CONCISE SUMMARY

ECOLOGY OF GREATER FLAMINGO *PHOENICOPTERUS ROSEUS* AND LESSER FLAMINGO *PHOENICOPTERUS MINOR* ON THE WETLANDS OF GUJARAT

ANIKA TERE

DEPARTMENT OF ZOOLOGY

FACULTY OF SCIENCE

THE M. S. UNIVERSITY OF BARODA

VADODARA-390 002

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Flamingos are one of the most beautiful waterbirds belonging to the order 'Phoenicopteriformes" and to the family 'Phoenicopteridae'. There are six species of flamingos in the world, of which two species occur in India *viz.*-Greater Flamingo *(Phoenicopterus roseus)* and the Lesser Flamingo *(Phoenicopterus minor)*. In India, the two species of flamingos are mainly found in Gujarat, Rajasthan, Andhra Pradesh, Orissa, Maharastra, Karnataka and Kerala.

Flamingos are gregarious wetland birds and generally found in groups, ranging from few to thousands or lakhs. Their most characteristic habitats are large alkaline or saline lakes or estuarine lagoons, lakes (may be far inland or near the sea), mangrove swamps, tidal flats, or sandy islands in the inter-tidal zone.

Flamingos are filter feeders. Greater Flamingos feed largely upon zooplanktons, whereas Lesser Flamingos feed exclusively on phytoplankton.

Greater Flamingos are known to breed regularly only in Gujarat state in the Indian subcontinent. "Flamingo City" in Great Rann of Kachchh is one of the largest breeding colony in the world and a single regular breeding site in entire Asia (Ogilvie and Ogilvie, 1986). They are colonial nesters and make mounds of mud. They attempt to nest only when the inundation of the area occurs. Even after establishing a colony, when the condition does not remain favourable they desert the colony. If they do not nest successfully for several years their number decreases. Because of their irregular breeding attempts and restricted distribution, Lesser Flamingos are listed as "Near Threatened Species" (Collar *et al.*, 2001) in Asia. Hence knowledge about the ecology of flamingos becomes important to take up conservation measures.

Very little is known about the ecology of Greater and Lesser Flamingos in India. Except for the records of their breeding events and nesting sites, detail knowledge about their

ecology *i e* population size, habitat preference, food, behavior, habitat suitability, *etc* is lacking. Keeping this in view, detailed investigation on the following aspects were taken up:

- Distribution and population estimation
- Habitat preference and habitat evaluation through Remote Sensing
- Food and feeding ecology
- Breeding ecology
- Behavior
- Conservation and management

1. Population Estimation and Distribution:

Both the species of flamingos were counted on different sites of (A) Coastal Area, such as 1) Gulf of Kachchh 2) Rann of Kachchh 3) Gulf of Khambhat 4) Other Coastal Sites and on (B)Inland Wetlands of Gujarat state during (i) Non-breeding season (January 2003); (ii) Breeding season (October 2003) and (iii) Post-breeding season (May-June 2004).

1.1 Non-breeding Season:

Total 32,943 Greater Flamingo and 3,72,778 Lesser Flamingo (total 4,05,721 flamingos) were counted at different sites in Gujarat state during the non-breeding season *i e* January 2003. Both the species of flamingos were largely distributed at the Coastal Wetlands (99.84%) and very small or negligible population was at Inland Wetlands (0.16%). The Greater Flamingos were equally distributed in Gulf of Kachchh (35.24%), Other Coastal Sites (36.63%) and Gulf of Khambhat (26.50%) A small population (1.63%) was also observed on Inland Fresh Water Wetlands. The Lesser Flamingos were concentrated to the Gulf of Khambhat (79.80%) with small population in Other Coastal Sites (11.46%) and Gulf of Kachchh (8.71%). Only a small fraction of total population (0.03%) was found on Inland Fresh Water Wetlands.

Based on Asian Waterfowl Census (AWC) data, Rose and Scott (1997) estimated about 1,50,000 Greater Flamingo and about 1,20,000 Lesser Flamingo in entire Asia. Recently, the estimated number of Greater Flamingo in the eastern Mediterranean, southwest and south Asia was 2,90,000 and Lesser Flamingos in all of South Asia was 1,50,000 (Wetland International, 2002). A total of 3,72,778 Lesser Flamingos and 32,943 Greater Flamingos could be counted in the present study from different sites of Gujarat state alone in January 2003. This is much higher count than what was ever estimated during earlier studies. Hence, special efforts are suggested to revise their population size in Asia.

1.2 Breeding Season:

Total 1,73,130 Greater Flamingos and 6,65,920 Lesser Flamingos, (total 8,39,050 flamingos) were recorded during the breeding season *i e* October 2003 at different sites of Gujarat state This is the highest count ever recorded in India. Total number of birds counted in October 2003 were more than double (8,39,050) as compared to the count of January 2003 *i e.* non-breeding season (4,05,721).

Major population of Greater Flamingo was on Rann of Kachchh (99.42%) while only a fraction was recorded from Gulf of Khambhat (00.58%). They were absent from Gulf of Kachchh, Other Coastal Sites and Inland Wetlands of Gujarat. Major population of Lesser Flamingo was recorded at Rann of Kachchh (92.70%) with very small population on Gulf of Khambhat (6.95%). Negligible numbers were recorded on Other Coastal Sites of Gujarat (0.30%) and Gulf of Kachchh (0.05%). They were absent in Inland Wetlands

Flamingos concentrated to their breeding site in Great Rann of Kachchh, during breeding season The tremendous increase in number of both the species of flamingos, during October 2003 suggested their immigration from the entire subcontinent to the Great Rann. Regular monitoring particularly through satellite tracking is urgently required to understand their inter-continental movements and migratory behavior.

1.3 Post-breeding Season:

Total 71,667 Greater Flamingos and 1,50,907 Lesser Flamingos (total 2,22,574 flamingos) were counted at different sites of Gujarat state during post-breeding season. Highest concentration of Flamingos was recorded in Gulf of Khambhat (68.29%), followed by Inland Wetland (12.27%) and Other Coastal Sites (10.39%). Comparatively low population was recorded in Rann of Kachchh (04.58%) and Gulf of Kachchh (04.47%).

Highest concentration of Greater Flamingos was found in Gulf of Khambhat (51.64%) and comparatively low number was found in Gulf of Kachchh (06.45%) and Other Coastal Sites (08.73%). Greater Flamingos had almost equal distribution in Rann of Kachchh (14.20%) and Inland Wetland (18.98%). Highest concentration of Lesser Flamingos was recorded in Gulf of Khambhat (76.19%) followed by Other Coastal Sites (11.17%) and Inland Wetlands (09.09%). Very low number was recorded at Gulf of Kachchh (03.54%). Only 23 Lesser Flamingos were recorded from Rann of Kachchh (0.01%).

Flamingos started radiating to different sites of Gujarat state from Rann of Kachchh, once the breeding season was over. Highest Concentration of both the species of Flamingos was recorded at Gulf of Khambhat, which shows the potentiality of this area for the flamingos during post-breeding season also.

1.4 Seasonal Variation in Distribution of Flamingos:

Comparison of the flamingo count of different seasons *i.e.* non-breeding, breeding and post-breeding periods, revealed variation in their distribution. They were found largely on the Coastal Wetlands during the non-breeding season. During breeding season, most of the flamingos left all the sites inhabited during non-breeding season and concentrated at their breeding site in Rann of Kachchh. In post-breeding season, the flamingos started radiating and occupying different sites of Gujarat from their breeding site (Rann of Kachchh), once the breeding season was over.

1.5 Gulf of Khambhat:

Regular monitoring of the Gulf of Khambhat, from August 2002 to May-June 2004, showed variations in numbers and distribution pattern of both the species during different seasons. The total number flamingos was comparatively less during August 2002 (35,647 birds) and October 2003 (47,300 birds) *i.e.* breeding season; increased in November 2002 (79,737 birds) and May-June 2004 (1, 69,012 birds) i.e. post-breeding season. The number of flamingos was highest in January 2003 (3, 06,230 birds) *i.e.* during Non-breeding season. This suggested that the Gulf of Khambhat is a preferred site of flamingos during non-breeding and post-breeding seasons.

The Gulf of Khambhat was divided into three zones (I) Western Fringe: entire coastal areas of Bhavnagar district (II) Northern Fringe: sea coast around Dholera of Ahmedabad district; Khambhat-Dhuwaran of Anand district and Dabka and surrounding sea coast of Vadodara district, and (III) Eastern Fringe: sea coast of entire Bharuch district

The flamingos were not distributed evenly in the entire Gulf of Khambhat. 87.50% of total population of Greater Flamingo and 93.45% Lesser Flamingo was on the western fringe during August 2002. 66.99% Greater Flamingo and 50.82% Lesser Flamingo were on the western fringe during November 2002. 88.00% Greater Flamingo and 63.94% Lesser Flamingo were on the western fringe during May-June 2004. The western fringe of Gulf of Khambhat was very important for both the species of flamingos. During January 2003, 75.50% of total population of Greater Flamingo was on the western fringe while 76.74% Lesser Flamingo were on the northern fringe. During October 2003, 80.00% of total population of Greater Flamingo was on the western fringe while 82.07% Lesser Flamingo were on the northern fringe. The northern fringe of Gulf of Khambhat was an important site for the Lesser Flamingos. Negligible number of flamingos on the sea coast around Bharuch and Navsari district suggested that the eastern fringe was not preferred by either of the species of flamingos.

2. Habitat Preference:

Both the species of flamingos were counted according to the different types of habitats in which they were found during non-breeding; breeding and post-breeding periods. All the aquatic habitats were broadly classified into two categories, *viz*, (A) Coastal Wetlands and (B) Inland Wetlands The Coastal Wetlands were further classified into three categories *viz*, (I) Sea coast/mudflats of i) Gujarat ii) Rann of Kachchh; (II) Salt Pans (III) Coastal Fresh Water Wetlands.

2.1 Non-breeding Season:

Habitat preference of two species of flamingos during non-breeding season was very apparent. They were largely concentrated at the Coastal Wetlands (99.84%) and negligible at the Inland Wetlands (0.16%). The Rann of Kachchh was dry hence the flamingos were distributed in rest of the habitats.

Greater Flamingos were found largely in the Salt Pans (70.66%) followed by the Coastal Fresh Water (19.38%), Sea Coast/Mudflats (8.33%) and Inland Fresh Water Wetland (1.63%). The Lesser Flamingos were more concentrated at the Sea Coast/Mudflats of Gujarat (76.71%). They were equally distributed at the Salt Pans (11.44%) and Coastal Fresh Water Wetlands (11.82%) and negligible at the Inland Fresh Water Wetlands (0.03%).

The Greater Flamingos preferred Salt Pans and Lesser Flamingos preferred Coastal Mudflats of Gujarat. The Lesser Flamingos' specificity for saline/alkaline wetlands was apparent. The Greater Flamingos were found on all the categories of wetlands, which indicated their adaptability and ability to exploit all types of wetlands.

2.2 Breeding Season:

During the breeding season, the Rann was inundated and highest concentration of flamingos was at the mudflats of Rann of Kachchh (94.09%). Negligible number was at the

Mudflat/Sea Coast of Gujarat (5.24%), Salt Pans (0.43%) and Coastal Fresh Water (0.24%). Both the species were absent from Inland Wetlands.

Highest number of Greater Flamingos was recorded from the mudflats of Rann of Kachchh (99.42%) with negligible number from the Salt Pans (0.58%). They were absent from Other Coastal Sites of Gujarat and Coastal Fresh Water Wetlands. Highest concentration of Lesser Flamingo was recorded from the Rann of Kachchh (92.70%) followed by the mudflats and Sea Coast of Gujarat (6.61%). Negligible number was recorded from Coastal Fresh Water Wetland (0.3%) and Salt Pans (0.39%).

During the breeding season, both the species of flamingos showed highest preference for the Mudflats of Rann

2.3 Post-breeding Season:

Both the species were more concentrated at Coastal Wetlands (87.73%) but a considerable population was also found at Inland Wetland (12.27%) Within the Coastal Wetlands, major concentration was at the Salt Pans (62.88%) followed by Sea Coast of Gujarat (19.77%) and Mudflats of Rann of Kachchh (4.58%). Negligible number of flamingos was recorded from the Coastal Fresh Water Wetland (0 50%)

Greater Flamingos were found largely at the Salt Pans (62.71%) followed by Inland Wetland (18.98%) and Mudflats of Rann of Kachchh (14.20%) Small number of Greater Flamingos was recorded from the Sea Coast and Mudflats of Gujarat (4.11%). They were absent at the Coastal Fresh Water Wetlands Lesser Flamingos were largely concentrated at the Salt Pans (62.96%) followed by Mudflats and Sea Coast of Gujarat state (27.20%). Considerable population was recorded from Inland Wetland (9 09%). They were negligible on the Mudflats of Great Rann of Kachchh (0.02%) and Coastal Fresh Water Wetlands (0.73%).

During the post-breeding season, the flamingos again occupied almost all different types of habitats. Greater Flamingos showed highest preference for the Salt Pans and also occupied large number of Inland Wetlands. The Lesser Flamingos also showed highest preference for the Salt Pans followed by the Seas Coast/Mudflats of Gujarat. Compared to the breeding season, both the species showed low preference for the Mudflats of Rann.

3. Food and Feeding Ecology:

3.1 Feeding Methods:

Flamingos feeding in different habitats were observed by using a spotting scope (20X80) and binoculars (10X50) and their feeding methods were noted. The depth of water in different habitats was recorded. The different feeding methods observed in flamingos were (i) Walk Feed (ii) Stamp Feed or Treading (iii) Tip Feed or Swim while Feeding (iv) Duck like Bobbing and (v) Feeding in Heron Manner.

3.2 Feeding Area:

Mainly four different feeding areas were identified (i) Mudflats: with shallow/no water (ii) Wetlands with shallow water, which included salt pans, tidal regulators, sewage ponds and village ponds. (iii) Wetlands with deep water, which included salt pans, sewage ponds, inundated Rann areas, *etc.* and (iv) Rice field.

A total of 533 Greater Flamingos were recorded inhabiting Rice-field at Sarkhej, Ahmedabad district, on June 28, 2003. Rice fields as a feeding area of Greater Flamingos is identified for the first time during the present study.

3.3 Gut Content Analysis:

Freshly dead specimens of a Greater Flamingo was collected from Bhirandiyara (23^0 32.038'N; 69^0 40.077'E), located about 50 km north to Bhuj, on Bhuj-Khavda road in the Great Rann of Kachchh. Freshly dead specimens of a Lesser Flamingo was collected from

Rann of Shiranivandh (23^0 54' 29.632''N; 70^0 32' 32.624''E) in Great Rann of Kachchh. The flamingos, died due to collision with power lines, were dissected and crop content was studies.

The gut content analysis of Lesser Flamingo showed that it fed exclusively on one type of food only *i.e. Navicula sp.* The Greater Flamingo fed exclusively on *Artemia* cysts. The later is known to feed on Artemia adults however, the cysts as the food are reported for the first time in India during this study.

3.4 Food in the Environment:

As the food is an ultimate factor for reproduction, the availability of food and its abundance in the surrounding environment of the nesting site (Flamingo City) was analyzed during the breeding season. The sampling of food and other data for water quality were taken at four different points, *viz* (1) at the edge of Nirveri, (2) 10 km from Nest Site, (3) 5 km form Nest site and (4) near Nesting site (Flamingo City), in February 2004 and April 2004. As the Flamingo City could not visited in October 2003, the sampling at the Point 4 could not be done.

In the beginning of breeding season *i.e.* October 2003, the 4 food items *viz.* fishes- *Cyprinodon disper,* cysts of *Artemia salina,* and *Chironomous* pupae were recorded from inundated water and *Chironomous* larvae from the substrate. The *Chironomous* larvae were abundant in the soft mud at point 1 (45/sample). The fishes were very small in size and abundant (8 fishes/ five attempt). The maximum depth of water was 180 cm. The depth of water between points 2 and 3 was 160-180 cm. The salinity of water was 51.2 ppt.

During active breeding season *i.e* February 2004, all 4 food items were found. Total 5 fishes/five efforts could be captured. The food was abundant. The salinity of water was 66.5 ppt. At the point 1 the depth of water was 40 cm. The depth was 50-64 cm between points 2 and 3. At the edge of Nest site, the water was about 10 m away from the nest site and the depth was 46 cm. At 50 m from the nest site, the depth of water was 64 cm. Total

21,000 Greater Flamingos (7,000Adult + 14,000Juveniles) were counted in February 2004, most of adults were engaged in breeding activities.

There was a 50% decrease in total food abundance, in April 2004 *i.e.* at the end of breeding season, compared to the active breeding season. The *Chironomous* larvae and pupae were totally absent from all the points. The *Cyprinodon* fishes were found dead, and floating in water. The number of *Artemia* cyst decreased by 44.49%. The adults *Artemia salina* were also found, however, many adults were dead and floating on the inundated water, while a few live adults were present at all the four spots. The salinity of the water was 80.6 ppt. The water level had decreased drastically. At the point-1 the depth was 12 cm and between point 2 and 3 it was 30-46 cm. The water had receded 500 m away from the nest site. Most of the adult birds left the nesting colony and only 259 adult Greater Flamingos were present along with 9,655 live juveniles at the nest site.

The Remote Sensing Technique was also used to determine food availability and evaluate the habitat conditions surrounding nesting site. OCM data of October 15, 2003 showed deep blue and light greenish blue colors, in Great Rann suggesting that the area was inundated with deep water. The IRS P6 data of November 22, 2003 showed drying of the Rann areas beyond Bela, Kuda and some white salt encrusted areas. However the Flamingo City was surrounded by water. The Chlorophyll Map of the Great Rann in October 2003 showed that the amount of Chlorophyll varied between 0.001 to 0.3 mg/lt. The green color in water, in MODIS data of October 2003 suggested the presence of primary food in water around the nesting ground. The light blue color in Great Rann in the OCM data of April 9, 2004, suggested wet soil between Khadir and Kuda and large number of salt encrusted high elevated areas. The Flamingo City was exposed out clearly seen as a dot. Light blue color with white shading suggested that the depth of water and its spread out area had decreased.

The co-relation of different physical factors with quality and quantity of food during different periods of breeding season suggested that the food abundance was highly affected by two factors (1) salinity and (2) depth of water. As the season pressed, water started

receding, which resulted in decrease in water depth and its spread out areas. This resulted in tremendous increase in salinity of water. The food organisms could not survive in high salinity water and hence the total food decreased. This in turn affected the number and breeding activities of flamingos and most of the adults deserted the colony.

4. Breeding Ecology:

4.1 Nesting History and Breeding Sites:

A complete account of breeding events of both the species of flamingos was prepared by (i) comparing all past records of their nesting in Gujarat state as well as in other states of India (ii) Local inquiries (iii) visits of nesting ground during the present study.

The Greater Flamingos were recorded breeding in Indian subcontinent for the first time by Shri Maharao Khengarji at the Flamingo City in Great Rann in 1983. The Greater Flamingos bred regularly after that, at Flamingo City with the gap of few years. Hence, the Flamingo City was known as the "Traditional Breeding Sites". During the present study they were found breeding regularly at Zinzuwada and Purabcheria on a small scale, hence it is established that the salt pans near Zinzuwada and Purabcheria are the "Alternate Breeding Sites" of Greater Flamingos. Large number of eggs discovered in Rann around Gatka, Karni *etc* suggested that the Greater Flamingos bred somewhere else in Great Rann beside Flamingo City.

During the present study, the Lesser Flamingos were found breding regularly at the Purabcheria and Zinzuwada. Hence now it is established that these two sites of Little Rann of Kachchh are "Traditional Breeding Sites" of Lesser Flamingos Besides this, large number of chicks recorded at the Rann of Bela and Kuda in Great Rann of Kachchh, suggested possibilities of their breeding in theses new areas also.

4.2 Breeding Season:

The breeding season of Lesser Flamingo varied at their two traditional breeding sites of Little Rann. At Purabcheria, they started nesting activities mostly in June or in early July. They terminated breeding activities in July due to egg collection by the local community. Certainly, it was never a true termination of breeding activity. At Zinzuwada, the Lesser Flamingos started breeding in late July-August and continued their activity till September-October or early November of the same year. The Greater Flamingos started nesting activities during September-October of one year and terminated their nesting activities by April-May of the next year at Flamingo City, in Great Rann of Kachchh. The length of breeding season depended on extent of inundation.

4.3 Nests of Flamingos:

The nests of flamingos are conical mounds of mud, the top of which contain a cavity in which an egg is laid.

At the Purabcheria, the Lesser Flamingos built nests in small clusters, distributed over a larger area on mudflats. At the Zinzuwada the nests were found within salt pans or in its proximity. The mean height of nests of Lesser Flamingos at Purabcheria was 11.69 ± 3.36 cm (n=20) and circumference at the base and at top was 145.80 ± 21.90 cm (n=20) and 67.45± 06.49 cm respectively. The inter-nest distance was 66.53 ± 12.41 cm (n=52). The mean height of nests Lesser Flamingos at Zinzuwada was 17.89 ± 5.54 cm (n=39) and circumference at the base and at top was 152.8 ± 27 cm (n=39) and 86.00 ± 05.49 cm (n=39) respectively. The inter-nest distance was 59.0 ± 14.62 cm (n=134).

The Greater Flamingos nested on the island which was about 160-180 cm in height. Three types of nests could be identified (i) Low elevated (ii) High elevated and (iii) Intermediate. The mean height of low elevated nests was 11.33 ± 3.32 cm (n=6) and circumference at the base and at top was 51.0 ± 07.21 cm (n=6) and 37.0 ± 04.62 cm (n=6) respectively. The inter-nest distance was 28.31 ± 06.48 cm (n=6). The mean height of high elevated nests was 33.20 ± 01.92 cm (n=5) and circumference at the base and at top was

72.60 ± 6.92 cm (n=5) and 48.4 ± 01.82 cm respectively. The inter-nest distance was 37.0 ± 07.22 cm (n=5). The mean height of intermediate nests was 19.83 ± 5.02 cm (n=5), circumference at the base and at top was 71.16 ± 9.94 cm (n=5) and 55.6 ± 2.91 cm respectively. The inter-nest distance was 31.52 ± 6.15 cm (n=5).

The shape of both the species was quite distinct. The nests of Lesser Flamingos were conical while those of Greater Flamingos were more cylindrical in shape. The circumference of nest of Lesser Flamingo at base was more (105-184.0 cm at Purabcheria; 130-227.0 cm at Zinzuwada) than the nest of Greater Flamingo (44.0-60.0 cm in low elevated; 64-83.0 cm in high elevated nests, at Flamingo City). The circumference of nest of Lesser Flamingo at top was also higher (57-83 cm at Purabcheria; 69-97 cm at Zinzuwada) than the nest of Greater Flamingo (30-40 low elevated; 46-50 cm high elevated). The concavity of top of Greater Flamingo's nest was deeper (1 to 3.5 cm) than the nests of Lesser Flamingos (less than 1 cm).

4.4 Eggs of Flamingos:

The eggs of flamingos were elongated oval in shape and chalky white in color. One egg was found in most of the nests; however, in some two eggs were present.

Mean length and mean width value of eggs of Greater Flamingos were 8.83 ± 0.46 cm (n=43) and 5.57 ± 0.18 cm (n=43) respectively. The ESI value varied from 56.64 to 70.55 with the mean value of 63.33 ± 3.24 (n=29). The mean volume was 1.41 ± 13.75 cm^3 (n=43).

Mean length and mean width value of eggs of Lesser Flamingos at Zinzuwada, during 2002, were 8.00 ± 0.35 cm (n=29) and 4.86 ± 0.19 cm (n=29) respectively. The ESI value varied from 53.20 to 66.96 with the mean value 60.79 ± 3.66. The mean volume was 96.48 ± 8.46 cm^3 (n=29).

Comparison the morphometry of eggs of both the species revealed that the maximum length and width of the eggs of Lesser Flamingos are overlapping with the minimum length and width of eggs of Greater Flamingos. Hence, eggs of both the species falling in this range can not be differentiated. However, eggs of Lesser Flamingos and Greater Flamingos can be distinguished by their minimum and maximum values respectively.

4.6 Factors Regulating Breeding of Flamingos:

Past records during which, the flamingos did not attempt to breed at the Flamingo City were referred and the physical conditions of the ground were compared with the Remote Sensing images of that duration. Similar comparison was done for the years, during which the flamingos bred successfully. The breeding attempts made by Greater Flamingos at the Flamingo City were correlated with the amount of precipitation and extent of inundation. During the present study, habitat evaluation of Flamingo City and surrounding area was done by remote sensing and verified through ground truth studies. The food abundance was monitored throughout the breeding season.

Inundation of habitat with shallow water was identified as an important factor for successful breeding. It ensured availability of loose mud for making nests, production of food around nest site and protected the colony from the ground predators. The nesting attempts were successful when the inundation by shallow brackish water around the breeding site was for sufficient period *i e* the period during which the eggs incubated and young fledged.

The food was an ultimate factor for breeding flamingos. They started breeding when the food was abundant and terminated breeding and deserted the colony when the food in surrounding water depleted, even though the area was still inundated in April 2004. Salinity was an important factor controlling the food in the nesting area and thereby regulating the breeding of flamingo.

4.7 Chick Mortality:

Heavy chick mortality of both the species of flamingos was observed at the Great Rann of Kachchh.

A) Lesser Flamingos:

(a) High Rates of Receding Water

During October 2003, the area of Rann around Bela and Kuda was inundated by shallow water (15 cm to 30 cm). The salinity of water was 55.2 ppt. The MODIS data of October 2003 showed presence of primary food in the water. From the Chlorophyll map the amount of primary food present in water was estimated between 3 to 9 mg /m^3. Total 11,220 chicks of Lesser Flamingos were observed along with 3,100 adults in Rann around Bela. The chicks were of 10-20 days old and unable to fly.

The area of Rann around Bela and Kuda become totally dry in December 2003. Water was absent in most of the areas and available only in a few very small ditches. Salinity of the remaining water increased tremandously (about 85.6 ppt). The IRS P6 data of November 22, 2003 showed complete drying of these areas of Rann. Total 2,700 dead bodies of chicks were observed bogged in salt at many places in Rann. About 300 chicks were observed lying motionless on the ground or water. The salt was deposited on the feathers of wing, neck, breast and abdomen as well as on the legs.

The rapid drying of area and tremendous increase in salinity of remaining water resulted in depletion of food. Most of the adult birds and juveniles able to fly left the site and only few adults with small chicks unable to fly remained. The chicks gradually became weak due to lack of food in the surrounding environment. Moreover, salt deposition while walking through the water, made their bodies heavier. The weaker and starved chicks with heavily loaded salt became unable to move to any safer site and finally died.

(b) Predation:

On December 15, 2003 about 50 Steppe Eagles (*Aquila nipalensis*) were observed preying upon the juvenile flock, in the Rann around Kuda. On December 23, 2003 no live chick was observed at the same sites, but there were a total of 1,650 remains of chicks preyed upon by the eagles. Predation of juveniles of Lesser Flamingo by the Steppe Eagles is recorded for the first time in the Indian subcontinent during the present study.

B) Greater Flamingos:

High Rates of Receding Water:

Total 21,000 Greater Flamingos were counted in February 2004 at the Flamingo City in Great Rann. Most of the adult birds were engaged in nesting. The water was about 10 m away from the nesting site where the depth was 46 cm. The depth of water at 50 m from the nest site was 64 cm. The OCM data of January 2004 showed inundation of Rann by deep water around Flamingo City. The salinity of water was 66.5 ppt and pH was 7.5. The food was abundant.

However, the water receded to 500 m away from the nest site. The salinity increased tremendously up to 80.6 ppt. The Remote Sensing Images showed decrease in water level and water spread area of the Rann There was a 50% decrease in total food abundance. At the end of the breeding season, only 259 adult Greater Flamingos were present along with 9,655 live juveniles in water. Total 1,102 chicks were dead and embedded in the soil of Rann, at the edge of nest site. The salt was also deposited on the legs, feathers of wing, neck, breast and abdomen.

4.8 Breeding Success:

The breeding success of Lesser Flamingos varied at different nesting sites during the study period. The nesting attempts by Lesser Flamingos failed in all the years, at Purabcheria in Little Rann due to egg stealing. The nesting attempt during 2002 near Zinzuwada in Little Rann was successful, however during following years the attempts failed due to flood (2003)

and insufficient inundation (2004). In spite of successful hatching of Lesser Flamingo in Great Rann around the Bela and Kuda, most of the young ones died.

At Flamingo City, the hatching success of Greater Flamingo during the year 2003-2004 was nearly cent percent; however the breeding success was reduced to 55.43 % due to heavy chick mortality at the end of breeding season.

5. Behavior:

The Behavioral patterns of flamingos were classified into (A) Egocentric , which is directed towards the individual itself and (B) Social behavior which deals with the interaction between the individuals. The later was further divided into (a) social behavior with direct interaction where two or more interact directly with each other, showing specific behavior and (b) social behavior without direct interaction which does not involve the direct interaction between individuals, but are performed in groups, have some impact on other individuals of the group and some time, followed by other individuals after performed by one.

Different Egocentric behaviors observed in flamingos were: (i) Wing-Leg Stretching (ii) Resting (iii) Bathing and (iv) Drinking Water.

The Social Behaviors which did not involved direct interaction with the other individuals were: (i) Alert Pasture (ii) Wing Salute (iii) Inverted Wing Salute (Bowing) (iv) Twist-Preen (v) Broken Neck Posture and (vi) Head Bobbing. The Social Behaviors which involved direct interaction between two or more individuals were: (i)Threat Behavior which included: Chrysanthemum/Threatening :Hooking and Ritual Bickering (ii) Sexual/Display Behavior.

6. Conservation and Management:

Threats to the flamingos identified during the study period were poaching, collision with the power lines and predation. Pollution was a major threat to their habitats. Threats to

their nesting colonies were: (i) Disturbances by human beings through eggs stealing activities and visits of the active nesting colonies (ii) Natural calamities such as cyclone, sudden flood during active nesting, over flooding of nesting grounds, drought years and high rates of receding water.

The management options suggested for the conservation of the flamingos are (i) Education and awareness among the local people surrounding the coastal areas regarding the conservation (ii) Social upliftment and alternative source of income generation to discourage people from poaching and egg stealing activities (iii) Enforcement of Law (iv) Protection through Legislation (v) Protection from high tension power lines by use of colored radium tags, which can shine at night and are clearly visible during daytime (vi) Management of pollution at their habitats (vii) Protection of Purabcheria Nesting site (viii) Protection of active nesting colony (ix) Rescue and rearing the young ones during high rates of receding water (x) Inundation of nesting grounds (xi) Habitat Protection / Designating flamingo habitat as Ramsar Site/Biosphere Reserve and (xii) discouraging Tourism at the nesting sites and encouraging it at regular foraging sites.

Anika Tere
(Candidate)

Dr. A. V. Ramchandran
(Guiding Teacher)
(Professor of Zoology)

Professor of Zoology
Department of Zoology
The Maharaja Sayajirao University
of Baroda, Vadodara-390 002.

Dr. P. V. Patel
(Professor and Head,
Dept. of Zoology)

Head of the Dept. of Zoology
Faculty of Science
The Maharaja Sayajirao University
of Baroda, Vadodara-390 002.

Dr. A. V. Ramchandran
(Dean, Faculty of Science)