CHAPTER: 1

Population trend and Roosting behaviour of Black kite (*Milvus migrans govinda*)

INTRODUCTION:

Avian population fluctuations have been shown to arise primarily from random demographic processes (Karr, 1982; Boag and Grant, 1984; Desante and Geupel, 1987) as well as movements of individuals within and among habitats (Greenberg, 1981, Karr and Freemark, 1983, Whellwright, 1983). Among these populations, raptors are of particular concern as they have great symbolic significance in many cultures and great value as potential indicator or umbrella species (Simberloff, 1998). These predators play important role in ecosystems because they can determine the community structure patterns of their prey (Menge *et al.*, 1994). As these umbrella species are known to occur at low population densities and have large individual home ranges, by protecting them we protect all the species on which they depend directly or indirectly and also those species which have similar requirements but smaller home ranges. Therefore, top predators like raptors are considered as key taxa in planning conservation strategies and also environmental impact assessments (Simberloff, 1998; Martinez *et al.*, 2003). They are quite sensitive to changes in habitat structure/fragmentation and have a high susceptibility to local extinction (Simberloff, 1988; Thiollay, 1989; Savard *et al.*, 2000; Chace and Walse, 2006). Hence, they act as valuable indicator species on changes and stresses in the various ecosystems including urban system. Nevertheless populations of raptors worldwide are declining and many species are threatened with extinction (IUCN, 2002).

Urbanization produces large scale extensions of once continuous natural habitats, causing its intense fragmentation. This results in extensive changes in the landscape (Clergeau and Quenot, 2007). The increased urbanization usually leads to an increase in the avian biomass with reduction in species richness (Marzluff, 2001; Rathod, 2009). This successive increase is reflected as increase in the population of certain species as urban settings are free from persecution as it provides adequate food supplies (Chace and Walse, 2006). Urban areas house a large proportion (~50%) of the world's human population (Brown *et al.*, 1998) and this proportion is increasing rapidly, particularly in the developing world (World Resources Institute, 1996). As natural habitats are encroached by urban settlements, it is clear that their impacts need to be mitigated, and their potential for conservation better understood and exploited. Numerous studies on avifauna have been carried out in urban landscapes. Many of these studies focus on birds in remnant forests, urban reserves or parks or urban habitats in general (Tomialojc, 1998, Natuhara and Imai, 1999; Park and Lee, 2000) while, other studies focus on the changes in bird communities across gradients of urbanization (Rathod, 2009). Many of these studies report that the density and structures of vegetation cover (both native and exotic), and the availability of anthropogenic food influence bird communities (Mills *et al.*, 1989; Munyenyembe *et al.*, 1989; Jokimäki and Suhonen, 1998; Maeda, 1998; Rathod, 2009). However, urban habitats have been considered to be of superior quality for raptors. Species that meet their food requirements within such settings exhibit positive population responses. Marzluff *et al.* (2001) have stated that in order to forecast the effects of human settlement, evaluating how increasing exurban development affects avian species with large area requirements is likely to help to identify the proximate factors that drive these changes.

The behavioural flexibility in the form of rapid adjustments to the new conditions, allows birds to respond rapidly to changing environment. The litheness to adapt to changes in landscape and habitat configurations is considered as a key to success for several avian species residing in urban areas. They are able to respond to urban environment due to an important component of their behaviour *i.e* colonizing. Though daily activities of a bird follow an endogenous or circadian rhythm, the exact time of their display varies from day to day. The variations are not random, but are related to concurrent changes in environmental factors *i.e* weather that can affect individual behaviour, natality, mortality and dispersal. These potential repercussions on population and community regulation, reflect that birds can alter their behaviour in response to changing environment (Reebs, 1986; Tester, 1987). Urbanization , is one such change in natural habitats that produces substantial and lasting effects on bird communities (Marzluff and Ewing, 2001) by altering the amount, composition and arrangement of vegetation (Hostetler, 2001, Melles *et al.*, 2003), creating barriers to movements (Fernandez-Juricic, 2000) and changing local temperature, food supply, predators, and parasites (Bowman and Woolfenden, 2001; Crooks *et al.*, 2001; Marzluff, 2001, Chance *et al.*, 2003; Thorington and Bowman, 2003; Sinclair *et al.*, 2005; White *et al.*, 2005).

Black kite (*Milvus migans govinda*) (Plate I) is one such resident urban raptor of Indian sub-continent. However, this raptor occurs in huge numbers in metro cities (Altkin, 1947; Ali and Reply, 1968; Mahabal and Bastawade, 1987; Rathod, 2009). As this species is abundant in the area it has been classified as least concerned (Bird Life International, 2009). However, being a member of family Accipitridae it is a schedule I species of Wild life Protection Act (1972), amendment 2008. Panuccio and Agostini (2010) described that Black Kites show intermediate behaviour between eagles and harriers. It also shows migratory as well as local movements in different regions. At the Strait of Gibraltar large numbers of kites gather to cross Central Mediterranean region through the Channel of Sicily and the Tyrrhenian Sea for spring migration (Agostini and Duchi 1994; Panuccio *et al.* 2004; Mellone *et al.* 2007) while in India though a resident species there are populations that show local movements (Altkin, 1947, Mahabal and Bastavade, 1987).

Black Kites have become very common species in the urban skies and their soaring and roosting behaviour in these built-up areas is a common scene. Further, this species is also known to form roosting aggregation in cities. In Vadodara (Lat22° 18' N, Long 73° 10' E) (Plate II)numbers of Black Kite start increasing mostly by the end of April and the beginning of May, when a significant percentage of immature birds are observed. As is also observed by several authors that non-breeders cross the Central Mediterranean during spring migration and conversely during autumn migration (max. 3600 over the island of Marettimo in 1998) peaking in late August, when mostly adults are observed (Agostini *et al.* 2000; Agostini *et al.,* 2004; Panuccio *et al.,* 2005; Panuccio *et al.,* 2007

Panuccio and Agostini (2010), in Vadodara also, the numbers increase by the month of August when monsoon sets in, with the arrival of local migratory population.

Population density is one of the major ecological characteristic pertaining to the ecosystem level energy use by the species (Makarieva *et al.*, 2005). Most studies concerning habitat use by raptors focus on 'microhabitat' variables such as tree characteristics, ground cover or perches, often measured at small detailed scales (Fuller, 1979; Andrew and Mosher, 1982; Cody, 1985; Verner *et al.*, 1986, Sanchez- Zapara and Calvo, 1999). As, there is a lack of documented information about the population trend and phenomenon of its roosting by Black Kites *Milvus migrans govinda* in response to change in climatic factors, the present study investigates the influence of different environmental factors *viz.* Temperature, Humidity and Rainfall in Vadodara over the three seasons summer, monsoon and winter. Thus, an attempt is made to analyze the distribution and density of Black kites in an urban semi-arid region of

Gujarat to discuss the influence of seasons on their distribution, fluctuation and density patterns and rooting behavior.

Many studies on diurnal activity patterns have focused on the communal roosting of birds, which is a well known phenomenon among numerous species like Starlings (Jumber, 1956), Herring Gulls (Schreiber, 1967), Corvids (Everding and Jones, 2004), *etc.* As far as raptors are concerned, roost counts can be a useful method for assessing and monitoring raptor populations as long as the counting regime is able to detect real differences in daily variability in roost size. In many communally roosting species the temporal patterns of roosting behaviour are also affected by various environmental factors which in turn have become modified due to urbanization and human interferences. Despite the extensive time spent by birds at roosts and their presumed vulnerability while asleep, little is known about the roosting behaviour of majority of species especially the communally roosting raptors of tropical region. In urban areas, the influence of increasing roads with vehicular traffic, direct loss of habitat, disturbance through the presence of humans during the construction processes and the presence of artificial light used to illuminate the area influencing photoperiod needs to be investigated.

The above mentioned human activities are known to impact wild populations in variety of ways including their distribution, habitat use, dispersal patterns, fecundity, survival, and energy budgets (Knight and Cole, 1991). Hence, in the present chapter, population fluctuation over the year as well as roosting behaviour of Black Kites (*Milvus migrans govinda*) in urban areas of Vadodara city, Central Gujarat, India is considered.

MATERIALS AND METHOD:

Black Kites are known to show pre-roosting behaviour (Plate 4) in the form of soaring around the roost before descending onto the roost in the evening. Three sites were identified while randomly searching for roosting sites in the city. These sites were surveyed for Kite populations about 6 times in a month from January 2009 to December 2011 before sunset time, either by direct observations or by surveying the potential tree assemblages where pre-roosting behaviour has been observed earlier.

1. <u>Study area</u>: Plate II and III

Three major locations could be identified in Vadodara city (22° 18' N, 73° 10' E) having varying degree of urbanization and human activities along with differences in their habitat composition. Of the three roosting sites, a major roosting congregation was observed in an undisturbed area of Sayaji Baug (commonly known as Kamati Baug) (22 ° 18'N, 73 ° 12'E). It is the largest public park in Western India stretching over 113 acres. A small river Vishwamitri cuts across the park. Park has rich flora of more than 98 species of trees (Thaker and Jasrai., 2005). An assemblage of trees on the eastern side of the park is used by kites for communal roosting.

The second assemblage of trees utilized for roosting is located near Vadodara railway station (22 ° 18'N, 73 ° 12'E). This roost is highly disturbed because of vehicular and rail traffic as well as continuous human activities. The third roost at Bhutdizapa (22"18' N, 73"12' E), is located right in the middle of the city and surrounded by concrete jungle. It is also a highly disturbed area.

2. Population size at Roosting:

The Black Kites were observed with naked eyes as well as with the help of field binoculars (10X magnification) whenever required. When kites are displaying their pre-roosting behaviour they can be accurately counted by point count method. Hence, the number of kites exhibiting pre-roosting behaviour was visually counted at each roost. Photographs were taken with the help of Canon D70. Simultaneously, to find out the effects of vehicular traffic, the number of vehicles passing in 1 hour at the time of roosting at three study sites was also noted. Population density was calculated as number of birds per roost and population size was noted as the mean of total number of Black kites observed monthly at the three sites.

3. Roost site characteristics:

To find out roost site characteristics, the tree species preferred for roosting by Black Kites were identified and their percentage calculated within 1 Km of each roost along with the total area occupied by the trees. The perimeter of each roost was walked on feet and the number of trees used for roosting were identified and on the basis of this percentage of trees used calculated.

As at each roost all the trees are typically of same age, their height was obtained using scale method and girth were obtained by a measuring tape to find out Diameter at breast height (DBH). The circumference of a tree trunk was divided by Π (3.14). The percentage of canopy cover was measured with the help of a mirror that has known numbers of grids marked on it with uniform length and width. For the evaluation of the tree canopy, the grid mirror was held under the canopy exactly parallel to the ground and the number of grids occupied by the image of the canopy and the grids that were exposed to light having no image of canopy were counted to find out percentage of canopy cover (Paletto and Tosi, 2009). The approximate linear distance from the centre of the roost to the nearest road and building was also measured by step counting method. The shape index for the roost was calculated using formula S = L-W/L, where L is the length of the roost and W is width. This index ranges from 0, when length and width of the roost are equal, to 1, for maximum difference between these two measures (Sarasola and Negro, 2006).

4. Meteorological parameters:

Temperature and humidity were recorded with the help of MEXTECH-Thermo-Hygro Clock J421CTH instrument while rainfall was obtained from the meteorological Division, Department of Physics, The M.S. University of Baroda, Vadodara. Information regarding three meteorological parameters *viz*. Temperature, Humidity and Rainfall were pooled monthly. As sun sets in the subtropical zone where Vadodara is located, before and after 7 p.m. depending on seasons, the time was considered as + or - with reference to 7 p.m.

5. Statistical analysis:

To correlate kite population with seasons, data was pooled into three seasons: Summer (February to May), Monsoon (June to September) and Winter (October to January). Rainfall data was not used for the analysis as rains occur only during monsoon in semi- arid zone of India. Multiple

Linear Regression (MLR) was employed to examine the effects of environmental variables on the fluctuations in the populations and roosting time of Black Kites. While Pearson correlation coefficient was employed to find out seasonal correlation between roosting time with sunset, humidity and temperature in three seasons. Statistical software package Graph Pad Prism 5.00 was used for both. Values are expressed as mean ± SE and test statistics were considered significant at $P < 0.05$. PAST was used mainly for the preparation of graphs.

Results:

Population fluctuation in Black Kites: (Seasonal-Table: 1, Monthly-Fig: 1)The Population of Black Kites at roost was highest during Monsoon (August) with mean 541.7 ± 17.33 individuals at Sayajibaug, 322 ± 9.18 at Railway station and 152 ± 4.41 at Bhutdizapa roost while lowest in summer (March-April-May) with mean 102.2 ± 3.7, 127 ± 6.8 and 77.33 ± 3.38 at Sayajibaug, Railway station and Bhutdizapa respectively. During winter the population of Black kites was 166 ± 7.1 at Sayajibaug, 162.2 ± 8.48 at Railway station and 105.3 ± 4.63 at Bhutdizapa.

Roost site characteristics (Table: 2):

At Sayajibaug roost, the number of Black Kites was highest in monsoon and increased from June to September varying between 400-700 birds/ 10 trees while lowest in summer from March to May with 120-150 birds/ 10 trees. Here, 44 trees of two species, Nilgiri (*Eucalyptus hybrid*- 8 trees-18.18%) and Asoka (*Saraca asoca*- 2 trees-4.5%) are used for roosting (Table 2). The mean height (in m.) and Girth (in cm.) of Nilgiri trees were 21.33 ± 1.32m. and 53 ± 0.84 cms. respectively while those of Asoka trees were 18.28 ± 2.01m. and 60 ±1.02 cms. respectively. Canopy cover of Nilgiri and Asoka were 56% and 50% respectively, while, the shape index for Nilgiri trees was 0.5 and for Asoka trees 0.6. The nearest building and road from roost at Sayajibaug were located at 490m and 402m respectively.

At the second roost *i.e.* near Vadodara Railway station also, maximum kites were counted during the months of Monsoon- June to September, ranging between 300-450 on 7 Maha neem (*Alianthus exelsa*) trees while minimum in summer from March to May ranging between 110-120 individuals. Here, 25 Maha Neem are present on one side of one kilometer long road. Out of these, 7 trees (28%) were used for roosting. The mean height (m) and Girth (cm) for Maha Neem were 21.33 ± 2.12m and 106 ± 1.89cm respectively. The mean canopy cover was 79 % ± 1.02 while the shape index for the roost was 0.66 and the distance to the nearest building and the road from the roost site were 30m. and 0m. respectively.

At the third roosting site *i.e.* Bhutdizapa the number of Kites occupying the roost was highest during the months of monsoon but from July to September with the numbers varying between 120-175 birds on 3 Neem *(Azadiracta indica)* trees and minimum during March to May ranging between 50-80 individuals. Here, the tree density was 8 trees/Km which is a monospecific assemblage. Out of these only 3 trees were used for roosting. The height (m) and girth (cm) of these trees were 19.81 ± 0.98m. and 89 ± 0.98 cm. respectively. Their canopy cover was 84% ± 0.83 while the shape index for the roost was 0.64 and the distance to the nearest building and road 100m. and 70m. respectively.

Distribution of Black kites in relation to anthropogenic activities:

The number of vehicles passing in 1 hour at the time of roosting was counted at three sites. At Sayajibaug assemblage of trees on Eastern side of the park has very low human intervention. Here, there is no vehicular traffic. The nearest main road is about 490m away. At the second study site Railway station the vehicular traffic is very heavy (600 ± 0.05 vehicles/ hour) at the time of roosting. In addition the noise of passing trains is also very high. This roost is located on the side of road hence the distance between road and roost is very low 4.2 m. Similarly around the third site, Bhutdizapa, also large number of vehicles pass at the time of roosting (800 ± 0.08 vehicles/ hour). This site is present in the centre of Vadodara city with concrete jungle and very few trees for roost. The habitat variables at three sites were Natural vegetation (Sayajibaug), commercial buildings with residential area (Railway Station) and Residential area – Old city (Bhutdizapa). At Railway station and Bhutdizapa roosts very low vegetation cover is present with minimal diversity in tree species.

Meteorological parameters: (Table: 3, Fig.2)

a. **Temperature (°C):** In Vadodara, significant fluctuations in the atmospheric temperature occur over the year. The mean temperature at roosting site and time was 30.2 °C ± 0.46 in monsoon 27.76 °C ±1.5 in winter while 32.44 °C ± 2.0 in summer.

b. **Humidity (%):**Lowest humidity levels occurred in summer (59.92 ± 5 %) while highest in Monsoon (79.9 ± 3.2%). Once the monsoon is over humidity levels drop significantly and in winter mean humidity was 69.41 ± 0.9%.

c. **Rainfall (mm):** As in Vadodara city the rains occurs only in monsoon, during the study period low 526.2 mm rainfall was recorded in 2009 while high 950.1 mm in 2010 and 850.5 mm in 2011 Hence, the mean annual rainfall was 775.6 ± 0.3 mm.

d. Sunset (p.m.): With the increase in the day length, the sunset time extends in summer (7:30 p.m. ± 2.34 min.) and monsoon (7:16 p.m. ± 1.68 min.) while with the arrival of winter sunset was early (6:18 p.m. ± 2.43 min.) due to decrease in the day length.

e. Roost Arrival time (p.m.): Arrival time of Black kites was recorded when first kite arrived at roost in the evening. The kites arrived before sunset. In summer, their arrival time was 7:22 p.m.± 2.25min. while in monsoon it was 7:05 p.m. ± 2.43, while in winter 6:08 p.m. ± 2.49 min. The arrival of Black Kites to their roosts is usually 5-15 minutes before the sunset. The Black Kites arrived at their roosts during monsoon earlier as compared to their delayed arrivals during the summer months.

Relation between Black kite Population and different environment variables- temperature and humidity at roosting time

Multiple Linear Regression analysis was employed to assess the relationship between fluctuations in population of kites (as dependant variable) and environmental variables like temperature and humidity at roosting time (as independent variable). Temperature and humidity in monsoon correlated with population significantly at R^2- 0.99 and 0.7 respectively. During summer and winter only temperature was explained with R^2 at 0.8 and 0.83 respectively while humidity did not show as much of positive relationship at all three roosting sites.

Multiple linear regression was also employed between roosting time (as dependent variable) and environmental variables like Sunset time, Temperature and Humidity (as independent variables). The results (Table:5 and Fig:4) show that, the regression coefficient $R^2$was highly positive for sunset 0.96, 0.94, and 0.96 at all the three roosting sites. Temperature also influenced roosting time by 90% in Sayajibaug , 89% at Railway station and 87 % at Bhutdizapa. However, humidity showed negative relationship at all three roosting sites (R^2- 0.57, 0.53, 0.56 respectively).

Seasonal correlation between roosting time with sunset time, humidity and temperature:

Pearson correlation coefficient is considered between roosting time and sunset time, temperature and humidity. All the three were significantly correlated during summer, with temperature negativerly at P <0.001 (P- -0.89***), with sunset positively correlated at P<0.05 (P- 0.69*) and with humidity positively correlated at P<0.001 (P-0.88***). However, in monsoon sunset time significantly correlated at p<0.001 (P-0.81***) while humidity positively correlated at p<0.05 (P- 0.7*). During winter sunset time positvely correlated at p<0.01 (P-0.76**).

Sunset was important for kites to arrive at roost in all seasons but it was more significant in monsson when humidity was high and significance was low in summer when humididy was low. In other words it can also be said that when humidity was high roosting time was correlated only at * in monsoon while humidity was low in summer, roosting time and humidity were highly significantly correlated. During winter only sunset time was significant at $p<0.01$ (P-.0.76**) to arrive at roost while temperature and humidity were nonsignificant.

General Observations:

Though, three permanent roosts were found during the study period, in Monsoon when additional migratory population arrives three temporary roosts were observed near two garbage dumping sites and a poultry farm.

Pre roosting display (Plate 4)

Generally, Black Kites gathered above the roost and were seen soaring in the sky for sometime before settling down. Such displays were intense towards the end of August and in early September (end of Monsoon). Black kites gathered and showed pre- roosting display for about 5 to 15 minutes before sunset. The flock comprising of 50 – 250 birds fly high up in the sky by circling around and then descending slowly on the roost tree and again ascending in the sky. After a period of 6-10 minutes the pre-roosting display ends and the flock slowly comes down at the roost. Sometimes, the kites which had already settled down also take off without making any noise and complete a round of about half a kilometer radius over the roost before settling down again. In summer, when temperature is high at ground level, the kites soar high in the sky for long time after sunset. Occasionally they are also seen soaring under clouds on hot days.

Table: 1 Population of kites during different seasons at the three roosts.

Name of different sites	Summer	Monsoon	Winter
Sayajibaug	102.2 ± 0.3.7	541.7 ± 17.33	166 ± 7.1
Railway Station	127 ± 6.8	322 ± 9.18	162.2± 8.48
Bhutdizapa	77.33 ± 3.38	152 ± 4.41	105.3 ± 4.63

Table 2: Characteristics of roost and roosting trees of Black Kites in Vadodara city

Roosting Site	Sayajibaug		Railway Station	Bhutizapa
1. Number of Black kite at Roost	400-700 birds on 10 trees		300-450 on 7 trees	120-175 birds on 3 trees
2. Tree Species used	*Eucalyptus* hybrid	*Saraca asoca*	*Alianthus exelsa*	*Azadiracta indica*
3.Trees/ Km	44		25	8
4. Trees used for roosting	8	2	7	3
5. Tree used (%)	18.18%	4.5%	28%	37.5%
6. Tree height (m)	21.33 ± 1.32	18.28 ± 2.01	21.33 ± 2.12	19.81 ± 1.89
7. Girth of tree (cm)	53 ± 0.84	60 ± 1.02	106 ± 1.89	89 ± 0.98
8. Canopy cover (%)	56% ± 0.56	50% ± 0.96	79% ± 1.02	84% ± 0.83
9. Shape Index (Roost)	0.5	0.6	0.66	0.64
10. Distance to nearest road (m)	490		0	70
11. Vehicular traffic per hour	0		600 ± 0.05	800 ± 0.08
12. Distance to nearest building (m)	402		30	100

Table: 3 Mean Temperature, Humidity, Sunset time and Arrival time of Black kites at Vadodara.

Parameters	**Summer**	**Monsoon**	**Winter**
Temperature at roosting time ^{0}C	32.44±2	30.2± 0.46	27.76±1.5
Humidity (%)	59.92± 5	79.9±3.2	69.41±0.9
Rainfall (mm)	-	775.6 mm ± 0.3	-
sunset time (p.m.)	7:30 ± 2.34	7:16 ±1.68	6:18 ±2.43
Arrival time (p.m.)	7:22 ±2.25	7:05 ±2.43	6.08±2.49
Difference arrival and sunset time	8 min	11 min	10 min

Table: 4 Relation between Black kite Population and environment variables-temperature and humidity at roosting time.

	R^2 value(Non significant)	
Seasons	**Temperature**	**Humidity**
Summer	0.8	0.15
Monsoon	0.99	0.7
Winter	0.83	0.18

Table: 5 Relation between Roosting time as dependent variable and environmental variables (Sunset time, Temperature and Humidity) as independent variables.

	Sunset	**Temperature**	**Humidity**
Sayajibaug			
R^2	0.96	0.9	0.57
Railway Station			
R^2	0.94	0.89	0.53
Bhutdizapa			
R^2	0.96	0.87	0.56

Table:6. Seasonal Correlation between roosting time with sunset time,humidity and temperature

	Summer	Monsoon	Winter
Temperature	-0.89***	0.51 NS	0.59 NS
Sunset time	0.69*	0.81***	0.76 **
Humidity	0.88***	0.7*	0.47 NS

* P<0.05, ** P<0.01, *** P<0.001, NS- Non significant

Fig: 1 Annual fluctuations in black kite population at three roosts.

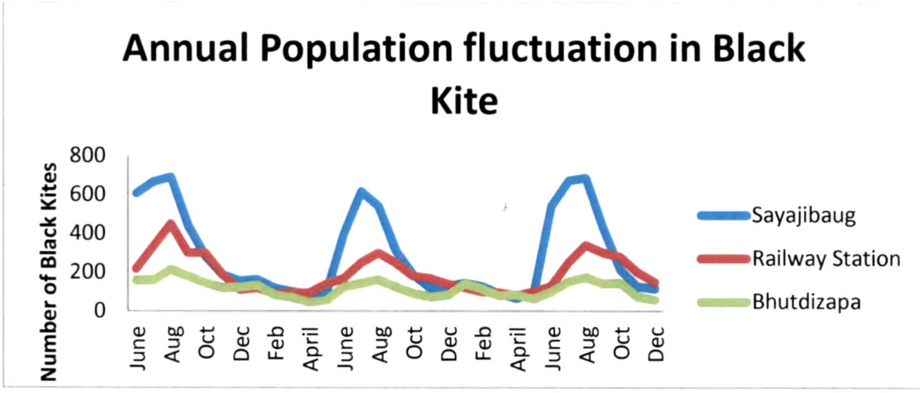


Fig: 2 Seasonal changes in Temperature, Humidity, Sunset time and roosting time of Black kites inVadodara.

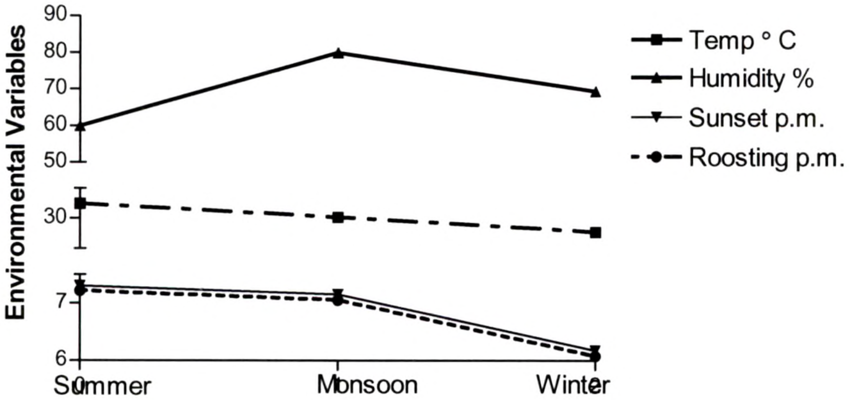


Fig:3 Relation between Black Kite Population with temperature and humidity in summer, monsoon and winter.

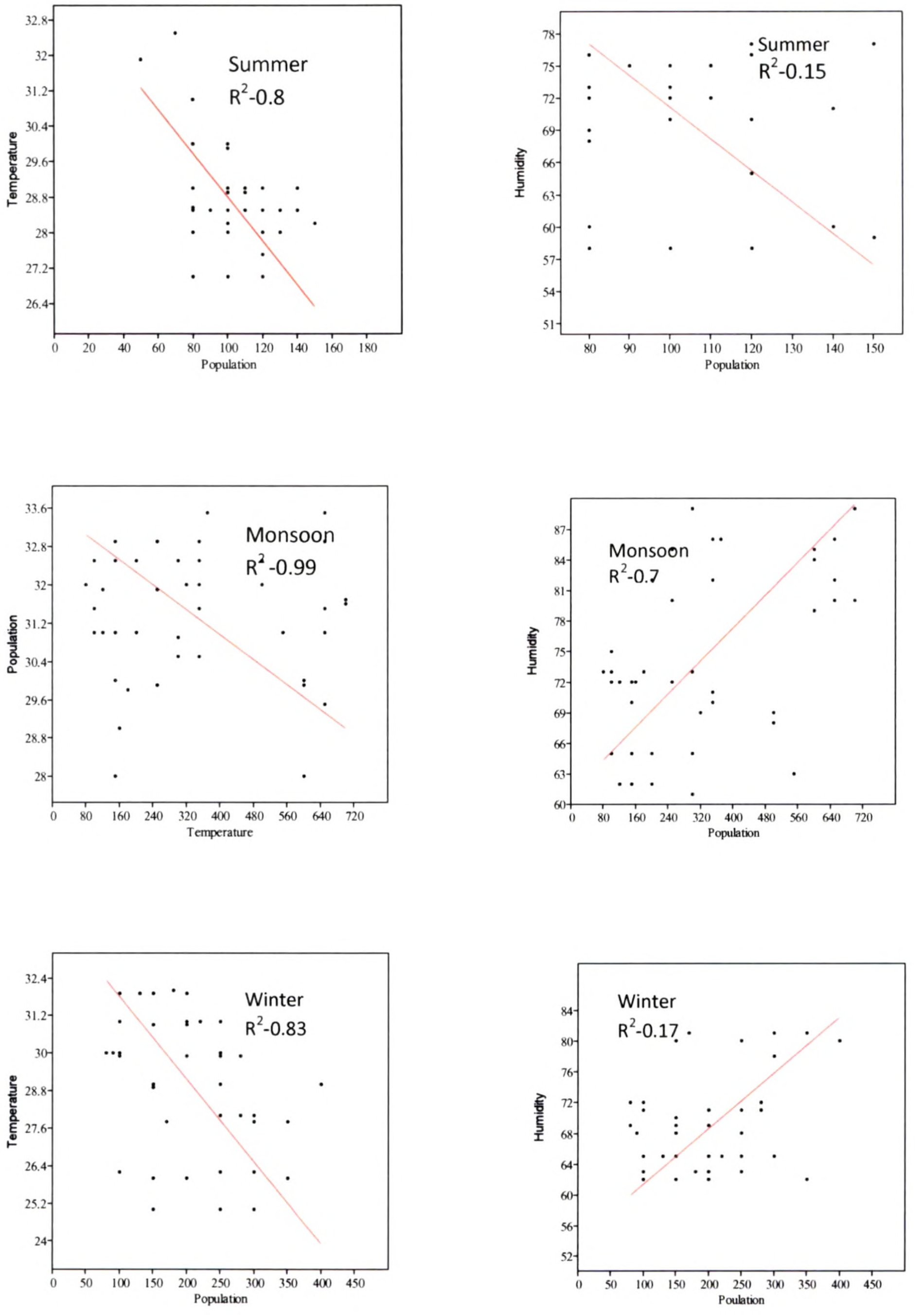
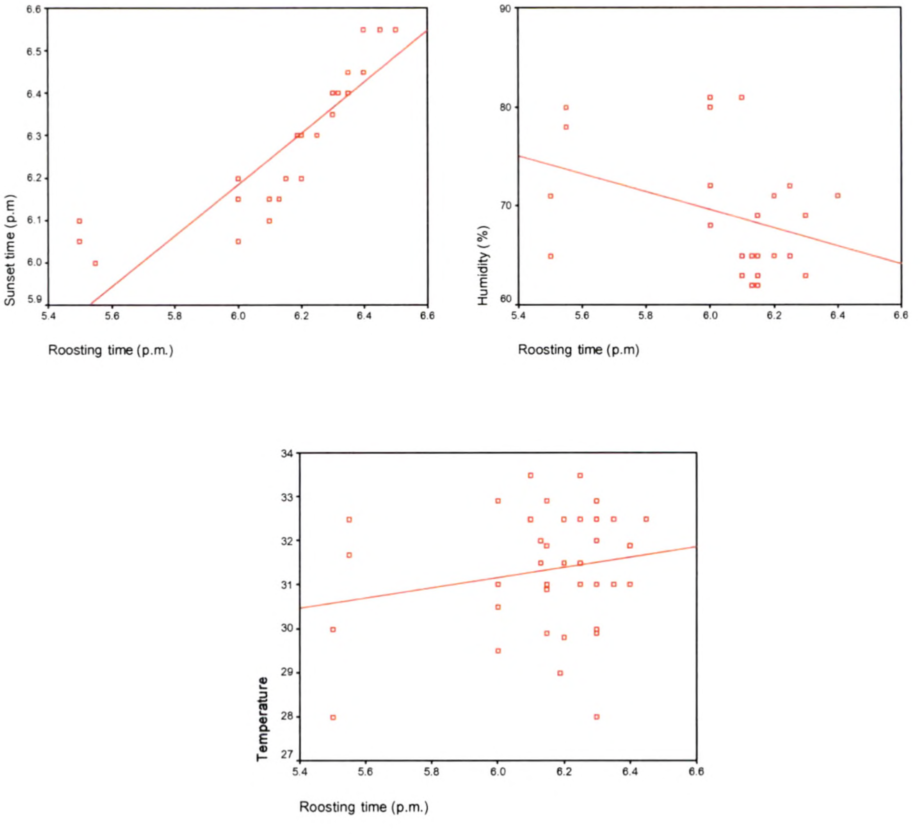


Fig: 4 Relation between roosting time with temperature, sunset time and humidity.



DISCUSSION:

Increasing urbanization worldwide is affecting local and global ecological systems negatively (Marzluff, 2001; Pickett *et al.*, 2001; Alberti *et al.*, 2003; Imhoff *et al.*, 2004) by perforating, isolating and degrading natural landscape (Meyer and Turner, 1992; Matlack, 1993; Marzluff and Hamel, 2001; Faeulkner, 2004). Biodiversity of urban ecosystems have been examined in response to urban changes (Middleton, 1994; Wackernagel and Rees, 1996).

Biodiversity conservation in urban environments is now a global focus of research (Morneau *et al.,* 1999; Park and Lee, 2000; Clergeau *et al.*, 2001; Porter *et al.*, 2001). There is growing recognition for the importance of urban environments (Savard *et al.*, 2000), especially in the remnants of natural ecosystems that persist in and around the areas (Bolger *et al.*, 1997; Crooks *et al.,* 2001). In many studies, birds have been used to investigate the factors influencing distribution, abundance and conservation status of urban fauna (e.g. Catterall *et al.,* 1991; Fernández-Juricic, 2000; Cooper, 2002; Jokimäki *et al.,* 2002). Ornithologists are concerned about the effects of wide-scale anthropogenic changes on ecosystems and have stressed on variations in biological integrity over large geographic areas (Carrete *et al.*, 2009). A common tool for monitoring biological integrity is the use of indicator species (Margules and Pressey, 2000).

Among the indicator species, raptors, because of their role in food chain; are considered as appropriate indicators for monitoring changes at the ecosystem scale (Tella *et al.*, 1998; Sánchez-Zapata *et al.*, 2003; Carrete and Donázar, 2005). They occur across a broad gradient of anthropogenic distribution from immaculate wilderness to metropolitan areas and many species are often associated with particular habitat type. However, the justification of this top predator (Black kite) as flagship or umbrella species (Sergio *et al.,* 2006) is based on their association with high biodiversity value in biological system (Sergio *et al.,* 2008). According to these researchers, the simulated network of protected sites constructed on the basis of raptors have been considered to be more efficient for conserving biodiversity than networks based on lower tropic level species. Rathod (2009) has associated Black Kite – *Milvus migrans govinda* with urban habitats as urban exploiter as they occur in huge number in metropolitan cities and are rarely seen in rural areas (Plate 4).

<u>Population fluctuation of Black kites at Vadodara:</u>

As it was observed by Mahabal and Bastawade (1987), in Pune, Maharashtra State; in Vadodara also maximum population of Black kites were noted during Monsoon (July-September) indicating arrival of migratory population from the southern parts of India. Sudden increase in number of kites was noted 3 to 4 days prior to the arrival of south-west monsoon of Indian subcontinent (Fig.1). The number reached to peak by month of August and/or September before retreating monsoon sets in the area. As per Mahabal and Bastawade (1987), the seasonal fluctuations in Black Kites populations occur due to immigration to city, emigration from city as well as addition of new generations. The later condition may not be adding significant number in August and September as this is the pre- breeding season for kites. In Vadodara, kites nest from September to March (Chapter:II).The avian population fluctuations have been shown to arise primarily from random demographic processes (Karr, 1982; Boag and Grant, 1984; DeSante and Geupel, 1987) and movement of individuals within and among habitats (Greenberg 1981; Karr and Freemark, 1983; Wheelwright, 1983). However, the present study notes the increase in number of Black Kites with arrival of migratory individuals into city. Individuals move in response to seasonal climatic changes (Root, 1988), breeding (Robinson *et al.*, 1992), or the temporal and spatial variations in food resources (Wheelwright, 1983; Levey, 1988; Blake and Loiselle, 1991; Powell and Bjork, 1994, Janicke and Chakarov, 2007). The fluctuating populations of Black kites showed positive relationship with environmental variables like temperature in all seasons and humidity only in monsoon (Table 4). Environmental factors and their interactions are believed to shape specific breeding and survival strategies in top predators like raptors. Indirect effects of weather on bird population are probably very noticeable like decline in food procurement and lowering predation rate by lowering predator availability. Death of large number of kites was unofficially reported during floods in Vadodara city in year 2005 (Padate, G. Personal communication) probably due to unavailability of food as garbage dumping sites along the river Vishwamitri were under water and probably poultry processing units were also closed. The black kites are generally seen foraging nearer to garbage dumps or poultry farms where they could easily get plenty of food in all seasons. Additionally in monsoon they are also observed feeding on insects at ground level which may not be available when area is flooded with water.

Varying geographic conditions, the erratic timing of rainfall and other environment limit our understanding of the movement patterns (Underhill *et al.,* 1999; Roshier *et al.*, 2002). Duringthe study period, rainfall was highly significantly correlated with the population of kites due to their arrival - as they emigrated from southern region to these comparatively drier parts of semi-arid zone where Vadodara is located. Explaining variations in population size over time remains a great challenge in ecology (May, 1999). The number of kites was high during rainy season and low in winter and summer. The high prey availability and comparatively drier habitat probably attract more individuals to this semi-arid zone during rainy season. In western semi-arid zone of India, where rainfall is comparatively low, insects emerge from their dormancy of hot summer days at the onset of monsoon. The annual rainfall is not the best way to understand the effect of climate on bird populations in a habitat such as this one in which potential evaporation nearly always exceeds rainfall. Rather, the length and severity of the dry season and also the occurrence of rains before the breeding season may be critical. However, this study shows the relationship of population of Black Kites with environmental variables as rainfall, humidity and temperature were significantly correlated with the arrival of the migratory Black Kites to these comparatively drier places.

Urban ecosystems have usually been examined in terms of their impact on biodiversity (Middleton, 1994; Wackernagel and Rees, 1996). Much can be learned by applying biodiversity concepts to the urban ecosystem itself. However, Raptors are known to cause special problems for the estimation of population status and trends (Fuller and Mosher, 1981; Titus *et al.,* 1990) because they usually disperse in wide areas and/or are secretive species that nest at low densities. Nevertheless, urban ecosystems are quite similar worldwide in terms of structure, function and constraint while they differ in terms of their geographical location, size and the type of landscape they modify. The landscapes in a city greatly influence plant and animal species that are found within the new artificial ecosystem (Savard *et al.,* 2000). The existing volume of vegetation in these urban areas supports proportional bird diversity (Emlen, 1974; Lancaster and Rees, 1979; Rathod, 2009). Black Kites in Vadodara city varied with the seasons and even from year to year. With the arrival of migratory population number of roosts (which were temporary) increased where both resident and migratory population shared the roost. The challenge of explaining variation in population size is amplified by migratory population where individuals spend parts of the year in different areas. Evidences suggest that conditions experienced during migration and in winter play an important role in population processes year round (Norris and Marra, 2007). When these species meet adequate food within the urban setting they can exhibit positive population responses. The landscape provides additional ample but unpredicted food supplies. Many falcon species have been shown to respond well to urban environment because of the large biomass of small birds (Dietrich and Ellenberg, 1981; Newton,

1986) as well as food provided directly or indirectly by men (Rathod,2009; Chapter: III).

Roosting behaviour:

Avian time activity budgets are strongly affected by the local environmental conditions (Elkins, 1988). When coping with the environmental factors, birds tend to alter their energy demands by modifying their behaviour. Many studies have focused on the activity patterns of communally roosting birds where the roosting activity is affected by various environmental factors (Eiserer, 1984). The environmental conditions in Vadodara, located in subtropics, fluctuate over the year with decrease in day length during winter ~ 11 hours and increase in summer ~ 13 hours. The sunset time actually serve as a proximate cue for birds for approaching the roost site (R^2= 0.9) with the roosting time of Black Kites as is reported also by Peh (2001). Studies on other species such as Common Myna (*Acridotheres tristis*) and White-Vented Myna (*A. javanicus*) have also shown that arrival of birds at their roosting site is significantly associated with sunset times (Jayson and

Mathew, 1995). As the day length decreases from summer to winter birds start arriving earlier and vice versa during summers when the day length is extended and the sunset time is delayed. However, in summer, Kites soar in the cooler skies till late in the evening as the temperature is higher at ground level due to heating of urban concrete structures and hence the roosting time is also further delayed significantly. Raptors are known to rise late in the day when sun is high in the sky and thermals develop and many of them may be seen soaring high in the sky in afternoon when temperature is maximum.

However, the Black kites leave their roosts on the day break and are frequently seen feeding early in the morning especially after a rainy night. In urban area, Black kites get plenty of food in the form of poultry leftover. This indicates that the food sources for these birds are abundant in an urbanized landscape. Therefore they are able to secure their daily food requirements before sunset and soar in the sky before roosting.

In an urban landscape like Vadodara the three roosts selected for the present study are located in the close proximity to either a poultry farm or dumping grounds where carcasses and other food items are available. Hence, copious amount of food is available for these urban scavengers. Since, the daily energy demands of these birds are easily met, they arrive early to their roosting sites usually about half an hour prior to the sunset time and exhibit leisurely pre-roosting displays. A similar correlation between sunset time and early arrival to roosting site has been reported for House crow (*Corvus splendens*) (Peh, 2002). However, it is suggested that the circadian rhythm also can play a role in controlling the roosting times (Swingland, 1976). For a diurnal bird, light perceptive machinery is also believed to cause a steady modification in the timing of roost arrivals with the seasonal change in sunset times while for nocturnal animals that seek shelter during the day, day-roost selection is likely to be an important determinant of individual fitness (Kerth *et al.*, 2001). Any energetic cost associated with choosing a potential roost reduces energy available for reproduction, resource defense and social activities, thus directly influencing individual fitness (Walsberg, 1986). Selection of a roost site is also influenced by factors including inter- and intra specific competition, predation, ectoparasitism and microclimate (Kerth *et al.*, 2001). Though for a predator species predation is not important the roosts must provide a suitable microclimate (Hayward and Garton, 1988) where heat loss can be minimized during periods of cold weather or maximized during warm weather (Ko¨rtner and Geiser, 1999). When choosing a roost, kites presumably weigh the importance of these factors to optimize thermal and energetic benefits as these roost have either huge aggregation of trees (Sayajibaug), vehicular and railway traffic (Railway station) or few trees amidst concrete structures (Bhutadizapa) that provides warmth to microclimate.

Insufficient data are available on the influences of environmental factors as well as anthropogenic factors on the roosting behaviour of raptors especially *Milvus migrans.* In the present study it seems that sunset time is important for birds to reach their roosting site. Humidity is also equally important as during days of low humidity (winter) there is highly significant positive correlation between humidity and roositng time and highly significant negative correlation with temperature. On hot summer days, kites may be seen soaring in the sky till late evening after sunset and descending to roost as the urban concrete starts cooling down, during monsoon availability of natural prey like insects satisfy their energetic needs and rain as well as clouds probably forces them to arrive at roost earlier. Mearns and Newton (1988), have also reported that during rains hunting is impaired in raptors like Peregrins.

Like other investigations carried out on various species of birds where the relative humidity or daily precipitation were negatively correlated with the arrival time of the birds to their roosting sites (Peh, 2002; Zammuto and Franks, 1981), it was observed that humidity was positively expressed with arrival time at which 50% of the Black Kites arrived. Hence, most of the Black Kites arrived earlier at roost sites when relative humidity was higher. The relative humidity varied according to the amount of precipitation. In a study by Janicke and Chakarov (2007), it is shown that for Common Raven (*Corvus corax*), weather conditions did not have any effect on the arrival times at communal roosting.

Many researchers have reported that the temperature also has a significant effect on the daily roosting time of birds like in Black Billed Magpie (Reebs, 1986), Chimney Swifts (Zammuto and Franks, 1981), Starlings (Jumber, 1956), House crows (Peh, 2002) *etc.* Black Kite's arrival times to their roost, in the present study, showed that temperatures also impinged on this important diurnal activity. Nevertheless, the current data showed that the influence of temperature may be dependent upon the interaction between sunset time and roosting behaviour. Thus, ambient temperature probably played role as a stimulus on the roosting time of Black Kites to some extent. However, the climate was never so cold that the Black Kites had to decrease their general activity level and return to their roost earlier.

Roost site characteristics:

The roost site characteristic in the present investigation demonstrates that Black Kites select roosts with certain physical attributes and in a changing environment especially in an urban context, they may shift their roost site preferences. The present results substantiate the capacities of

Black Kites to respond to changes in resource availability. The analysis of urban Black Kite roost site characteristics showed the importance of the tree height and canopy cover. Similar studies have been conducted by May *et al.*, (2004) and Everding and Jones (2006) on Spotted Owl (*Strix occidentalis*) and in Torresian Crow (*Corvus orru*) respectively. The importance of canopy density has been previously shown by Lyon and Caccamise (1981) for rural Starling roosts and also in urban roosts of House Crow *Corvus spendens* (Peh, 2002) and Common Myna *Acridotheres tristis* (Xu *et al.,* 2002). These authors have not only emphasized on the importance of canopy cover for the purpose of protection from exposure to wind and rain (Holmgren, 2004) but also suggested that dense twig and perch configuration is preferred by some species of birds. For raptor which prefers to roost on edges of branches, the canopy cover and height of tree is also important. Dense canopy cover is expected to have more branches to roost and also keep individual distance. Further, some other factors like distance from feeding grounds and availability of water may also play significant role in roost selection.

Several *Eucalyptus*, *Saraca asoca, Alianthus exelsa* and *Azadiracta indica* trees are present in the city but only certain tree aggregations are used by Black kites for roosting. The percentage of canopy cover was comparatively low at trees of Sayajibaug but it is a totally undisturbed patch of vegetation due to river Vishwamitri on two sides and Zoo Aviary on the other side. Anthropogenic variables like human disturbance and vehicular traffic did not affect the roosting of Black kites. Though at smaller tree cluster Bhutdizapa, traffic was maximum but kites were minimum. Here, number of trees available for roost is also less. At Sayajibaug, where maximum trees are available, largest roost was noted while several trees with vehicular as well as railway movement at Vadodara Railway Station also had moderate number of roosting kites. Though, in Vadodara Kites are observed to roost on top of trees, in Ahmedabad where trees are scattered or less in number they are observed to roost on tree less ground/ agricultural fields near a patch of garbage hill which is accumulating garbage of the city for last few decades.

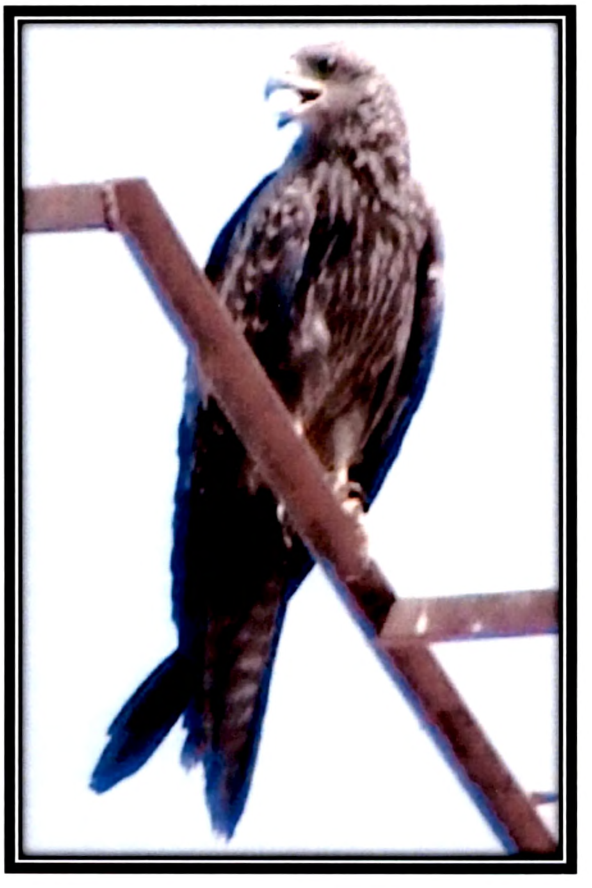
According to World Resources Institute, (1996), Wildlife conservation in urban habitats is increasingly important due to current urbanization trends. The different approaches to studying birds in urban landscapes point out the importance of the habitat island ecological theory as a research framework for the management and conservation of urban birds. Approximately 80% of the human population from industrialized countries is concentrated in urban areas and in the next decade, urban sprawl is expected to reach such a magnitude that several natural areas surrounding cities will give way to buildings and residential areas. Although some long-term efforts to understanding wildlife dynamics in cities are under way (Grimm *et al.*, 2000) very little has been done in order to foretell the influence of urban expansion on wildlife and to develop management strategies aimed at diminishing these impacts (Hadidian *et al.*, 1997). A need to study urban biodiversity to improve ecological knowledge in urban planning is stressed (Niemelä, 1999a; Savard *et al.,* 2000). Urban landscape has several special feature of an ecosystem. However, the mosaic phenomena, specific disturbance regimes, and the 'heat island' phenomena of urban system are expected to influence the dynamics and structure of urban wild life populations and communities (Rebele, 1994). Most studies on urban wildlife have focused on birds, and the information gathered up to now allows the comparison of different cities in relation to bird abundance and diversity patterns (Clergeau *et al.*, 2001).

Thus, this study adds the information on the association of roosting behaviour of Black Kites to several environmental variables like temperature, humidity but no effects of anthropogenic activities. Sunset time, temperature and humidity are significantly correlated with the arrival time of the Black Kite to their roosting aggregation, while temperature had a very little effect on this daily activity. Further, the Black Kites prefer certain features of trees while selecting their roosts. These may be tree height, shape and canopy cover. This understanding of roosting behaviour and roost site preference of *Milvus migrans govinda* might be useful pertaining to the management and conservation of such species in an urban landscape.

Carnivores are often used as reliable indicator species owing to their position at the top of the food web and to a number of life history traits (low density or low fecundity) that make them particularly vulnerable to human-induced alterations of their supporting ecosystems (Sergio *et al.*, 2008). However, in Vadodara city increased numbers of Black kites shows their high adaption to the urban area.

In the present investigation, the apparent lack of information on influence of weather conditions on the fluctuation in population and roosting times of Black Kites could be resolved to some extent. The ample feeding sources probably permits the species to reach the roosting site in time to select preferred roosting positions within an accessible distance from the roost. We assume that the abundance of food supply in urban area has probably enabled the Black Kites to spend less time in acquiring food, making them immune to various weather conditions and spend some time soaring leisurely in the sky before reaching roost in response to declining light conditions due to setting sun. Adequate food supply also influenced the migratory population. Further, the roosting time is significantly correlated with the sunset time and temperature. The sunset time may act as a proximate signal for approaching the roost site by Black Kites along with some light sensitive mechanism under playing to cause the regular shift in timing of roost arrivals with the change in the time of sunset.

Plate 1. Adult Black kite (*Milvus migrans govinda*)



Juvenile Black kite (*Milvus migrans govinda*)

Plate 2. Location of three roost of Black kites in Vadodara City

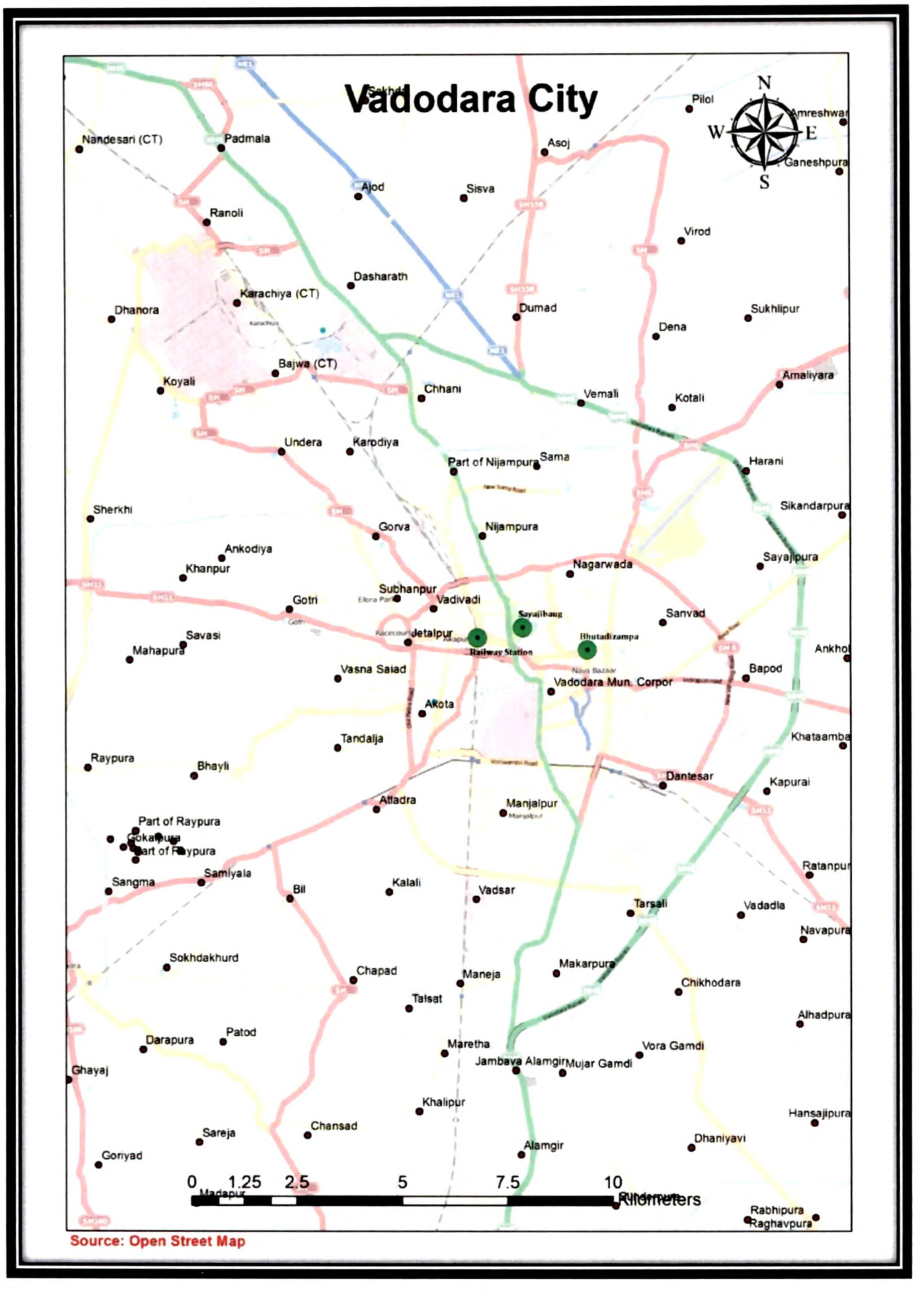


Plate 3. Google Earth Image of three roosting sites of Vadodara City

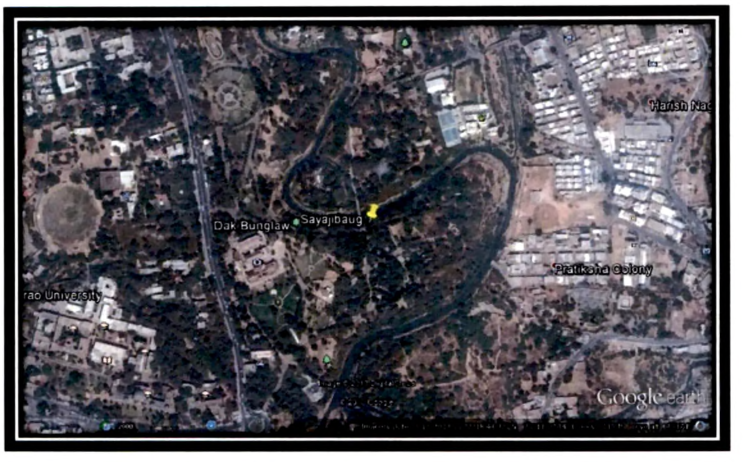


Plate 4. Pre roosting Behaviour of Black Kite *(Milvus migrans govinda)*

Huge Roosting aggregation of Black kites *(Milvus migrans govinda) in Metro city-Delhi*