Chapter 4 Behavioral Studies

Behavioral studies in Lesser Flamingos were carried out in relation to different habitat types. The studies were carried out both over the non-breeding and breeding phase of their annual cycle. Flamingo's diurnal activity pattern during breeding as well as non-breeding period was studied in detail.

Activity budgeting

The activity budget study has been recognized as an important tool for understanding habitat use and niche separation (Rave and Baldassarre 1989) and therefore has been used as an important tool for managing a bird's habitat. Activity budgeting studies quantifies the time animals allocate to different activities. Activity budget studies of water fowl provide a better insight to the role of seasonally used habitat in relation to the annual cycle.

Activity Patterns of Adult Lesser Flamingos

During the present study, a strong relationship between Lesser Flamingos habitat and time allocated to each activity was recorded. Also, there were marked differences observed in time spent in feeding by species in different habitats. The differences in behavioral patterns were also observed among adult and juvenile flamingos (Plate 3 A, B, C).

Behavioral patterns at Kumbharwada

There was a marked difference in the activity pattern of adult Lesser Flamingos during different time blocks in a day. 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).

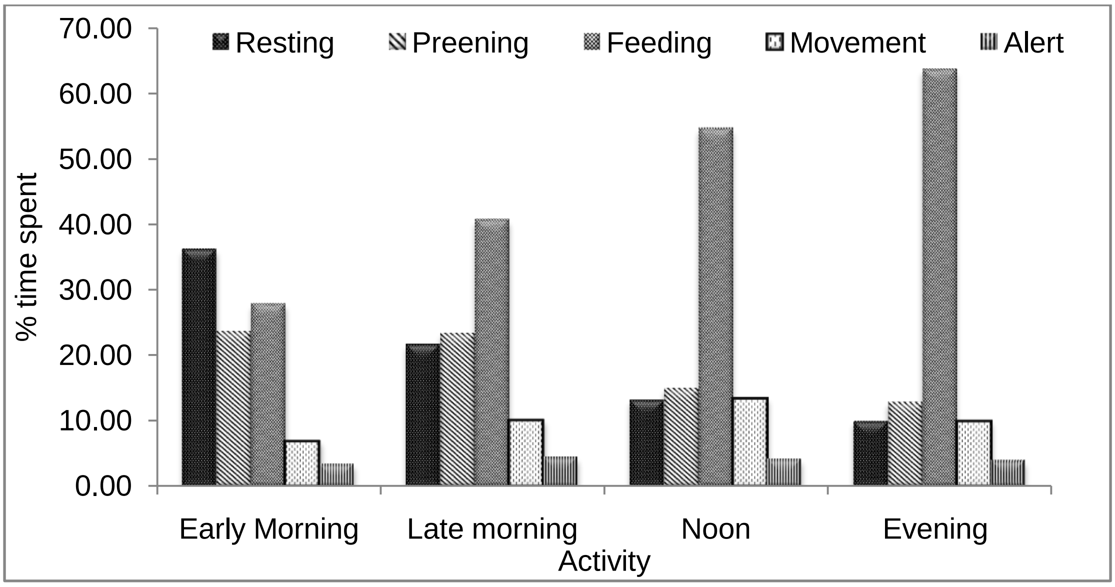


Fig 1: Time spent (in %) by Lesser Flamingos in different time blocks at Kumbharwada site

Feeding and resting activities differed significantly over different time blocks. Feeding activity was minimal during early morning hours ($\bar{x}$= = 28.4% ± 29.7; n= 559, t=6.7,95% CI (25.96, 30.9), p=0.001)and gradually peaks as the day progresses and is maximum during late evening ($\bar{x}$ = 63.2 % ± 25.8, 95% CI (61.51, 65.58), t=42.09, p=0.001) (Fig. 2 & 3), whereas resting activity is at peak during early morning hours ($\bar{x}$ = 37.4 % ± 29.5, 95% CI (34.89, 39.98), t=13.46, p=0.001) (Fig. 4 & 5),and gradually decreased as the day progressed and was minimum in the evening. Time spent in preening did not vary much throughout the day from early morning to evening (F=2.62, df =3, P=0.46). Similarly time spent in movement also did not vary significantly across the day length (F=3.88, df =3, P=0.018) (Fig 1).

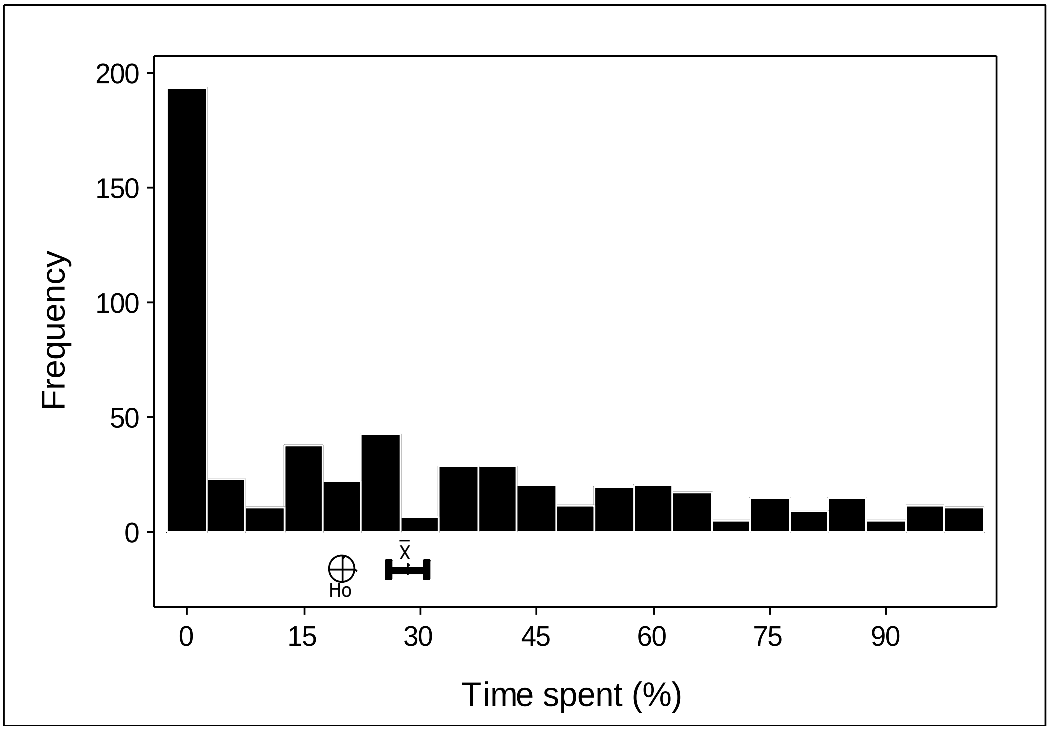


Fig 2: Histogram of feeding activity during early morning (06:00 to 9:00 hrs) with Ho and 95% t-confidence interval for the mean

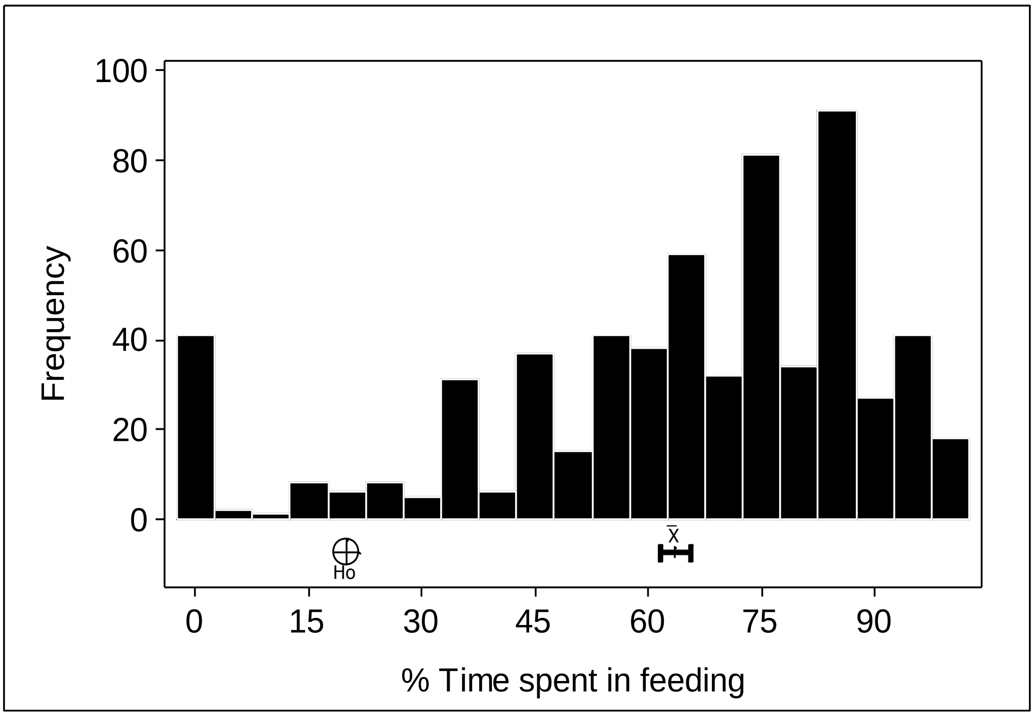


Fig 3: Histogram of feeding activity during late evening (15:00 hrs to sunset) with Ho and 95% t-confidence interval for the mean

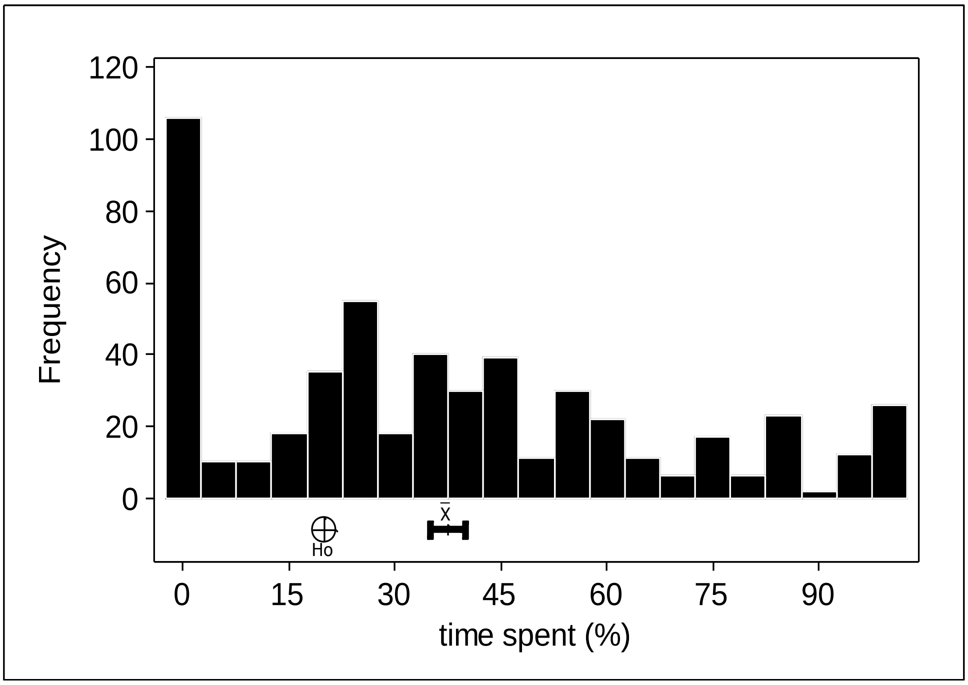


Fig 4: Histogram of resting activity during early morning (06:00 to 9:00 hrs) with Ho and 95% t-confidence interval for the mean

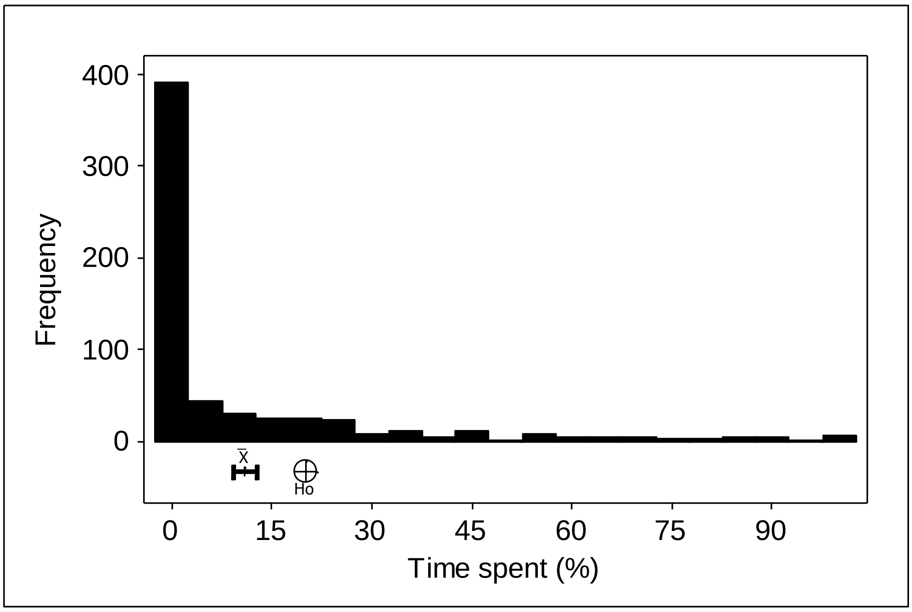


Fig 5: Histogram of resting activity during evening (15:00 hrs to sunset) with Ho and 95% t-confidence interval for the mean

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) (Fig 6).

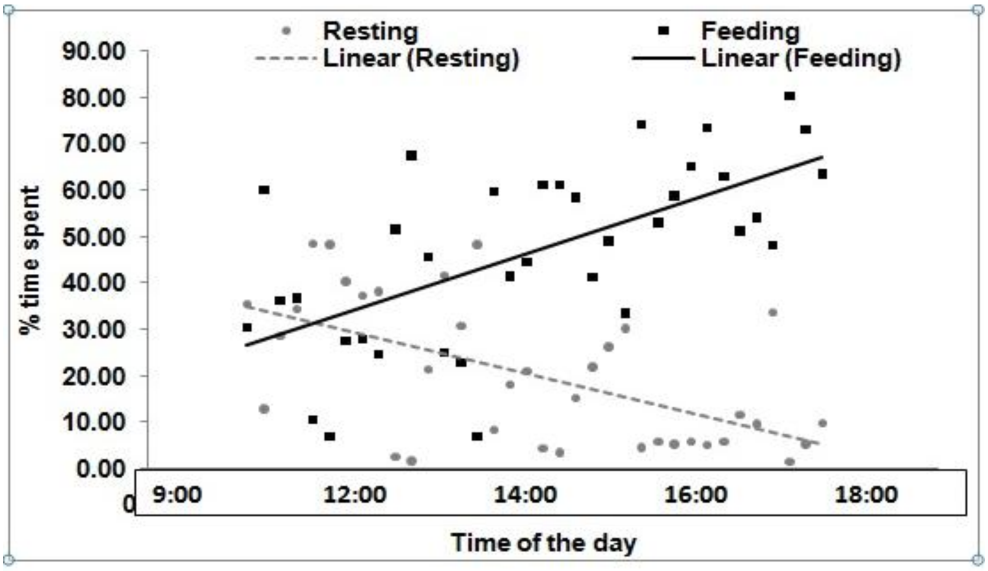


Fig 6: Variation in time spent in feeding and resting behavior through different blocks

Behavioral patterns in relation to Habitat Types – Kumbharwada site

Kumbharwada site showed marked differences in habitat characteristics. Based on the habitat types, the entire habitat was classified into three broad categories viz. i) Sewage waste water areas (Sewage pans)- KWvSP1, KWSP-2 and KWSP3 ii) Active saltpans (Used Saltpans) – KWUSP1 and KWUSP3 area iii) Abandoned saltpan –KW ASP1 and KWASP2. The areas have been differentiated based on the land use pattern, vegetation type they support, amount of water they receive, the source of water and salinity.

Flamingos showed significant variations in time spent in different activities among different sampling periods and within different habitat types. Also they used these habitats differently during different time blocks. Water level in these habitats varied with season and the amount of water present in a given habitat governed the time spent by flamingos in each activity. Water level fluctuated more in sewage pans and abandoned saltpans in Kumbharwada more prominently as compared to saltpans, as the latter was used for salt manufacturing and the water level was regulated in saltpans for salt production. Three different categories based on water level presence were categorized, low (0-10 cm) depth, medium 10-30 cm, and high water level (30 cm and above). Activity samples were taken at all different water levels and different time blocks in all the three marked habitat types in Kumbharwada site.

Sewage Waste water Pans

These sewage pans are specialized habitat in a way that, they are highly polluted and with maximum anthropogenic pressure. the sewage pans of Kumbharwada received waters from the southern portion of southern part of sewage pans (KW SP3) receives waste water from the industries of the Bhavnagar Industrial Development Corporation (GIDC) and KW SP1 received house hold waste sewage, residual water from the saltpans and some part through precipitation during monsoonal months. The average water depth recorded in this habitat was 25.7 cm ± 3.1.

Activity pattern at Low water level

The low water areas in sewage pans were used differently in different time blocks, during early morning 35.7% ($\bar{x}$ =35.5 % ± 24.2, p=0.001) of time was spent in resting followed by 30.6% time in feeding ($\bar{x}$ =31.4 % ± 29.0, p=0.031). During noon, time spent in feeding increased to 61.2 % ($\bar{x}$ =61.2 % ± 22.1) and inversely, time spent in resting reduced to 4.4% ($\bar{x}$ =4.4 % ± 5.8). In low water level areas, flamingos spent 65.1% ($\bar{x}$ =74.1 % ± 13.9) of their time in feeding, 14.5% ($\bar{x}$ =8.8 % ± 5.9) of time in preening, 11.5% time in movement and 6.0% time in resting during evening hours (Fig. 7, Plate 1A 2A).

Activity pattern at moderate water level

The medium water level areas (10-30 cm depth) in sewage pans were mostly used for feeding. During early morning 13.1% ($\bar{x}$ =13.1 % ± 12.2, p=0.01) of time was spent in resting followed by 30.6% time in feeding ($\bar{x}$ =60.2 % ± 28.9 p=0.001). Preening activity was highest ($\bar{x}$ =15.8 ±10.2, p=0.05) during the morning and lowest during late evening ($\bar{x}$ =9.5 ±9.07, p=0.001). During noon, time spent in movement increased to 19.5 % ($\bar{x}$ =19.5 % ± 14.4, p=0.85).Flamingos spent 73.4% of their evening time in feeding ($\bar{x}$ =73.4 % ± 21.4, p=0.001) (Fig. 8) (Plate 1B).

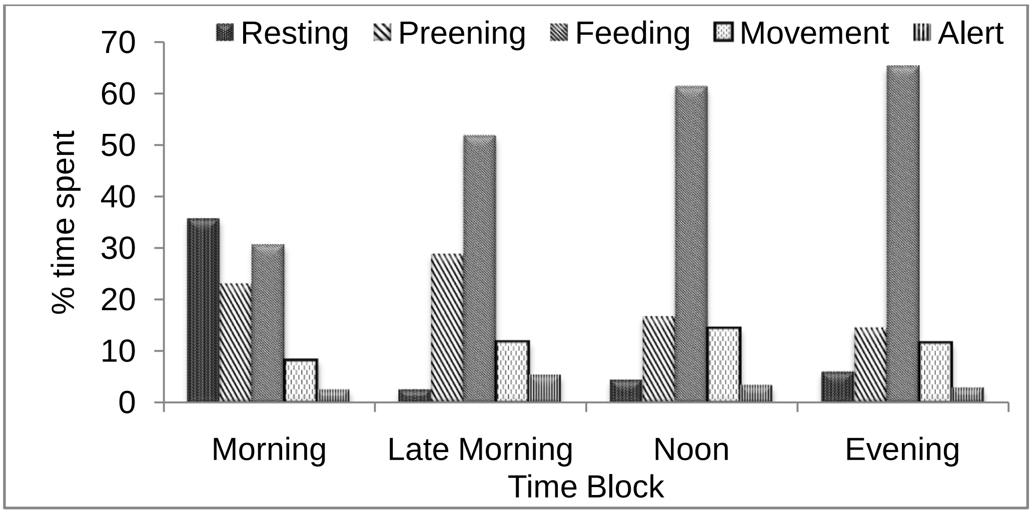


Fig 7: Activity pattern at Low water level (<10 cm) at Kumbharwada site in Sewage pans

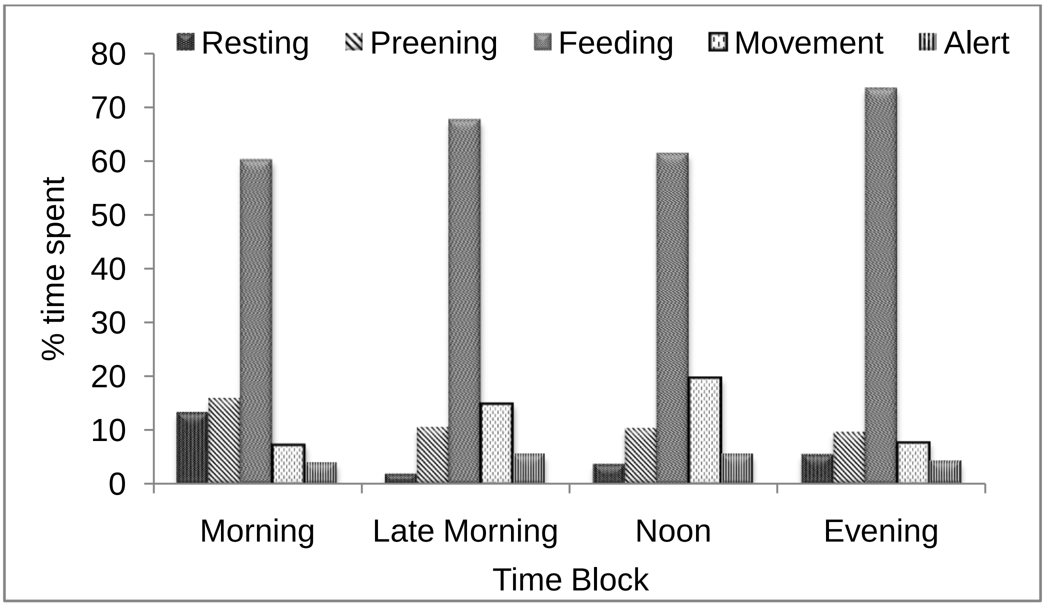


Fig 8: Activity pattern at mid water level (10-30 cm) at Kumbharwada site in Sewage pans

Activity pattern at high water level

Flamingos in Kumbharwada sewage pans usually avoided the high water level areas (water level > 30cm). However, they used these areas during different time blocks for resting and preening activities. During early morning, flamingos spent 28.8% time in resting (x̄ =35.6 ± 18.6) and16.8% (x̄ =16.7 % ± 14.7) time in preening. Movement activity did not vary significantly over different time blocks (F=3.42, df = 3, P=0.02). (Fig. 9) (Plate 1C).

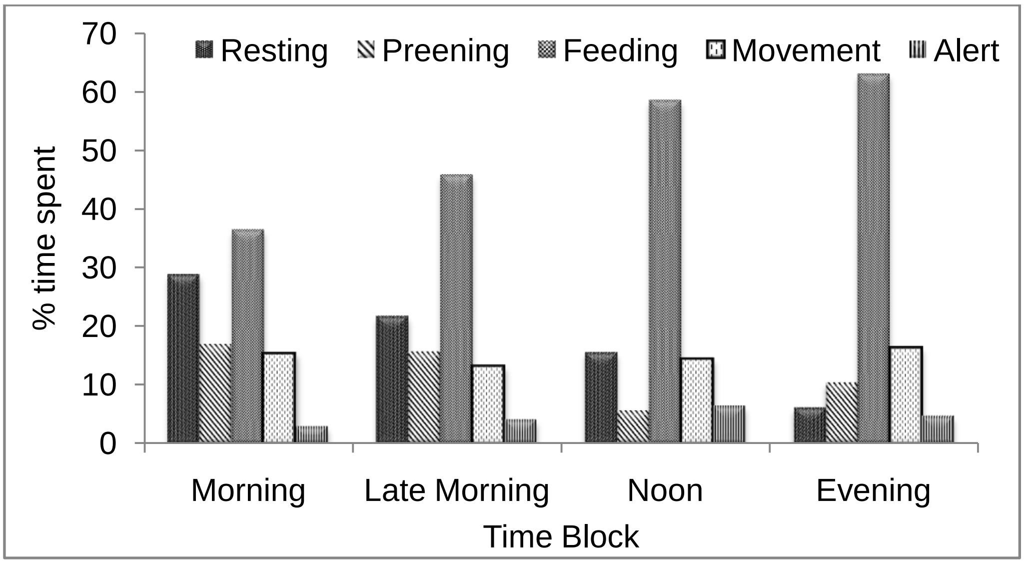


Fig 9: Activity pattern at High water level (>30 cm) at Kumbharwada site in Sewage pans

Salt Pans

Saltpans at Kumbharwada site covers 50% of the total study area and were comparatively less utilized for various activities by the species. As these habitats were more prone to anthropogenic pressure and movement of local salt workers, it was less utilized taking into account its extent and spread. The water level was moderate most time of the year as salt manufacturing process was in progress. The saltpan habitat were mainly used for resting activities as these high saline areas may be providing insufficient food supply to the flamingos. The average water depth recorded in this habitat was 29.5 cm ± 3.4.

Activity pattern at low water level

Lesser Flamingos in saltpans with very low water level spent comparatively higher time in resting and preening. On an average flamingo spent 27.5 %(x̄ =41.4 % ± 31.3) of their daylight hours resting and 22.5 % (x̄ =23.0 ± 16.3) time preening, both of which constitute about 50% of their diurnal time. Feeding was at its peak during evening hours (x̄ =51.2 ± 23.5) (Fig. 10).

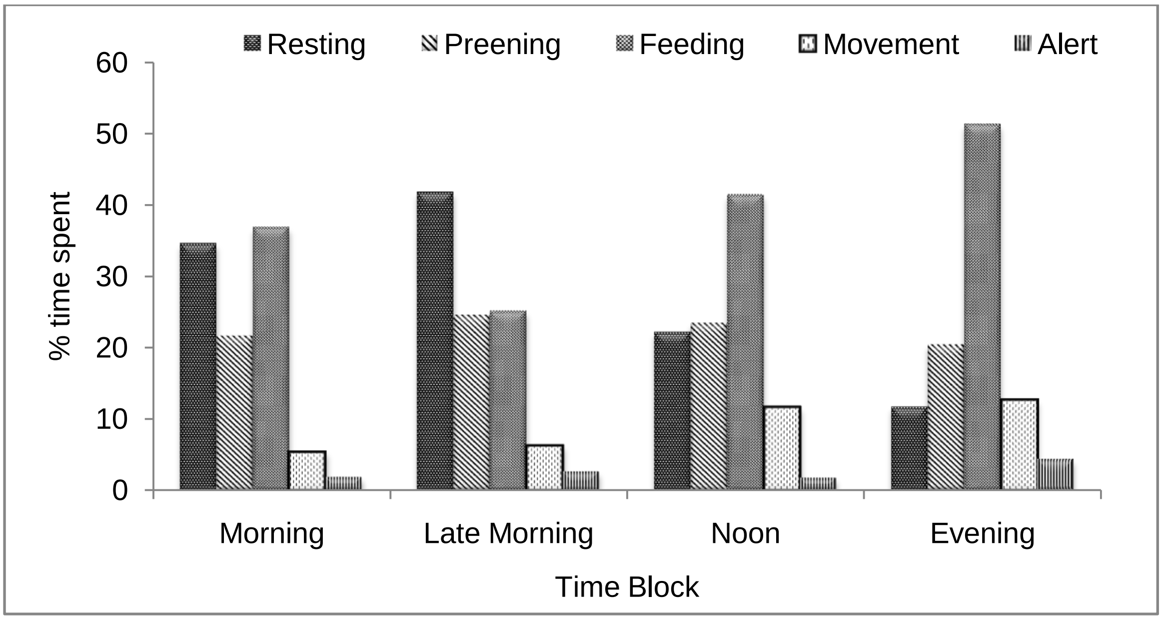


Fig 10: Activity pattern of Flamingos at Low water level (<10 cm) at Kumbharwada site in Salt pans

Activity pattern at Moderate water level

Resting and preening constituted 52.5% of total time spent by flamingos in saltpans with moderate water level. During early morning hours, preening (34.3%) and resting (48.6%) were at their peak at ($F=3.89$, $df = 4$, $P=0.02$).and together constituted 83% of their diurnal time budget.

Lesser Flamingos in saltpans with moderate water level spent comparatively higher time in resting and preening. Time spent in feeding during early morning hours was 10.6% which was the least time spent by the species compared to other habitat types during this part of time block ($p > 0.01$) was at its peak during evening hours (x̄ =51.2 ± 23.5) (Fig. 11).

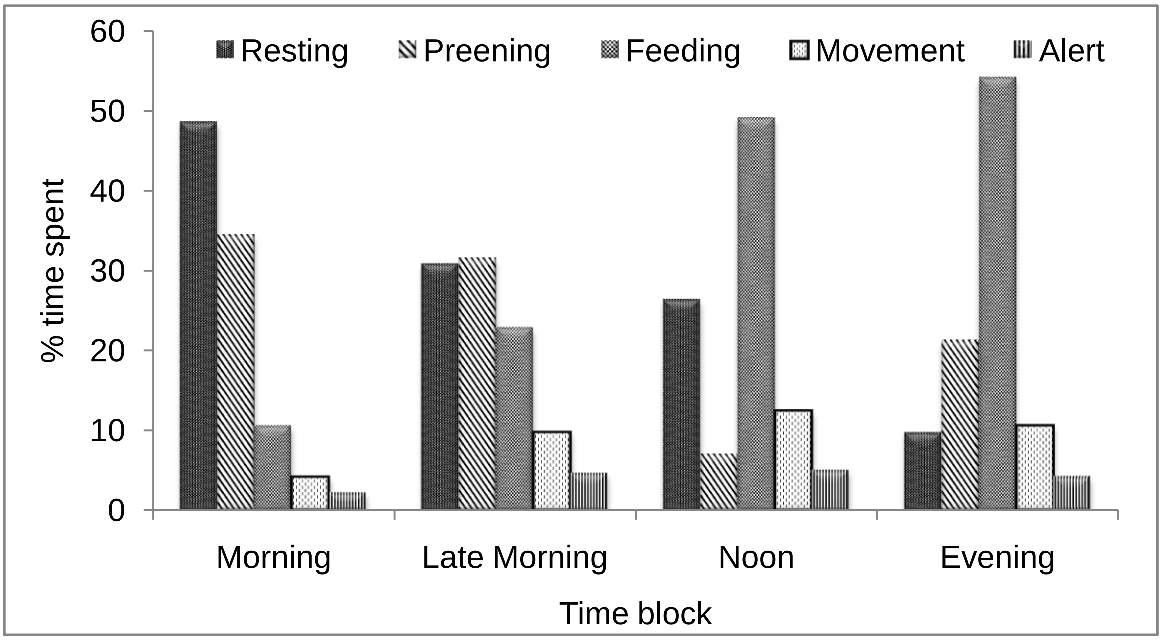


Fig 11: Activity pattern of Flamingos at Moderate water level (10-30 cm) at Kumbharwada site in Salt pans

Activity pattern at High water level

Saltpans which were regularly used for salt manufacturing processes were rarely observed with high water levels (> 30cm) and were less frequently used by the Lesser Flamingos. Flamingos used this habitat only during monsoon months (July-August) that too in very low number and proportion as majority of the adult Lesser Flamingo population had left for breeding to other sites.

Resting and preening were the most dominant activities throughout the day. Flamingos spent on an average 38.5% of their diurnal time in resting and 24.4% of their time in preening. Resting 48.5% ($\bar{x}$= 48.4% ± 25.1) and preening 36.5% ($\bar{x}$= 36.3 ± 16.8) activities were at its peak during early morning hours. Time spent in alertness did not vary significantly throughout the day, and birds spent an average 3.1% (F=3.67, df = 3, P=0.04) of their time in alert (Fig. 12).

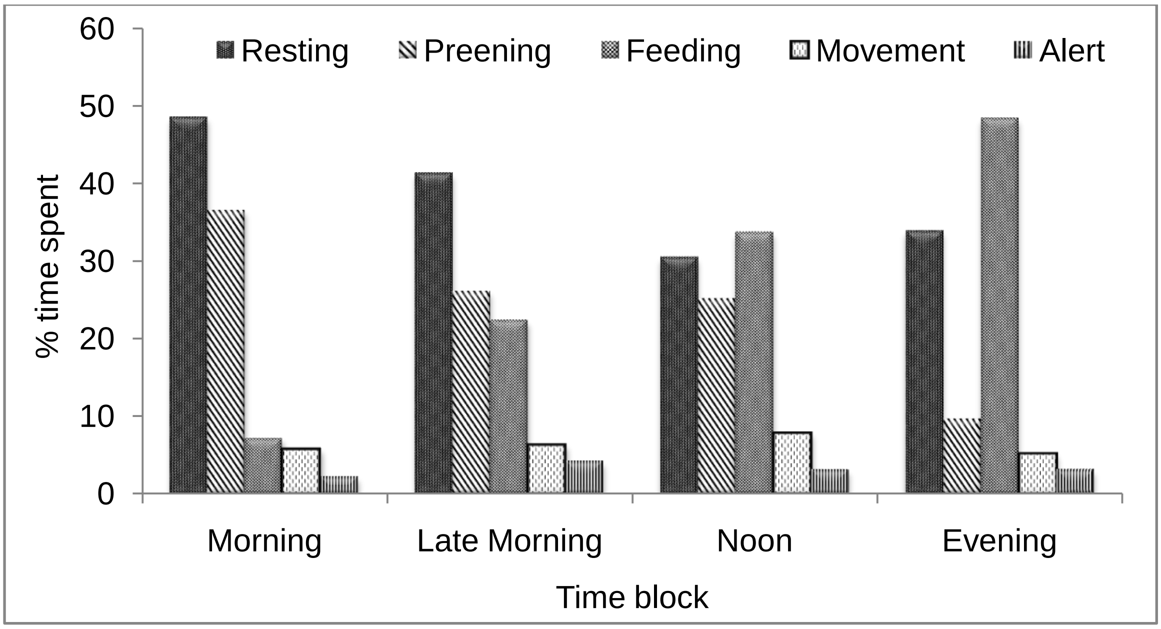


Fig 12: Activity pattern of Flamingos at high water level (> 30 cm) at Kumbharwada site in Salt pans

Abandoned Salt Pans

Abandoned saltpans or fellow lands constituted about 3% of the total area under study, however this was the most utilized habitat by flamingos during drier periods (April and May) as water level in sewage pans recedes making those habitat unsuitable for feeding by flamingos. Moreover, this habitat also showed marked differences in water level throughout the study period. The average water depth recorded in this habitat was 16.8 cm ± 9.2.

Activity pattern at low water level

Abandoned saltpans or fellow lands receive water during monsoon months through precipitation or through discharge of excessive saline ground water not suitable for salt manufacturing. These low water level areas in fellow lands with scattered vegetation serve as an important habitat for flamingos and are widely used for feeding and other activities.

Flamingos spent about 60.5% ($\bar{x}$ =50.9 ± 32.6) of their diurnal time in feeding in fellow lands with water level ≤10 cm. The flamingos on an average spent nearly equal time in resting, [13.9%, (x̄ =14.2 ± 12.6)] and preening [13.4%, (14.5 ± 11.5)]. Flamingos spent most of their time in feeding during noon and evening hours compared to other activities (F=11.2, df = 4, P=0.001). Feeding activity increased during subsequent time blocks and was highest in the evening where flamingos spent 80.3% of their time in feeding (x̄ =80.2 ± 12.3) (Fig. 13).

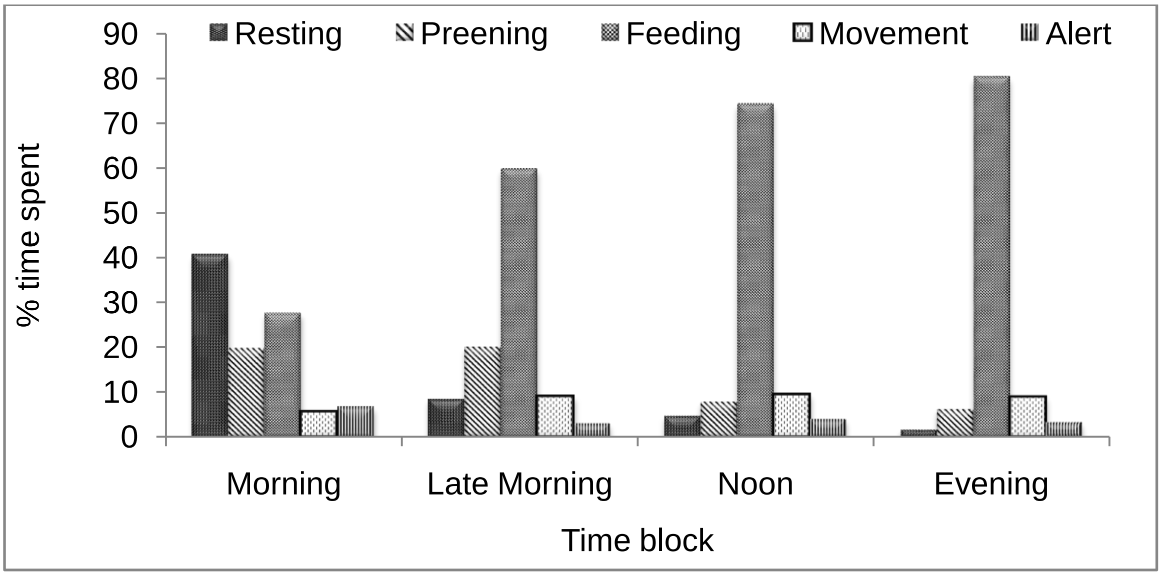


Fig 13: Activity pattern of Flamingos at Low water level (<10 cm) at Kumbharwada site in Fellow Land / ASP

Activity pattern at Moderate water level

Flamingos were observed in these habitats only during winter or post monsoon season as these areas were inundated with rain water during January and February months. The use of this habitat by flamingos varied as among different months as during dry season, flamingos had to abandon these habitats of very less or no water.

Flamingos spent 48.9 % of their diurnal time in this habitat for feeding, followed by preening (20.3%), resting (16.8%). Time spent in movement (9.3%) and alert (4.7) was less. During early morning, flamingos spend 37% (x̄ =37.4 ± 26.1) time in feeding and 26.1% (x̄ =26.1 ± 17.1) time in preening, thus both activities constituted about 63.6% of their early morning activity.

Feeding activity was maximum during evening hours (73.15 ± 18.5). There was a significant difference from the expected value of time spent feeding in evening (X^2 = 141.2, DF= 4, p>0.001) (Fig. 14).

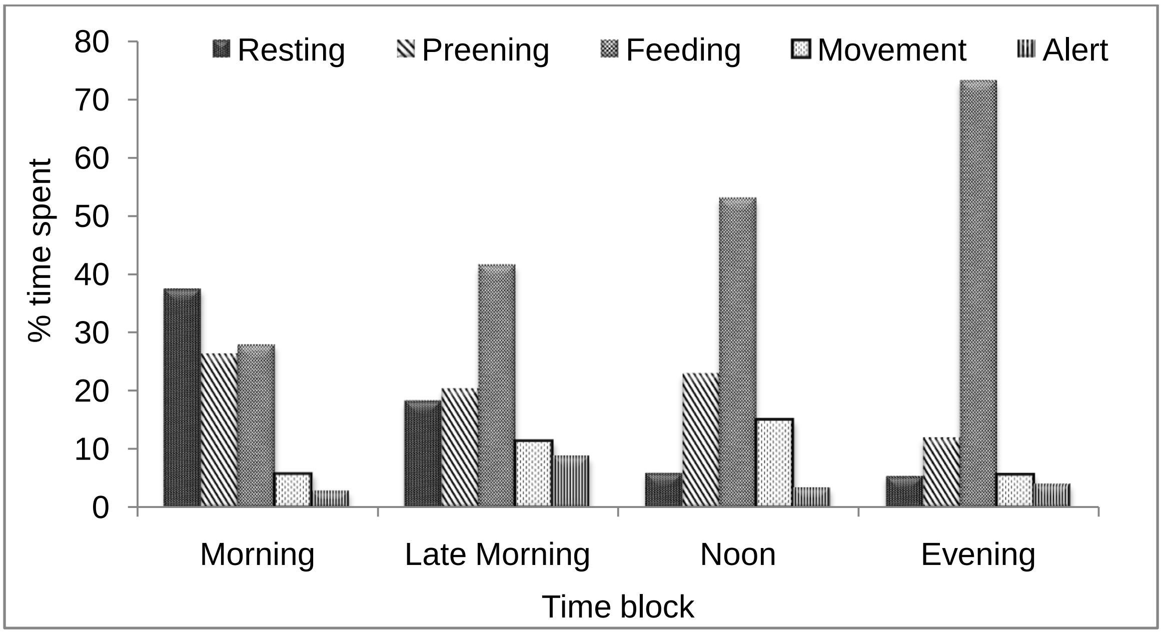


Fig 14: Activity pattern of Flamingos at moderate water level (10-30 cm) at Kumbharwada site in abandoned saltpans

Activity pattern at High water level

Flamingos used abandoned saltpans habitat primarily for resting and preening activities during the time when they are not actively feeding. However, a small proportion of birds were observed feeding in this habitat also. Higher water levels are less calm and also the availability of other good feeding sites nearby induces flamingos to avoid this habitat as a potential feeding site (Plate 2C).

Lesser Flamingos spent 48% of their diurnal time foraging in this habitat which was moderately lower (X^2 = 1.47, DF= 4, p<0.05)than their feeding time spent in moderate and low water level in similar habitat conditions. Resting, akin to other sites was at its peak during early morning hours ($\bar{x}$ =38.1 ± 30.0). As the day progressed, time spent in resting decreases and was lowest during late evening (11.7%). Time spent in alert did not vary significantly across the time blocks (Fig. 15).

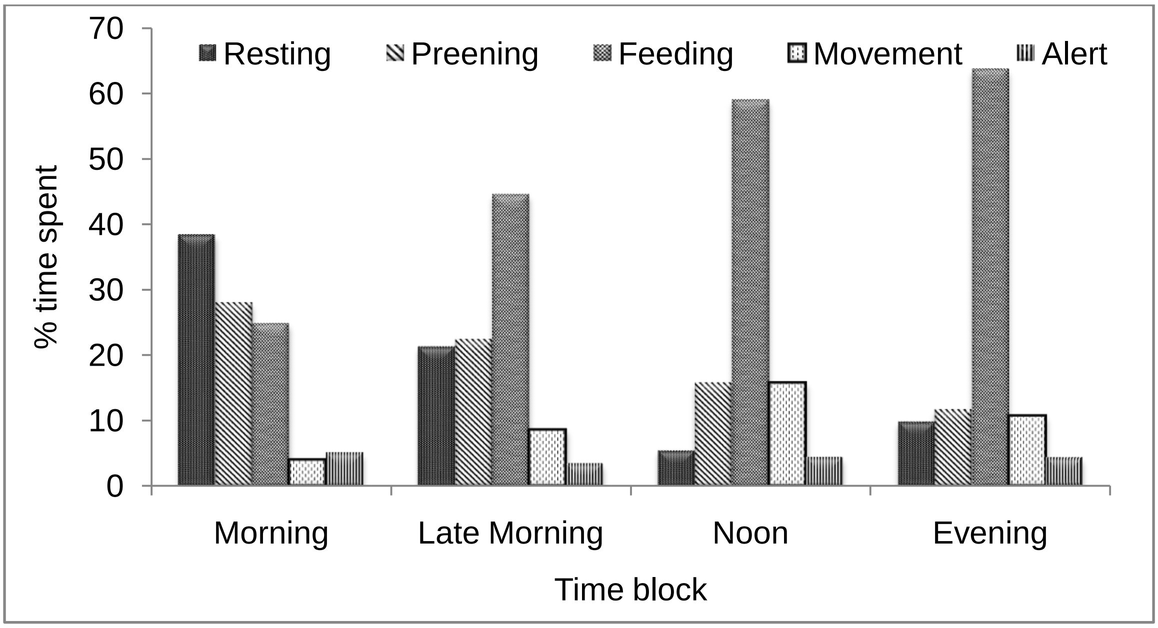


Fig 15: Activity pattern of Flamingos at High water level (> 30 cm) at Kumbharwada site in abandoned saltpans

Behavioral patterns in relation to Habitat Types – Newport site

Newport saltpans lie in the eastern boundary of the Bhavnagar town. It separates the Western Coastal Belt of Gulf of Khambhat along Bhavnagar coast from the mainland of the Bhavnagar city. The area is totally saline with high degree of salt production activity compared to Kumbharwada site. The area also has some abandoned salt pans which are not used for salt manufacturing. However, most part of the study area (379 hectares, 39.9% of the study area) is used for salt manufacturing. The area is totally devoid of vegetation except some outgrowth of *Prosopis* spp. on the periphery. The area also supports a good diversity of water birds especially coastal waders.

Newport area is further divided into three zones based on the habitat/land use category and habitat features. The area is divided into i) Used Saltpans, (NPUSP) ii) Abandoned salt pans (NPASP) and iii) Mudflats (NPMF) adjoining the creek areas of Gulf of Khambhat (Table 2.2).

Flamingos showed strong variations in time spent in different activities among different sampling periods and within habitat types. Also they used these habitats differently during different time blocks. Water level in these habitats varied with season and the amount of water present in a given habitat governed the time spent by flamingos in each activity. Water level fluctuated more in abandoned saltpans and mudflats more prominently compared to used saltpans, as the latter was used for salt manufacturing and the water level was regulated in saltpans for salt production. Three different categories based on water level presence were categorized, low (0-10 cm) depth, medium 10-30 cm, and high water level (30 cm and above). Activity samples were taken at all different water levels and different time blocks in all the three marked habitat types in Newport site.

Overall scenario – Newport site

There were significant differences in the activity pattern of adult Lesser Flamingos during different time blocks in a day. Overall, on an average adult Lesser Flamingos at Newport site spent 53.1% of their diurnal time in feeding, followed by resting (19.1 %), preening (14.6%), movement (9.4%) and alert (4.26 %). Resting activity was highest during early morning hours (mean 28.2 % ± 11.6, range 8.3% - 46.9%), and was least during late evening (12.6 % ± 9.8, range 3.4% - 34.3%). Feeding occurred all throughout the day, but it was at its peak ($\bar{x}$ = 60.9 % ± 14.0) during evening hours (16:00 to sunset) (Fig. 16).

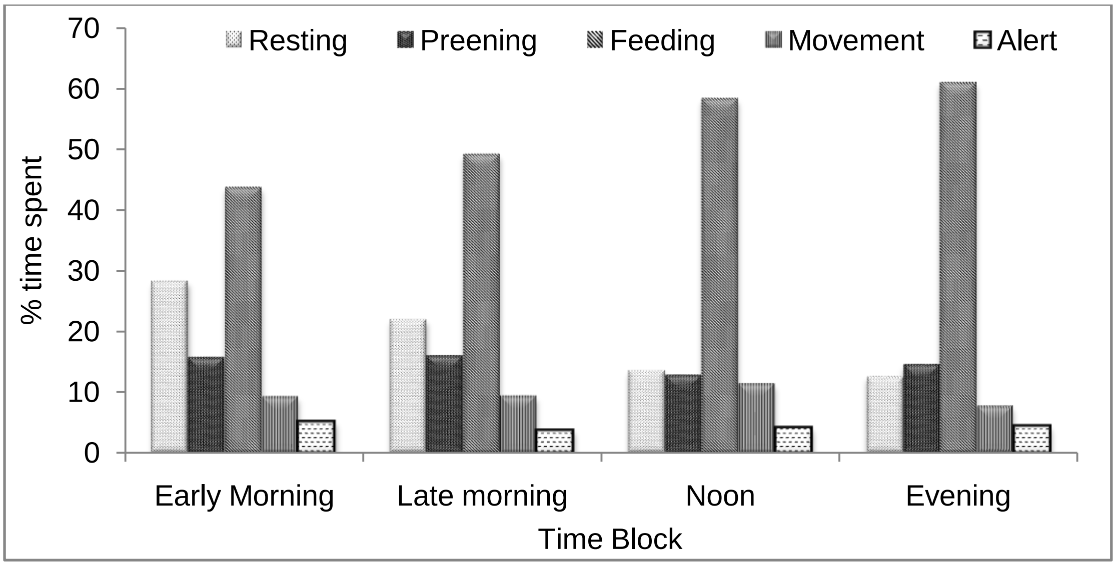


Fig 16: time spent (%) by Lesser Flamingos in different time blocks at Newport site

Used Salt Pans

Used saltpans habitat covered approximately 40.0% of the total study area at Newport site. These areas were located towards the coast of Gulf of Khambhat and were used for salt production during entire study period. Water levels in this habitat did not fluctuate much as water level was maintained for salt production activities except during late June or during the onset of monsoon.

Activity pattern at low water level

Lesser Flamingos in used saltpans with very low water level spent higher time in resting and preening. On an average flamingo spent 27.5 % ($\bar{x}$ =41.4 % ± 31.3) of their daylight hours resting and 22.5 % ($\bar{x}$ =23.0 ± 16.3) time preening, both of which constitute about 50% of their diurnal time. Feeding was at its peak during evening hours ($\bar{x}$ =51.2 ± 23.5) (Fig. 17).

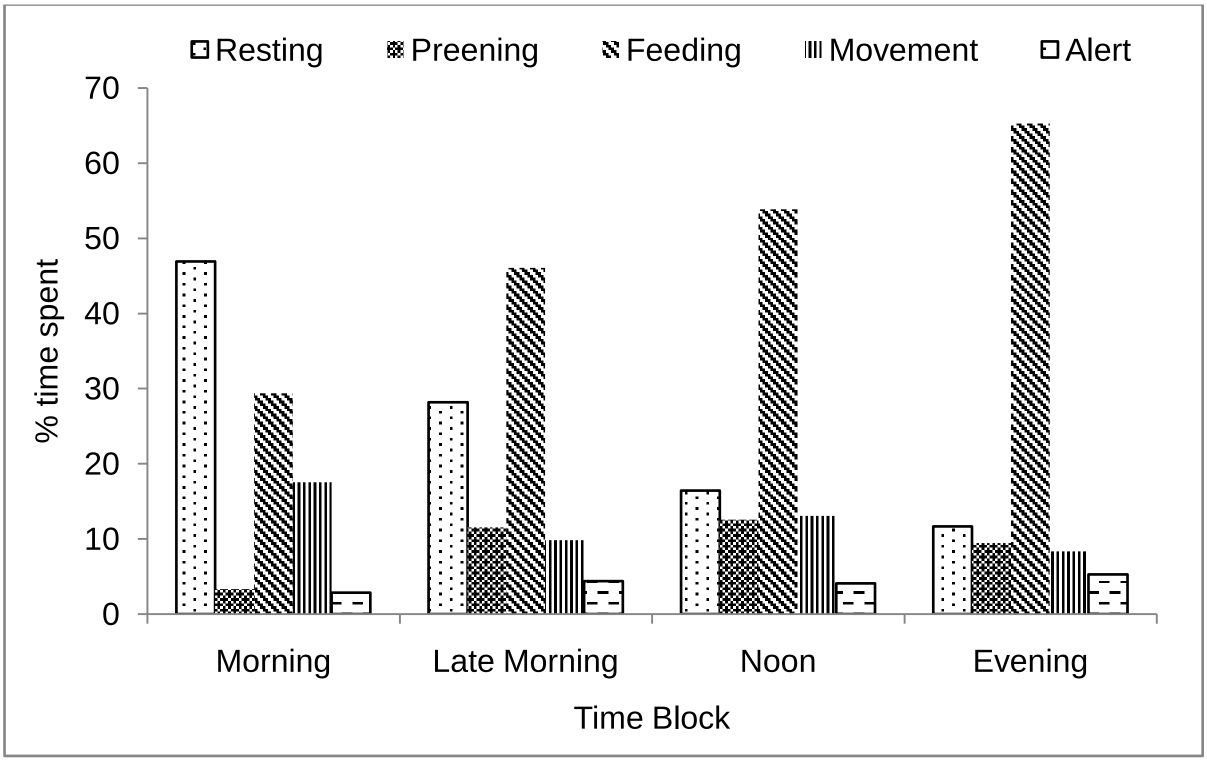


Fig 17: Activity pattern at Low water level (<10 cm) at Newport site in Used Saltpans habitat

Activity pattern at moderate water level

Resting and feeding constituted 69.1% of total time spent by flamingos in saltpans with moderate water level. During early morning hours, resting (34.3%), feeding (29.8%) and preening (24.2%) were the major activities. Resting and preening were at their peak at early morning and gradually decreased as the day progressed and were least during evening hours.

Lesser Flamingos in saltpans with moderate water level spent comparatively higher time in resting and preening (Fig. 18). Time spent in resting during early morning hours was 40.1% which was the comparatively highest time spent by the species compared to other habitat types during this early morning ($p > 0.01$). Feeding was at its peak during evening hours ($\bar{x} = 56.1 \pm 14.2$ %) (Fig. 18).

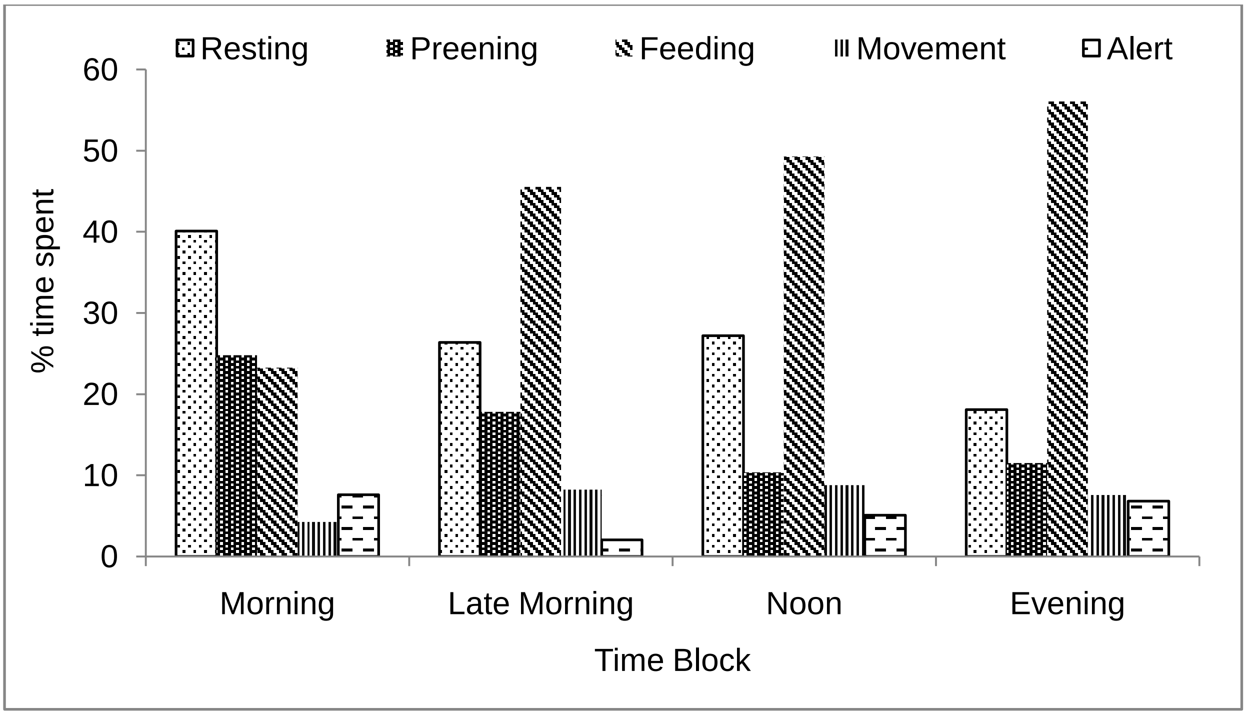


Fig 18: Activity pattern at Moderate water level (10-30 cm) at Newport site in Used Saltpans habitat

Activity pattern at High water level

Flamingos avoided this habitat and the activity pattern data collected for the high water level in this habitat class was too small to bring any conclusion regarding flamingo's use of this habitat type.

Abandoned saltpans

Abandoned saltpans were used mainly for feeding activities at Newport site compared to other habitat types. Feeding was the major activity at abandoned saltpans followed by preening.

Activity pattern at Low water level

At low water levels, flamingos spent about 30.0% ± 12.8 time in preening activity which was comparatively higher during early morning hours compared to other habitat types. Flamingos spent just 3.9% ± 1.6 in alert throughout the day. Feeding activity was highest during noon. Birds spent about 63.1% ± 22.1 of their time in feeding which was highest during noon. Feeding activity was highest during evening (68.6% ± 8.3) (Fig. 19).

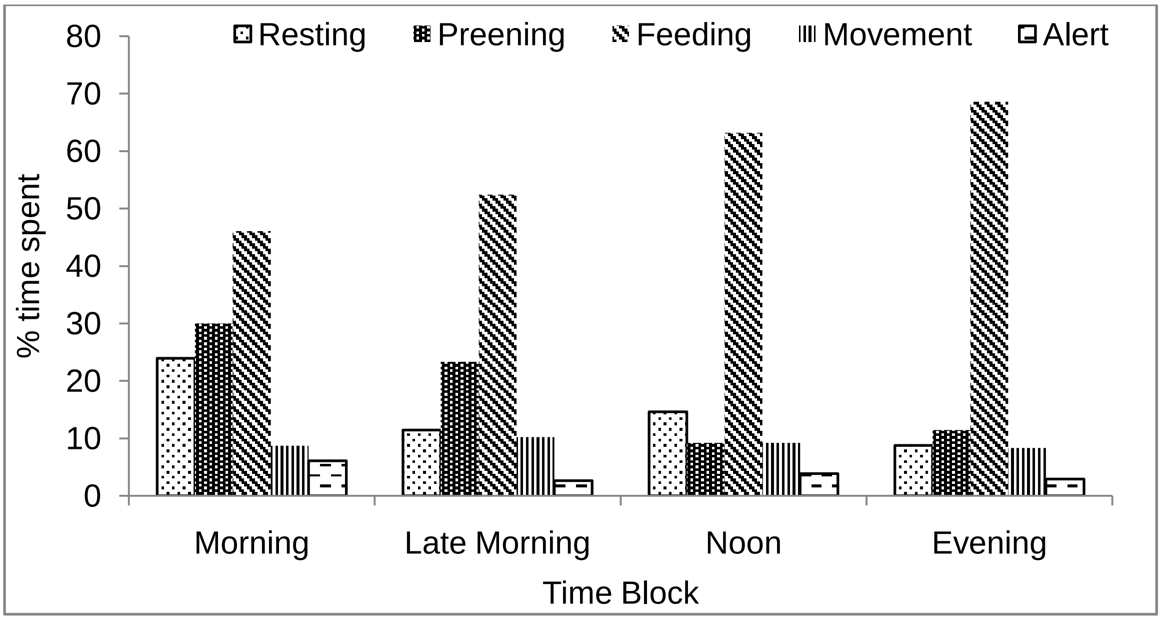


Fig. 19 Activity pattern at Low water level (<10 cm) at Newport site in Abandoned saltpans habitat

Activity pattern at Moderate water level

These habitats were most favored by flamingos and were most of the times observed in these habitats. However, its use was more prominent during early winter or post monsoon period as these habitats are inundated with optimum water levels. The use of this habitat by flamingos varied among different months as during dry season, flamingos had to abandon these habitats because of very less or no water.

Flamingos spent 59.6 % of their diurnal time in this habitat for feeding, followed by preening (16.5%), movement (6.2%). Time spent in Resting (3.4 %) and alert (2.8) was less. During early morning, flamingos spend 40.8% ± 27.3 (Range 6% -100%) time in feeding and 25.5% ± 17.1 time in preening, thus both activities constituted about 66.3% of their early morning activity time budget. Feeding activity was maximum during evening hours (71.0 ± 23.5). Only 3.1% ± 1.2 of time was spent in resting throughout the day (Fig. 20).

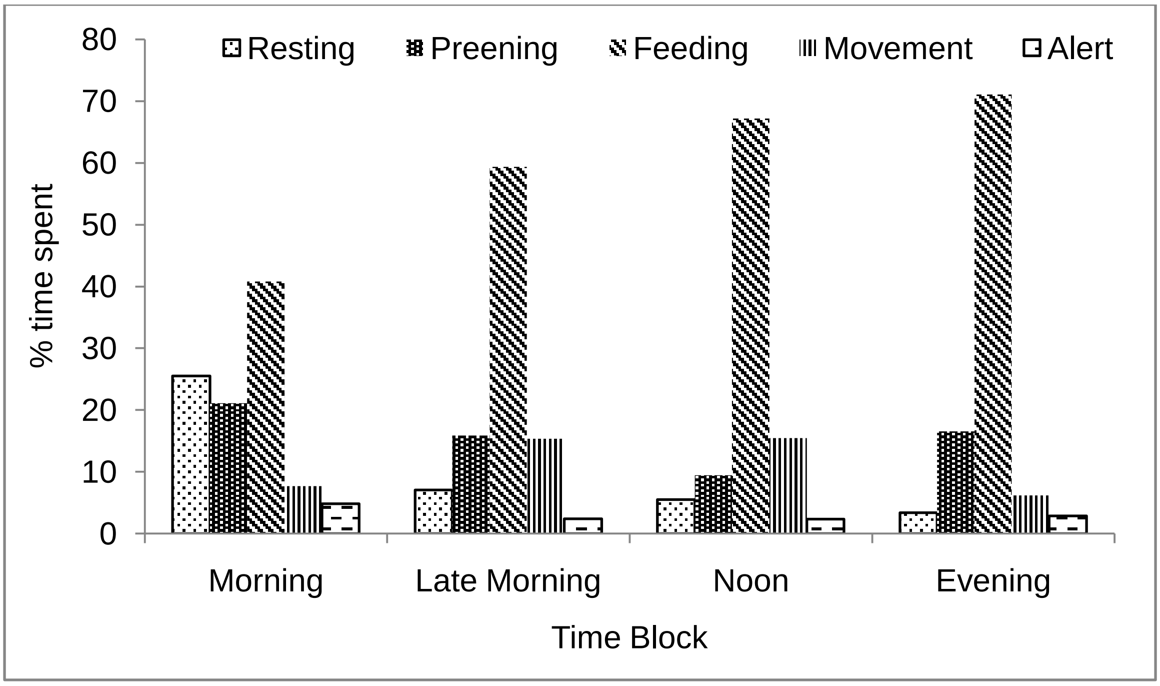


Fig 20: Activity pattern at Moderate water level (10-30 cm) at Newport site in abandoned saltpans habitat

Activity pattern at High water level

Flamingos used abandoned saltpans habitat with moderate water level primarily for feeding activities. The water level in abandoned saltpans seldom crossed 30 cm as salt pans bunds were weak and could not store water above certain level. However, during post monsoon, the water level was above 30 cm. A small proportion of birds were observed feeding in this habitat. Higher water levels are less calm and also the availability of other good feeding sites nearby induces flamingos to avoid this habitat as a potential feeding site.

Lesser Flamingos spent 49.3% of their diurnal time foraging in this habitat which was moderately lower (X^2 = 62.0, DF= 4, p<0.05) than their feeding time spent in moderate and low water level in similar habitat conditions. Resting, akin to other sites was at its peak during early morning hours ($\bar{x}$ =38.3 ± 27.0). As the day progressed, time spent in preening decreases and was lowest during late evening (11.1%). Time spent in alert did not vary significantly across the time blocks (4.0% ± 0.3) (Fig. 21).

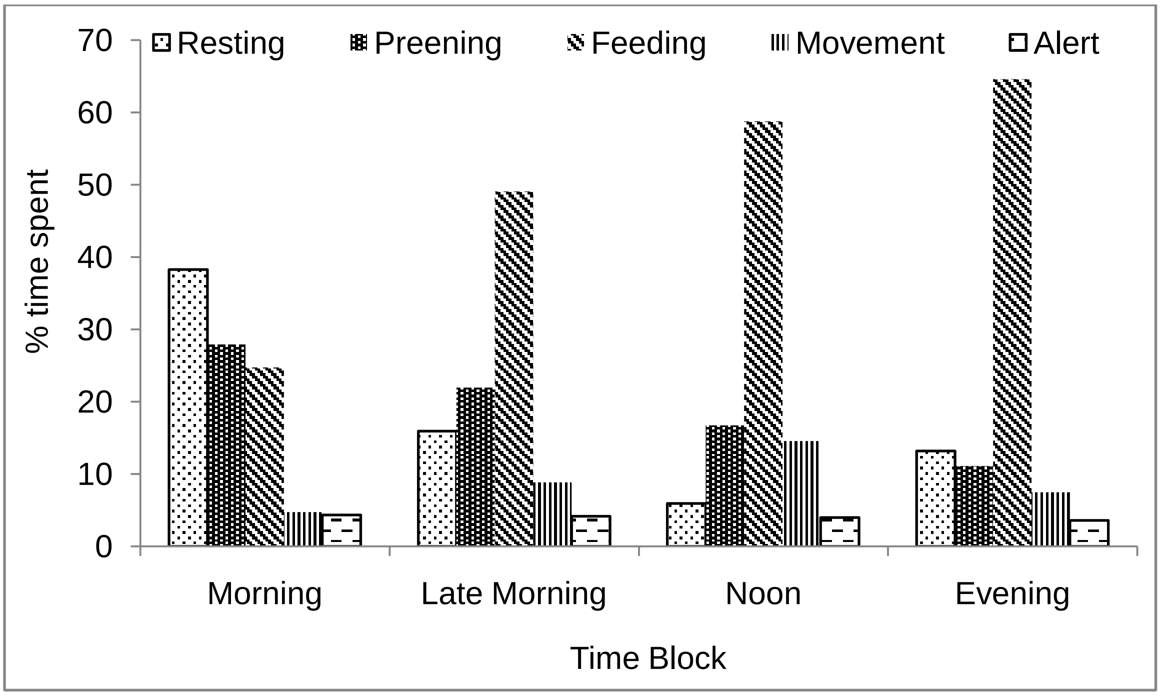


Fig 21: Activity pattern of Flamingos at High water level (> 30 cm) at Newport site in abandoned saltpans habitat

Mudflats

A mudflat occupied about 30.6% of the total study area at Newport site and was used by flamingos for feeding during high tide only. The water level in mudflats fluctuated the most as it was highly dependent on the tidal amplitude. Flamingos spent about 56% of their total diurnal time in feeding.

Activity pattern at Low water level

Flamingos spent most of their diurnal time in feeding during low water levels in mudflats at Newport site. They spent 65.0% ± 5.9 of their diurnal time feeding. Movement was other major activity at mudflats, birds spent 13.4 % ± 1.1 diurnal time in movement followed by preening 7.3% ± 2.9. Time spent in feeding (56.4%) and preening (1.7%) was least during morning (56.4%) and increased as the day progressed. Resting was highest in the morning (25.2%) and was least during evening hours (4.6%) (Fig. 22).

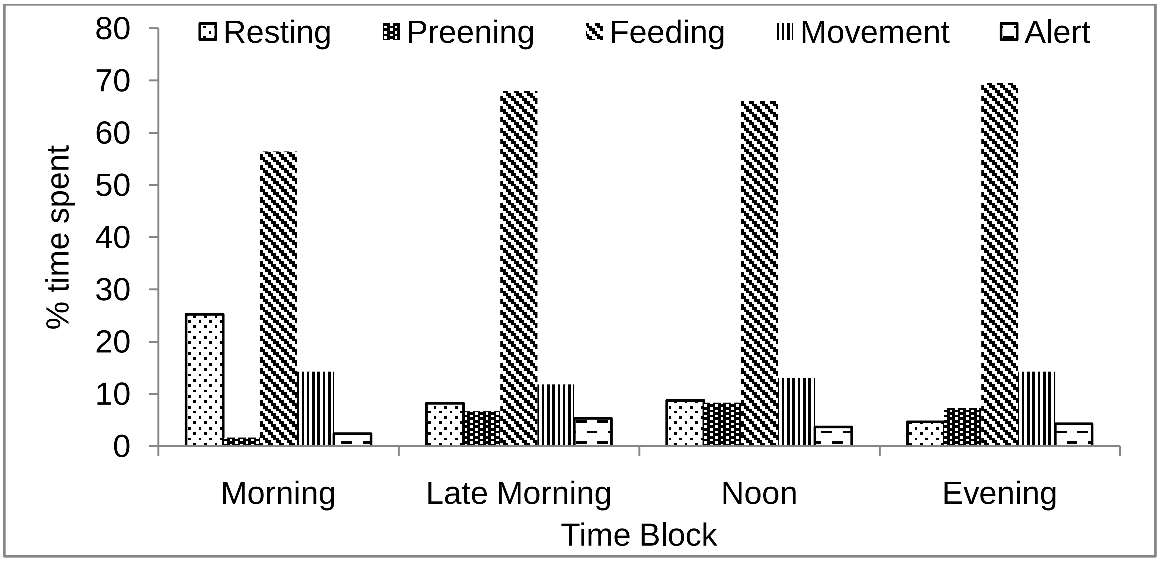


Fig 22: Activity pattern at Low water level (<10 cm) at Newport site in Mudflats habitat

Activity pattern at Moderate water level

Feeding was the main activity of flamingos in mudflats with moderate water levels (59.6%) followed by resting (15.1%). Resting (23.3% ± 8.2), and movement (10.2 % ± 3.6) was highest during early morning hours. Flamingos spent very little time in Alert and also it not fluctuates much throughout the day (5.6 % ± 0.6). Feeding was highest during evening hours (67.7% ± 17.6) (Fig. 23).

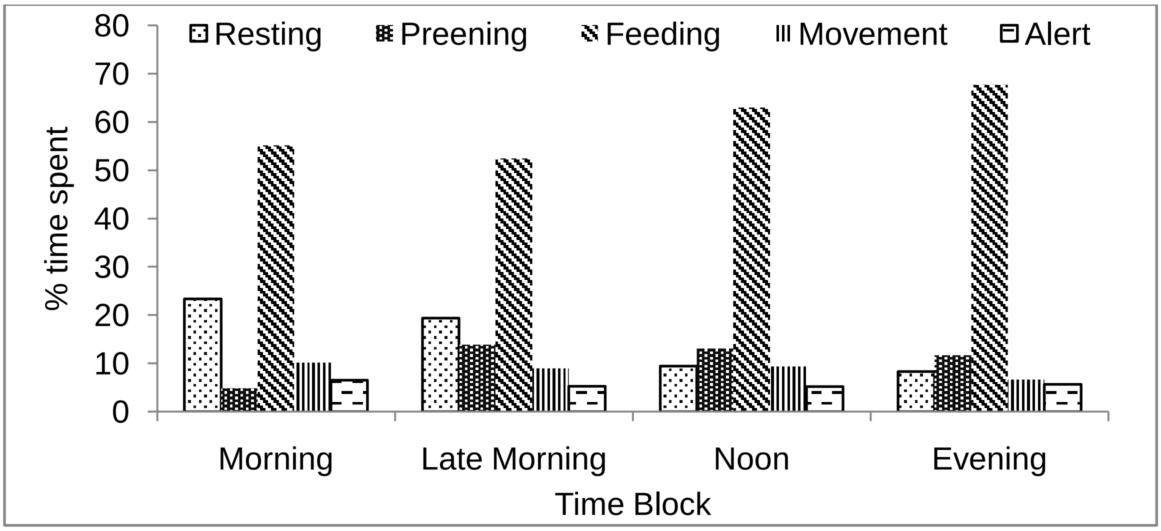


Fig 23: Activity pattern at Moderate water level (10-30 cm) at Newport site in Mudflat habitat

Activity pattern at high water level

Mudflats were inundated with water during high tide only and thus, flamingos had restricted use of this habitat. The mudflats when inundated with water level > 30 cm were abandoned by the flamingos. Thus, the activity of the species in this habitat could not be recorded.

Activity Pattern of Juveniles

Diurnal time budgets of juvenile Lesser Flamingos showed significant differences as compared to adults. Feeding was the dominant activity of juveniles at all the study sites. Though, food intake and availability of food may be the primary reason for diurnal feeding, juveniles activity-budgets may also be influenced by habitat characteristics which plays significant role in determining their other activities.

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.

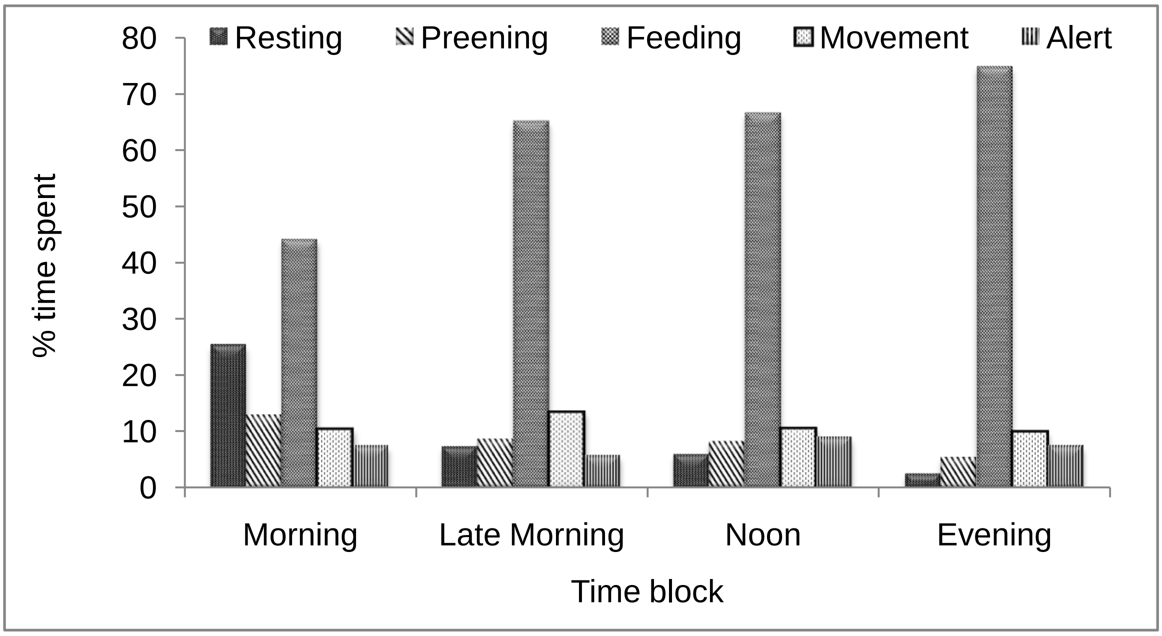


Fig 24: Activity pattern of juvenile Lesser Flamingos in study area

The average time spent by juveniles in preening is less compared to adults (23.6%) during this time block. The time spent in resting decreases considerably as the day progresses and juveniles engage most of their diurnal time during late morning, noon and evening in feeding. Feeding is the main activity of juveniles in the evening (74.9%), which is significantly more as compared to the adult's (63.6%) (Fig. 24).

As, adults are more vigilant to their surroundings, they spent lesser time in alert or vigilance. The time spent in alert or vigilance by juvenile Lesser Flamingos was comparatively higher than adults. They spent 7.3% ± 1.3 of their diurnal time in alert as compared to adults (3.9%). The time spent in movement was also considerably higher in juveniles throughout the day. Juvenile spent 11.0% ± 1.5 of their diurnal time in movement, whereas adults spent 9.9% ± 2.6 of their diurnal time in movements. The reason for higher amount of time spent in movements can be attributed to exploration for food items and search for areas of higher food density and safety (Fig. 24)

Time wise flock size

Flamingos also showed variation in flock size in relation to time of the day. It was observed that, flamingos in morning were compactly placed near each other during resting and also during early foraging periods. Later, as the day progressed, the flamingo flocks starts to spread out and form loose foraging/resting/preening colonies. The data for diurnal variation in flock size was collected from Kumbharwada site only.

Group size fluctuated during the day, with larger groups being observed during the morning and smaller groups from midday to evening. ($r = -0.74$, $p=0.004$, $n = 13$). The average flock size in the morning at Kumbharwada was 290 individuals (SD=100, Range: 169-461 birds) which reduced to 137 birds (SD=32 range: 95-207 birds) in the noon and 75 individuals in the evening (SD=18 range: 52-96 birds) (Fig. 25).

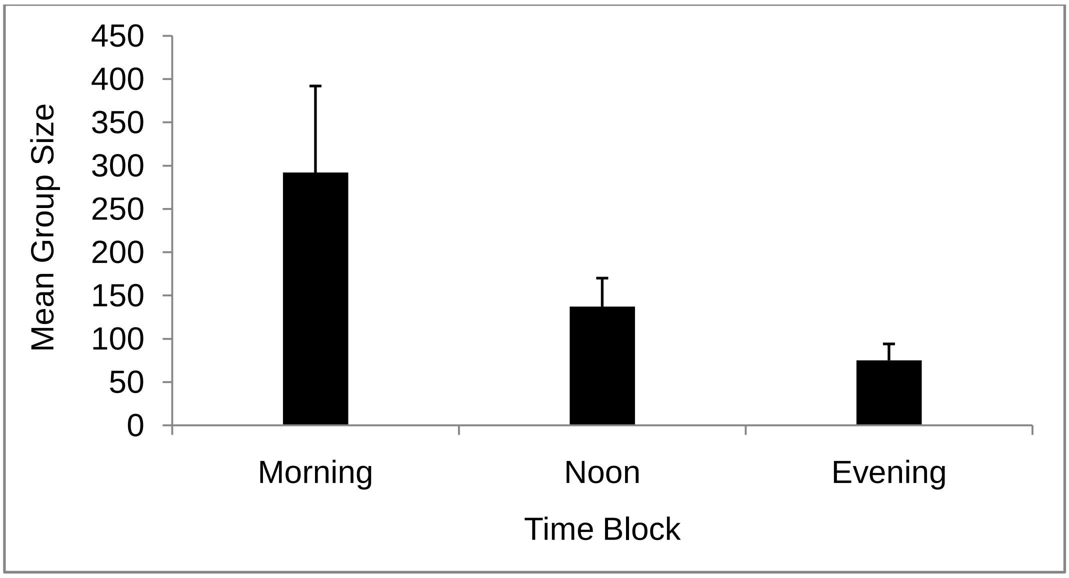


Fig 25: Mean group size in different time blocks at Kumbharwada site

Activity Pattern at Other Congregation Sites

Activity budgets were also studied at other sites of flamingo congregation besides Newport and Kumbharwada site to assess the difference in time spent in various activities at undisturbed sites. Activity budgets were studies at Vadgam near Khambhat which is the northern most point of Gulf of Khambhat and point of juncture of Sabarmati River.

Vadgam (Sabarmati estuary, GoKh)

This is one of the important non-breeding habitats of Lesser Flamingos in the Northern Gulf of Khambhat. During the present study, flamingo flocks ranging from 7,244 individuals to 21,500 birds were observed. The Sabarmati estuary at Vadgam is also one of the important feeding grounds for Lesser Flamingos as flamingos were also observed during breeding season (Plate 2B).

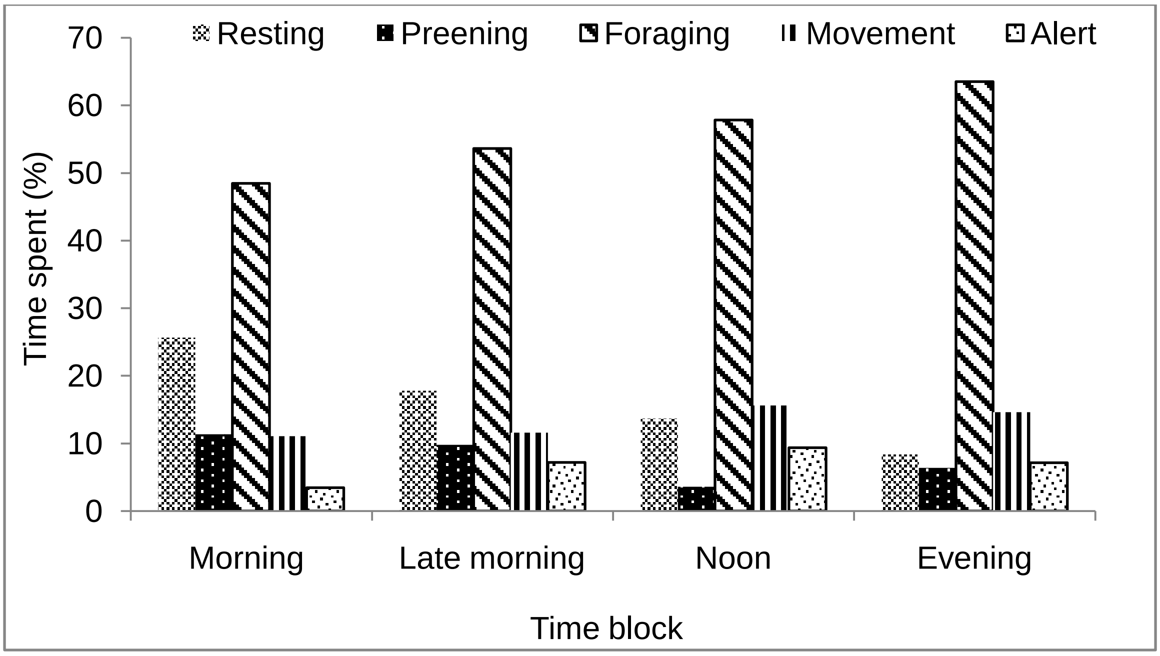


Fig 26: Activity pattern of Lesser Flamingos at Vadgam (GoKh)

Flamingos at Vadgam spent comparatively lower time in feeding as compared to study sites in Bhavnagar. They spent 55.8 % of the total diurnal time feeding as compared to 63.6% at Bhavnagar ($F=6.0$, $DF=3$, $p<0.05$). Time spent in resting throughout the day was less at Vadgam site (16.3 % ± 7.2) as compared to Kumbharwada site (20.2 %± 11.7) suggesting that flamingos at Vadgam site spent more time in other activities than resting and feeding. The species spent 13.2% of their time in movement as compared to 9.9% at Kumbharwada site. Time spent in alert was comparatively higher at Vadgam (6.8 %± 2.4) than Kumbharwada site (3.8 %± 0.4). Time spent in foraging was highest in the evening similar to Kumbharwada site; flamingos at Vadgam spent 63.5% time in feeding (Fig. 26).

Little Rann of Kachchh

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.

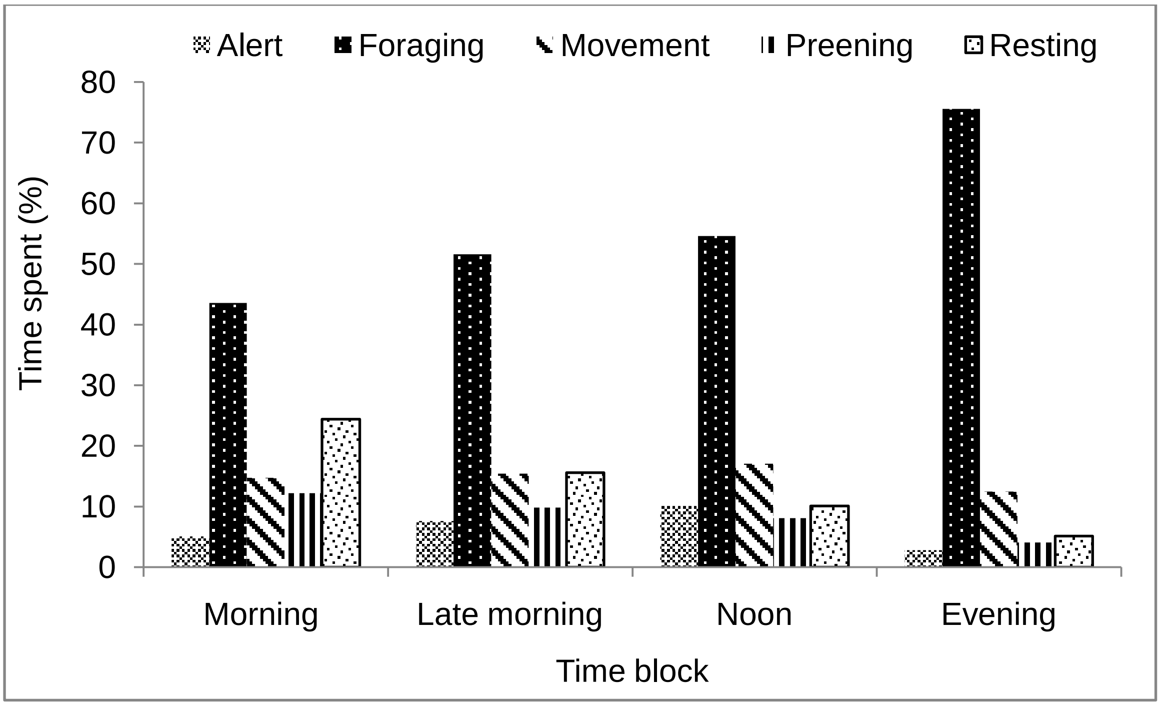


Fig 27: Activity pattern of Lesser Flamingos at Little Rann of Kachchh (LRK)

Flamingos at LRK spent comparatively lesser time in feeding as compared to study sites in Bhavnagar. They spent 56.3 % of the total diurnal time feeding as compared to 63.6% at Bhavnagar. The mean time spent in alert was 6.3% ± 3.2 and in preening was 8.5% ± 3.4. Resting was highest during morning (24.4%) similar to other sites. Moreover, the time spent in movement was significantly higher in LRK (14.9 ± 1.9) as compared to Kumbharwada site (9.9 ± 2.6) ($F=1.94$, $DF=3$, $p<0.05$). Feeding was highest during evening hours (75.6%) analogous to Kumbharwada and Vadgam sites (Fig. 27).

Behavior in Relation to Group Size

To investigate whether activities of a group varies according to the group size, we collected data on number of flamingos in a group and % time allotted by flamingos in relation to its group size.

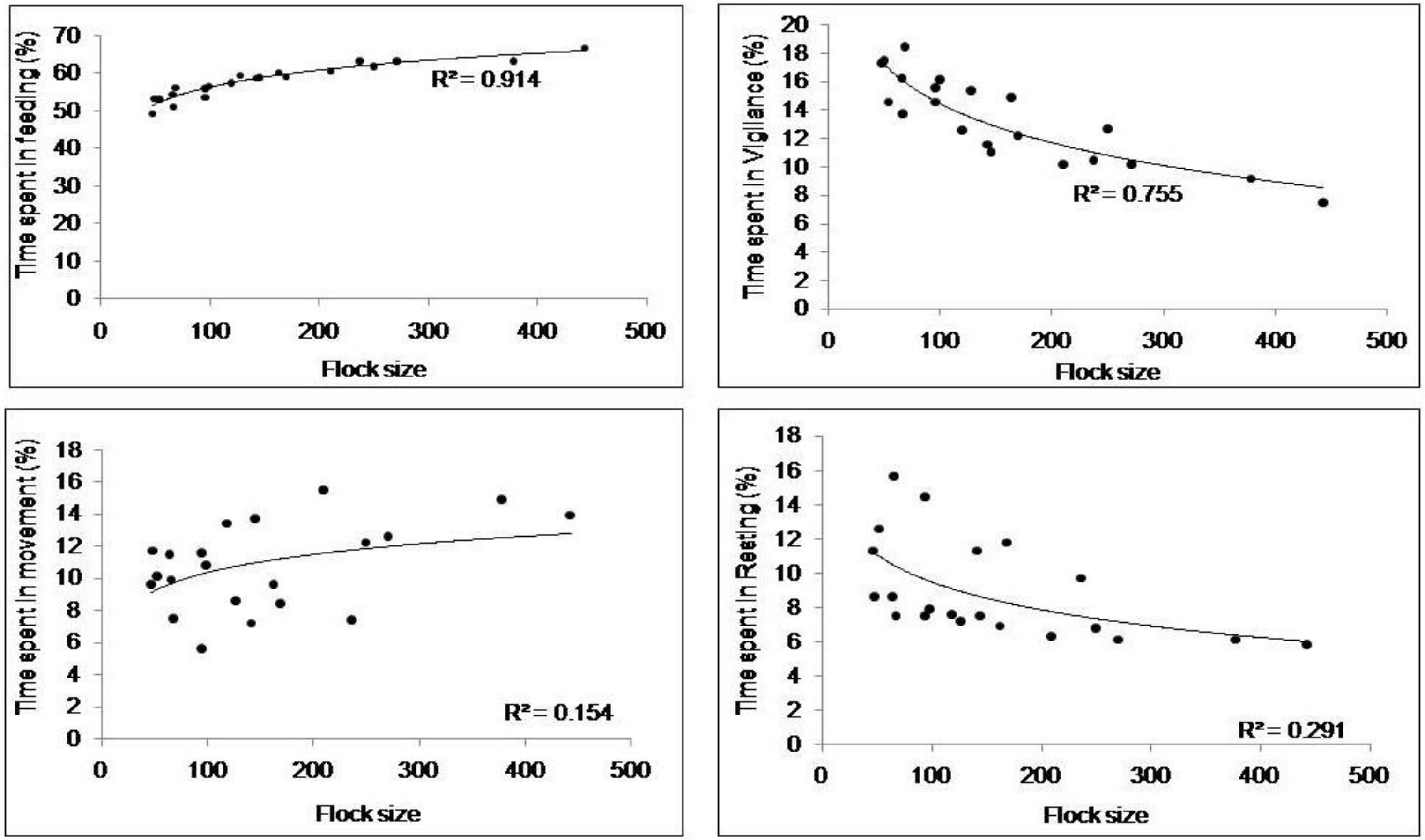


Fig 28: Logarithmic regression analyses showing the proportion of time spent on various behavioral categories in relation to flock size in Lesser flamingo

The relations between the mean time spent on each behavior with group size and period of day were analyzed by logarithm and linear regression analysis.

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) (Fig. 28).

The reason for larger flocks spending more time in feeding could be a means to avoid inter species competition for available food resources. With smaller flocks, the available food resources are less likely to be consumed and thus smaller flocks feed at their ease (Fig. 28). Moreover, the time spent in alert/vigilance is significantly higher in smaller flocks, this is because as a smaller flock, it is very likely to be preyed upon by a predator or keep vigilance on probable threat. With large groups, there are many eyes well spread across the area to keep an eye on possible threat or predator, thus allowing flamingos to spend more time in feeding.

Behavior at Breeding Sites

Activity patterns of Lesser Flamingos were studied at Surajbari breeding site in Gulf of Kachchh (GoK) with a major objective of assessing the difference in activity pattern of the species at both breeding and non-breeding the sites (Plate 4B).

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. Resting similar to non-breeding habitats was the dominant activity during early morning hours (77.3%) but was comparatively higher than non-breeding site. Flamingos spent only 8.6% of their diurnal time feeding, which is significantly low as compared to non-breeding sites. There was no significant difference in time spent in alert/vigilance at both sites (5.6 % at Cherwari and 3.9% at Kumbharwada site) (Fig. 29).

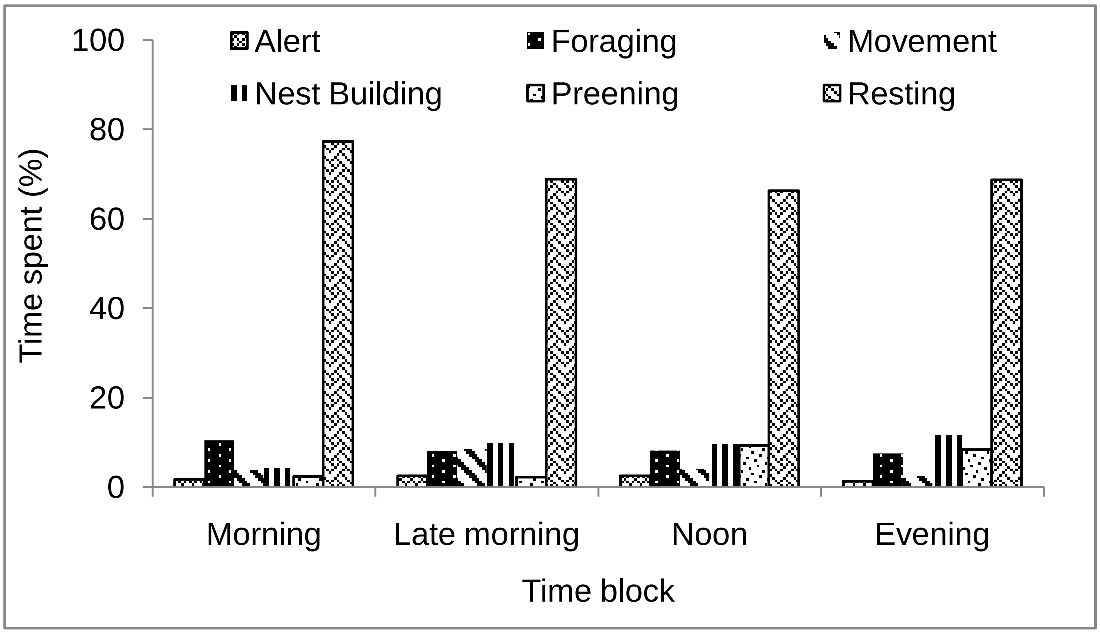


Fig 29: Activity pattern of Lesser Flamingos at Surajbari creek (Breeding site)

The steep decrease in time spent for feeding implies that Flamingos may rely (at least partially) on nutrient reserves acquired before the onset of nesting as reported for several species of geese (Ankney and MacInnes 1978, Raveling 1979).

Commencement of Breeding Activities (Display)

Flamingos perform special rituals prior to their migration to breeding grounds. Such breeding displays were recorded at Kumbharwada site Bhavnagar. Breeding displays starts during mid May or last week of May and continues for around two weeks. Number of displaying flocks, time spent in displays were measured (Plate 4A).

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, $p < 005$). It was observed that larger flocks displayed for a longer time as compared to smaller flocks (Table 1).

Table 1: Flock size and time spent on courtship displays by Flamingos

Time (second) spent by Flamingos in Display	Flock size	Time (second) spent by flamingos in Display	Flock size
68	18	63	33
64	24	45	18
75	23	51	29
71	31	106	41
110	47	121	54
95	38	138	36
106	48	99	21
113	52	142	47
132	61		

Associated Avifauna

Kumbharwada and Newport saltpans have been classified as Important Bird Area (IBA) by BNHS and Birdlife International. The mosaic of habitats at Kumbharwada makes it an ideal haven for not only for flamingos but a number of other residents as well as migratory avifauna.

A total of 124 species of birds belonging to 29 families were observed at both Newport and Kumbharwada sites. Of these 123 species, 60 species were aquatic while 63 species were terrestrial. Of these, 82 species are resident and 41 species are migratory (Table 2).

Table 2: Associated avifauna at study sites

Sr. No.	Name of Bird	Scientific Name of Bird	Terrestrial/ Aquatic	Resident / Migratory
1	Grey Francolin	*Francolinus pondicerianus*	Terrestrial	Resident
2	Rain Quail	*Coturnix coromandelica*	Terrestrial	Resident
3	Lesser Whistling-duck	*Dendrocygna javanica*	Aquatic	Resident
4	Comb Duck	*Sarkidiornis melanotos*	Aquatic	Resident
5	Gadwall	*Anas strepera*	Aquatic	Migratory
6	Eurasian Wigeon	*Anas penelope*	Aquatic	Migratory
7	Spot-billed Duck	*Anas poecilorhyncha*	Aquatic	Resident
8	Northern Shoveller	*Anas clypeata*	Aquatic	Migratory
9	Northern Pintail	*Anas acuta*	Aquatic	Migratory
10	Garganey	*Anas querquedula*	Aquatic	Migratory
11	Common Teal	*Anas crecca*	Aquatic	Migratory
12	Greater Flamingo	*Phoenicopterus ruber*	Aquatic	Resident
13	Painted Stork	*Mycteria leucocephala*	Aquatic	Resident
14	Black-headed Ibis	*Threskiornis melanocephalus*	Aquatic	Resident
15	Black Ibis	*Pseudibis papillosa*	Aquatic	Resident
16	Glossy Ibis	*Plegadis falcinellus*	Aquatic	Resident
17	Eurasian Spoonbill	*Platalea leucorodia*	Aquatic	Resident
18	Black-crowned Night-heron	*Nycticorax nycticorax*	Aquatic	Resident
19	Indian Pond-heron	*Ardeola grayii*	Aquatic	Resident
20	Cattle Egret	*Bubulcus ibis*	Aquatic	Resident
21	Grey Heron	*Ardea cinerea*	Aquatic	Resident
22	Purple Heron	*Ardea purpurea*	Aquatic	Resident
23	Great Egret	*Egretta alba*	Aquatic	Resident
24	Intermediate Egret	*Egretta intermedia*	Aquatic	Resident
25	Little Egret	*Egretta garzetta*	Aquatic	Resident
26	Western Reef-egret	*Egretta gularis*	Aquatic	Resident
27	Little Cormorant	*Phalacrocorax niger*	Aquatic	Resident
28	Indian Cormorant	*Phalacrocorax fuscicollis*	Aquatic	Resident
29	Common Kestrel	*Falco tinnunculus*	Terrestrial	Resident
30	Osprey	*Pandion haliaetus*	Aquatic	Resident
31	Black-winged Kite	*Elanus caeruleus*	Terrestrial	Resident

Sr. No.	Name of Bird	Scientific Name of Bird	Terrestrial/ Aquatic	Resident / Migratory
32	Western Marsh Harrier	*Circus aeruginosus*	Terrestrial	Migratory
33	Pallid Harrier	*Circus macrourus*	Terrestrial	Migratory
34	Montagu's Harrier	*Circus pygargus*	Terrestrial	Migratory
35	Shikra	*Accipiter badius cenchroides*	Terrestrial	Resident
36	Greater Spotted Eagle	*Aquila clanga*	Terrestrial	Migratory
37	Steppe Eagle	*Aquila nipalensis*	Terrestrial	Migratory
38	White-breasted Waterhen	*Amaurornis phoenicurus*	Aquatic	Resident
39	Purple Swamphen	*Porphyrio porphyrio*	Aquatic	Resident
40	Common Coot	*Fulica atra*	Aquatic	Resident
41	Demoiselle Crane	*Grus virgo*	Terrestrial	Migratory
42	Common Crane	*Grus grus*	Terrestrial	Migratory
43	Black-winged Stilt	*Himantopus himantopus*	Aquatic	Resident
44	Pied Avocet	*Recurvirostra avosetta*	Aquatic	Migratory
45	Red-wattled Lapwing	*Vanellus indicus*	Aquatic	Resident
46	Common Ringed Plover	*Charadrius hiaticula*	Aquatic	Migratory
47	Little Ringed Plover	*Charadrius dubius*	Aquatic	Resident
48	Kentish Plover	*Charadrius alexandrinus*	Aquatic	Migratory
49	Pintail Snipe	*Gallinago stenura*	Aquatic	Resident
50	Black-tailed Godwit	*Limosa limosa*	Aquatic	Migratory
51	Whimbrel	*Numenius phaeopus*	Aquatic	Migratory
52	Eurasian Curlew	*Numenius arquata*	Aquatic	Migratory
53	Common Redshank	*Tringa totanus*	Aquatic	Migratory
54	Marsh Sandpiper	*Tringa stagnatilis*	Aquatic	Migratory
55	Common Greenshank	*Tringa nebularia*	Aquatic	Migratory
56	Green Sandpiper	*Tringa ochropus*	Aquatic	Migratory
57	Wood Sandpiper	*Tringa glareola*	Aquatic	Migratory
58	Terek Sandpiper	*Xenus cinereus*	Aquatic	Migratory
59	Common Sandpiper	*Actitis hypoleucos*	Aquatic	Migratory
60	Little Stint	*Calidris minuta*	Aquatic	Migratory
61	Temminck's Stint	*Calidris temminckii*	Aquatic	Migratory
62	Dunlin	*Calidris alpina*	Aquatic	Migratory
63	Ruff	*Philomachus pugnax*	Aquatic	Migratory

Sr. No.	Name of Bird	Scientific Name of Bird	Terrestrial/ Aquatic	Resident / Migratory
64	Brown-headed Gull	*Larus brunnicephalus*	Aquatic	Migratory
65	Gull-billed Tern	*Sterna nilotica*	Aquatic	Resident
66	River Tern	*Sterna aurantia*	Aquatic	Resident
67	Whiskered Tern	*Chlidonias hybrida*	Aquatic	Resident
68	Rock Pigeon	*Columba livia*	Terrestrial	Resident
69	Oriental Turtle-dove	*Streptopelia orientalis*	Terrestrial	Resident
70	Red Collared-dove	*Streptopelia tranquebarica*	Terrestrial	Resident
71	Eurasian Collared-dove	*Streptopelia decaocto*	Terrestrial	Resident
72	Laughing Dove	*Streptopelia senegalensis*	Terrestrial	Resident
73	Rose-ringed Parakeet	*Psittacula krameri*	Terrestrial	Resident
74	Pied Cuckoo	*Clamator jacobinus*	Terrestrial	Migratory
75	Greater Coucal	*Centropus sinensis*	Terrestrial	Resident
76	Spotted Owlet	*Athene brama*	Terrestrial	Resident
77	Common Swift	*Apus apus*	Terrestrial	Resident
78	House Swift	*Apus affinis*	Terrestrial	Resident
79	European Roller	*Coracias garrulus*	Terrestrial	Migratory
80	Indian Roller	*Coracias benghalensis*	Terrestrial	Resident
81	White-throated Kingfisher	*Halcyon smyrnensis*	Aquatic	Resident
82	Common Kingfisher	*Alcedo atthis*	Aquatic	Resident
83	Lesser Pied Kingfisher	*Ceryle rudis*	Aquatic	Resident
84	Green Bee-eater	*Merops orientalis*	Terrestrial	Resident
85	Blue-tailed Bee-eater	*Merops philippinus*	Terrestrial	Migratory
86	Common Hoopoe	*Upupa epops*	Terrestrial	Resident
87	Bay-backed Shrike	*Lanius vittatus*	Terrestrial	Resident
88	Long-tailed Shrike	*Lanius schach erythronotus*	Terrestrial	Resident
89	Southern Grey Shrike	*Lanius meridionalis*	Terrestrial	Resident
90	Black Drongo	*Dicrurus macrocercus*	Terrestrial	Resident
91	House Crow	*Corvus splendens*	Terrestrial	Resident
92	Jungle Crow	*Corvus macrorhynchos*	Terrestrial	Resident
93	Dusky Crag-martin	*Hirundo concolor*	Terrestrial	Resident
94	Wire-tailed Swallow	*Hirundo smithii*	Terrestrial	Resident
95	Red-rumped Swallow	*Hirundo daurica*	Terrestrial	Resident

Sr. No.	Name of Bird	Scientific Name of Bird	Terrestrial/ Aquatic	Resident / Migratory
96	Singing Bushlark	*Mirafra cantillans*	Terrestrial	Resident
97	Indian Bushlark	*Mirafra erythroptera*	Terrestrial	Resident
98	Rufous-tailed Lark	*Ammomanes phoenicura*	Terrestrial	Resident
99	Crested Lark	*Galerida cristata*	Terrestrial	Resident
100	Ashy-crowned Sparrow Lark	*Eremopterix griseu*	Terrestrial	Resident
101	Zitting Cisticola	*Cisticola juncidis*	Terrestrial	Resident
102	Rufous-fronted Prinia	*Prinia buchanani*	Terrestrial	Resident
103	Grey-breasted Prinia	*Prinia hodgsonii*	Terrestrial	Resident
104	Ashy Prinia	*Prinia socialis*	Terrestrial	Resident
105	Red-vented Bulbul	*Pycnonotus cafer*	Terrestrial	Resident
106	Greenish Warbler	*Phylloscopus trochiloides*	Terrestrial	Resident
107	Common Babbler	*Turdoides caudatus*	Terrestrial	Resident
108	Large Grey Babbler	*Turdoides malcolmi*	Terrestrial	Resident
109	Common Myna	*Acridotheres tristis*	Terrestrial	Resident
110	Bank Myna	*Acridotheres ginginianus*	Terrestrial	Resident
111	Brahminy Starling	*Sturnus pagodarum*	Terrestrial	Resident
112	Rosy Starling	*Sturnus roseus*	Terrestrial	Migratory
113	Indian Robin	*Saxicoloides fulicata*	Terrestrial	Resident
114	Common Stonechat	*Saxicola torquata*	Terrestrial	Migratory
115	Isabelline Wheatear	*Oenanthe isabellina*	Terrestrial	Migratory
116	Purple Sunbird	*Nectarinia asiatic*	Terrestrial	Resident
117	House Sparrow	*Passer domesticus*	Terrestrial	Resident
118	Indian Silverbill	*Lonchura malabarica*	Terrestrial	Resident
119	White Wagtail	*Motacilla alba*	Terrestrial	Migratory
120	Citrine Wagtail	*Motacilla citreola*	Aquatic	Migratory
121	Western Yellow Wagtail	*Motacilla flava*	Aquatic	Migratory
122	Tawny Pipit	*Anthus campestris*	Terrestrial	Migratory
123	Rufous tailed Shrike	*Lanius isabellinus*	Aquatic	Resident

DISCUSSION

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). Similar trend in decline in time spent in feeding during onset of breeding season was also recorded for Andean Flamingos (Raveling 1979).

Flamingos are gregarious birds and form very large feeding groups. They form large foraging flocks, which can be interpreted as a effect of the high patchiness of food distribution. 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). Lesser Flamingos require shallow eutrophic wetlands and water bodies which are more saline than those used by the Greater Flamingos, because it feeds mainly on blue-green algae that bloom under these conditions (Brown et al., 1982). During the wet season, Lesser Flamingos at Lake Abijata were observed in mudflat habitat where diatoms may be plentiful (Kumssa and Bekele, 2014).

Feeding usually was the major activity of flamingo, probably because of the small size of their prey items that flamingos are forced to spend more time on feeding than on other forms of behavior. During present study also, flamingos were chiefly engaged in feeding activities at all the major habitat types. The present study showed a significant increase in the percentage time spent in feeding during evening hours. More feeding activity of flamingo in the late afternoon may reflect their need to obtain energy for overnight energetic requirements. The general pattern of flamingo feeding in different regions worldwide is that they fed mainly during morning and late afternoon to early evening and roosted during the midday (Bildstein et al., 1991). Flamingos during the non-breeding phase at the study site spent > 40% of their time in feeding, which is consistent with the results of previous works on the closely related species (*Phoenicopterus ruber*) (e.g. Schmitz and Baldassarre, 1992).

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). The larger flocks displayed intense feeding behavior and spent comparatively higher time in feeding due to intra-species competition for the available food resources. As the present study did not deal with the density of available food resources the behavior patterns were correlated with physical habitat features only. However, earlier studies on other species of Flamingos have demonstrated that, the food density and availability alone does not play a significant role in species' distribution (Caraco, 1979). Moreover, study by Kihwele et al. (2014) suggests that water temperature, salinity and DO levels regulate the temporal and spatial abundance and diversity of phytoplankton, their blooms, and the abundance and distribution of the phytoplankton.

In the present study, flamingos showed slight behavioral 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. For example, a study on Lesser Flamingo in Kenya found pronounced fluctuations in flamingo numbers that were not correlated to algal densities (their main food item; Vareschi, 1978) an distribution of Chilean Flamingos (*Phoenicopterus chilensis*) in Peru was not related to food abundance but negatively related to fish densities, which compete flamingos for invertebrate prey (Hurlbert et al., 1986).

During present study, we did not observe any predation attempt against flamingos, despite the presence of predators, such as the marsh harrier (*Circus aeruginosus*), Jungle cat (*Felis chaus*) and stray dogs, in the study area. However, flamingos were frequently disturbed by grazing cattle and stray dogs, which were thus probably perceived as a predation risk and may have been the cause for time spent in alert or vigilance while feeding. It was observed that time spent in alert reduced with larger flocks ($r = 0.75$). Overall, this vigilance level was negatively related to flock size. Similar diurnal decreases in vigilance with flock size have been documented in other populations of flamingos (Schmitz and Baldassarre, 1992; Beauchamp and McNeil, 2003). Interestingly, it was observed that juveniles spent more time in alert/vigilance as compared to adults during all the months. One possible explanation of the observed age related vigilance in juvenile flamingo flocks could be that young flamingos in mixed flocks rely on presence of adults to decrease their vigilance time. Moreover, adults have higher experience in detecting dangers and their better informative value, allowing them to decrease their vigilance level and to increase their foraging time (Schmitz and Baldassarre, 1992.)

The finding of the present behavioral study underlines the complexity of social and ecological factors affecting the behaviour 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 behaviour and feeding ecology of the studied flmingo flocks.

Plate 1

A. Lesser Flamingo feeding at very low water level (> 10 cm)

B. Lesser Flamingo feeding at very moderate water level (10-30 cm)

C. Flamingos feeding at high water level (> 30 cm)

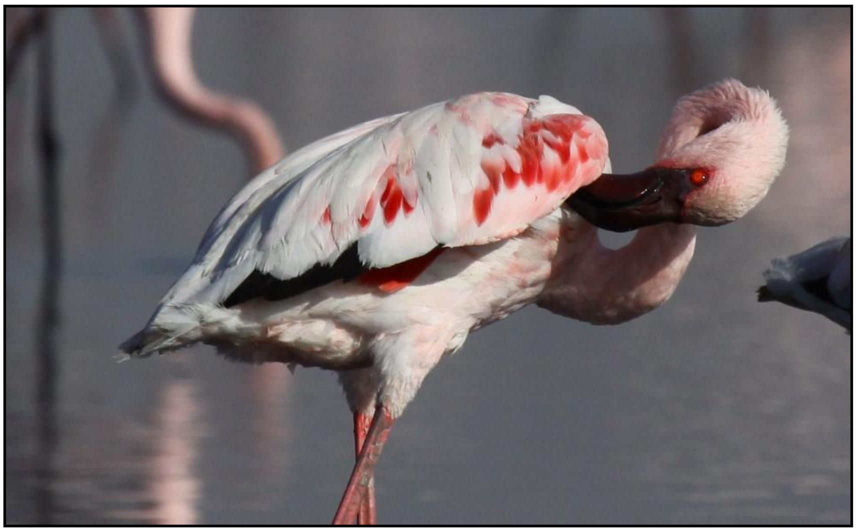
Plate 2

A. Flamingos feeding in wet mud

B. Flamingos feeding in wet mud at Roniyo beyt

C. Deep water feeding at Kumbharwada site

Plate 3



A. Lesser Flamingo – Preening

B. Lesser Flamingo – Movement

C. Lesser Flamingo – Alert

Plate 4

A. Lesser Flamingo engaged in breeding display

B. Lesser Flamingos engaged in Nest building at Cherwari site