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Alain J. Crivelli, Yossi Leshem, Taniu Mitchev, Hans Jerrentrup. Where do palaeartic great white pelicans (*Pelecanus onocrotalus*) presently overwinter ?. *Revue d'Écologie (La Terre et La Vie)*, 1991, 46 (2), pp.145-171. <hal-03528391>

HAL Id: hal-03528391

<https://hal.science/hal-03528391v1>

Submitted on 17 Jan 2022

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WHERE DO PALAEARCTIC GREAT
WHITE PELICANS (*PELECANUS ONOCROTALUS*)
PRESENTLY OVERWINTER ?

Alain J. CRIVELLI*, Yossi LESHEM**, Taniu MITCHEV***
and Hans JERRENTROP****

The Great White Pelican, *Pelecanus onocrotalus*, is widely distributed in eastern Europe, Asia and Africa. Crivelli and Schreiber (1984) distinguished two geographically separate populations of this species : one in eastern Europe and Asia and the other in Africa. They have estimated the European-Asian population to be around 15 000-20 000 pairs and they noted that the numbers of this species have decreased sharply since the beginning of this century. On the contrary, the African population remains stable with a breeding population around 75 000 pairs, although some changes have occurred in the distribution of the breeding colonies.

Since 1984, The European-Asian population seems to have recovered, although some breeding colonies have disappeared (e.g. in Turkey) or their size has decreased (e.g. in Greece). However, the detailed information on the population trends and the biology of the Great White Pelican nesting in the Palearctic, which is necessary for effective conservation and management measures, is practically non-existent.

Studies on the breeding biology, the feeding ecology and movements of the Great White Pelican have only been carried out in Africa (e.g. Brown and Urban, 1969 ; Berry *et al.*, 1973 ; Guillet and Crowe, 1983). These studies only deal with sedentary or nomadic populations living under tropical climatic conditions. None of these populations are migratory. In contrast, the European-Asian population of *Pelecanus onocrotalus* is truly migratory, visiting the Palearctic only in Spring and Summer, during the breeding season. This population has not been adequately studied up to now (Dementiev and Gladkov, 1951 ; Bauer and Glutz von Blotzheim, 1966 ; Cramp *et al.*, 1977). Although studies on the breeding biology and the feeding ecology have recently been carried out in north-western Greece (Hatzilacos, 1986 ; unpubl. data ; Crivelli and Catsadorakis, unpubl. data), little is known about the migratory movements of the Great White Pelican population nesting in the Palearctic and its behaviour outside the breeding season.

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Roberts (1979) studied spring and autumn migration of large soaring birds at Burgas (Bulgaria) along the Black Sea coast. He counted 3 632 Great White Pelicans migrating north between the 11th of March and the 24th of May 1977, and 1 478 between the 18th of February and the 12th of April 1978. In autumn 1976 (10th September-30th October 1976) he counted 2 706 *P. onocrotalus* migrating south. Van der Have *et al.* (1988) counted 7 700 Great White Pelicans migrating in a westerly to north-westerly direction from the 2nd of April to the 16th of May 1987 in the Cukurova delta in south-eastern Turkey. Sutherland and Brooks (1981) have studied the migration of raptors and pelicans at Belen Pass (Lebanon) in autumn. They recorded 7 273 Great White Pelicans migrating south between the 2nd and the 23rd of September 1976. Paaz (1972) counted 30 000 *P. onocrotalus* during autumn migration between the 16th September and the 21st November 1971 at the Huleh Nature Reserve, northern Israel. In spring 1971 (1st April-6th May) he counted 16 000 Great White Pelicans migrating north, and 8 500 in spring 1974 (20th March-23rd April). Additional data on irregular observations of migrating *P. onocrotalus* can be found scattered in numerous publications (Rotter, 1953; Meinertzhagen, 1954; Mountfort and Ferguson-Lees, 1961; Harrison *et al.*, 1962; Safriel, 1968; Sapetin, 1968; Mitchev and Simeonov, 1981; Van der Ven, 1982; Cramp, 1983; Flint and Stewart, 1983; Yom-Tov, 1988). Finally little is known about altitude and diel timing of pelican migration (Kerlinger and Moore, 1989).

Reliable data on wintering are scarce. Last century and early this century Great White Pelicans were described as wintering in great numbers in Egypt, more especially in the Nile Delta, in the Suez canal and on the Nile sand banks south to Wadi Halfa (Cavendish Taylor, 1859; Brehm, 1911; Raw, 1921; Meinertzhagen, 1930) and few in Sudan (Chapman, 1921). Nowadays, all the reports show clearly that they are no longer wintering in Egypt and that flocks only fly across this country during migration (Horvath, 1959; Short and Horne, 1981; Meiniger and Mullié, 1981; Goodman and Abdel Mowla Atta, 1987; Goodman and Meininger, 1989). However, other reports show that Great White Pelicans can be found in variable numbers during winter time in southern Iraq (Georg and Vieillard, 1970; Koning and Dijkzen, 1973; Scott and Carp, 1982), in Sudan (Smith, 1960; Cave and MacDonald, 1955), in Iran, Pakistan and India (Behrouzi-Rad, *pers. comm.*; D.S. Scott, *pers. comm.*; Van der Ven, 1987, 1988). In addition, some reports show clearly the absence of Great White Pelicans in winter in the following potential wintering areas: the Sudd in Sudan (Mefit-Babtje, 1983), in North Yemen (Brooks *et al.*, 1988) and in Djibouti (A. Laurent, *pers. comm.*).

The aim of this paper is to assess the current status of *P. onocrotalus* nesting in the Palaearctic, to review the existing ringing data on this species, to document with new original data the timing, the numbers and routes of migration, and to investigate the problem of the location of its wintering grounds.

METHODS

The migration and movements of the Great White Pelicans have been studied in Greece since 1985, in Bulgaria since 1979, and in Israel since 1987. Colour ringing started at Lake Mikri Prespa, north-western Greece, in 1984 and studies on the breeding biology and feeding ecology in 1986.

GREECE

Since December 1984, monthly counts of the Great White Pelicans have been carried out at Lake Kerkini, an irrigation reservoir, 90 km north of the town of Thessaloniki as well as in the Porto Lago area, a coastal wetland 250 km east of the same town . Counts were made by the same observer over one to three consecutive days, according to the year, always using the same routes around and within the wetlands by car and boat. As far as possible, immature birds were systematically distinguished from adults. Special attention was paid to searching for colour ringed birds and the number of legs scanned was counted. Additional data on the use of other Greek wetlands by the Great White Pelican were obtained irregularly. From April to October 1987 four consecutive days were spent at least once per month in both areas in order to assess day to day variations in the numbers of pelicans present.

BULGARIA

From 1979 to 1989, all-day observations were maintained between mid-August until the end of October, from 8 AM to 6 PM, from an observation point located at the westernmost part of the Black Sea Coast : the Bay of Burgas. The observation point covers an airspace of approximately 10 km in radius ; the visibility is usually more than 10 km on 90 % of the days, during this period of the year. Binoculars and telescopes plus the radar installations of Burgas and Varna airports were used. Flocks of pelicans were counted at the time of their changing from soaring to gliding flight. Some of those flocks were photographed and the numbers obtained visually compared to those counted on the photographs. Pelicans that spent the night on the Atanasovo lake, a hypersaline coastal lake 5 km north of the town of Burgas, were counted on the day they took off from the lake.

ISRAEL

The pelican survey was centered on three main areas in the northern part of Israel which pelicans were found to prefer. Point 1 : Hula Nature Reserve. Until 1952, the Hula reserve included a large lake with an area of 13 km², and a marsh 50 km² in area. In 1952 the government of Israel decided to drain the marsh and use the land for agriculture (alfalfa, cotton, fruit orchards and fish ponds). The remains of the lake and the marsh (only 3.25 km²) were designated as a nature reserve, attracting pelicans for their main night roost, and in some years a few hundred pelicans which make up the wintering population. Point 2 : Kishon Reservoir (or Kfar Baruch Reservoir). This is a complex of water supply reservoirs established to solve problems of irrigation and of the water supply in northern Israel. Point 3 : Afeq Nature Reserve and the complex of fishponds and reservoirs along the Mediterranean coast in the Zevulun and Acre valleys. The complex includes a small concentration of natural springs and many fish ponds and reservoirs. At each of these points, 2-3 volunteers counted the numbers of pelicans passing over the area from north to south each day, throughout the

migration season. Every evening, the survey teams at each point counted the number of pelicans landing before dark. The next morning, they checked the numbers leaving for the south and those staying. They also tried to allocate the pelicans to three age classes (adult, immature and juvenile). Between 20th August and 18th October, the raptor migration survey teams counted the numbers of pelicans passing over observation points, across the breadth of Israel. Since some of the flocks are harassed by fishermen, the birds sometimes moved from one place to another. In order to avoid double counts, we only used the data on the numbers of night roosting pelicans, which were rechecked the next morning. Some flocks, mainly from the end of October to mid-November, stay for a few day (up to 10) and roam in the northern parts of Israel foraging for food. Such flocks were counted only once, on the day they left the roosting area. Data collected from other areas in central Israel, south of the survey line, were included only in cases where the number of birds in a flock counted on one day was not identical with the number counted in the north on the previous day.

Flocks of migrating pelicans were also followed in flight using a motorized glider, from the time of their takeoff from observation sites in northern Israel until the evening or until they crossed the Egyptian border in the south (Fig. 1). During these flights, we learned that in almost all cases flocks which moved south did not return north to roost. Only in exceptional cases (such as days with strong eastern or southeastern winds) did the flocks move from east to west, and were liable to cause an error due to double counting.

Unpublished data on the ringing and recoveries, on the breeding status and on the movements of the Great White Pelican have been received from USSR (N.

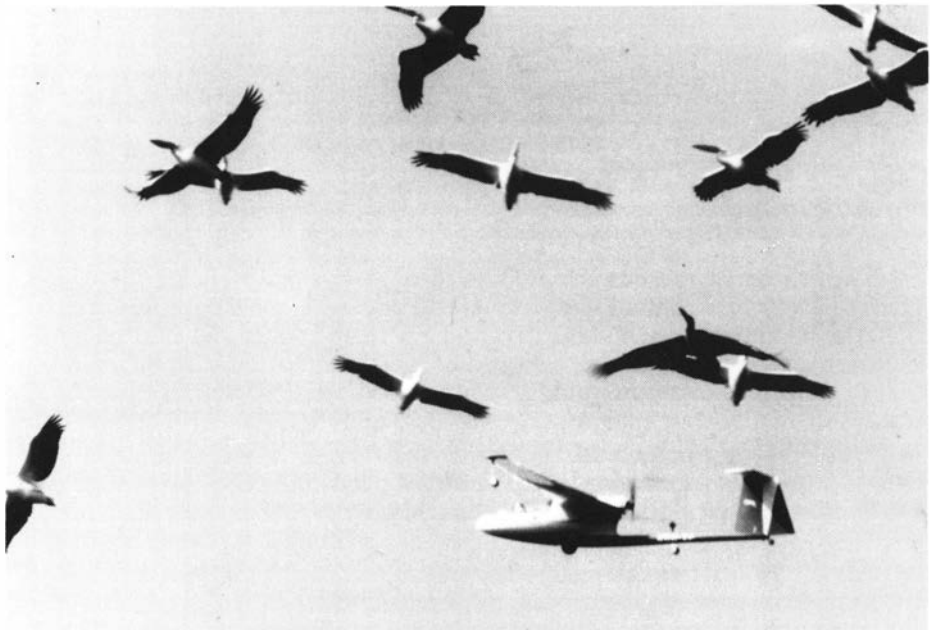


Figure 1. — With the migrating pelicans, as seen from the glider (Ofer Bahat, IRIC).

Vronsky, *pers. comm.*; E. Gavrilov and A. Zhatkanbaev *pers. comm.*). Finally, one of us (T. Mitchev) visited the Danube delta (Rumania) in spring 1989 and 1990 to census the breeding colonies of pelicans as well as to ring chicks with engraved colour rings.

We carried out a simulation of the population dynamics of the Great White Pelican using the Leslie matrix model with a program based on Lebreton (1981). We ran the simulation using hypothetical annual survival rates of 0.59, 0.84 and 0.90 at 1, 2 and between 3-20 years of age, respectively, based on published data on the American White Pelican, *Pelecanus erythrorhynchos* (Strait and Sloan, 1974; Ryder, 1981). Breeding success was considered as either 0.7 or 0.9 chicks fledged per breeding pair (Brown and Urban, 1969; Crivelli *et al.*, *in press*). The life expectancy was assumed to be 20 years. The number of breeding pairs used in the model was based on table I, according to the hypothesis tested. The age at first reproduction and the proportion of females breeding at this age were calculated by the model. We considered that 100 % of females were breeding at the age at first reproduction + one year, and that the sex-ratio of the population was 1 : 1.

RESULTS

Current status (Table I)

Since the last estimate of the size of the breeding population of the Great White Pelican in the Palaearctic (Crivelli *et al.*, *in press*), much new information on the status of this species in the USSR has been received (Vinogradov and Auezov, *pers. comm.*; A. Zhatkanbaev, *pers. comm.*), which increases the numbers of breeding pairs of this species in the Palaearctic.

In USSR and in Rumania the number of breeding pairs of the Great White Pelican has recently increased. In north-western Greece, at Lake Mikri Prespa, the last breeding colony of *P. onocrotalus* in the European community is showing a declining trend in the number of breeding pairs (Crivelli and Catsadorakis, unpubl. data). In Turkey the situation is bad and it is not known whether the Great White Pelican is still breeding in this country. Probably some breeding still occurs in the Hotamis and Eregli marshes (Central Anatolia), and on Lake Van close to the Iranian border. However, to our knowledge, there is no recent undisputable record of this species nesting in Turkey. In Iran, *P. onocrotalus* breeds in three areas: Lake Uromiyeh, Lake Parishan and Lake Bakhtagan. The Lake Uromiyeh colony is the largest with several hundred breeding pairs. In Irak, *P. onocrotalus* was recorded as breeding last century and early this century (up to 1923) in several areas (Ticehurst *et al.*, 1926); however, no breeding colony has been observed there recently. The Great White Pelican is probably breeding on the borders of Pakistan (Sind Province) and India (Gujarat Province) in the Indus Delta; up to 20 000 pairs might breed here (WWF-Pakistan, *pers. comm.*). However, it seems that nobody was able to find the colony and to census it due to the difficulties of visiting this area. The only breeding record for this region is Ali (1962) who discovered a breeding colony of several hundred pairs of *P. onocrotalus* in 1959 in the Rann of Kutch (Gujarat Province). Outside Pakistan and India, a reasonable estimate of the present number of breeding pairs of the Great White Pelican in the Palaearctic is more than 10 000.

TABLEAU I

The remaining breeding grounds of Pelecanus onocrotalus in the Palaearctic, with estimated numbers of breeding pairs and estimated numbers of breeding grounds.

Country	Number of breeding pairs	Number of breeding grounds
Greece	40-150	1
Rumania	3 000-3 500	1
Turkey	500-1 500	2
Iran	235-550	3
Iraq	?	?
USSR	3 070-4 300	16-18
Pakistan/India	?	?
Total	7 345-10 500	23-25

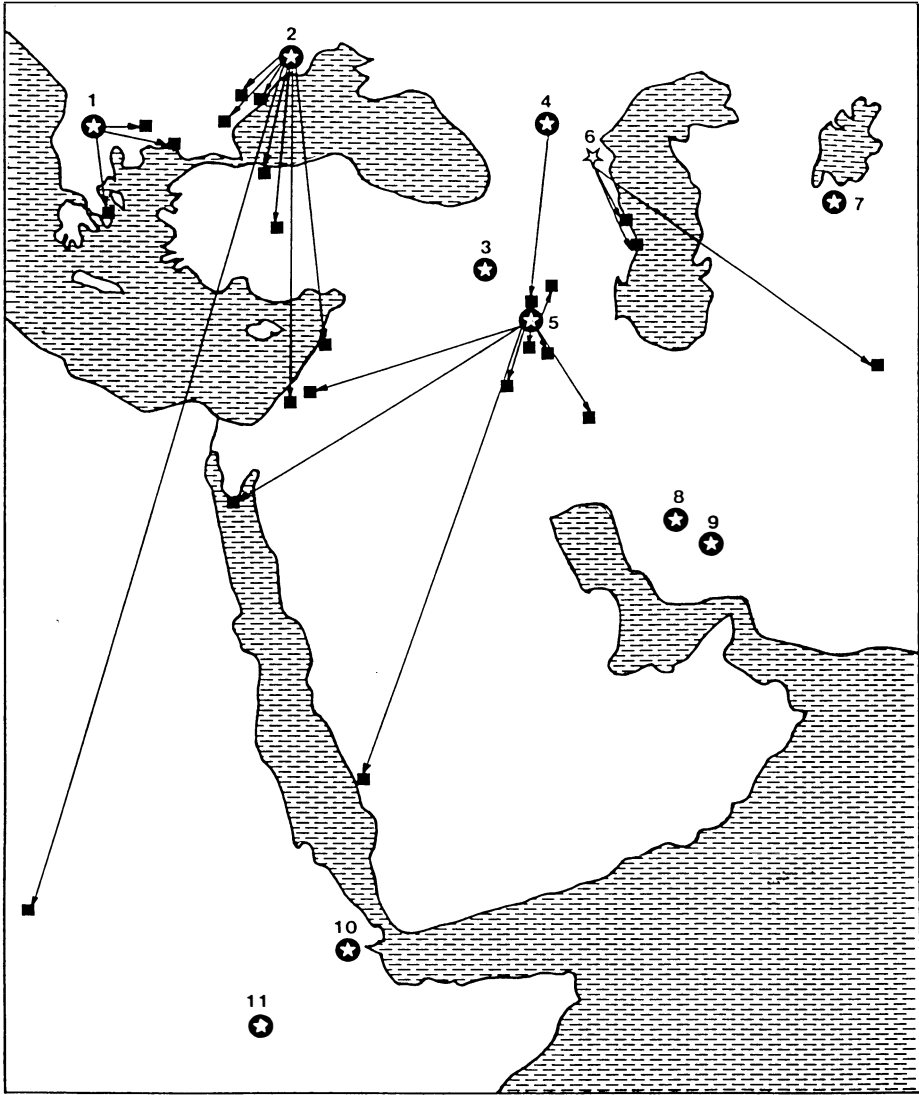
Ringling

Great White Pelicans have been ringed in small numbers throughout their breeding range, with the exception of Turkey (Fig. 2). From 1957 to 1970, 731 chicks were ringed in Rumania and 8 recoveries were recorded: one in Sudan, three in Bulgaria, one in Israel, two in Turkey and one in Syria. All these birds were found either as juveniles or one year old, but not older. The most interesting recovery is that of a bird ringed in July 1961 in the Danube Delta and found dead on the 16th November 1961 at El Dean in the Darfur province in Sudan (I. Catuneanu, *pers. comm.*). Since 1970, some ringing with metal rings has taken place, but no information is available. In 1989, 71 chicks of *P. onocrotalus* were ringed in the Danube Delta with blue engraved plastic rings (four digits); 62 of them were also metal ringed.

Between 1972 and 1988, 2 116 chicks of *P. onocrotalus* were ringed in Iran. 30 recoveries were recorded: 25 from west and south Iran, two from Iraq, one from Israel, one from Egypt and one from Saudi Arabia (B. Behrouzi-Rad, *pers. comm.*).

Between 1925 and 1978, 256 Great White Pelicans were ringed in the USSR and four recoveries were recorded: three of them were birds ringed in 1961 at Koktyubei (Dagestan), a breeding colony which no longer exists (Sapetin, 1968). The four recoveries were of juvenile birds. Since 1978 more than 2 000 chicks of the Great White Pelican breeding at Lake Balkhash (Kazakhstan, USSR) have been ringed. Seven recoveries were recorded, of which two were found dead in winter in the Indus River Delta region (E. Gavrilov and A. Zhatkanbaev, *pers. comm.*).

Between 1984 and 1989, 142 chicks of *P. onocrotalus* were ringed in Greece with colour plastic engraved rings (4 digit code). Up to now the only resightings were at Lake Kerkini, in the Porto-Lago area, and near Athens (Greece).



- Recoveries
- ✱ Former breeding colony
- Present breeding colonies

Figure 2. — Recoveries of birds ringed with metal rings in four different breeding colonies (2, 4, 5, 6) and with colour rings in two colonies (1, 2). The breeding colonies (*) are as follows : 1. Lake Mikri Prespa (Greece); 2. Danube Delta (Rumania); 3. Lake Van (Turkey); 4. Lake Manych-Gudilo (USSR); 5. Lake Uromieh (Iran); 6. Koktyubei, Terek delta, Dagestan (USSR); no longer existing; 7. Aral Sea (USSR); 8. Lake Parishan (Iran); 9. Lake Bakhtagan (Iran); 10. Lake Abe (Djibouti-Ethiopia); 11. Lake Shala (Ethiopia).

Timing and routes of migration

Lake Kerkini, northern Greece, is the most important stopover on the migration route of the Great White Pelicans nesting at Lake Mikri Prespa, north-western Greece, the most western breeding colony of this species in the Palaearctic. Most of the chicks born in the late spring at Lake Mikri Prespa leave this breeding area 3 to 5 weeks after fledging. These birds are first seen in the 3rd week of August at Lake Kerkini (Table II), where they stay for only a short period of time. At the same time, the breeding adults also start their autumn migration, the majority of them being observed at Lake Kerkini from September up to end of October. In Spring, the monthly censuses (Table II) show that the first birds can arrive as early as March, the majority of them migrating from April up to mid-May. An important result of this monitoring programme at Lake Kerkini is that a large number of immature and subadult Great White Pelicans return from their wintering grounds in the tropics to the Palaearctic region where they oversummer until the next autumn migration. For example, in Spring 1986 one year and two years old *P. onocrotalus* ringed at Lake Mikri Prespa were observed at Lake Kerkini. These immature and subadult birds use this wetland continuously from March to October ; however, their numbers vary considerably from year to year. In the spring of 1986 an unusually high number was recorded in May and June. Most of these immature birds observed at Lake Kerkini leave the area after a stay of several weeks, and wander throughout Greece. They can be observed from time to time in several Greek wetlands (e.g. Lake Koronia, Lake Veggoritis, Lake Kastoria). Immature birds were also observed on the breeding grounds, at Lake Mikri Prespa ; they are however continuously chased by the breeding adults and therefore quickly leave the area. As no ringed immatures have ever been seen here, it is not known whether they originated from this colony.

Day to day variations in the numbers of Great White Pelicans at Lake Kerkini (Table III) show that the numbers of birds present (both adult and immature birds) fluctuate considerably (up to 73 %) from one day to another.

The next stopover during autumn migration of the Great White Pelican nesting at Lake Mikri Prespa was thought to be the Porto-Lago coastal area. However our monitoring programme shows that it is not the case ; only few birds have been observed staying at this area in autumn or spring (e.g. 1985 and 1986, Table IV). In contrast *P. onocrotalus* used this area more intensively in spring 1987 than in the former years, though not in such great numbers as at Lake Kerkini. Again, immature birds, one-year-old or more have been recorded at Porto-Lago. For example, in November 1986, out of 12 immatures observed, six were young of the year and 6 were one-year-old birds ; among them one had been ringed in spring 1985 at Lake Mikri Prespa. In the summer there are almost no Great White Pelicans in the Porto-Lago area. Day to day variations (up to 950 %) in the number of Great White Pelicans in this area (Table V) show that most of the birds stay only for a day or so. This fact might explain how pelicans stopping for a day in this area could be missed without an intensive monitoring programme. In autumn, the birds probably migrate in one day from Lake Kerkini directly to the Evros delta, at the border between Greece and Turkey. From there they will continue their route, 200 km more to the east to the next stopover on the autumn migration route of this species : Lake Manyas. It is on this lake that the breeding population of Lake Mikri Prespa mixes with the breeding population from the Danube Delta (Rumania). The migration, especially the autumn migration, of the

TABLE II

Number of Great White Pelicans present at Lake Kerkini (northern Greece) from January to December, 1985, to 1987.

	J	F	M	A	M	J	J	A	S	O	N	D
1985												
Adult	0*	0	0	28	0	0	—	188	180	0	12	10
Immature**	0	0	0	10	11	0	—	4	85	0	0	0
Unkown	0	2	4	0	46	6	—	0	0	0	0	0
Total	0	2	4	38	57	6	—	192	265	0	12	10
1986												
Adult	4	0	26	11	72	18	—	78	0	0	0	—
Immature	0	0	14	77	254	144	—	32	25	25	0	—
Unknown	0	0	0	0	0	91	—	140	275	325	47	—
Total	4	0	40	88	326	253	—	250	300	350	47	—
1987												
Adult	2	2	0	42	46	37	27	295	0	0	11	—
Immature	0	0	0	3	35	17	53	36	134	3	27	—
Unknown	0	0	0	5	33	0	0	4	288	314	7	—
Total	2	2	0	50	114	54	80	335	422	317	45	—

* Maximum number of birds during the month.

** Birds 1 and 2 years old.

Great White Pelican nesting in Rumania has been studied in detail from 1979 to 1989 at Burgas, a coastal area along the Bulgarian Black Sea coast, rich in lagoons, brackish lakes and freshwater reservoirs (Table VI). The Burgas area is located half way between the Danube Delta and Manyas Lake in Turkey, and is a major stopover for Great White Pelicans during both spring and autumn migration. The Danube breeding colony is the largest in the Palaearctic with 3 000-3 500 breeding pairs nesting in the Nature Reserve of Rosca-Buhaiova within the upper part of the Danube Delta. The daily counts made from mid-August to the end of October show than an impressive number of *P. onocrotalus* migrate south from Rumania to Turkey along the Black Sea coast in autumn. The maximum number of birds observed in one day (1 610 to 7 666 individuals) is generally observed not later than the first week of October. However, the highest number of migrating birds per month is observed either in September or in October. These birds fly directly from the Burgas area to Manyas Lake where they meet birds coming from Greece. From this area they cross Turkey, flying south-east over Central Anatolia and reaching their last stopover in Turkey: the Goksu and the Cukurova delta areas. To fly from Lake Manyas to these deltas the Great White Pelicans need at least two days of travelling, and the most probable stopovers seem to be the lakes Seyfe, Eber and Aksehir (Van den Berk *et al.*; 1985; Roder, 1985; Philippona, 1985; Bijlsma and Roder, 1986; Lensing, 1987; Van Windem *et al.*, 1989) that are half way between Lake Manyas and the Goksu-Cukurova deltas. From their last stopover in Turkey the pelicans continue their migration flying over the Belen Pass in Lebanon (Sutherland and

TABLE III

Day to day variation of counts of Great White Pelicans at Lake Kerkini, northern Greece from April to October 1987.

Date	Adult	Immature**	Unknown	Total	Variation in %
08.IV.87	15	19	0	34	+ 47.1
09.IV.87	3	10	37	50	—
10.IV.87	42	3	5	50	- 20.0
11.IV.87	0	0	40	40	
15.V.87	25	55	0	80	- 3.8
16.V.87	14	63	0	77	- 5.2
17.V.87	16	57	0	73	
01.VI.87	5	17	0	22	+ 72.7
02.VI.87	22	16	0	38	+ 42.1
03.VI.87	37	17	0	54	- 18.5
04.VI.87	37	7	0	44	
04.VIII.87	235	25	0	260	+ 8.8
05.VIII.87	247	36	0	283	+ 18.4
06.VIII.87	295	36	4	335	- 0.9
07.VIII.87	0	0	332	332	
20.VIII.87	0	0	270	270	- 3.7
21.VIII.87	0	0	260	260	+ 38.5
22.VIII.87	0	1	359	360	—
23.VIII.87	0	1	359	360	
13.IX.8è	0	0	380	380	+ 11.1
14.IX.8è	0	134	288	422	- 2.8
15.IX.87	0	58	352	410	
14.X.87	0	3	314	317	- 45.7
15.X.87	129	19	24	172	+ 10.5
16.X.87	0	0	190	190	- 10.5
17.X.87	106	25	39	170	

** Birds 1 and 2 years old.

Brooks, 1981) and finally arrive in northern Israel, where the first migrating Great White Pelicans appear late July. However, the majority start to migrate through Israel in September (Table VI). The total number of birds migrating over Israel from 1987 to 1989 were certainly minimum numbers because any possible double observations were eliminated. Almost every day new flocks of pelicans can be seen arriving in the northern part of Israel. Most of the flocks arrive between 2 PM and 4 PM, few arriving later. They spend the night on lakes, fishponds and reservoirs, but also sometimes on the ground, in ploughed fields. Large flocks can stay up to seven days in the north of Israel (at Hula Nature Reserve, in the northern coastal valley and in Zevulun Valley).

In 1988, out of 43 661 Great White Pelicans counted near the coast in northern Israel, 3 979 first year birds (9.11 %) and 1 225 second year immatures

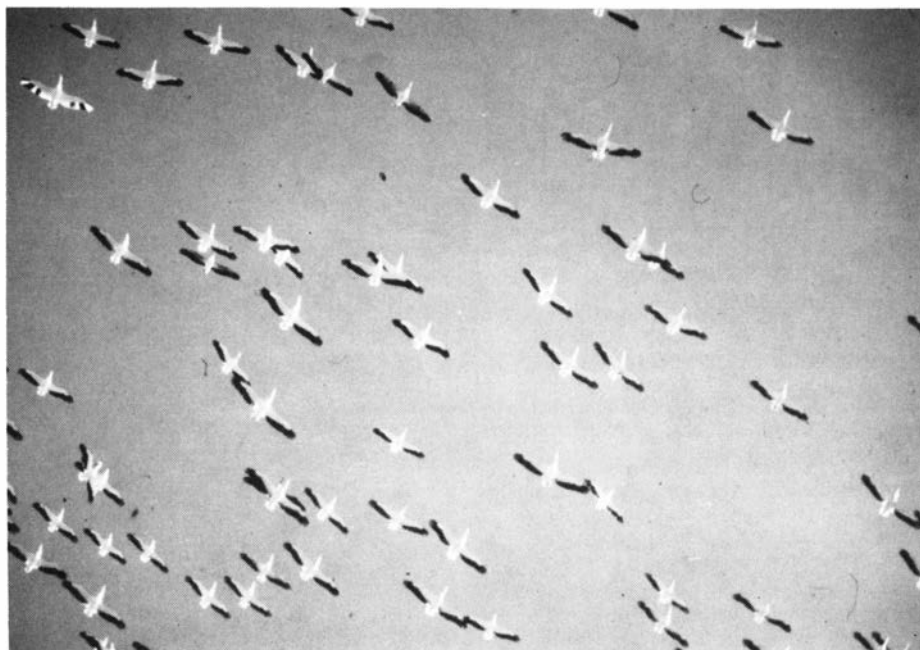


Figure 3. — Migrating Great White Pelicans (Y. Leshem, IRIC).

or subadult birds (2.85 %) were detected. At the Kishon Reservoir, out of 38 790 Great White Pelicans counted, 2 063 birds were not adult (5.31 %).

In the autumns of 1987 and 1988, 17 and 5 successful flights with a motorized glider were respectively undertaken (Fig. 3). The characteristics of four flights made in October 1987 are presented in table VII. A longitudinal cross section of a typical flight of Great White Pelicans along the Mediterranean coast from northern Israel to the Egyptian border is shown on figure 4. These flights lasted between 6.5 and 10.5 hours according to the meteorological conditions. The migration route used is always the same and the Great White Pelicans generally fly across Israel in one day. The pelicans take off usually around 9 and 10 AM and land between 4 and 5 PM (Fig. 5). The takeoff of the pelican from the water is clumsy. In preparation for takeoff the pelican runs on the surface of the water flapping its wings strongly. After several hundred metres of flapping, low-level flight, the pelicans head in formation for the first thermal and start to gain height. As they reach the top of thermal (at an altitude where the hot air has cooled down) they start gliding in tens of parallel V-formations, 300 to 1 500 metres wide (depending on the size of the flock). In this manner they glide at a speed up to 60-70 km/hour depending on the climatic conditions, and lose height. As soon as one V-formation finds a new thermal it starts turning to gain height and all the other V-formations quickly join it as though sucked to it by a vacuum, and again all of them rise strongly together towards the sky. This method is so energy saving that it enables the pelicans to glide all the day long, without even one flap of their wings, during suitable meteorological conditions.

TABLE IV

Number of Great White Pelicans present at Porto-Lago area (northern Greece) from January to December 1985 to 1987.

	J	F	M	A	M	J	J	A	S	O	N	D
1985												
Adult	0*	0	0	0	0	—	0	0	0	0	2	7
Immature**	0	0	0	0	0	—	0	0	0	0	0	5
Unknown	0	0	2	0	0	—	0	0	0	0	0	0
Total	0	0	2	0	0	—	0	0	0	0	2	12
1985												
Adult	5	3	10	0	0	2	—	0	0	1	23	—
Immature	2	3	3	0	0	15	—	17	0	0	12	—
Unknown	0	0	0	0	0	0	—	0	0	0	—	—
Total	7	6	13	0	0	17	—	17	0	1	35	—
1987												
Adult	0	0	23	50	29	0	0	2	0	4	25	—
Immature	0	1	0	7	13	0	0	0	0	1	17	—
Unknown	0	0	0	0	0	0	0	0	0	0	0	—
Total	0	1	23	57	42	0	0	2	0	5	42	—

* Maximum number of birds during the month.

** Birds 1 and 2 years old.

After the Great White Pelicans have crossed the Israeli-Egyptian border, it is difficult to continue to describe their migration to the south, because there are hardly any observation of these birds in autumn in Egypt or in the Red Sea area, with the exception of 750 Great White Pelicans observed migrating south on the 4th of November 1977 at the Aswan Dam (Short and Horne, 1981), 1 000 birds on the 21st of October 1957 at Nag Hammadi, north of Luxor, 350 birds on the 22nd of October 1957 along the River Nile (Horvath, 1959), 110 birds on the 19th of November 1978 at Aswan, 500 on the 29th of November 1978 at Luxor and 100 on the 21st of October 1979 at Nag Hammadi (P. Meininger, *pers. comm.*). During spring migration only one observation south of the Nile Delta is available: 100 Great White Pelicans soaring over the Aswan Dam on the 6th of March 1979.

The spring migration follows the reverse route of that of the autumn migration, but is less well documented and, unlike the autumn, there are no systematic counts available (Meinertzhagen, 1954b; Mounfort and Ferguson-Lees, 1961; Roberts, 1979). It starts early March in Egypt and lasts until late May in Greece (Table II and IV). The first breeding birds arrive at Lake Mikri Prespa (north-western Greece) from mid-March to the end of March according to the year (Crivelli and Catsadorakis, unpubl. data), and egg-laying starts in mid-April (Crivelli *et al.*, *in press*).

Wintering

Great White Pelicans do not winter either in Greece or in Turkey. The few individuals observed during winter time in these two countries are weak, sick or

TABLE V

Day to day variation of counts of Great White Pelicans at Porto-Lago, northern Greece from April to August 1987.

Date	Adult	Immature**	Unknown	Total	Variation in %
31.III.87	50	7	0	57	—
01.IV.87	6	2	0	8	- 86.0
02.IV.87	0	5	0	5	- 37.5
03.IV.87	5	9	0	14	+ 180.0
12.IV.87	0	0	0	0	—
13.IV.87	25	13	13	54	—
14.IV.87	5	27	0	32	- 40.7
07.IV.87	0	0	4	4	—
08.V.87	29	13	0	42	+ 950.0
09.V.87	0	0	0	0	—
10.V.87	0	0	0	0	—
08.VI.87	0	0	0	0	—
09.VI.87	0	0	0	0	—
10.VI.87	0	0	0	0	—
27.VII.87	0	0	0	0	—
28.VII.87	0	0	0	0	—
29.VII.87	0	0	0	0	—
30.VII.87	0	0	0	0	—
13.VIII.87	0	0	0	0	—
14.VIII.87	0	0	0	0	—
15.VIII.87	0	0	0	0	—
25.VIII.87	0	0	0	0	—
26.VIII.87	0	0	0	0	—
27.VIII.87	0	0	0	0	—
28.VIII.87	0	0	0	0	—

** Birds 1 and 2 years old.

wounded birds. On the contrary, a few hundred *P. onocrotalus* do regularly winter in Israel. But we still do not know where all the Great White Pelicans migrating south over Israel will winter. They no longer do so in Egypt (Meininger and Mullié, 1981 ; Goodman and Meiniger, 1989), so they must therefore winter either in Sudan or in eastern central Africa (e.g. Ethiopia, Kenya, Uganda, Tanzania or Zaïre).

Several wintering grounds are known in western and southern Asia, in the USSR, Iran, Iraq, Pakistan and India (Scott and Carp, 1982 ; Van der Ven, 1987, 1988 ; Crivelli *et al.*, *in press*). Only a few hundreds birds are counted in January each year in Iran and the USSR, in Turkmenia (Poslavski and Shirekov, 1990) and along the Persian Gulf and in Seistan wetlands on the border between Iran and Afghanistan. Ten years ago, 3 600 Great White Pelicans were counted wintering in Iran, particularly near Basrah in the delta of the Rivers Euphrates

TABLE VI

Autumn migration of Great White Pelicans along the Bulgarian Black Sea coast and throughout Israel.

Year	Period of observation	Date of peak	N in peak	Number of migrating pelicans					
				July	Aug.	Sept.	Oct.	Nov.	Total
Bulgaria									
1979	12.VIII-27.X	21.VIII	4 379	—	6 803	9 412	3 212	—	19 427
1980	10.VIII-29.X	25.IX	1 862	—	2 026	6 449	3 465	—	11 940
1981	14.VIII-27.X	03.IX	3 700	—	1 975	8 197	8 540	—	18 712
1982	11.VIII-28.X	01.X	3 024	—	1 284	6 346	5 332	—	12 962
1983	10.VIII-26.X	22.IX	1 610	—	1 483	4 122	5 364	—	10 969
1984	28.VIII-29.X	11.X	3 130	—	881	4 177	8 300	—	13 358
1985	11.VIII-22.X	19.IX	1 696	—	4 638	6 533	7 334	—	18 505
1986	10.VIII-24.X	04.X	2 395	—	2 295	7 840	13 560	—	23 695
1987	14.VIII-26.X	02.X	5 720	—	1 651	12 985	11 760	—	26 396
1988	19.VIII-24.X	19.IX	3 302	—	881	11 608	10 880	—	23 369
1989	10.VIII-27.X	13.IX	7 666	—	2 917	17 810	5 116	—	25 843
Israël									
1981*	07.X-23.XI	11.XI	5 596	—	—	—	15 635	21 860	37 495
1984**	23.IC-29.XI	18.XI	7 000	—	—	480	12 150	27 000	39 630
1987	17.VII-22.XI	27.X	7 100	400	0	7 200	39 753	18 216	65 569
1988	17.VII-22.XI	27.X	6 182	39	326	4 549	49 482	22 513	76 909
1989	10.VIII-18.XI	28.X	6 737	—	828	10 184	56 959	8 552	76 523

* Counts made only at the Hula Nature Reserve (Karen Barasch, *pers. comm.*).

** Counts made only at the Hula Nature Reserve (Nature Reserves Authority, *pers. comm.*).

and Tigris (Carp and Scott, 1982), however no recent information is available for this area. In Pakistan, up to 26 000 were recorded in January (Van der Ven, 1987, 1988 ; Scott and Rose, 1989) in several wetlands (Nurr-Ri, Lake Jobo, Hub Reservoir, Lake Hudero). Up to 6 000 were also counted wintering in the Gujarat province of north western India in January. The great majority of the Great White

TABLE VII

Detailed features of four successful flights with the Great White Pelicans in autumn 1987.

Date	Start at	Land at	Number of birds in the flock	Total km	Average speed (km/hr)
12.X.87	8 : 50	16 : 58	280	272.0	33.3
20.X.87	9 : 18	16 : 31	350	282.9	39.3
21.X.87	9 : 06	16 : 34*	650	296.6	39.2
25.X.87	9 : 40	16 : 09	980	198.6	30.5

* This flock continued over the border to Egypt.

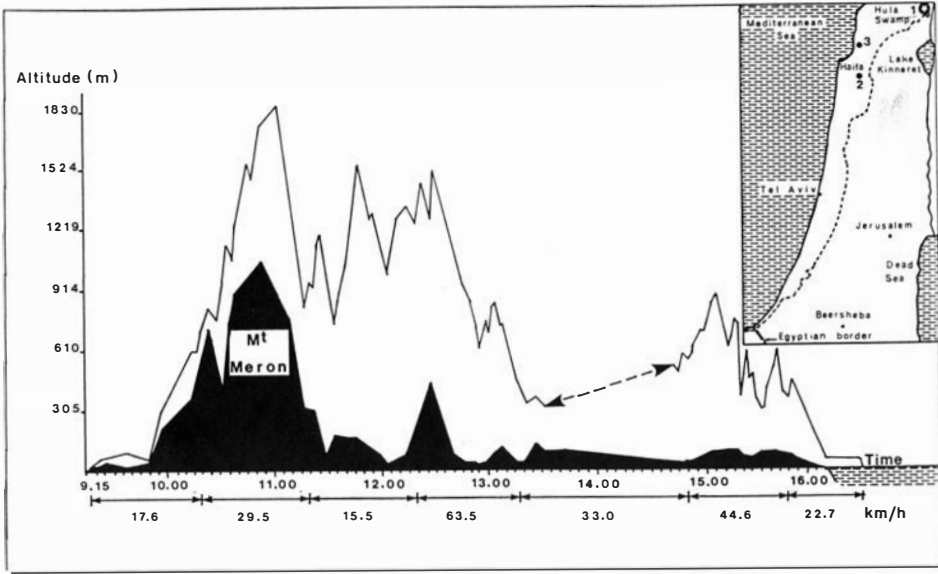


Figure 4. — Longitudinal cross-section of a typical flight of Great White Pelicans from northern Israel to the Egyptian border. This is the flight of the 10th October 1987 (Table VII). Between 1.30 PM and 2.30 PM the flight was followed by radar, as the motor-glider had to land to refuel. The trajectory of the flight is shown as a dotted line on the map together with the three main sites where pelicans were counted.

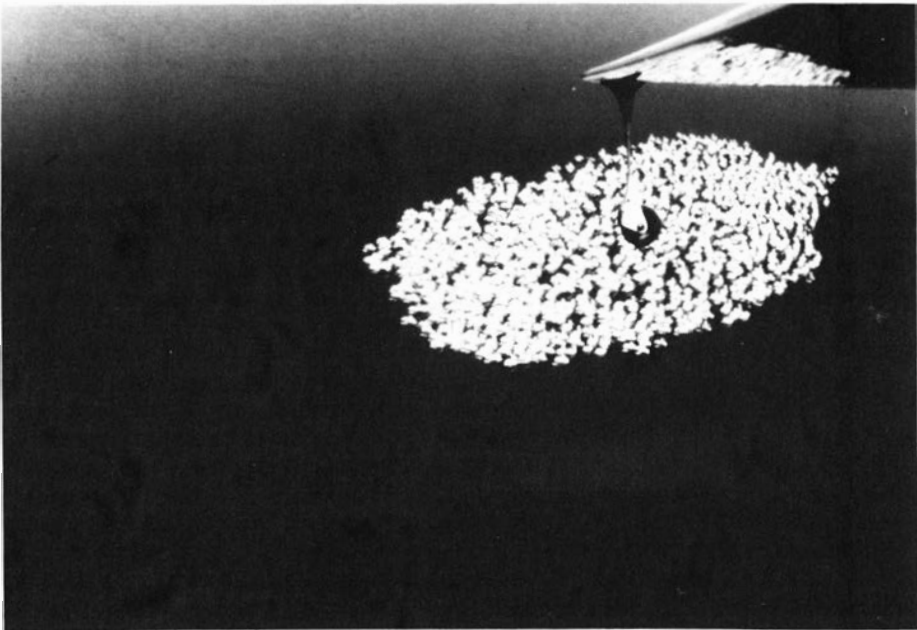


Figure 5. — End of day landing in the Mediterranean Sea, three miles off the coast, near Han-Junes, Gaza strip (Ron Be'er, IRIC).



Figure 6. — Migrating Great White Pelicans over the Negev Desert in Israel (Y. Leshem, IRIC).

Pelicans observed wintering in Pakistan and in India are certainly birds nesting in this area or in the Lake Balkhash breeding colonies (Kazakhstan, USSR).

DISCUSSION

Current status

The most recent data on the size of the population of Great White Pelicans breeding in the Palaearctic are somewhat reassuring. It would appear that the general decline observed during the 1960s and 1970s has stopped, that a stabilisation in the numbers of breeders is now occurring and that a slight increase is becoming apparent in certain areas, especially in the Turgai and Lake Balkhash regions of the USSR and in the Danube Delta in Rumania. There are, however, still some disturbing situations : in Greece and Iran a decrease in the number of breeding birds was recorded in the 1980s without any identifiable cause or causes, and despite the fact that these two colonies are situated in national parks where in principle they are well protected. Are these decreases due to problems outside of the breeding sites or are they simply a reflection of counting bias in estimating the numbers of breeders ? It is too early to give an answer at present. The situation in Turkey is even more serious : no undisputable evidence of a breeding colony of Great White Pelicans has been produced in this country since 1974 (Lehman,

1974). There is an urgent need for an aerial survey, at the end of May or early June, of the potential breeding sites of this species in Turkey (e.g. the Eregli and Sultan Marshes and Lake Van). The same should also be undertaken in the provinces of Sind (Pakistan) and Gujrat (India) to determine whether Great White Pelicans really nest in this region and also whether they breed regularly every year or only intermittently.

All these statements are based on counts of breeding pairs carried out by different observers often using different methods. The correct counting of a breeding colony is not easy (Sidle and Ferguson, 1982). The larger the colony (> 250 pairs), the more difficult the count. It is also more difficult to census a colony situated in a reedbed (e.g. the Danube Delta) than a colony on a rocky island (e.g. Lake Uromiyeh) or an unvegetated island (e.g. Lake Manych-Gudilo). Finally, all the Pelecanidae have a prolonged breeding season, frequently with re-nesting, which requires not a single count, but often two or three counts, to be able to obtain a reliable estimate (Crivelli, 1987). In the future a standard aerial method for censusing breeding colonies of Pelecanidae in the Palaearctic must be developed and validated by means of reliable ground counts. When the method has been perfected it should be used each year in all colonies. At the same time an attempt could be made to develop a protocol for estimating the reproductive success of these same colonies by aerial counting.

Migration

Although the timing of migration and routes taken by Great White Pelicans breeding in the western Palaearctic (Greece, Rumania, Turkey, Iran) are now well known, the routes used by those breeding in the USSR (Fig. 3) remain tentative. Our hypothesis for the migration route taken by birds nesting at Lake Balkhash seems reasonable since it is based on two recoveries and on observations of birds migrating along the Irano-Afghan border, where they are obliged to circumvent the high mountain chains of the Kiriziya and Tadjhikistan regions. In contrast, the migration routes described for Great White Pelicans breeding in the Turgai area and on the Aral Sea are much more hypothetical (Fig. 7). These are based essentially on three facts :

— flamingos ringed on Lake Tengiz in the Turgai region have been recovered in Tunisia (Johnson, 1989) ;

— numerous Great White Pelicans are observed on passage in both the autumn and spring migration periods in the Volga Delta at the north of the Caspian Sea, and then on the Russo-Turkish border at the latitude of the Black Sea (Van der Ven, 1982) ;

— finally, if we do not accept that the breeding birds from these two regions migrate in autumn around the north of the Caspian Sea and then move south-west towards Israel, it is impossible to explain the large number of birds migrating across this country from north to south (see below). No difference is observed from one year to another in the timing and migration routes of Great White Pelicans. Similarly, the same wetlands are used as stopovers, both in spring and autumn.

The average speed of Great White Pelicans on migration can be estimated at between 30 and 40 km/h as a result of the flights undertaken with the motorized

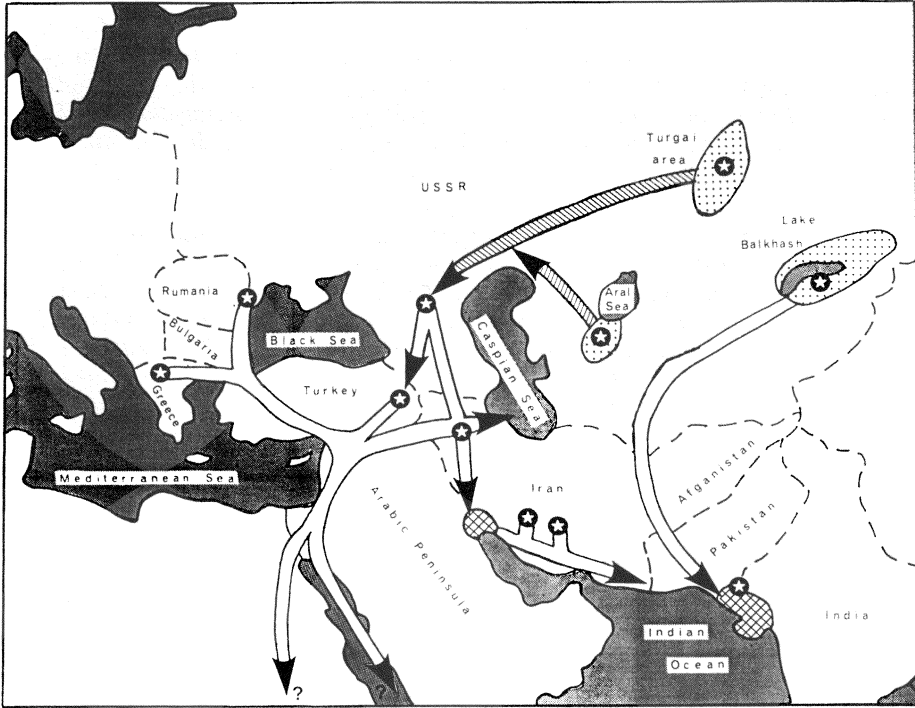


Figure 7. — Map summarising migration routes and wintering areas of Great White Pelican breeding in the Palearctic. White : routes confirmed by observations or recoveries ; shaded : routes drawn according to hypothesis given in text ; cross hatched : wintering grounds.

glider (Table VII). This is slightly less than the 45 km/h described by Pennycuik (1972) in east Africa over, admittedly, a lesser distance than those we have observed. Depending on the meteorological conditions, Great White Pelicans can therefore cover between 200 and 300 km per day. These distances correspond very well with the distances covered by pelicans between two stopovers on their migrations. Din (1979) reported the quantity of adipose tissue (subcutaneous, abdominal, stomach and mesenteric fat) in 56 male and 22 female Great White Pelicans shot in Uganda. An average of 281.1 g of fat (range : 18-1 239 g) was found in males, but this quantity was only 126.1 g in females (range : 30-463 g). The amount of fat consumed in the four flights shown in table VII can be estimated using the method described by Pennycuik (1989). If we take the average quantities of fat given above for each sex, we can calculate that the males could theoretically cover between 2 500 and 4 200 km, and the females 1 100 to 2 000 km, without feeding — just by using their fat reserves. Our experience shows us that Great White Pelicans do not feed systematically at each stopover, often because the wetlands visited do not provide favourable feeding conditions (e.g. shallow waters) or because the fish density is too low, or because the costs in time and energy would be too great. Nevertheless, when the feeding conditions are favourable the Great White Pelicans take advantage of them, and in the space of

less than an hour they can feed to satiation. A good example is the fish ponds situated in northern Israel ; these are extremely rich in fish (ca. 5 000 kg/ha, Sarig, 1990) and are intensively used by pelicans migrating across this region. Thus, because of their lipid reserves and the low-energy cost of soaring flight (soaring flight is less than one fourth as costly as powered flight, Pennycuik, 1975), the Great White Pelicans can undertake this long migration under optimal conditions.

Despite this perfect migratory strategy, the pelicans run certain risks during migration, as is demonstrated by two examples. On the 25th November 1985, ca 200 Great White Pelicans were found dead on a small mountain lake at 3 200 metres altitude near Mount Aydas between the towns of Ereğli and Mersin, in south-west Turkey (G. Magnin, *pers. comm.*). These birds were probably surprised by bad weather and were forced to land on the lake. The bad conditions probably lasted for several days, preventing them from taking off. With the temperatures below 0° C and the lake being fish-less as is often the case with high altitude lakes, the pelicans probably died from exhaustion. The second example is very recent : on the 6th-7th April 1990, 20-30 km south of Haifa (Israel), 300 Great White Pelicans were found dead, and 45 individuals dying, on the beach of the Mediterranean coast. It is likely that these birds were drifted from their usual migration route by strong head winds and that they died of exhaustion trying to continue towards the north, despite the unfavourable meteorological conditions and the low probability of finding food ; the Mediterranean sea is rarely used as a feeding site by these birds. We have observed that, if the winds are head on and too strong (> 25-30 km/h), the pelicans can take off, but they cannot make headway and are forced to land and await better conditions (Richardson, 1990). It should be noted that several cases of massive mortality have also been reported in north America, with the American White Pelican, following violent storms or hail storms (Higgins and Johnson, 1978). We have also observed that Great White Pelicans can remain on the breeding or stopover sites for several days without making any movement because of bad weather. It is easy to imagine that if these adverse conditions last too long, and if the feeding conditions are poor or non-existent, the birds with the least fat reserves risk dying on the spot. We don't know whether such incidents during migration are frequent or not, but they show clearly that risks exist, and that they can cause the deaths of hundreds of birds.

To our knowledge, this is the first time that overall figures for the scale of migration of *Pelecanus onocrotalus* have been presented. Independent estimates of the numbers of pelicans observed on autumn migration are given for three different regions : Lake Kerkini (northern Greece), the Burgas coastal region (Bulgaria) and the north-south crossing of Israel. On looking at these very high figures (Tables II and IV) one question immediately arises : where do all these birds come from ? At first we thought that the figures must be wrong, and that they were overestimated. Then we thought that it must be figures for the number of breeding birds in the study area that were wrong. Our figures for the numbers of migrating birds were high in all three areas, although they were obtained by different people, using independent methods and with a critical approach. All our estimates are conservative, that is to say that all Great White Pelicans that could have been counted twice were eliminated. They are therefore minimum figures. Our figures for breeding pairs are if anything underestimated and should be treated with caution (see preceding paragraph). The possibilities of either of these figures being grossly wrong can therefore be rejected.

Using the data obtained at Lake Kerkini, we have put forward the hypothesis that a large number of immature (1 and 2 years) and non-breeding sub-adult (between 3 and ? years) Great White Pelicans return to the Palaearctic region in the spring to oversummer and that their numbers, added to those of the breeders and young of the year, should approximate to the estimates of total numbers made during migration. We have therefore carried out simulations of the population dynamics of the three study areas.

If we assume that the reproductive success is 0.9 chicks/pair and the age at first breeding calculated by the model is 7 years, at which age 88.1 % of birds breed, the total number of birds that should be present at autumn migration (breeders + non-breeders + young of the year) can be calculated as follows :

— at Lake Kerkini, for 100 breeding pairs at Lake Mikri Prespa we should have about 620 pelicans on migration ;

— for the Bulgarian coast at Burgas, for 3 000 to 3 500 breeding pairs in the Danube Delta there should be between 18 566 and 21 662 Great White Pelicans on autumn migration ;

— finally, if we consider that the pelicans breeding in the Turgai depression and in the Aral Sea region also migrate through Israel (Fig. 7), the breeding population would be about 10 000 pairs and the model would estimate that 62 888 Great White Pelicans should cross this country.

The estimates of the numbers of Great White Pelicans during migration in the three countries calculated by the model are remarkably close to those estimated from direct observations (Tables II and VI) and seem to confirm our hypothesis.

The key to the high numbers of Great White Pelicans observed in this study at Lake Kerkini, at Burgas and in Israel is therefore the large number of non-breeding birds, aged from 1 to 6 years, which come back each spring to the Palaearctic to spend the summer. We estimate that in the spring, 54 % of non-breeding and 46 % of breeding Great White Pelicans return from the wintering areas towards the breeding sites. As shown in tables II and IV, only those birds aged between one and two years (immatures) can be recognised by their plumage. After two years, the birds resemble the adults and it is therefore difficult to know if they are breeders or not, except for a brief period at the start of the breeding season when the breeders have a knob on the forehead. At Lake Kerkini (Table II), our monthly counts show quite clearly that both immature (up to 254 individuals in May 1986) and « adults » oversummer on this lake. Unfortunately, we do not know with certainty if these « adult » birds are non-breeders, since they could also be breeding birds from Lake Mikri Prespa coming to feed at Kerkini (Crivelli, 1984 ; Crivelli and Catsadorakis, unpubl. data ; Hatzilacos, unpubl. data). In our opinion there is no evidence at present to show that the « adult » Great White Pelicans counted in June, July and August on Lake Kerkini are breeding birds from Mikri Prespa. A very simple method of answering this question would be to mark adult Great White Pelicans at the Mikri Prespa breeding colony with picric acid and see whether these birds regularly visit Lake Kerkini. We have not been able to do this up until now because of lack of authorisation. Several tens of Great White Pelicans also summer at Burgas on the Bulgarian Black Sea coast (P. Simeonov, *pers. comm.*).

We have not been able to find other reports in the literature of concentrations of non-breeding Great White Pelicans during the summer. If our hypothesis is confirmed, it is likely that many of the non-breeding *P. onocrotalus* in adult

plumage are present on the breeding grounds mixed in with the breeders, and that they are overlooked because it is very difficult to count the number of birds present on the breeding sites exactly.

Wintering

The great majority of Great White Pelicans used to winter in the Nile Delta at the end of the 19th and beginning of the 20th centuries (Cavendish Taylor, 1859; Brehm, 1911; Raw, 1921; Chapman, 1921). Nowadays, because of the many changes that have occurred in the delta (drainage, agriculture, industry) and mounting human population pressure *Pelecanus onocrotalus* no longer winters in the delta. So, where do the Great White Pelicans breeding in the Palaearctic now winter? There is no doubt that the birds have found a new wintering area to the south of the Nile Delta, but where? Examination of figure 1 reveals that there are only two recoveries south of the Nile Delta. The first is that of a bird ringed in the Danube Delta (Rumania) in spring 1961 and found dead in November 1961 in the Darfur province of Sudan; the second is that of a pelican ringed at Lake Uromiyeh (Iran) in spring 1988 and found in December 1988 on the Red Sea coast at Jizan (Saudi Arabia). In the case of the first recovery, Cave and MacDonald (1955) and Smith (1960) considered that the Great White Pelican was « fairly common from October to April on rivers in Sudan » in the 1950s. Unfortunately, it is difficult to find observations in the 1970s and 1980s showing that Great White Pelicans breeding in the Palaearctic winter in Sudan (Hollander, 1987). The most favourable area in Sudan for such wintering would be the Sudd in the south (Rzoska, 1974; De Pauw and Spiers, 1977; Sutcliffe *et al.*, 1989; Bailey, 1989). More than 125 000 km² are temporarily flooded in the Sudd from May to November. In December, the water level starts to go down in these wetlands, which are considered to be rich in fish (Hickley and Bailey, 1987; Bailey, 1989), until only a few more or less extensive pools remain. In February only permanent wetlands are present (15 000 to 30 000 km²).

Ninety percent of the permanently flooded wetlands are covered by shaded-swamp vegetation (*Typha domingensis*, *Cyperus papyrus* and *Eichhornia crassipes*) which is inhospitable both for fish and Great White Pelicans (Beadle, 1981; Hickley and Bailey, 1986). No concentration of *P. onocrotalus* has been observed in the Sudd between the months of November and February (Mefit-Babtie, 1983; A. Guillet, *pers. comm.*). Despite this negative result, if the paucity of observations available from this region is taken into account, it is not possible at present, to entirely exclude the possibility that the Great White Pelicans winter in the Sudanese Sudd. The second recovery, made in mid-winter, tends to suggest that Great White Pelicans breeding in the Palaearctic winter along the Red Sea coasts. Unfortunately, although more observations are available from this area, all are negative or anecdotal (Meinertzhagen, 1954a; Jennings, 1981; Jennings *et al.*, 1982; Brooks *et al.*, 1988; Goodman and Atta, 1987; Symens, 1989). A third possible wintering area remains for Great White Pelicans: tropical east-central Africa (Ethiopia, Djibouti, Uganda, Kenya, Tanzania, Zaire). Two breeding colonies of Great White Pelicans are known in Djibouti and Ethiopia (Lakes Shala and Abe), but no major influx of pelicans has been observed between November and February in these two countries (Urban and Brown, 1971; A. Laurent *pers. comm.*). There is no evidence of a strong influx, between November

and February, of Great White Pelicans coming from the Palaearctic and increasing the number of the sedentary birds on the many lakes of the Rift Valley (Kenya and Tanzania) (Brown *et al.*, 1973 ; Bartholomew and Pennycuik, 1973). Monthly aerial counts of Great White Pelicans on Lake Victoria between 1969 and 1972 showed no major arrival between November and February (Din and Eltringham, 1974). Finally some isolated observations have been made of pelicans, sometimes in large groups, on the vast areas of Zaire, on Lake Victoria and on rivers (Lippens and Wille, 1976).

We therefore still do not know where the 70 000-80 000 Great White Pelicans, which migrate south each year from the Palaearctic, winter after they have crossed Israel. But the most likely hypothesis is that these birds winter in the Sudanese Sudd, scattered over the 125 000 km² of seasonally flooded wetlands in this region, thus explaining the absence of any observation of large concentrations of these birds. Everything seems to be favourable for the wintering of the Great White Pelican in this area : vast shallow wetlands, rich in fish and with very little human disturbance. Another factor reinforces this hypothesis : if the Great White Pelicans winter in the Sudd, the conditions are no longer favourable for them from February onwards, which could explain why these very gregarious birds return to the Palaearctic in the spring, whether they are breeders or not. On the other hand, if the Great White Pelicans were to winter along the Red Sea coast or in tropical equatorial Africa, where the environmental conditions are more stable and uniform, these birds would have no reason to return to the Palaearctic so long as they were non-breeders (c.f. Greater Flamingos, A.R. Johnson, *pers. comm.*). It is essential that our two main hypotheses (the return of non-breeders and wintering in the Sudd), be verified before drawing up a conservation strategy for Great White Pelicans breeding in the Palaearctic. It has to be recognised that ringing with metal rings, even carried out on a large scale, has not provided the replies which are needed. We also doubt that a massive ringing with colour rings could help us test these two hypotheses because the observation pressure on the migration routes, breeding sites and potential wintering areas is too low and is unlikely to intensify in the near future. Colour ringing should, however, be maintained in certain colonies where regular observations are carried out in the breeding season in order to answer other questions (e.g. the age at first breeding). Only satellite tracking (e.g. Argos beacons) would enable us to test our two hypotheses. In addition it would also enable us to verify the migration routes that we have described in this paper, and because of its spectacular aspects would attract attention to this species which is sorely in need.

SUMMARY

The population of Great White pelicans *Pelecanus onocrotalus* breeding in the Palaearctic (from Greece to the USSR) is estimated at more than 10 000 pairs. This species has, however, been very little studied and the restricted amount of ringing carried out on this bird has not greatly improved our knowledge of its migration routes and wintering areas. Counts have been carried out during the autumn migration period over several years at three different sites (Greece, Bulgaria and Israel) and the migration routes, the stopover sites and the numbers of birds can now be described with precision. By using a motorized glider, migrating pelicans could be followed from the north to the south of Israel in a

single day, the average speed could be estimated and further information on the flight capabilities could be obtained. After the discovery of very high numbers during the migration period, the hypothesis has been advanced that non-breeding Great White pelicans do not remain on their wintering grounds, but return each spring to oversummer in the Palaearctic. The majority of the population of Great White pelicans breeding in the Palaearctic used to winter in the Nile delta (Egypt) at the start of this century. Because of the numerous developments carried out in the delta, however, they no longer winter there and they have been forced to find another wintering area further south. Unfortunately, this new site is still unknown and several hypotheses are proposed. Finally we recommend that movements be monitored by satellite in the future in order to discover the new wintering site(s) of this species and to confirm the correctness of the migration routes described in this study.

RÉSUMÉ

La population de pélicans blancs, *Pelecanus onocrotalus*, nicheuse dans le Paléarctique (de la Grèce à l'URSS) est estimée à plus de 10 000 couples. Pourtant cette espèce a été très peu étudiée et le baguage restreint de ces oiseaux n'a guère contribué à améliorer nos connaissances sur les routes de migration et sur l'hivernage de cette espèce. Nous avons effectué des dénombrements pendant la période migratoire automnale, sur plusieurs années et en trois sites différents (Grèce, Bulgarie et Israël) et nous pouvons maintenant décrire avec précision les voies de migration, les sites d'escale et les effectifs de cette espèce. L'utilisation d'un planeur motorisé nous a permis de suivre les pélicans blancs en migration, du nord au sud d'Israël en une seule journée, d'estimer leur vitesse moyenne et d'approfondir nos connaissances sur les possibilités de vol de cette espèce. La découverte d'effectifs très importants en période migratoire nous a amenés à émettre l'hypothèse que les pélicans blancs non nicheurs ne restent pas sur leurs lieux d'hivernage, mais reviennent chaque printemps en zone paléarctique pour estiver. En effet la majorité de la population de pélicans blancs nicheuse dans le Paléarctique hivernaient au début du siècle dans le delta du Nil (Égypte). Actuellement, à cause des nombreux aménagements réalisés dans ce delta, les pélicans blancs n'y hivernent plus et ils ont été contraints de trouver un nouveau site d'hivernage plus au sud. Malheureusement ce nouveau site est encore inconnu et plusieurs hypothèses sont proposées. Nous recommandons à l'avenir le suivi par satellite afin de découvrir le ou les nouveaux sites d'hivernage de cette espèce et de confirmer l'exactitude des voies migratoires proposées dans cette étude.

ACKNOWLEDGMENTS

This study has been funded by the EEC Research Division (DG XII), the Basler Stiftung für biologische Forschung (Switzerland), WWF International (Project N° 3422) and by Foundation Tour du Valat. We thank Messrs G. Magnin, G. Catsadorakis, M. Malakou, D. Hatzilacos, T. Naziridis, F. Dupont, V. Pomakov for their help in the field in Greece, Bulgaria and Turkey. In Israel, thanks are due to all the officers of the Israeli Air Force for their close collaboration at all stages of this project, to the Ministry of Science and Development, the Ecology Foundation, and the Society for the Protection of Nature, for helping to fund this study, to the Israel Airport Authority for the permit to use the radar, to S. Blitzblau, R. Beer, G. Keil, S. Mcgey, D. Alon and all the other volunteers who

followed the pelican flocks, to the N.R.A. staff for helping with data, to E. Peretz, M. Pinkus and other glider pilots-Eit Company, to Prof. Y. Yom Tov, Tel Aviv University, supervisor of Y. Leshem PhD thesis and all the IRIC staff who were involved in the project. We also thank Vincent Boy from Tour du Valat for his statistical advice.

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