel was positively correlated with the distance from the breeding area (df=27, $r^2=0.15$, $P<0.05$).

4.1.2.2 Numbers and age

The autumn migration pattern shows a bimodal curve, with a first peak in the second half of August, from 14 August to 1 September, and a second peak in the first half of September, from 6 to 17 September (Figure II.11). Only few flocks were seen before 14 August. From the second half of September until the middle of October at the most a few hundred storks migrated through daily. In 1993, the first wave was early from 14 to 23 August, the earliest within the last 6 years. The second wave was from 4 to 17 September. Between 1993 and 1996, more storks passed in the first wave in August than in the second wave in September. However in 1997, only 66274 storks passed from 21 August to 1 September and the very large number of 464191 passed from 3 to 15 September (Figure II.11).

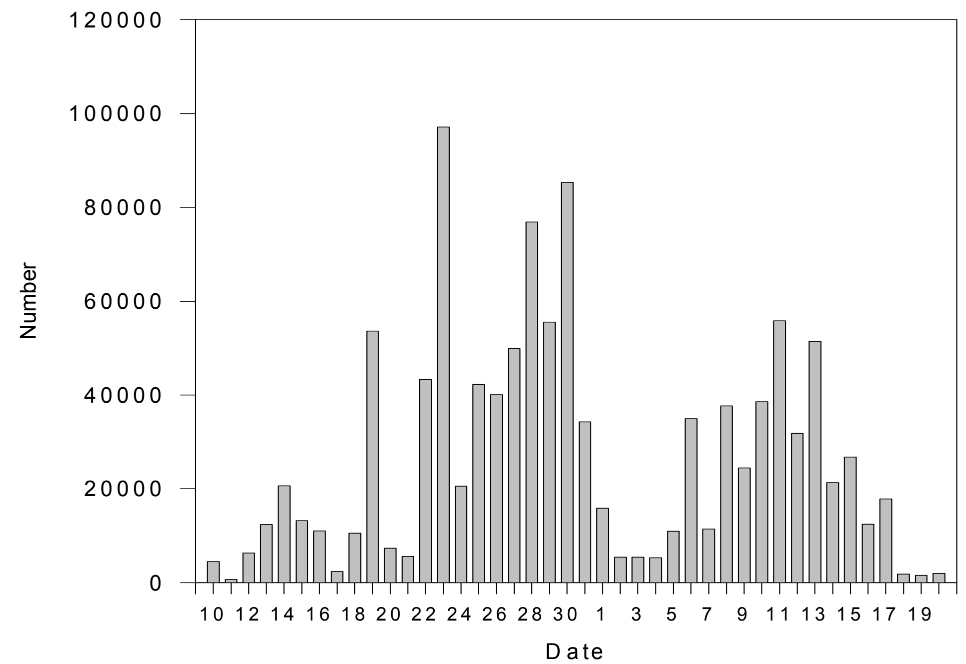


Figure II.11. ***Total daily numbers of White Storks counted in the Bet She'an Valley in autumn 1993-96.***

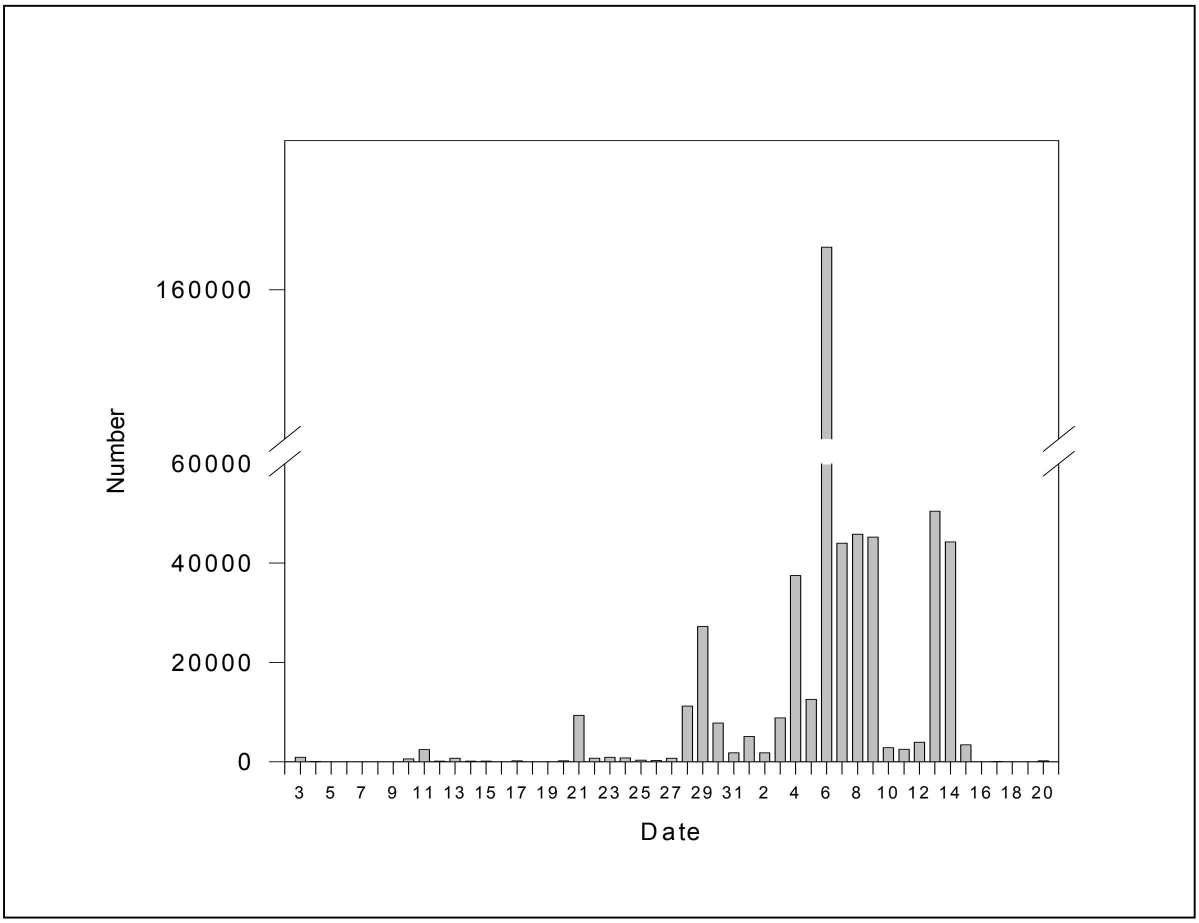


Figure II.12. ***Daily number of White Storks counted in the Bet She'an Valley in autumn 1997.***

The number of White Storks passing through the Bet She'an Valley on days in August and September 1993-96 was positively correlated with maximum temperature on that day (df=128, r^2=0.06, P<0.01).

Before 10 August, the few migrants were adult and 2nd-winter storks (Figure II.13). The storks in the migration wave from 13 August to 2 September were mainly 1st-winter storks. In September, most migrants in the flocks were adults. The number of adults of about 30 % in August was higher than the number of 1st-winters in the second wave in September (<10 %).

In autumn 1960-96, 48 marked White Storks were found or observed in Israel. The pattern of their finding dates does not correspond with field observations. 6 out of 11 adults were found in August and 5 in September (Figure II.14). From 8 2nd-winter and 29 1st-winter storks, 5 and 11 respectively, were found in August. Based on recovery data, the mean arrival date for marked

1st-winter storks is 6 September (s.d.= 11 days). In contrast, the first migration wave with mainly 1st-winter storks is between 22 and 31 August (Figure II.12 and 13).

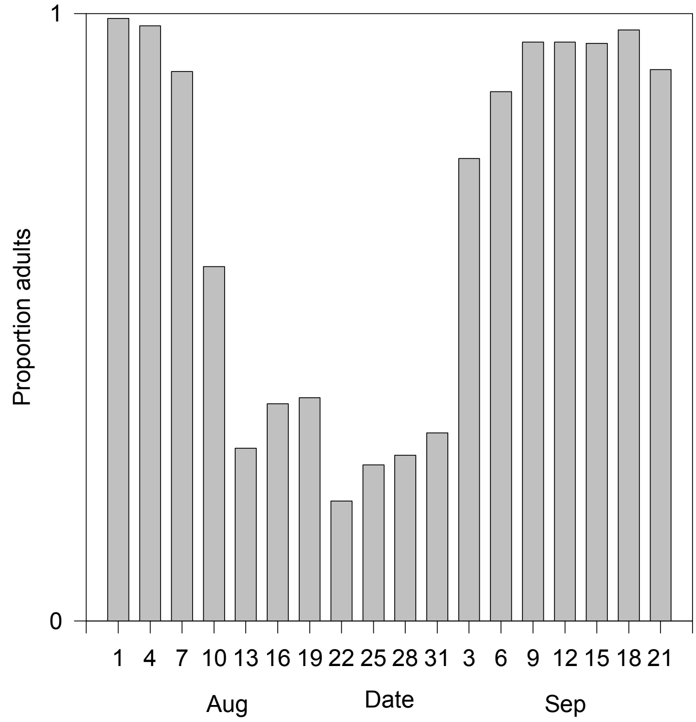


Figure II.13. ***Age-ratio of migrating White Storks, controlled on the ground (autumn 1993-96, n=190626).***

Many of the early migrating adult storks in August might be 2nd-winters. In a migrating flock that was poisoned at Hafetz Hayyim on the Coastal Plain on 19 August 1994, 17 White Storks were older than one year and survived, 4 1st-winter died. One 3rd-winter was ringed in the Czech Republic, the others were not marked but 11 were 2nd-winter and 6 were 3rd-winter birds or older.

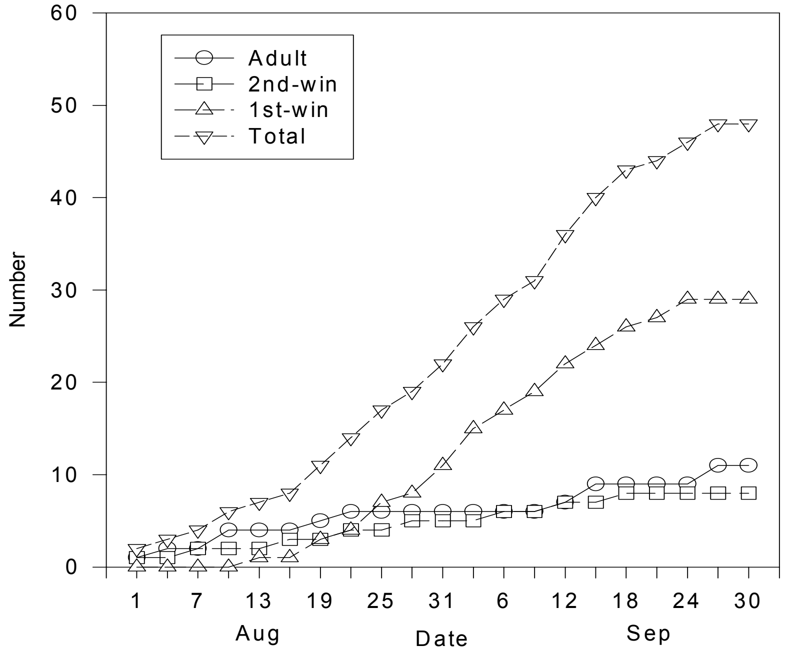


Figure II.14. ***Cumulative number of marked White Storks of different age groups, ringed in Europe and controlled in autumn in Israel (n=48).***

In autumn 1996, 278916 White Storks on migration were counted. If we combine age-ratio in migrating flocks and numbers passing during 3-day periods (Figure II.13), 127510 were 1st-winter birds, i.e. 46 %.

In autumn 1997, 532634 White Storks were counted from 19 August to 20 September. During that period, we controlled the age of 46118 migrating storks. Age-ratio, combined with numbers passing during 3-day periods shows that 96756 were 1st-winter storks, which is 18 %.

4.2 Spring

4.2.1 Total number and flock size

Total number. The stork spring migration in the Bet She'an Valley was counted on 63 out of 80 days from 28 February till 18 May 1995. In spring, weather conditions are very good for observations because there is no haze. This made that migrating flocks could be observed up to a distance of 20 km. In spring 1995, 387296 migrating White Storks were counted. In spring 1996, we did not count all passing flocks but we collected information on the behaviour of the flocks on the ground and checked for rings and age.

Flock size. In March 1995, we observed 63 flocks of more than 1000 storks. They represent 81 % of the total number passing in March (Table II.19). In April and May, the flocks were smaller and most storks passed in flocks of 101 to 1000 birds.

Table II.19. ***Flock size of migrating White Storks in spring 1995.***

Month	Flock size	Number of flocks	% of total migrants
March	1 - 10	20	0.04
	11 - 100	71	1
	101 – 1000	116	18
	>1000	63	81
April	1 - 10	42	0.3
	11 - 100	201	9
	101 – 1000	161	57
	>1000	15	34
May	1 - 10	22	1
	11 - 100	82	24
	101 – 1000	30	63
	>1000	1	11

The mean flock size in March was 1039 storks (Table II.20). The flocks were much smaller in April and May. We observed the largest flock of 48400 storks passing through the centre of the Jordan Valley at 11.31 h on 24 March 1995.

Table II.20. ***Mean flock size of migrating White Storks in spring 1995.***

Month	Mean flock size	s.d.
March	1039	3252
April	228	473
May	94	183

Migrating White Stork flocks took off from 7.13 to 10.55 h. Mean take-off time was 9.01 h in March and 8.36 h in April and May (Table II.21, sunrise is at 4.44 h on 20 March, 4.16 h on 10 April and 3.41 h on 10 May). Flocks were observed landing from 13.00 to 18.30 h, but the mean landing time was 15.30 h (Table II.21, sunset is at 16.48 h on 20 March, 17.01 h on 10 April and 17.20 h on 10 May).

Table II.21. ***Timing of take off and landing of migrating flocks in the Bet She'an Valley in spring 1995.***

Period	Take-off	s.d.	Number of groups
March	9.01 h	0.37 h	67
April-May	8.36 h	0.45 h	144
Period	Landing	s.d.	Number of groups
March	15.35 h	1.13 h	49
April-May	15.30 h	0.58 h	52
Range : Take-off :	March : 7.47 h - 10.55 h April-May : 7.13 h - 10.49 h		
Range : Landing :	March : 13.09 h - 17.39 h April-May : 14.00 h - 18.30 h		

Take-off time in March (1995/96) was not correlated with flock size (df=82, r^2=0.007, P=0.46). In April and May, take-off time was negatively correlated with flock size (df=172, r^2=0.025, P<0.05). In March (1995/96), large flocks were landing later than small flocks (positive correlation, df=58, r^2=0.075, P<0.05). In April and May, there was no correlation between landing time and flock size (df=58, r^2=0.053, P=0.08).

4.2.2 Timing

In 1995 and 1996, the first migrating White Storks appeared in the Bet She'an Valley at the end of February. In 1995, real migration started quite suddenly with 11056 storks on 8 March (Figure II.15). Migration continued with good numbers on 12 (15467) and 16 March (11376). The migration peak was in the second half of March when we observed very strong migration on 24 (104634), 26 (56835) and 27 March (27516). Almost 189000 storks passed on these 3 days. In April more than 1000 storks passed daily, with peak numbers on 3 (12244), 14 (12840) and 28 April (17209). In May, only a few hundred storks passed daily except on 2 (3880) and 7 May (3895).

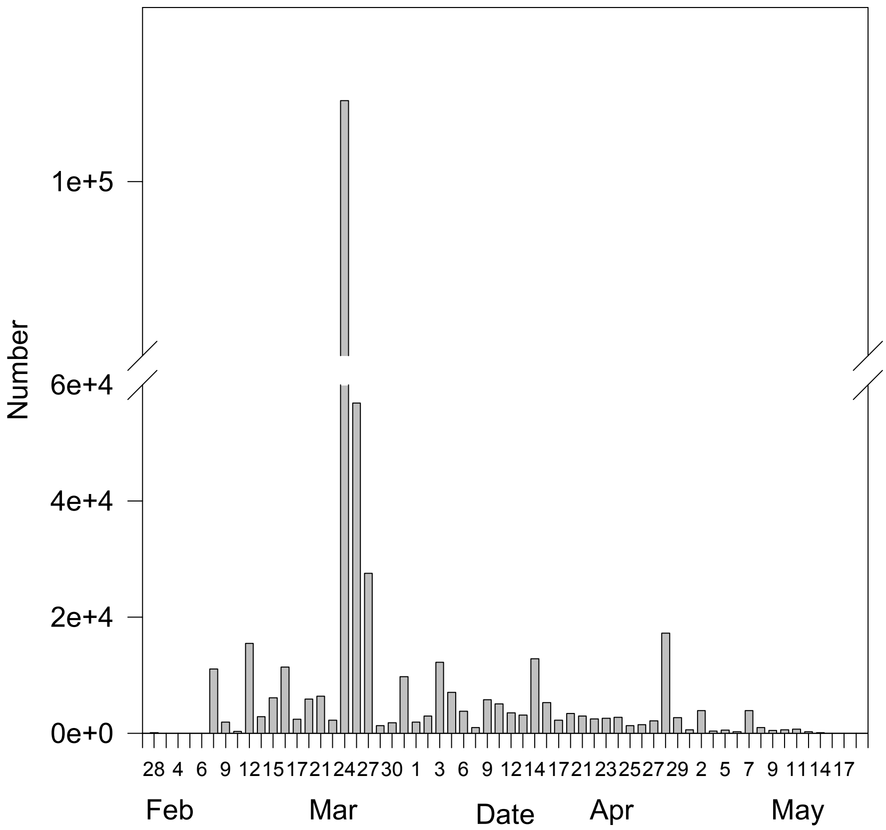


Figure II.15. ***Daily number of migrating White Storks in the Bet She'an Valley in spring 1995 (1 observation post).***

White Storks from northern breeding areas passed through the Middle East later in the autumn migration season. If this separation continues, this could suggest that the north to south winter distribution in Africa might be a reflection of the location of the breeding area.

From the dataset of the IBRC we used information on 35 1st-winter and 45 adult marked White Storks on their spring arrival in Israel. If all the storks of a certain age group started migrating synchronously, their arrival time in Israel would reflect their winter distribution in Africa. There was no correlation between the spring arrival date in Israel and the distance to the breeding area for 1st-winter storks (df=33, r^2=0.02, P=0.47) or adult storks (df=43, r^2=0.03, P=0.74).

We controlled the age of 109464 storks in spring 1995 and 45924 in spring 1996. Until 25 March, almost all migrating storks controlled in the Bet She'an Valley were adults (Figure II.16). From 26 to 28 March, 79 % were adults in 1995 (13110 controlled), but only 37 % were adults in 1996 (1151 controlled). Thus the majority of the 189000 storks passing during the peak migration between 24 and 27 March 1995 were adults. At the end of March and the first week of April, more than 60 % were 1st-winter storks and later in April and May, about 90 % were 1st-winter storks.

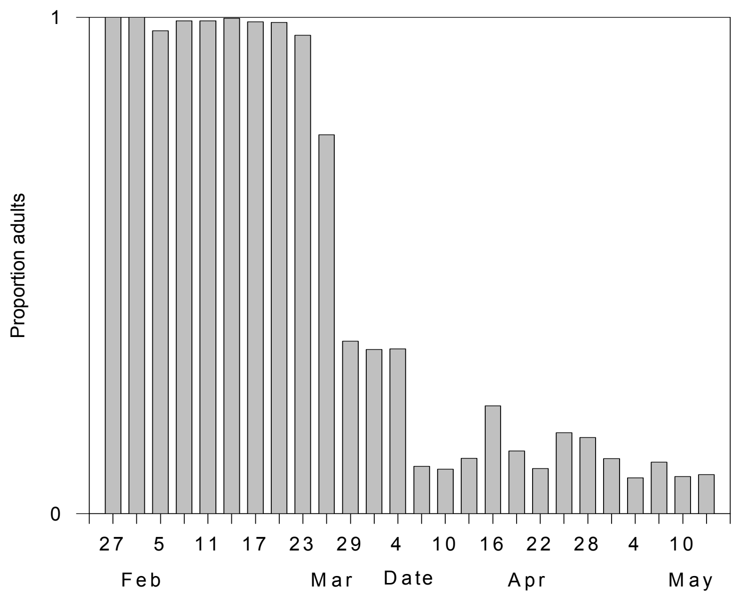


Figure II.16. ***Spring age-ratio of migrating White Storks controlled on the ground (Mean value of 1995 and 1996).***

These observations are confirmed by recoveries of marked storks in Israel (Fig. II.16). 31 (69%) out of 45 adult storks were found before April, while only 2 out of 35 1st-winter storks were found in March. Non-breeding 2nd-winter storks were found throughout the whole migration period.

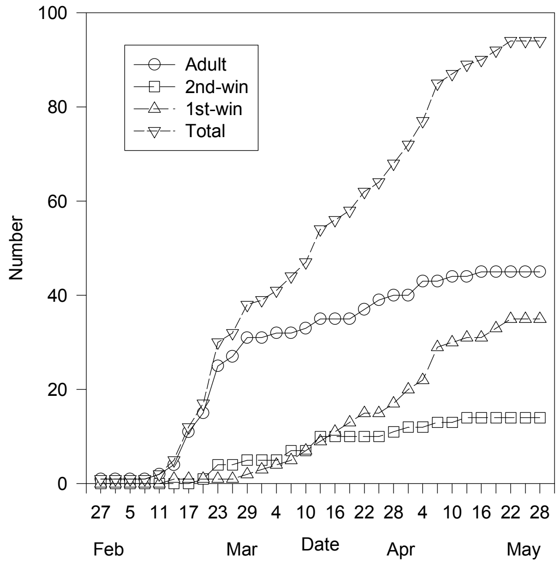


Figure II.17. ***Cumulative number of marked White Storks of different age groups, ringed in Europe and controlled in spring in Israel (n=94).***

5. Stopover sites

5.1 Stopover sites in Europe to Africa

Location of stopover sites. Tagged storks interrupted their migration for one or more days. Many tagged storks stopped for a short period in Germany, Poland and central European countries (Figure II.18). These stops were soon after their departure and might have been influenced by weather conditions. Further south, tagged storks were stopping for more than a week at bottleneck areas at the Bosphorus and Iskenderum in Turkey. In addition, No *94549* stopped for 12 days at fishponds in Israel and No *96992* stayed 21 days at Lake Nasser in Egypt.

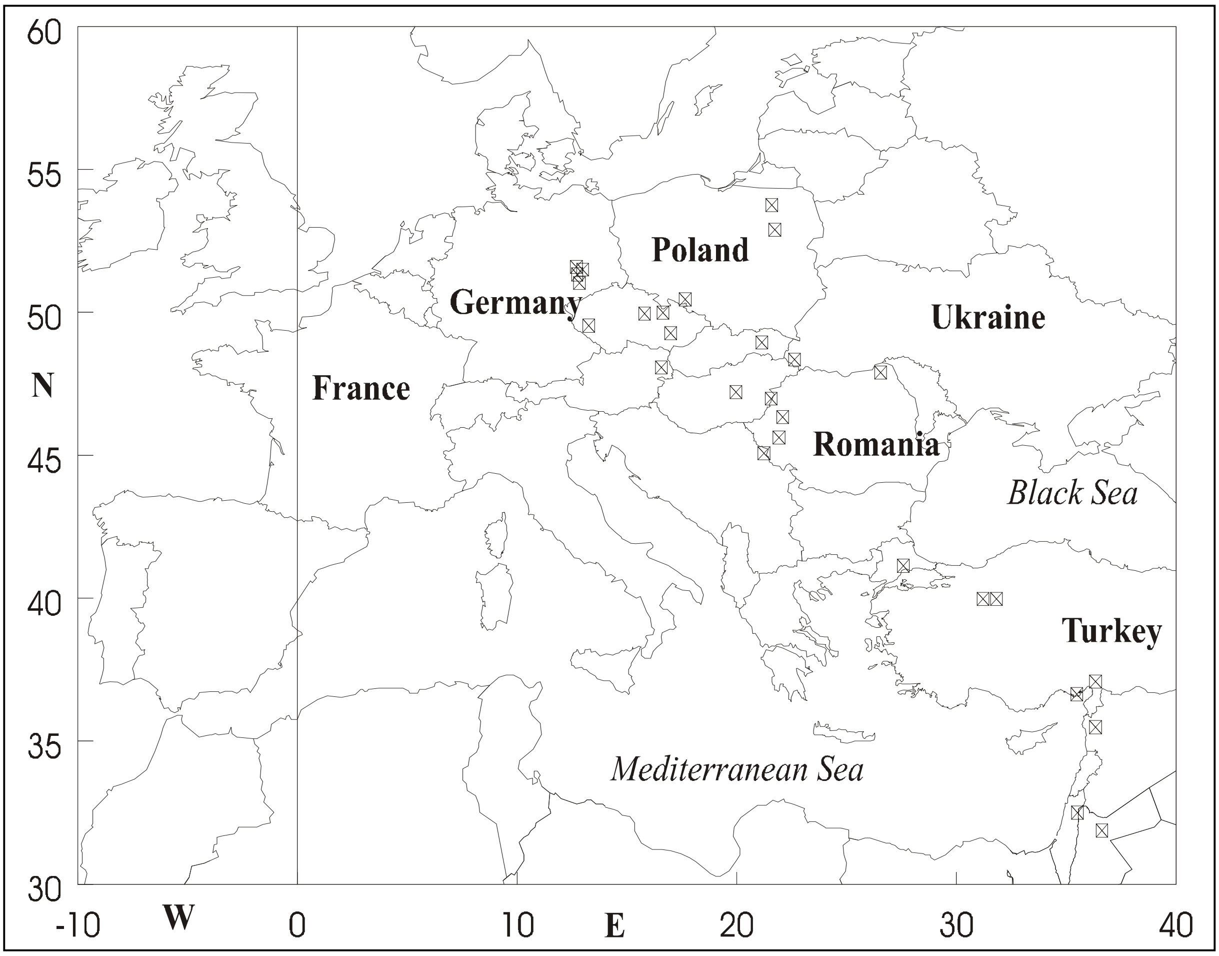


Figure II.18. ***Location of stopover sites of tagged storks, where they stayed longer than one night (1991-1996).***

If a certain location is important as a stopover site, we expect that many storks try to land in different years at this place. Thus, when we look at tagged storks we expect that the mean distance between night locations of individuals will be small and the proportion of birds within a small radius (<30 km) will be high.

The mean location of the one night stopover sites is based on data from satellite-tracked birds (Figure II.19). We plotted the night locations of 27 migrating storks and these locations grouped at a certain longitude and latitude were used for the analysis. Locations of individuals that stayed more than 100 km from each other were not used. We calculated the mean location of the roost site and the distance of each stork to this point. We used the proportion of storks roosting within a distance of 30 and 50 km from the mean location (Table VIII.3). The difference in the number of tagged individuals (6 to 16) in a certain area is caused by different choices of stopover sites and programme times of the transmitters (each day or every 2 days).

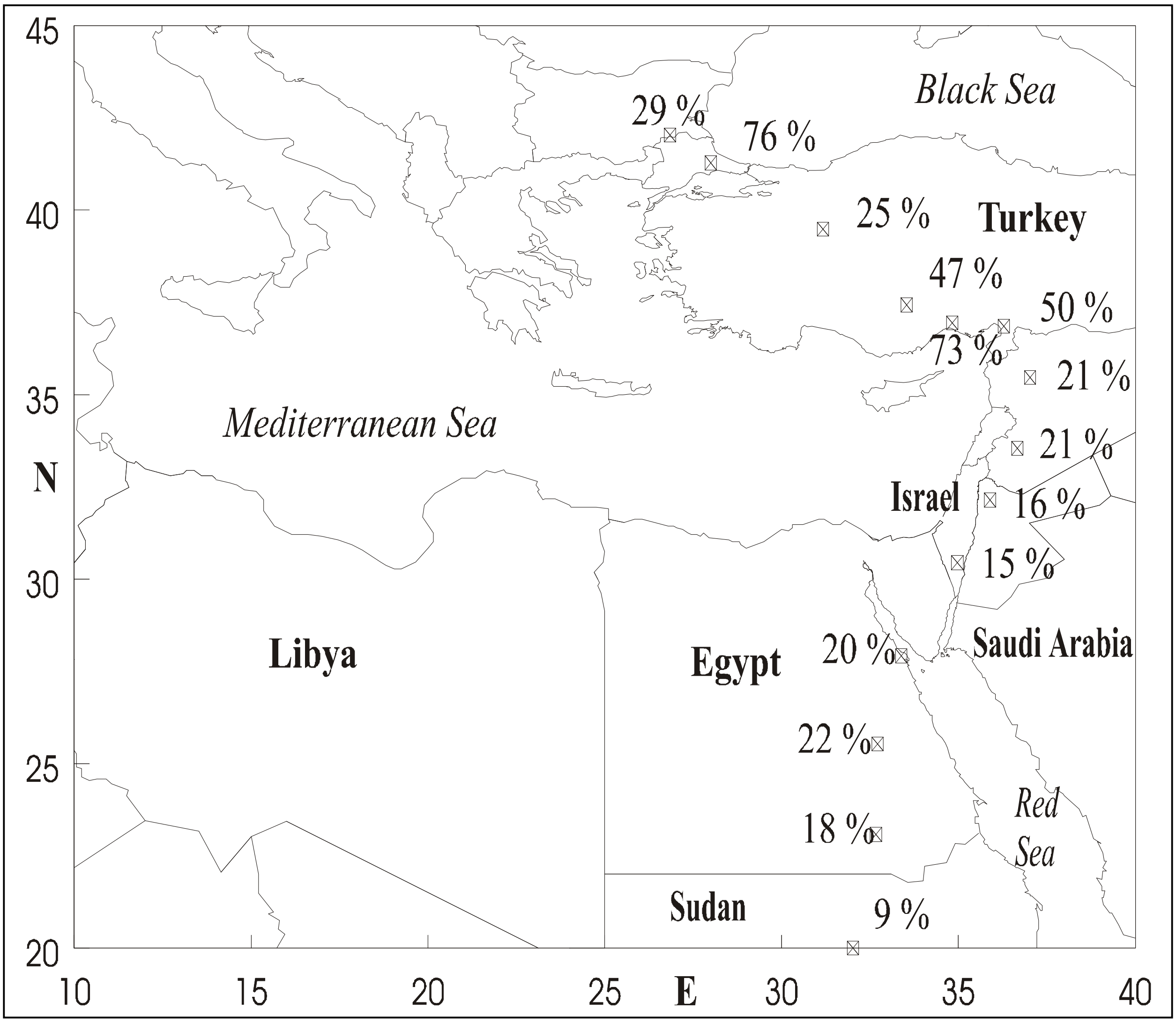


Figure II.19. ***Mean stopover sites of tagged White Storks.***

At the bottleneck areas at the Bosphorus, Goksu delta and Iskenderum tagged storks roosted at traditional sites with 50 to 76 % of the individuals roosting in a radius of 50 km (Figure II.19, Table VIII.3). In central Turkey and Bulgaria storks concentrated to a lesser extent with 25, 47 and 29 %. At areas in Syria, Jordan, Israel, Egypt and Sudan, the distances between night locations of tagged storks were larger, so there were no concentration points.

Behaviour at stopover sites. During the expeditions in eastern Europe and Turkey we collected data on the behaviour of tagged storks. At first light or maximal short after sunrise the tagged storks left their roost and landed close to that site. During the 4 hours until take off on migration the birds in Europe were feeding during 2,5 hour. In Turkey was the time between leaving the roosting site and the take off on migration much shorter, only 2,5 hours. During this period the tagged storks were feeding for 0,5 hours. No data could be gathered on the behaviour of the storks in the evening.
We can assume that during the migration to Europe the migrating tagged storks had sufficient time to catch a substantial amount of food, especially because they often landed near tractors. In the fields where tractors were ploughing or mowing the storks could easily catch food. The reduction in time that storks spend feeding in Turkey can partly be explained by the dry habitats storks chose to roost in. In these habitats are potential food items scarce. The better thermal conditions also shortens the time the storks have to wait for take off.

5.2 Bet She’an Valley as stopover site

5.2.1 Numbers and behaviour.

We distinguish 4 types of behaviour of migrating stork flocks. *Take-off* is the start on migration. *Touch and go*, is the behaviour of a group that landed to drink or rest and which took off soon after. *Passing* is when a group was migrating through the area without landing. *Landing* groups were landing to roost or feed and stayed for the night.

Autumn behaviour We observed large differences between autumns in the proportion of passing storks that stopped in the Bet She’an Valley (Table II.22). 27 to 39 % of migrating storks stopped in the area. In August, 16 to 44 % of migrating storks landed in the Bet She'an Valley to roost, which is similar to the 13 to 41 % that landed to roost in September. In autumn 1996, we observed only 15 % coming to roost, while in other autumns about 30 % roosted locally (Table II.22). In 1994 and 1996, 11 and 12 % landed to drink compared to only 4 and 5 % in other autumns.

Table II.22. ***Summary of the behaviour of White Storks migrating through the Bet She'an Valley in autumn 1993-97.***

Period	Passing	Number stopping over Landing	Touch and go	Total
Aut 1993	274405	85762 (31%)	12498 (5%)	98260 (36%)
Aut 1994	313108	85966 (27%)	34678 (11%)	120644(39%)
Aut 1995	249670	84639 (34%)	12409 (5%)	97048 (39%)
Aut 1996	278916	41181 (15%)	34761 (12%)	75942 (27%)
Aut 1997	538272	158565(29%)	24081 (4%)	182646(34%)

As shown in Table II.23, in most autumns more migrating storks landed to drink (*Touch and go*) in August than in September. The proportion of storks stopping in the Bet She'an Valley in 1995-97 was even twice as high in August as in September. Only a few hundred storks migrated through in October, so these data are left out.

In autumn, we made total counts of the storks on fishponds and fields after the morning take-off. The storks then present that are summering, wintering or migrating storks stopping for a longer period, since most migrating storks are flying at that time of the day. Compared to the ten thousands of storks passing on migration, the number of 750 to 780 local storks is small (Table II.24). At least 50 % of these storks were summering and in September wintering storks.

Table II.23. ***Behaviour of White Storks migrating through the Bet She'an Valley in August and September 1993-97.***

Period	Passing	Number stopping over Landing	Touch and go	Total stopover
Aug 1993	162765	39853	8697	48550 (30%)
Aug 1994	221901	55717	33928	89645 (40%)
Aug 1995	163798	71583	7459	79042 (48%)
Aug 1996	148390	23579	28375	51954 (35%)
Aug 1997	66873	24030	15528	39558 (59%)
Sep 1993	111399	45841	3801	49642 (45%)
Sep 1994	91146	30249	750	30999 (34%)
Sep 1995	85160	12956	4950	17906 (21%)
Sep 1996	130430	17601	6386	23987 (18%)
Sep 1997	471399	134535	8553	143088 (30%)

Table II.24. ***Numbers of local White Storks during total counts in autumn in the Bet She'an Valley from 1993 to 1996.***

	Range	Mean number	s.d.	n
August	88 – 2033	752	552	20
September	296 – 1302	783	294	18

The mean number of 1st-winter birds present during total counts in August was 40 birds. These birds are certainly migrants stopping over and this insignificant number is a further indication of the small proportion of migrants that interrupt their migration.

Spring behaviour In spring 1995 we observed about 30 % of the migrating storks landing in the Bet She’an Valley (Table II.25). There were almost no storks landing to drink, while the proportion of migrating birds landing to roost and feed was around 30 % in the first migration peak in March and also during the migration period of young birds in April and May.

Table II.25. ***Behaviour of White Storks migrating through the Bet She'an Valley in spring 1995.***

Period	Passing	Number stopping over		
		Landing	Touch and go	Total
Feb-Mar	268653	75789	1155	76944 (29%)
Apr-May	118643	35934	1514	37448 (32%)
Total	387296	111723 (29%)	2669 (1%)	114392 (30%)

Daily pattern in autumn When we look at the behaviour for half an hour intervals of White Storks passing through the Bet She'an Valley in autumn in Figure II.20 and 21, we state that the time of arrival in the area is a determinant factor in the behaviour of the storks. After the morning take off from 6.00 till 10.30 h, there were almost no birds landing during the next 3 hours (Figure II.20 and 21). Storks that did land before midday came to drink. More and larger flocks landed during midday (11.30-14.00 h) to drink (touch and go) but did not stay in the area very long. In larger flocks, storks still land to drink, while the first are taking off again. These drinking flocks stayed on the ground no longer than 15 to 30 minutes. Some individual storks and small groups landed to roost and feed throughout the day, but it is difficult to distinguish them from local birds. Their total number is very small compared to the large numbers of passing birds. Some of the large flocks that were passing between 14.30 and 16.00 h did not land because they were disturbed. In August, the first larger flocks of more than 500 birds had landed to roost from 13.30 h. After 16.00 h, almost all groups had landed in the area (Figure II.20).

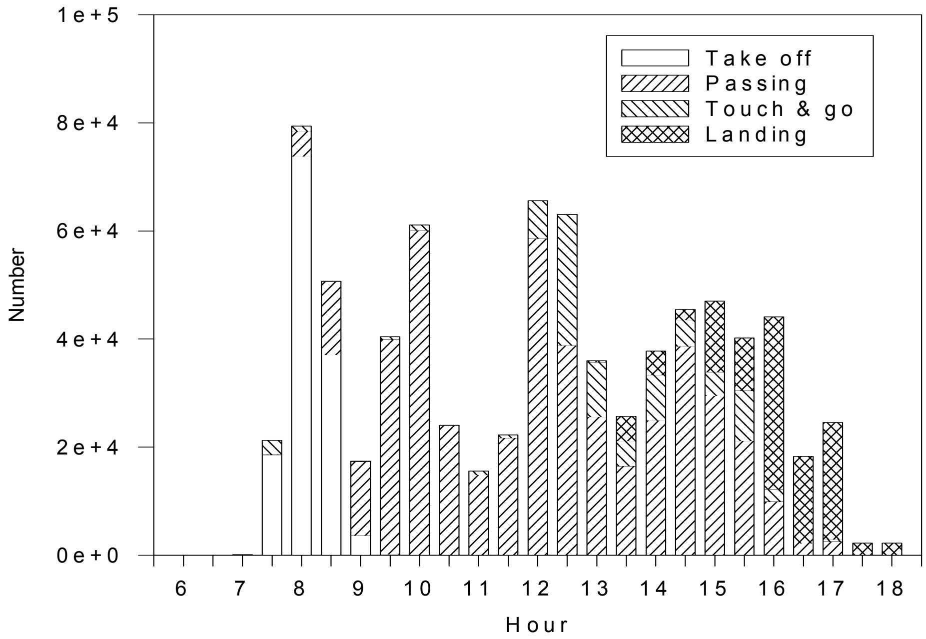


Figure II.20. ***Behaviour per half hour of White Storks passing the Bet She'an Valley in August (1993-96).***

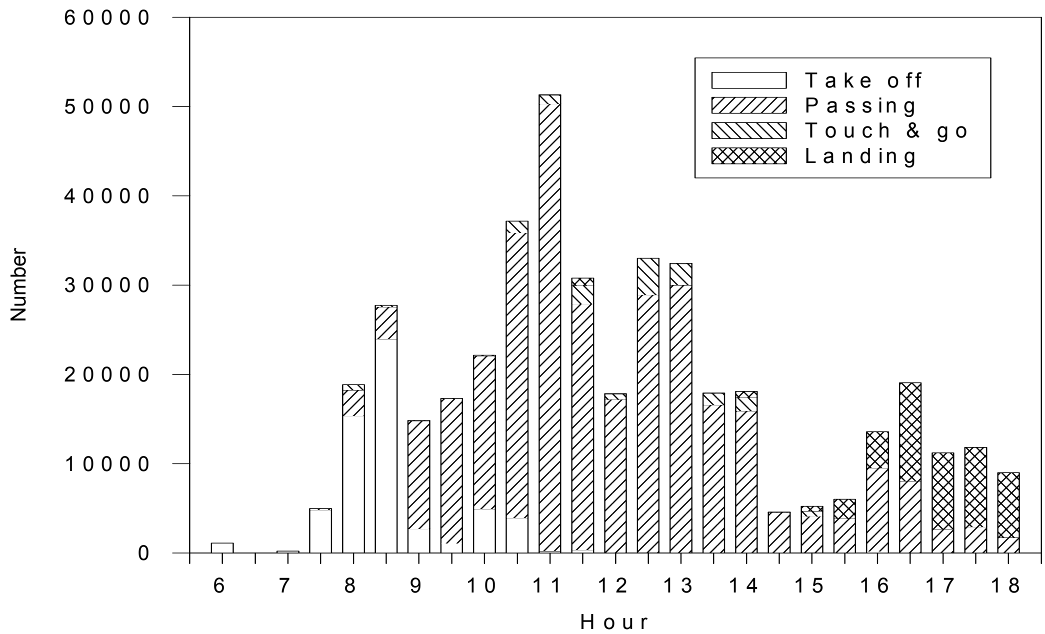


Figure II.21. ***Behaviour per half hour of White Storks passing the Bet She'an Valley in September (1993-96).***

In September, less storks landed to drink than in August and the flocks landed later (Figure II.21). We observed large flocks of up to 12000 birds that continued their migration after sunset. They arrived in the Bet She'an Valley from Jordan, gained height above the eastern slopes of the valley and continued to fly south, not attracted by the fishponds.

Daily pattern in spring In March 1995, storks started to take off from 7.30 h till 10.30 h, but not all at the same time (Figure II.22). In the afternoon, we observed only small numbers of migrants. Before midday, there were only very few storks that landed to feed or drink in the area. In April and May, storks took off from 7.00 to 10.30 h, with a peak between 7.30 and 8.30 h (Figure II.23). Throughout the day, a small proportion of storks landed to feed or drink in the study area.

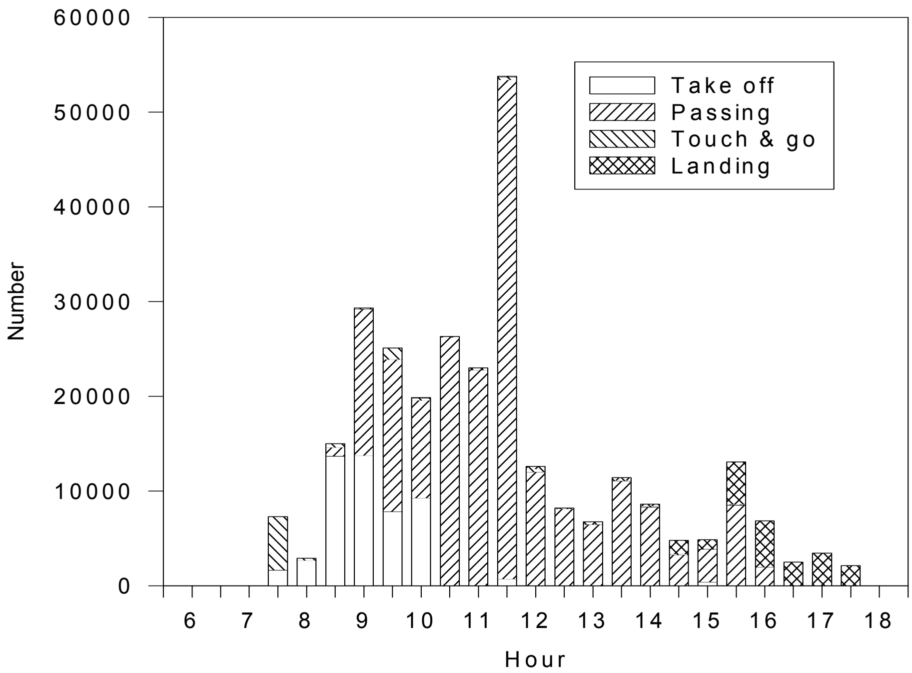


Figure II.22. ***Behaviour per half hour of White Storks passing the Bet She'an Valley in March 1995.***

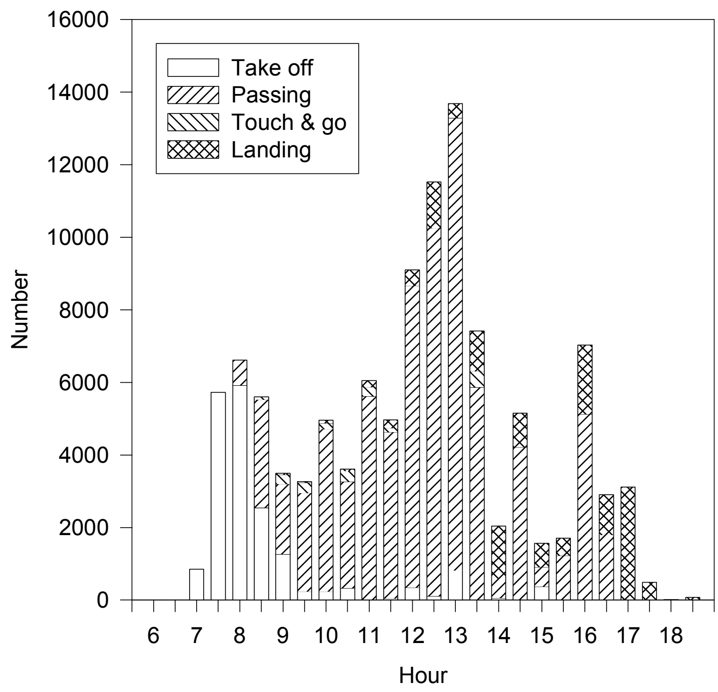


Figure II.23. ***Behaviour per half hour of White Storks passing the Bet She'an Valley in April and May 1995.***

5.2.2 Behaviour of landing Storks

5.2.2.1 Numbers

We classified the behaviour of storks that landed to roost in 3 types : feeding, resting and performing movements. Feeding birds looked for food by walking around or actually feeding. Resting storks were preening or dozing. Storks were moving by flying between roost sites and feeding or resting sites. So, these categories do not include the take off for migration. The number of controlled birds after 8.00 h is smaller because many storks started their migration around this time. Most storks were migrating and landing in large groups. Not all the birds in a flock necessarily behave in the same way. For instance, only part of a flock in a field would try to forage. We noted a flock of 1000 birds of which 20 % were feeding, i.e. 200 feeding and 800 resting birds. In autumn, the storks left the pond were they had been sleeping from sunrise till 1.5 hour after sunrise (Figure II.24 and 25). After this time, they remained at the same place until take-off. In the morning hours, less than 10 % were feeding, the majority were resting. About 5 to 10 % of the storks that landed early in the afternoon from 14.30 to 16.30 h were feeding but later most birds were resting. They flew to roosting sites after sunset.

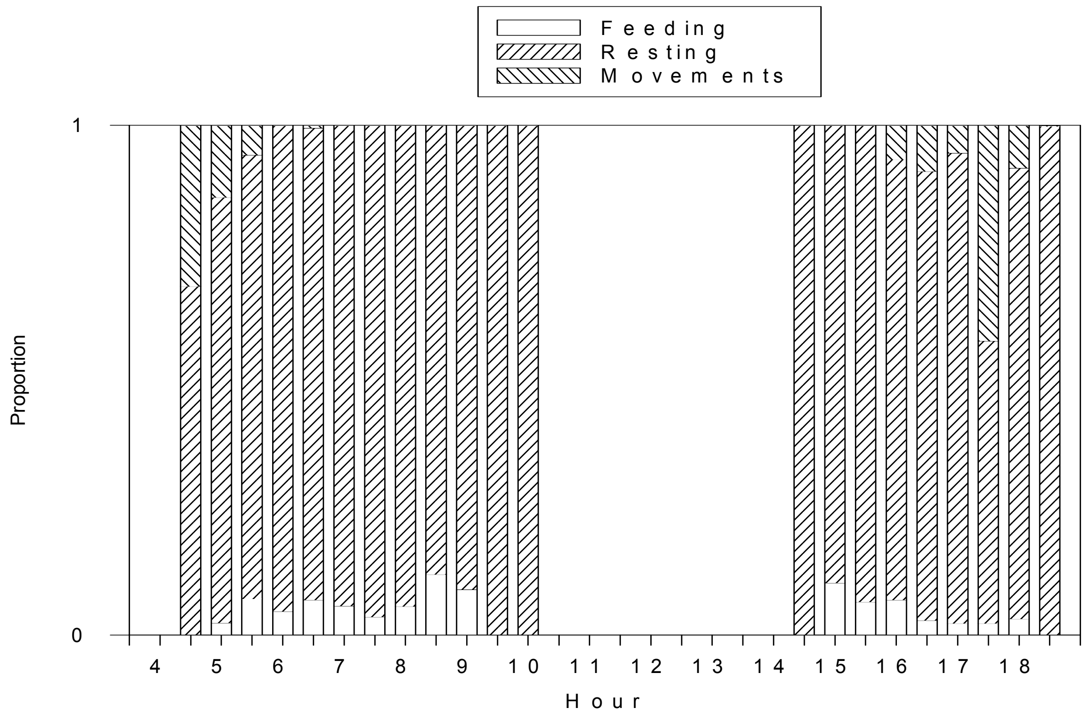


Figure II.24. ***Behaviour of migrating White Storks landing in the Bet She'an Valley in August (1993-96).***

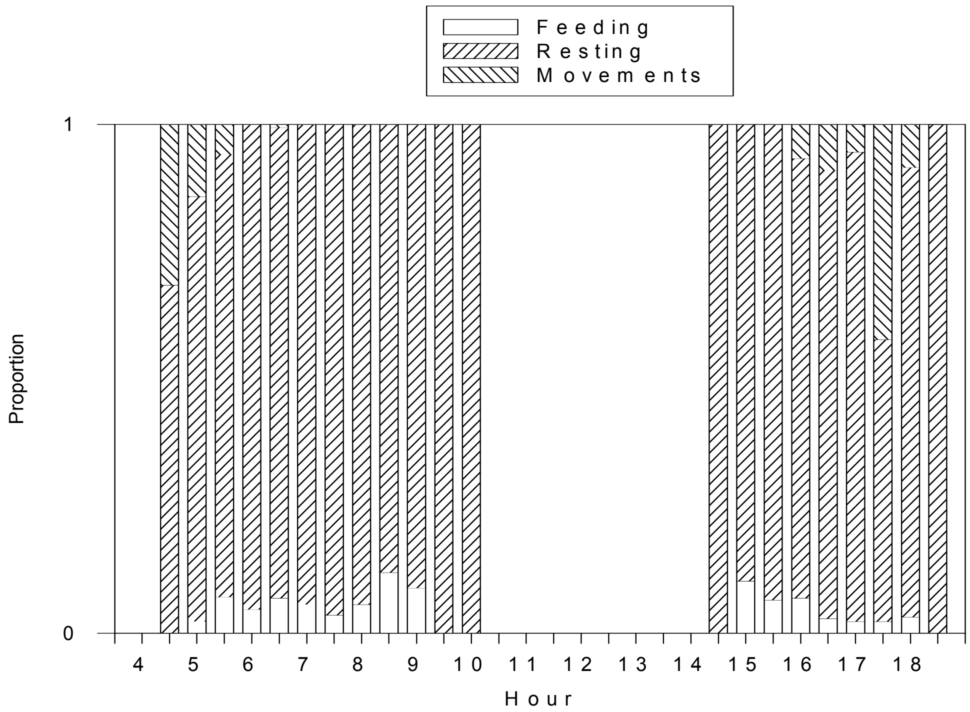


Figure II.25. ***Behaviour of migrating White Storks landing in the Bet She'an Valley in September(1993-96).***

In spring, storks left the roosting site from sunrise till 1.5 h after sunrise. In March, April and May, we observed storks feeding throughout the day (Figure II.26 and 27). Before most of the storks took off between 8.00 and 9.00 h, 20 to 40 % were feeding in March and 50 to 70 % in April. In the afternoon less birds were feeding than in the morning. Storks flew to the roosting site after sunset.

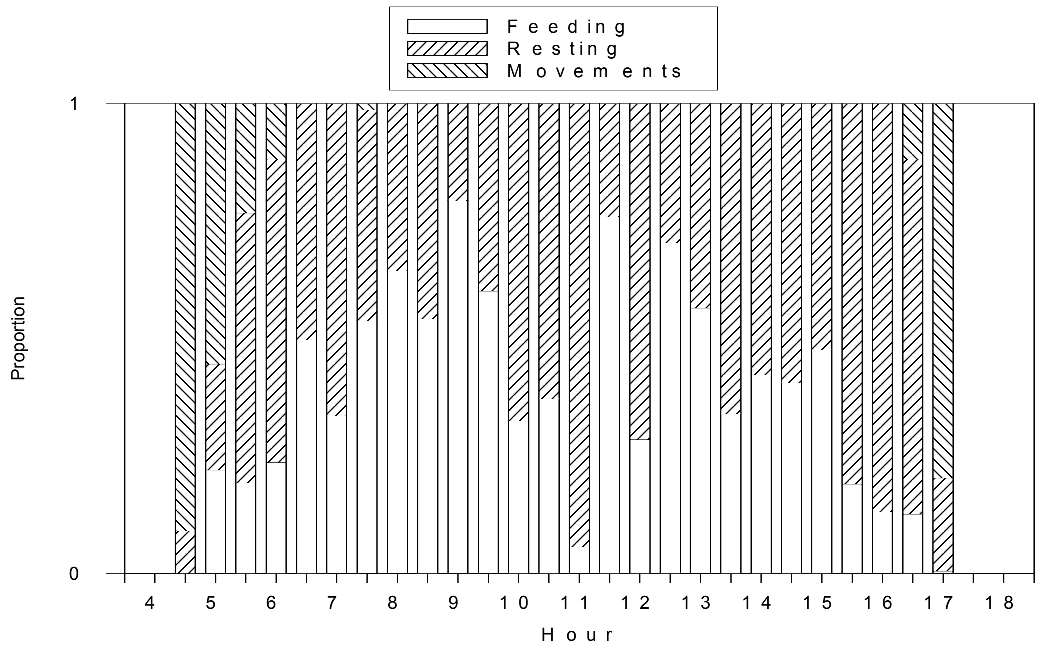


Figure II.26. ***Behaviour of migrating White Storks landing in the Bet She'an Valley in March 1995.***

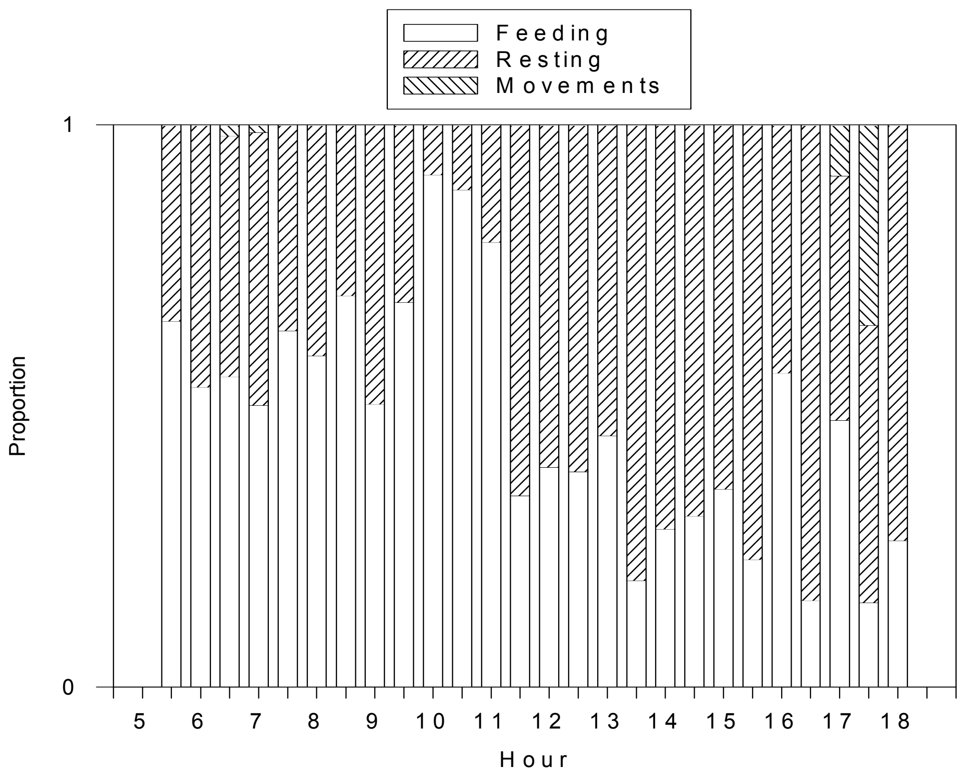


Figure II.27. ***Behaviour of White Storks landing in the Bet She'an Valley in April and May 1995.***

5.2.2.2 Habitat choice of landing migrating Storks

Habitat choice in autumn. In August, most migrating flocks landed on fishponds to rest in the afternoon (Table II.26). On alfalfa fields, which are a potential feeding ground, there was only one big flock landing in 1993. If there were no suitable fishponds available the flocks landed on arable lands, which are dry ploughed fields. In the morning, some flocks flew to alfalfa fields and most storks were now resting on ploughed fields. Garbage dumps were not visited.

Table II.26. ***Proportion of migrating White Storks present in different habitats in August 1993-96.***

	Fishpond	Alfalfa	Arable land	Garbage dump	Total
August 1993					
Morning	32 %	6 %	62 %	0 %	29578
Afternoon	69 %	12 %	19 %	0 %	31141
August 1994					
Morning	49 %	5 %	46 %	0 %	30923
Afternoon	91 %	4 %	5 %	0 %	31637
August 1995					
Morning	25 %	3 %	72 %	0 %	38500
Afternoon	92 %	3 %	4 %	0 %	24853
August 1996					
Morning	36 %	10 %	54 %	0 %	8042
Afternoon	73 %	1 %	26 %	0 %	9493

The habitat choice of storks in September was similar to that in August (Table II.27). The majority landed in the afternoon at ponds and no storks landed on alfalfa fields. Storks left the ponds in the morning and flew to ploughed fields and exceptionally to alfalfa fields. Garbage dumps were rarely visited.

Table II.27. ***Proportion of migrating White Storks present in different habitats in September 1993-96.***

	Fishpond	Alfalfa	Arable land	Garbage dump	Total
Sep 1993					
Morning	58 %	0 %	42 %	0 %	25013
Afternoon	96 %	0 %	4 %	0 %	18769
Sep 1994					
Morning	15 %	25 %	61 %	0 %	5881
Afternoon	70 %	0 %	30 %	0 %	13236
Sep 1995					
Morning	69 %	0 %	30 %	1 %	3779
Afternoon	77 %	0 %	23 %	0 %	5974
Sep 1996					
Morning	45 %	0 %	55 %	0 %	4700
Afternoon	100 %	0 %	0 %	0 %	7689

Habitat choice in spring. In spring, more than 50 % of the migrants landed at fishponds to feed or rest (Table II.28). But compared to autumn more birds landed on fields and on garbage dumps to feed. In the morning, most storks flew to fields or garbage dumps. In spring 1996, there were more storks that used the garbage dump than in 1995.

Table II.28. ***Proportion of migrating White Storks present in different habitats in spring 1995 and 1996.***

	Fishpond	Alfalfa	Arable land	Garbage dump	Total
Spring 1995					
Morning	27 %	36 %	36 %	0.4 %	71183
Afternoon	54 %	12 %	35 %	0.3 %	53437
Spring 1996					
Morning	18 %	31 %	34 %	17 %	53597
Afternoon	63 %	2 %	25 %	10 %	59379

Landing at fishponds. In autumn and spring, migrating storks preferred to rest and roost on completely or partially drained medium sized grow-out ponds. These ponds have a size of about 350 x 100 m, high reeds grow at the edge, water is shallow and there is no disturbance. The very large reservoirs in the area were not used as roosting sites. Storks preferred smaller ponds, but not storage ponds because these were to small. They liked to rest away from the road towards the open water and concentrated in the centre of the pond and in the part which contained water. Completely dry ponds were rarely used. The largest flock of 32000 storks rested in a pond of 2 ha with all birds standing very close together in the centre and in the water.

We had the impression that roosting local storks attracted migrating flocks to land. Flocks did not land just anywhere on a pond but were heading to good sites, even when they had to fly against their normal migratory direction. The sites where flocks preferred to land, were situated in the eastern or southern part of the Bet She’an Valley. No large flocks were found roosting west of Scheluhot. The ponds of Ma'oz Hayyim-New Etan, Ma'ale Gilboa, En Hanaziv, Tirat Zevi, Hamadya (border) and Gesher were the most important fishpond areas for landing storks. Some flocks roosted at Kefar Ruppin, Scheluhot and Sede Eliyahu.

After they landed, most storks were preening and resting. Very few individuals left the large resting flocks to feed at fishponds with local birds. When a pond was only partially drained, some birds tried to feed on dead or living fish. These individuals searching around for food were mainly 1st-winter storks.

Landing on fields. Storks used fields as resting sites but never slept in these open areas. When part of a larger flock started to land in a field, the whole flock usually followed. The fields were always big enough to receive thousands of storks, there are no hedges or fences. Birds that landed on fields had to move to trees or fishponds to sleep. In most cases suitable fishponds were not very close to the landing site, otherwise birds would have landed on the pond, so they slept on electricity poles or pylons, single trees, small bushes or tree-lines. In the morning, the flocks preferred to stay on the pond to rest if conditions were optimal. When disturbed or when there was not enough water in the pond, the storks left to fields, formed a dense flock and rested until the weather conditions (thermals) were suitable for take-off. If the field where the birds were resting, was close to an alfalfa or another suitable field, at least part of the flock would start to feed. In the morning, a higher percentage of storks were trying to feed compared to the afternoon. If we compare fields to ponds, there was a larger percentage of the flock that tried to feed or walked around. On several occasions, the first birds to look around for food were 1st-winter storks. Although some storks tried to feed on fields in autumn, the flocks did not land especially on alfalfa and turf fields which contained more potential food resources than dry, ploughed fields.

6. Migration patterns in successive years

Migration and stopover days. We could follow 4 tagged storks during their spring and autumn migratory flight. '*Polsky*' and '*Prinzessin*' were followed during 3 years, but in one spring the transmitter of '*Prinzessin*' failed and its route could not be completely tracked (Table II.29).

Table II.29. ***Autumn and spring migration pattern of tagged storks.***

Code	Route	Period	Days
'Polsky'	Poland-Sudan	22.08-11.09.96	21
	Sudan-Poland	31.03-16.05.97	47 (24)
'Polsky'	Poland-Sudan	14.08-01.09.97	19
	Sudan-Poland	09.03-09.04.98	32 (22)
'Polsky'	Poland-Sudan	22.08-08.09.98	18
	Sudan-Poland	12.03-15.04.99	35 (22)
'Prinzessin'	Germany-Sudan	29.08-19.09.94	21
	Sudan-Germany	6.04-25.05.95	49 (23)
'Prinzessin'	Germany-Sudan	25.08-17.09.97	24
	Sudan-Germany	? -24.04.98	?
'Prinzessin'	Germany-Sudan	23.08-07.09.98	16
	Sudan-Germany	28.03-30.04.99	34 (23)
No 98552	Poland-Sudan	26.08-08.09.98	14
	Sudan-Poland	19.03-15.04.99	28 (25)
No 981979	Poland-Sudan	29.08-20.09.98	23
	Sudan-Poland	10.03-28.03.99	19 (17)

The storks needed only 14 to 24 days to fly from the breeding area to Sudan, but more than twice as much to cover the same distance in spring. Only No *981979* covered the distance Sudan to Poland in 19 days in spring compared to 23 in autumn (Table II.29). This large difference is caused by more and longer stopovers in spring and shorter daily distances covered on days with bad weather conditions.

If we look at the amount of time the same individuals needed to pass through areas with good thermalling conditions, there is almost no difference between spring and autumn migration. 'Polsky' needed 10 days in autumn as well as in spring to fly from Syria to Sudan and back (Table VIII.2). It took No *96552* 10 days to fly from southeast Turkey to Sudan in autumn and 11 days for the same journey in spring. No *96992* had to fly 4 days from Israel to southern Egypt and 5 days for the same distance in spring. *'Prinzessin'* flew from Israel to Sudan within 5 days and back in spring within 7 days. No *98552* covered the distance between Sudan and Syria in 7 days in autumn and in 8 days in spring. No *981979* needed 6 days in autumn and 8 days in spring from Israel to Sudan (Table VIII.2).

Choice of stopover sites. We observed only two marked migrating storks during more than one season in Israel. The adult stork *L4149* stayed in the Bet She'an Valley from 6 to 19 August 1995 and returned to the same area from 29 March to 2 April 1996. The 2nd-winter stork *L4244* stayed in the Bet She'an Valley from 10 to 30 August 1995 and was observed at the coast at Ma'agan Michael on 9 September 1996 (Y.Perlman, pers.com.).

To describe the importance of the repeated use of stopover sites we have to rely on the observations on tagged storks. We compared the locations of stopover sites of 5 tagged storks in Table VIII.4 to VIII.8, which are summarized in Table II.30. We measured the distance between night locations of the storks passing through the same area as during the previous migration. Not every site could be compared because for some nights we have no data or the location was not in the same region.

'*Prinz*' roosted in Europe at different places in both autumns (Table VIII.4). After crossing the Bosphorus it slept 41 km northwest of the site in 1994, but in the Middle East it stayed at 86 to 125 km from previously used sites. In Sudan, the distance between the sites was twice quite small, 34 and 55 km.

Table II.30. *Distance between night stopover locations of White Storks during different migration seasons (distance in km).*

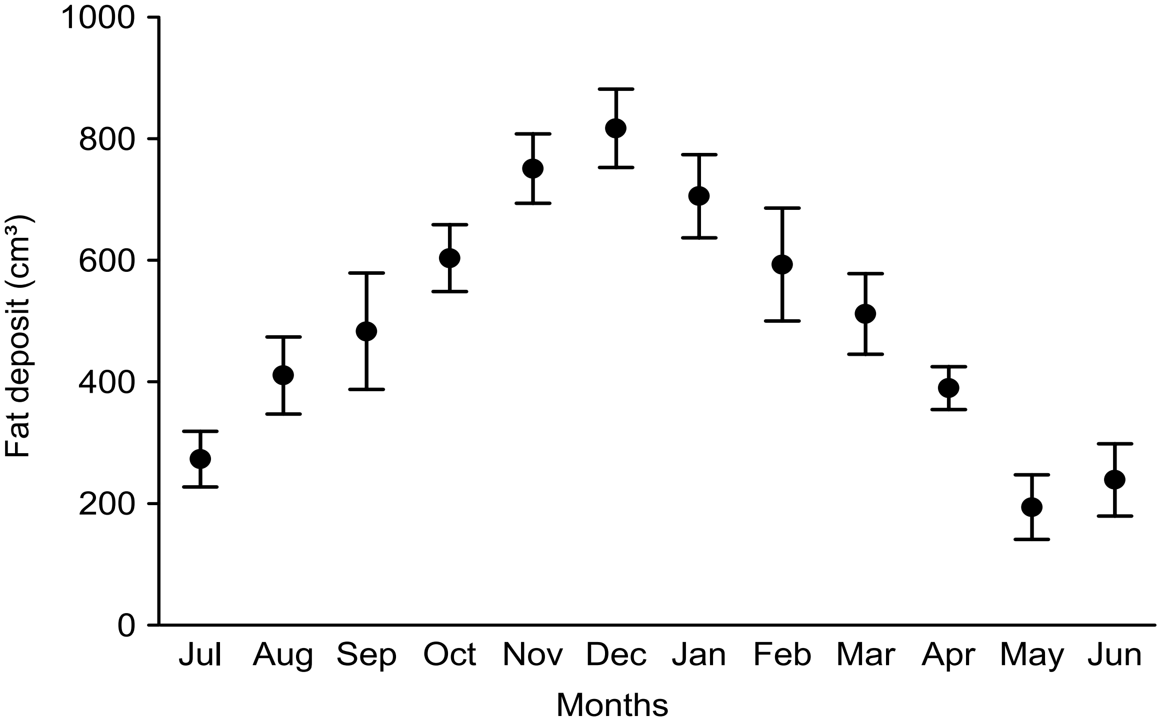
	Period	Europe	Middle-East	Africa
'Prinz'	aut94-aut96	59-219	41-125	34-165
'Prinzessin'	aut94-spr95	303-337	33- 94	131-211
'Polsky'	aut96-spr97	34-118	47-197	84-157
No 96552	aut96-spr97	39	74-139	104-185
No 96992	aut96-spr97	-	24-141	93-162

In spring, '*Prinzessin'* stayed for 8 to 10 days in Sudan at 12°02'N 33°43'E, while in autumn it was at 11°44'N 34°56'E. '*Prinzessin*' followed a slightly different route in spring in Sudan (15°N) and southern Egypt (21°N)(Table VIII.5). In autumn, it had passed more east of the 6-days spring stopover site in the Golan Heights. In Europe, it flew more than 300 km to the east in spring. In Turkey, it used spring and autumn roost sites closer to each other, 72 and 33 km. *'Polsky'* used a similar route in spring and autumn (Table VIII.6). In eastern Europe, it roosted at 53 and 34 km from the autumn roost. In Bulgaria (42°N), near the Bosphorus (40°N) and Iskenderum (37°N), it used roosting sites between 54 and 77 km from each other. In Israel, it used stopover sites in the Negev in spring, but in autumn it migrated through Jordan. Near the Red Sea (27°N) and along the Nile (23°N), it roosted at 47 and 84 km from its autumn location. No *96552* stayed in Sudan for 3 days in spring close to the place where it had stayed in September (15°04'N 32°24'E and 15°00'N 32°33'E). Further along the migration route it used quite different stopover locations in spring and autumn migration in Africa and the Middle East (Table VIII.7). It had stayed in autumn at 39 km from the location at the Bosphorus where it stayed 10 days in spring. No *96992* used different roosting sites along the Nile and in Sinai (29°N, Table VIII.8). In Israel, it stayed in the Negev for 14 days in spring at a location which it passed in autumn slightly more east and in Syria, the distances between spring and autumn locations were only 24, 31 and 56 km.

7. Energy budget

In order to understand the energetics of White Stork migration, including possible energy loading (fat deposition) before and during migration, the following study was carried out. 12 test birds (young storks) from Saxony-Anhalt were monitored for 15 months to follow seasonal changes in body mass (by monthly weighing) and in the internal organs (mainly breast muscles) and tissues (mainly fat depots and water content) by monthly MRI and MR-spectroscopy. The body mass data of the captive storks were compared to those of large samples of conspecifics trapped in Saxony-Anhalt and Israel. The breast muscles of the experimental storks exhibited the prolonged growth typical of the juveniles of large species but no conspicuous change during the migration periods. The experimental study further revealed that – surprisingly – fat deposition (Figure II.28) and body mass (Figure II.29) are low during both the outward and the homeward journey and peak in mid-winter.

Figure II.28. ***Annual variation of the entire visceral abdominal fat depot (means and***



standard deviations) of the test storks as established by MR tomography.

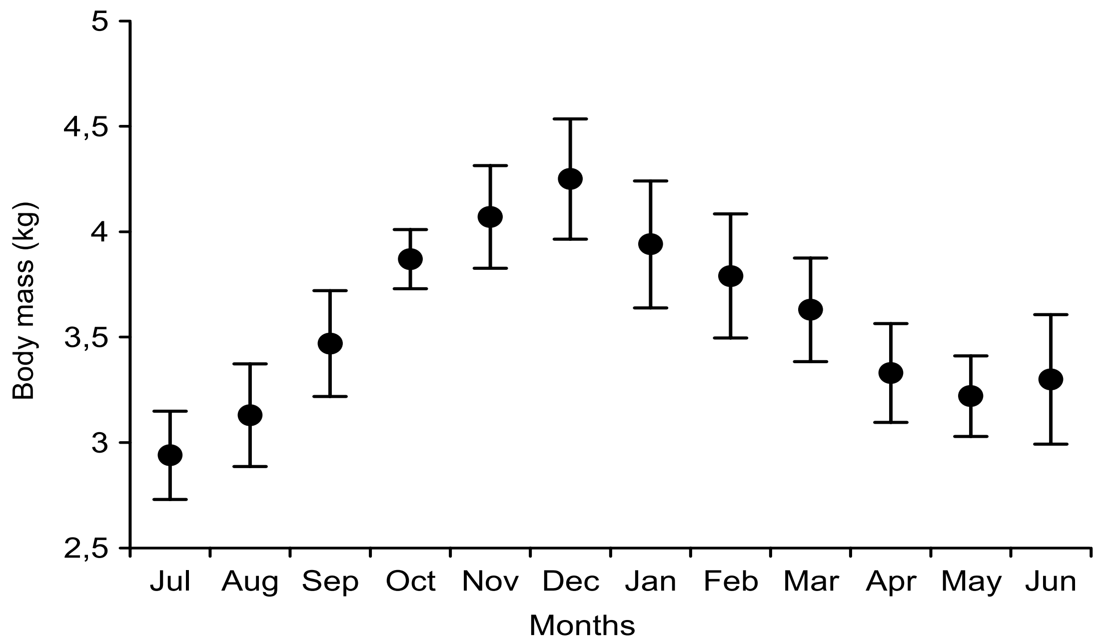


Figure II.29. ***Annual variation in body mass (means and standard deviations) of a test group of White Storks of the eastern population in Germany in a photoperiod that was partly natural (during the breeding season) and partly stimulated (during the winter season).***

These findings are in full accordance with the low body weights found for White Storks in Saxony-Anhalt before takeoff, and are consistent with the finding of low weight in birds passing through Israel during migration but high weight in birds wintering there (Chapter I.6.3). This indicates that White Storks migrate along the eastern route with no, or no substantial, fat depots. In accordance with this finding, the experimental storks showed no discernible hyperphagia during the migratory periods. This again corresponds to the behaviour of free-living conspecifics which – at least on the outward journey – evidently feed mainly to meet their immediate needs when in eastern Europe, more opportunistically when approaching the Mediterranean Sea, and practically not at all in Israel (Chapters II.2; II.5.2). The detailed laboratory (MRI) study showed that the body mass increase towards a peak in winter is precisely paralleled and caused by visceral and cutaneous/subcutaneous fat depots. Their occurrence in mid-winter is interpreted as an adaptation to unpredictable conditions in the winter quarters (Sudan to South Africa).

It is clear from these energetic studies as well as from our satellite tracking studies and investigations at staging areas along the migratory route that White Storks have a very peculiar mode of migration. We call it the MSOM type – from "**m**ostly travelling every day", "**s**eldom inserting whole-day rests", "**o**pportunistically feeding" and "**m**oderate or no fat depots developing" (to distinguish it from the normal types ILHB for "intermittently migrating" and NNHB "migration non stop; for details see Berthold et al. 2001). It is likely that White Storks that begin migration in central or eastern Europe with low or even without fat depots lose weight on the outward trip and do not regain it until they reach Africa. Body weight samples from storks of Saxony-Anhalt and Israel are in favour of this view (Berthold et al. 2001).

8. Discussion

Migration routes. The migration routes followed by tagged storks correspond with previous descriptions of migrating storks in this century. Tagged individuals followed narrow routes through the Middle East until Lake Nasser in southern Egypt and Sudan. They avoided crossing large water bodies and passed along narrow migration flyways through the Bosphorus region, Iskenderum and flew through the Syrian Rift and the Jordan Valley to El Tor in Sinai where they crossed the Red Sea. In these bottleneck areas, storks still have to cross several kilometres of water. In Sinai, the Gulf of Suez is 25 to 30 km wide, in Turkey the Bosphorus is only 1 to 5 km wide and the Gulf of Iskenderum up to 30 km. In Spain, they cross the Strait of Gibraltar, which is 14 to 20 km wide. Only 3 out of 33 tagged storks avoided the Sea of Marmara by flying across the Dardanelles, which confirms the data from ring recoveries and ground observations stating that maximally 25 % will cross the Sea of Marmara and the Daranelles (Bijlsma 1987, Kasparek and Kilic 1989). Most tagged storks reached the Mediterranean Sea at the Göksu Delta and followed the shore line to Iskenderum in southeast Turkey. The tagged storks could have avoided the crossing of the Red Sea by flying through Suez, but none of them did so and they crossed the southern part of the Gulf of Suez near El Tor, which was also observed by Koch et al. (1966) and Safriel (1968). Small numbers cross the Gulf of Suez south of El Tor at Ras Mohammed, the southern point of Sinai. At this point there are islands that could attract the migrating flocks (Koch et al. 1966). This information from the tagged storks confirms the exceptional observations of storks flying across the Mediterranean Sea. Exceptional was the arrival of about 1000 storks in Cyprus, which is about 80 km from the Turkish mainland, on 31 August and 1 September 1978 (Schüz 1980). Most storks left the island during the next days.

Fidelity to migration routes. The 5 tagged storks, including the male wintering near Lake Chad, were faithful to their eastern bound migration in spring. There is only one indication in the literature that not all White Storks choose the same route every autumn. 97 % of ringed adult storks breeding in northwest Germany took a southeasterly direction. However, from 1st-winter storks of the same area, 24 % migrated southwest (Meybohm 1993). This was after the data had been corrected for a 2.44 higher recovery rate on the western route.

Because of the high mortality risk it is unlikely that many storks survive crossing the Mediterranean Sea from Italy to Tunisia and can return on the same route in spring. Marked eastern storks that were found in Tunisia and Libya were mainly 1st-winter storks, found in the summer period (Schüz and Böhringer 1950). Thiollay (1967) observed White Storks at Cap Bon (Tunisia) only in the first half of April. This confirms the ring data, because at this time most migrants are 1st-winter storks. These data show that this route is not a regular route for a significant number of eastern storks.

Timing of autumn migration. From 1988 to 1992, there were only a few stations in the eastern part of the Bet She'an Valley after 5 September. Part of the migration was certainly missed. From 1993, an observation post was manned further south in the valley at Tirat Zevi, where more storks were observed entering the valley from the east. Thus the increase in the numbers of storks counted in the Bet She'an Valley until 1993 is a result of better coverage.

Between countries there are large differences in the proportion of breeding storks that are marked. From 169 storks recovered from 1969 to 1996 in Israel, 88 (52%) were ringed in Germany. However, in Germany only 4155 breeding pairs are counted (Kaatz 1999), which is much less than in the more important breeding sites in Poland, White Russia, Ukraine and the Baltic States. In the latter countries, there are at least 88600 breeding pairs (Grischtschenko 1999, Janaus and Stipniece 1999, Malinauskas and Zurba 1999, Petrov et al. 1999 and Samusenko 1999) and only 31 (18%) were recovered in Israel between 1969 and 1996.

In Israel we observed a bimodal migration wave with mainly 1st-winter storks passing in the second half of August and adult storks passing from 4 to 17 September. In August, 2nd-winter storks joined the flocks of young birds. In Gibraltar, most storks pass between 26 July and 25 August (Lazaro and Fernandez-Cruz 1989). The first migration wave at the end of July is mainly composed of 1st-winter Spanish storks. Central European storks arrive at the beginning of August, but most 1st-winter storks are recovered in Spain at the end of August and during the first decade of September (Bernis 1980). This is confirmed by the observation that west German 1st-winter storks left the nest in the middle of August and immediately started their autumn migration (Bairlein 1979). These 1st-winter storks reached the Gibraltar area before the adults (Lazaro and Fernandez-Cruz 1989). Young White Storks from northern breeding areas left later and arrived after southern birds in Israel. Storks from northeast Germany leave punctually in the third decade of August (Schüz 1952). Storks from Ukraine start in the last decade of August, but some storks stay until the beginning of October (Grischtschenko et al. 1995). The departure in

Greece takes place in August (Martens 1966). In southern Poland in 1973-87, 188 adult stork pairs left the nests between 10 August and 10 September, with mean departure date on 27 August (Profus 1991). In Bulgaria, White Storks migrate through from the end of July and peak numbers occur in the second half of August (Michev and Profirov 1989). The daily numbers of migrating storks were smaller than 500 after 10 September and were on most days not more than 100. At the Bosphorus, there are two migration peaks at 16 and 31 August, while 800 km southeast at Iskenderum (Belen Pass), peak passage occurred at 26 August and 5 September (Kasparek and Kilic 1989).
Meinertzhagen (1930) observed a migration timing in northern Syria similar to the timing assessed in recent surveys. White Storks arrived in large numbers in the third week of August and migration lasted until mid-September. This timing of autumn migration has stayed the same until now (Schüz 1955, Mendelssohn 1975, this study). First migrating flocks appear at the end of July.

In Israel, we observed that in the first migration wave in August about 70 % were 1st-winter storks, while less than 10 % were young birds in the second wave in September. This distribution of age groups is slightly different from observations in Spain. Lazaro and Fernandez-Cruz (1989) checked the age of 5325 resting storks in the period of 21 July to 31 August 1985 in the Gibraltar zone. During peak passage at the end of July and the beginning of August, the proportion of adults was less than 10 %. In the middle of August, about 50 % were adults.

1996 was a year with a normal breeding season. We estimated that in this autumn in Israel 46 % of the migrants were 1st-winter storks. In the exceptional year 1997, only 18 % were young storks. In 1985 in Spain, 74.5 % were 1st-winter storks and 25.5 % adult birds (Lazaro and Fernandez-Cruz 1989). These data do not correspond with the estimation of Schüz (*in* Bauer and Glutz 1966), that the population at 1 August is composed of 29 % of 1st-winter storks, 41 % of non-breeding 2 to 19-year-old storks and 29 % of breeding adults. The higher proportion of young storks in Spain can be explained by the fact that most storks in Gibraltar are Spanish storks which migrated only a few hundred kilometres. Tagged storks showed a very high mortality in Europe and many young storks had died before they could reach Israel. Furthermore, a higher proportion of adults might stay in Spain or leave later.

The proportion of the total number of autumn migrants passing on peak days in Israel is comparable with Bulgaria. In Israel, 14 to 34 % passed on peak days and in Bulgaria 15 to 24 % (Michev and Profirov 1989). The maximum in Bulgaria was 38439 storks on 27 August 1983, while in Israel on peak days 40000 to 66000 (1990-1996) passed and exceptionally 162856 on 6 September 1997.

From 1993 to 1996 the mean flock size in Israel was 310 to 471 in August, 165 to 359 in September and 11-16 storks in October. In 1997, the flocks were unusually small in August and large in September. At other migration points, similar flock sizes were observed. Sutherland and Brooks (1981) observed a mean flock size of 287.7 storks on autumn migration through the Belen Pass in Turkey. In Bulgaria, the mean flock size in autumn 1979-83 was 650, 375 and 26 birds in August, September and October, respectively (Michev and Profirov 1989). However, there were much larger flocks in Israel. The largest flock in Bulgaria was 21000 storks and between 1979 and 1983 6 flocks contained more than 10000 birds (Michev and Profirov 1989). At the Belen Pass in Turkey, the largest flock contained only 4000 storks (Sutherland and Brooks 1981). In Israel, we observed the largest flock of 34800 storks on 6 September 1997 and 60 to 75 % of all storks passed in flocks larger than 1000 storks. The peak of 162856 storks on 6 September 1997 is exceptional, but there are a few observations of large flocks on autumn migration. At 28°21' N, 100000 storks crossed the Gulf of Suez on 2 September 1903 (Von Staden *in* Koch et al. 1966). Hundreds of thousands crossed the Gulf of Suez, 48 km northeast from El Tor in September 1907 (Kaufman *in* Schüz 1955), and 70000 crossed the Gulf of Suez at 28°05'N on 31 August 1929 (Wellmann *in* Schüz 1955).

Timing of spring migration. The arrival time of storks in Israel depends on their departure from the wintering grounds. Weather and food conditions determine if storks will mainly winter in central or southern Africa (Dallinga and Schoenmakers 1984). For instance, after the dry winter of 1972, most storks passed through Africa in April and May in contrast to the normal migration from the middle of February to the end of April (Schulz 1988). On the breeding grounds, the females normally arrive as the second partner. The second bird arrives on an average about 8 days after the first (Bauer and Glutz 1966, Dallinga and Schoenmakers 1989). There are insufficient data to determine whether males leave the wintering grounds earlier. In winters with a large locust supply, there was little variation in the time of arrival of eastern storks in Oldenburg, with about 75 % of the nests occupied before 11 April (Dallinga and

Schoenmakers 1989). In years with low supply of locust, spring arrival was more spread and only 15 % arrived before 11 April. We observed migrating storks in Israel from the end of February till the end of May. Large numbers of adults passed in the second half of March. In April and May, a large proportion were 1st-winter storks. Wintering young storks left Israel 2 weeks to a month after the adult storks.

Ring data show that adult storks arrived in southern Africa together with young storks in November and December, but seemed to start earlier on spring migration. In Uganda and Kenya, most adults were found in February and March and 1st-winter storks in March and April (Schulz 1988). The spring surveys in Israel and particularly in the Bet She'an Valley covered only a small part of the migration front. This explains the difference in total numbers, depending on weather conditions (Table II.31). In 1984, both western and eastern migration axis was covered and a total of 416414 White Storks were counted (Leshem 1991, Leshem and Yom Tov 1996b). During later springs, only the western axis was covered and 132251 (1986) to 301048 (1988) storks were counted (Leshem 1991). In 1995, we observed in the Bet She'an Valley twice as many storks as in 1984 (Table II.31).

Table II.31. ***Spring migration counts of White Storks in the Bet She'an Valley.***

Year	Number	Period	Observation stations
1984	167518	11.03 - 21.04 (Horin and Adar 1986)	1-2 observation posts
1992	89538	1.03 - 31.05 (Arieli 1993)	1 observation post
1995	387296	28.02 - 18.05 (this study)	1 observation post

In some spring migrations, many adult storks passed on peak days in the second half of March (Table II.32). In 1984, most storks passed in the second half of March, with 36747 birds on 19 March and 50000 birds between 23 and 25 March (Horin and Adar 1986). In April, there was still a daily passage of up to 8000 birds. Leshem and Yom Tov (1996b) give 2 April as the mean spring migration day.

Table II.32. ***Peak spring migration days in the Middle East.***

Date	Number	Location
20.03.87	82000-115000	Hurghada (Egypt, Red Sea coast)(Steiof 1987)
19.03.84	36747	Bet She'an Valley
24.03.95	104634	Bet She'an Valley
26.03.95	56835	Bet She'an Valley
26.03.96	120000	Bet She'an Valley (J.Smith, pers.com.)
27.03.96	61500	Hula Valley (J.Smith, pers.com.)

Western storks arrive earlier than eastern storks on the breeding grounds. Adult western storks arrive in Morocco along the Atlantic coast from November onwards, where many storks are present in January and February (Jespersen 1951, Jenni et al. 1991). The mean arrival date of western storks in Alsace (France) was 19 March (s.d.=3 days) in 1948-68 (Schierer *in* Dallinga and Schoenmakers 1989).

In southern Africa, storks start their spring migration quite massively at the end of January (Milstein 1965) or in February (Schüz 1952). In Zambia, White Storks pass through in March (Benson 1967). This does not correspond with data from Uganda, where White Storks have finished migrating north by mid-February at the latest (Pitman 1934). In Sudan, storks passed in spring at high altitudes, almost invisible with the naked eye and could easily be overlooked (Mathiasson 1963). First migration in Egypt was observed from the middle or end of February to the first week of March (Reed and Lovejoy 1969, Short and Horne 1981, Goodman and Meininger 1989). One flock of 600 storks was at Ras Budran on 14 February 1984 (Goodman and Meininger 1989).
White Storks pass already in large numbers through the Middle East around 10 March and most storks pass in the second half of March (Schüz 1955). 'Large numbers' were observed near El Tor at 23 March 1936 (Moreau 1938). In April, large numbers are still passing through but in May and June only few storks pass (Schüz 1955, Safriel 1968, Mendelssohn 1975). Storks start their spring migration in Turkey from the end of February or in the first decade of March, but larger numbers arrive at Istanbul only from 15 March onwards (Kasparek and Kilic 1989, Kumerloeve 1961, Mauve 1938). Migration continues until June. Peak numbers pass in the second half of March and a smaller peak occurs at the end of April or beginning of May (Kasparek and Kilic 1989). White Storks arrive in Greece from the middle of March to the

middle of April (Martens 1966). In Ukraine, White Storks arrive from the first decade of March until the second decade of April. Peak arrival occurs in the third decade of March and at the beginning of April (Grischtschenko et al. 1995). The passage of adults in the second half of March means that about two weeks later the storks arrive at their most northern breeding sites. From 1973 to 1987 in southern Poland, the mean arrival date of the first stork on the nests was 3 April and of the second bird 7 April (Profus 1991). In Lower Silesia, storks arrived on their nest from 5 March to 22 May (n=130). The first partner occupied the nest on 5 April on an average, the second on 10 April (Kujawa in Profus 1991). In Milicz (north Poland), the arrival peak from 1959 to 1968 was in the second week of April (Mrugasiewicz 1972).

Schüz (1954) supports the hypothesis of Rudolf Fischer from Israel, that storks on spring migration migrate only during days with Chamsin. During this weather phenomenon there is an eastern wind and the temperature is high. Fischer watched stork migration along the coast near Haifa and observed storks only on days with Chamsin. We believe that this was because the migration axis moved west, shifted by the eastern wind. Thermals and other air currents make migration possible on most days in the Jordan Valley and Negev (Mendelssohn 1975).

Migration speed. Tagged storks on autumn migration flew mean daily distances of 227, 278 and 292 km in Europe, Middle East and Africa. They covered a maximal distance of 621 km on one day. We observed no differences between adults and 1st-winters.

This difference may be caused by less favourable weather conditions in Europe. Some birds rested one or more days soon after they started their migration. Rain and wind may cause bad thermal conditions, in a way that the storks have to interrupt their migration. Until they reach Bulgaria, most stork flocks are small, containing tens to exceptionally hundreds of birds (M.Kaatz, pers.com.). This could allow the birds to make more and longer feeding or resting stops during the day, which cause a shorter daily leg. The tagged male 'Caesar' was followed by a glider and flew in Europe on 27 August 1994 and 29 August 1994 for a shorter period of about 4.5 h and covered only 115 km and 88 km. On 28 August 1994, it flew during 9.40 h and covered a distance of 334 km (Kaatz et al. 1996).

Ringing dates don’t give any information about the onset of migration, thus there are only few reliable data available from the ringing method. Based on ring recoveries, autumn migration speed was calculated between 100 and 200 km (Haverschmidt 1949). One German stork left its nest on 3 August 1933 and was recovered 2 nights later in Italy, about 610 km from its nest. This individual flew 305 km a day (Haverschmidt 1949). Our observations are comparable with data collected with radar and motorgliders. Michev and Profirov (1989) calculated a daily autumn migration distance of 317 km above land, based on a migration speed of 38.2 km/h and a mean migration day of 8.18 h of groups tracked by radar near Burgas in Bulgaria. For 28 satellite-tracked White Storks, we measured a similar daily distance of 324 km. Leshem and Yom-Tov (1996a) followed White Stork flocks in Israel in a glider, mainly during spring migration and found a mean velocity of 38.7 km/h. With a mean soaring time of 9 h, the storks covered a mean distance of 348 km. During autumn migration, 27 tagged storks flew a daily distance of 317 km near the Dead Sea (31°00'N 25°20'E). White Stork 'Bob' with ring *Helgoland 2188*, at that moment a 7th-winter bird, left Zimbabwe (18°16'S 29°55'E) at 1 February 1979 and arrived in Germany (53°39'N 7°43'E) on 28 March 1979 (Meybohm and Fiedler 1983). This stork flew about 9012 km in 55 days with a mean daily distance of 164 km. In the Bet She'an Valley, take-off and landing time were different in spring and autumn. We observed migrating flocks taking off from 6.15 h till 11.06 h in autumn and from 7.13 h till 10.55 h in spring. Migrating White Storks were landing from 12.48 h till 18.00 h in autumn and from 13.09 h till 18.30 h in spring. This is a much wider range than found by other observers (Table II.33).

Table II.33. ***Take-off and landing time of migrating White Stork flocks.***

Location	Take-off	Landing	Ref.
Bet She'an V.	6.15 - 11.06 h	12.48 - 18.00 h	
Israel	7.30 - 8.30 h	15.30 - 16.30 h	(1)
Belen (Turkey)	Before 10.00 h	15.00 - 17.00 h	(2)
Bulgaria	7.00- 9.40 h	15.35 - 18.40 h	(3)

(1) Leshem (1991), (2) Sutherland and Brooks (1981), (3) Michev and Profirov (1989).

If we take mean take-off and landing time as indication of daily migration period, White Storks in the Bet She'an Valley flew 7.12 h in August and 7.29 h in September. This is less than the 9 h mean migration time a day, that Leshem and Yom Tov (1996a) found in Israel in spring and autumn. In Bulgaria, storks migrated also longer in autumn with 8.18 h per day (Michev and Profirov 1989). In Bulgaria, the flocks landed about 1.30 h later than in Israel (Table II.34). This difference might be caused by the presence of good landing sites in the Bet She'an Valley and higher temperatures, which could influence flocks to land earlier.

Table II.34. ***Mean take-off and landing time of migrating White Stork flocks in autumn in Bet She'an Valley and Bulgaria (Michev and Profirev 1989).***

Location	Take-off	Landing
Israel : Aug	8.42 h (s.d.=0.29,n=639)	15.54 h (s.d.=1.09,n=134)
Sep	8.50 h (s.d.=0.38,n=519)	16.19 h (s.d.=0.56,n=59)
Bulgaria	8.27 h (s.d.=0.20,n=53)	17.25 h (s.d.=0.48,n=40)

Although we observed many flocks of up to 10000 birds still gliding at high altitudes after sunset, we have no indications of storks flying during the night. Bramley (1979) observed flocks of 15 to 270 White Storks migrating at night (19.30 h to 22.30 h) at 24 February 1978 in Algeria. They used the heath of flaring stacks of oil plants to gain height and soar. The total passage that night was estimated at 8000 storks.

Reed and Lovejoy (1969) define 'Chamsin' as an overcast period with falling temperatures, strong winds and blowing dust, lasting sometimes for several days. They observed that storks were earth-bound under such conditions and could not move to feed or drink. Rain and strong wind did not prevent spring migration of storks through the Jordan Valley (Horin and Adar 1986, this study). Storks landed shortly during thunderstorms but continued their migration as soon as possible.

Autumn stopover. If we compare the mean number of migration days with the mean number of migration plus stopover days, there is not much difference. This means that the majority of the storks had a migration pattern in which they tried to reach the pre-wintering areas in Chad and Sudan as fast as possible. Observations in the Bet She'an Valley support this fast migration. The large flocks of migrating Storks never stayed longer than a few hours or one night in the area. Only a very few storks stopped for a longer period in the valley, which offers very good food conditions with large areas of fishponds and alfalfa fields. There was no difference in the behaviour between young and adult storks, however flocks tended to land earlier in August. Whether a flock was landing or not was determined by their arrival time in the area. Before midday, all groups passed while in the afternoon some flocks landed to drink. In central Europe, tagged storks were in small flocks and were attracted by tractors working on fields to feed in their vicinity (M.Kaatz, pers.com.).

Schüz (1952) stated that storks fly slower in autumn, covering a daily distance of 100 km. He observed that they left the eastern breeding grounds in the 3rd decade of August and only arrived at the end of November in southern Africa. In later publications he wrote that White Storks migrate fast because there is no food available in the Middle East (Schüz 1955).

Spring stopover. Tagged storks flew fast through areas with good thermalling conditions in Africa and Sinai. There was one exception, the male *94555* flew very slow and followed the Nile until Suez. This is probably only done by young or weak storks (Schüz 1955). In 1997, 3 tagged storks were held up in Israel and southeast Turkey. Marked storks in Israel stayed for a short period, mostly only for one night. This was the case for adults in March as well as for 1st-winters in April and May.

Our observations confirm that White Storks on spring migration migrate fast, without long stops (Schüz 1952 and 1955, Schulz 1986). They cover a mean daily distance of 150 km (Schüz 1952). Only the non-breeding and sick storks stay long, breeding adults fly fast to the breeding area (Schüz 1955). In March, the feeding conditions are normally good after the rain in desert areas as the Negev and in mountain regions as the Golan Heights. These good feeding conditions attract storks to land and they feed for long periods and fly only short distances (Hutson in Schüz 1955). Some flocks may even rest for some days in Israel (Schulz 1988). We observed many storks feeding in fields but most of them left during the late morning and were replaced by new groups. In the Bet She'an Valley, there were 3 other observations of marked storks that stayed at least 7, 3 and 7 days (Fiedler 1996).

Selective use of stopover sites. In general the storks used similar migration routes in autumn as in spring. In most cases, the storks had passed in autumn the stopover sites they used for a longer period in spring. While tagged storks used sites for 1 to 15 days in spring, only one of these sites was used for a longer period in autumn. Most of these places were only passed in flight during the previous autumn. Along most parts of their migration route from Europe to Africa, tagged storks roosted at different sites. Only near bottleneck areas at the Bosphorus and Iskenderum were many birds roosting at '*traditional*' sites. At the very good roosting sites in the Bet She'an

Valley about 16 to 40 % of passing storks were landing to roost. In autumn, the fishponds are important as a drinking site, many large migrating flocks interrupted their migration to drink. The same was observed in Eilat, where White Storks land more often near water in autumn, trying to drink and feed. Many are tired and a few can be caught by hand (Safriel 1968).
Near Burgas in Bulgaria, every year about 10 % of the total number of passing migrants land to roost near the lake Atanasovsko Esero and the surrounding agricultural area (Michev and Profirov 1989). Storks land to roost on arable land, meadows, alfalfa fields and on dikes along lakes. However, no flocks were observed looking for food or eating on autumn migration. In autumn, there are only a few hundreds of storks that stay for several days in the stopover site. Marked birds that stayed longer than one night stopped for about 10 days, feeding mainly on fish. In Uzbekistan, up to 1500 White Storks concentrate at fish farms in autumn (Shernazarov 1999).

In spring, particularly in March, storks do not have to fly to special '*traditional*' feeding sites but may land in desert as well as in agricultural areas. In April and May food is more restricted to agricultural areas and mountain areas. In the western Negev, White Storks feed intensively on darkling beetles (Tenebrionidae, Coloptera), very abundant species in habitats with high plant cover (Groner 1994). In autumn, storks are only looking for a suitable place to sleep and the landing site need not good feeding conditions. Therefore, many of the tagged storks used different stopover sites in spring when they stayed for a longer period to feed.

Many authors mention storks feeding in spring (Mauve 1938, Meinertzhagen 1954, Schulz 1988, Schüz 1955). We observed foraging storks every morning in spring, while they were waiting for the formation of thermals. In April, the conditions for migration are better earlier in the morning and storks take off sooner. In Egypt, many of the spring migrants were feeding each morning in the fields, while waiting for the thermals (Reed and Lovejoy 1969). Tragenza (in Reed and Lovejoy 1969) observed that most flocks arriving at the Aswan-Qena stretch of the Nile in spring remain in flocks and do not forage in the fields.

During spring 1992, 13575 White Storks landed to roost in the Bet She'an Valley. This is 15 % of the counted passing storks (Arieli1993). We observed that about 30 % of migrating storks landed to feed in spring, i.e. less than in autumn. This means that many other areas along the migration route might serve as feeding places.

Energy reserves. When storks try to migrate as fast as possible, they must start their migration with sufficient energy reserves. Their soaring behaviour on migration allows them to save a lot of energy. Long migration days of 8 to 10 hours leave them few time to look for suitable feeding sites (Michev and Profirov 1989, Leshem and Yom-Tov 1996a). In addition the large size of autumn flocks in the Middle East of up to 30000 birds makes it difficult for an individual to find enough food on stopover sites.

Measurements show that storks increase their body mass with 15 to 20 % before migration. Freely ranging 1st-winter storks in France with an access to unlimited food supplies had a body mass of 3.8 to 4.1 kg in early September. Five storks returning in spring in May and June had a body mass of 3.4 to 3.6 kg (Michard et al. 1995). A young stork marked in Planckendael (Belgium) arrived in Strassbourg (Elzas-France) at the beginning of August after a flight of almost 350 km. During 8 days at the beginning of August its body mass increased from 3.1 to 3.6 kg and in the next 10 days from 3.6 to 3.9 kg (Michard et al. 1997). In June, 14 males had a mean body mass of 3.3 kg and 14 females a mean body mass of 3.2 kg. In July and August, 12 males had a mean body mass of 4 kg and 12 females a body mass of 3.5 kg (Steinbacher in Bauer and Glutz 1966), which is an increase of 19 and 12 % for males and females. The same change in body mass was noted for captive storks of different age classes (Hall et al. 1987). In August and September, 1st-winter storks showed an increase in body mass in August and September of 350 g for females and 450 g for males. In the same period, adult storks showed an increase of 900 g for males and females.

In which form the energy is stored is open for discussion. Hall et al. (1987) suspected that the increase in body mass was not due to an important deposition of fat stores, but appeared to be muscular. In contrast, Milstein (1965) found subcutane and other fat depositions in storks that were shot at the end of January during good feeding conditions.

Pennycuick (1972) estimated that White Storks use 23 times more energy in powered flight than by soaring. He calculated that a stork uses 0.672 g fat per km in powered flight, compared to 0.029 g fat per km in soaring flight. When they migrate by soaring, a 3.4 kg stork would use about 23 g fat per day. With this consumption of energy the storks could reach their pre-wintering areas with a fat load of around 500 g.

In general, storks use soaring flight whenever possible. Above land, storks used flapping flight in Sudan and Egypt on cloudy days (Reed and Lovejoy 1969). We observed the same in Israel, but in spring some flocks left before thermal conditions were good and flew up to tens of kilometers in flapping flight. Storks used also flapping flight to fly against the wind.

Every autumn and particularly in August, large flocks land to drink at the fishponds. The fact that more storks were seen in the valley on hot days might be explained by their shift in search of water. In desert areas, many storks are found exhausted and extremely thin, weighing less than 2 kg (Mendelssohn 1975). Sometimes, they recover quickly when force fed and rehydrated.
Near Ophira and Ras Mohammed in southwest Sinai, hundreds of storks die every autumn from exhaustion and dehydration. The number of 1000 storks that die from exhaustion is probably underestimated (Schulz 1988). It is very hard to save these storks, about 1/3 survived after treatment (Bruun in Schulz 1988). Dr. James Dinsmore has been trying with some success to rescue exhausted migrating storks near Sharm El-Sheikh in Sinai. In 1994, he and his co-workers found 1347 ! dead storks between July and December. No less than 754 storks died of migratory stress (dehydration and/or malnutrition). From 574 aged storks, 71 % were 1st-winter storks.
We observed also that 1st-winters storks had a weaker condition than adults (chapter I). An explanation for the late arrival of young storks in spring was that although all storks start to migrate, 1st-winter storks might drop out to forage during the day in an attempt to replenish nutritional reserves (Hall et al. 1987). Marked young storks and flocks in August, April and May migrated fast and only very few young storks stayed behind.

Leadership from migratory-experienced adults. Many authors mentioned that young storks have to be guided by adults to complete their first migration successfully (von Schweppenburg 1936, Bauer and Glutz 1966, Meybohm 1993). Meybohm (1993) states that in years with good breeding results the proportion of southwesterly migrants (against southeasterly migrants) was considerably higher in storks from northwest Germany. The author thinks that this was probably due to lack of leadership by experienced adults. In years with many non-breeding adults i.e. "Störungsjahren", there are more adults in the early migrating flocks of young storks. They could lead them to take the eastern, instead of the western route.
Although age categories do not always migrate together, they face the same challenges during migration. The flocks in September, with many adults, showed a higher migration urge than the

groups in August. We found young storks dead from exhaustion in large migrating flocks in September and also in Sinai most of the 1st-winters were found dead in September (J.Dinsmore, pers.com.). This might be caused by the fact that young storks wanted to stay in the migrating flock even when they should have stopped or because the weaker birds arrive later in the Middle East. Many adults in a flock of young birds might not always be positive for them.

If guiding by adults was an important factor for a successful migration of 1st-winter storks, we could expect that adults would leave the breeding grounds together with their young.

Chapter III : Summering

1. Introduction

Breeding adults migrate to their nest site before the start of the European summer, but most storks only start to breed for the first time when they are 3 or 4 years old (Cramp and Simmons 1977, Bairlein and Zink 1979). This implies that 1st and 2nd-summer birds and non-breeding adults have different options where to spend the summer. They might stay on the wintering grounds or move to new sites with good food conditions in Africa and thus remain south of the species' breeding range (Cramp and Simmons 1977). According to Libbert (1954), large numbers of White Storks stay in the Middle East during 'summer'. The study site at the fishponds of the Bet She'an Valley should thus be an ideal place to observe summering storks. Otherwise, German male and female storks settled as adults within a mean distance of 33 and 61 km respectively, from their birth place (Zink 1967). So their migratory activity might lead them close to their birth place or near other sites within the breeding range of the species, suitable for a future nesting place.

In this chapter, we analyse the onset and end of migration of 1st-summer storks and which storks summer in the Middle East.

2. Summering in Israel

2.1 Numbers

In summer, White Stork concentrate near garbage dumps and fishpond complexes. Hundreds of storks stay each summer near garbage dumps in Tel Aviv and 200 to 1400 storks summer in the Bet She'an Valley (Table III.1). In 1997, an exceptional high number of 4000 to 5000 storks stayed in Israel during summer, particularly in the Bet She'an Valley.

Table III.1. ***Numbers of White Storks summering in the Bet She'an Valley.***

Year	Number	Date
1993	200- 400	1-13.08.93
1994	900	10.08.94
1995	1400	6.08.95
1996	700- 800	23-26.08.96
1997	4000-5000	18-27.08.97

2.2 Age

As in autumn migrating White Storks stay in the study area only for one night, midday is a good time to check local birds. On 23 August 1996, we found 738 local White Storks in the Bet She'an Valley, 62 of which were adults (8 %), 56 were 1st-winter birds (8 %) and 544 (74 %) were 1st-summer birds (2nd-cal year). The age of 76 storks could not be determined. Between 18 and 21 August 1997, we controlled 2096 local White Storks in the Bet She'an Valley. Only 41 were 1st-winter birds (2 %) and 508 were adults (24 %). 1547 (74 %) storks were 1st-summer birds.

During the period June to 10 August, 13 White Storks with rings were found in Israel (Table VIII.9). 7 out of these 13 storks were 1st-summers, 3 were 2nd-summers, 2 were 3rd-summers and one 4th-summer. These storks were ringed in Germany (7), Poland (2), Czech Republic (2) and Estonia (1).

2.3 Timing and behaviour

Arrival of summering birds. It was difficult to observe when exactly unmarked storks arrive to their summering place. We observed the behaviour of 14 marked storks in spring 1995 (Table III.2). In April, only 2 out of 10 marked storks stayed behind. In May, 0 out 4 marked storks were still passing through which might indicate that many non-breeding storks were still migrating in May.

Table III.2. ***Number of marked White Storks arriving during spring migration in 1995 and number of these marked storks staying in the Bet She'an Valley in summer.***

Age	April 1 decade	2 decade	3 decade	May 1 decade
1st-winter	-	0 out of 4	1 out of 1	0 out of 4
Adult	0 out of 1	1 out of 2	0 out of 2	-

In the middle of May 1995, about 900 White Storks stayed in the Bet She'an Valley, while in August there were about 1400 storks summering. These additional birds must have arrived after the second half of May.

Departure of summering birds. Summering storks left the study area gradually and were replaced by wintering storks. Two birds marked in spring during the second half of April, left the Bet She'an Valley at the middle of August. Many of the storks captured in August were summering storks, most of them left before the middle of September (Figure III.1). Out of 39 storks captured before 16 September, 38 left the Bet She'an Valley.

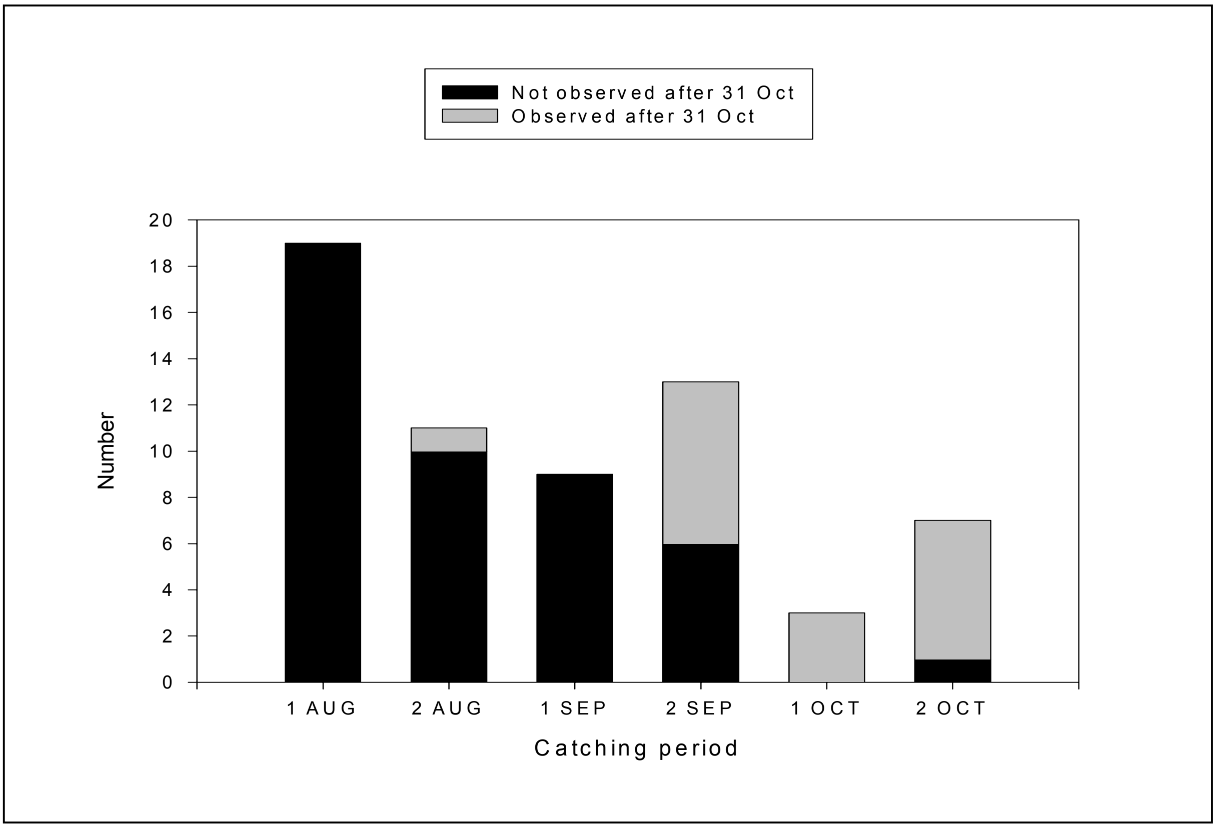


Figure III.1. ***Behaviour of marked White Storks captured in the Bet She'an Valley.***

3. Summering in Europe and Africa

Only 2 out of 34 tagged 1st-winter storks could be tracked during their first spring migration. No *981981* started its migration from Mozambique (16°S) on 30 March 1999 and interrupted its migration at the Red Sea near 27°40'N 33°36'E on 24 April 1999. It did not cross the Red Sea, but instead, returned to the Nile at 28°55'N 31°13'E. No *981982* started its migration on 6 April 1999 from southern Zambia and stopped on 16 May 1999 at 26°28'N 27°43'E in the Libyan Desert.

In addition, observations on the age ratio in migrating flocks in the Bet She'an Valley reveal how many 1st-winter White Storks summer in Europe or stay in Africa. During spring 1995, we counted 386660 White Storks on their migration through the Bet She'an Valley. The age-ratio in these migrating groups during three day periods is shown in Figure II.13 (Chapter II. 4.1.2.1). When we take the number of birds passing through during these periods, 127650 storks were in their first winter. This is about 33 % of the total number counted on spring migration. These White Storks passed Israel to summer in Europe or Turkey.

Summering 1st-winter birds migrate back to Africa from July onwards in the autumn of their 2nd-calendar year; we call them 1st-summer or 2nd-winter birds. 1st-winter and adult storks are easily determinable from a large distance by the difference in colour of bill and legs, but it takes more time to control migrating flocks for the presence of 2nd-winter birds. To find these 2nd-winter birds among the adults, the presence of black inner median coverts and the moulting pattern has to be checked carefully. In most cases, there was not enough time to check a sufficient number of birds. From 10124 storks, controlled in autumn 1995-97 only 9 % were 2nd-winter birds (Table VIII.10).

In a migrating flock that was found poisoned near Tel Aviv on 19 August 1994, 11 out of 17 adults were 2nd-winter White Storks. From these 11 birds, 2 were males (bill 173 mm) , 7 were females (bill <168 mm) and from 2 storks the sex was unknown. Out of 24 measured 2nd-winter storks in autumn 1993-1997, 11 were males, 9 were females and from 4 storks the sex was unknown.

4. Discussion

Only very few observational data were collected on the migratory behaviour and summering grounds of non-breeding White Storks, although the location of their summering places might have an important influence on future breeding sites or success. Based on ring recoveries previous authors state that non-breeding White Storks are spending the summer far south of the breeding range (Libbert 1954, Cramp and Simmons 1977) or at a few tens to hundreds of km from the place of birth (*eastern storks* : Hornberger 1954, *western storks* : Bairlein 1981 or *Magreb storks* : Jenni et al. 1991).

To understand which factors determine the summering location of non-breeding storks we focus on the following : (1) How to define the summer period and which method should be used ? (2) How do non-breeding storks behave during the migration season ?, (3) Where do storks end their spring migration ? (4) Which and how many storks stay 'behind' ?

How to define the summer period and which method should be used ?

Libbert (1954) and Schmidt (1987) defined the summer period as the period from 1 April to 15 August. According to Libberts data eastern storks arrived on the breeding grounds at the end of March and beginning of April and started their autumn migration at 15 August. Thus, adults still in Africa at the end of March, would never reach their breeding grounds. In addition, storks which were observed in Africa on the 20 August didn't return to their northern birth place in summer.

Our data show that on 1 April, most 1st-winter storks only just started their spring migration and many of the adult eastern White Storks were still migrating at this time. On 15 August, many 1st-summer storks migrated already through the Middle East on their way south.

If we use Libbert's and Schmidt's definition of the summer period for the interpretation of ring recoveries, we can only find that during summer White Storks are in Africa or the Middle East because they are still migrating. To locate the summering grounds one should only consider the data from the non-breeding storks from the beginning of June to mid July for the eastern population. Bairlein (1981) examined the ring recoveries on a monthly basis, avoiding the definition of 'summer' and 'winter' periods.

When we interpret the age ratio of recoveries from the breeding ground, we have to be aware that, especially in Germany, many rings are read by telescope. Therefore, adult storks have a higher chance to be seen on a nest than non-breeding storks which are mostly younger than 4 years. In western Germany the recovery-ratio of adults compared to 3 year old or younger storks is 10 : 1. In the former DDR this ratio is 2.5 : 1 (Schmidt 1987).

How do non-breeding storks behave during the migration season ?

Summering storks left the Bet She'an Valley to winter more to the south. At the same time, 1st-winter storks that wintered in Israel migrated north during spring. The 1st-winter storks started their spring migration a few weeks to a month after adult storks from the middle of March. Large numbers of young storks migrated through Israel in April, while several thousands were still passing in May.

Where do storks end their spring migration ?

Based on our observations on the proportion of ages, we estimated the number of 1st-winter storks that migrated north through Israel in the spring of 1995 at 127650 birds. This is about 33 % of the total of 386660 storks that migrated through and must be a high proportion of the total number of 1st-winter storks. Bairlein's (1981) analysis of marked White Storks from the German and French part of the Upper Rhine Valley may give us an idea on where these non-breeding birds fly to. He found that 1st-winter storks stayed in their wintering areas in west Africa south from the Sahara until January. Recoveries north from the main wintering grounds increased during February and March, about one month after the departure of the adults. In June, most 1st-summer storks were recovered close to their birth place (Figure III.2). These are recoveries of western storks but also very few eastern and Maghreb storks stayed in Africa in June of their 1st-summer (Hornberger 1954, Bairlein 1981, Kania 1985, Jenni et al. 1991). At least 25 and 31 % of French, German and Spanish 1st-summer storks, respectively, reached their birth places (Libbert 1954, Bairlein 1981, Michard et al. 1995, Tortosa et al. 1995). Furthermore, about 70 % are summering closer than 600 km from their birth places, i.e. inside Europe (Bairlein 1981, Jenni et al. 1991).

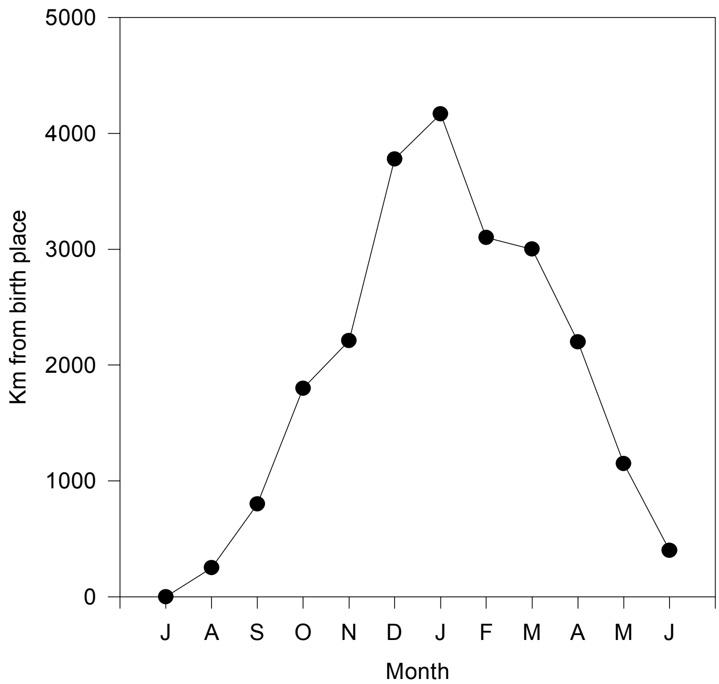


Figure III.2. ***Distance of the mean recovery site from the birth place of western White Storks recovered in their first year (from Bairlein 1981).***

Observations of summering storks are reported from sites all along the migration route from southern Africa, Kenya, the Middle East to northern Europe (Schüz 1955, Creutz 1975, Meybohm 1993).

The recent analysis of the ring data suggest a change in the summering location of 1st-summer storks (Fiedler 2000). In May-August 1945-75, 22 European 1st-summer storks were more than 4000 km away from their birth place, while in May-August 1976-96 only one 1st-summer stork was recovered more than 4000 km from its breeding place. There are unfortunately no detailed field observations from the past to compare with.

Which and how many storks stay 'behind' ?

The distance and time travelled from the wintering area or condition and food availability might be factors that determine where a non-breeding stork will stop.

In the Bet She'an Valley 200 to 1400 storks stayed all summer on the fishponds. The majority of those summering storks (up to 75 %) were 1st-summer storks. The small amount of data on the age-ratio of non-breeding migrants suggests that as many females as males migrate to Europe. This observation does not confirm the theory of Hall et al. (1987) who stated that the higher initial body mass of males should result in a summering area closer to their birth place.

Storks in weakened condition might interrupt their migration early, as we observed in 1997. During this 'Störungsjahr', there was only a small proportion of storks that arrived on the breeding grounds in time to start nesting (C.andM. Kaatz 1999). In summer 1997, an exceptional high number of 4000 to 5000 storks summered in the Bet She'an Valley and thousands of storks were counted in other parts of Israel (D.Alon, pers.com.). Observations in August showed that most (74 %) of the summering storks were 1st-summer birds rather than adults. This suggests that the bad weather conditions in March, with heavy rain and cloud cover for weeks (J.Szabo, pers.com.) were not the main reason why thousands of storks stayed in Israel. Most 1st-winter storks passed Israel in April, when also in 1997 weather conditions were better. Large numbers of young White Storks might have been in a bad condition when they came from Africa, which forced them to stay in Israel. This implies that the distance between the summering area and the birth place of a non-breeding stork depends on the condition of the individual at the start of the spring migration. Hall et al. (1987) observed a higher rate of body mass loss in 1st-winter storks compared to adults. To survive, younger storks would have to stop more often to feed and gradually fall behind the migrating adults until migration urge ceases (Berthold 1975). The high number of 1st-summer storks in Israel in 1997 suggests a relation with energetic condition in combination with weather conditions along the migration route. The 200 White Storks still present in Natal (South Africa) in the third week of July 1973 were unusually weak storks (Maclean et al. 1973).

Chapter IV: Wintering

1. Introduction

The majority of European storks winter in Africa in the Sahel, Sudan zones and central and southern East Africa. Despite their gregarious and conspicuous behaviour only few studies were carried out on factors determining first choice and repeated use of wintering sites, age composition and movements. The analysis of ring recoveries was about the only source of information on the wintering distribution and behaviour of the species. In this chapter, we use the data of tagged storks to interpret the choice of pre-wintering area, repeated behaviour and wintering locations.

The last decades storks started to winter in the Iberian peninsula and Israel (Paz 1987, Schulz 1988). While the number of storks were yearly counted in January, there are only few data on arrival and departure, age composition and factors influencing the number of wintering storks in Israel. We examined the composition and behaviour of White Stork flocks wintering in Israel and factors determining the number of birds.

2. Wintering in Israel

2.1 Origin

Out of 13 marked White Storks found in Israel during the winter period from October to February, 10 were ringed as nestlings in Germany (Table IV.1). From other countries of the northern part of the breeding range no marked storks were found, but both tagged White Storks wintering in Israel came from the northern breeding area. One tagged stork was tracked from Israel to northeastern Poland (53°15'N 22°19'E) and one to White Russia (54°39'N 30°22'E). Three wintering storks were ringed in central and southern Europe in former Czechoslovakia, Greece and Austria (Table IV.1).

Table IV.1. ***Origin of marked White Storks, ringed outside Israel and found or observed in Israel in 1969-96 (IBRC) and number of ringed storks controlled during the winter period (October-February).***

Country of origin	Number found in Israel	Wintering
Denmark	1	0
Germany	88	10
Poland	21	0
Lithuania	4	0
Latvia	1	0
Estonia	4	0
Russia	2	0
Czech Rep. and Slovakia	13	1
Former Yugoslavia	12	0
Hungary	4	0
Ukraine	1	0
Austria	4	1
Greece	14	1

2.2 Numbers and wintering areas

From the early 1960s, the numbers of wintering storks gradually increased from 305 in winter 1965/66, 1545 in 1969/70 to a peak of 4700 in 1976/77 (Figure IV.1). In the 1980s, only about 1700 storks wintered and in 1990 to 1992, the number decreased to 1000. The decrease in the number of wintering storks coincided with the sharp cut in the total area of fishponds from 1975 till 1987.

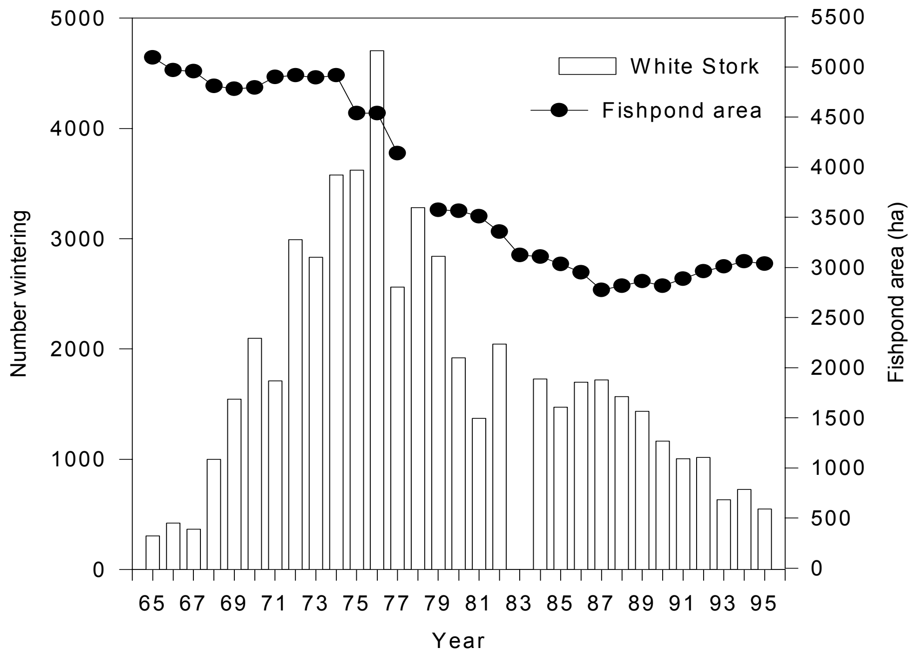


Figure IV.1. ***Numbers of White Storks during January counts (Israel Nature Reserve Authority).***

In January, the most White Storks were counted in the Coastal Plain, Bet She'an Valley, Zevulon Valley and Hula Valley (Table IV.2). Single storks or small groups were observed in the Golan Heights, West Galilee and Western Negev.

Table IV.2. ***Mean number and proportion per region () of wintering White Storks, during January counts by INRA (1969-94).***

	Mean number and proportion	s.d.	Range
Hula Valley	146 (6)	165	0 - 630
Bet She'an Valley	709 (34)	421	109 - 1583
Zevulon Valley	335 (18)	276	0 - 926
Coastal Plain	859 (42)	504	130 – 2311

In January, there were always storks present in the Coastal Plain and the Bet She'an Valley (Table IV.2). Numbers were small in the Hula Valley and in some years, there was no stork present. In the Zevulon Valley, there were almost 1000 storks in some winters (1972/73 and 1975/76), but none in other winters, as e.g. 1984/85.

During some of our counts, we covered more of the potential stork areas than the people of Israel Nature Reserve Authority during January counts. We observed more or a comparable number of storks, 691 vs. 634 in 1993/94, 1061 vs. 727 in 1994/95, 1116 vs. 550 in 1995/96, 912 vs. 1211 in 1996/97 and 938 vs. 1042 in 1997/98 (Table IV.3).

Table IV.3. ***Numbers of wintering White Storks in Israel in 1993-97 (this study).***

	1993/94	1994/95	1995/96	1996/97	1997/98
Hula Valley	11	4	23	124	104
Bet She'an Valley	680	338	342	368	413
Zevulon Valley	?	345	269	0	374
Coastal Plain	?	374	482	420	47
Total	+691	1061	1116	912	938

(+) In 1993, we did not check the Zevulon Valley and Coastal Plain.

2.3 Timing

2.3.1 Autumn arrival

Wintering storks were arriving in the Bet She'an Valley from the second half of September. Out of 39 marked storks ringed in August and the first half of September in 1993-97, only one was observed in winter (Figure IV.2). While in the second half of September, 7 out of 13 and in October, 9 out of 10 captured storks wintered locally.

12 wintering marked adults arrived between 8 September and 8 October, after the main migration period (Table VIII.11). In 1996, 3 storks arrived on 19 September, two of them arrived together in Ma'ale Gilboa as the only White Storks in a flock of Black Storks. Between different years, the arrival times of the same individual varied between 1 and 18 days.

2.3.2 Spring departure

We collected data on the spring departure of 4 ringed and 5 tagged storks wintering in Israel and 11 tagged storks wintering in Africa (Table VIII.12). 5 out of 9 adult storks left Israel in February and one male was last observed on 23 January and another on 3 March. Two storks that were possibly in a weaker condition left at 20 March and 14 April, respectively. Because of the departure of the wintering adults, the number of local White Storks in the Bet She'an Valley dropped from 309 in January to 84 in the second half of February in 1995. At least 50 out of these 84 remaining storks were 1st-winter storks. While on 15 February 1995, 550 storks stayed in the Zevulon Valley, only 142 were present on 2 March 1995. The locally wintering 1st-winter storks stayed at least until the middle of March. The two tagged 1st-winter storks wintering in Africa started late on 30 March and 6 April, respectively (Table VIII.12). From adult storks we collected 12 starting dates 6 of which were 19 to 26 February. Furthermore, 3 started in the first half of March and 3 storks started in the second half of March. Departure time was not correlated with the distance to the breeding site (df=12, r^2=0.001, P=0.92).

'*Prinzessin*' and '*Polsky*' were tracked for several years and had starting dates that differed for up to 3 weeks.

2.4 Composition of wintering flocks

The proportion of 1st-winter storks in the wintering population changed between years. Only 3 to 4 % were present in winter 1993/94, 6 to 7 % in 1995/96 and 1996/97 and 13 to 16 % in winter 1994/95 (Table IV.4). At the beginning of December 1997, the proportion of 1st-winter storks in flocks was even 19 %.

From 15 wintering adult storks we collected data on bill length. Three wintering storks had a short bill of 152 to 158 mm and were thus sexed as females. From one bird the sex was unknown and the other 11 wintering storks had a bill length of 175 to 198 mm (mean 185 mm) and were therefore sexed as males. We tried to check by telescope on the basis of bill length whether adults were males or females. We estimated, that in December 1997, 18 out of 164 storks might have been females.

Table IV.4. ***Percentage of 1st-winter White Storks in flocks of local birds, between brackets is number of birds controlled.***

Month	1993/94	1994/95	1995/96	1996/97	1997/98
September	11 (6702)	13 (11958)	4 (10045)	9 (21293)	9 (20439)
October	4 (4774)	10 (5272)	5 (7200)	6 (12017)	12 (2871)
November	3 (318)	14 (3488)	7 (5026)	7 (3956)	?
December	?	13 (1545)	6 (692)	?	19 (1600)
January	?	16 (371)	?	?	?
February	?	12 (1729)	?	?	?

2.5 Site fidelity of wintering storks

At least 11 out of 24 wintering storks returned in one or more successive winters to Israel (Table IV.5). None of the 4 marked 1st-winter storks were seen again. We observed one adult stork during 5 successive winters (1993-97) and 2 adults during 4 successive winters (1994-97).

Table IV.5. ***Proportion of wintering White Storks resighted during one or more successive winters in Israel.***

	1993/94	1994/95	1995/96	1996/97	Total
Adult	2/9	5/9	2/3	-	9/17
2nd-winter	-	-	1/2	1/1	2/3
1st-winter	-	0/3	0/1	-	0/4

There are two additional data of marked storks resighted in the wintering period in Israel (Israel Bird Ringing Centre). One German bird ringed in 1978 was controlled in the Bet She’an Valley in winter 1982/83, 1983/84 and found dead in 1984/85. One stork observed in winter 1983/84 was seen again in 1986/87.

2.6 Behaviour

The activity of local flocks of White Storks during the day is shown in Figure IV.3.

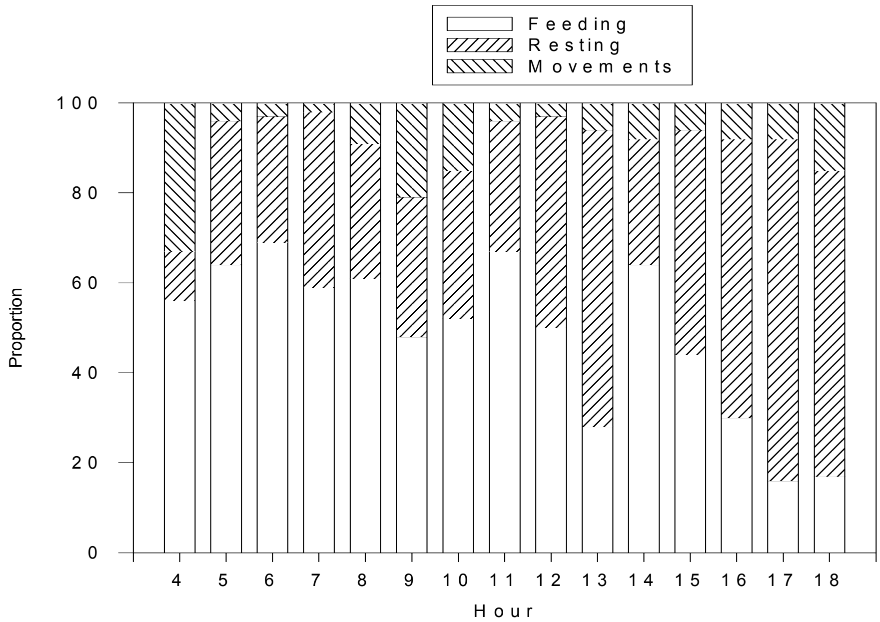


Figure IV.3. ***Activity per hour of local White Stork flocks during August-November 1993.***

Before sunrise, White Storks already left the sleeping site and flew to fishponds. Most birds started to feed as soon as they arrived on a pond. Between 5.00 and 8.00 h only very few birds moved around, most storks were feeding or birds that had eaten enough were resting. Between 8.00 and 10.00 h more flocks moved around to find new feeding sites or suitable resting places. During the hottest part of the day, many flocks were still feeding, but more birds liked to rest on fields or fishponds. Between 14.00 and 16.00 h there was a new peak in feeding activity. After 17.00 h most storks were resting or flew to roosting sites.

This general behaviour does not always reflect the behaviour of an individual bird. The time that White Storks needed to feed depended on the amount of available food. Early in autumn, the storks could easily find the 2 or 3 dead fish of 15 to 20 cm that they needed daily. Later in the season, less dead fish were available and the storks had to feed for longer periods on small living fish in drained fishponds. For lack of time, we could not observe the same local flock all day, but we estimate that a flock is resting at least 70 % of the day.

2.7 Feeding habitats

In autumn and winter, most White Storks were feeding at filled and partially drained ponds (Table IV.6). Alfalfa and Turf fields were used by small numbers of birds. Arable land was rarely used as a feeding site. White Storks were feeding on piles of dead fish at garbage dumps or near emptied ponds. From November onwards and during spring, most White Storks were feeding on garbage dumps.

Table IV.6. ***Summary of habitat choice of local White Storks.***

Period	Drained ponds	Filled ponds	Garbage dumps
Dec-Apr	few	rare	many
May-Sep	few	many	rare
Oct-Nov	many	few	few

White Storks were present at different fishpond complexes. After the main migration period, we made 26 total counts in the Bet She'an Valley during 18 September and 6 November 1993. Concentrations of White Storks at a certain fishpond complex represented 11 to 89 % of the total number in the area. The mean proportion was 40 % in a flock (s.d.= 22).

Drained ponds . The arrival of White Storks at a drained reservoir of Ma'oz Hayyim is shown in Figure IV.4.

Some White Storks arrived at the pond when drainage was started. Largest numbers were present when the pond was drained for 70 %. At that moment, there were dead fish on the banks and the small living fish could easily be caught in the remaining shallow water where all fish were concentrated. The storks left after 3 days, but their number increased 2 weeks later, when the pond was completely empty and again many dead fish were available.

Although White Storks were attracted by drained ponds throughout the year, it was in October and November that these drained ponds became the most important habitat.

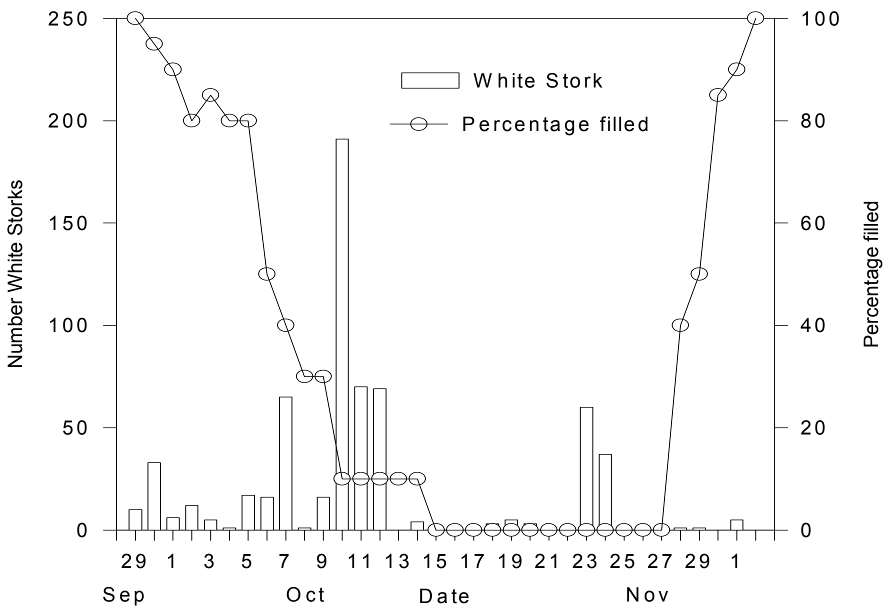


Figure IV.4. ***Numbers of local White Storks feeding in Ma'oz Hayyim on fishpond no. 9 in autumn of 1993.***

The location of the ponds is an important factor for the presence of White as well as of Black Storks. In Reshafim and Newe Ur, White Storks were rarely observed. In Ma'oz Hayyim and Ma'ale Gilboa there were always storks present.

Filled ponds. During summer, White Storks feed on dead fish washed ashore on the banks of a pond. At some ponds, many fish died of oxygen deficiency and storks concentrated on these reservoirs. During most of the years this happened at the same ponds. These ponds are large reservoirs, the edges of which are lined with stones without much vegetation on at least one side. If there was no disturbance, the majority of local storks in the Bet She'an Valley were feeding at these ponds. They were not all used at the same time, there was a shift throughout the season. From the second half of September, there were less dead fish in filled ponds. The storks were getting more and more dependent on drained ponds to find dead fish and to catch small living fish or they looked for dead fish on garbage dumps.

Garbage dumps. White Storks were observed feeding at garbage dumps with waste food near Tel Aviv (Lod), Hadera and Kefar Masaryk (Zevulon Valley). Storks were also feeding on dead fish, thrown on to small garbage dumps at kibbutzim. Northeast of the fishponds of

Newe Etan, there are the sewage ponds of a factory in Bet She'an. In this factory, Turkey and chicken are slaughtered and their blood, bones and parts of the flesh and skin flow through pipes into the sewage ponds. From December onwards, we observed almost all storks at this site, especially when there were no drained ponds. In spring 1996, large groups landed here to feed. In November 1995, all storks in Kefar Masaryk (Zevulon Valley) were feeding at the garbage dump and not at filled ponds nearby.

2.8 Age dependent choice of feeding habitats

Local White Storks in the Bet She'an Valley were feeding almost exclusively on fish in summer, autumn and early winter. We observed adult White Storks chasing 1st-winters away from dead fish. Adult White Storks were also aggressive against adult and 1st-winter Black Storks.

We observed White Storks feeding in canals, rivers, drained ponds, sewage ponds, filled ponds and at garbage dumps. These feeding habitats can be separated by the availability of and difficulty in collecting food. Small dead fish are found easily on garbage dumps and when ponds are completely drained. Along filled ponds in summer, there are many large dead fish, died from oxygen deficiency. Small living fish can easily be caught in canals and are difficult to be captured in rivers and partially drained ponds.

The proportion of 1st-winter storks in flocks looking for food varied between habitats in the period from September to November 1993-96 (habitats : canal, drained pond, filled pond, garbage, dead fish, river; ANOVA : $F_{5,10}=4.19$, $P<0.05$). Flocks feeding in canals and drained ponds, where fish was easily available, had a higher proportion of 1st-winter storks (Figure IV.5). Small numbers of 1st-winters were feeding in rivers, where food was available under natural conditions.

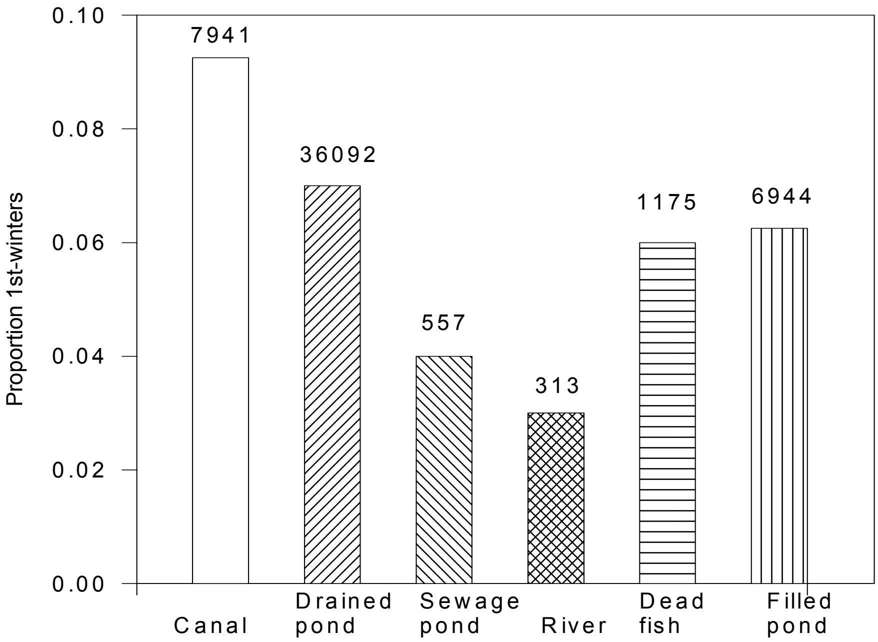


Figure IV.5. ***Proportion of 1st-winter White Storks looking for food in different habitats and feeding conditions.***

2.9 Effects of fish farms on numbers of wintering Storks

Fish are the main food source of wintering White Storks in Israel. We controlled if there was an effect of fish farms on the number of wintering birds. The number of storks increased in the 1960s and 1970s. In some years, the growth rate was very high, +273 % in 1968, +55 % in 1969 and +75 % in 1972. After the peak number was reached in 1973, the number of locally wintering White Storks was positively correlated with the total area of fishponds (ha) in 1974-95 (df=19, r^2=0.75, P=0.00000).

2.10 Movements

There were large differences in site fidelity among storks. 4 out of 7 tagged storks only stayed in one fishpond area, while 3 other storks were moving between areas (Table IV.7). For example, male stork No *94554* was captured in Hamadya in the Bet She'an Valley on 28

September 1994. It flew to the Hula Valley in the middle of October and returned to the Bet She'an Valley on 14 December 1994. In following years, it arrived at Ma'ale Gilboa on 20 September 1995, disappeared for a month and came back to the Bet She'an Valley on 24 October. It came back to Ma'ale Gilboa on 19 September 1996 and was in the Hula Valley in Lahavot Habashan on 21 October 1996. On 7 October 1997, it was again present in Lahavot Habashan.

Table IV.7. ***Number of observation days of tagged White Storks in fishpond areas in Israel.***

Code	Age	Total	Bet She'an	Zevulon	Coastal Pl.	Hula
No 93553	Adult	32	23	3	6	0
No 93554	Adult	35	5	19	11	0
No 94554	Adult	23	7	0	0	16
No 94556	Adult	26	26	0	0	0
No 94557	Adult	18	18	0	0	0
No 95544	1st-w.	97	97	0	0	0
No 95553	Adult	70	70	0	0	0

2.11 Roosting

Storks used a suitable roosting site that was close to the feeding area and thus individuals changed their roosting site throughout the winter period. We observed storks flying up to 10 km to a roosting site.

There were 3 types of roosting sites used by White Storks : fishponds, trees and pylons.
Until the middle of September, local storks preferred to sleep on fishponds. Later, the disturbance on ponds became too heavy and from that moment, the most important roosting site was a line of Eucalyptus trees southwest of Kibbutz Newe Etan. Several types of tree species were used to sleep on, but they preferred dead trees and Eucalyptus trees. In August, some local Storks slept in Pine trees at Ma'oz Hayyim. Single Date trees *Phoenix dactylifera* were sometimes used by small groups of roosting Storks, mainly by migrants. Local Storks did not sleep in fields. Sometimes small numbers of local Storks were sitting in fields early in the morning, but they had been sleeping on trees close to these fields. Storks feeding in the centre of the Jordan Valley would roost on trees near Newe Etan or at suitably drained fishponds. Some individuals were roosting in Pine trees near Kefar Ruppin and Tirat Zevi.

Storks feeding in the western Bet She'an Valley were roosting in ponds of Messilot and Bet Alfa or on trees or pylons near Geva and Nir David. Storks feeding in the northern part of the Jordan Valley were roosting on trees and pylons near Gesher.

3. Wintering in Africa

3.1 Location of pre-wintering areas

During 1992-98, we collected information on pre-wintering areas of 25 different tagged White Storks. Two were captured in Israel, 9 in Poland and 14 in Germany. Only 6 were 1st-winter storks. We define the pre-wintering area as the location where storks finish their autumn migration. We considered autumn migration as ended, when storks had crossed the latitude of 19°N and moved less than 50 km a day during at least 5 days. Daily distance was measured between night locations. Storks were considered to leave the pre-wintering site when they moved more than 200 km in 2 days from the first night location.

The coordinates and time spent in the pre-wintering area of the tagged storks are shown in Table VIII.13. Tagged storks were staying in 3 regions in Chad and Sudan. The Eastern pre-wintering area was located east from the White Nile at Wad Medani and northeast from the Blue Nile in the Shukriya region, both in Sudan, between 13°N to 16°30’N and 33°E to 36°E (Figure IV.6). The central pre-wintering area was located west of the White Nile in a large area around the Nuba mountains in Sudan, between 10°N to 14°30’N and 26°E to 33°E. The western pre-wintering area was located in Ouaddai, east Chad and in Darfur, western Sudan, between 11°N to 14°N and 18°E and 25°E.

The location of the pre-wintering area in the east, west or central zone was partly visible in the storks’ migration direction, when they passed along the east side of Lake Nasser at circa 23°00'N 33°00'E (Point A in Figure IV.6, Table VIII.14). 16 tagged storks continued migrating due south from the east side of Lake Nasser and crossed the Nubian Desert towards 20°00'N 33°00’E (from A to B in Figure IV.6). Of these 16 birds, 7 changed their migration direction to west southwest, when they approached again the Nile at circa 20°00'N 32°50'E and flew to a western pre-wintering area. The 9 other storks flew to a pre-wintering area in the east. 8 tagged storks continued their migration along or close to the western corner of Lake Nasser further southwest and stayed close to the Nile (from A to C in Figure IV.6). From these 8 storks, 3 moved on to a central pre-wintering area and 5 to a western site. None of these birds flew northeast to follow the Nile upstream to Merowe (point C in Figure IV.6, ca. 18°20'N 31°45'E).

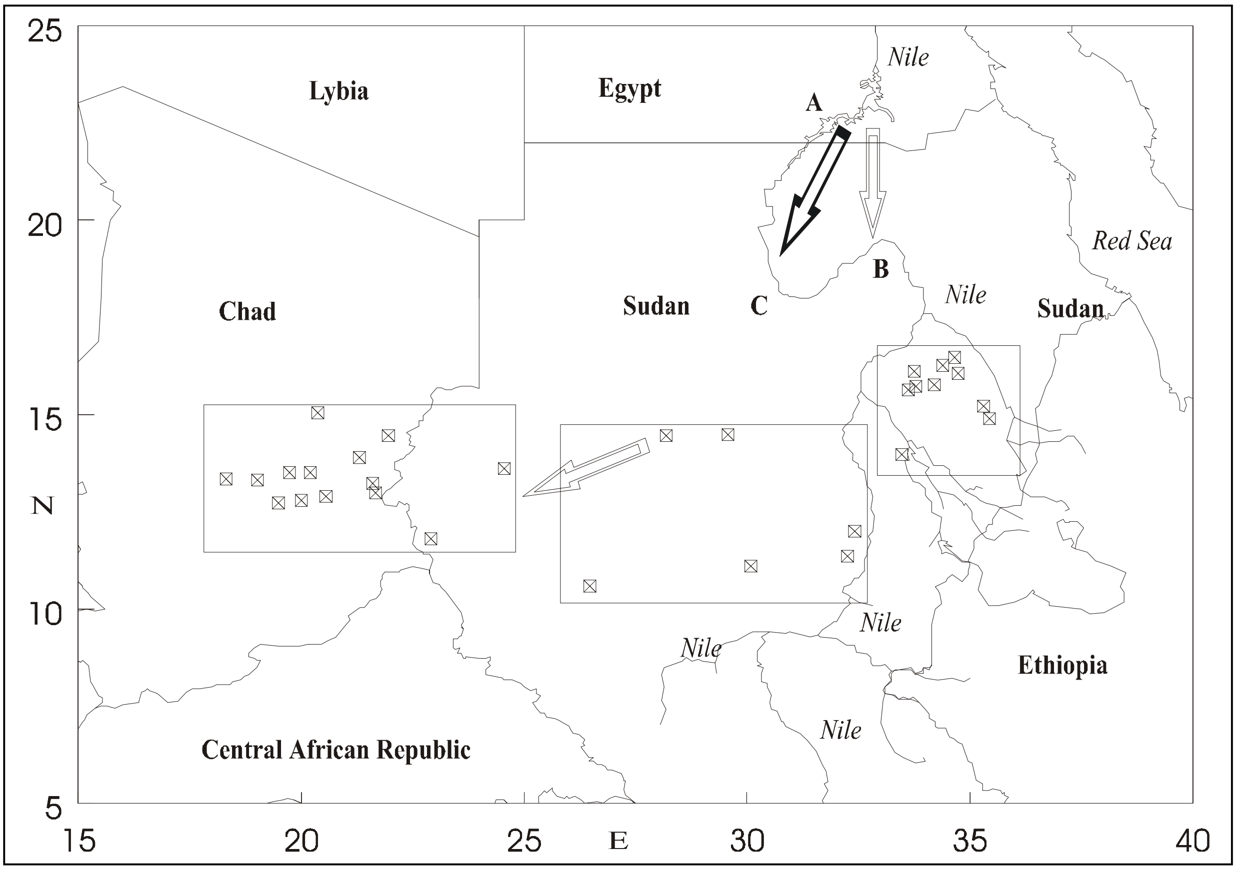


Figure IV.6. ***Location of pre-wintering areas of tagged White Storks.***

The tagged White Storks stayed at one pre-wintering site between 5 to 144 days. From 4 storks (+), the transmitters had failed before the birds left the sites (Table VIII.13).

The number of days spent at the pre-wintering site varied between years (ANOVA : $F_{6,10}$=6.43, P=0.01). Region ($F_{2,10}$=0.75, P=0.50), age ($F_{1,10}$=0.04, P=0.84) and arrival day ($F_{1,10}$=0.04, P=0.84) had no significant influence. Only one set of data was used for those storks tracked during several winters (we used 'Prinz' 1994, 'Prinzessin' 1994, 'Polsky' 1996).

Table IV.8. ***Number of days tagged storks stayed in the pre-wintering area.***

Year	Number days	std	Number individuals
1992	56	-	1
1993	68	-	1
1994	56	12	4
1995	54	-	1
1996	28.7	10.6	7
1997	68	-	1
1998	70.8	4.4	6

3.2 Repeated choice of pre-wintering area

3 individuals were followed in different autumns. The male '*Prinz*' was tracked in autumn 1994 and 1996 and chose the same pre-wintering area, it flew twice to the western area (13°14'N 21°36'E and 11°48'N 22°54'E, distance 213 km).

The female '*Prinzessin*' was tracked in autumn 1994, 1997 and 1998. It flew to the eastern area (15°13'N 35°18'E) in 1994, in 1997, it flew 621 km west to the central area (14°29'N 29°34'E) and, in 1998, to the eastern area (15°46’N 34°12’E, Figure IV.7 and 8). The distance between both sites in the eastern area is 133 km.

In 1996, 1997 as well as in 1998 *‘Polsky’* flew to the western area (12°59'N 21°40'E, 13°19'N 19°01'E and 13°21’N 18°19’E). The locations in 1996 and 1998 were only 76 km apart, while the 1997-site was 289 km and 364 km away from the sites in 1996 and 1998.

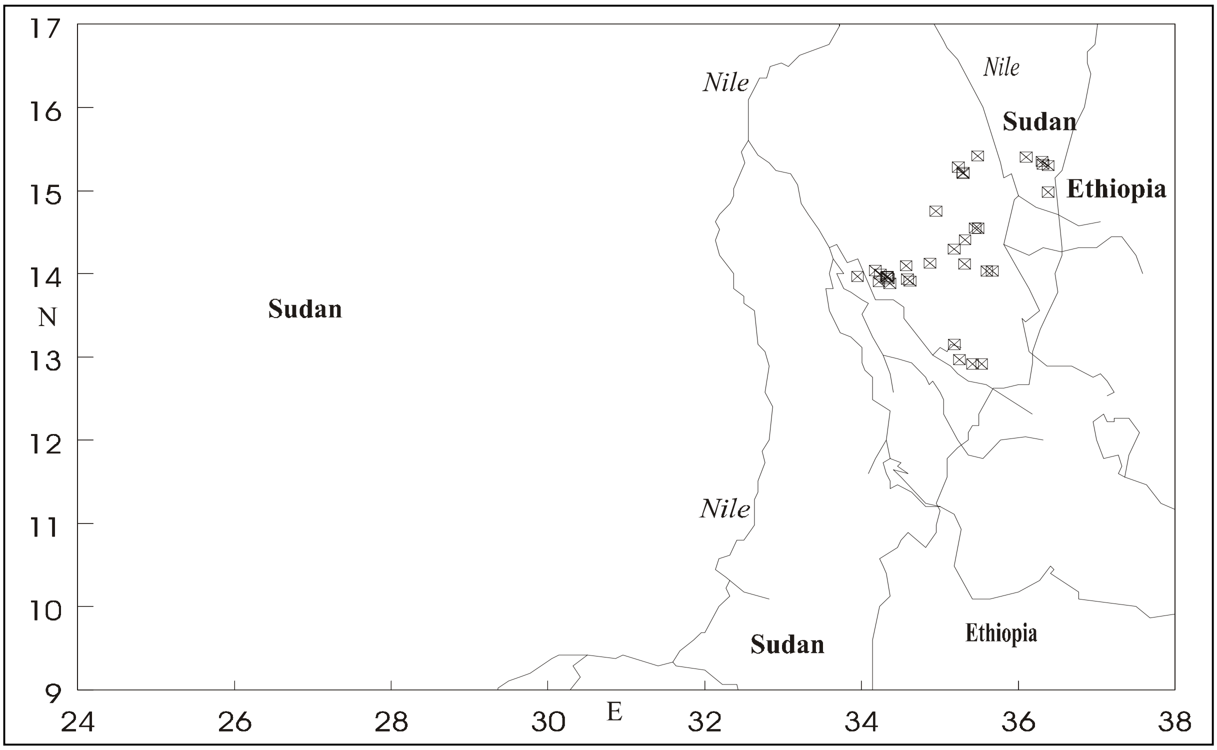


Figure IV.7. ***Pre-wintering area of 'Prinzessin' in 1994.***

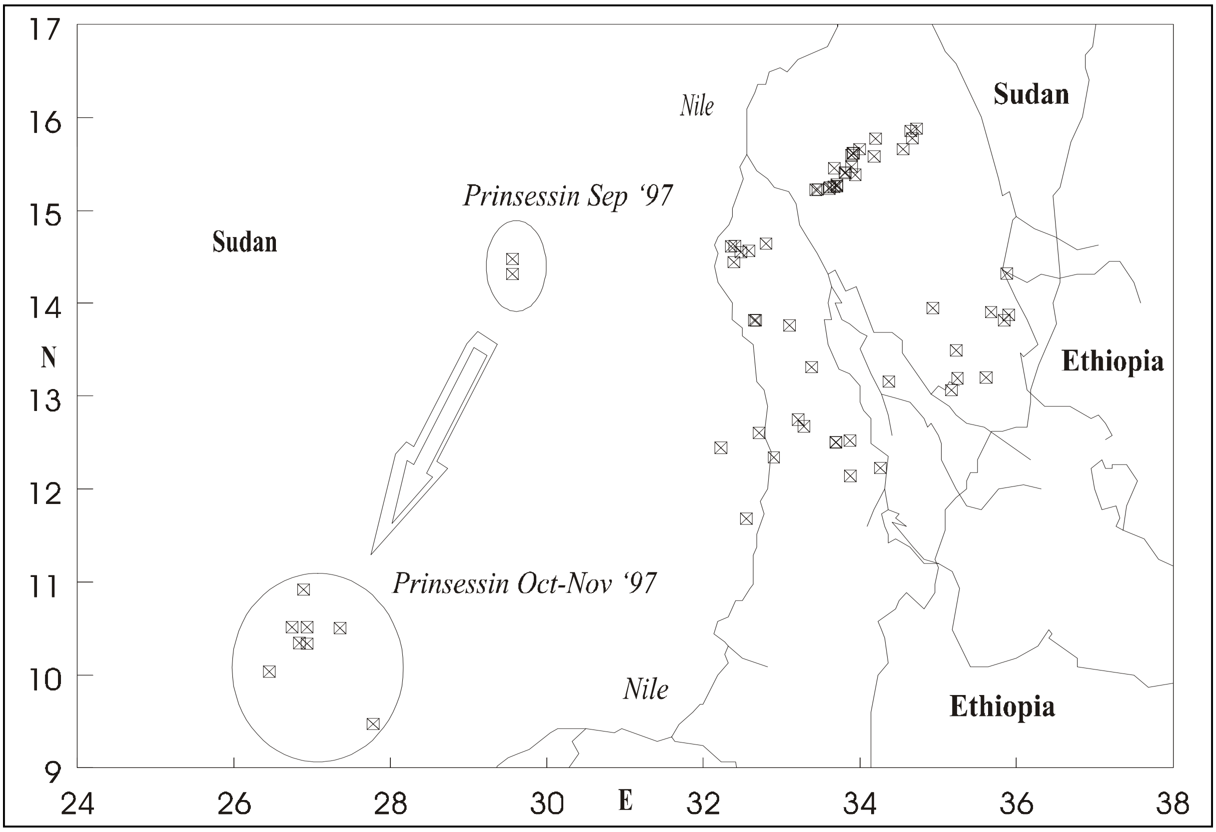


Figure IV.8. ***Pre-wintering area of 'Prinzessin' in 1997/98 (in circles) and 1998/99 (eastern sector).***

3.3 Location of wintering areas

After leaving the pre-wintering area, the tagged storks stayed in Sudan (5) or flew to Chad (3), Central African Republic (1), Uganda (1), Kenya (1), Tanzania (2), Botswana (3), Zimbabwe (1), Zambia (1), Mozambique (1) and South Africa (4 ; Table VIII.15). From the storks wintering north of the equator, 3 storks in Sudan, one in Uganda, one in the Central African Republic and 2 in Chad were not tracked during the complete wintering period. No tagged storks crossed the equator before the second half of November. Two adult storks crossed it in the second half of November, 4 storks in the first half of December and a further 4 birds in the second half of December. One adult crossed the equator on 13 January and two 1st-winter storks late in the season on 26 January and 3 February 1999, respectively (Table VIII.15).

'*Prinzessin*' did not use the same wintering areas but flew to Tanzania in 1994/95, Kenya in 1996/97 and South Africa in 1998/99. '*Polsky*' stayed at two different locations in Kenya in 1996/97 and 1997/98 and in Sudan in 1998/99 (Table VIII.15).

4. Discussion

Numbers of storks wintering in Europe and Middle East. An increasing number of storks is observed in winter near the breeding area, even in northern parts of the breeding range in Denmark and Germany (Bauer and Glutz 1966, Schulz 1988, Anon. 1997). In Ukraine, 121 single White Storks were found wintering between 1980 and 1989 (Grischtschenko 1991). In most countries along the Mediterranean Sea and in Arabia the numbers of wintering storks are small. In Tunisia, observations in November and December are very rare (Lauthe 1989). In Greece, there are no cases of successful wintering reported (Martens 1966). In Turkey, only a few storks are wintering in locations along the main autumn migration axis and continuous wintering has not been proved (Kasparek and Kilic 1989). In adjacent Syria, 350 storks were counted in January 1995 (Delany et al. 1999). In Egypt, there are only a few records every winter (Goodmann and Meininger 1989), while in southeast Sinai a few tens to hundreds winter on a garbage dump (Dinsmore, pers.com.). In Saudi Arabia, 300 to 350 storks wintered in January 1995/96 (Delany et al. 1999). In the southern part of Arabia, White Storks winter sometimes in 'large' numbers as occurred in 1936/37 (Haverschmidt 1949). In east Arabia, single storks and exceptionally small flocks winter in the Arabian Gulf States and Oman

(Bundy and Warr 1980, Gallagher 1989). Northern Israel and southern Spain and Portugal are the only regions in the Mediterranean area, where thousands of storks stay throughout the winter period. In Israel, the real increase started in 1968/69 to a maximum of 4700 individuals in 1976/77. This is more than a decade before the occurrence of storks on the Iberian Peninsula during October and November (Bernis 1959, Tortosa et al. 1995). Later, an increasing number was observed in Spain staying in autumn (Tortosa 1992). In 1991 and 1992, already 3000 White Storks wintered in the marshes of the Guadalquivir in the south of Spain. In the same area, 3900 storks were present in November 1995, while all over Spain a total of 7600 storks were wintering (Anon. 1997). A positive trend was also observed in Portugal, where 1187 wintering storks were counted in November 1995 (Rosa et al. 1999). The highest numbers were counted in the southern districts Faro and Setubal. During the late 1970s, their numbers in Israel decreased sharply to stabilize on the level of 2000 individuals during the 1980s and to decrease gradually to about 1000 storks in the late 1990s. Mendelssohn (1975) mentions better protection of the species, increase of irrigated agriculture and increase of water area as factors responsible for the growing numbers of wintering and summering storks in Israel. It is interesting that numbers only increased after winter 1967/68, when the total fishpond area had already been on the highest level for several years. After the peak in the mid 1970s, the number of wintering storks decreased along with the total fishpond area. Our results confirm the importance of fishponds. Storks concentrated in large numbers at ponds with many dead fishes. The mean concentration coefficient was 40 %, with a maximum of 89 %. However, we found almost no storks feeding in fields, on the contrary, the Hula Valley with large areas of Alfalfa fields had the lowest number of wintering storks of all fishpond areas. Agricultural areas were not important, but the garbage dumps are temporary feeding sites from December to April, crucial for the survival of the wintering storks. Garbage dumps, rice and alfalfa fields are quite recent potential feeding sites in Spain (Schulz 1994). In irrigation canals, the storks may also feed on Red Swamp Crawfish *Procambarus clarkii* (Tortosa et al. 1995).

Location and importance of pre-wintering areas in Africa. While the regular wintering areas of the White Stork are found south of 14°N (Schüz 1959), all tagged storks stopped for several weeks in Sudan or east Chad over a vast area of more than 2000 km between 16° to 10°N and 16° to 36°E.

Based on observations and ring recoveries, Schulz (1986) locates the main pre-wintering area in Sudan, south of Khartoum, between 16° and 12°N and 28° to 36°E. Most observations and most autumn recoveries were in the grass savannah east of the White Nile, particularly near Wad Medani, towards the border with Ethiopia. These areas are used every year and the limits are well defined, but the numbers of storks differ between years (Schulz 1988). West of the White Nile, there are less recoveries and fewer observations. Only near the area of Jebel Marra were storks observed regularly. In the region of Nyala and Bahr-el-Arab and Bahr-el-Ghazal even a few thousands would winter (Hogg et al. 1984). During a survey in September and October 1986, Hogg observed 3000 storks along the road in Wad Medani and 6000 storks between White and Blue Nile. In west Sudan, in the provinces Kordofan and Darfur, most storks were observed migrating through without resting for a longer time (Schulz 1988). South of 10°N -in the floodplain of the Sudd- the vegetation would be too high for foraging. Our data show that west Sudan and east Chad are more important pre-wintering areas than previous observations predicted. Out of 17 tagged storks, only 5 stayed east of the White Nile.

Although all tagged storks stopped at a pre-wintering site and crossed the equator only after the second half of November, there are some other interesting observations. In the early 20th century some 1st-winter storks arrived in South Africa at the end of September (Haverschmidt 1949). Dean (1964) made a similar observation, he counted the highest numbers of White Storks in the Rukwa Valley in Tanzania in September 1959 (2200), but it is not clear whether these were newly arriving or summering storks. These birds could only stop for a very short time at a pre-wintering site.

Tagged White Storks arrived in the pre-wintering area from the middle of September and left the area from the end of October till the middle of December. Field observations and ring data show that White Storks arrive in central Sudan from August until early October (Schüz and Böhringer 1950, Schulz 1986). From the middle of October, storks start leaving Sudan to the south, although some individuals stay all winter (Schulz 1988). In 1986, the departure coincided with a change in wind direction from south to north (Schulz 1988). From November to February, ringed 1st-winter birds were reported from Uganda to South Africa (Schüz and Bohringer 1950). These observations correspond with the arrival of migrating storks in Kenya at the end of October and beginning of November (Pomeroy 1989, Schulz 1988).

The number of days tagged storks roosted in the pre-wintering area varied between years. Other factors such as region, age or arrival date had no influence. In 1996/97, tagged storks stayed in the pre-wintering area only for 29 days, compared to 54 to 71 days in other years. The consequence of this difficult winter for storks was the severe 'Störungsjahr' 1997, when large numbers of storks arrived too late in the breeding area (C. and M. Kaatz 1999). There are previous data on the distribution of eastern White Storks related to the occurence of pest species. In years with extensive rains and thus higher food availability in east Africa, White Storks arrive later and in smaller numbers in southern Africa (Dean 1964). In years with dry conditions in northern parts of east Africa, up to 200000 would 'winter' in South Africa (Schulz 1988). For example, large numbers of storks arrived in 1972/73 in Natal, South Africa (Maclean et al. 1973). In spring 1973, White Storks arrived late and in smaller numbers in central Europe (Schüz and Szijj 1975).

Fidelity to wintering grounds. At least 11 out of 20 marked adult storks returned to Israel in successive winters. None of the 4 wintering young storks were observed in later seasons. The three tagged storks that were tracked during several winters returned to roughly the same pre-wintering area. Only '*Prinzessin*' choose in one autumn a pre-wintering site almost 700 km away from the sites in other years. Although two tagged storks were faithful to their region in early winter, they moved to different wintering sites each year, even thousands of kilometres apart.

There are very few data in the literature on fidelity of storks to their wintering site. One remarkable ring sequence was collected from 'Bob', a pullus ringed on 25 June 1972 in Dorum-Marren (53°43'N 8°35'E), Germany (ring : *Helgoland 2188;* Meybohm and Fiedler 1983). On 6 November 1972 'Bob' arrived in a very weak condition at a farm in Gatooma (18°16'S 29°55'E), Zimbabwe and was fed. This stork migrated back to Europe and returned till 1981 to this same place in Zimbabwe. In southwest Spain, 2 out of 32 ringed birds observed in November 1991 were also observed in November 1992 (Tortosa et al. 1995). This is a very low proportion compared to the Israeli data.

We can conclude that White Storks seem to return to the same area as in the previous autumn. However, only on sites with predictable, good food resources the storks stay all winter. Taking into account their gregarious behaviour and concentrations near locust outbreaks it is unlikely that many storks show a high fidelity to their wintering sites in Africa.

Which factors determine the choice of wintering site ? The composition of the wintering populations in Israel and Spain suggests an influence of age (1), sex (2), timing (3) and possibly the location of breeding area (4) on the distribution of storks in the wintering area. These observations suggest a higher proportion of 1st-winter storks and females on southern wintering grounds. From previous studies we know that the White Stork is a highly gregarious and migratory species also in the winter quarters. The choice of wintering areas is strongly influenced by climatic conditions determining the food availability (5; Dallinga and Schoenmakers 1989).

(1) Age

The proportion of 1st-winter storks in the Israeli wintering population is lower than in the overall population. We observed differences between winters in the proportion of 1st-winter storks, only 3 to 4 % were present in winter 1993/94, 6 to 7 % in 1995/96 and 1996/97, 13 to 16 % in winter 1994/95 and 12 to 19 % in winter 1997/98. Previous observers report the absence of 1st-winter White Storks in wintering groups in December and January in Israel (Fiedler 1986, Bich 1996). There are also only two ring recoveries of 1st-winter storks in winter (Raviv 1989). The very low proportion of young storks was also observed in southwest Spain, where 7 out of 63 different marked storks (6%) observed in November 1991 and 1992 were 1st-winters (Tortosa et al. 1995). This percentage is very low, on autumn migration 1st-winters represent about 40 % or more of the population. Even in years with a bad breeding season as in 1997, 18 % were 1st-winters.

Bairlein (1981) described an effect of age. In December, 4 out of 10 adult western White Storks were recovered north of the Sahara, 3 of them in Spain. In December, the mean distance between recovery site and birth place was shorter for adults 3185 km than for 1st-winter storks 3778 km. For storks recovered in January, this distance was 3740 km and 4167 km for adults and young birds, respectively and not significant. For eastern storks there are contradictory data on the existence of age related wintering zones. In Uganda and Kenya, Schüz and Bohringer (1950) found a proportion of 56 % 1st-winter storks, recovered in December and January. In southern Africa, however, 71 % of the recovered storks were in their 1st-winter. According to Cramp and Simmons (1977), the proportion of 1st-winter storks is higher in South Africa than further north. This is confirmed by ring recoveries in southern Africa, which show a ratio between 1st-winter and adult storks of 2:1 from November to April (Oatley and Rammesmayer 1988). During May and October the ratio between 1st-winter and older storks is 1:1. In contrast, Kania (1985) found no age-related differences between the wintering grounds of Polish storks recovered in December and January and neither did Schmidt (1987) find any differences in the wintering areas of German storks of different age groups. This contradictory data might be caused by the fact that 1st-winter storks start on autumn migration one to two weeks before the adults on autumn migration and thus more south.

(2) Sex

In Israel, 11 out of 14 captured wintering storks were males, which is confirmed by observations that only few females are present in the flocks. From other regions there are no observations of the sex of wintering storks. Males might have an advantage in successfully claiming their nest site by arriving early (Berthold 1988).

(3) Timing

Wintering storks arrived in Israel only after the main migration period from the second half of September. Marked storks repeated this behaviour yearly and always arrived after the bulk of migration. Like tagged adult storks in Africa, many Israeli adult storks started their spring migration in February. The starting date was not correlated with the distance to the breeding site.

(4) Location of breeding area

In Israel, marked wintering storks were long-distance migrants from northern and central breeding areas. The Israeli breeding birds, that are almost all ringed were only observed on migration. This is in contrast with the Spanish wintering population in the Guadalquivir marshes, where most marked storks have hatched in the Guadalquivir and Huelva area (n=60) and only few (n=5) came from other areas in Spain (Tortosa et al. 1995).

Western European and Maghreb 1st-winter storks were recovered at different areas south of the Sahara (Jenni et al. 1991, Mullié et al. 1995). The mean coordinate of recovery for western

European storks was in the western Sahel (13°07'N 8°09'W, n=25) and further east (12°07'N 3°03'E, n=17) for Maghreb storks. Tunisian storks were mainly recovered even further east in the Lake Chad basin (Lauthe 1989). We observed how White Storks from southern breeding areas passing through Israel earlier than northern birds. As was shown for western storks, it is possible that there is a relation between winter distribution and origin in eastern storks. In December and January, storks from northwest Poland were recovered more commonly in the northern part of the winter quarters than storks from southeast Poland (Kania 1985). From 7 storks recovered in Africa, north of 5°N, only one came from southeast Poland. 20 out of 37 storks from northeast Poland were recovered south of 24°S.

(5) Food availability

The variation in the choice of and time spent in the pre-wintering area can be explained by varying food availability -mainly locusts-, low vegetation (savannah, farmland) and the presence of water (pools or river ; Schulz 1986). In Africa, White Storks feed on Red Locust *Nomadacris septemfasciata* and Desert Locust *Schistocerca gregaria,* the occurrence of which is influenced by the amount of yearly rainfall (Verheyen 1950, Vesey-FitzGerald 1955, Dallinga and Schoenmakers 1989). Insect abundance strongly increases after periods of rain, with moths and beetles appearing within 24 h of rainfall (Sinclear 1978). White Storks mostly visit dry savannahs, meadows in river floodplains and lakes as well as cultivated fields. Storks wander about searching for food. They are attracted by regions where it has recently rained, burned areas and insect plagues (Dean 1964, Schulz 1988). Schulz (1986) observed that flocks changed feeding and roosting areas by more than 10 km in a few days. Changes in prey abundance occur quickly, the density of 30 locusts/m² decreased to only 0.5 locusts/m² within a few days. The storks chose the sites in relation to the presence of food. The African Armyworm *Spodoptera exempta* is also an important potential prey species (Dallinga and Schoenmakers 1989). In January 1987 in an area of 25 km² in Tanzania, 100000 storks were feeding on massive numbers of Army-worms. Almost no storks were seen in southern Africa that winter (Schulz 1988). It is unclear which proportion of storks are feeding in man-made habitats in the pre-wintering area and what effect this might have on stork numbers. But in southern Africa, the regional distribution of recoveries of the White Stork is concentrated in the summer-rainfall area (Oatley and Rammesmayer 1988) and most storks are observed in man-altered habitats, mainly in alfalfa fields (Allan 1989). The expansion of storks to the southwest Cape coincided with the introduction of alfalfa as a ley crop.

We can summarize that the winter distribution of eastern storks is related to food availability and timing rather than to age and origin.

What caused the population changes of wintering storks in Israel ?

The composition and numbers of wintering storks in Israel and Spain can be determined by different conditions. Do storks have a migratory system with genetically programmed distances (1), or is wintering in Israel a conditional strategy determined by external circumstances (2).

(1) Migration timing, direction and migratory distances are genetically determined (Berthold 1988). Wintering as far north as possible might have selective advantages in terms of survival and reproduction. If this is the case, the genetically programmed short-distance migrants will be favoured. This would produce a gradual increase in numbers. In this scenario, we do not expect any strong yearly differences, while the proportion of both sexes might be equal. We observed large differences in the proportion of 1st-winters in the population and males were dominant in numbers. Whether there is a substantial genetic basis for the local wintering of storks in Europe remains open until variable behaviour of reintroduced storks can be analyzed in more detail (Jenni et al. 1991, van der Have and Jonkers 1996).

(2) If condition is a determining factor for the choice of a northern wintering site we might expect very weak or strong birds. In Ukraine, more than 50 % out of 121 singly wintering White Storks were unfit and only 10 % wintered completely independently of humans, the rest was either fed or kept in semi-captivity (Grischtschenko 1991). The unfit condition of these storks might have stopped their autumn migration, but are the storks in Israel and Spain also unfit to continue to migrate to Africa ? As shown in II.1.2, 1st-winter storks have a worse condition than adults on migration. But only a very low proportion of 1st-winters are wintering in Israel and Spain (this study, Tortosa et al. 1995). Some wounded birds certainly tried to stay in Israel, but weak birds arrived throughout the migration period and wintering storks only its end. Storks wintering in Israel left for their breeding grounds and a high proportion returned, we expect that a weak bird cannot breed and migrate successfully. In the 'Störungsjahr' 1997 more 1st-winter storks arrived late and a higher proportion tried to winter in Israel. Are storks wintering in northern areas very fit birds ? Storks wintering in Israel were mainly adult males. Theoretically we should expect a proportion of 40 % or more 1st-winters

in the population, but there were only 3 to 19 %. But is this an effect of competition ? We observed 1st-winter storks choosing habitats with easily reachable food, however migrant 1st-winters could not be pushed out by dominant adults, because they had not arrived yet when young storks passed through.

To summarize we can say that late migrants try to stay in Israel, if local food conditions are sufficient. The late migrants that succeed in staying all winter in northerly areas are adult males.

Chapter V :Threats

1. Introduction

Previous studies revealed a very high mortality rate of this large soaring bird of up to 52 to 74 % for 1st-winters and 25 to 50 % for adult storks (Bairlein and Zink 1979, Lebreton 1981, Dallinga and Schoenmakers 1984). These mortality data of White Storks are based on the analysis of ring recoveries (Bairlein 1981, Schultz 1988). In this chapter, we compare these data with an analysis of the regional unbiased data of tagged storks. To understand the importance of different causes of mortality, we took notes on the number and the probable causes of dead or injuries of storks in the important roosting sites in Israel.

2. Mortality

2.1 Mortality of tagged White Storks

Only 7 out of 24 1st-winter tagged White Storks reached northern Sudan (Table V.1). Not included are the 2 storks the transmitters of which had failed. Compared to the Middle East and North Africa and taken into account the number of kilometres in the regions, four times as many young birds died in Europe. In contrast, 18 of 19 tagged adults reached the pre-wintering areas in Sudan. None of the adults died on autumn migration in Europe or Turkey. Not included are 2 adults the transmitters of which failed on migration and No *95550* that migrated to Yemen. 4 out of 7 surviving 1st-winters storks were tagged shortly before fledging or free-living and 3 were kept in a cage for a short period.

One year after tagging, only 12 out of 22 adult storks were still alive. From the total of 31 tagged adults, 9 transmitters stopped due to technical problems and were not used in this analysis. All 21 1st-winter storks were dead after one year, 6 transmitters stopped due to technical problems.
From some tagged storks we know the exact cause of death. One adult was shot in Yemen, one was wounded at its leg and died in Turkey and one hit powerlines in Zimbabwe. Three 1st-winters storks died after hitting powerlines, one was wounded. One stork was found in Germany eaten by a White-tailed Sea Eagle *Haliaeetus albicilla* but it was not clear, whether the bird was killed by the eagle or had died before.

Table V.1. ***Number of tagged White Storks that died on autumn migration from Germany and Poland to northern Sudan (1991-98).***

	Germany-Poland Bosphorus Europe	Bosphorus Iskenderum Turkey	Iskenderum Sinai Middle East	Sinai Sudan North Africa	Tagged (n)
1st-winter	12	1	2	2	24
Adult	0	0	1	0	19
Km	1760	780	1040	1000	

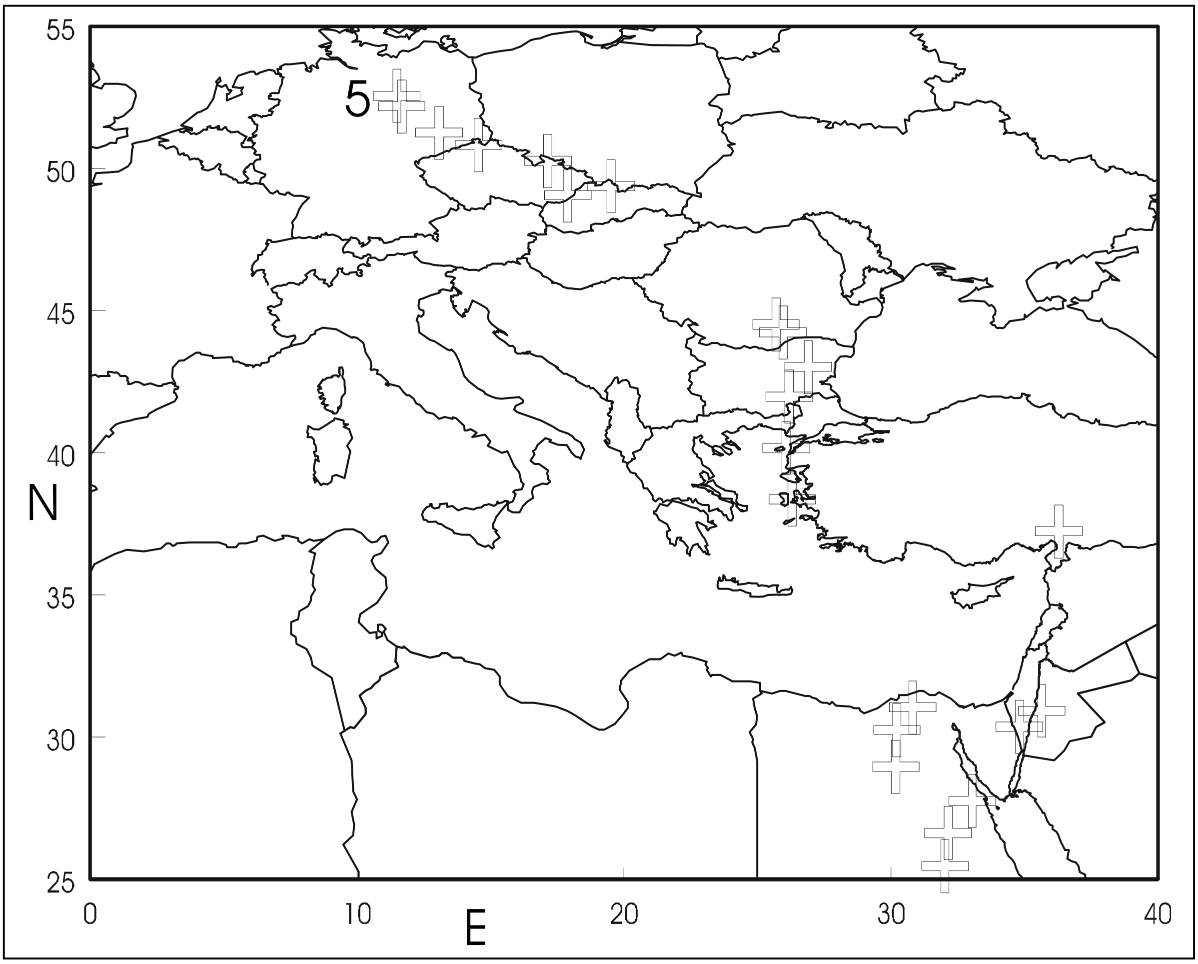


Figure V.1. ***Locations where tagged storks were killed in Europe.***

Tagged storks died along the migration flyway and especially close to the breeding area (Figure V.1). In Africa, many tagged storks died from an unknown cause in Egypt (Figure V.2). Exhaustion after crossing the desert might be an explanation for this high mortality. We lost tagged birds in many different countries of the prewintering and wintering but without being concentrated in a certain area.

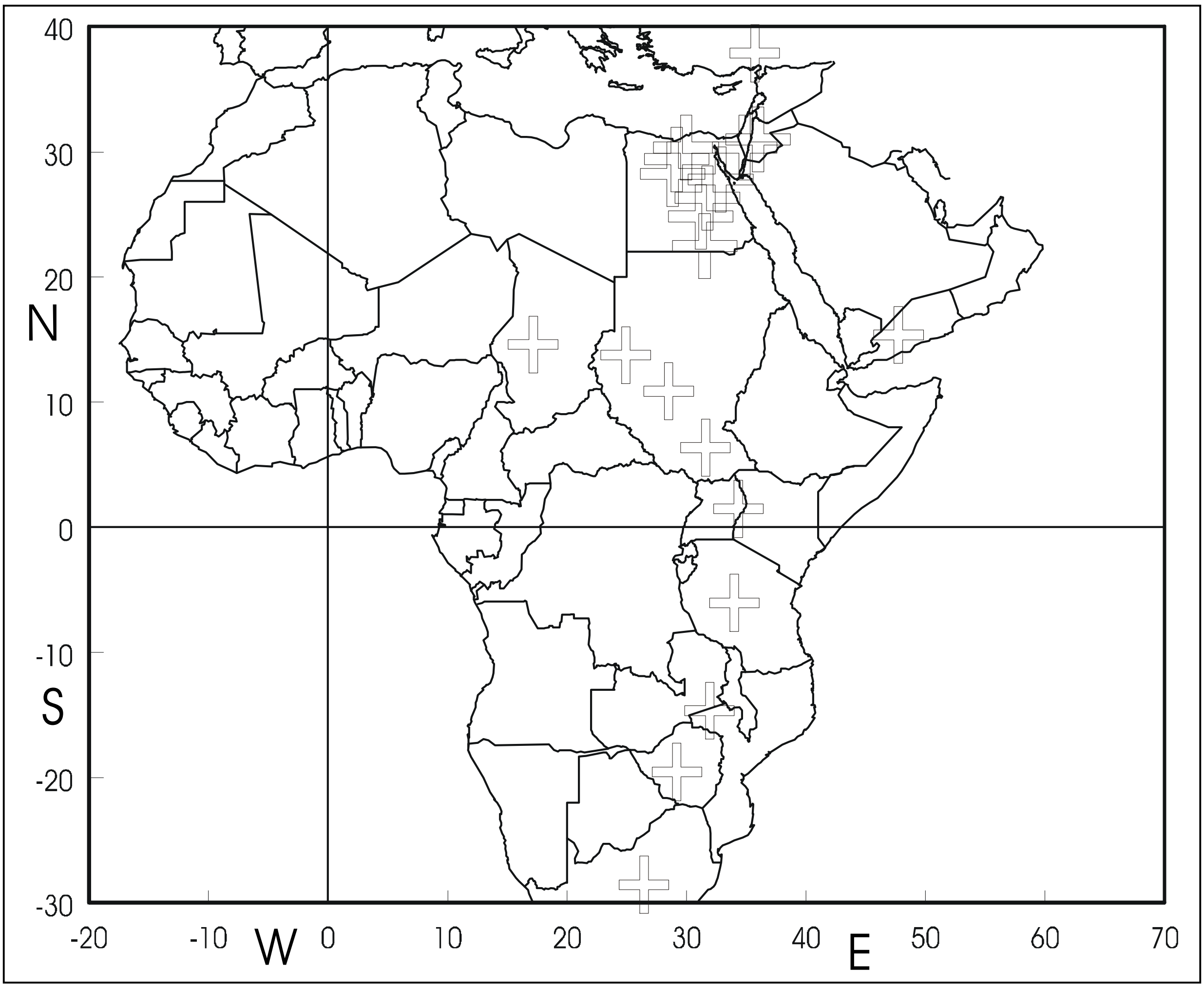


Figure V.2. ***Locations where tagged storks died in Africa.***

2.2 Mortality of White Storks in Europe and Turkey

From 1995 to 1999, Michael Kaatz and his co-workers followed tagged storks on their migration route in autumn and spring. During these expeditions they recorded information on the probable cause of death of 84 White Storks (Table V.2).

Table V.2. ***Number and cause of death of White Storks found dead in Europe and Turkey.***

	Powerlines	Predator	Killed on road	Injury	Bad condition
Autumn 1995	1	0	0	0	0
Autumn 1996	0	0	0	4	12
Spring 1997	8	2	21	0	20
Autumn 1997	0	0	0	4	3
Spring 1998	0	0	0	0	0
Autumn 1998	1	0	0	6	2
Spring 1999	0	0	0	0	0
Total	10	2	21	14	37

Remarkable is the high number of storks killed on the road in spring 1997. At that time the weather conditions in Turkey were very poor and hungry Storks were looking for food everywhere they could, including the side of the road. Only 12 % of the birds that were found were killed by hitting powerlines.

2.3 Mortality of White Storks in the Bet She'an Valley

During the study period, we collected 147 dead White Storks in the Bet She'an Valley (Table V.3). Most birds were found dead in autumn. The numbers of dead birds were high in autumn of 1993 and 1994, due to hitting electric wires (Table V.4).

The causes of death of these 147 White Storks are listed in Table V.4. Overall most storks were killed by collisions with electric wires.

Table V.3. ***Number of White Storks found dead.***

		Adult	1st-winter	Unknown age	Total
Autumn	1993	11	18	0	29
Autumn	1994	9	49	0	58
Spring	1995	2	6	3	11
Autumn	1995	5	7	0	12
Spring	1996	7	8	0	15
Autumn	1996	1	4	3	8
Autumn	1997	7	6	1	14

Table V.4. ***Causes of death of White Storks found in the Bet She'an Valley (1993-97).***

	Adult	1st-winter	Unknown age	Total
Electric wires	22	62	3	87
Stuck in mud	4	2	4	10
Bad condition	0	19	0	19
Killed by raptor	1	2	0	3
Choked in fish	4	1	0	5
Killed on road	0	2	0	2
Caught in tree	0	1	0	1
Killed in net	0	1	0	1
Cause unknown	11	8	0	19

Several hundreds of wounded storks were observed in the Bet She’an Valley (Table V.5). There might be a number of double-counts in the total of storks with broken legs.

Table V.5. ***Observations of wounded White Storks during 1993-97. The total includes birds of unknown age.***

	Adult	1st-winter	Total
Broken wing	15	17	33
Broken leg	240	74	324
Broken beak	3	1	4
Shot	1	0	1
Bad condition	12	11	25
Stuck in mud	5	5	10
Swollen leg	3	1	4

In Table V.6, the number of observations of wounded storks is compared with the total number of storks controlled on the ground in autumn 1996 and 1997. Maximally 2 out of 1000 storks were wounded. On several occasions storks with broken legs were observed arriving in migrant flocks. Several of them were also seen leaving the area with migrants. Most of the wounded storks had a partially broken and healed tarsus. Others had clear cut wounds, with part of the tarsus cut off. Most of the badly wounded storks with splintered tibia or tarsus and broken wings died soon.

Table V.6. ***Observations of wounded White Storks compared to the total number of observations in autumn 1996 and 1997.***

Period	Wounded	Controlled	% Wounded
09.96	42	21293	0.20
10.96	9	12017	0.07
11.96	4	3956	0.10
08-10.97	65	88119	0.07

Some wounded storks were observed for a longer period. In autumn 1995, we observed a 1st-winter bird with a broken bill from 11 August to 7 September. The upper and lower bill was cut in half. In August 1995, we caught a 2nd-winter bird with a swollen foot, which could not walk in a normal manner. We observed it from 15 August 1995 to 7 March 1996 at several places in the Bet She'an Valley. It succeeded in eating dead fishes along edges of fishponds and in feeding at the sewage ponds near Newe Etan.

One adult White Stork found in Geva in autumn 1993 and one 1st-winter in autumn 1996 in Hamadya were killed by a 1st-winter Bonelli's Eagle *Hieraaetus fasciatus*. In autumn 1992, several White Storks were killed by a Bonelli's Eagle at Kefar Ruppin.

After the take-off of migrating storks, we found several birds in bad condition at the roosting sites. Most of these storks in bad condition and found dead were 1st-winter birds (Table V.4). Furthermore, 25 storks were found weakened but still alive, half of them were adults (Table V.5). Two 1st-winter birds were found exhausted and died later, after their flock had been disturbed several times. Both birds were found 8 km away from the original landing site. On that day, there was a strong westerly wind.

All 20 storks that were found sticking in the mud of a pond had broken legs, a damaged wing or were in bad condition. Birds with a broken leg or wing seemed to have no chance to get out of the mud alive.

87 out of 147 storks were killed by hitting electric wires and another 33 and 324 storks had broken wings or legs also mainly caused by hitting electric wires. The majority of killed storks in this group were 1st-winter birds (Table V.7). In contrast, there were many more adults with a broken leg and an equal number of both age-groups with broken wings.

Table V.7. ***Number of White Storks killed directly by hitting electric wires.***

	Adult	1st-winter	Total
Autumn 1993	5	11	16
Autumn 1994	4	36	40
Spring 1995	2	5	9
Autumn 1995	2	4	6
Spring 1996	5	4	9
Autumn 1996	0	2	2
Autumn 1997	4	0	5

Poisoning of White Storks was not observed in the Bet She'an Valley during the study period. Only 2 storks were found dead in an alfalfa field. In November 1996, several Black Kites and Marsh Harriers *Circus aeruginosus* were found poisoned in an alfalfa field of Kefar Ruppin after the field had been sprayed with pesticides against rodents. Luckily, no storks were foraging on these fields.

Particularly in autumn 1993 and 1994, White Storks were observed contaminated with oil (Table V.8). Most contaminated birds had oil on breasts and necks, some birds had oil on the wings. Most individuals had several oil stains, one individual was completely black with oil. None of the birds were found dead, although some birds looked severely weakened. Most of the contaminated storks were adults.

Table V.8. ***Observations of White Storks polluted with oil.***

	Adult	1st-winter	Unknown age	Total
Autumn 1993	72	11	2	85
Autumn 1994	29	1	0	30
Spring 1995	0	2	0	2
Autumn 1995	4	0	0	4
Autumn 1996	1	0	0	1
Autumn 1997	0	0	0	0

On 31 August 1993, there were 421 local White Storks in the area of which 15 were polluted with oil (4 %). In 1993, no oil polluted storks were seen before 22 August and after 10 September (only one on 29 September). Before 22 August 1993, 55000 storks passed the area, but no birds were seen with oil. In autumn 1996 and 1997, only one stork was contaminated. We have no indications on how and where these birds have been contaminated with oil.

3. Disturbance

On several occasions, thousands of roosting storks were disturbed and some flew against electric wires (Table V.9).

Table V.9. ***Number of White Storks in roosting flocks, disturbed and killed by hitting electric wires.***

Date	Place	Flock size	Number killed
19.08.93	Kefar Ruppin	10400	2 1st-w, 1 ad
20.08.93	Ma'oz Hayyim	3700	4 1st-w, 2 ad
25.08.93	Kefar Ruppin	1116	3 1st-w
14.08.94	Tirat Zevi	2000	3 1st-w
13.03.96	Ma'ale Gilboa	3500	5 ad

The storks were immediately killed or their wings and legs were broken. This was observed in autumn as well as in spring and both 1st-winter and adult storks were killed or wounded when disturbed (Table V.4,5 and 9).

Disturbance is an important factor for the migrants in the Bet She'an Valley and is certainly not incidental. More than half of the very large flocks of more than 1000 birds were chased (Table V.10). We observed that the migrant flocks were more often disturbed in spring than in autumn. Some groups were disturbed by accident but especially in spring birds were chased by hunters chasing Pelicans and cormorants from the fishpond and fields.

Table V.10. ***Number of disturbed migrant White Stork flocks in the Bet She'an Valley.***

Period	Flock size	Number	Prop. disturbed
Aut 1993-95	100-1000	223	36 %
Spr 1995	100-1000	228	58 %
Aut 1993-95	>1000	69	48 %
Spr 1995	>1000	21	62 %

4. Contamination with biocides

The results obtained from a total of 66 samples are listed in Tables V.11-15 and can be interpreted as follows. On the whole, the contamination levels can be considered relatively low and non-critical, apart from a value of over 1,500 ng g^{-1} DDT in the liver of one stork in Israel. Even though the values given here should in general not be regarded as acutely toxic, there is still an evident tendency towards relatively high contaminant concentrations in the samples from Israel. It would follow that White Storks are especially likely to become contaminated with biocides in Israel, despite the fact that they normally spend only a very brief time there. For this reason, further samples from Israel should be examined regularly in order to check the extent to which contamination reaches critical values, at which it can have an effect especially if the birds exert themselves severely during migration. Another interesting finding is that the biocide levels of old storks from eastern Germany are no different from those of juveniles. This means that the old birds on the migration routes and in the winter quarters probably do not become contaminated substantially beyond the situations in the breeding grounds. Finally, comparison with published research (Büthe et al. 1981) indicates that storks originating in eastern Germany have mercury and HCB levels similar to those of conspecifics studied in Lower Saxony at the beginning of the 1980's, but their DDT and PCB levels are only about one-third as high.

In addition to the 66 samples considered in detail here, we examined three others taken from storks found dead in Turkey during 1997, which were suspected of having been poisoned by the pesticide Lambda-Cyhalothrin. However, no evidence of such contamination was detectable, and only one bird showed an elevated liver content of DDE (over 1,500 ng g^{-1}).

Table V.11. ***White Stork: number of samples of material examined for contamination with environmental chemicals, 1994-2000; [1]sufficient only for mercury contamination.***

Region	Years	Liver	Blood	Serum	Total
Eastern Germany	1994-1998	9	9	-	18
Israel	1998-2000	7	4 (+6[1])	23	40
Egypt	1999	4	4	-	8
Total		20	17	23	66

Table V.12. ***Contaminant concentrations (mg g-1 wet weight) in blood and liver of White Storks of eastern Germany, aged <1 to several years, found dead in the years 1994-1998.***

Contaminant	Liver		Blood	
	1st winter (n=6)	adult (n=3)	1st winter (n=6)	adult (n=3)
Mercury	483,3 ±4217	339,9 ±4019	115,1 ±1200	152,2 ±1822
HCB	23,4 ± 420	29,8 ± 466	0,4 ± 6	0,3 ± 1
PCB	45,0 ± 475	41,9 ± 449	10,9 ± 55	13,1 ± 35
HCH	5,6 ± 65	3,2 ± 21	5,8 ± 38	6,9 ± 28
DDT	41,1 ± 368	60,1 ± 281	3,4 ± 30	2,7 ± 31
Chlordane	0,04 ± 0,11	0,0 ± 0	0,04 ± 0,07	0,0 ± 0
Nonachlore	0,11 ± 0,10	0,13 ± 0,14	0,44 ± 0,89	0,08 ± 0,08

Table V.13. ***Correlation coefficients for the concentrations of environmental chemicals in the liver and blood of 13 White Storks in Germany and Egypt.***

Contaminant	r	P
Mercury	0,78	<0,01
HCB	0,31	n.s.
PCB	0,69	<0,01
HCH	0,31	n.s.
DDT	0,51	n.s.
Chlordane	0,23	n.s.
Nonachlore	0,26	n.s.

(r>0,553 : p<0,05; r>0,684 : p<0,01)

Table V.14. ***Comparison of the contaminant loads (ng x g^{-1} wet weight) in the blood and liver of White Storks in the breeding grounds (Germany) and in the regions of passage through Israel and Egypt. For the geographical comparison the highest concentrations are underlined, and concentrations severalfold higher are in bold face. [1] only mercury.***

Contaminant		Germany	Israel	Egypt
Blood	n	9	4 (10[1])	4
Mercury		<u>127,4 ±132,8</u>	86,0 ± 153,6	39,7 ± 23,5
HCB		0,4 ± 0,5	**<u>1,3 ± 0,9</u>**	0,3 ± 0,2
PCB		11,6 ± 4,8	**<u>54,0 ± 24,4</u>**	41,1 ± 28,1
HCH		6,2 ± 3,4	**<u>26,2 ± 8,4</u>**	9,3 ± 3,9
DDT		3,1 ± 2,8	**<u>33,9 ± 35,6</u>**	1,5 ± 2,7
Chlordane		0,03 ± 0,06	0,0 ± 0	0,6 ± 0,5
Nonachlore		<u>0,32 ± 0,73</u>	0,15 ± 0,06	0,4 ± 0,3
Liver	n	9	7	4
Mercury		435,5 ±395,8	<u>516,9 ± 492,7</u>	76,4 ± 27,8
HCB		25,5 ± 40,7	<u>26,2 ± 28,9</u>	1,8 ± 0,9
PCB		44,0 ± 43,8	190,3 ± 201,9	<u>257,6 ±191,7</u>
HCH		4,8 ± 5,4	26,9 ± 19,4	<u>32,2 ± 21,6</u>
DDT		47,5 ± 33,7	**<u>5614,1 ± 19330,1</u>**	9,8 ± 9,7
Chlordane		0,06 ± 0,10	**<u>0,7 ± 0,8</u>**	0,10 ± 0,20
Nonachlore		0,12 ± 0,11	**<u>19,9 ± 24,4</u>**	0,30 ± 0,40

Table V.15. ***Mercury concentrations (ng x g^{-1} wet weight) in the serum of White Storks in Israel during various seasons and years. For the geographical comparison the concentrations severalfold higher are in bold face.***

	Summer 1998	Spring 1999	Summer 1999	Autumn 1999	Winter 2000
X ±sd	20,7 ± 1,5	22,7 ± 21,1	**105,0 ± 132,0**	**160 ± 90,6**	19,9 ± 19,2
n	3	3	4	4	9

5. Discussion

Studying mortality by using satellite-tracking rules out the possible regional differences in the probability of rings being found and reported. However the high costs of the transmitters are a limiting factor. The autumn migration mortality of 17 out of 24 satellite-tracked 1st-winter storks is high (71 %). This is especially high compared to ring data, which include mortality during autumn migration, the wintering period and spring migration. The autumn mortality of 1 out of 19 adult tagged storks (5 %) corresponds with ring data. Ring data from White Storks originating from Baden-Württemberg (Germany), Alsace (France) and the Netherlands showed that annual mortality rates and size of the breeding population were correlated (Table V.16). In a period with a stable population size, 1st-year mortality varied between 52 % and 68 %, annual adult mortality between 25 % and 31 %. In a period with a declining population size, 1st-year mortality was between 61 % and 74 %, and annual adult mortality between 36 % and 50 % (Bairlein and Zink 1979, Lebreton 1981, Dallinga and Schoenmakers 1984).

Table V.16. ***Mortality rates of White Storks from the western population.***

Region	Period	Annual mortality	
		1st-winter	Adult
South Germany (1)	1950-59	0.60	0.25
	1960-76	0.74	0.26
Alsace (2)	1950-59	0.52	0.25
	1960-71	0.61	0.40
The Netherlands (3)	1912-35	0.68	0.31
	1936-55	0.73	0.50

Bairlein and Zink (1979), (2) Lebreton (1981), (3) Dallinga and Schoenmakers (1984).

Only 3 out of 17 treated storks reached northern Sudan, while 4 out of 7 pulli and free-living storks survived the migration to Sudan. These data strongly suggest that the high 1st-winter mortality of tagged storks can partially be explained by the fact that most young storks from the 'Storchenhof' in Loburg were not adapted to free flight before release. Furthermore, the period in which the birds were released and negative effects of the transmitter could explain, to a lesser extent, the higher mortality. However, the normal mortality of transmitter equipped adult storks makes the latter explanation fairly unlikely.

What are the main threats for storks at an important, intensively cultivated stopover site ?

Only about 150 out of the 70000 to 180000 storks that stopped during migration seasons in the Bet She'an Valley were found dead. To this number we have to add the 0.1 to 0.2 % wounded storks that might have died later or could not return to the breeding area. The most important causes of death (59 %) and injuries (90 %) were collisions with electric wires and electrocution. Especially 1st-winter storks chose electricity poles as roosting sites in autumn. These poles were close to fishponds or trees where the rest of the flock was roosting. If they touched several wires during take-off, they were electrocuted. In spring, fewer storks were roosting on poles, most storks were roosting on trees. In every fishpond complex, there are electric wires between the ponds. Electricity is used for fish-feeders and machines that generate oxygen in the water. While more 1st-winters were killed by hitting powerlines, an equal number of 1st-winters and adults were found with broken wings. Many adults seem to crash into powerlines without being killed, given the high number of wounded adult storks. Thus, it seems that 1st-winters have more serious injuries of fatalities compared to adults. Ring analyses showed that also in Europe collisions with electric wires are the most important cause of death (Schulz 1988). From 294 storks found dead in Germany, 226 (=77%) were killed by hitting electric wires (Riegel and Winkel 1971). Previous authors also observed that the proportion of 1st-winter storks killed by flying against electric wires is higher compared to adult storks (Riegel and Winkel 1971, Bairlein and Zink 1979). Even if direct mortality caused by disturbance is not extremely high, these unnecessary killings could easily be prevented if undisturbed roosting sites were available. Adult as well as 1st-winters birds were killed through the disturbance and hitting wires. In autumn, there is on most days a very strong western wind of 4 to 5 beaufort in the afternoon. Low flying storks have a lot of problems when trying to avoid wires, because they are blown away by the strong wind. This is an important cause for the high numbers of wounded storks with broken legs or wings (Table V.5).

In nets that were used to protect fishponds against birds, we found one stork dead and one we released alive. At least 27 White Storks that were killed in these nets in the Bet She'an Valley in spring 1997 (K.Meyrom and J.Szabo, pers.com.) are worth to be mentioned in this report but are not added to the numbers of dead storks in Table V.3 because this data was not collected during our fieldwork.

In autumn 1993 and 1994 were at least 115, mainly adult, White Storks contaminated with oil. It seems likely that the storks were polluted with oil while they were drinking or washing themselves, but this must have happened outside the study area. The high percentage of adult birds is especially unusual because there are few adults in the migrating flocks at the end of August, when many contaminated birds arrived in the area. Oil pollution is not mentioned in the literature as a cause of dead for White Storks (Schulz 1988). Dr. James Dinsmore (pers.com.) found 426 dead storks with oil contamination in southern Sinai. This was a total of 1347 storks found dead between July and December 1994. Clark and Gorney (1987) found oil contamination in raptors during spring migration in Eilat. 55 out of 1054 checked raptors of 9 species showed oil contamination (5 %). It is interesting that during spring migration in Israel White Storks showed rarely traces of oil pollution, but that all contaminated storks were seen in autumn.

Bonelli's Eagles seem to be one of the few natural enemies of migrating and wintering White Storks. Attacks of this eagle against a flock of White Storks were observed in Morocco (Probst and Knötzsch 1975).

Chapter VI: Summary and Conclusions

These conclusions are primarily regarding a comprehensive plan for the conservation of the White Stork on the eastern migration route.

General Summary, Conservation Plan

To formulate a comprehensive plan for the conservation of the White Stork in conformity with the "Bonn Convention" (CMS), along the eastern migration route from the breeding grounds across Israel into the staging areas in northeastern Africa, it was essential to investigate the entire process of migration, including resting behaviour as well as the energetic and ecological aspects. Our approach employed satellite tracking (of 75 individuals), observations of storks in aviaries by methods including magnetic resonance imaging (MRI) and spectroscopy (MRS) (12 birds over 15 months), and extensive field studies. The main result of the investigation is that the White Stork exhibits, at least on the eastern route, a particular mode of migration not previously described in this form for any bird species, with the following characteristics: (i) very rapid travel from the breeding region into North African staging areas, normally with flight periods every day, lasting about 8-10 hours and separated by 14-16 hours of rest. The ca. 4600-km distance to latitude 18°N is covered in an average of 18-19 days by both young and adult storks. (ii) Rest periods of a whole day or even several days are the exception, and their occurrence seems to be prompted by external circumstances rather than prescribed in the endogenous migration program. (iii) Body mass and fat deposition are low during the outward (and the homeward) journey and peak in midwinter, which is interpreted as an adaptation to unpredictable conditions in the winter quarters. (iv) There is no discernible hyperphagia during migration; instead, on the outward journey the storks evidently feed mainly to meet their immediate needs when in eastern Europe, more opportunistically when approaching the Mediterranean Sea, and practically not at all in Israel. According to this observation and the comparison of body weights in Saxony-Anhalt and Israel, it is likely that storks lose weight on the outward trip and do not regain it until they reach Africa. We call the migration mode of the White Stork, which travels predominantly in gliding flight, the MSOM type (from "**m**ostly travelling every day", "**s**eldom inserting whole-day rests", "**o**pportunistically feeding" and "**m**oderate or no fat depots developing"), and distinguish it from the types ILHB (for intermittently migrating) and NNHB (migrating non stop). It is clear from these results that maintenance and successful migration of White Storks along the eastern route do not crucially depend on special staging areas with an exceptionally abundant nutritional basis. Undisturbed stopover sites, prevention of hunting pressure and the availability of uncontaminated food within a normal range appear to be sufficient. However, mainly due to the fact that migration is concentrated in a narrow migration corridor, there are inevitably areas where storks assemble in large numbers for staging. They are partly known from the literature, and in our study others were revealed as focal areas of locations from satellite tracking (Chapter II.5.1, Table VIII.3). These areas should preferably be conserved by bilateral contracts within the scope of the Bonn Convention in the "Stepping Stone Project", which is being initiated as a consequence of this study.

In the following, we provide brief, summarizing answers to the 23 questions raised in Chapter I and refer to the Chapters where the corresponding data are treated.

Section A.

A1) Into what regions can a stork departing from Central Europe continue to migrate undisturbed: as far as Slovakia, to the Balkans or into Turkey and beyond?

Our data show that storks are disturbed all along their migratory flyway, including the breeding and wintering area (Chapter V.2). We must distinguish between different age-groups, rather than between regions. 1st-winter storks are particularly vulnerable (Chapter IV.2.8, V.2).

A2) What kinds of disturbances are encountered?

Disturbances can be classified as human-related or natural.

Natural disturbances are geographical barriers such as water, mountain areas and desert regions (Chapter II.3). Human-related disturbances are powerlines, habitat destruction (breeding and staging sites), persecution, pollution and incidental or intentional disturbance (Chapter V.2, V.3, V.4).

A3) In which sections of the migration route are they encountered?

Natural barriers are bottleneck areas near the coast, especially the Sea of Marmara and Bosphorus in western Turkey, Iskenderum in southeastern Turkey and the Red Sea in Sinai, Egypt. Mountain areas in Turkey and southeastern Europe were an obstacle for adult birds on spring migration.

The scarcity of fresh water between southeast Turkey and Qena in Egypt is an important factor to take into account. Large numbers of storks changed their route and interrupted their migration to drink at fishponds in Israel.

Storks encounter human-related disturbances all along the migratory flyway. These disturbance have an important impact at places where many young storks concentrate, e.g. in early stages of the migration and at bottleneck areas in Turkey, Israel and Egypt. Direct human-related disturbance seems to be less important in most of the wintering area.

A4) When storks finish their day's flight, do they regularly find places to rest undisturbed, where they can also look for food in peace the next morning before taking off again?

It is clear from our results that successful autumn migration of White Storks along the eastern route do not crucially depend on special staging areas with an exceptionally abundant food supply. In spring, the birds need and seem to find sufficient food supply, both in the Middle East and in Europe. Undisturbed stopover sites, prevention of hunting pressure and the availability of uncontaminated food within a normal range appears to be sufficient, but due to the fact that migration is concentrated in a narrow migration corridor, we have to be constantly aware that this situation can change quickly. Of special concern are geographical bottleneck areas that are densely populated and intensively used (Chapter V.3).

A5) What happens when disturbances do occur — for instance, are family groups easily broken apart?

Our results show that in areas where there is a significant number of storks the group formation is not depending on the family. Storks act as an individual but form loose flocks on migration and at the staging and wintering areas. Flocking might be important as behaviour in determining the choice of the correct migration direction, optimizing the energy balance, optimizing the choice of suitable habitats in staging and wintering areas (Chapter II.4.1, II.4.2).

Most migrating and wintering White Storks showed a strong flocking tendency in many aspects of their behaviour, such as feeding, resting, roosting and flying. We have to conclude that providing conditions to ensure the formation of flocks can be crucial for the survival of each individual (Chapter II.5.2, V.3).

A6) When migrating flocks of storks are disrupted by disturbances, can the individuals continue to migrate normally in differently composed flocks?

Crucial for the well being of storks is that the habitat is sufficiently large to allow storks to form flocks. Dangerous situations occur when migrating flocks are disturbed on the staging areas (Chapter II.5.2.2.2, V.3).

A7) Can 1st-winter storks for example, while migrating alone or in a grouping other than the original one, maintain the normal daily stages with orientation typical of the species, or is the further progress of their migration as a whole at risk?

1st-winter storks proved to be especially vulnerable on their first spring and autumn migration, as well as on their first wintering site. Tagged 1st-winter and adult storks showed no differences in migration speed or pattern, but 1st-winters proved to be more vulnerable in making mistakes in orientation and risked to get exhausted (Chapter II.2).

A8) Does the main mass of the storks within a migration corridor travel so closely bundled together, visiting particular staging areas so regularly, that specific conservation measures can very easily protect a large proportion of the individual populations?

Data from the tagged storks and from literature clearly show that storks follow each year and each season the same, narrow flyway. Resting and feeding sites near bottleneck areas are used each year and are crucial for the condition of large flocks of storks. Several places along the flyway are important for exhausted birds that need a few days to recover (e.g. in Egypt : southern Sinai, Nile Valley, Nile near Qena; Israel : Bet She'an Valley, western Negev, Eilat; Turkey : Bosphorus region, Iskenderum; southeastern Bulgaria)(Chapter II.5.1, II.5.2.2, II.8).

A9) Must storks that stop to rest in areas of intensive agriculture stay longer than usual, because the feeding conditions are more difficult, before they can start out on the next stage of migration?

The onset of the main part of a flock is triggered by weather conditions, rather than feeding conditions. Weak single storks might encounter severe problems in intensively used agricultural land, such as lack of food and frequent disturbance (Chapter II.4, V.3).

A10) It is known that storks differ in the distance they can cover per stage; are these differences best explained by different endogenous programming of the birds or rather primarily by a diversity of more or less pronounced environmental change and/or deterioration? What influence is exerted by normal and unusual climate and weather factors, for example on the migration routes and the daily stages?

Differences in the migration pattern of individuals could not be explained by age but by region and season. Storks try to use thermals to migrate fast and these weather conditions are better in Africa and the Middle East, compared to Europe. Unusual weather conditions drifted tagged storks away from the typical flyway or concentrated birds like in autumn 1997 in the Jordan Valley. The combination of cold and heavy rain forced storks to interrupt their migration for several days in spring (Chapter II.2, II.4.1.1).

Section B. Additional questions.

B1) Can it be definitely established that the eastern storks, on their way from eastern Germany to the Mediterranean region, at present find conditions for flight and rest so favourable that they can generally pass through Israel in a few days and without feeding, on the basis of reserves accumulated during the preceding journey?

Tagged storks on autumn migration moved fast from the breeding area to the pre-wintering site. On spring migration storks stopped at several location and especially from Egypt till Bulgaria (Chapter I.6.4, II.2).

B2) Do these reserves take the form of fat stores and if so, to what extent?

MR tomography and measurements of body mass showed that storks store a very limited amount of fat and other reserves before and during the migration period. (Chapter II.7, II.8)

B3) Can it be reliably documented that the storks on migration to the Mediterranean region feed mainly in agricultural areas?

Storks rarely feed on autumn migration in the Middle East and due to the lack of large natural wetlands are often forced to land in intensively used agricultural areas (Chapter II.5.2.2).

B4) What supplementary role is played by large wetlands, protected or requiring protection, as resting sites and sources of food?

Large wetlands are not only important as a potential resting site for the sometimes very large flocks of migrating birds but are also important as a refuge area for exhausted or weakened storks. During some years, hundreds of exhausted storks arrived at bottleneck areas (Chapter II.8 *energy reserves*).

An important role of wetlands in southeastern Europe and the Middle East is that these sites are important summering sites for immature storks. Every year, from May till August, are more than 130000 1st-winter storks looking for a good summering site in this region or elsewhere in Europe (Chapter II.3).

B5) Are mice the primary source of food during stopovers? What other kinds of food also contribute?

Storks are very opportunistic in their food choice and use all potential food sources. This can be food available on garbage dumps, large insects, dead or (rarely) living fish, rodents and even butterflies (Chapter II.5.2.2, IV.2.7).

B6) To what extent can the current conditions for resting and feeding as far as the Mediterranean region be regarded as stable and ensured for the future, or what needs to be protected now or in future?

Our observations in Israel showed that there is an increase in the level of disturbance, partly due to the increase in economic and tourist activity as well as a population increase. We have strong indications that this is also true for sites along the flyway in Turkey and Egypt. As mentioned earlier priority has to be given to the protection of sites at the bottleneck areas (Chapter V.3).

B7) What are the reasons for the starved state of storks found in Israel in the spring, while returning from their winter quarters? Are they suffering from fat and/or protein deficiency?

Tagged storks moved fast through Africa on their return migration. The long distance, high migratory activity and the often less optimal weather conditions demands a strong energy input of the migrating stork. MR tomography and body mass measurements showed that the storks have very limited reserves before and during spring migration (Chapter II.2, II.7). The role of protein storage before and during migration remains open and needs a special intensive study.

B8) If it is a matter of protein deficiency, is this so severe that it could impair breeding success in the breeding grounds (by reducing the clutch size)?

Individual breeding success can be influenced by protein deficiency. What is more important is that the population breeding success is strongly influenced by food availability in the wintering areas as described by Dallinga and Schoenmakers (1989). In a winter as 1996/97, bad feeding conditions forced an important part of the population to migrate to southern Africa and birds returned late and in weak condition to the Middle East and the breeding area. In autumn 1997 we observed very few young storks on migration and more young birds than usual wintered in Israel (Chapter II.4.1, Chapter II.8).

B9) In the case of protein deficiency, which could result in smaller clutches, reduced breeding success and hence a more or less rapid decline of the population, it would surely be essentially impossible to take countermeasures in the winter quarters (e.g., by reducing local efforts to suppress migratory locusts). But one possibility is in theory

available: might it be possible to supply the adult storks with high-quality protein food for a brief period after they have returned to the breeding grounds, so that they become capable of laying clutches of optimal size? Tests relevant to this highly promising possibility should be conducted without delay.

During the course of our study it was not possible to do these experiments but it is important to keep in mind that poor feeding conditions in Africa not only affect breeding adults but also immature birds, which are also crucial for the dynamics of the population.

B10) In our previous studies on migrating storks of the eastern population, most of the disturbances (some with lethal consequences) and most of the birds falling victim to collisions, oil contamination etc. have been recorded in Israel, though it should be noted that the highest concentrations of storks altogether are also found here. This situation needs to be quantified, with the aim of answering the question: do such casualties have long-term repercussions with respect to population decline, or are they within tolerable limits?

Almost all types of human related disturbances have been described in the staging areas in Israel, but data collected in other areas (such as Turkey and Egypt) seem to confirm that the situation in Israel is the rule rather than the exception. We should be aware of the negative effects of disturbance, persecution and habitat loss and tackle these problems at all important staging sites along the narrow flyway (Chapter V.5).

B11) Will it be possible, by equipping many more storks with transmitters and tracking them, to pinpoint the most commonly used wintering areas within what we now know to be the enormously extensive (from Yemen to South Africa and Nigeria) winter quarters?

We could follow only few tagged storks during consecutive seasons but these data suggest that the potential wintering area is in fact very large and that storks are each year attracted to different places. This is in contrast with storks wintering in Israel and Spain, which proved to be very faithful to their wintering region (Chapter IV.4).

B12) If wintering centres can be specified as in Point 11, what are the local ecological conditions for the storks? Are special studies needed? Are protective measures necessary and practicable?

Following a few storks each year with satellite transmitters is important to monitor the behaviour in the African winter quarters. Long term protective measures, e.g. promotion schemes, anti hunting lobby, pesticide reduction are useful to safeguard storks (Chapter IV.4).

B13) Is it possible to assess whether hunting of storks in Africa by the indigenous population is so intensive as to put the stocks at risk?

The data collected from tagged storks do not suggest a specific problem of hunting of storks in Africa. Many of the casualties in Europe and the Middle East are man-related and could be solved in the long term (Chapter V.2).

VII.a. References

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VII.b. Publications

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VIII. Appendix

Table VIII.1A. ***List of satellite-tracked White Storks.***

Code	Captured	Age	Remarks
‘Prinz’	Germany	Adult	Male tracked 1994/95 (*No 94550*), 1996/97 (*No 96991*)
'Prinzessin'	Germany	Adult	Female tracked 1994/95 (*No 94552*), 1996/97 (*No 97543*), 1998/99 (*No 98544*)
‘Polsky’	Poland	Adult	Tracked 1996/97, 1997/98, 1998/99, (*No 96551*)
91554	Germany	1st-winter	
91555	Germany	1st-winter	
91556	Germany	1st-winter	No data
91557	Germany	1st-winter	
91558	Germany	1st-winter	No data
91559	Germany	1st-winter	West migrant
92542	Germany	1st-winter	
92544	Germany	1st-winter	West migrant
92545	Germany	1st-winter	
92546	Germany	Adult	long time kept in a cage (data not used)
92547	Germany	1st-winter	No data
92548	Germany	1st-winter	
92549	Germany	1st-winter	
92550	Germany	1st-winter	
92551	Germany	1st-winter	
92552	Germany	1st-winter	West migrant
92553	Germany	1st-winter	West migrant
93553	Israel	Adult	
93554	Israel	Adult	
93555	Germany	Adult	
93556	Germany	Adult	
93557	Germany	Adult	
93559	Germany	1st-winter	
94548	Germany	1st-winter	
94549	Germany	Adult	
94551	Germany	Adult	transmitter problem Egypt
94553	Germany	1st-winter	
94554	Israel	Adult	Male
94555	Germany	Adult	Male
94556	Israel	Adult	
94557	Israel	Adult	
94558	Germany	Adult	No data
94559	Germany	1st-winter	
95542	Israel	Adult	
95543	Germany	1st-winter	
95544	Israel	1st-winter	
95545	Germany	1st-winter	
95546	Germany	1st-winter	
95549	Germany	1st-winter	
95550	Germany	Adult	Female
95553	Israel	Adult	
95558	Germany	1st-winter	
96552	Poland	Adult	
96554	Germany	1st-winter	
96555	Germany	Adult	Male
96556	Germany	1st-winter	long time treated (not used)

96559	Germany	1st-winter	long time treated (not used)
96992	Poland	Adult	
96993a	Germany	1st-winter	
96993b	Germany	1st-winter	
96994	Israel	Adult	Male
96995	Poland	Adult	
97542	Israel	Adult	Male
97544	Germany	1st-winter	No data
97546	Poland	Adult	Female (transmitter out Ukraine)
97548	Poland	Adult	Male
97549	Poland	Adult	Male (transmitter problem Sudan)
97553	Germany	Adult	Male (transmitter problem Chad)
978883	Germany	1st-winter	(transmitter problem Turkey)
978885	Germany	1st-winter	(transmitter problem Czech Republic)
981979	Poland	Adult	Male
981980	Germany	1st-winter	
981981	Germany	1st-winter	
981982	Germany	1st-winter	
98546	Poland	Adult	
98552	Poland	Adult	
98555	Poland	Adult	

Table VIII.2. ***Comparison of the number of migration days on spring and autumn migration between night locations of the same individual.***

Stork	Location	Date	Location	Date
‘Polsky’ ‘96	34°16'N 36°55'E	1.09	33°39'N 36°53'E	6.04
	13°23'N 20°02'E	11.09	13°08'N 34°01'E	27.03
	2898 km		*2385 km*	
No 96552	37°21'N 33°35'E	2.09	37°04'N 34°33'E	5.04
	15°38'N 33°31'E	12.09	15°24'N 32°28'E	25.03
	2416 km		*2419 km*	
No 96992	31°25'N 34°14'E	28.09	31°15'N 34°24'E	13.04
	22°42'N 31°42'E	2.10	22°43'N 33°15'E	7.04
	1001 km		*974 km*	
No 98552	34°42’N 36°59’E	3.09	35°09’N 36°19’E	25.03
	16°28’N 34°41’E	10.09	17°18’N 32°33’E	17.03
	2128 km		*2044 km*	
‘Prinzessin’’98	32°10’N 36°16’E	3.09	32°14’N 35°30’E	2.04
	17°28’N 33°12’E	8.09	17°28’N 33°17’E	26.03
	1731 km		*1699 km*	
No 981979	33°10’N 36°10’E	15.09	32°39’N 35°29’E	15.03
	15°55’N 32°57’E	21.09	15°52’N 34°05’E	7.03
	1992 km		*1922 km*	

Table VIII.3 : ***Mean location of one night stopover sites of satellite-tracked White Storks on autumn migration (1991-96).***

Mean location	Indiv.	<30 km		<51 km
		(%)	(%)	
42°02'N 26°50'E 9	14	29		south Bulgaria
41°17'N 28°00'E	10	33	76	Bosphorus
39°29'N 31°10'E	16	14	25	central Turkey
37°26'N 33°32'E	10	25	47	Karaman, southern Turkey
36°57'N 34°49'E	6	60	73	Goksu delta
36°51'N 36°17'E	13	23	50	Iskenderum
35°28'N 37°02'E	13	6	21	northern Syria
33°33'N 36°40'E	16	9	21	southern Syria
32°09'N 35°54'E	11	11	16	northwest Jordan
30°27'N 34°58'E	15	5	15	southern Dead Sea
27°55'N 33°23'E	15	9	20	Red Sea
25°32'N 32°43'E	15	9	22	Nile
23°05'N 32°40'E	15	8	18	Lake Nasser
19°58'N 32°01'E	10	2	9	northern Sudan

Table VIII.4. ***Distance between night stopover locations in autumn 1994 and autumn 1996 of 'Prinz'.***

1994	Location	1996	Location	Distance
30.08	48°30'N 19°08'E	10.09	48°41'N 18°23'E	59 W
1.09	47°59'N 22°05'E	13.09	47°14'N 21°33'E	92 SW
5.09	43°43'N 26°43'E	14.09	45°32'N 25°39'E	219 NW
7.09	38°57'N 31°32'E	16.09	39°16'N 31°18'E	41 NW
9.09	35°49'N 37°40'E	18.09	36°25'N 36°57'E	93 NW
11.09	29°41'N 33°54'E	22.09	29°07'N 35°01'E	125 SE
13.09	25°46'N 32°51'E	23.09	26°32'N 32°56'E	86 N
15.09	18°09'N 31°08'E	27.09	17°56'N 30°54'E	34 SW
17.09	14°54'N 26°46'E	1.10	14°51'N 28°18'E	165 E
19.09	12°26'N 24°27'E	7.10	12°08'N 24°03'E	55 SW

Table VIII.5. ***Distance between night stopover locations in autumn 1994 and spring 1995 of 'Prinzessin'.***

1994	Location	1995	Location	Distance
30.08	48°43'N 19°12'E	17.05	49°36'N 23°38'E	337 E
1.09	48°06'N 21°57'E	15.05	47°50'N 26°00'E	303 E
3.09	46°54'N 23°09'E	11.05	46°36'N 27°18'E	318 E
7.09	39°14'N 31°03'E	30.04	39°32'N 31°04'E	33 N
9.09	36°45'N 36°16'E	26.04	37°16'N 35°47'E	72 NW
13.09	27°19'N 34°20'E	12.04	27°12'N 33°23'E	95 W
15.09	21°39'N 32°46'E	10.04	22°09'N 33°55'E	131 NE
17.09	15°49'N 34°32'E	6.04	13°58'N 34°06'E	211 S

Table VIII.6. ***Distance between night stopover locations in autumn 1996 and spring 1997 of 'Polsky'.***

1996	Location	1997	Location	Distance
24.08	50°35'N 24°13'E	13.05	51°01'N 24°31'E	53 NE
26.08	47°35'N 25°51'E	12.05	47°51'E 26°04'E	34 NE
27.08	45°21'E 27°15'E	11.05	45°09'N 25°46'E	118 W
28.08	42°19'N 26°50'E	10.05	42°34'N 26°07'E	65 NW
29.08	40°16'N 29°44'E	8.05	40°55'N 29°26'E	77 N
31.08	36°56'N 36°05'E	30.04	37°11'N 36°36'E	54 NE
1.09	34°16'N 36°55'E	13.04	34°38'N 39°01'E	197 E
2.09	31°39'N 37°13'E	5.04	31°39'N 35°56'E	121 W
3.09	30°52'N 36°11'E	4.04	30°11'N 35°14'E	118 SW
4.09	27°52'N 33°19'E	3.04	27°27'N 33°25'E	47 S
6.09	23°36'N 32°20'E	1.04	23°12'N 33°02'E	84 SE
7.09	20°20'N 31°26'E	31.03	20°44'N 32°53'E	157 E

Table VIII.7. ***Distance between night stopover locations in autumn 1996 and spring 1997 of No 96552.***

1996	Location	1997	Location	Distance
1.09	40°03'N 30°15'E	29.04	39°48'N 30°34'E	39 SE
2.09	37°21'N 33°35'E	19.04	38°05'N 33°31'E	82 N
3.09	35°59'N 37°09'E	3.04	34°48'N 36°39'E	139 S
5.09	32°00'N 36°12'E	2.04	32°01'N 35°25'E	74 W
6.09	31°58'N 35°25'E	1.04	31°03'N 34°42'E	122 SW
7.09	29°26'N 34°02'E	31.03	30°13'N 34°13'E	89 N
8.09	25°42'N 32°49'E	30.03	27°17'N 33°24'E	185 N
9.09	22°38'N 32°59'E	27.03	22°19'N 33°56'E	104 E
10.09	19°14'N 32°10'E	26.03	17°40'N 32°08'E	174 S

Table VIII.8. ***Distance between night stopover locations in autumn 1996 and spring 1997 of 'No 96992'.***

1996	Location	1997	Location	Distance
19.09	35°29'N 36°20'E	15.05	34°59'N 36°24'E	56 S
27.09	33°26'N 35°50'E	5.05	33°12'N 35°39'E	31 SW
28.09	31°25'N 34°14'E	13.04	31°15'N 34°24'E	24 SE
29.09	28°55'N 33°31'E	12.04	29°57'N 34°13'E	133 NE
30.09	26°11'N 32°26'E	9.04	26°26'N 33°49'E	141 E
1.10	24°25'N 32°34'E	8.04	25°04'N 33°09'E	93 NE
2.10	22°42'N 31°40'E	7.04	22°43'N 33°15'E	162 E

Table VIII.9. ***Marked White Storks found during summer in known summering areas in Israel.***

Ring	Date	Age	Origin
Warsaw B526357	11.06.58	1st-summer	Poland
Helgoland H 9874	10.07.64	1st-summer	Germany
Radolfzell B61488	03.06.71	1st-summer	Germany
Praha B14606	05.06.71	1st-summer	Czech Republic
Hiddensee 205060	06.07.72	1st-summer	Germany
Hiddensee 250788	09.06.73	4th-summer	Germany
Helgoland 228734	19.06.73	2nd-summer	Germany
Hiddensee K6926	01.08.74	1st-summer	Germany
Praha L 255	30.07.79	1st-summer	Czech Republic
Moskwa A100545	06.08.79	2nd-summer	Estonia
Hiddensee A2297	03.08.80	2nd-summer	Germany
Gdansk VE403	23.07.95	3rd-summer	Poland
Hiddensee CA 2140	10.08.95	3rd-summer	Germany

Table VIII.10. ***Number of 2nd-winter and adult White Storks in migrating flocks***.

Date	Adult	2nd-winter	Flock size
27.08.95	51	129	377
27.08.95	63	66	210
27.08.95	0	61	850
28.08.95	291	159	1500
5.09.95	1296	144	2000
5.09.95	103	6	110
10.09.95	47	3	52
10.09.95	65	2	70
11.09.95	219	23	20
24.08.96	6	6	19
24.08.96	39	41	1300
25.08.96	45	8	77
25.08.96	31	14	45
25.08.96	67	22	92
25.08.96	221	99	1200
29.08.96	41	11	181
30.08.96	47	19	1134
27.08.97	58	52	176
28.08.97	39	34	77
29.08.97	234	23	497
30.08.97	103	18	137

Table VIII.11. ***Arrival of wintering White Storks marked in previous seasons.***

Code	Age	Arrival date
German White Stork I	Adult	18.09.94
German White Stork II	Adult	18.09.95
"		19.09.96
"		30.09.97
L 4122	Adult	20.09.95
"		19.09.96
"		07.10.97
L 4124	Adult	17.09.95
L 4129	Adult	08.10.95
L 4247	3rd-winter	08.09.96
L 4113	Adult	19.09.96
"		30.09.97

Table VIII.12. ***Start spring migration of tagged and marked storks.***

Code	Age and sex	Date	Wintering area
No 93556	adult male	24.02.94	Botswana
'Prinzessin'	adult female	17.03.95	Tanzania
	adult female	?	Kenya
	adult female	26.02.99	South Africa
No 94555	adult male	27.02.95	Chad
'Polsky'	adult	22.03.97	Kenya
	adult	26.02.98	Kenya
	adult	10.03.99	Sudan
No 96552	adult	26.02.97	Botswana
No 96992	adult	30.03.97	Sudan
No 98552	adult	19.02.99	Botswana
No 98555	adult	12.03.99	Botswana
No 981979	adult	08.03.99	Sudan
No 981981	1st-winter	30.03.99	Mozambique
No 981982	1st-winter	06.04.99	southern Zambia
No 93553	adult	17.02.94	Israel
No 93554	adult	17.02.94	Israel
No 94554	adult male	09.02.95	Israel
No 94556	adult male	27.02.95	Israel
No 94557	adult male	18.02.95	Israel
L 4128	adult male	23.01.95	Israel
L 4129	adult male	20.03.95	Israel*
L 4131	adult female	14.04.95	Israel**
German	adult	03.03.95	Israel

* Right tarsus broken and healed
** Wing coverts in bad condition

Table VIII.13. ***Location and time spend in the pre-wintering area.***

Stork	Age	Location		Period	Days
'Prinz'	Ad	west	13°14'N 21°36'E	22.09.94-04.11.94	44
'Prinz'	Ad	west	11°48'N 22°54'E	16.10.96-23.10.96	8
		centr.	10°15'N 27°09'E	29.10.96-03.11.96	6
'Prinzessin'	Ad	east	15°13'N 35°18'E	23.09.94-28.11.94	67
'Prinzessin'	Ad	centr.	14°29'N 29°34'E	20.09.97-03.10.97	14
		centr.	10°55'N 26°53'E	04.10.97-21.11.97	49
'Prinzessin'	Ad	east	15°46'N 34°12'E	13.09.98-07.12.98	86
'Polsky'	Ad	west	12°59'N 21°40'E	23.09.96-09.10.96	17
		west	11°48'N 23°08'E	13.10.96-22.10.96	10
'Polsky'	Ad	west	13°19'N 19°01'E	14.09.97-03.11.97	51
'Polsky'	Ad	west	13°21'N 18°19'E	15.09.98-05.02.99	144
No 92550	1w	east	16°16'N 34°23'E	13.09-07.11	56
No 93555	Ad	west	12°44'N 19°29'E	20.10-30.10	11+
No 93556	Ad	centr.	10°35'N 26°28'E	21.09-27.11	68
No 94549	Ad	centr.	12°00'N 32°25'E	09.10-12.12	65
No 94555	Ad	west	13°37'N 24°33'E	17.09-21.09	5
		west	13°03'N 16°29'E	09.10-19.11	42
No 94559	1w	east	14°54'N 35°26'E	19.09-15.10	27+
No 95542	Ad	east	16°07'N 33°45'E	27.09-19.11	54
No 96552	Ad	east	15°38'N 33°37'E	13.09-03.10	21
		west	11°53'N 23°16'E	07.10-01.12	59
No 96554	1w	east	13°58'N 33°28'E	08.11-23.11	16
No 96555	Ad	west	13°31'N 20°12'E	27.09-06.11	41
No 96992	Ad	centr.	11°06'N 30°05'E	30.10-12.12	44
No 96993	1w	west	14°28'N 28°11'E	24.09-30.09	7
		west	12°35'N 24°11'E	07.10-09.11	34+
No 96994	Ad	centr.	11°22'N 32°15'E	17.10-06.11	21
No 96995	Ad	west	12°54'N 20°33'E	07.10-07.11	31
No 97548	Ad	east	16°04'N 34°44'E	29.08-28.09	31
		east	13°08'N 33°25'E	04.10-09.11	37
No 97553	Ad	west	13°31'N 19°44'E	21.09-25.10	35+
No 981979	Ad	east	15°44'N 33°47'E	23.09-26.11	65
No 981981	1w	west	15°03'N 20°22'E	14.09-26.11	74
No 981982	1w	west	14°28'N 21°57'E	14.09-26.11	74
No 98546	Ad	west	12°48'N 20°00'E	25.09-07.11	44
		west	12°38'N 16°38'E	10.11-10.12	32
No 98552	Ad	east	16°29'N 34°39'E	11.09-17.11	68
No 98555	Ad	west	13°54'N 21°18'E	28.09-04.12	68

+ : transmitter failed or stork dead

Table VIII.14. ***Behaviour of 14 tagged White Storks migrating to their pre-wintering area.***

Stork	Age	Pre-wintering area	Crossing 19°N	Direction at Lake Nasser
No 92550	1w	east	11.09	south
No 93555	Ad	west	20.09	?
No 93556	Ad	central	12.09	?
No 94549	Ad	central	01.10	southwest
No 94555	Ad	west	13.09	south
No 94559	1w	east	03.09	south
No 95542	Ad	east	21.09	south
No 96552	Ad	east	11.09	south
No 96554	1w	east	05.11	south
No 96555	Ad	west	17.09	south
No 96992	Ad	central	25.10	south southwest
No 96993	1w	west	22.09	southwest
No 96994	Ad	central	28.09	southwest
No 96995	Ad	west	18.09	south
No 97548	Ad	east	26.08	south
No 97553	Ad	west	17.09	south
No 981979	Ad	east	20.09	south
No 981981	1w	west	09.09	southwest
No 981982	1w	west	08.09	south southwest
No 98546	Ad	west	19.09	south
No 98552	Ad	east	09.09	south
No 98555	Ad	west	19.09	south
'Prinz' '94	Ad*	west	15.09	?
'Prinz' '96		west	27.09	south southwest
'Prinzessin' 97	Ad	east	17.09	south southwest
'Prinzessin' 98		east	08.09	south
'Polsky' 96	Ad	west	08.09	southwest
'Polsky' 97		west	02.09	south
'Polsky' 98		west	08.09	southwest

Table VIII.15. ***Most southern winter location of tagged White Storks and the crossing day of the equator during their southward migration.***

Stork	Age	Origin	Wintering	Cross equator
No 92550	1w	Germany	+ Uganda	-
No 93555	Ad	Germany	+ Sudan	-
No 93556	Ad	Germany	South Africa	23.12.93
No 94549	Ad	Germany	+ Kenya	-
No 94555	Ad	Germany	Chad	-
No 95542	Ad	'Israel'	+ Tanzania	03.12.95
No 96552	Ad	Poland	Botswana	17.12.96
No 96554	1w	Germany	+ Sudan	-
No 96555	Ad	Germany	+ Sudan	-
No 96992	Ad	Poland	Sudan	-
No 96994	Ad	'Israel'	+ South Africa	15.11.96
No 96995	Ad	Poland	+ Chad	-
No *97548*	Ad	Poland	South Africa	24.11.97
No *97553*	Ad	Germany	+Chad	-
No *98546*	Ad	Poland	+Central Afr. Rep.	-
No *98552*	Ad	Poland	Botswana	06.12.98
No *98555*	Ad	Poland	Botswana	21.12.99
No *981979*	Ad	Poland	Sudan	-
No *981981*	1w	Germany	Mozambique	03.02.99
No *981982*	1w	Germany	Zambia	26.01.99
'Prinz'	Ad	Germany	+ Zimbabwe	23.12.96
'Prinzessin' 1994/95	Ad	Germany	Tanzania	13.01.95
'Prinzessin' 1997/98			Kenya	-
'Prinzessin' 1998/99			South Africa	15.12.98
'Polsky' 1996/97	Ad	Poland	Kenya	13.12.96
'Polsky' 1997/98			Kenya	-
'Polsky' 1998/99			Sudan	-

+ no further data collected