MOVEMENTS OF GREATER FLAMINGOS (*PHOENICOPTERUS RUBER ROSEUS*) IN THE WESTERN PALEARCTIC

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This study of the movements of Greater flamingos (*Phoenicopterus ruber roseus*) in the western Palearctic is part of a major long-term research project on the breeding biology, population structure and dynamics of flamingos in this part of their range. Unlike birds with a clear-cut pattern of seasonal migrations Greater flamingos have a complex pattern of movements in the western Palearctic where they are described as migratory, partially migratory, dispersive and at times erratic (Cramp & Simmons, 1977). There is little published information on the movements of individual flamingos although almost 40 000 have been ringed in the Camargue (metal rings 1947-1961, plastic rings 1977 onwards), Iran, Russia and Spain. This paper makes use of recoveries and resightings of these birds to describe the main long-distance movements made by flamingos within the west Mediterranean basin and across the limits of this region, and thus defines the range of Camargue born birds.

Greater flamingos are widely distributed in the Old World, occurring in suitable wetlands in southern Europe, south-west Asia and much of Africa (Cramp and Simmons, 1977 ; Kahl, 1975). They are most commonly found in extensive, shallow brackish or saline lagoons, many of which are only temporary. They also occur on tidal flats in West Africa and the Gulf of Gabès in Tunisia. In many parts of their range the birds are present throughout the year but in others they occur only seasonally, on passage or erratically (Cramp & Simmons, 1977).

The results presented here should soon be complemented by data on the movements of flamingos marked in Spain since 1986.

METHODS

Distribution

Detailed information on the distribution of flamingos around the Mediterranean and in north-west Africa has been obtained mainly by the sites and species monitoring programme of the I.W.R.B. (International Waterfowl and Wetlands

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Research Bureau). The most important wetlands (Figure 1) are coastal and situated in a relatively narrow belt around the Mediterranean (except mainland Italy and much of Greece) and the western Sahara. Both Sardinia and Cyprus regularly host large numbers of flamingos but they are infrequent on the other Mediterranean islands (Corsica, Balearics, Sicily, Malta...) where suitable habitat is lacking.

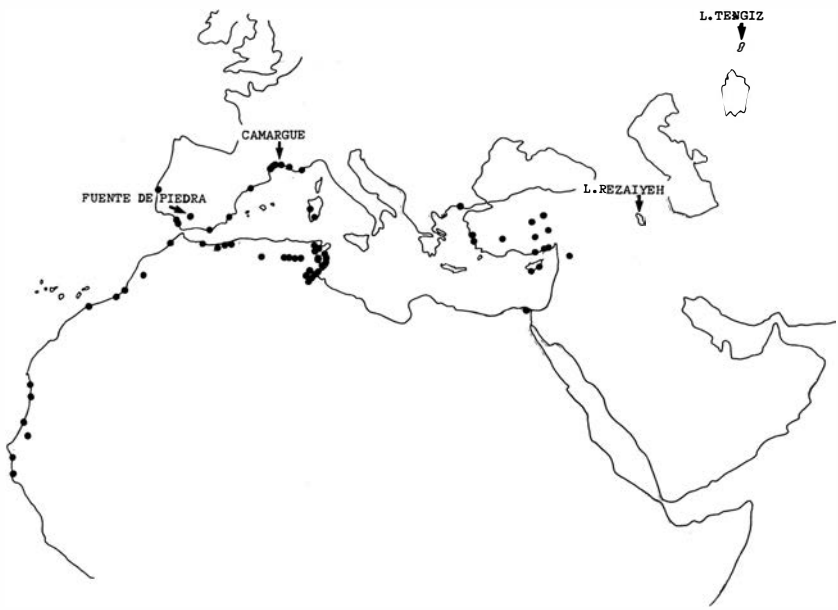

Figure 1. — Wetlands in the Mediterranean region and West Africa regularly frequented by hundreds or thousands of flamingos and the main ringing sites.

Movements

Movements of flamingos have been documented by five methods : 1) from recoveries of ringed birds found dead, 2) from resightings of flamingos wearing coded leg-bands or collars, 3) from sightings of juveniles (age less than one year) in areas where breeding does not occur or before the local young take wing (juveniles are recognisable as such during their first year of life. An experienced observer can also differenciate between juveniles just on the wing and birds one or two months older), 4) from analysis of counts and 5) from direct observations of migrating flamingos flying out to sea. Site faithfulness and fidelity to breeding areas have been documented only by resightings of flamingos ringed in the Camargue.

Marking schemes

Large numbers of flamingos have been marked at four localities in the western Palearctic where the species breeds and/or undergoes a simultaneous moult of the

flight feathers (Table I). Most have been ringed as chicks but some flightless full-grown birds have been marked in Asia. In the Camargue over 7 000 chicks have been given Darvic rings since 1977 as part of a long-term study into the breeding biology and population dynamics of flamingos. These rings bear individual combinations which can be read in the field at distances up to 400 metres. A similar study was initiated in Spain in 1986.

TABLE I

Summary of Greater Flamingo (Phoenicopterus ruber roseus) *ringing activities in the Western Palearctic 1947-1987.*

	Site	Year(s)	Type of ring	Numbers ringed			Sightings and/ or recoveries	Ref.
				juvs	ads	total		
FRANCE	Camargue (Bouches-du-Rhône)	1947-1961	some wing tags, mostly aluminium rings on tibia	6 417	0	6 417	515	(1)
		1977-1987	plastic bands coded	7 220	0	7 220	57 000	(2)
SPAIN	Fuente de Piedra (Malaga)	1964-1986	aluminium rings on tibia	231	0	231	1	(3)
		1986-1987	plastic bands coded	1 322	0	1 322	980	(4)
	Marismas (Huelva-Sevilla)	1984	aluminium ring on tibia, some with plastic band (not coded)	157	0	157	4	(5)
IRAN	L. Rezaiyeh (Azerbaijan)	1970	neck collars	2 250	0	2 250	2	(6)
		1971-1981	metal ring on tibia	8 928	381	9 309	90	(6)
		1983	neck bands		100	100		(7)
U.S.S.R.	Caspian Sea East coast (Turkmenistan)	1935-1981	aluminium ring on tarsus			614		(8)
	L. Tengiz (Kazakhstan)	1967-1980	aluminium ring on tarsus	8 109+	3 446+	12 040	90+	(8)

Note : all of the chicks marked in Spain with plastic leg bands also carry a metal ring on other tibia, as do many of those marked in the Camargue.

(1) Johnson 1983, (2) Archives of Tour du Valat, (3) Bernis & Fernandez-Cruz 1965, Fernandez-Cruz 1970, Blasco *et al.* 1979, (4) M. Rendon, *pers. com.*, (5) J. Calderon, *pers. com.*, (6) Argyle 1975, 1976, (7) Dept. of the Environment, Tehran, (8) Ringing Centre, Moscow.

Recoveries and resightings

Recoveries are dependent upon the public finding and reporting dead birds and resightings upon ornithologists equipped with telescopes reading and repor-

ting their observations respectively. Therefore, records will come mainly from areas which are regularly frequented by flamingos and also easily accessible to bird watchers.

RESULTS

RECOVERIES AND RESIGHTINGS OF MARKED BIRDS

Recoveries and resightings of flamingos from three of the four ringing centres are summarised in Tables II-IV. Details of some of the most representative are presented in full in Tables VII and VIII. Below, the major generalisations revealed by inspection of these data will be described, supplemented wherever possible by information on movements gleaned from other sources.

DISPERSAL FROM COLONIES

The geographical areas within which recoveries have been reported from the two main ringing sites, Camargue and Reziayeh, are shown in Figure 2. Flamingos disperse from both areas in all directions (except north from the Camargue which is already on the northern edge of the species' range). These two colonies are 3 500 km apart and the zones of recovery show little overlap. As yet there are few recoveries of birds marked at Fuente de Piedra, and little quantitative information from Tenghiz, but it is known that birds marked in Kazakhstan at either Tenghiz or on the east coast of the Caspian Sea have been reported from Iran, Iraq, Egypt, Cyprus and France as well as from Pakistan (E.I. Gavrilov, *pers. com.*).

FLYWAYS

The major flyways can be discerned by connecting the main areas where flamingos have been recovered or resighted away from the ringing locations. The main routes are :

1) *Southern France to Senegal via Spain, (Portugal), Morocco and Mauritania*

This coastal flyway extends 3 800 km SSW from the Camargue to Senegal, perhaps as far as Guinea-Bissau which is the southern limit of the species' range in West Africa. Recoveries, resightings and observations of juveniles indicate that some birds may travel the whole length of this flyway. However, within this axis, many shorter movements occur between the important concentrations of flamingos in the deltas of the Rhone and Guadalquivir, Fuente de Piedra, Banc d'Arguin and several sites in Senegal. Clearly, movements take place in both directions, although recoveries and resightings give undue weight to southerly movements.

TABLE II

Foreign recoveries and resightings of flamingos ringed as chicks in the Camargue, S. France, 1947-1987.

	Spain	Tunisia	Sardinia	Morocco	Algeria	Portugal	Balearic Islands	Italy	Senegal	Libya	Sicily	Mauritania	Turkey	Corsica	Greece	Total
Metal ring recoveries	168	64	23	23	12	8	3	3	3	2	1	1	1	—	—	312
Leg band recoveries	31	15	35	3	—	1	—	—	—	1	1	1	—	1	—	89
Leg band resightings	986	659	590	54	1	1	—	5	45	2	1	11	—	—	3	

Note : birds resighted in different countries/regions will appear twice (or more) in this table. To date 31.12.1986.

TABLE III

Foreign recoveries and resightings of flamingos ringed as chicks in Fuente de Piedra (Malaga) Spain.

	France	Tunisia	Morocco	Portugal	Mauritania	Total
Metal ring recoveries					1	1
Leg band resightings	60	21	13	1	—	95

The resightings data were kindly provided by M. Rendon and to date 31.12.1986.

TABLE IV

Foreign recoveries of flamingos ringed at Lake Rezaiyeh, Iran (from Argyll 1975, 1976, Meininger & Mullié 1981 and Ringing Center, Tehran).

Country	Iraq	India	Pakistan	Libya	Egypt	Turkey	Saudi Arabia	Qatar	Muscat & Oman	Syria	Ethiopia	U.S.S.R.	Somalia	Dubai	Bahrein	Sudan	Cyprus	France
Recovered	14	12	9	8	8	6	3	3	3	3	3	2	2	2	1	1	1	1

Note : some of these birds were ringed as chicks, others as moulting adults.

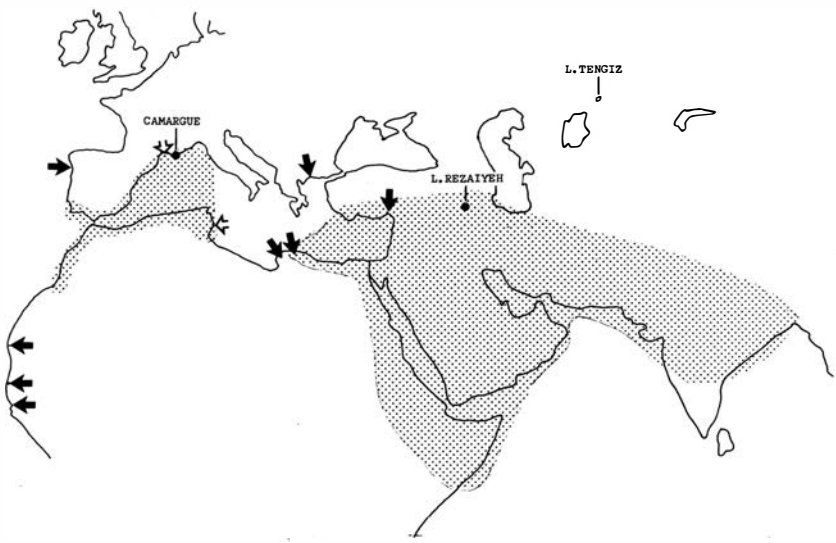

Figure 2. — Dispersal of flamingos from non-neighbouring breeding sites.
The two stippled zones encompass 99 % of all recoveries and resightings of flamingos from the Camargue (N = 45 000) and from Lake Rezaiyeh (N = 90) respectively (Iranian data are from Argyle 1975, 1976 and from the Ringing Centre in Tehran.) Arrows indicate outlying recoveries/resightings from the Camargue (black arrows) and from Lakes Rezaiyeh and Tengiz (white arrows).

Stemming from this flyway are less important branches along the valley of the Oued Draa in southern Morocco towards Dayet Iriqui and the temporary wetlands of western Algeria, and from south-western Spain into southern Portugal.

2) *Andalucia to Tunisia*

This flyway was discovered by resighting in Tunisia both Camargue-ringed adults and Spanish-ringed juveniles identified in Spain only a few days before. There are no sightings to demonstrate a return movement WNW, although this must surely occur.

3) *Camargue to Sardinia and/or Tunisia*

The other major flyway to and from the Camargue is NNW-SSE across the sea. There are many recoveries and resightings in Tunisia of birds ringed in the Camargue and observations of juveniles of Tunisian origin in France (Table V). The important wetlands for flamingos in Sardinia lie in the path of this flyway and resightings show that some birds use the island as a staging post. There is little doubt, however, that many birds make the direct crossing from southern France

TABLE V

Observations of juvenile flamingos depicting post-fledging dispersal northwards.

Sightings of juveniles believed to be of S. Mauritanian origin

Date	*Region/country*	*Remarks-references*
19.05.1986	Baie d'Arguin, Mauritania	6 on 19-20.05., 10 on 21.05. and 30 on 22.05. ARJ, P. Campredon
26.06.1986	Fuente de Piedra, Spain	ARJ
2.07.1986	Camargue, France	ARJ
10.05.1987	Banc d'Arguin, Mauritania	P. Campredon *(com. pers.)*
23.05.1987	Berre (Bouches-du-Rhône), France	P. Bayle *(com. pers.)*
4.06.1987	Marismas, Spain	G. Theler *(com. pers.)*
31.07.1987	Camargue, France	ARJ

Sightings of juveniles believed to be of Moroccan origin

Date	*Region/country*	*Remarks-references*
14.06.1965	Camargue, France	Johnson 1966, Robin 1966

Sightings of juveniles believed to be of Tunisian origin

Date	*Region/country*	*Remarks-references*
22.07.1970	Camargue, France	320 ind. Johnson 1973. Breeding likely in Tunisia after heavy rains in Sept. 1969.

Sightings of juveniles believed or known to be of Spanish origin

Date	*Region/country*	*Remarks-references*
11.07.1979	Camargue, France	
23.07.1986	Camargue, France	Ringed birds confirm Fuente de Piedra origin
30.07.1987	Hérault, France	

to northern Tunisia (850 km). There is no evidence that the Salins d'Hyères (Var) forms part of this flyway (see discussion).

4) *Asia minor to Libya and eastern Mediterranean*

Recoveries in Libya, Egypt, Turkey, Syria, Cyprus and France of flamingos marked at Lake Reziayeh, Iran (Table IV) suggest a roughly E-W flyway from Asia. To these can be added a recovery and a resighting in Tunisia of flamingos marked in Kazakhstan. From the Caspian birds could reach Libya via Syria and Egypt, or via Turkey, Syria and/or Cyprus. In Cyprus 5-10 000 flamingos regularly winter and they are believed by Foers (1984) to be of Iranian or Russian, rather than Turkish origin. However, flamingos which breed at Tuz Golu and Kurbaga on the Anatolian plateau move south in winter to the Mediterranean coast of Turkey from where some birds must on occasion cross to Cyprus. The bird recovered recently in the south of France presumably travelled via Tunisia.

This flyway of 2-4 000 km takes flamingos of Asiatic origin into wetlands in Libya and Tunisia also frequented by birds originating from the West Mediterranean. There is also a recovery of a Camargue-ringed flamingo in Adana (Turkey) demonstrating movement eastwards from the West Mediterranean into Asia.

These four main flyways link most of the wetlands frequented by flamingos from West Africa to Asia Minor via the Mediterranean basin. Other less important flight lines complete the connection with outlying localities.

THE TIMING OF MOVEMENTS

Movements are considered in relation to time of year and breeding season, the latter varying with latitude (Johnson, 1983).

Post-fledging dispersal

Since flamingos breed at only very few sites in any one year and because juvenile flamingos are easily distinguished from older birds (Johnson, 1983), some post-fledging movements can be detected by the appearance of young in places where breeding does not occur, or before the local young are able to fly. In the Mediterranean and West Africa there is a latitudinal gradient in laying dates (Johnson, 1983). Therefore, in some years it is possible to follow the northward progression of young flamingos fledged from colonies in the south (Table VI).

TABLE VI

Temporal and spatial distribution of recoveries of Camargue-ringed juvenile flamingos during post-fledging dispersal (birds found dead or shot wearing Paris Museum metal rings).

	S.W. Flyway								S.E. Flyway				
	Morocco	Algeria W.	Portugal	Andalucia	N. Spain Balearics	W. of Rhône delta	Camargue	E. of Rhône delta	Italy	Sardinia	Algeria E.	Tunisia	Sicily
August	—	—	—	1	—	2	1	1	—	—	—	—	—
September	3	—	1	11	2	5	4	—	—	1	1	5	—
October	2	3	5	27	4	9	1	1	2	4	3	3	—
November	2	—	1	6	1	4	1	—	—	1	—	4	1
December	2	—	—	4	2	1	—	—	—	1	—	3	—
January	—	—	—	3	1	—	—	—	1	—	—	5	—

Note : most young take wing from the breeding lagoon during August.

Some indication of the speed of dispersal of juveniles from the Camargue colonies is given by the distribution of recoveries of metal ringed birds found dead

in their first autumn (Table VI, see also Table VII for resightings). Most birds leave the crêche in the second half of August, and by the end of September there are recoveries from as far afield as Morocco and Tunisia. The bulk of the recoveries are in Spain in September/October ; there are none in the Camargue after November.

Post-breeding dispersal of adults

The timing of dispersal from the breeding colonies depends on several factors eg. the commencement and spread of laying at individual colonies, their breeding success, the extent of renesting after failure etc... This means that post-breeding dispersal will be occurring over many months from the beginning of the year in Senegal to as late as November in the north. Thus, flocks of flamingos have been observed departing SE-SSE over the sea from the Camargue on five evenings in August, 13 in September, six in October and on two evenings in November (see below).

Failed breeders often disperse immediately after losing an egg or chick and so it is possible that some individuals fail at a southern colony and re-nest at a colony further north later the same year. Clearly therefore, post-breeding dispersal will overlap in time both pre-nuptial and « reverse » migrations (see below).

Pre-nuptial « migration »

Flamingos converge on colonies prior to and during the breeding season. Intensive observations of marked birds in the Camargue (1983-86) and at Fuente de Piedra (1986) have shown that colonies are visited by many young birds in full plumage (but few in juvenile or immature plumage). The timing of these movements tends to vary with the latitude of the colony i.e. February to April in southern Spain, about one month earlier in Tunisia and one month later in the Camargue. The direction and extent of these pre-nuptial movements obviously varies between years according to which breeding sites are occupied.

Pre-nuptial movements cease once all breeding pairs have settled in a colony. However, in the Camargue (where the lagoon in which the colony is situated never dries out) the aggregation of nesting and non-breeding birds provides a continuing attraction and there is a great turnover in visiting birds throughout the long breeding season. Thus, pre-nuptial movements overlap in time both post-breeding dispersal from colonies further south, and movements induced by drought in other areas (« reverse » migration). Pre-breeding movements occur along all of the flyways, principally in a northerly direction but easterly away from the Mediterranean in the case of Flyway 4.

« Reverse » migration

Many of the wetlands frequented by flamingos are temporary, particularly those bordering the Sahara. They are flooded to a variable degree by precipitation in July-August in Senegal but from September onwards, and even in spring, elsewhere. In years of drought they may remain dry. The characteristic nomadic movements of flamingos are a consequence of this unpredictability in the timing

TABLE VII

A selection of eleven sightings/recoveries of Camargue-ringed flamingos illustrating the different types of movements and records of site faithfulness referred to in text.

ringed :	Camargue 22.07.83 resighted 18.08.83 (ring code PH4)
resighted :	Sine Saloum, SENEGAL c. 13° 45′ N/16° 30′ W, 26.11.83, 3 800 km S.W. (obs. J. Taris)
ringed :	Camargue 1.08.54 (ring code Paris CA 2969)
recovered :	Adana, TURKEY 37° 00′ N/35° 19′ E, 23.03.57, 2 600 km E.S.E.
ringed :	Camargue 2.08.78 (ring code DAG)
resighted :	Oristano, SARDINIA 40° 01′ N/08° 26′ E, 14.09. & 21.10.78, 550 km S.S.E. (obs. P. Orsini)
resighted :	Ichkeul, TUNISIA 37° 10′ N/09° 40′ E, 23.11.78, 340 km S.S.E. (obs. A.R. Johnson)
ringed :	Camargue 24.07.84 (two individuals)
resighted :	Al Haniyah, (Cyrenaica) LIBYA 32° 51′ N/21° 32′ E, September-December 84 (obs. L. Cornwallis)
ringed :	Camargue 2.08.78 resighted Aigues-Mortes (Gard) 13.09.78 at 15 hrs (obs. J. Walmsley)
resighted :	Oristano, SARDINIA 14.09.78 at 11 hrs, 550 km S.S.E. (obs. P. Orsini)
ringed :	Camargue 20.07.77 (ring code AUK)
resighted :	Tunis, TUNISIA 36° 49′ N/10° 14′ E, 15.08.80, 850 km S.S.E. (obs. M. Smart)
resighted :	Oristano, SARDINIA 1.09.80 (obs. G. Pinna)
resighted :	Frontignan (Hérault) FRANCE 9.10.80 (obs. A.R. Johnson)
ringed :	Camargue 2.08.78 (ring code CTC)
resighted :	Fuente de Piedra (Malaga) SPAIN 13.04.86 (obs. G. Theler)
resighted :	Palavas (Hérault) FRANCE 15.04.86 (obs. J. Walmsley)

ringed :	Camargue 20.07.77 (ring code BZU) resighted 18 times in Hérault to 1982
resighted :	Frontignan (Hérault) 43° 27′ N/03° 45′ E, 15.10.82
resighted :	St-Nazaire-en-Royans (Drôme) 45° 04′ N/05° 15′ E, 14 and 20.11.82 (obs. L. Cistac)
resighted :	Camargue 27.04.83 on (breeding)
ringed :	Camargue 2.08.78 (ring code CYB) resighted in France 1980, 1983.
resighted :	Thyna (Sfax) TUNISIA 34° 40′ N/10° 45′ E, 8.02.84
resighted :	Camargue area 28.04.84. Thirty-four more sightings to 18.07.85
resighted :	Thyna (Sfax) TUNISIA 7.11.85, 12.12.85, 17.01.86
resighted :	Camargue 4.04.86. Four more sightings to 7.06.86
resighted :	Tunis, TUNISIA 5.08.86 and Thyna (Sfax) 13.08.86
resighted :	Camargue area 5.04.87. Five more sightings to 6.08.87
ringed :	Camargue 2.08.78 (ring code CRH) resighted in Spain in 1982
recovered :	Venaco (Corte) CORSICA 42° 14′ N/09° 10′ E, 18.01.85
ringed :	Camargue 27.07.82 (ring code AC3)
resighted :	P.N. Doñana (Huelva) SPAIN c. 36° 50′ N/06° 19′ W (obs. E.B. Doñana)
resighted :	Thyna (Sfax) TUNISIA 30.08.87, c. 1 500 km E.S.E. (obs. T. Gaultier)

1) Post-fledging dispersal to West Africa and the most southerly report of a Camargue-ringed flamingo. 2) The furthest east a Camargue-ringed flamingo has been reported. 3) Post-fledging dispersal to S.E. 4) Movement east beyond normal range to an area probably frequented mostly by flamingos originating from Asiatic rather than west Mediterranean colonies. 5) One of the few long-distance movements on record with such a short lapse of time between observations. Evidence of a night crossing of the Mediterranean. 6) Reverse migration north across Mediterranean at the end of summer ; many similar records some years. 7) Spring movement north from Spain to France. 8) The most northerly report of a Camargue-ringed flamingo ; this bird was driven up the Rhône Valley during S.E. gales and later returned to normal range. 9) Faithful to Tunisia outside breeding season. 10) Cold weather movement presumably from south coast of France and the only recovery in Corsica. 11) Movement from Andalusia to Tunisia.

and amount of rainfall in particular regions. As wetlands dry out and/or as food becomes scarce, flamingos are forced to move elsewhere, either to permanent water bodies nearby (e.g. salines or the coast) or over great distances. An example of the latter are the movements between N. Africa and France between August and October. This means that the western Mediterranean basin is traversed by flamingos in both northerly and southerly directions in August-October (see post-breeding dispersal above).

Movements in response to severe weather

Long-distance movements caused by extreme meteorological conditions other than drought, probably only occur on the northern fringe of the flamingo's range. Two vagaries of the weather can cause exceptional movements, gales and prolonged freezing conditions.

Gales. Exceptionally strong SE winds (126 kph) blew across much of France on 7-8 November 1982. Sea-water was forced into many of the brackish, coastal lagoons where flamingos occur. During or immediately after the gales, small numbers of flamingos (at least 10 individuals) were reported from several inland localities in southern France (Allier, Charente, Isère, Tarn, Marne and Drôme) up to 550 km north of the Mediterranean coast. One of these birds was ringed and later returned to the coast (Table VII), (Hafner *et al.,* 1985).

Severe cold. For two weeks in January 1985, almost all the lagoons frequented by flamingos in France were frozen over. The bodies of 3 000 flamingos were recovered, but many birds attempted to escape the cold by moving southwards across the Mediterranean. Evidence for this comes from observations of flamingos on Corsica where the species is very rare. Between 8-25 January flamingos were reported from 21 localities and included a flock of 150-200 birds. Only five were reported as injured or dead and presumably most moved on south to Sardinia or N. Africa.

MIGRATORY BEHAVIOUR

Long-distance movements of flamingos are seldom observed directly, presumably because they take place mainly at night (Brown, 1975) and/or over the sea. Flocks seen arriving (or departing) at a particular locality may have made only a local movement and the few unequivocal records of visible migration are of birds departing from the Camargue.

Between 1973 and 1986, departures over the sea from the Camargue were observed on 26 evenings out of 34 between August 19 and November 5. Departing flocks contained between 2 and 340 individuals (mean 71 ; n = 57 ; Figure 3) and were never composed solely of first-year birds.

Departures were recorded only when there was either no wind (five evenings) or the wind was light to moderate and from WNW-NNW (21 evenings). During periods of NW wind (régime Mistral) the sky is usually cloudless and the visibility excellent. On evenings when departures were recorded, there was no cloud on 18 occasions and cloud cover only once reached 4/8. All these presumed trans-Mediterranean flights left the Camargue in the evening, supporting the contention that flamingos usually migrate at night (Brown, 1975).

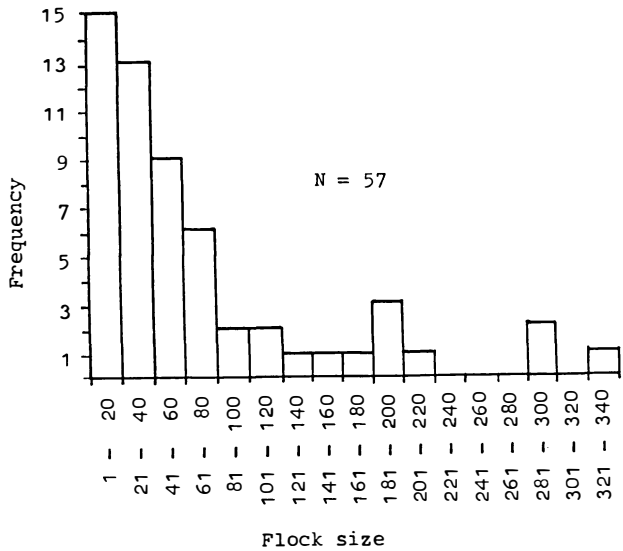

Figure 3. — Flock size of flamingos departing from the Camargue on post-nuptial, trans-Mediterranean flights.

The flight directions of departing flocks are shown in Figure 4. Flights either head off immediately in a SSE direction or waiver between several southerly headings before setting off to the SSE. Frequently some individual were seen to break away and return before the flock reached the horizon. Most flocks were estimated to leave at an altitude between 50-100 m (range 50-250 m) a.s.l.

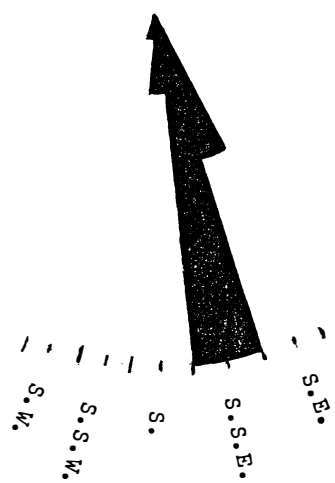

Figure 4. — Flight directions of post-nuptial departures of flamingos from the Camargue (centre of rosette) over the sea. The length of flight direction is proportional to the percentage of departures.

SITE FIDELITY

Site fidelity is difficult to quantify because of spatial and temporal uneveness in observer effort and because the chances of identifying a particular bird depend on water-depth, distance from the observer etc... However, resighting of birds wearing darvic rings has shown that at least some individuals remain sedentary for long periods (e.g. Figure 5). It has also provided a first indication of the proportions of birds of Camargue origin which breed in the different colonies in the west Mediterranean and west Africa.

In 1986, intensive observations were made at both breeding colonies in the western Mediterranean. 392 darvic-ringed birds were found breeding in the Camargue and 44 at Fuente de Piedra. The efficiency of detection differed between the two colonies and allowing for birds missed, the number of ringed birds estimated to have bred at the two colonies was 559 and 82 respectively. Another bird of Camargue origin (ringed in 1977) was seen, but not proved to be breeding, among 10 000 birds checked for rings during a visit to the colony at Banc d'Arguin in Mauritania in May 1986. Thus, of the 642 flamingos ringed in the Camargue and known to have bred in 1986, 87.1 % bred at their natal colony and 12.8 % moved to the nex nearest, in Spain. However, two of the Spanish birds, both nine years old, had bred in the Camargue in 1985, while a third was known to have visited there.

DISCUSSION

Resightings and recoveries of marked flamingos

Reports of marked birds found dead and resightings of Darvic ringed individuals will come mainly from areas frequented regularly by both humans and flamingos. Therefore, there are few reports of marked birds from areas such as the Banc d'Arguin in Mauritania where many flamingos occur but few ornithologists observe them. This means that the real pattern of flamingo movements and distribution may not match exactly that inferred from recoveries and resightings of marked birds. The biases introduced by these geographical irregularities in resighting effort could potentially be overcome by recording the proportion of flamingos observed which were checked for rings. However, simple inspection of the recovery and resighting information was deemed sufficient to identify the major flyways and to describe the normal seasonal movements undertaken by flamingos.

Dispersal from colonies

There is little spatial overlap in the recoveries (and resightings) of flamingos ringed at the two main study sites, Camargue and Rezaiyeh. In contrast, flamingos originating from the colonies in France and Spain clearly share to a large extent wetlands throughout the western Mediterranean. If flamingos were to be ringed in Tunisia, Sinai and Turkey this would doubtless reveal similar overlap in the ranges of birds originating from adjacent colonies in the eastern Mediterranean and Asia Minor.

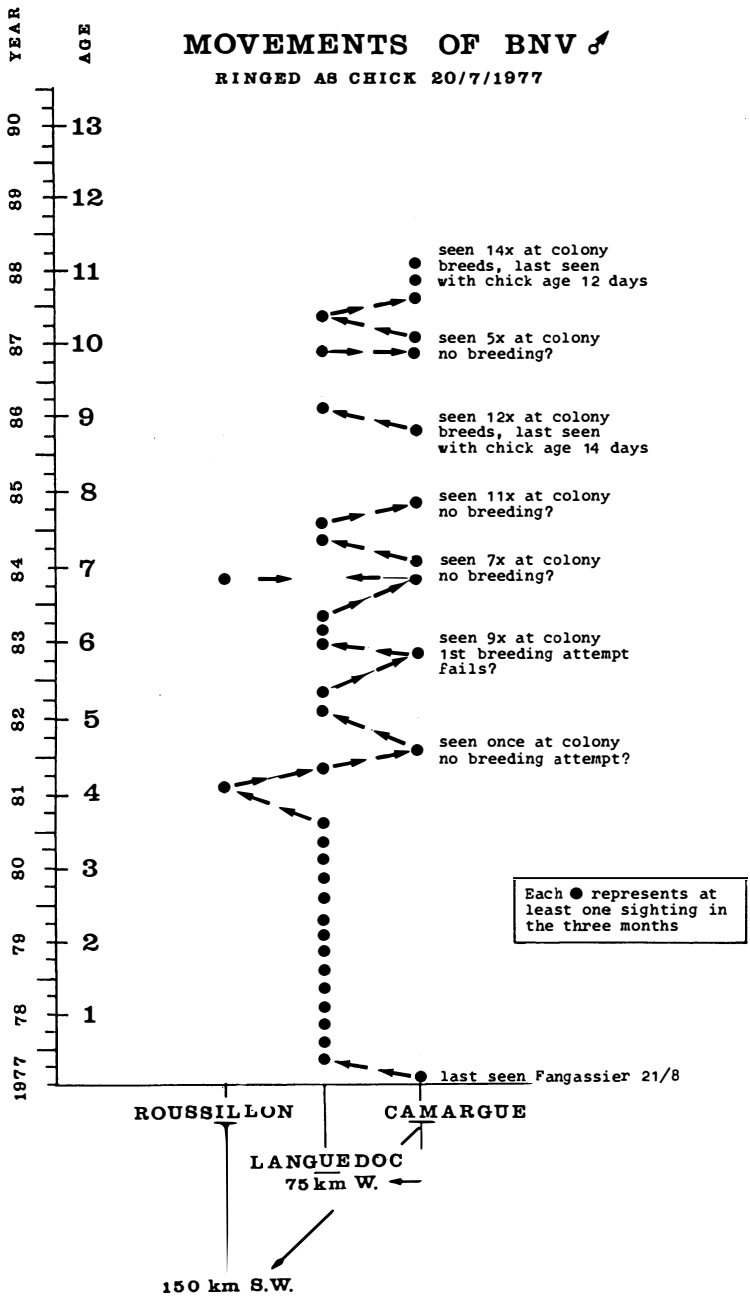

Figure 5. — The documented movements of an individually marked flamingo seen 130 times during its first eleven years of life.

Brown *et al.* (1982) suggested that there are discrete populations of Greater flamingos centred on four areas. These are 1) Europe and the Middle East migrating in winter to North and East Africa, 2) Mauritania and Senegal, 3) East Africa Rift Valley and 4) southern Africa. However, the information presented here suggests that this division is too simplistic. Flamingos from the west Mediterranean colonies (Camargue, Fuente de Piedra) clearly mingle with those from Mauritania in the non-breeding season. The extent to which this occurs will be further demonstrated by the new ringing programme in Spain (and perhaps future ringing in Mauritania). In fact it seems quite likely that birds from neighbouring colonies come into contact throughout areas 1) and 2) above and 3) and 4) above. However ; it seems unlikely that there is any movement of birds between West Africa and either East or southern Africa because of the large gap in distribution caused by a lack of suitable habitat (*viz.* Equatorial forest, Sahara desert).

Breeding site fidelity and movements between colonies

Intensive observations in France and Spain showed that 13 % of the Camargue Darvic-ringed flamingos breeding in 1986 were nesting at Fuente de Piedra, 950 km from their natal colony. Only one Camargue bird was found during a brief visit to the next nearest colony in Mauritania (3 500 km from the Camargue). However, there are still comparatively few Camargue-ringed birds of breeding age as Darvic ringing only started in 1977. The chances of demonstrating recruitment to colonies in Mauritania by flamingos reared in the Camargue will increase as more ringed birds start to breed. The new ringing programme started at Fuente de Piedra in 1986 will eventually indicate the extent to which birds from here recruit to colonies in Mauritania and elsewhere.

One surprising result was that two of the Camargue ringed birds breeding at Fuente de Piedra in 1986 had previously bred in the Camargue (one and two years earlier respectively), albeit unsuccessfully. Previously it was thought that birds would only change breeding sites between years if the original site became unsuitable. This was not the case here as breeding has occurred at both Fuente de Piedra and the Camargue each year since 1984.

Timing and extent of migratory movements

Although some individuals probably undertake movements of up to 4 000 km in a particular season, flamingos are not true migrants in the accepted sense (Evans, 1985) ; their overall range in the Mediterranean and West Africa is much the same in winter as in summer but their distribution is not. For example, in France the number of flamingos is generally twice as high in summer as in winter (Johnson, 1983), there being a pronounced southward movement in autumn and a return in spring. However, this shift in the population is undoubtedly more complex than suggested by counts alone. It is probably driven as much by habitat seasonality and availability (Johnson *in press*), and the age and reproductive status of individual birds, as by season.

In France, where the effort to resight Darvic-ringed birds remains reasonably constant from year to year, it has been shown that some individuals have shown no tendency to migrate during their first ten years of life. Similarly, many birds

TABLE VIII

A selection of recoveries in the Mediterranean region of Greater flamingos ringed at Lake Rezaiyeh (Azerbaijan), Iran c. 37° 20′ N/45° 40′ E and at Lake Tengiz (Kazakhstan) U.S.S.R. 50° 24′ N/68° 57′ E (from Argyle 1975, 1976 and data from Ringing Centres in Tehran and Moskow).

ringed :	Lake Rezaiyeh, IRAN, 26.08.73 (ring code LL 3880)
recovered :	Homs, SYRIA 34° 44′ N/36° 43′ E, 10.10.74
ringed :	Lake Rezaiyeh, IRAN, 27.08.73 (ring code LL 4531)
recovered :	Karatas (Adana), TURKEY 36° 32′ N/35° 22′ E, 20.11.73
ringed :	Lake Rezaiyeh, IRAN, 25.08.73 (ring code LL 3796)
recovered :	Near Izmir, TURKEY 38° 25′ N/27° 00′ E, 7.01.74
ringed :	Lake Rezaiyeh, IRAN, 7.08.72 (ring code LL 2665)
recovered :	Larnaca, CYPRUS 34° 53′ N/33° 38′ E, 00.03.73
ringed :	Lake Rezaiyeh, IRAN, 00.08.70 (ring code LL 1946)
recovered :	El Hannia, Beida, LIBYA 32° 55′ N/21° 40′ E, 00.12.70
ringed :	Lake Rezaiyeh, IRAN, 6.08.85 (ring code LL 21122)
recovered :	Thau (Hérault), FRANCE 43° 21′ N/03° 32′ E, 25.01.87
ringed :	Lake Tengiz, U.S.S.R., 16.07.78 (ring code B 133831)
recovered :	Thyna (Sfax), TUNISIA 34° 40′ N/10° 45′ E, 00.03/04.83
ringed :	Lake Tengiz, U.S.S.R., 11.08.80 (neck collar K 001)
resighted :	Sidi Mansour (Sfax), TUNISIA 34° 48′ N/10° 52′ E, 11.02.84

Note : these two Russian recoveries reveal movements of 4 800 km. W.S.W. and are the longest recorded for the species.

reared in the Camargue which have emigrated to Tunisia, remain faithful to a particular area until reaching maturity. At this time they move away to visit a colony, but not necessarily to breed, often returning subsequently to the area frequented earlier.

In many cases the area in which birds spend their time up to maturity and subsequently the non-breeding season, will have been frequented since post-fledging dispersal. There seem to be marked differences between cohorts in their tendency to winter in different geographical regions. Reasons for this are unclear but may be related to conditions in the Camargue immediately after fledging and wind speed and direction at the time of dispersal.

The very high rate of recoveries and resightings of Camargue-ringed flamingos in Tunisia demonstrates the extent to which the breeding birds of the Rhône delta are dependent outside the breeding season upon wetlands situated 800-1 000 km to the south. (They are similarly dependent upon Spanish wetlands). Although some birds moving between France and Tunisia stop off in Sardinia (as numerous resightings show), it seems likely that others make a non-stop crossing and this seems to be achieved mainly by night, with a clear sky and favourable tail winds, at least at departure. In this respect flamingos do not differ from other

large water birds. For example, in North America Canada Geese (*Branta canadensis*) have been radio-tracked over very similar distances during the fall migration (Wege & Raveling, 1983). Four out of seven birds tracked in 1973 completed an 855 km flight non-stop and in 1974 one bird out of eight did so. The geese departed on migration only with following surface winds, either after sun-set or during mid-morning and completed the flight in times ranging from approximately 8 to 11.5 hrs. Cranes (*Grus grus*) and Bewick's Swans (*Cygnus columbiana bewickii*) have been shown to migrate in Europe under similar conditions (Alerstam & Bauer, 1973 ; Evans, 1979).

The Mistral (N.N.W.) is one of the dominant winds of the Camargue and clearly favours migrants leaving the Rhône delta for Sardinia and Tunisia which lie exactly in the wind's path. There is no evidence to show that the salins d'Hyères (Var), 125 km east of the Camargue are used as a staging post along flyway 2. The lack of favourable winds may explain this.

From the foregoing it is clear that it is easy to generalise about movements of flamingos in the West Mediterranean. However, these generalisations conceal a great deal of variation due to individual and/or cohort differences in movement patterns and habitat seasonality. The proximate and ultimate factors (both environmental and physiological) responsible for this variation will be more difficult to unravel.

SUMMARY

Some of the temporal and spatial (long distance) movements undertaken by Greater flamingos in the western Palearctic are illustrated here, in particular by analysis of recoveries of birds ringed in the Camargue, Iran, Spain and Russia and by the resightings of Camargue-banded birds. Sightings of juveniles also reveal movements. The area under review is centred on the western Mediterranean but extends to West Africa and to S.W. Asia, this zone constituting the N.W. fringe of the species' world-wide distribution.

The Mediterranean is regularly crossed by flamingos, seemingly mostly at night, and in addition to seasonal movements to and from the breeding areas birds are displaced by temporary phenomena such as droughts, storms, prolonged frosts. The overall pattern of movements is complex and there are marked individual differences. Some birds undertake movements of 3-4 000 km or more, whilst others have revealed sedentariness within France during their first 10 years of life. Many birds show a high level of site faithfulness.

There is considerable range overlap from colonies 1 000 km apart, and to a lesser degree of non-neighbouring colonies separated by much greater distances. Flamingos born in the Camargue have been recorded breeding in Andalucia, even birds having bred formerly in the Camargue, and this in spite of breeding having taken place simultaneously at both localities.

RÉSUMÉ

L'analyse des reprises d'oiseaux bagués en Camargue, en Espagne, en Iran et en Russie, ainsi que les observations d'oiseaux camarguais porteurs de bagues

codées lisibles sur le terrain illustrent les déplacements (au long cours) dans l'espace et dans le temps, effectués par les flamants roses dans la partie occidentale de la région Paléarctique. Les observations de flamants juvéniles font également apparaître certains déplacements. La région étudiée est centrée sur la Méditerranée occidentale mais s'étend jusqu'en Afrique de l'ouest et au sud-ouest asiatique. Cette zone représente la frange nord-ouest de la répartition mondiale de cette sous-espèce.

La Méditerranée est régulièrement traversée par les flamants, surtout de nuit semble-t-il. Aux mouvements saisonniers entre les sites de reproduction et les quartiers d'hiver s'ajoutent des déplacements dus à des phénomènes plus aléatoires, tels que sécheresse, tempêtes, longues périodes de gel. Il existe des différences individuelles importantes ; certaines oiseaux effectuent une véritable migration de plusieurs milliers de kilomètres, alors que d'autres se révèlent sédentaires (en France) durant les dix premières années de leur vie. Le schéma des mouvements est donc complexe.

On note un taux d'échange élevé entre deux colonies distantes de 1 000 km (Camargue et Fuente de Piedra). Ainsi, des flamants bagués en Camargue ont niché en Andalousie, et certains d'entre-eux avaient pourtant déjà niché en Camargue auparavant. Pour des colonies non voisines beaucoup plus éloignées l'une de l'autre (Camargue et Rezaiyeh) on constate un chevauchement de l'aire de dispersion globale des individus.

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