Chapter 1 Population of Lesser Flamingo

The information about Lesser Flamingo population in India is available through Asian Waterfowl Census (AWC) (Perennou and Mundkur 1992; Mundkur and Taylor 1993; Lopez and Mundkur, 1997). The present study involves population estimates from Sewage pans, and Saltpans of Kumbharwada and saltpans and mudflats of Newport site located on the outskirt of Bhavnagar City of Gujarat, India. The Lesser Flamingo population in the study area was higher (Table 1) during the initial study period (Table 1) however, due to subsequent changes and modifications in some part of their habitat; its population was observed to be declining (Table 1).

The highest numbers of flamingos (10,775 individuals) were observed in the month of January in 2009 and lowest numbers (154, all sub-adults) were observed in the month of September 2010. This low count is due to the fact that majority of the adult Lesser Flamingos had left these two sites and migrated to the breeding grounds in Little and Great Rann of Kachchh.

Of the two sites, about 67.1 % (± 3.98 SE, 95% CI (58.53, 75.74), p=0.01) of the total population was observed at Kumbharwada site and 32.9 % of population was observed at Newport site (± 14.9, SE, 95% CI (24.3.53, 41.5), p=0.01).

Table 1: Number of Lesser Flamingo at both the study sites from 2009-2012 (Non-breeding phase)

	Population (mean & SD)							
	2009		2010		2011		2012	
	Adults	Juvenile (mean & SD)	Adults (mean & SD)	Juvenile (mean & SD)	Adults (mean & SD)	Juvenile (mean & SD)	Adult (mean & SD)	Juvenile (mean & SD)
Months	Kumbharwada site							
January-February	6240 ± 1390	1600 ± 399	3715 ± 763	850 ± 179	2606 ± 480	660 ± 86	4611 ± 182	808 ± 143
March-April	1390 ± 958	430 ± 142	4765 ± 920	415 ± 48	2076 ± 393	610 ± 99	2686 ± 404	158 ± 17
May-June	2776 ± 1039	88 ± 20	3163 ± 619	290 ± 17	2478 ± 768	518 ± 46	6283 ± 1134	134 ± 21
Months	Newport site							
January-February	898 ± 165	197 ± 86	1939 ± 284	411 ± 110	2623 ± 618	172 ± 55	4839 ± 956	808 ± 157
March-April	3010 ± 1167	810 ± 198	3229 ± 725	372 ± 91	6875 ± 1357	405 ± 195	2069 ± 706	358 ± 122
May-June	1807 ± 590	712 ± 100	1692 ± 948	262 ± 83	9480 ± 1439	372 ± 66	3714 ± 1080	112 ± 61

The values are Mean ± SD of monthly observations.

Population in Kumbharwada

Kumbharwada has been one of the important feeding sites of Lesser Flamingos in Gujarat (Gadhvi, 2008; Parasharya and Tere, 2004). The flamingos arrive at Kumbharwada site during the months of December-January and stays up to June-July which marks the breeding season of the species in the state (Plate 1 A, B, C). However, during August and September, scattered populations in small numbers of sub-adults and juvenile Lesser Flamingos were observed in Kumbharwada and Newport areas which were not considered for the population data and further analysis (Plate 3 A,B).

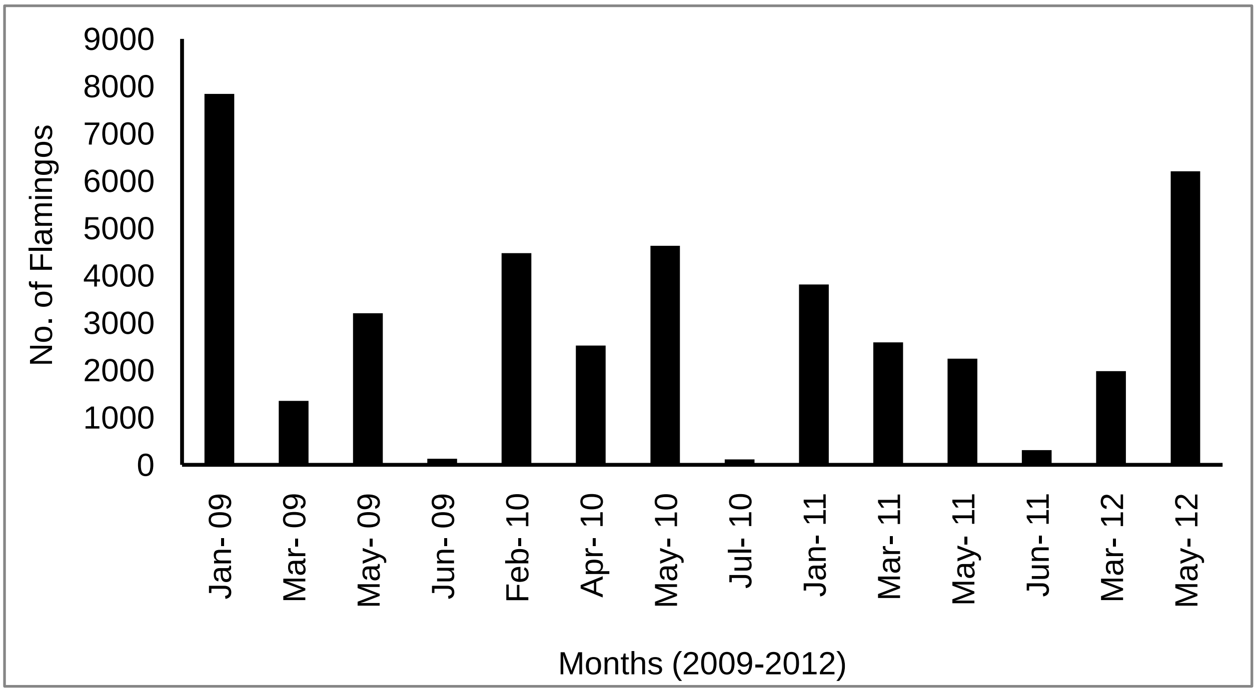

Fig 1: Estimates of Flamingo numbers at Kumbharwada (2009-2012)

A total of 7840 Lesser Flamingos were recorded from Kumbharwada site during Jan-Feb 2009 which was the highest count of flamingos at this site during the present study. The population later spread to nearby coastal areas and saltpans and the population reduced to subsequently to 1820 birds in March-April and 2864 in May-June 2009. A similar trend was also recorded in 2010 were initially the Flamingo 6651 flamingos were recorded in January-February 2010 and reduced to 1571 birds in March-April 2010. In May-June, the population increased to 4124 individuals. In Jan-Feb 2011, the mean population was 3266 individuals, which in May-June 2011 reduced to 2996 individuals. Similarly in 2012, 5419 flamingos were recorded in January-February, and in March-April only 344 individuals were recorded from the Kumbharwada site, which was lowest count of the species for that year (Fig 1 and Fig 3).

Population of Juvenile Lesser Flamingos

Kumbharwada area has been traditional feeding sites for both adults and juvenile Lesser Flamingos in India. During the present study also, juvenile Lesser Flamingos (age > 1 year) were recorded from various habitat types in Kumbharwada (Plate 1 B). The highest number of juveniles (1600 ± 399) was recorded in January-February 2009, which was also the period of highest count of Adult Lesser Flamingos from the Kumbharwada site. 850 ± 179 juveniles were recorded during January-February 2010 and 290 ± 17 juveniles were recorded during March 2010. In June 2010, only 88 juveniles were recorded, which was the lowest count at Kumbharwada site during the study period (Table 1).

A clear trend of decline in the juvenile population was recorded from January to May during the study period. The lowest population of juveniles was recorded during March-April 2012.

Population in Newport Saltpans

Newport saltpans akin to Kumbharwada saltpans are important feeding ground of Lesser Flamingos in Bhavnagar. However, the population of Flamingos at Newport saltpans has never been out numbered population at Kumbharwada during the study period. This may be due to various salt manufacturing activities around the flamingo habitats at Newport saltpans (Plate 2 A).

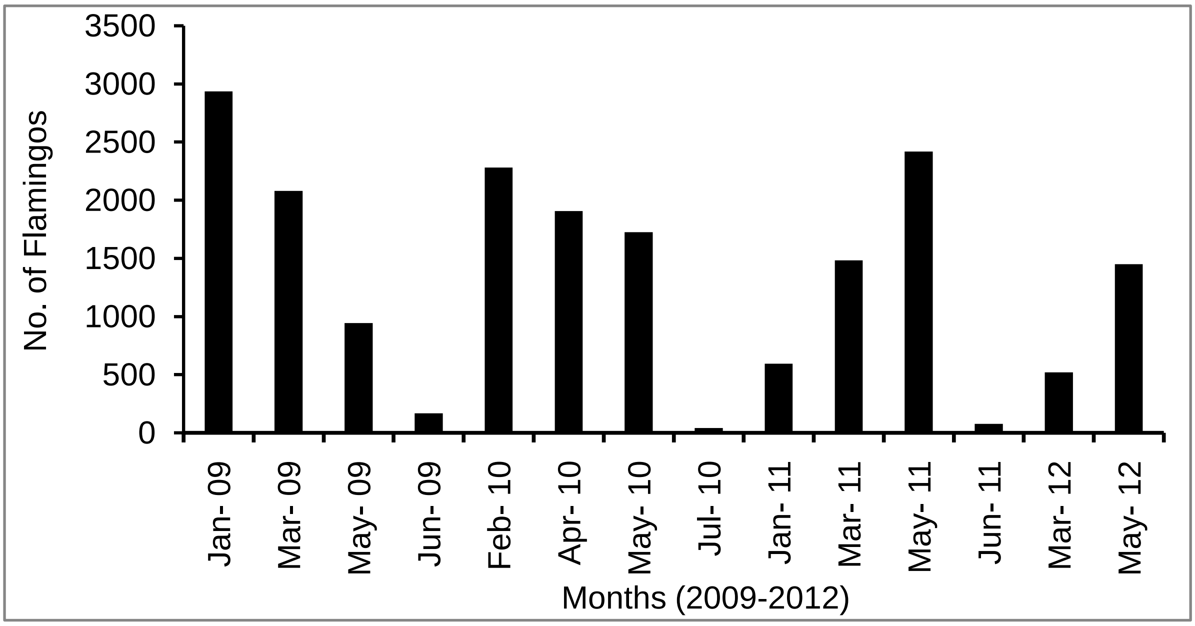

Fig 2: Estimates of Flamingo numbers at Newport saltpans

During the present study, 2935 Lesser Flamingos were recorded in January 2009, which was the highest count of the species at Newport study site during the present study. This area has traditionally been important feeding habitat of the species due to its vicinity to the Gulf of Khambhat, but recent anthropogenic activities especially salt manufacturing has compelled flamingos to leave this area and move to coastal areas of Ghogha and other coastal sites (Fig 2).

The population trend declined in subsequent months as the salt manufacturing activities are at its peak in mid-summer and thus only 2080 birds were recorded in March, 945 in May and just 169 individuals in July 2009. Similar trend in population fluctuation was also repeated in 2010 wherein population was highest (2280 individuals) in January and lowest in July (42 individuals) (Fig 2 and Fig 3).

Population of Juvenile Lesser Flamingos

Newport site is also one of the important feeding grounds for juvenile Lesser Flamingos. Moreover, during breeding season, juvenile or sub-adult Lesser Flamingos were observed only at Newport site.

The highest number of juveniles at Newport site (810 ± 198) was recorded during March 2009. 411 ± 110 juveniles were recorded during January-February 2010 and 262 ± 83 juveniles were recorded during March 2010. In June 2012, only 112 ± 61 juveniles were recorded, which was the lowest count at Kumbharwada site during the study period (Table 1).

<u>Comparative account of both the study sites</u>

Considering the overall population of Gujarat and India, it appears that, the Kumbharwada area and New Port saltpans collectively holds sizable population of Lesser Flamingo which in year 2009 accounted for about 3.6 % of the total population of Gulf of Khambhat.

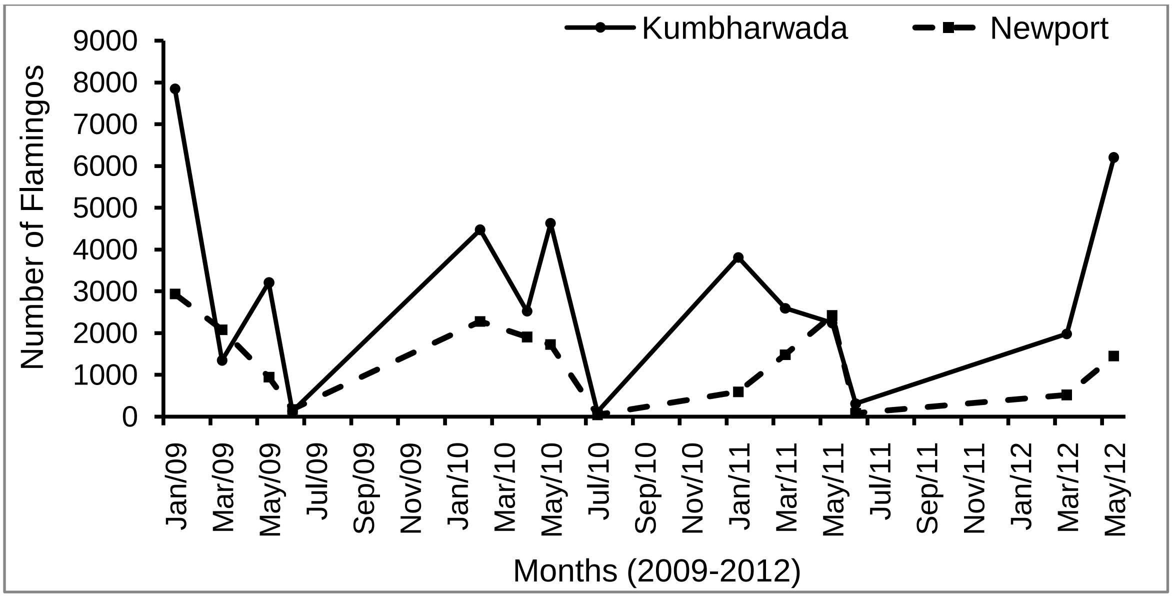

Fig 3: Number of Lesser Flamingos on both the study sites (2009-2012)

Past records on the population of Lesser Flamingo in these areas have also indicated that the area is a major feeding ground for Lesser Flamingos during the non-breeding season (Gadhvi, 2000; Tere and Parasharya, 2004).

Distribution of Lesser Flamingos at two sites

Lesser Flamingos were observed to be utilizing the Kumbharwada site more than Newport site. Of the total population in 2009, 58.2% of the Lesser Flamingos were observed at Kumbharwada site as compared to 41.8% at

Newport Site. Similarly, 67.2% flamingos were observed at Kumbharwada site in 2010. Due to conversion of abandoned saltpans into salt manufacturing fields, only 19.9 % flamingos were observed in Newport site (Fig 4). Thus, flamingos were observed switching habitats depending on various factors such as habitat alteration, food availability, water level and other factors ($t=4.3$, $p<0.001$) (fig. 4).

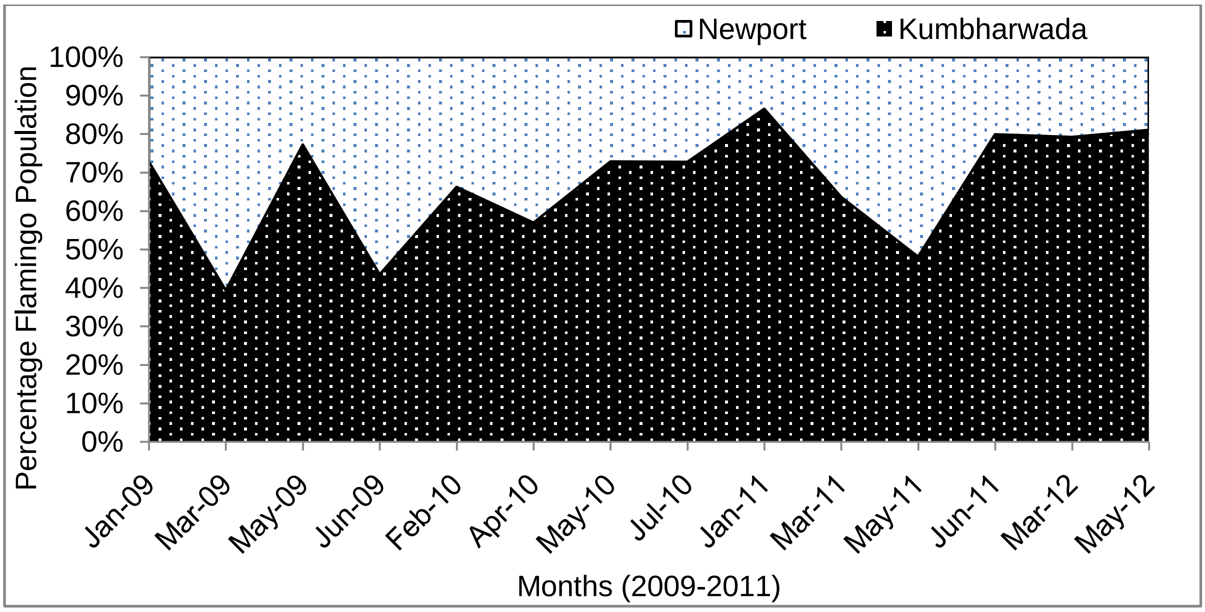

Fig 4: Flamingo distribution at two study sites across the study period

Ratio of Adult to Juvenile Flamingos

Sampling the proportion of juveniles among flocks of shorebirds is a potential tool for estimating how successful annual reproduction has been for birds migrating between breeding and non-breeding sites. During the present study also, an attempt to study adult juvenile ratio was made so as to know the population structure and habitat utilization by both adult and juvenile Lesser Flamingos.

The proportion of juveniles (Table 1) at both sites was highest in 2009 (17.33 ± 1.29), in year 2010, the proportion reduced to 15.69 ± 2.90. The percentage of juvenile Lesser Flamingos was lowest in 2012 13.83 ± 2.54. This decrease was mainly due to conversion of abandoned salt pan areas into salt manufacturing units at New Port site and increase in the anthropogenic activities at the Kumbharwada site (Table 2).

Table 2: Percentage proportion of Juvenile Lesser Flamingos at both sites

Year	**n**	**Adult ∑n**	**Juvenile ∑n**	**% of Juveniles** (±SD)
2009	18	75042	13007	17.33 ± 1.29
2010	18	69868	10963	15.69 ± 2.90
2011	18	42971	6481	15.08 ± 5.25
2012	18	81480	11265	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 (Fig 5).

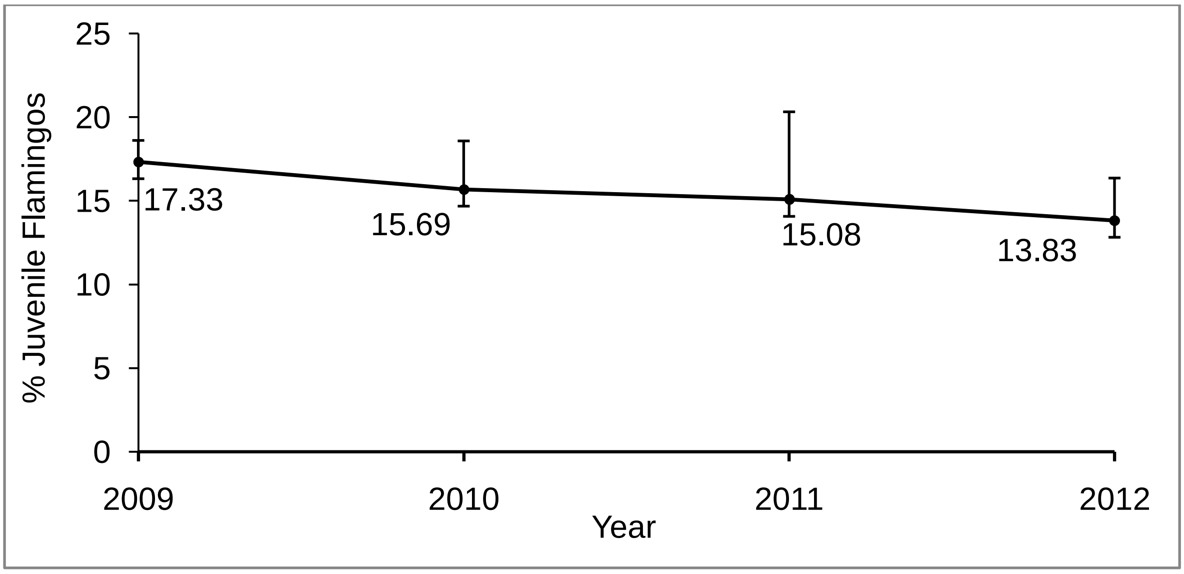

Fig 5: Rate of change in % of juvenile population at both the study sites

Density of Lesser Flamingos

Kumbharwada and Newport sites, as described earlier, were divided into different micro-habitats based on various hydrological and habitat features.

Density of flamingos was calculated as number of adult Lesser Flamingos per hectare.

Kumbharwada Site

Based on the habitat types, the entire habitat was classified into three broad categories viz. i) Sewage waste water areas (Sewage pans) ii) Active saltpans (Used Saltpans) area iii) Fellow Land and iv) Abandoned saltpan. The areas have been differentiated based on vegetation type they support, amount of water they receive, source of water (fresh or saline) and salinity.

Table 3: Density of Lesser Flamingo in various habitat types at Kumbharwada site

Sr. No.	Habitat Type	Area (Ha.)	n	No. of Flamingos ∑n	Avg. Density (Indi./Ha)	Std. Dev
1	Sewage waste water areas (Sewage pans)	230.2	16	8009	15.9	8.6
2	Active Saltpans	247.0	8	1168	20.9	17.7
3	Abandoned saltpan	15.0	8	3347	10.4	7.6

In Sewage ponds, the average density of adult Lesser Flamingos was 15.9 ± 8.6 individuals per hectare (maximum 38.7, minimum 5.17), in abandoned salt pans the density was 20.9 ± 17.6 birds/ hectare (maximum 51.5, minimum 3.3) and in used saltpans habitat it was 10.4 ± 7.6 (maximum 25.3, minimum 2.6) (Table 3). The reason for higher standard deviation or higher fluctuation in density in used saltpan habitat is due to the limited use of this habitat by flamingos i.e. for resting only. Thus, during late mornings and noon when flamingos are busy feeding, they avoid this habitat resulting into low density of birds in these habitats.

Newport Site

Abandoned saltpans showed the highest density of 16.5 individuals/ ha. ± 13.3 (maximum 41.9 indi./ha, minimum 5.1 indi./ ha) among all the three habitat types at Newport site. This was followed by used saltpan habitat type. The average density in used saltpan habitat was 5.1 indi/ ha ± 3.19 (maximum

10.3 indi./ha, minimum 2.1 indi./ ha). Mudflats showed the lowest density of 3.6 indi./ ha ± 1.7 (maximum 6.1 indi./ha, minimum 1.2 indi./ ha). The reason for low density in mudflats is mainly due to frequent water level changes and vast area of mudflats of which only a small portion was utilized by flamingos (Table 4).

Compared to Kumbharwada site, the Newport site showed significant differences in density as Newport site is very close to Gulf of Khambhat and thus flamingos are attracted by the mudflats of GoKh. Flamingo density varied within different habitat types and also showed temporal variation in relation to time of the day, food availability, water level and other ecological factors.

Table 4: Density of Lesser Flamingo in various habitat types at Newport site

Sr. No.	Habitat Type	Area (Ha.)	n	No. of Flamingos ∑n	Avg. Density	Std. Dev
1	Used Saltpans	379	16	6606	5.1	3.19
2	Abandoned saltpans	278.8	12	7657	16.5	13.3
3	Mud flats	290	12	4279	3.6	1.72

Other Major Congregation Sites

Major congregations of Lesser Flamingo are found in Gujarat. The portion of Gulf of Khambhat (GoKh) near Dholera-Roniyo bet in Ahmedabad and Bhavnagar districts and that of Gulf of Kachchh (GoK) near Surajbari (along the Surajbari creek), in Kachchh district are two well-known areas where large non-breeding and breeding congregations occur, respectively (Tere, 2005; Mundkur et al., 1989).

During the present study, population of the species in other coastal areas of Gulf of Khambhat, known breeding sites and other major congregation sites of the species in Gujarat such as Little Rann of Kachchh and Great Rann of Kachchh was observed to study the their use of different habitat by the species (Table 5). All these sites were visited regularly during both breeding and non-breeding season except Roniyo beyt which is not accessible during breeding season (monsoon) due to high winds and rainy season.

Table 5: Population estimates at other major congregation sites of Lesser Flamingo

Congregation Sites	2009		2010		2011		2012	
	Non-breeding Season	Breeding Season	Non-breeding Season	Breeding Season	Non-breeding Season	Breeding Season	Non-breeding Season	Breeding Season
Sabarmati Estuary (Vadgam)	7244	3515	21500	4100	1990	1070	11458	6270
Little Rann of Kachchh	1428	23600	11,250	49,800	4028	66,700	5800	37,400
Roniyo Beyt	12700	NA	72000	NA	13500	NA	NA	NA
Surajbari Creek	00	78000	31	19800	00	44600	00	17300

Sabarmati Estuary, Vadgam (22^0 10' 56.6" N and 72^0 23' 11.8" E)

This is one of the important non-breeding habitats of Lesser Flamingos in the Northern Gulf of Khambhat. During the present study, 7,244 Lesser Flamingos were observed during March 2009, 21,500 birds were observed during March 2010, 1990 individuals were observed during April 2011 and 11458 birds were recorded during March 2012. The Sabarmati estuary at Vadgam is also one of the important feeding grounds for sub-adult and juvenile Lesser Flamingos as flamingos were also observed during breeding season of the species. During the breeding season of 2009 and 2010, 3515 and 4100 Lesser Flamingos were observed respectively, while in 2011 and 2012, 1070 and 6270 birds were observed all of which were sub-adults (Table 5).

Roniyo Beyt (Gulf of Khambhat) ($22^0$09'39.3" N and $72^0$21'49.2" E)

Roniyo beyt in the Gulf of Khambhat was visited to know the population of Lesser Flamingos in the Gulf. As, the beyt is amidst the Gulf of Khambhat, it is merely impossible to reach Roniyo beyt after the month of May and hence, data collected for Roniyo beyt is only for non-breeding season. During the present study, Roniyo beyt could not be surveyed in 2011. A total of 12700 Lesser Flamingos were observed in February 2009, 72000 birds in 2010 which is approximately 9% of the total global population of the species, and 13,500 birds in 2011 (Table 5). The count of 72000 birds in February 2010 was the highest population of Lesser Flamingo recorded during the present study. Thus Roniyo beyt is considered as one of the important feeding grounds of Lesser Flamingos in Gujarat.

Little Rann of Kachchh (22°55’ to 24°35’ N and 70°30’E to 71°45’ E)

Littler Rann of Kachchh or Wild Ass Sanctuary is one of the six known breeding sites of Lesser Flamingos in the world. It one of the very few important habitats for Lesser Flamingos in Gujarat used by flamingos both during breeding and non-breeding season (Plate 2 B). However, during the breeding season (July to October) large congregations of Lesser Flamingos are observed at the points of convergence of Sarswati, Rupen and Banas Rivers into the Little Rann. About 23,600 Lesser Flamingos were observed during the field visit of July2009; about 49,800 individuals were recorded during July 2010. Similarly, 66,700 birds were recorded during October 2011 and 37,400 individuals were recorded during July 2012. Lesser Flamingos were also recorded during non-breeding season in Little Rann of Kachchh mainly near Dehgam Dhasi, Tikar Dhasi and Navatalav (Table 5). A total of 11,250 birds were recorded during January 2010 and 4028 birds during February 2011 (Plate 3 C).

Surajbari Creek (23^0 12' 30.3" N and 70^0 45' 38.8" E)

Surajbari creek or Hadkiya creek is at the point where tidal waters of Gulf of Kachchh enter Little Rann of Kachchh. The mudflats of Surajbari provide an ideal habitat for nesting of Lesser Flamingos and thus attract thousands of birds during breeding season (Plate 2 C). This site was only once surveyed during non-breeding season and it was observed that, Lesser Flamingos do not use this site during non-breeding season. Only 31 Lesser Flamingos were observed during January 2010 and no birds were recorded during subsequent years during the study period (Table 5) (Plate 4 A).

A total of 78,000 individuals of adult Lesser Flamingos were observed in the mudflats of Surajbari Creek during the breeding season of June 2009, this was one of the highest breeding congregation recorded during the present study and forms 12-15% of the total estimated population in Asia (Rose and Scott 1997) and 2.43% - 3.51% of the global population of the species (Rose and Scott 1997). Also in subsequent breeding seasons 19,800 and 44,600 individuals were recorded in July 2010 and July 2011 respectively.

Flock Size of Lesser Flamingo

Animals foraging in groups often benefit from a decreased predation risk (Caraco et al., 1980; Elgar, 1989) by increasing the chance of being detected earlier by a predator. Also, individuals in larger groups may benefit from a greater confusion of predators (Roberts, 1996; Schradin, 2000). As a consequence of these benefits, animals in larger flocks can adapt their vigilance by decreasing scan rate (Randler, 2005; Dias, 2006; Sansom et al., 2008). However, flock size is affected by many other variables such as food density and quality, competition, an individual’s position within the group, its sex, age and dominance, vegetation cover, weather conditions and time of day (Elgar, 1989).

Due to this potential trade-off between feeding and scanning for approaching predators, foraging in larger flocks can increase the food-intake, provided that foraging in larger groups is not negatively affected by interference competition (Clark and Mangel, 1986).

Kumbharwada Site

Focal observations were recorded on 7896 individuals (6938 adults and 958 juveniles) from 188 flocks, including 67 adult-only flocks, 63 young-only flocks and 58 mixed flocks (Table 6).

Table 6: Flock size of Lesser Flamingos at Kumbharwada site

Flock Type	No. of Samples(n)	Minimum	Maximum	x̄ ±Std. Dev.
All Adult	67	1	203	74 ± 40
Mixed Flock	58	1	461	128 ± 82
All Juveniles	53	3	73	38 ± 24

Adult flock size ranged from 1 to 203 individuals (Table 6). Indeed, mixed flocks were significantly larger than single-age flocks (F=0.23, DF=66 and 57, p < 0.05) also, significant difference was found between adult-only and young-only flocks (F= 2.64, DF=66 and 52, p < 0.00=5).

<u>Newport Site</u>

Focal observations were recorded on 9343 individuals (3443 adults, 1391 juveniles, 4509 adult and juvenile) from 152 flocks, including 51 adult-only flocks, 43 young-only flocks and 58 mixed flocks (Table 7).

Table 7: Flock size of Lesser Flamingos at Newport site

Flock Type	No. of Samples(n)	Minimum	Maximum	x̄ ±Std. Dev.
All Adult	51	1	146	67± 30
Mixed Flock	58	1	177	77 ± 37
All Juveniles	43	2	52	33 ± 21

Adult flock size ranged from 1 to 146 individuals (Table 7). Mixed flocks ranged from 1 to 177 individuals and juveniles flocks ranged from 2 to 52 individuals. At Newport site adult flock size were significantly smaller than adult flocks at Kumbharwada site (F=1.7, DF= 66, 51, p= 0.02) also, significant difference was found between juvenile flocks and adult-only flocks at Newport site (F= 2.28, DF= 50 and 41, p > 0.051).

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).

A total of 7840 Lesser Flamingos were recorded from Kumbharwada site during the present study, 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. Though, earlier studies have reported the abundance of the flamingo in the coastal areas of Bhavnagar (Tere, 2003) no site specific data has been collected.

The population later spread to nearby coastal areas and saltpans and the population reduced to subsequently to 1820 birds in March-April. During March-April, 2012 only 344 individuals were recorded from the Kumbharwada site, which was lowest count of the species for during the entire study period.

Lesser Flamingo prefers more saline habitat than the Greater Flamingo, especially salt pans, salt works evaporation ponds and coastal mudflats (Berry, 1972;, Williams and Velasquez 1997, Tere 2003). In East Africa these conditions may bring together hundreds to millions of birds (Brown and Root 1971). The distribution of Lesser Flamingo within habitats varied on a monthly and sometimes on a daily basis. This distribution could possibly be caused by variations in the phytoplankton species composition and abundance within and between pans.

Lesser Flamingos were observed to be utilizing the Kumbharwada site more than Newport site. Of the total population in 2009, 58.2% of the Lesser Flamingos were observed at Kumbharwada site as compared to 41.8% at Newport Site. Similarly, 67.2% flamingos were observed at Kumbharwada site in 2010. Moreover, during the latter years of the study period, the Newport site had undergone drastic habitat modifications (development of new saltpans); only 19.9% flamingos were observed in Newport site in year 2012. Thus, flamingos were observed switching habitats depending on various factors such as habitat alteration, food availability, water level and other factors.

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.

The average juvenile: adult ratio (No. of juveniles/No. of adults) from 2009 to 2012 was 0.15 and never exceeded even 0.5 for any annual value. Although, during the study period this ratio was steady (ranged from 0.14 to 0.17) the juvenile: adult ratio is negatively correlated with time (years), ($r = -0.98$, $p= 0.014$), suggesting the decline over the study period. This may indicate that juveniles are more susceptible to factors affecting the population, including habitat degradation and alteration in the physic-chemical properties of water. If these trends are present in other non-breeding areas, it is possible that annual juvenile survival may be quite low (Williams and Velásquez 1997).

Flamingos are also distributed over other coastal areas of the state and in the Little and Great Rann of Kachchh. Specie's major congregation sites were also surveyed so as to know the population status of the species during breeding and non-breeding phase of specie's life cycle. 72,000 individuals were recorded during March 2010 at Roniyo beyt in Gulf of Khambhat. However, there are records of sighting of 1,50,000 birds by other observers (Uday Vora, Personal communication). This large number of flamingos in Gulf of Khambhat, including the population at coastal areas of Bhavnagar establishes the importance of western Gulf of Khambhat as one of the potential sites for flamingos during non-breeding season. Surajbari creek is other such site where congregations up to 78,000 birds were observed during nesting season of 2009. This is one of the largest breeding congregations recorded at this site during the present study. Earlier studies have reported congregation of 3,00,000 birds in year 2004 (Parasharya and Tere, 2006).

Plate 1

A. Lesser Flamingos at Sewage pans at Kumbharwada site

B. Adult and Juvenile Flamingos at Kumbharwada site

C. Large congregation at Kumbharwada Site

Plate 2

A. Feeding congregation at Newport site

B. Lesser Flamingo congregation in Little Rann of Kachchh

C. Breeding congregation at Surajbari Creek

Plate 3

A. Kumbharwada site during August to November (No flamingos)

B. Newport site during August to November (Greater Flamingos)

C. Adult and Juvenile flocks in Little Rann of Kachchh

Plate 4

A. Breeding congregation at Surajbari site in 2009