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BREEDING BIOLOGY OF THE GREATER FLAMINGO

(PHOENICOPTERUS RUBER ROSEUS) IN

LAKE REZAIYEH NATIONAL PARK, IRAN

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BREEDING BIOLOGY OF THE GREATER FLAMINGO (PHOENICOPTERUS RUBER ROSEUS) IN LAKE REZAIYEH NATIONAL PARK, IRAN

By

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ABSTRACT

BREEDING BIOLOGY OF THE GREATER FLAMINGO
(PHOENICOPTERUS RUBER ROSEUS) IN
LAKE REZAIYEH NATIONAL PARK, IRAN

By

Mohammad Ali Ashtiani Zarandi

This study of the breeding biology of the Greater Flamingos (Phoenicopterus ruber roseus) in Lake Rezaiyeh National Park, Iran, occurred from June 20th through September 15th, 1976. Lake Rezaiyeh is a salt lake of 5,000 Km^2.

There were breeding and non-breeding flamingos present during the summer of 1976. Breeding birds occupied Jodareh-Bala and Myaneh Islands in the center of the lake, while the non-breeders utilized the estuaries of the five rivers entering the southern part of the lake. Approximately 23,000 breeding, 30,000 non-breeding, and 9,000 chicks were present. Boat censuses showed that the breeding flamingos were concentrated around the breeding islands during the incubation period (June and early July) and the second week after hatching when the chicks began to enter the water. In September the chicks were concentrated in

two creches, and the breeding flamingos were dispersed throughout the northcentral part of the lake, returning to feed the young at daily intervals. Non-breeders occupied the south and southeastern part of the lake throughout the summer.

Analyses of esophagus and gizzard samples showed that brine shrimps formed approximately 93 percent of the flamingos' diet. Brine shrimps (Artemia salina) were four times as dense in the south part of the lake as in the north. Although the salt concentration was much higher in the north part of the lake compared with the south, in both cases the salt concentration was too high for the brine shrimp to reproduce. Apparently, brine shrimp reproduce in the estuaries in the southern part of the lake.

The flamingo laid one egg on the bare substrate. The incubation period was 29 to 30 days. Both sexes incubate the eggs for at least part of each day, and the rate of nest relief was found to be highest at 4:00-5:00 A.M. and 5:00-6:00 P.M. Hatching occurred between July 8th and 31st. Nearly 89 percent of the eggs hatched and the number of fledglings was estimated to be 81 percent of all eggs laid. Herring Gulls were the only predators. Eleven percent of the eggs and six percent of the recently hatched chicks were taken by the Herring Gulls. This accounted for 90 percent of all mortality, with the 10 percent due to unknown natural causes.

Chicks entered the water at 16 days of age. Pattern of growth of the chick was described. The chicks with an approximate age of one week were fed by adults between three and four times a day, with each feeding period ranging between one and six minutes. As the chicks became older the frequency of feeding decreased to once or twice a day.

The length of the molt for breeders and non-breeders was 36 and 35 days, respectively. Non-breeders began to molt in the first week of July and the breeders at the end of July. Flamingos at Lake Rezaiyeh appear to breed for the first time between four to five years of age.

in memory of my mother

ACKNOWLEDGMENTS

Many people were very helpful to me during the course of this study. In particular, I would like to single out the following:

I wish to express my deepest appreciation to Mr. Eskandar Firouz, Deputy Prime Minister and Director of the Department of Environmental Conservation for providing me with the opportunity to continue my education in the field of waterfowl management, and to study the biology of the Greater Flamingo. I also thank Dr. Sheibani, Assistant Director of the Iranian Department of Environmental Conservation for his assistance.

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Thanks to Dr. Porter, Department of Zoology, Michigan State University, for identification of invertebrates in stomach samples of flamingos.

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Finally, I offer my deep gratitude and respect to my father and brothers who provided encouragement and moral support during the study.

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CHAPTER I

INTRODUCTION

The Greater Flamingo (Phoenicopterus ruber roseus) occurs throughout Africa, Europe, Southwest Asia, and north to Lake Tangiz, Kazakh, U.S.S.R. (Kahl 1975). The breeding range extends north to Lake Tangiz, U.S.S.R., south to Capetown in South Africa, west to Dakar in West Africa, and east to Abb-e-Istadeh in Afghanistan (Figure 1). The Camargue in France is the only site in Europe where species breed (Johnson 1975).

The occurrence of flamingos in Iran was reported by Capito (1925) who obtained a specimen near Ganaweh in southwestern Iran in February, 1925 (Figure 2). Witherby (1926) observed two flamingos in Bushire (southern Iran) in March, 1925. Another Iranian record is that of Buxton (1921) who reported a flock of twelve adults in July, 1921, at Rula Rud, between Anzeli and Astara in northern Iran. The Greater Flamingo occurs on Lakes Neiriz and Parishan in southern Iran. Summer censuses by personnel of the Iran Department of the Environment's Ornithology Unit on Lakes Neiriz and Parishan have ranged between 1,000 and 8,000 birds. According to Scott (1975), small breeding

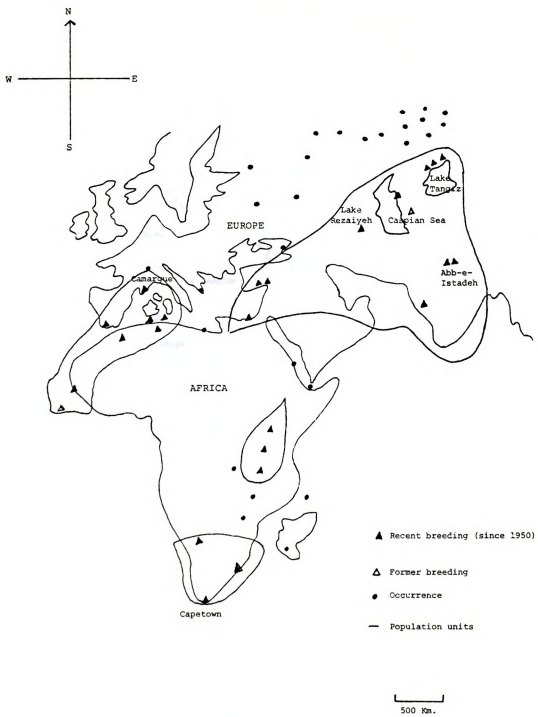

Figure 1. Distribution of the Greater Flamingo in Asia, Africa, and Europe (from Kahl 1975).

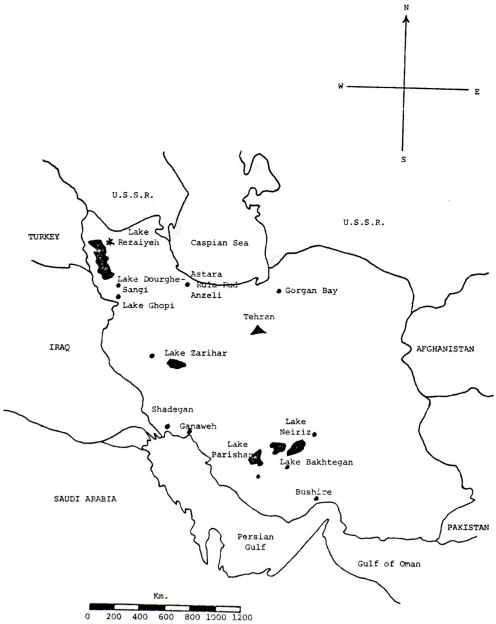

Figure 2. Sites where Greater Flamingos have been observed in Iran.

colonies also once occurred at Lake Bakhtegan in southern Iran (Figure 2), but there have been no breeding records since 1965. Although Gunther in 1899 (cited by Scott 1975) was the first to report that the Greater Flamingo was present at Lake Rezaiyeh (formerly Lake Urmi) in northwest Iran, he did not find any evidence of breeding. Savage (1964) reported that no flamingos were nesting at Lake Rezaiyeh in 1960. Personnel of the Iranian Department of Game and Fish found Greater Flamingos nesting at Lake Rezaiyeh National Park for the first time in 1964.

In August of 1970, the Ornithology Unit of the Iranian Department of Environmental Conservation (DEC) initiated a flamingo research program. In that year, 2,280 flamingo chicks were marked at Lake Rezaiyeh with blue neck bands. According to Scott (1975), only two birds have subsequently been recaptured. In 1971, the Ornithology Unit began to use monel metal leg rings, and since that time 3,994 flamingo chicks have been ringed (1,000 in 1971; 1,495 in 1972; 1,499 in 1973) (see Appendix 1). Argyle (1975)reported that of 2,495 chicks ringed in 1971 and 1972, a total of 80 recoveries have been recorded from Iran, Azarbaijan (U.S.S.R.), Persian Gulf states, Saudi Arabia, Iraq, Syria, Turkey, Cyprus, Libya, Ethiopia, Pakistan, and India (see Appendix 2).

This study was initiated to obtain descriptive information on the activities of the Greater Flamingo at Lake Rezaiyeh National Park. More specifically, this study attempts to estimate the number of birds that were present on Lake Rezaiyeh during the summer; identify which areas on the lake were used by the birds; obtain specific information on breeding activities, including chronology, pattern of incubation, nest success, growth, and the feeding pattern of juvenile birds; document the molt process in regard to its timing and duration; sample plankton, water, and the lake bottom to provide information on flamingo food resources and water quality which might influence distribution of flamingos on the lake. The D.E.C. has been ringing Greater Flamingos at Lake Rezaiyeh for the past six years and the additional data collected since Scott (1975) reported on migration routes and wintering areas is summarized. The combined data might then form a more definite biological basis for the management of the Greater Flamingo at Lake Rezaiyeh National Park in Iran.

CHAPTER II

LITERATURE REVIEW

According to the findings of the International Flamingo Symposium (1975), all flamingos are included in the genus Phoenicopterus. The following systematic names were chosen by the International Flamingo Symposium (1975) to represent the world's species and subspecies:

Variety	Scientific Name
Caribbean	P. ruber ruber
Greater	P. ruber roseus
Lesser	P. minor
Chilean	P. chilensis
Andean	P. andinus
James'	P. jamesi

Poncy (1926) noted that flamingos nest in brackish lagoons of steppes and deltas situated between the isothermic curves of $+24^{\circ}C$ and $+26^{\circ}C$ in July in the Palearctic region. The same July curve is mentioned by Poncy (1926) for the lower part of the Caspian Sea. From all of this evidence, Allen (1956) concluded that a July mean of close to $26.7^{\circ}C$ provides environmental conditions that are required for

successful reproductive activity in this species. Allen (1956) believed that original flamingo breeding sites may have been in favorable environments in southern Spain and France, the brackish lakes of the Nile Delta, and in similar areas in the Caspian region.

Scott (1975) reported that, although flamingos are distributed throughout the world, their occurrence is restricted to shallow alkaline lakes and salt lagoons, usually without vegetation. He also noted that the flamingos breed irregularly and unpredictably, and form long-term mating relationships. In regard to pair-bonding, Studer-Thiersch (1975) reported that the pairs remain together during succeeding breeding seasons. Even outside the breeding season the mates are closer to each other than to other birds while sleeping and carrying out other activities.

Kahl (1975) reported that courtship displays in all species of flamingos occur in large groups. Although both sexes take part, displays usually are initiated by males. The displays of the male are more pronounced than those of females (Rooth 1968). According to Kahl (1975), ritualized behavior is contagious and when one bird in a group starts a certain type of display, this is often followed by other birds. Displaying flamingos can be observed throughout the year. Periods of high intensity display often occur months before and after actual nesting activities.

Performing groups are even seen at times and locations where breeding is not likely (Brown 1958).

Normally, pair-formation is followed at once by nest building and egg laying. Flamingos usually breed in large colonies on mud flats. They construct nests by building a small mound of mud with a cup in the center to hold the egg. The flamingos at Lake Elmenteita in Kenya (Brown 1958) and Lake Rezaiyeh in Iran (Scott 1975) which breed on rocky islands without making nests appear to be exceptions.

The clutch has been reported by Allen (1956), Broekuysen (1975), Brown (1958), Gallet (1950), and Salim Ali (1945) to be a single egg. Chapman (1905, 1908), Drable (1936), Uys and Martin (1961), and Yeat (1950) all determined that both sexes incubate and that the incubation period is between 29 and 31 days. Guichard (1951) reported that the birds relieve each other on the nest early in the morning and again late in the afternoon. Salim Ali (1945) noted in the Great Rann Colony in India that most nest relief changes occurred at night. Chapman (1905) noted that there is no relation between sex and the time of day that a parent incubates the egg, both sexes evidently incubating during the day and, doubtless, during the night also. According to Allen (1956), the pattern of nest relief can be influenced by the relative distance that must be travelled to obtain food. If long distances are involved, nest relief may occur at 24-hour intervals.

Hatching and the development of the young have been observed and recorded in detail by Chapman (1905), Gallet (1950), Allen (1956), and Brown (1958). Allen (1956) reported that during the first week of life young flamingos have short legs and bill, and that the body is covered with natal down. According to Chapman (1905), the white natal down does not change to the gray of the post-natal plumage until the young are about one month old. Allen (1956) reported that the chick at age of about 10 days begins to take on the appearance of its kind, and the legs gradually become elongated. He also noted that the chicks gather in creches after about two weeks.

Chapman (1905) in Allen (1956) determined that the chicks are fed by their parents for three months with regurgitated liquid food. Adult flamingos feed the chicks by standing behind them and reaching over and putting the tip of the upper mandible on the tip of the chick's lower mandible (Brown 1958). Gallet (1950) reported that adult flamingos do not recognize their young and feed any chick that appears to be hungry. Salim Ali (1945) and Allen (1956) support this view, and the latter authority observed that there is a biological advantage of a creche system where any adult feeds any hungry chick. Nevertheless, Brown (1958) reported that the adults in Kenya feed only their own chicks. According to him, the chicks recognize their parents through their distinctive voices.

Flamingos are filter feeders. According to Chapman (1908), when the bird is feeding with its bill under water, the lower portion of the bill remains steady while the upper portion moves rapidly so that the water escapes from each side of the base of the bill and the food remains in the beak. Allen (1956) states that flamingos keep their bills in the mud and move in a steady, but irregular, track. Middlemiss (1961) reported that the Greater Flamingo feeds while either moving forward or backward. The mechanism of filter feeding has also been described by Buffon (1781) and Chapman (1905, 1908), (both in Allen 1956), Clark (1895) and Gallet (1949, 1950). All seem to agree that the bird's head is submerged and the feet are moved up and down to bring the prey into the beak. Gregoire de Guirtchitch (1936), Gallet (1950), and Ridley et al. (1955) have described how flamingos tip up to feed on the bottom in water which is slightly deeper than their leg length.

With regard to food eaten by the Greater Flamingo, Gadow (1892) noted that flamingos fed on "organic slime" and algae. Madon (1932) commented on the rarity of organic elements in the stomach contents, while Gallet (1950) concluded that the masses of small red worms, mollusca, and gastropoda (Neritina Sp., Cerithium Sp., and Rissoina Sp.) found in bottom sediments were the essential, if not the exclusive diet of the flamingos in the Camargue area.

Zahl (1949), cited by Allen (1956), reported that flamingos obtain nutrients from small mollusks which inhabit the lake bottoms. Guichard (1951), cited by Allen (1956), believed that the flamingos in the Camargue feed on brine shrimp (Artemia salina). Brown (1958) noted that although the Greater Flamingos in East Africa fed on copepods and chironomid larva, they also obtained blue green algae from the water. Issakov (1948) reported that the winter food of the flamingos consisted mainly of crustacea and small mollusks. He also noted that brine shrimp and their eggs were the main food of the flamingos at Kara-Bogoz Bay and at Urmi Lake (the old name for Lake Rezaiyeh).

The molt has been described in the flamingo by Allen (1956), Brown (1958, 1975), McCann (1939, 1947), and Middlemiss (1961). Allen (1956) noted that the flight feathers are shed together and that the birds are incapable of flying for several weeks. Brown (1958) reported that molt occurs before, during, or after breeding, or outside the breeding season altogether. Duplaix-Hall and Kear (1975) state that although wing molt normally occurs after egg laying, it can occur before, and even during incubation in some cases.

CHAPTER III

STUDY AREA

Lake Rezaiyeh is located in the lower part of the Azarbaijan Plateau of northwestern Iran (Figure 2). The lake is approximately 140 Km x 36 Km, which is about 5,000 Km^2 of surface area. There are 56 islands in the lake, but only four islands (Espir, Ashk, Kabudan, and Shahi) have fresh water springs. All the islands except Shahi are uninhabited. Two of the islands (Jodareh-Bala and Myaneh) were occupied by the breeding pairs of the Greater Flamingos during this study (Figure 3).

The average and maximum depth of Lake Rezaiyeh in the summer of 1976 was 5.6 m. and 11.0 m., respectively. The north part of the lake was deeper than the south and the deepest part, in the northwestern part of Shahi Island, was found to be 11.0 m. There are no outlets. The main source of water comes from melting snow. The water levels vary as much as 200 cm. each year. The highest water level occurs during the first half of July and the highest water temperature in August (Figure 4). Salt concentrations in the lake vary inversely with the water levels.

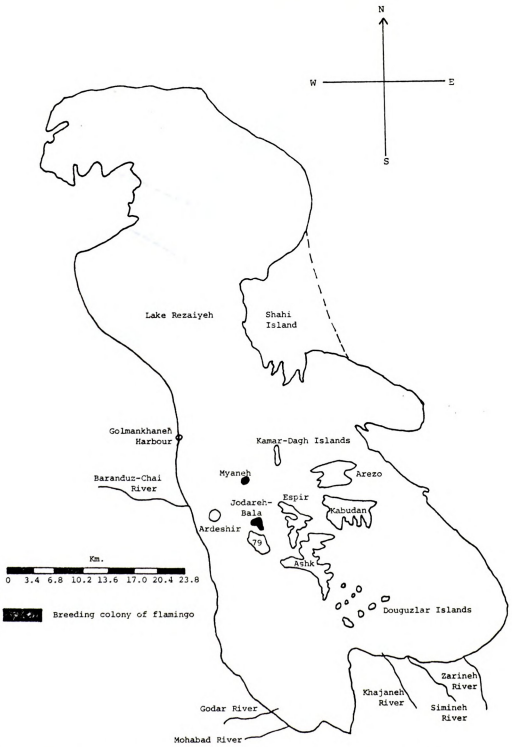

Figure 3. The study area, Jodareh-Bala Breeding Colony of the Greater Flamingo and Herring Gull in Lake Rezaiyeh National Park, Iran.

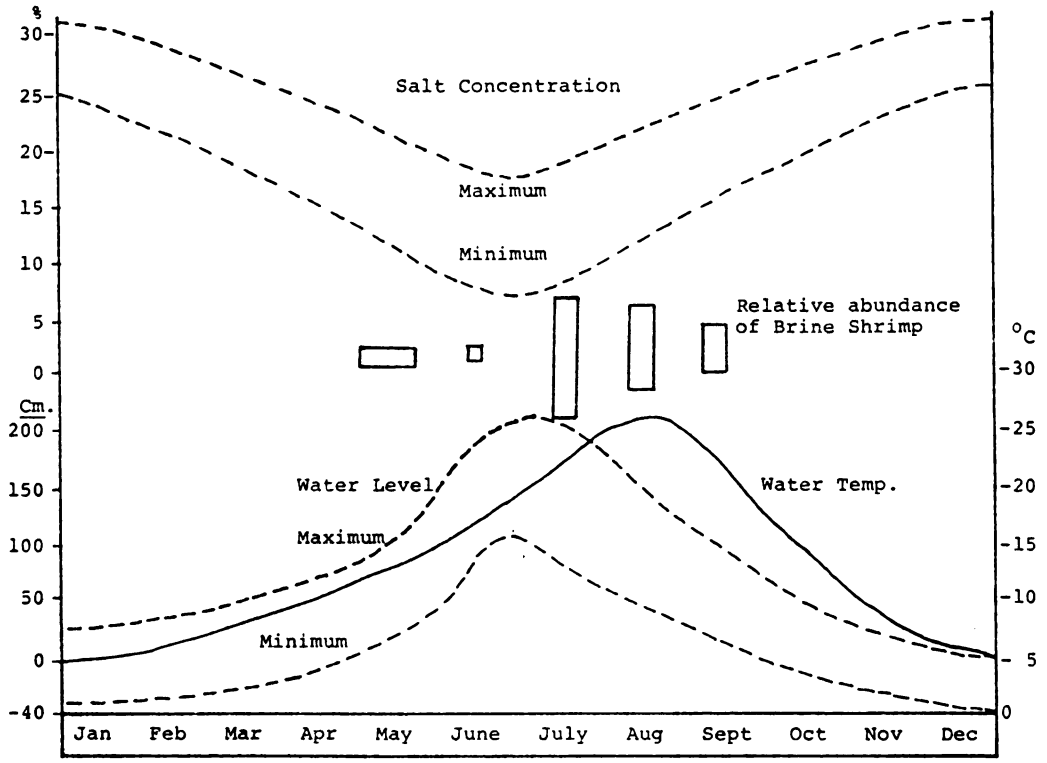

Figure 4. Relationship between the abundance of brine shrimp (Artemia salina), salt concentration, water level, and water temperature in Lake Rezaiyeh National Park, Iran. (From Plattner 1955, cited by Savage 1964)

Although no fish are present in the lake, there are large populations of brine shrimp (Artemia salina)[1] and blue green algae (Entromorpha intestinalis). Abundance of brine shrimp is correlated with the water level and salt concentration cycle (Figure 4). The blue green algae population becomes numerous in the lake before the brine shrimp become numerous, and disappears in August (Savage 1964). Plattner (1955), cited by Savage (1964), found that in those years when concentrations of salt remain around or below 20 percent, blue green algae becomes very abundant.

Brine shrimp provide abundant food for water birds who breed around Lake Rezaiyeh, including Ruddy Shelduck (Tadorna ferruginea), Shelduck (Tadorna tadorna), Greater Flamingo, Herring Gull (Larus argentatus), and Slender-billed Gull (L. genei). The White Pelican (Pelicanus onocrutalus) breeds on the Douguzlar Islands (southern part of the lake), and feeds on the fresh water rivers in the southern part of the lake. The number of Flamingos, Pelicans, Shelducks, and Herring Gulls observed at Lake Rezaiyeh National Park during 1970-1976 are summarized in Table 1.

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[1]Plattner (1955), cited by Savage (1964), reported Artemia salina, but Gunther (1899) reported Artemia urmiana. Dr. Porter, Michigan State University, agrees with Artemia salina.

TABLE 1

NUMBER OF GREATER FLAMINGOS, WHITE PELICANS, SHELDUCKS, AND HERRING GULLS OBSERVED FROM THE SUMMERS OF 1970 TO 1976 IN LAKE REZAIYEH NATIONAL PARK, IRAN (Data of 1970 through 1975 from D.E.C. and data of 1976 from this study)

	Year						
Species	1970	1971	1972	1973	1974	1975	1976
Total Flamingos (breeding, chicks, and non-breeding)	40,000	50,000	50,000	58,000	38,000	47,000	61,000
Breeding Flamingos	*	17,500	17,500	22,500	*	*	23,000
White Pelican	2,800	1,545	3,500	1,250	890	1,137	3,700
Shelduck	*	5,300	5,700	34,750	10,420	18,641	63,000
Herring Gull	*	4,100	8,200	3,300	10,361	5,542	12,000

*Data not available

CHAPTER IV

METHODS AND MATERIALS

Number of Flamingos at Lake Rezaiyeh National Park

Estimates were made of the number of breeding and non-breeding flamingos by two aerial censuses, nineteen boat censuses of the breeding and chick flamingos, and six boat censuses of non-breeding flamingos.

Aerial censuses were made on June 30th and September 12th from a single engine Super-Cub airplane. The first aerial census was conducted in the morning (11:30 A.M.-2:00 P.M.) following Route 1 (Figure 5) and in the afternoon (3:30-6:30 P.M.) following Route 2 (Figure 5) for a total route of 825 Km. A 1.2 Km strip was surveyed on each side of the aircraft. The area covered during the census was approximately 40 percent of the 5,000 Km^2 surface area of the lake. Counting was started from the Golmankhaneh Harbour along the west short and continued toward the southwest, south, and southeast part of the lake. From the southeast shore the census ran back parallel to the south shore of the lake at a distance of 18 Km. After flying about 45 Km. toward the west shore, the direction of flight was changed from west toward the Jodareh-Bala breeding colony.

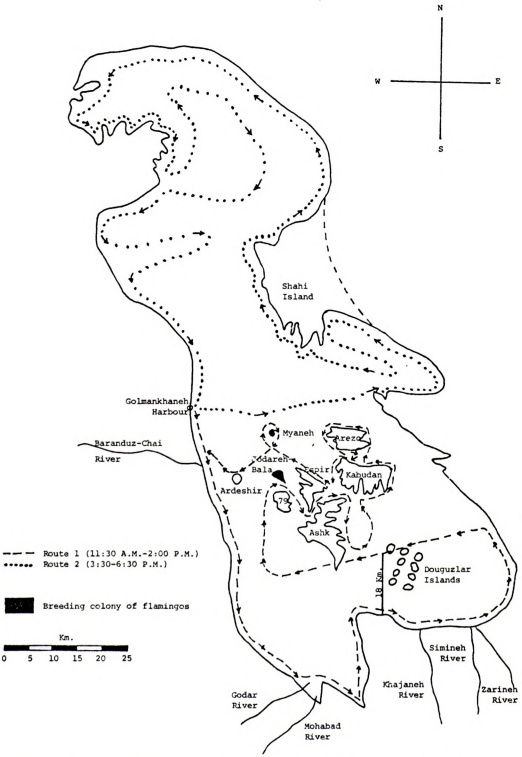

Figure 5. The aerial routes used to count the number of Greater Flamingos in Lake Rezaiyeh National Park on June 30, 1976.

Ashk, Espir, Kabudan, Arezo, and Myaneh (breeding colony) Islands (Figure 3) were surveyed by flying along the shores of those islands (Figure 5). The second aerial survey (Route 3) was conducted in the morning (10:00 A.M.-12:20 P.M.)(Figure 6) and in the afternoon (Route 4) (2:00-4:30 P.M.) (Figure 6). All flamingos were counted within the same size strips as the first aerial survey along a 725 Km. route in September. The area censused was about 35 percent of the total surface area of the lake.

When a very large group of flamingos was observed, their numbers were estimated by counting a group of 500 birds and using this group size to estimate the total number of birds within the entire group.

Twenty-five boat censuses were conducted in 24 days, from June 23rd through September 8th, (five days for counting the non-breeding and 19 days for counting the breeding and chick flamingos). On June 26th, both breeding and non-breeding flamingos were counted from the boat along two different routes (Figure 7). A 45 Km. route, 1 Km. wide (0.5 Km on each side of the boat), was used to count the number of breeding and chick flamingos located in the central part of the lake (Figure 7). Counts of non-breeding flamingos were made along a 85 Km. route with the same strip width as used for counting the breeding flamingos. Counting was done early in the morning or in the afternoon (the earliest time in the morning was 7:00 A.M. and the latest

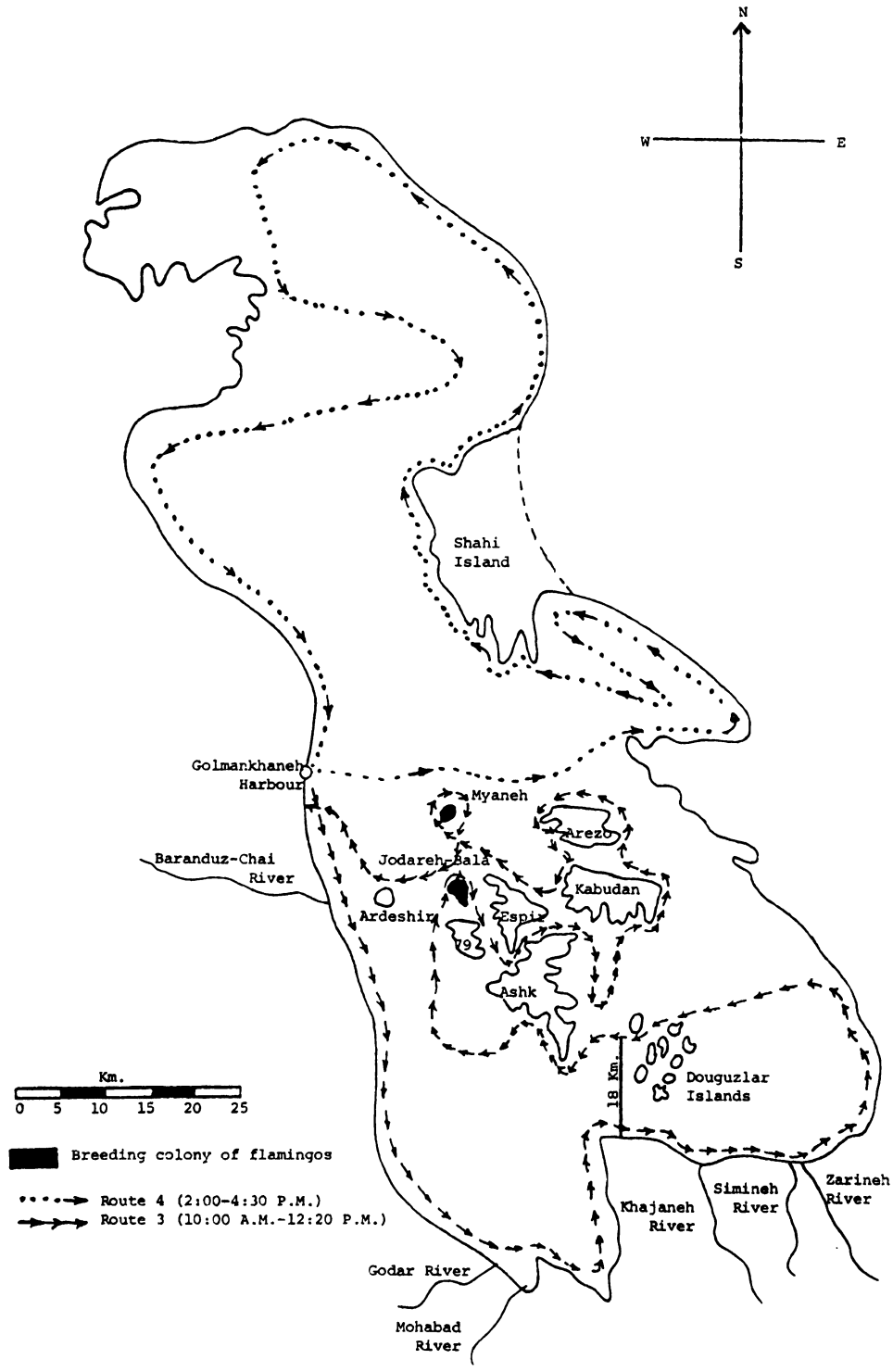

Figure 6. The aerial routes used to count the number of Greater Flamingos in Lake Rezaiyeh National Park on September 12, 1976.

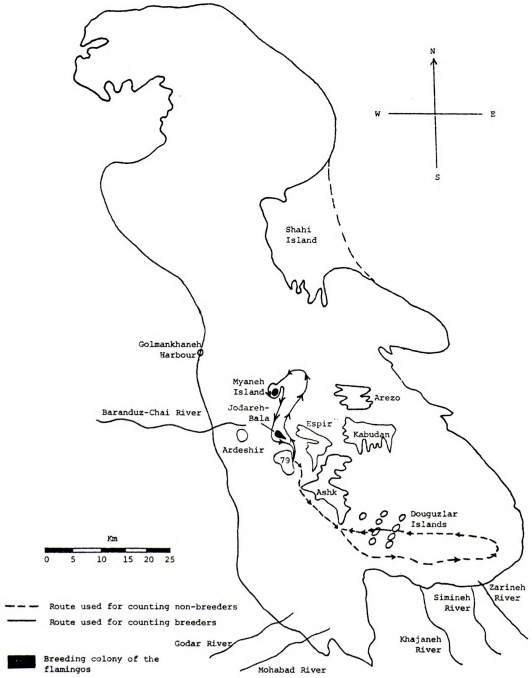

Figure 7. The boat route used to count the breeding and chick flamingos in Lake Rezaiyeh National Park, Iran

time in the afternoon was 7:30 P.M.). Between 10:00 A.M. and 3:00 P.M. the visibility was poor because of the sun, and it was difficult to see birds at distances greater than 350 m. from the boat. The best distance for observing the flamingos was approximately 500 m. from each side of the boat. Each count of the breeders and chicks along the route was made in an average of three hours. Counts of the number of non-breeders was conducted in an average of six hours.

Nest initiation data for 1976 were reported by Abdulah Gahremani from the Environmental Conservation Office in West Azarbaijan Province. I collected the incubation and hatching data during June and July of 1976. One thousand three hundred nests were studied during the incubation period and 1,650 nests during the hatching.

The time and approximate rate of nest relief were determined by counting the number of incoming flamingos that flew toward the breeding colony, landed on the water, then swam to the island and finally walked up to their nests.

Fifty-four nests located in an isolated portion of the southeastern part of Jodareh-Bala Breeding Island were chosen for detailed study. These data were obtained over 19 days with a 2 hour per day period of observation from a blind. The eggs were not marked, because I did not want to disturb the breeding colony. The clutch size was one and the egg was on bare ground. This situation made it easy to

determine the individual fate from the blind on the breeding island. Eggs laid in nests were not included in this study because they were not observable from the blind, and I did not wish to continuously disturb the breeding colony by close observation.

The total sizes of the nesting areas of the colonies were measured after adults and chicks had left the islands. At this time, 38 abandoned eggs were measured with a vernier caliper, and materials from seven nests were collected and identified.

Observations of feeding of chicks by adults were made from a blind with a binocular and also on Island No. 79 (Figure 3) with a spotting scope. The feeding frequency of the chicks fed by the adults was measured by direct observation (67 chicks during the first week, 35 chicks during the second week, and 19 chicks during the third week after hatching). These observations were conducted two days a week, starting July 10th and continuing through August 14th, with a total of 1.5 hours per day of observation.

Percentages of young flamingos on the breeding island, and/or on the water, were measured during the summer by looking at the young through the spotting scope and counting them on the island and/or on the water. These observations started on July 8th and continued through September 12th. Some of these observations (from July 10th through August 14th) were made at the same time as the observations on

feeding of chicks by adults. A total of 15 days, with an average of 1.5 hours per day, was spent during this process.

For determining growth rate of the chicks, the body weight and lengths of the bill, wing, and tarsus of 300 chicks were measured at two-week intervals. The first measurement was made when the chicks were around 20 days old. The second, third, and fourth measurements were made at two-week intervals until the chicks were about 62 days old. The length of the bill was measured from the base of the feathers to the tip of the bill (culmen). The length of the wing was measured from the wrist to the tip of the longest primary feather. The length of the metatarsus was measured from the heel to the end of the metatarsus (joint with toes). Measurement of the growth of the chicks began on July 29th and continued until September 5th.

The food contents in the esophagus and gizzard of five adult flamingos were collected in both July and September 1976. The 10 samples were measured volumetrically and identified. The volume of the food contents present in the esophagus and gizzard was measured by using a graduated cylinder. One stomach sample from a flamingo chick was taken on August 16th. The food content of the chick sample was analyzed.

The period of molt was studied by capturing 189 flamingos associated with the breeding colonies and 108 flamingos not associated with the breeding colonies at the

beginning of the molt. Each bird was marked with a black plastic neck band and metal leg band. Marked birds were recaptured over a six-week period (late July through early September) and growth of the wing feathers was measured. Since few marked birds were recaptured (9 breeding birds and 5 birds not associated with the breeding colonies), the growth of the wing feathers of 70 arbitrarily chosen unmarked birds was measured at weekly intervals during the molting period to find an average growth rate. Observations of molting birds began on July 23th and continued through September 14th. A total of 19 days, with an average of 2.5 hours per day, was spent on these observations.

Approximate age of first breeding was estimated by capturing previously banded flamingos that were not associated with the breeding colonies (non-breeders). The age of non-breeding flamingos was contrasted with the age of birds captured from the breeding segment of the population.

To obtain information about parasites, five flamingos (the same flamingos which were used to study food preferences) were shot during September. Cestode specimens were collected from the intestines and identified by Bruce A. Lindement, parasitology specialist, Department of Microbiology and Public Health, Michigan State University. Even though some of the specimens were stained, the thickness

of the worm did not lend itself to location of internal structures. However, external characters and ova structure were sufficient to identify the parasite to family. Identification was based on characters used by Wardle et al. (1952).

Water depth was measured at Lake Rezaiyeh during the summer, and at the same time and place brine shrimp and water samples were taken. Those samples were taken to find out if there is any relationship between salinity of the water and number of brine shrimp. Using the 200^{cc} Zemitt samples made it possible to take samples from different depths in the water. To take a sample, first the cover in the upper part of the sampler was kept open by using two springs, then the sampler with the open cover was sent to the selective depth. It was possible to close the top of the sampler by sending a weight along the string to the top of the sampler which closes the cover. The number of brine shrimp in each sample were counted and recorded.

Thirteen soil samples from the bottom of the lake were taken with a boat anchor. Concentrations of anions and cations of the water were measured by taking 254 water samples from different parts of the lake with a 100^{cc} plastic bottle. Water and soil samples were analyzed by the Water Pollution Control Unit, D.E.C.

Percent weight of salt in the water was measured by taking 60, 300^{cc}, samples of water and comparing the dry weight of the salts with total weight of the salts dissolved in the water. The amount of salt in each sample was measured by weighing the sample and the container, removing the water by evaporation on a $400^{o}C$ stove, and then subtracting the weight of the salt from the weight of the original and of the sample plus container.

CHAPTER V

RESULTS AND DISCUSSION

Number, Distribution, and Movement of the Greater Flamingos in Lake Rezaiyeh National Park

My study of the breeding biology of the Greater Flamingo at Lake Rezaiyeh during June through September 1976 showed that breeding and non-breeding segments of the population occupied separate parts of the lake (Figure 8). Results of 14 returns of 189 banded breeding birds and 108 non-breeding birds during the molting period (July 10th to September 1st) indicate that the segments of the population are isolated from one another.

The breeding segment nested on two islands (Jodareh-Bala and Myaneh) in the center of the lake (Figure 3). The non-breeding segment was located along the south shore of the lake more or less associated with the mouths of the five rivers which form the main fresh-water source of the lake (Figure 9).

Results of aerial censuses showed about 23,000 breeding and 30,000 non-breeding flamingos were present. The number of breeding and non-breeding flamingos remained approximately the same in the June and September censuses (Table 2). The Jodareh-Bala Breeding Colony consisted of 14,000 breeding adults and the Myaneh Breeding Colony consisted of 8,500 breeding adults.

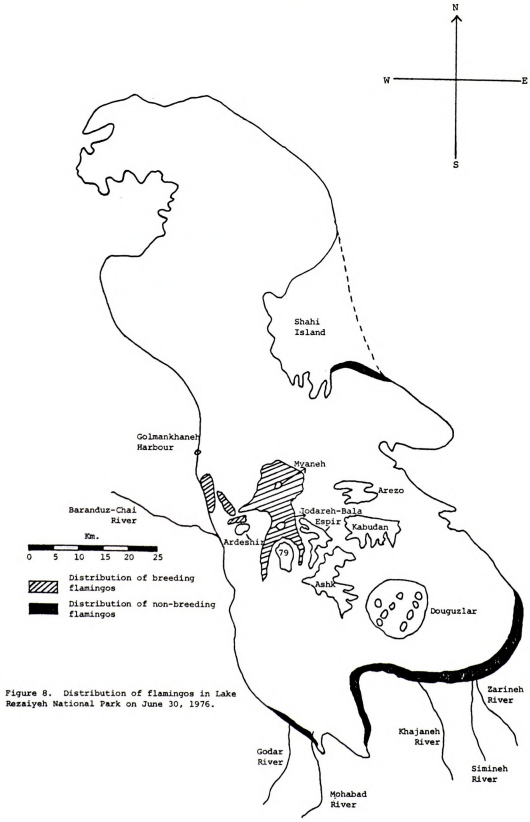

Figure 8. Distribution of flamingos in Lake Rezaiyeh National Park on June 30, 1976.

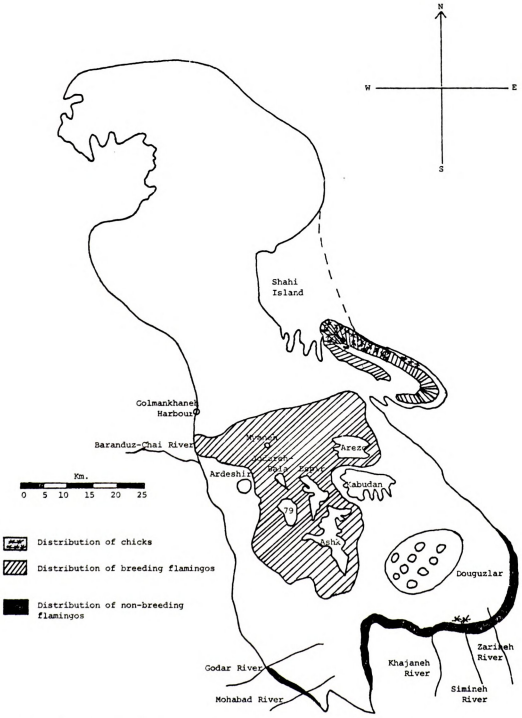

Figure 9. Distribution of flamingos in Lake Rezaiyeh National Park, Iran, on September 12, 1976.

TABLE 2

NUMBER OF BREEDING FLAMINGOS, FLAMINGOS NOT ASSOCIATED WITH THE BREEDING COLONIES, AND NUMBER OF CHICKS IN TWO AERIAL CENSUSES IN LAKE REZAIYEH NATIONAL PARK, IRAN

	Number of Flamingos			
Date	Breeding	Non-Breeding	Number of Chicks	Total
June 30	22,500	30,000	-	52,000
Sept. 12	23,000	29,000	9,000	61,000

Nine thousand chicks were observed on September 12th. Seven hundred and fifty chicks were located at the southern end of the lake and the rest of them in the southeast part of Shahi Island (Figure 9).

Since the census flights did not cover the entire surface area of the lake, these data cannot be regarded as absolute counts of the population. However, from observations along the entire north shore of the lake (Figure 5), during which no flamingos were observed, it is likely that the area which was censused was the area with the highest concentrations of flamingos at Lake Rezaiyeh, and that the reported figures included most of the birds found on the lake.

Breeding flamingos were concentrated around the two breeding islands (Table 3) (Figure 10, A & B). There was no significant difference in the number of breeding birds in the water surrounding the breeding islands during the incubation and hatching periods (Table 4). The number of breeding flamingos observed along the boat route decreased significantly during fledgling period. The decrease in number was due to the chicks entering the water at the end of July and moving to the north central part of the lake during August. The adult breeding flamingos dispersed throughout the entire central part of the lake (Figure 10, C & D), returning daily to feed the chicks in the creches.

TABLE 3

RESULTS OF 19 BOAT CENSUSES OF BREEDING FLAMINGOS AND CHICKS IN LAKE REZAIYEH NATIONAL PARK, IRAN

Date	Number of Breeding Flamingos	Number of Chicks	Total Number of Breeding Flamingos and Chicks
June 23	9,000	-	9,000
June 26	5,400	-	5,400
July 1	6,000	-	6,000
July 5	5,700	-	5,700
July 8	4,000	140	4,140
July 11	7,000	430	7,430
July 14	5,500	750	6,250
July 19	9,000	700	9,700
July 21	7,500	1,200	8,700
July 24	6,500	1,800	8,300
July 27	7,000	2,800	9,800
Aug. 4	6,000	3,500	9,500
Aug. 7	4,500	4,500	9,000
Aug. 11	4,600	6,300	10,900
Aug. 14	5,000	3,800	8,800
Aug. 20	3,500	3,200	6,700
Aug. 29	3,000	4,000	7,000
Sep. 5	4,000	2,800	6,800
Sep. 8	2,500	2,500	5,000

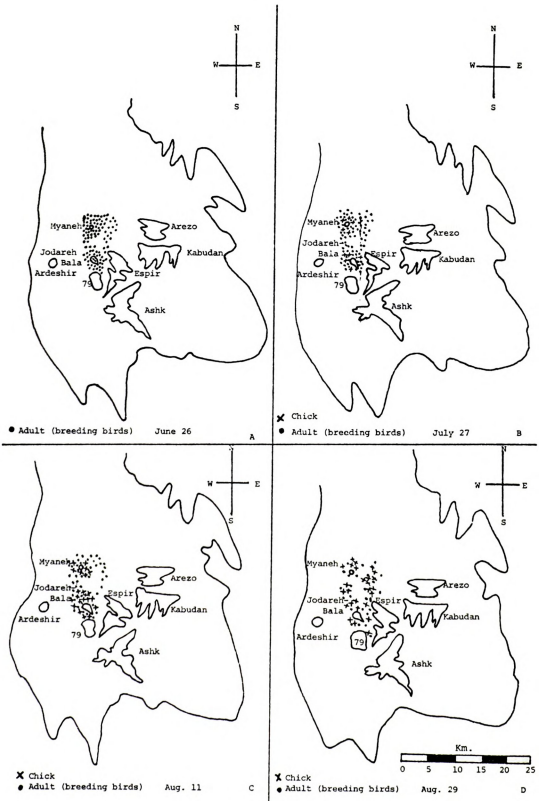

Figure 10. Distribution of breeding ard chick flamingos observed along a 35 Km. route in Lake Rezaiyeh National Park during the summer of 1576.

TABLE 4

COMPARISON OF MEAN NUMBERS OF BREEDING FLAMINGOS DURING INCUBATION, HATCHING, AND FLEDGLING PERIODS BASED UPON 19 BOAT CENSUSES IN LAKE REZAIYEH NATIONAL PARK, IRAN

Date	No. Censuses	95% Confidence Interval on Mean	
June 23-July 5 (incubation)	4	6525 ± 265	N.S = T = 0.116
July 8-July 27 (hatching)	7	6642 ± 1455	S = T = 2.963
Aug. 4-Sept. 8 (fledgling)	8	4137 ± 945	

Observations from a vantage point on Island 79 during July through early September provided information on the movement of chicks prior to the formation of creches at the south part of Shahi Island and in the south part of the lake at the end of August (Table 5). Chicks began swimming at 16 days of age, and returned to the island at night. At 21 days, the juvenile flamingos came together to form creches ranging from 100 to 3,000 individual birds. Each creche was accompanied by from 2 to 27 adults depending on the number of chicks. The creches were found in the water immediately around the breeding islands during late July and August. In September the chicks congregated in two creches, a large one composed of 8,250 young which was located in the southeast part of Shahi Island (Figure 9) and a small creche with 750 young which was located near the mouth of the Simineh River (southern part of the lake) (Figure 9).

Results of six boat censuses of the non-breeding flamingos are reported in Table 6. Since these numbers were obviously low due to poor conditions for observation (compared with the results of aerial censuses) and since they fluctuated greatly, no conclusion can be formed about the movement patterns of the non-breeding birds other than that throughout the entire June through September period they remained closely associated with the estuaries of the rivers entering the south part of the lake (Figures 8 and 9).

TABLE 5

PERCENTAGE OF YOUNG FLAMINGOS OBSERVED ON BREEDING ISLAND AND/OR IN THE WATER DURING THE FIRST AND SECOND MONTH, AFTER HATCHING IN LAKE REZAIYEH NATIONAL PARK, IRAN

Date	Percent of Young Observed on Land	Percent of Young Observed on the Water
July 8	100	0
July 10	100	0
July 14	100	0
July 19	100	0
July 21	100	0
July 23	89	11
July 30	78	22
Aug. 8	67	33
Aug. 13	31	69
Aug. 18	2	98
Aug. 23	1	99
Aug. 29	>1	100
Sep. 5	3	97
Sep. 9	1	99
Sep. 12*	0	100

*Aerial census

TABLE 6

RESULTS OF SIX BOAT CENSUSES OF NON-BREEDING FLAMINGOS IN LAKE REZAIYEH NATIONAL PARK, IRAN

Date	Number of Non-Breeding Flamingos
June 29	5,700
July 6	9,000
July 15	4,500
July 26	7,000
Aug. 17	2,500
Sept. 2	4,000

Nest Chronology

Since I did not arrive on the study area until June 20th, data on the beginning of nest initiation and incubation were obtained from Abdulah Gahremani of the Environmental Conservation Office in Rezaiyeh. Nests were initiated approximately between May 28th and July 2, 1976. The dates females began incubating ranged from June 3rd to July 17th, with 68 percent beginning between June 11th and July 1st. Chicks began hatching from July 8th to 31st, with 78 percent between July 10th and 20th (Figure 11).

Breeding Colony Observations

Nesting

The breeding sites on Lake Rezaiyeh National Park were a series of sandy and stony islands rising from 1 to 5.5 m. above the surface of the lake.

Jodareh-Bala and Myaneh Islands were the only nesting sites at Lake Rezaiyeh National Park in 1976. Jodareh-Bala Island was about 60,000 m^2, but only 6,000 m^2 of the south and southeast part of this island was occupied by the breeding flamingos. This portion of the Jodareh-Bala Island is bare of vegetation (Figure 12). Myaneh Breeding Island is about 2,000 m^2 and is located northwest of Espir Island, between Kabudan and Golmankhaneh Harbour (Figure 13). Myaneh Island is completely bare of vegetation and is entirely occupied by breeding flamingos.

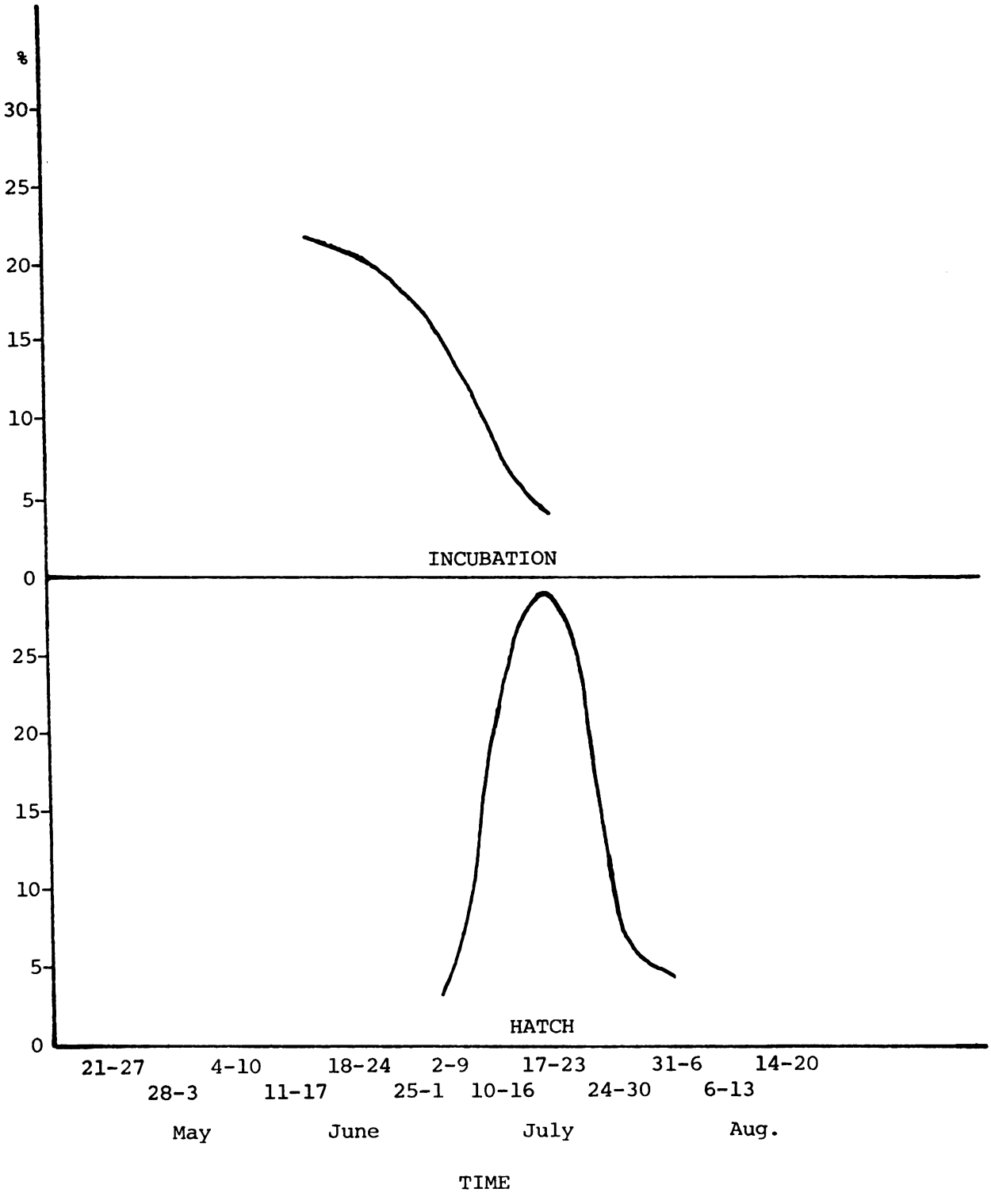

Figure 11. The chronology of nesting activity (incubation and hatching) of the Greater Flamingos in Lake Rezaiyeh National Park, Iran.

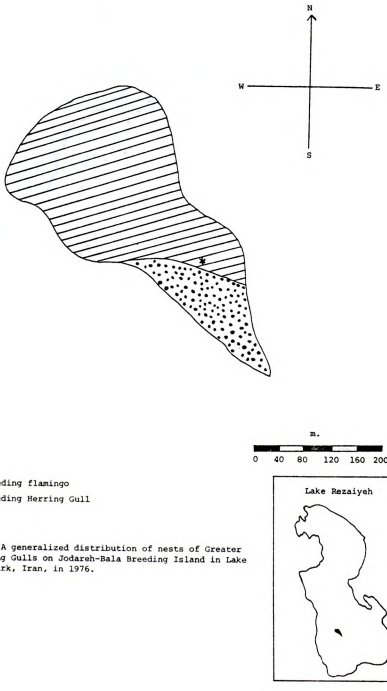

Figure 12. A generalized distribution of nests of Greater Flamingos and Herring Gulls on Jodareh-Bala Breeding Island in Lake Rezaiyeh National Park, Iran, in 1976.

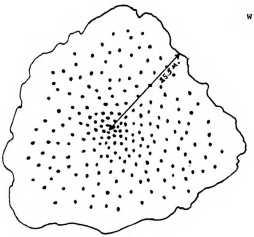

Figure 13. A generalized distribution of nests of the Greater Flamingos on *Myaneh* Breeding Island in Lake Rezaiyeh National Park, Iran, in 1976.

According to the observations of the DEC, the flamingos have nested on a total of six islands at various times since 1970. These islands have similar topography in that all are relatively low, with gentle slopes leading to the water. Based on observations beginning in 1970, Myaneh Island supported breeding birds from 1973 through 1976. The southwest part of Kabudan Island was used by breeding flamingos from 1970 to 1972, the northeast part of Ashk Island from 1974 to 1975, and the Jodareh-Bala Island during the summer of 1976.

One factor which appears to have caused the shift in breeding colony sites is development of herbaceous vegetation on sites which were previously bare mineral soil. Myaneh Island, which had been used by the breeding flamingos for four years continuously, was bare of vegetation originally and has remained so. All the other islands went from a bare mineral soil condition to a vegetated condition with the exception of Douguzlar Island where competition with White Pelicans appears to inhibit flamingo nesting. Perhaps the development of vegetation is a response to the accumulation of nutrients from the flamingos' guano.

The results of this study show that 99 percent of the breeding pairs of flamingos nest on bare rocks , with 1 percent building a low nest made of feathers, feces, small stones, and grasses. This has also been observed by Brown

(1958), in Africa, but is contrary to other flamingo studies (Allen 1956, Dampier 1967, McCann 1939, Maynard 1888, and Seehehm 1882) in which flamingos built their nests with mud. In my study, mud nests could not be made because the islands were rocky and the waters around the breeding islands were too deep to allow construction of nest mounds as occurs in most areas where flamingos nest.

Nests were distributed more or less randomly on Jodareh-Bala Island, but showed a definite clumping at the center of Myaneh Island (Figures 12 and 13). The apparent reason for the latter effect was the irregular topography around the rocky margin of Myaneh Island which presumably prevented a secure nesting site. The southeast shore of Jodareh-Bala Island was smooth and sandy, and seemed to be suitable nesting habitat to within about one and a half meters from the water.

Observation of 2,000 nests on June 25th showed a clutch size of one. This agrees with most other studies (Allen 1956, Broekhuysen 1975, Brown 1958, and Salim Ali 1945), but differs from Chapman (1884) and Gallet (1954), who reported that two eggs are sometimes laid.

A total of 38 eggs from two breeding colonies were measured after the breeding flamingos and the chicks left the islands. Egg length ($\bar{X} \pm SD$) was 88 ± 5.05 mm. and width was 52 ± 3.31 mm. This is close to measurements reported by Allen (1956), Brown (1958), McCann (1939, 1947), Macleod (1962), and Uys and Martin (1961).

The incubation period was from June 3rd to July 17th, with 68 percent of the birds beginning incubation between June 11th and July 1st. The average incubation period based on observations of 54 individual eggs was 29 to 30 days. This is within the range of 29 to 31 days reported earlier (Brown 1958, Chapman 1905, 1908, Drable 1936, and Yeates 1950). Both sexes were found to incubate the egg. The egg was touched and occasionally moved by the parent's bill and it was also moved into contact with the brood patch immediately after the birds settled on the nest.

Throughout the day, flamingos flew to the breeding colony to relieve their mate that was incubating the egg. They landed on the water about 10-50 m. from the breeding island, swam to the island, and then walked to their nests. When this happened the incubating bird left the nest, walked toward the water, and after staying between 5-20 minutes in the water, flew away toward the Baranduz-Chai River, located in the west part of the lake. According to observations made from 4:00 A.M. to 9:00 P.M. on June 20, 1976, on Jodareh-Bala Island, the rate of nest relief peaked at 1,740 changes per hour between 4:00-5:00 A.M. and 1,200 changes per hour between 5:00-6:00 P.M., with the lowest rate of 60 changes per hour between 1:00-2:00 P.M. and between 8:00-9:00 P.M. (Table 7). This follows most other studies (Allen 1956, Studer-Thiersch 1975, Gallet 1950,

TABLE 7

TIME AND APPROXIMATE RATE OF NEST RELIEF OF FLAMINGOS ASSOCIATED WITH THE JODAREH-BALA BREEDING COLONY IN LAKE REZAIYEH NATIONAL PARK, FROM 4:00 A.M. TO 9:00 P.M. ON JUNE 20, 1976

Time	Number of Changes Observed During Time Period
4-5 A.M.	1,740
5-6 A.M.	1,140
6-7 A.M.	660
7-8 A.M.	480
8-9 A.M.	360
9-10 A.M.	240
10-11 A.M.	240
11-12 A.M.	180
12-1 P.M.	120
1-2 P.M.	60
2-3 P.M.	80
3-4 P.M.	360
4-5 P.M.	540
5-6 P.M.	1,200
6-7 P.M.	600
7-8 P.M.	300
8-9 P.M.	60

and Uys and Martin 1961) except for Brown (1958), who reported that nest relief may take place once a day at night if the feeding grounds are distant.

The chicks were observed to eat their egg shells during the first and second days after hatching as reported earlier by Brown (1958), Chapman (1905), and Gallet (1950).

The main constituent of one stomach sample from a flamingo chick was partially-digested brine shrimp. Gallet (1950) described it as a "simple viscid mucus". Yeates(1950) describes it as a "white liquid" which may be produced by some form of regurgitation.

The individual fate of 54 nests located in a readily visible portion of the Jodareh-Bala Breeding Colony was determined (Table 8). This portion of the breeding island was easily defined by being abruptly about 15 cm. lower in elevation. It is believed that these 54 nests were representative of the whole colony. Nearly 89 percent of the eggs hatched and the number of fledglings was 81 percent of all eggs laid.

Herring Gulls were the only predators observed at the flamingo breeding colonies. The breeding colonies of the Herring Gulls were located on Jodareh-Bala, Ardeshir, Kamar-Dagh, and Douguzlar Islands (Figure 3). Eleven percent of the eggs and six percent of the recently hatched chicks were taken by Herring Gulls. This accounted for 90 percent of all mortality, with the other 10 percent due to unknown natural causes.

TABLE 8

FLEDGLING SUCCESS OF THE GREATER FLAMINGO IN JODAREH-BALA BREEDING COLONY IN LAKE REZAIYEH NATIONAL PARK, IRAN, 1976

Fate	Number	Percent
Number of eggs	54	100
Predation of eggs by H. Gulls	6	11
Number of eggs hatched	48	89
Number of young killed by H. Gull	3	6
Young lost by other natural causes	1	2
Fledgling success (chicks left the breeding island)	44	81

Fledgling success was high compared with breeding records from other areas. Brown (1958), reporting from Africa, found the breeding success (young reared to egg laid) of the Greater Flamingo averaged 10 percent per annum over a 21-year period. Taking East Africa as a whole, the breeding success of the Greater Flamingos might be about 35 percent of eggs laid and 14 percent overall without the catastrophic predation of the Marabou Stork.

The high fledgling success at Lake Rezaiyeh was due to the fact that the Greater Flamingo was largely protected in this area, both from disturbance by man and predation by mammalian predators.

Two stomach samples from freshly dead Herring Gulls showed that brine shrimp formed the main food item of their diet. This supports the idea that the gulls are not dependent on the flamingo eggs and chicks for their food. Certainly the Herring Gulls at Lake Rezaiyeh do not have the same disasterous effect as predation of Marabou Storks on the population of flamingos in East Africa, whose primary food source was flamingo eggs and chicks (Brown 1958).

Feeding of Chicks by the Adults

An adult flamingo fed the chick by standing behind it and reaching over and putting the tip of its upper mandible on the tip of the chick's lower mandible. Apparently, adults feed the chicks by regurgitation.

When flamingo chicks were approximately one week old, they were fed between three and four times a day with each feeding period ranging from one to six minutes (Table 9). As the chicks became older, the frequency of feeding decreased to once or twice a day. However, the feeding intervals lengthened to 12-18 minutes. Adults fed the young most frequently early in the morning and in the afternoon (Figure 14).

Growth of Chicks

The newly hatched chick was covered with down and had a straight beak. When the chick was about 17 days old, the upper jaw began to curve downward, and by four to five weeks of age there was a definite curvature in the shape of the bill. This was in contrast with Allen (1956), who found that the upper jaw began to curve at 11 days of age.

Flamingo chicks increased in weight from 453 $\pm$ 187 g. at twenty days of age to 2,920 $\pm$ 862 g. at 62 days (Table 10). The bill grew faster in the first four weeks after hatching than in the second four weeks. The rate of growth of the wings was low in the first four weeks after hatching, and the maximum rate of wing growth occurred between six and eight weeks of age. Rate of growth of tarsus was higher between four to six weeks than during the two to four-week period after hatching. Based upon the observation of 49 banded young, the fledgling period was estimated to be about 80 days.

TABLE 9

LENGTH OF THE FEEDING PERIOD OF JUVENILE FLAMINGOS AGES ONE, TWO, AND THREE WEEKS OLD, FED BY ADULTS IN LAKE REZAIYEH NATIONAL PARK, IRAN

Length of Feeding Period Min.	One Week		Two Weeks		Three Weeks	
	Number	Percent	Number	Percent	Number	Percent
1	8	12				
2	9	13				
3	13	20				
4	14	21				
5	11	16				
6	12	18				
7			7	20		
8			8	23		
9			5	14		
10			6	17		
11			5	14		
12			4	12		
13					5	26
14					6	32
15					2	11
16					3	16
17					2	10
18					1	5
Total	67	100	35	100	19	100

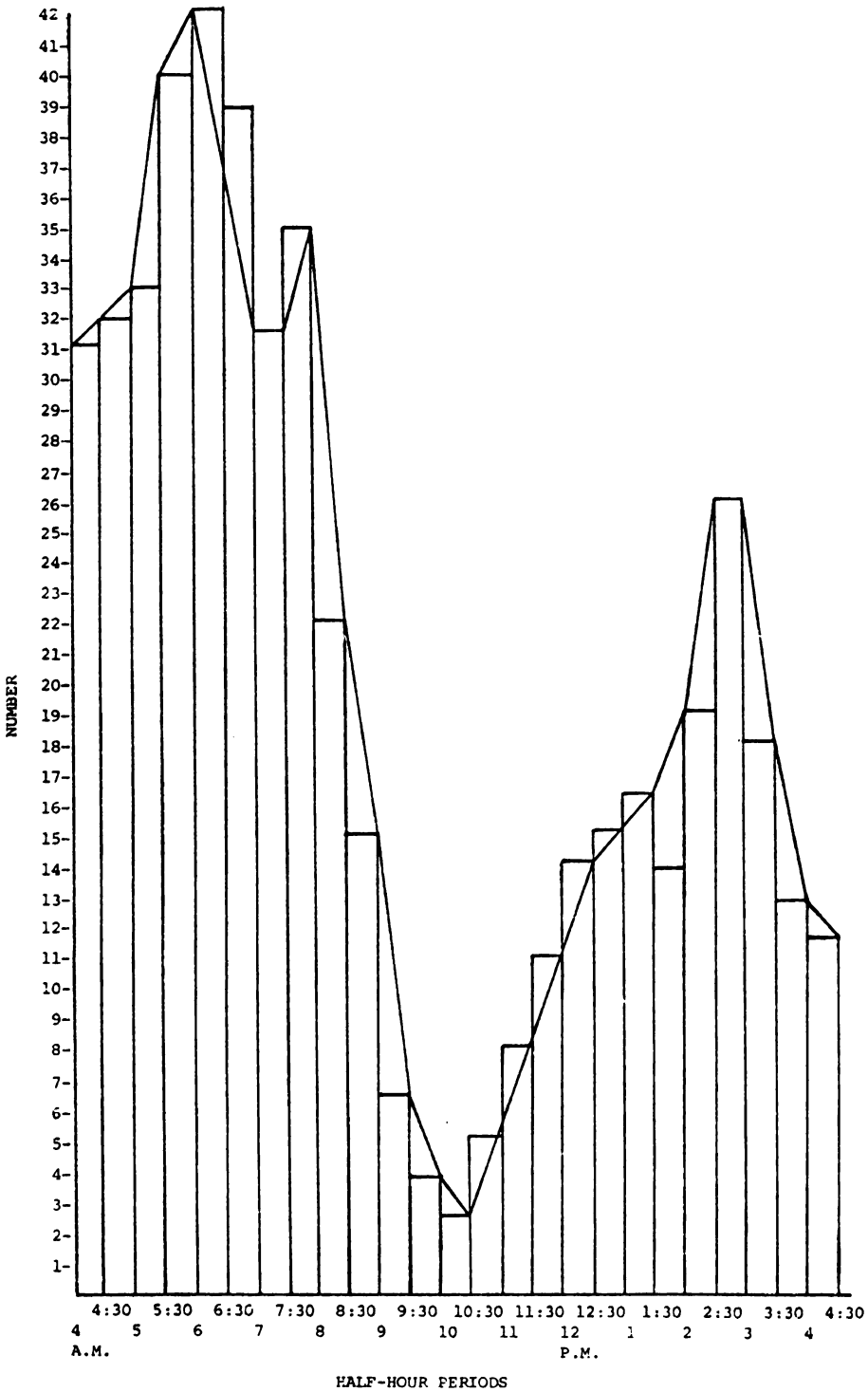

Figure 14. Number of flamingo chicks fed by adults during half-hour intervals in Lake Rezaiyeh National Park on July 11, 1976.

TABLE 10

GROWTH OF JUVENILE FLAMINGOS EXPRESSED BY WEEKLY MEASUREMENTS ($\bar{X} \pm SD$) OF THE BODY WEIGHT, AND LENGTH OF BILL, WING, AND TARSUS OF 70 BIRDS RANGING FROM 14 TO 62 DAYS OF AGE, IN LAKE REZAIYEH NATIONAL PARK, IRAN

Approximate Age (Day)	Number of Birds Measured	Weight g.	Bill mm.	Wing mm.	Tarsus mm.
14-20	70	453 ± 187	49 ± 10	9 ± 3	92 ± 18
20-34	70	1519 ± 787	75 ± 26	45 ± 21	140 ± 49
34-48	70	2634 ± 745	84 ± 18	148 ± 61	197 ± 31
48-62	70	2920 ± 862	102 ± 21	358 ± 92	250 ± 39

Food Preference, Distribution of Food, and Feeding Behavior

The food habits of five adult flamingos collected during July, and five adults in September 1976, were analyzed by examination of esophagus and gizzard contents.

Ninety-three percent of the food by volume in the gizzard and esophagus (both breeders and flamingos that were not associated with the breeding colonies) was brine shrimp and brine shrimp eggs. Less than 0.5 percent of the food in the samples was Calonoida and Cyclopoida (order Copepoda). About 1.5 percent of the diet was blue green algae. Grit and mud constituted an average 4.5 percent of the gizzard contents. The percent animal matter in esophagus and gizzard samples decreased from 93.3 and 94.1 percent, respectively, in July to 91.0 and 89.4 percent in September (Table 11). According to Issakov (1948), the winter food of the Greater Flamingo in Lake Tangiz (U.S.S.R.) consisted mainly of crustaceae and small mollusks. Brine shrimp and its eggs was the main food of the flamingos at the Kara-Bogos Bay (U.S.S.R.) and at Urmi Lake (old name for Lake Rezaiyeh National Park) in northern Iran in the past (Issakov 1948). Brown (1958) reported that although the Greater Flamingos in East Africa fed on Copepodes and Chironomid larva, they were not exclusively dependent on animal matter for food, but also obtained blue green algae from the water.

TABLE 11

A COMPARISON OF THE PERCENT BY VOLUME OF ANIMAL MATERIAL FOUND IN THE ESOPHAGUS AND GIZZARD OF THE GREATER FLAMINGO COLLECTED IN JULY AND SEPTEMBER IN LAKE REZAIYEH NATIONAL PARK, IRAN

		Esophagus		Gizzard	
Month	Number of Samples	Mean Volume ml	Mean Percent Animal Material*	Mean Volume ml	Mean Percent Animal Material
July	5	10	93.5	33	94.1
September	5	8	91.0	30	89.4

*About 93% brine shrimp, and less than 1% Calonoida and Cyclopoida

Based on 252 samples of brine shrimp taken throughout the lake, the density of brine shrimp was found to be greater in the southern part of the lake than in the north (average 180 and 35 brine shrimp per liter of water, respectively).

Water samples taken along with the brine shrimp samples showed that the amount of $C\bar{l}$(meg/l) in the southern part of the lake was less than that in the north (Appendix 3). The total average weight of salts in 300 g. water samples was also less in the southern part of the lake than in the north (48 g. compared to 60 g.). The results of soil analyses show the higher pH in the north part of the lake than in the south (Appendix 4). All of the fresh-water sources in the lake were located in the south, southeast, and southwest, which accounts for the lower concentration of salt.

There was a significant inverse relationship between the number of brine shrimp and salinity of the water in the above samples ($t = 5.3$ with 30 d.f. $r = -0.69$). Plattner (1955), cited by Savage (1964), found that brine shrimp in the laboratory did not hatch at salt concentrations higher than 11 percent. He, therefore, concluded that hatching must occur mainly near the mouth of rivers where salt concentrations are lower. Since the salt concentrations observed from my samples were 16 percent by weight in the south part of the lake, I concluded that the shrimp were

reproducing in the mouth of the rivers, though I took no water samples at those points.

During this study, breeding flamingos were observed feeding upside down near the breeding islands in an average depth of 5.5 m. and also feeding in the mud of the shallow part of the lake near Baranduz-Chai River (west part of the lake) (Figure 3) during June and July. Non-breeding flamingos were observed feeding on the bottom of the south and southeast shore of the lake during the whole summer. This feeding behavior is similar to that described by Allexander (1829), Brown (1958, 1966, 1971, 1975), Buffon (1950), Issakov (1948), Madon (1932), Percy (1955), and Salim Ali (1945). All of them believe that the Greater Flamingo normally wades in shallow water, and Brown (1975) reported that the Greater Flamingos usually wade in water up to 70-80 cm. deep and sometimes swim and upend to get the food from the bottom in up to 120-130 cm. of water.

Parasites

The cestode was found to be of the Anoplocephalidae family. Specimens exhibited characters of the family Anoplocephalidae as listed by Wardle and McLeod, p. 347:

1. medium to large forms
2. well-segmented body
3. eggs commonly with a characteristic embryonic membrane drawn into a pair of cross-tapered processes.
4. adults parasitic in . . . birds.

Identification of specimens to genus was difficult because of non-visibility of internal structure. However it is speculated that these specimens belong to the genus Paronia Diamare, 1900, based on the description in Wardle and McLeod, p. 365. The literature cited in Wardle and McLeod describing the genus Paronia was not readily available at the Michigan State University Library.

Genus: Paronia Diamare, 1900

1. medium sized forms
2. double genitalia per segment
3. pyriform apparatus of egg rudimentary or lacking
4. adults in birds

Molting

Greater Flamingos molt at Lake Rezaiyeh National Park. The primary and secondary wing feathers are shed simultaneously, and the birds are flightless. The birds that were not associated with the breeding colonies started to molt in the first week of July. This was about three weeks earlier than the breeding birds. The breeding birds began to molt at the end of July, after the juveniles left the breeding islands and formed into creches. The mean flightless period of birds that were not associated with the breeding colonies and of breeding birds was 35 and 36 days, respectively.

Brown (1958) believes that molting may occur before, during, or after breeding, or outside the breeding season altogether.

Age of First Breeding

There was no information about the age of first breeding of the Greater Flamingo in the wild, before this study. Duplaix and Kear (1975) reported that in captivity both sexes probably mature at three years of age. Many people from the zoos (Duplaix et al. 1975) report that newly acquired flocks of adults take three years to start displaying and building nests, and typically six years before any eggs are hatched.

The age of sexual maturity of the Greater Flamingo at Lake Rezaiyeh National Park was estimated by capturing five banded flamingos that were not associated with the breeding colonies and comparing their age to five banded birds captured from the breeding segment of the population. The oldest flamingo not associated with the breeding colonies was four years and the rest of them were between one and three years old. The banded birds captured near the breeding colonies had been banded as adults, during the molting period of 1971 at Lake Rezaiyeh National Park and they were at least five years old. I suggest the age of first breeding at Lake Rezaiyeh is 4 or 5 years of age.

Migration

Many reports on the migration of flamingos in the south Caspian region have been summarized by Schuz (1959) and by Ferguson (1972), cited by Scott (1975), and large numbers have accumulated since then (Scott 1975, Argyle 1975). These data will be summarized here.

The flamingo ringing program at Lake Rezaiyeh was started in the breeding season of 1970 when 2,250 flamingo pulli were neck-banded with blue colors, and 242 adults were ringed with conventional monel leg rings (Argyle 1975). By the end of 1974, a total of 5,686 flamingos had been ringed. According to Argyle (1975), banding recoveries range from Libya in the west (8 recoveries), south of Sudan (1), Ethiopia (3), and Somalia (1), and 15 east to the Bay of Bengal (11 recoveries in India) (Appendix 2 and Figure 15). Argyle (1975) reported that the results of these recoveries "demonstrates a very wide post-juvenile dispersal of flamingos which had not hitherto been suspected." He also noted that the adult flamingos from the Lake Rezaiyeh Colonies seem to winter almost entirely in central Fars (southcentral part of Iran) and along the coast of the Persian Gulf and southern Baluchestan (southeastern part of Iran).

Scott (1975) reported that the majority of the Gorgan Bay (Figure 2) population appears to enter Iran (from October to April) (Appendix 5) by way of the east coast of the Caspian, even though small numbers have been observed along the south coast of the Caspian Sea in autumn moving from west to east.

Seven adult flamingos banded at Tangiz Lake Colony in Kazakhstan (U.S.S.R.) and two adults banded on migration at Gazan Kuli Reserve in Russia were recovered between

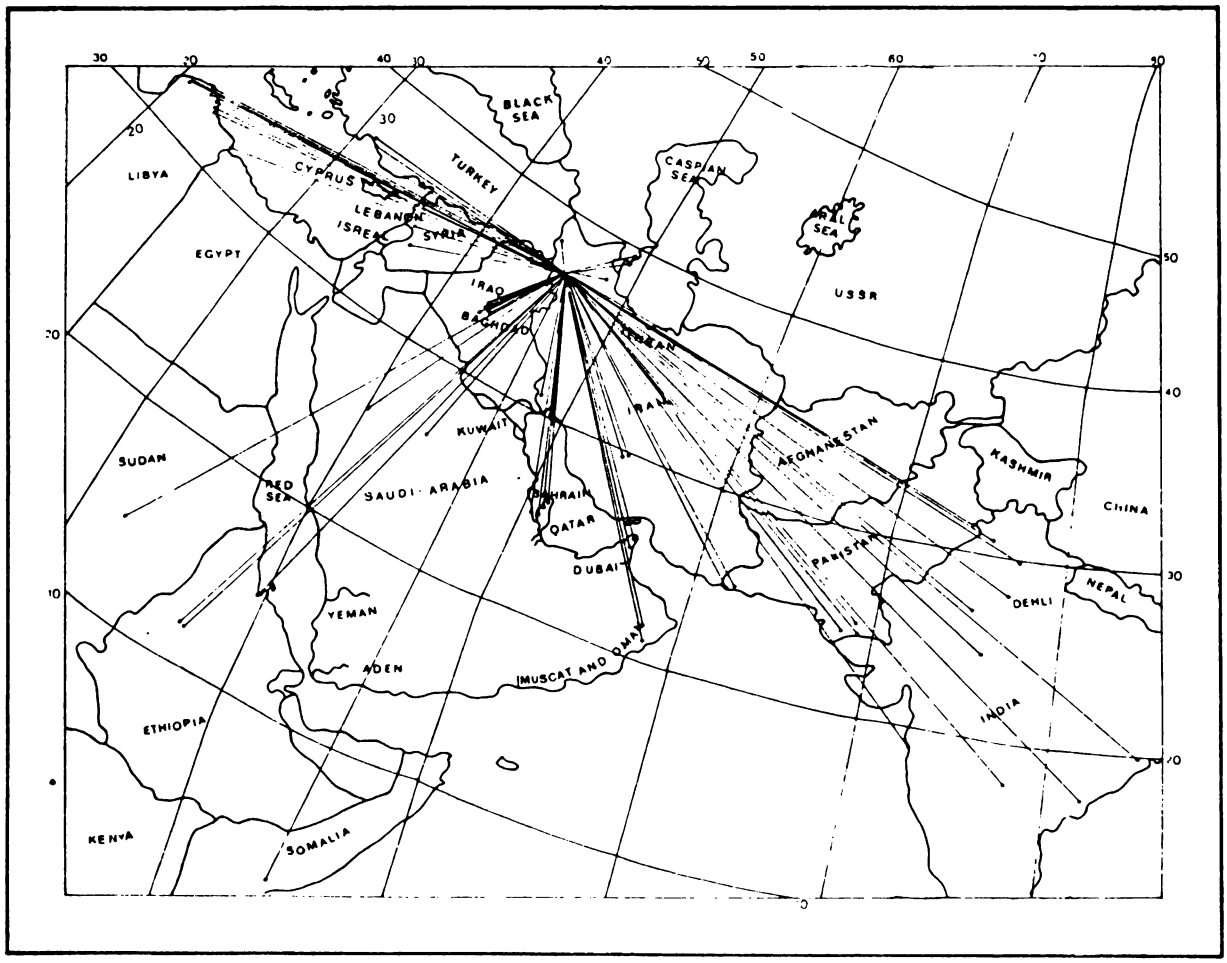

Figure 15. Recoveries of flamingos ringed as pulli in Lake Rezaiyeh National Park (37°25'N, 45°30'E) (from Argyle 1975, Department of the Environment, Iran).

September and March in Iran. Five in the southeast Caspian, one in the southwest Caspian, one near Lake Rezaiyeh, and three in central Fars (south part of Iran) were recovered (see Appendix 5). According to Scott (1975), there is some interchange between flamingos from Lake Rezaiyeh in Iran and Lake Tangiz in Russia. He also noted that most of the Gorgan Bay (north part of Iran) population comes from Russia.

In regard to the dispersal of juveniles, the results of the counts conducted in mid-winter by the personnel of DEC have demonstrated that few first-winter birds remain in Iran throughout the winter (Scott 1975).

According to the results of band recoveries, Scott (1975) hypothesizes that the young flamingos disperse widely, generally southward, from Iran rather than following well-defined migration routes. Recoveries in Iran, the Persian Gulf States, Saudi Arabia, Syria, Turkey, and Cyprus occurred in the period of October-December or March-April and could, therefore, relate to birds on migration.

Some of the yearling flamingos return to Lake Rezaiyeh, but Scott (1975) believed that it is possible that these birds had come from other breeding colonies and were still wandering. The fact that only two birds have been recovered outside Iran during their second year might indicate that flamingos usually return to Iran during their first summer. The results of the recoveries during this study

indicate that flamingos that were associated with the breeding colonies and those not associated with the breeding colonies return to Lake Rezaiyeh one through four years following their banding.

CHAPTER VI

MANAGEMENT RECOMMENDATIONS

The following recommendations are necessary if the present flamingo population in Lake Rezaiyeh National Park is to be maintained or increased in the future.

1. My study suggests that the deltas of the five rivers entering Lake Rezaiyeh in the south may be important to the survival of the flamingos, because the estuaries are the only places that salt concentrations are low enough in the entire lake to allow brine shrimp to breed during the period the flamingos are nesting. In addition, the non-breeding component of the flamingo population is found exclusively in the area of the estuaries. Survival of the flamingo population at Lake Rezaiyeh depends upon an adequate flow of fresh water into the lake to maintain a dense population of brine shrimp. Studies should be carried out to determine the minimal flow of fresh water necessary for this purpose. Diversion of river water for agricultural purposes should not reduce the volume of flow below this minimum.

2. During the incubation period some of the breeding flamingos use the Baranduz-Chai River for drinking fresh water and bathing. This river is very important to the survival of the breeding flamingos. More attention must be paid to this river and its importance to flamingos. Dam building by the farmers along the river prevents fresh water from coming into the lake during the summer and interferes with the ecological requirement of Greater Flamingos at Lake Rezaiyeh. Another damaging factor to the Greater Flamingos' ecological system would be an increase in pollution of the river (such as pesticides) which may lead to loss of important food organisms or effect the flamingos' breeding physiology.
3. Since it appears that the flamingos require bare soil or rock for nesting sites, selective cutting of the vegetation on areas of suitable topography may well provide additional nesting habitat for the population. Care should be taken to insure that at least some of the islands known to have been flamingo breeding habitat are bare of vegetation prior to the arrival of the breeding population every spring.
4. No competition for breeding habitat appears to be occurring between Herring Gulls and flamingos, but there may be competition for breeding sites between flamingos and pelicans when the pelican population

is high. This relationship should be studied. It is possible that selective cutting of vegetation on areas that are preferred by both species could reduce the problem.

5. Controlling the travel of aircraft during the breeding season (May 14th through July 25th) would be desirable. The flying of airplanes lower than 800 m. over the breeding colony invariably causes all adults to flush, thus leaving eggs and chicks vulnerable to gull predation. I recommend that all air travel, except by biologists directly concerned with flamingo research, should be restricted from approaching closer than 5 Km. to the nesting colonies. During census flights of the breeding colonies by DEC personnel, an altitude of at least 600 m. should be maintained. Markers visible from the air should be set out on the shores of the lake indicating to pilots the areas to be avoided.
6. Movements of boats should be restricted in the vicinity of the breeding colonies during the egg laying, incubation, and hatching periods (May 14th through July 25th). Boats, like airplanes, cause adult flamingos to take flight and leave eggs and chicks vulnerable to predation. I recommend that boat traffic, except by DEC personnel studying the flamingos, be prohibited from approaching to within closer than 3 Km. of the breeding colonies between these dates.

7. A lake tour for any interested tourists could be easily established after July 25th. By this date the chicks have entered the water and there is no longer any problem of disturbing the breeding colonies. Tours should be under the control of park service personnel who have been trained by the DEC biologists. Prior to July 25th, any viewing of the breeding colony must be under the control of trained park service personnel or DEC biologists.
8. Additional research is needed to determine the rate of fledglings and survival of the various age classes of adults. This information is necessary for an understanding of the population dynamics of this flamingo population.

Observations should be continued on the sites chosen by flamingos for breeding colonies. We need to have a better understanding of the physical requirements of the breeding habitat and the potential competition for nesting sites with White Pelicans.

Population size should be studied during the four seasons by aerial survey. Using aerial photography of all parts of the lake more or less simultaneously (at least within two to three days) will help to get more information about the number of the flamingos at Lake Rezaiyeh. Surveys should cover the whole area, including Lake Dourgheh-Sanghi near Neghadeh, and Lake Ghopi between Mohabad and Meiyandoab (Figure 2).

APPENDIX

APPENDIX 1

NUMBER OF ADULT AND CHICK FLAMINGOS RINGED AT LAKE REZAIYEH NATIONAL PARK, IRAN (FROM SCOTT 1975)

Year	Adult	Chicks
1970	238	2,280*
1971	-	1,000
1972	-	1,495
1973	-	1,499
1974	-	1,450
1975	102	1,026
1976	427	1,746

*Blue collars only

APPENDIX 2

RECOVERIES OF GREATER FLAMINGOS RINGED AS CHICKS
AT LAKE RESAIYEH NATIONAL PARK, IRAN,
37 25' N 45 30' E (FROM ARGYLE 1975)

Country of Recovery	Date of Recovery					
	1st W Sep-Mar	1st S Apr-Aug	2nd W Sep-Mar	2nd S Apr-Aug	3rd W Sep-Mar	Total
Iran	7	4	2	1	0	14
Azarbaijan (U.S.S.R.)	2	0	0	0	0	2
Turkey	5	0	1	0	0	6
Cyprus	1	0	0	0	0	1
Syria	2	0	0	0	0	2
Iraq	8	0	4	0	0	12
Qatar	3	0	0	0	0	3
Bahrain	0	0	1	0	0	1
Dubai	2	0	0	0	0	2
Muscat & Oman	3	0	0	0	0	3
Saudi Arabia	2	0	0	0	0	2
Libya	7	0	1	0	0	8
Ethiopia	3	0	0	0	0	3
Sudan	1	0	0	0	0	1
Somalia	1	0	0	0	0	1
Pakistan	5	0	3	0	0	8
India	8	2	0	0	1	10
Total	60	6	12	1	1	80

APPENDIX 3

WATER SAMPLE ANALYSIS FROM THE LAKE REZAIYEH NATIONAL PARK, IRAN

	Location	Temp. °C	pH	E.C.x10^{-6}	Total Hardness mg/l	Anion meg/l				Cation meg/l			
						HCO_3^-	Co_3^{--}	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	K^+	Na^+
North part of the lake	Nazlow-Chai River	28	8.5	-	192	3.92	0	-	2300	2.24	1.6	0.60	390
	Ghopie-Gazan	28	8.5	-	24,700	5.80	0	-	3000	26	284.0	32	4380
	Nazlow-Chai, near Zanbil Daghie	28	7.7	-	280	6.40	0	-	1200	3.12	3.9	0.16	2700
	Boghe-Daghie	28	8.9	-	244	2.80	0	-	2100	2.50	1.2	0.06	1600
Central part of the lake	Baranduz-Chai River, near Arab-Loe village	28	8.7	-	155.6	3.44	0	-	0.05	2.32	1.1	0.05	0.28
	Gholmankhaneh Harbour	28	8.5	-	22,000	5.84	0	-	245.0	24.80	328.0	0.06	3000
	South of the Kabudan Island	28	9.0	-	88	2.60	0.2	-	90	0.80	1.5	0.20	50.40
	East of the Arezo Island	28	7.8	-	1,476	3.10	0	-	38	7	16.8	0.20	38.40
	East of the Kabudan Island	28	6.9	-	3,000	-	-	-	26.6	22.10	15.2	-	-
South part of the lake	Southeast of the lake	28	8.6	-	23,060	4.30	1.4	-	0.2	24.60	15.0	27.20	28
	South of the lake	28	8.5	-	26,130	4.90	1.1	-	22.5	29.40	29.1	28	28.80
	Southeast of the lake	28	8.5	-	27,820	3.80	2.2	-	25	29	405.0	27.20	27.20
	Southeast of the lake	28	9.2	-	232	2.60	2.5	-	4	2.90	4.5	0.03	14
	Southeast of the lake	28	8.5	-	24,060	4.50	1.3	-	75.0	29.60	432.0	25	54.40
	Southeast of the lake	28	8.2	-	640	3.60	0	-	37.8	3.40	10.4	0.03	38
	Southeast of the lake	28	8.8	-	680	6.60	0.3	-	10.5	3	17.3	1.20	9.10
	Southeast of the lake	28	8.6	-	720	5.80	0	-	22	3,80	34.6	2.40	20
	Gherdeh-Soreh-Dashkhaneh	28	8.6	-	760	3.40	0	-	19	3.44	4.70	0.14	13.60

APPENDIX 4

RESULTS OF SOIL ANALYSES TAKEN IN LAKE BEZAIYEH
NATIONAL PARK DURING JULY 15-22, 1976

Location	Depth m.	S.P.	ECo x 10^3	pH	Co_3Ca Total	Co_3Ca Active	So_4Ca m.e/100	O.C.%	A.V.P. ppm	A.V.K. ppm	A.V.N. ppm	Total N %	% Sand	% Silt	% Clay	C.E.C.
Gherdeh-More-Dashkhaneh	2.0	90	83.5	7.5	15	-	-	-	23	1160	-	0.23	2	70	28	28
Hassanahad Payien	2.5	87	60.2	7.0	20	-	-	-	13	900	-	0.22	6	64	30	26
Ghopie-Gazan	4.0	94	75.7	7.3	17	-	-	-	-	1000	-	0.24	2	66	32	26
Southwest of Kolasangoha	6.0	48	210	7.3	39	-	-	-	16	1240	-	0.07	34	40	26	13
Southwest of Kywan	5.0	64	300	7.6	39	-	-	-	6	1640	-	0.14	26	54	20	15
400 m. north of Ardeshir Island	8.0	82	200	7.7	26	-	-	-	6	1800	-	0.10	8	28	20	15
Baranduz-Chai River (near Jarihan)	1.5	43	175	7.7	22	-	-	-	15	600	-	0.04	32	44	24	8.5
Northwest of Shahi Island	-	99	160	8.0	18	-	-	-	16	1100	-	0.05	10	60	30	18
Near Rashakan	1.0	60	190	7.6	32	-	-	-	8	750	-	0.08	46	22	32	12
Boghe-Daghie	3.0	60	65	7.6	-	-	-	-	-	900	-	0.30	16	32	52	34
South of Espir Island	6.0	61	210	7.7	49.4	-	-	-	5	1200	-	0.09	46	24	30	17
Rahmanlo Harbour	2.0	56	200	7.2	12	-	-	-	9	1280	-	0.21	34	32	34	17
Near Gohadlo	0.1	35	110	7.7	12	-	-	-	2	350	-	0.05	70	12	18	7
East of Shahi Island	-	80	150	8.1	14.5	-	-	-	13	860	-	0.06	17	28	55	15.5

APPENDIX 5

IRANIAN RECOVERIES OF GREATER FLAMINGOS RINGED AS ADULTS IN U.S.S.R. AND AT LAKE REZAIYEH NATIONAL PARK, IRAN (FROM SCOTT 1975)

Ringed	Recovered	Locality	Coordinates
Ringed at Tangiz Lake, Kazakhstan 50°18'N, 69°00'E			
23.7.67	-.11.71	Gorgan Bay, Mazandaran	36°50'N, 53°45'E
-.7.68	-. 3.69	Gorgan Bay, Mazandaran	36°50'N, 53°45'E
23.7.69	12.12.69	Hassanlu Marsh, Lake Rezaiyeh	37°03'N, 45°28'E
29.7.70	29.10.70	Zarghan, Fars	29°30'N, 52°40'E
16.6.71	3. 9.72	Kaftar Lake, Fars	30°35'N, 52°45'E
17.8.71	10. 3.72	Gorgan Bay, Mazandaran	36°50'N, 53°45'E
17.8.71	4. 2.72	Bandar Pahlavi, Gilan	37°30'N, 49°30'E
Ringed at Gasan-Kuli Reserve, Turkmenistan 37°27'N, 53°56'E			
10.10.64	24.10.70	Caspian shore near Gomishan	37°05'N, 54°01'E
27.10.65	4. 2.70	Gorgan Bay, Mazandaran	36°50'N, 53°45'E
Ringed at Lake Rezaiyeh, Azarbaijan 37°25'N, 45°30'E			
17. 8.70	12. 2.72	Lake Tashk, Fars	29°45'N, 53°30'E

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