Summary

More than 1200 species of birds inhabit India for at least part of their lives. They inhabit our forests, grasslands, deserts, wetlands, coastlines, and urban areas. Though they are everywhere, there are species that are declining at rapid rate and are on the verge of extinction (e.g. Great Indian Bustards, White-rumped Vulture etc.). However, birds and their habitats are threatened, principally as the result of human activities. Habitat loss and degradation results from activities such as extensive development, industrial agriculture, energy production, and natural-resource extraction.

Six species of Flamingos are known, all in the family Phoenicopteridae. These six species of Flamingos occurs in Africa, Asia, Europe, North America and South America. Of these six species, two species of Flamingos are found in India, The Greater Flamingo and the Lesser Flamingo. Both these species of Flamingos are resident and breeds in the Little Rann of Kachchh in Gujarat.

Lesser Flamingos (*Phoeniconaias minor)*

Lesser Flamingo (*Phoeniconaias* minor) is classified “Near Threatened” in the 2006 IUCN Red List of Threatened Species. The species is also listed in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) Action Plan, Appendix II of the Bonn Convention (CMS) and Appendix II of the CITES Convention. The Lesser Flamingo occurs regularly in 29 countries from West Africa, across sub-Saharan Africa and along the SW Asian coast to South Asia, and occurs as a vagrant in 25 additional countries. Though, its global population occurs in 10 primary range states, regular breeding is confined to just five sites in four of these countries (Childress et al. 2007).

Gujarat is one of the strong hold states of the ‘Lesser Flamingo (Phoenicopterus minor) in India. The portion of Gulf of Khambhat (GOKh) near Dholera-Roniyo bet in Ahmedabad and Bhavnagar districts, the coastal

areas of Bhavnagar, Jamnagar and Kachchh are major congregation sites for flamingos in non-breeding season (Tere 2005, Mundkar et al. 1989).

Why Are They Important on Global Map?

Due to its erratic breeding nature and very few known breeding sites, the population of Lesser Flamingo appears to be undergoing a moderately rapid decline (IUCN, 2001) and thus classified as 'Near Threatened' Species. Considering the population of Lesser Flamingo in India, Gujarat is the major stronghold of the species harboring more than 95% of the total Indian population and providing the two known breeding sites in the country. The species has never successfully bred outside Gujarat.

Lacunae

Most of the populations of Lesser Flamingos generally exists in remote areas, and thus were not studied in detail until recently (Morrison, 1975). The remoteness of many colonies has further restricted research efforts because investigators often cannot remain on site for extended periods. Studies have now addressed all species of flamingos (Ogilvie and Ogilvie, 1986), but nearly all investigations have focused on the breeding portion of the annual cycle. So far, studies on the Lesser Flamingos in Gujarat (India) have mainly focused on the breeding status, its distribution in the wetlands of Gujarat and its breeding distribution in the state. Informal attempts have been made so far to study its habitat characteristics during non-breeding season. Also no studies have so far addressed the behavioral pattern of the species both during the breeding and non-breeding cycle of the species. Understanding characteristics of this variable habitat and how flamingo use it, it is necessary to secure survival of the Lesser Flamingo population in the region.

Objectives

1. Study the habitat ecology of Lesser Flamingos at major sites of its congregation in Gulf of Khambhat: the non-breeding habitat.

2. Study behavioral ecology of Flamingo during breeding and non-breeding cycle.

3. Identify the threats to its key/ favorable habitats and conservation measures.

Study Area

The study area of the present study was broadly classified into two categories viz. Breeding areas and non breeding areas. The breeding habitat includes Surajbari Creek in the Little Rann of Kachchh and other breeding sites in the Little Rann of Kachchh. The non-breeding ground includes Kumbharwada Sewage ponds, saltpans and Newport saltpans of Bhavnagar district. Bhavnagar district is on the coastal region of the Saurashtra peninsula abutting the Gulf of Khambhat. Kumbharwada area lies in the northern boundary of the town of Bhavnagar. The area also has few saltpans of which some are abandoned (not used) and some are active. Based on the habitat types, the entire habitat was classified into three broad categories viz. i) Active saltpans area ii) Abandoned saltpan area and iii) Sewage waste water ponds. Newport saltpans on the other hand lie in the eastern boundary of the Bhavnagar town. The area is totally saline with high degree of salt production activity compared to Kumbharwada Saltpans. Besides the above sites, the data on breeding habitat and behavior during the breeding habitats were collected from the Little Rann of Kachchh, Cherwari mudflats, Flamingo city (Great Rann of Kachchh).

Materials & methods

The population estimation of Lesser Flamingo was done using point count method at various sites during the survey. The birds were counted using the block count method whenever large congregations were observed. The surveys at breeding sites were conducted from May to December when nesting congregations have been reported by previous studies. Whenever a breeding congregation was observed, the activity of the bird was monitored. The counts were made of number of birds present during early morning,

afternoon and evening. The numbers of built nests, nests in construction, birds engaged in courtship display were also enumerated. Efforts were also made to identify new nesting colonies.

Flamingo numbers were estimated through censuses from one or several points from the edge of the salt-pans depending on the size and shape of the lake/pan, by using Nikon binoculars of 10 X 50 magnification and Nikon spotting scope of 40X magnification. Besides counting the total bird population at any area, neighboring areas, between which bird movements were frequent, were counted on the same day. However, those areas were not considered for data analysis.

Behavioral Aspects

Different habitats available to the flamingos and their behavior in relation to habitat types over the non-breeding portion of their annual cycle were characterized. Flamingo's diurnal activity pattern during breeding as well as non-breeding period was studied in detail. Activity behaviors were recorded using Focal Animal Sampling techniques (Altmann, 1974). Activity-budget data were collected during diurnal hours (sunrise to sunset) with each day divided into three time blocks of: (1) morning; (2) afternoon; and (3) late afternoon or evening. Activities were categorized as feeding/foraging (Rooth, 1976), resting, locomotion/movement (flying and walking), preening, and alert. Movement with head up while foraging was classified as movement whilst movement with head down while feeding was recorded as foraging.

Habitat Characterization

The data were collected on salinity, pH, and dissolved oxygen (DO) and water temperature whenever the Lesser Flamingos were observed. Salinity was measured at every location of Flamingo presence or absence. A quadrate frame of 100 x 100 cm was designed to estimate the grass cover on the ground. The quadrate was further divided into 10X10 cm smaller sub-

quadrates and visual counting of each quadrate for the ground cover was made, and this was then further converted to % ground cover and % of bare ground. Sediment composition of the nests and adjoining potential nesting habitats were carried out to know the silt-clay-sand composition of the nesting habitats. Nesting soil from degraded/washed nests and soil samples from nearby mud-flats were collected to know if any marked difference in selection of nesting substratum was observed in flamingos. Foraging habitat selection was analyzed by the use of the Savage selectivity Index.

Results

Population

A total of 7840 Lesser Flamingos were recorded from Kumbharwada site during January 2009, which was also the highest count of flamingos at this site during the present study. This count is higher than reported by Tere during 2002 (6577 individuals), while Gadhvi and Zhala (2001), observed similar counts during 2001. Moreover, the stray notes on flamingo congregation in Kumbharwada has shown flamingo population at around 5000-9000 individuals (Bhatt, 2000; Gadhvi, 2001, 2009; Parasharya, 2005) which is in line with the population data collected during the present study.

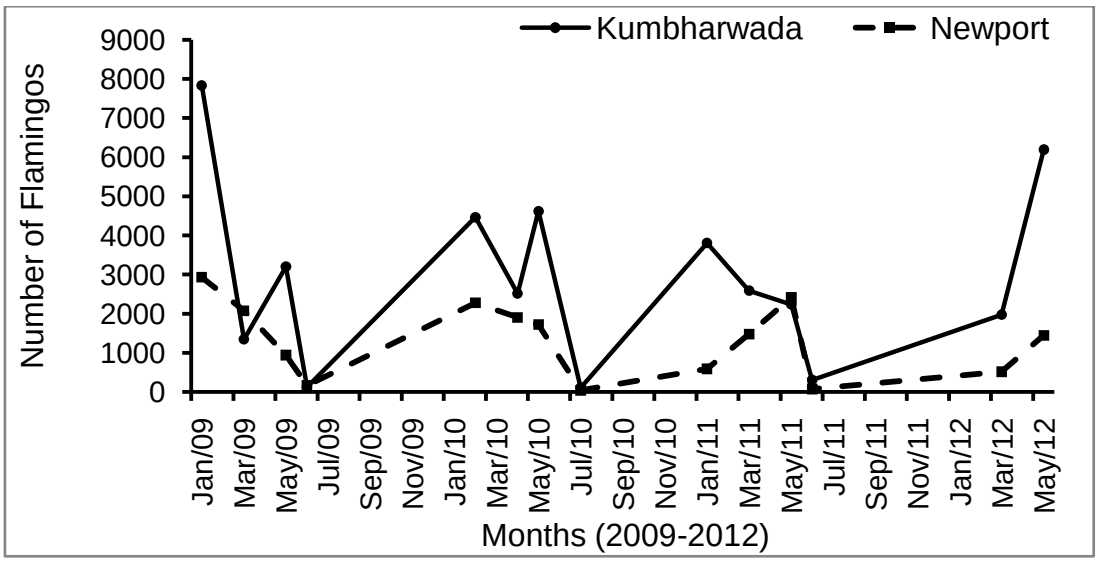


Fig 1: Comparative account of Lesser Flamingo population at both sites

At Newport site, 2935 Lesser Flamingos were recorded in January 2009. The population trend declined in subsequent months as the salt manufacturing activities are at its peak in mid-summer and thus in July 2011 42 individuals were recorded (Fig. 1).

The proportion of juveniles at both sites was highest in 2009 (17.33 ± 1.29). The percentage of juvenile Lesser Flamingos was lowest in 2012 13.83 ± 2.54. The current trend in decline in number of juveniles is negatively correlated with time (years), (r^2= -0.986, P= 0.014), suggesting that the decline may continue over the years if the habitat alteration continues over the impending period. Density of Lesser Flamingos was comparatively higher at Kumbharwada (15.7 individuals/ Ha.) site as compared to the Newport site (8.4 individuals/ Ha.) (F=0.55, $F_{critical}$ = 0.05, p=0.04). This difference in density could be due to the availability of different types of habitats at Kumbharwada site and also may be related to abundance of species' food resources.

Habitat Characterization

Both abiotic and biotic conditions fluctuated markedly but very differently at two sites used by flamingos in the study area. Salinity increased in the dry season as fresh water input decreases and evaporation is intensified. However, shallow salt pans of Newport were more saline than Kumbharwada saltpans because the Kumbharwada lacked the mediating effects of ocean tides and on the other hand (i.e. at Newport saltpans) freshwater input was less, and as they were shallower, the evaporation rates were higher. Various physical parameters of habitat governing flamingo distribution in the study area were evaluated for its association with occurrence of the species in various habitat types in both Kumbharwada and Newport sites.

Flamingos in Kumbharwada Sewage ponds and abandoned saltpans preferred areas with low salinity. During the present study, flamingos were evenly distributed with salinity in different habitat types, however, the extreme

saline saltpan habitats at both the sites were avoided by the flamingos and were only used for resting activity.

The DO values at sewage ponds habitat at Kumbharwada site, showed slightly positive correlation with flamingo numbers ($r = 0.48$, $p < 0.001$). However, a weak correlation was observed between flamingo numbers and DO in abandoned saltpan habitats. Used saltpans were mainly used for resting and self maintenance activities only and also these habitats showed depleted levels of which did not show correlations with flamingo numbers.

Considering the habitat preference of the species, the species used abandoned saltpans at both site more than its extent. Also sewage ponds at Kumbharwada sites were more preferred compared to other sites. This preference for a particular habitat suggests the water level, DO and salinity levels of the species. However, density and abundance of food may also be one of the regulating factors.

Breeding Ecology

The nesting season of the Lesser Flamingos observed during the present study was from mid July to October in different breeding habitats surveyed such as Cherwari creek, Littler Rann of Kachchh, Great Rann of Kachchh. During the present study, the nesting of the species was not recorded at its traditional breeding sites, including the well known Anda beyt or Flamingo city (in 2011). The species also congregate in large numbers at Little Rann of Kachchh, but did not engage itself in nesting. Nests of Lesser flamingo are conical in shape with basal diameter being about 1.1 to 1.6 times that of the top. Nests are built in clusters ranging from 32 in 2009, 16 in 2010 and 23 in 2011.

The mean nest density during the breeding season of 2009 was 1.28, in 2010 it was 1.09 and in 2011 it was 1.13, which did not show much variation (Table 1). Number of nests in clusters also varied among different breeding seasons

with 10 to 240 in 2009, 12 to 69 in 2010 and 8 to 142 in 2011. Nest height measured by other authors at Surajbari site was 11.7 cm (min 6.4 cm and max 18.0 cm) (Tere, 2005).

Table 1: Comparative statement showing nesting details of Lesser Flamingo at Surajbari nesting site

Sr. No.	Year	Total No. of Nests	Area (ha)	No. of Nest clusters	Average No. of nests in a cluster (± SD)	Nest Density (nests/sq. mtr) (± SD)
1	2009	2387	1.48	32	74.6 ± 60.2	1.28 ± 0.48
2	2010	596	0.94	16	37.2 ± 18.7	1.09 ± 0.39
3	2011	1025	1.06	23	44.5 ± 38.6	1.13 ± 0.37

The present study recorded the nests with mean height of 30.1 cm (range 29.4 to 30.8) which is high as compared to studies carried out by Tere (2005). Studies carried out in Africa have also recorded 20.3 cm high nests (Brown and Root, 1971) which is slightly smaller than height of nests recorded at Surajbari from 2009 to 2011 nesting season. The basal diameter recorded during the present study was 41.7 cm (range 35.4 to 46.1). Eggs measured for length and breadth at Surajbari nesting site were 72.83 mm (3.30 SD) X 49.15 mm (1.95 SD). The largest egg measured was 77.43 mm X 47.23 mm and smallest egg measured was 63.48 mm X 48.9 mm.

Behavioral studies

Feeding was the dominant activity each month among adult flamingos, but feeding decreased during the nesting period in May and June as time spent in nest building and resting increased. This decrease was not significant ($P > 0.05$) but nevertheless could imply that Lesser Flamingos rely (at least

partially) on nutrient reserves acquired before the onset of nesting as reported for several species of geese (Ankney and MacInnes, 1978).

Overall, on an average adult Lesser Flamingos at Kumbharwada site spent 46.6% of their diurnal time in feeding, followed by resting (20.2%), preening (18.6%), movement (9.9%) and alert (3.86%). Resting activity was highest during early morning hours (36.17% ± 13.34, SE 4.45), and was least during late evening (9.95 % ± 9.46, SE 3.15) Feeding occurred all throughout the day, but it was at its peak ($\bar{x}$ = 63.6% ± 25.8, SE= 1.03) during evening hours (16:00 to sunset) (Fig. 2).

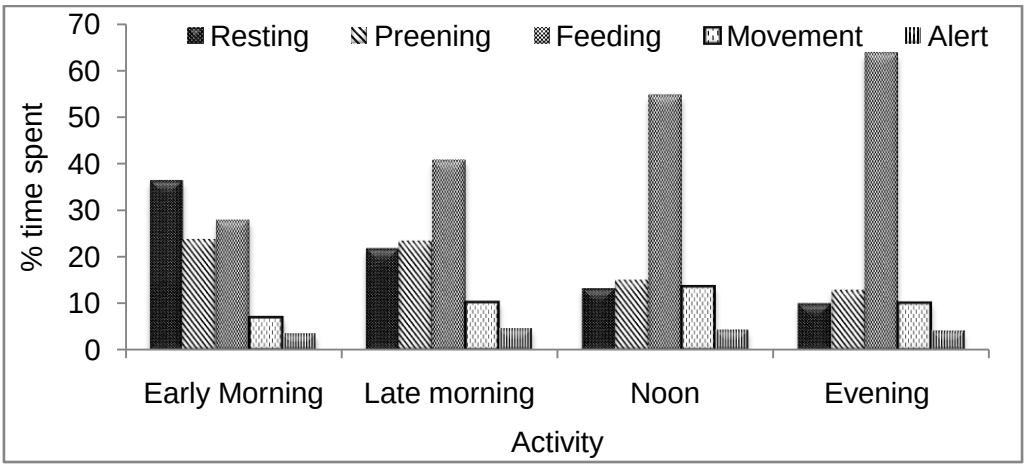


Fig 2: Time spent (in %) by Lesser Flamingos in different time blocks at Kumbharwada site

An inverse proportion in time spent in feeding and resting behavior was observed among different time blocks in flamingos. Feeding and Resting showed negative correlation during late evening. (R^2= - 0.58, p<0.001). Juveniles at both Kumbharwada and Newport site spent considerable time in feeding followed by movement and resting. Flamingos spent 25.3% ± 14.9 of their early morning time resting and 12.8% time preening. Feeding was the main activity of juveniles in the evening (74.9%), which is significantly more as compared to the adult's (63.6%). Resting was the predominant activity of adult breeding flamingos at Surajbari creek, followed by nest building and preening. Flamingos spent 70.3 % of its diurnal time resting and 8.8% time in

nest building. Flamingos spent only 8.6% of their diurnal time feeding, which is significantly low as compared to non-breeding sites.

Group size fluctuated during the day, with larger groups being observed during the morning and smaller groups from midday to evening. ($r = -0.74$, $p=0.004$, $n = 13$). Logarithmic regression showed that vigilance and time spent in resting decreased as group size increased ($r^2 = - 0.85$, $p < 0.001$ for alert and $r^2= -0.53$, $p < 0.001$ for resting, DF=20), (Fig. 28). Inversely, time spent in movement and feeding increased their frequency with group size ($r^2 = - 0.90$, $p < 0.001$, for feeding and $r^2= 0.46$ ($p < 0.001$ for movement, DF=20). It was observed that mean time spent by Lesser Flamingos in display was 95.4 ± 30.2 seconds (min 45 - max 142 seconds). The average flock size displaying varied and did not follow any particular pattern. The mean flock size displaying was 36 birds ± 13 (min 18 - max 61). A positive correlation was observed between flock size and display time ($r^2 =0.77$, $p <$ 005).

Threats and Conservation Management

During the present study, various threats were identified at both the breeding and non-breeding habitats. The major threats at breeding habitats are both natural and anthropogenic.

Breeding site

One of the major threats observed at Surajbari nesting site is egg lifting by fishermen and local community of surrounding villages. There are reports of single fishermen collecting 200-300 eggs in a day. As, Cherwari mudflats are located amongst the Hadkiya creek, the waters during highest high tide (full moon day) inundates the nesting and the nests built near the edges of the small channels are washed off or are damaged.

During the present study, flamingo city was visited during March 2011. It was observed that the island or the 'Anda beyt' is under serious threat of erosion.

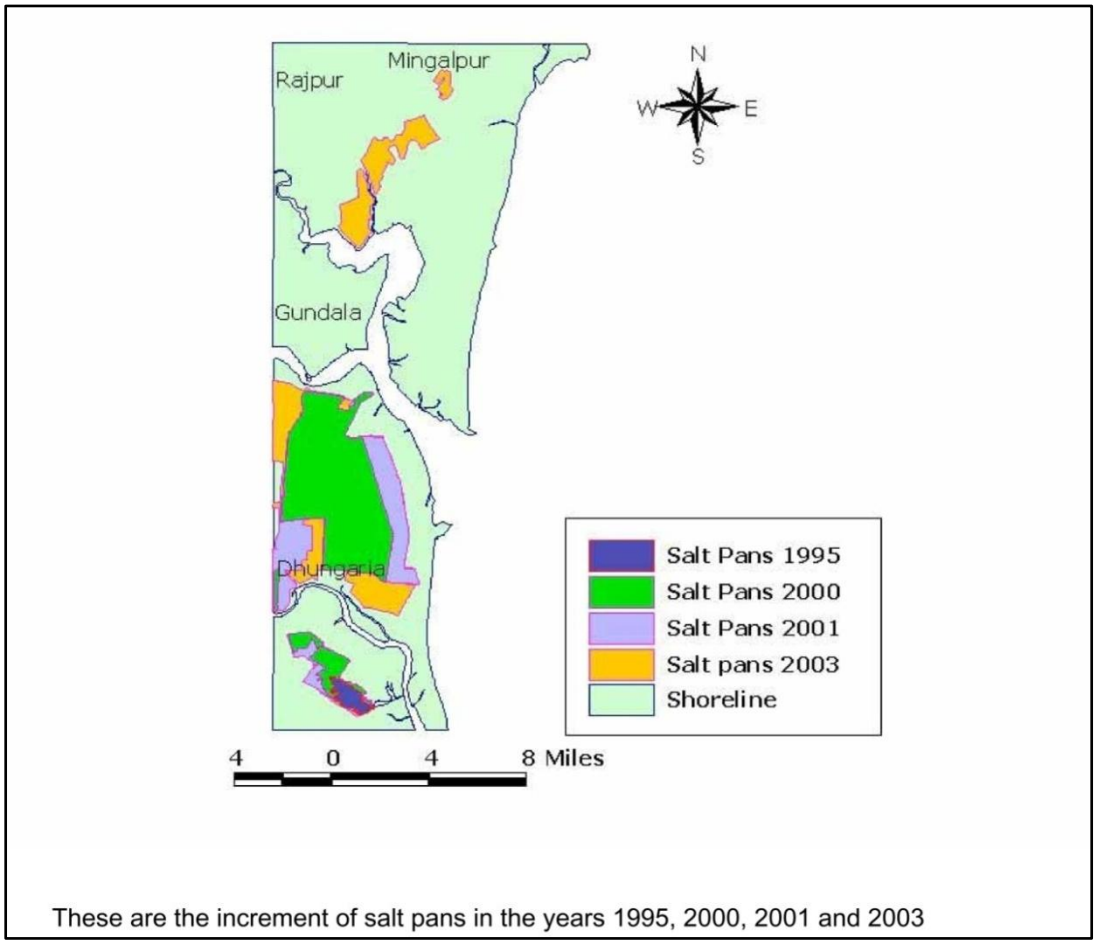
Due to the inundation of tidal waters from Cori creek and excess rain water from Banas River, the island area has reduced drastically. The total area of flamingo city during Salim Ali's visit in April 1945 was 9.83 Hectare (1,17,600 sq yards) (JBNHS, Vol. 45). During 2011 visit (present study), the measured area of flamingo city was 2.89 hectares, suggesting the decrease of almost 70.6% in total area of flamingo city during the span of 66 years (1945 to 2011). Thus, suggesting a decline of 0.10 Hectare per year.

Non-breeding site

Major part of the Kumbharwada site being a sewage water ponds, it is highly prone to disturbance by un-treated waste water disposal from surrounding industries, other disposal of industrial wastes, house hold wastes and from cattle owned by surrounding dwellers.Cattle herds of slum dwellers living around the Kumbharwada site, pose a serious threat to feeding habitats of Lesser Flamingo. The cattle herds, especially buffalo use Kumbharwada sewage area and cool itself by lying in mud or sewage open water habitats during the heat of the day, disturbing the feeding activity of the flamingo (Plate 1A, B). It was observed that, industries surrounding the Kumbharwada area release the untreated waste water into the Sewage ponds which are highly acidic or basic disturbing the water chemistry of the area and ultimately affecting the primary productivity of the ponds. *P. coarctata*, a salinity indicator grass species has been observed to spread very rapidly in the sewage pan area of the Kumbharwada study site. The species showed increase in its spread among different years.

A study carried out by Charatkar et al. (2004), shows that the there is a tremendous increase in area under saltpans category in Gulf of Khambhat since past decade. The area under saltpans which was 6.8 sq.km in 1995 increased ten folds in five years (58.79 sq km in 2000). In 2001, the area under saltpans increased to 78.68 sq.km showing the rise of 33.7% in one year. In 2003, the area under saltpans was 112.32 Sq km, showing the rise of 42.8% (Fig. 2).

One of the important threats to flamingo habitats is conversion of coastal waste lands into salt pans. During the recent period, many such areas at Newport site and Kumbharwada site are being converted to saltpans. These conversion leads to the reduction in the feeding areas for flamingos, as saltpans are rarely used for feeding by flamingos (present study).



Source: Source: Charatkar et al. (2004)

Fig 2: Increment in area of saltpans from 1995-2003

Discussion

The Lesser Flamingo is a highly itinerant species (Evans, 1985), moving frequently and impulsively from lake to lake within the Great Rift Valley (Brown, 1975; Vareschi, 1978; Tuite, 1979; Brown et al., 1982; Tuite, 2000), and between salt pans and other wetlands in southern Africa (Borello et al*.,* 1998; Mc Culloch et al*.,* 2003), but returning to the same breeding sites. Traditionally, the frequent inter-lake movements have been thought to be associated with fluctuation in food abundance (Vareschi, 1978; Tuite, 1979).

Both abiotic and biotic conditions fluctuated markedly but very differently at two sites used by flamingos in the study area. Salinity increased in the dry season as fresh water input decreases and evaporation is intensified.

Flamingos are adapted to high saline conditions and can tolerate salinities above 150 ppt (Allen, 1956). But salinity indirectly affects flamingos because it affects distribution and abundance of the food base (Britton and Johnson 1987; Hurlburt et al., 1986). The present study is first of its kind since earlier studies have only addressed the population pattern of the species in various coastal habitats of Gujarat (Tere, 2005). The utilization of these habitats by flamingos is a result of several interacting factors.

The present study demonstrates that, climatic conditions influence the hydrological balance and water chemistry which in turn determines site physical characteristics and Lesser Flamingo distribution and activities, foraging style and flock dynamics, hydrological balance and water chemistry also influences the courtship behaviour and breeding requirements and success of the species.

Lesser Flamingos do not necessarily breed every year. They breed only when conditions are suitable and optimum water levels are maintained throughout their breeding cycle (Brown and Root, 1971). Lesser Flamingos do not breed even if the climatic conditions or state of the mudflats appear suitable for nesting at certain sites (Brown and Root 1971). Water level fluctuations have

been found to affect flamingo breeding by wave destruction of nest mounds and lack of access to freshwater and food (Brown, 1973; Cezilly, et. al., 1995; Simmons, 1996). The incidence of Flamingos abandoning the nesting site in Little Rann of Kachchh was also recorded during 2011, where around 3000 abandoned nests with eggs and chicks were recorded during the present study.

Flamingos are gregarious birds and form very large feeding groups. Lesser Flamingo mainly preferred the sewage ponds, abandoned saltpans and mudflats in the study area with shallow water regime. This preference for shallow water bodies may be related to the species' foraging behavior, characterized by feeding on small diatoms and Spirulina near the lake banks (Brown, 2008). Feeding was the dominant activity each month among adult flamingos, but feeding decreased during the nesting period in May and June as time spent in nest building and resting increased. There was a significant difference in the time allotted to feeding by adult and juvenile/sub-adult Lesser Flamingos at both Kumbharwada and Newport site. Juveniles/sub-adults spent relatively more time in feeding as compared to adults as juveniles initially are less successful at feeding and thus spend more time in feeding (Carss, 1993). In the present study, flamingos showed slight behavioural differences at different water levels: they foraged in shallower water, rested and preened in deeper water. Other studies have also shown that flamingo numbers are not correlated with food abundances.

The finding of the present behavioral study underlines the complexity of social and ecological factors affecting the behavior of group-living species. They also suggest that the spatial distribution of suitable feeding areas, optimum salinity, DO and water level in the studied habitats, seem to influence the flocking behavior and feeding ecology of the studied flmingo flocks.

The present study demonstrates various threats identified at both breeding and non breeding habitats of the species. The threats at breeding sites included egg proliferation, disturbance to nesting sites by fishermen, damming of rivers that drain into LRK resulting into low or no water at the time of flamingo breeding. Threats at breeding sites include pollution from the surrounding industries at Kumbharwada and conversion of abandoned saltpans into salt manufacturing units at Newport site.

Lesser flamingos appear to utilize sites within lakes selectively depending on climatic, hydrological, limnological as well as the physical characteristics. The present study have only been done on two different habitat types in Gulf of Khambhat and at one breeding site in Cherwari. There is a need for a comprehensive research on post-breeding dispersal, breeding biology of the species and flamingo movements within sites to appraise ecological conditions in other flamingo breeding and non-breeding sites in the state. This will enable design of effective intervention strategies that are specific to critical sites that ensures lesser flamingo's conservation.