"Ecology of Black Kite (Milvus migrans govinda) with quantification of heavy metals in various tissues."

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In Zoology

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CERTIFICATE

This is to certify that the thesis entitled **"***Ecology of Black Kite (Milvus migrans govinda) with quantification of heavy metals in various tissues."* Submitted by *Ms. Sandhya Godshe* for the degree of Doctor of Philosophy has been carried out under my guidance in the Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda. The matter presented in this incorporates the results of investigation of the independent research carried out by the researcher herself. The matter contained in this thesis has not been submitted elsewhere for the award of any other degree.

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DECLARATION

I hereby declare that the entire work embodied in this thesis has been carried out by me under the supervision and guidance of Dr. Geeta Padate and to the best of my knowledge no part of the thesis has been submitted for any degree or diploma to this University or any other University or Institution in India or World.

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A THESIS IS SUBMITTED

TO

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN

ZOOLOGY

Dedicated

To

My Dear

Parents

Acknowledgement

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Contents

		Page No.
1.	Introduction	1
2.	Chapter 1: Population trend and Roosting behaviour of Black kite (*Milvus migrans govinda*)	9
3.	Chapter 2: Nesting Ecology	56
4.	Chapter 3: Feeding Ecology	76
5.	Chapter 4: Analysis of Toxic and Essential Elements	92
6.	Summary	122
7.	General Considerations	127
8.	References	132
9.	Publications	183

INTRODUCTION

Ecology is the science of determining how species within an environment relate to one another and also how species are distributed and abundant in a particular habitat. This is important in understanding the health of an ecosystem. With the high rate of urbanization globally and the rapid loss of wild habitats, cities are now viewed as challenging ecosystems for sustaining rich biotic communities. Over last few decades urban ecosystems have therefore become ecological challenges in conservation, restoration, and reconciliation of ecology (Miller and Hobbs, 2002; Rosenzweig, 2003). Designing sustainable urban ecosystems that support species rich bird communities also includes maintaining key ecosystem services, such as clean air and water, waste decomposition, and pest control. Cities consist of mixtures of built up habitats and green patches. Although urbanization increases total bird densities, it appears that only a few species contribute to this increase. Kark *et al.* (2007) describes these species as “Urban exploters”. These are the species that can exploit urban resources and coexist and thrive and contribute to the biomass in the most built parts of the city, such as business hubs and industrial zones where vegetation may almost be absent. In Vadodara species like Blue Rock Pigeons (*Columba livia*), House crow (*Corvus splendens*), Common Myna (*Acridotheres tristis*), House swifts (*Apus affinins*) and Black Kites (*Milvus migrans govinda*) are described as urban exploiters (Rathod, 2009). While food density is normally high in urban settings, the main source is of low quality anthropogenic refuge.

Birds, specifically raptors, are excellent indicators of environmental health. Their changing populations often provide clues to the overall health of their habitat (Estrella *et al.*, 1998). Raptors have fascinated humans for thousands of years due to their keen senses, hunting skills, power, behaviour, complex migration and occupation of key niches in ecosystem. Raptors play critical ecological roles often impacting ecosystems making them keystone and flagship species for conservation efforts (Palomino and Carrascal, 2007). Though found in low densities, using raptors as umbrella species in conservation can protect entire ecosystem and all the species that live within that community. They are quite sensitive to changes in habitat structure and fragmentation and have a high susceptibility to local extinction (Simberloff, 1988). Population of raptors is declining worldwide and many species are threatened with extinction (IUCN, 2002). However, Black Kite -*Milvus migrnas govinda* is an urban exploiter found in huge number in many urban areas of northern and western India.

Black Kite (*Milvus migrnas govinda)* is classified in Order: Falconiformes and Family: Accipitridae with hawks, eagles, old world vultures, buzzards *etc*. In Latin Genus *Milvus* means 'Kite' while species *migrans* means 'migrating/ wandering'. Race *govinda* meaning 'cow finder' comes from Hindu mythology (Naoroji, 2007) as this race is common in Indian subcontinent.

There are 3 races of Black Kite, *M. m. migrans, M. m. lineatus, and M. m. govinda* in India (Ali, 1979; Navroji, 2007*).* The Black kite (*Milvus migrans govinda) is* a common resident bird of prey of urban environs in many parts of the world (Ali, 1979). It can be easily identified by its brown colour and long forked tail, brown eyes and yellowish legs and feet. The adult is overall dark brown variably tinged with rufus colour. Adult *M. m. govinda* measures between 54-59 cm and has a wing span between 102- 107 cm. while, juvenile is overall dark brown with black spots but liberally mottled. *M. m. migrans* is larger species. Among the races *M. m. lineatus* is commonly known as Black eared Kite. It is also larger than *M. m. govinda*, more prominent and with extensive white patches at base of primaries, has extensively streaked head and neck and paler brown under parts lacking russet tone (Navroji, 2007).

Huge populations of *M. m. govinda* can be observed in many cities of western and northern India. They can be seen feeding at garbage dumps or soaring on thermals developed by urban concrete jungles. At sunset time they gather in large numbers at roosts and show Pre roosting behaviour in the form of soaring around the roost. The population of black kite is reported to fluctuate as well as shift their roosts seasonally (Mahabal and Bastawade, 1987). These authors have considered fluctuations in population of kites in Pune city central India in 3 phases of annual cycle: Pre breeding season – June to September, Breeding season

- October to February, Post breeding season – March to May. Based on this, as first step while studying ecology of Black kites *M. m. govinda* in western semi-arid subtropical zone of India, a study of annual fluctuations in their population is carried out.

For the survival of a bird species its successful nesting is important. As this species is adapted to urban habitats its nesting ecology with reference to nest site selection is also considered in the present study. An individual's fecundity and survival depends upon choice of nest site which may in turn determine the structure and growth rate of populations, and the evolution of species (Clark *et al.*, 2004). As selection of nesting site is equally important for the survival of a species, present study also deals with nest site selection, tree species used, its characteristics and whether nesting is successful or not.

Food is the most important factor influencing the abundance and distribution of birds in any ecosystem (Pimm, 1982; Polis, 1991; Begon *et al.*, 1996). A non-invasive method for the study of prey species of raptors is study of undigested food particles in regurgitated pallets.

Hence, investigations on regurgitated palates of Black Kites are also considered in the present study at Vadodara.

Pollution is one of the major problems of urban environment. Urban areas get polluted not only due to industries but also due to vehicular emissions. As a result of escalating generation of evidences that bird populations are particularly sensitive to the changes produced by human in the environment, potential use of birds as indicator for environmental pollution has been widely recognized. Environmental contamination caused due to men is a relatively novel concept, in ecological times. Stressors like pollutants negatively affect individuals and entire ecosystems via air and water around the world, even in the areas relatively free of contaminants (Iwata *et al.*, 1993). However, in the past few decades, many efforts have been made regarding monitoring of health of an ecosystem. Birds are one of the best indicators for bio-monitoring the environmental changes as they are on the pinnacle of the food chain. Among the birds raptors are the most intensively studied group of species which are at the apex position in the food chain and show the spatial integration of contaminant levels in their extended home ranges (Altmeyer *et al*., 1991; Esselink *et al*., 1995; Pain *et al.,* 1995; Garcia- Fernandez *et al.*, 1997). However, being extremely mobile, they feeding over a wide geographical range making it complicated to determine the source and site for their toxic ingestion. However the present investigation also includes quantification of various toxic as well as trace elements from tissues like liver, kidney, muscles and feathers of Black Kite (*Milvus migrans govinda*) from the most polluted city of Gujarat, Ahmedabad.

Though the Black Kite is not under immediate threat of population decline it is exposed so several threats in urban environment. One has to learn from the example of vultures. The decline in the population of *Gyps species,* which was thriving till 1993, and declined by 95% in late 1990s (Prakash *et al.,* 2003, Green *et al.,* 2004) is now known fact. Before anything happens to Black Kite *M. m. govinda;* one of the "List Concerned" Species according to bird Life International and adapted very well to urban habitats; its status and ecology needs to be documents. This study expected to provide information regarding its population size, breeding success, feeding ecology and different stressors encountered by them in cities in western India.

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^{o} 18’ N, Long 73^{o} 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^o 18’ N, 73^o 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 ^{o} 18’N, 73 ^{o} 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 ^{o} 18’N, 73 ^{o} 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.

<u>Meteorological parameters</u>: (Table: 3, Fig.2)

a. **Temperature (^oC):** In Vadodara, significant fluctuations in the atmospheric temperature occur over the year. The mean temperature at roosting site and time was 30.2 ^oC ± 0.46 in monsoon 27.76 ^oC ±1.5 in winter while 32.44 ^oC ± 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 ^0C	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.

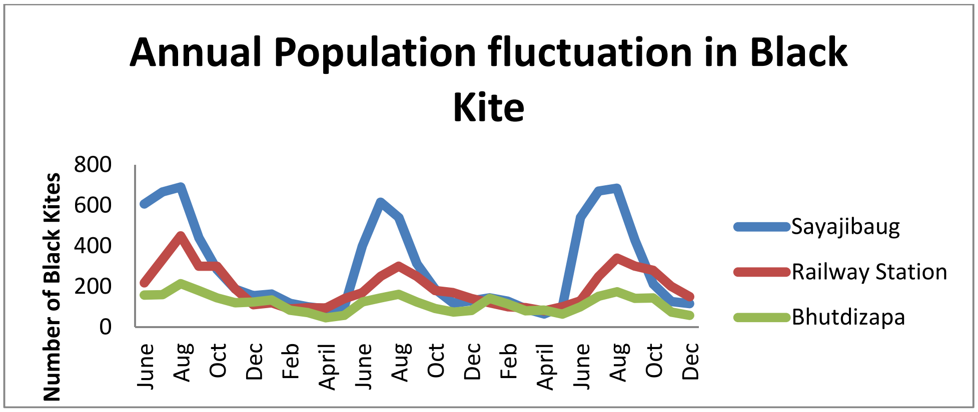


Fig: 2 Seasonal changes in Temperature, Humidity, Sunset time and roosting time of Black kites inVadodara.

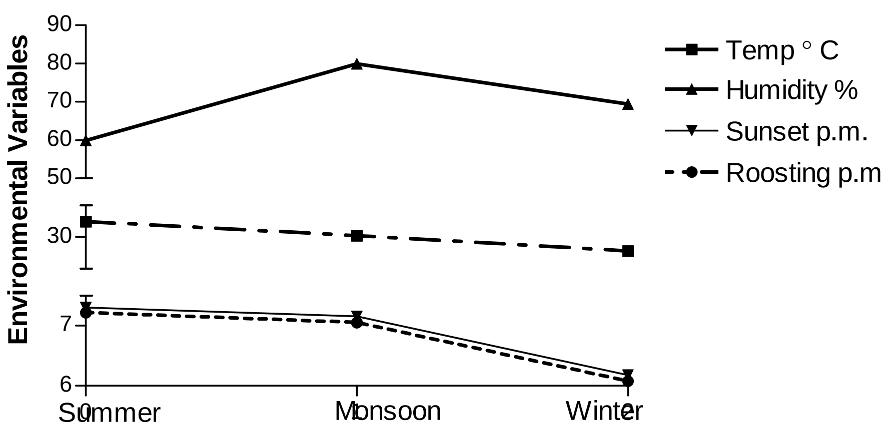


Fig:3 Relation between Black Kite Population with temperature and humidity in summer, monsoon and winter.

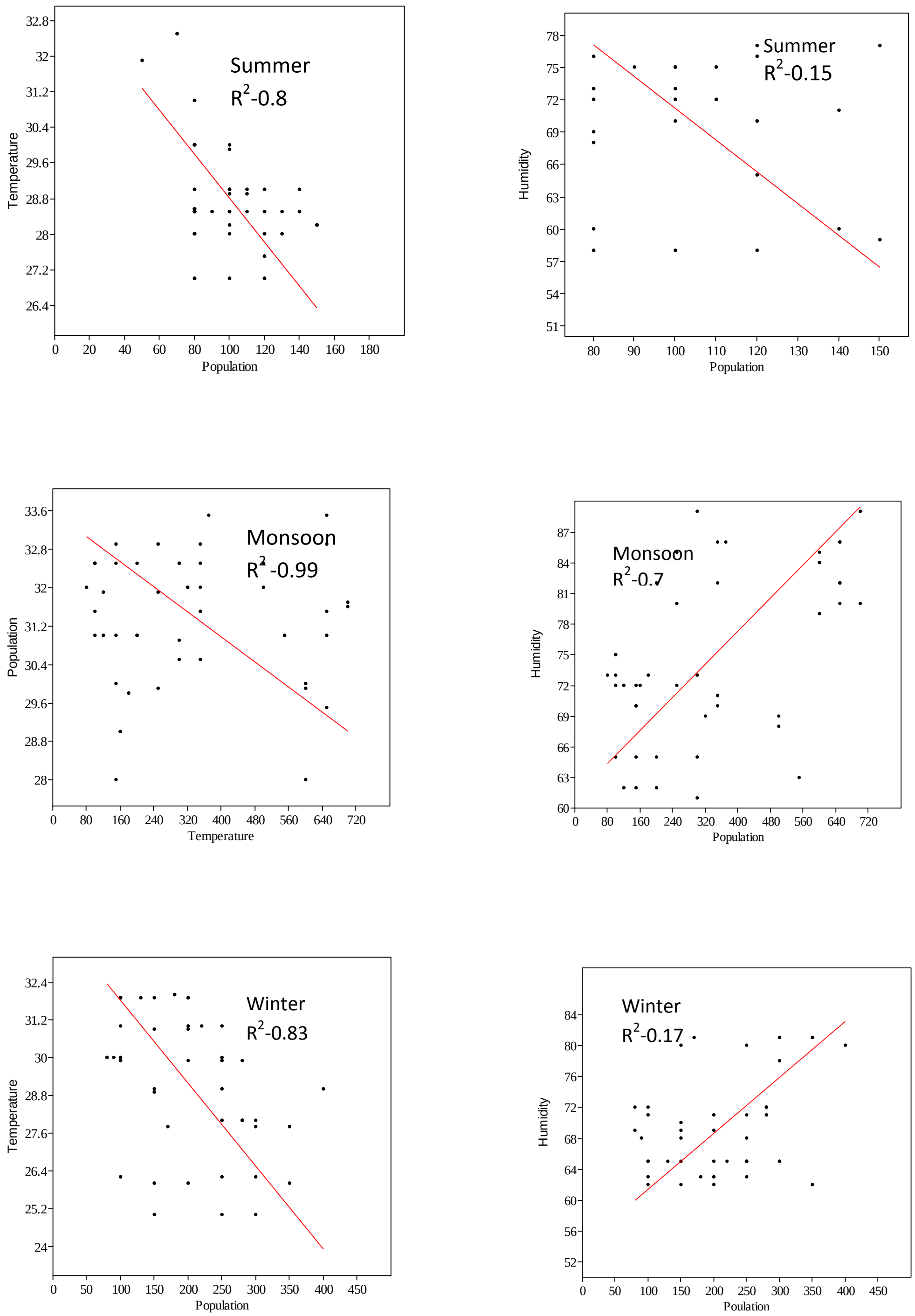
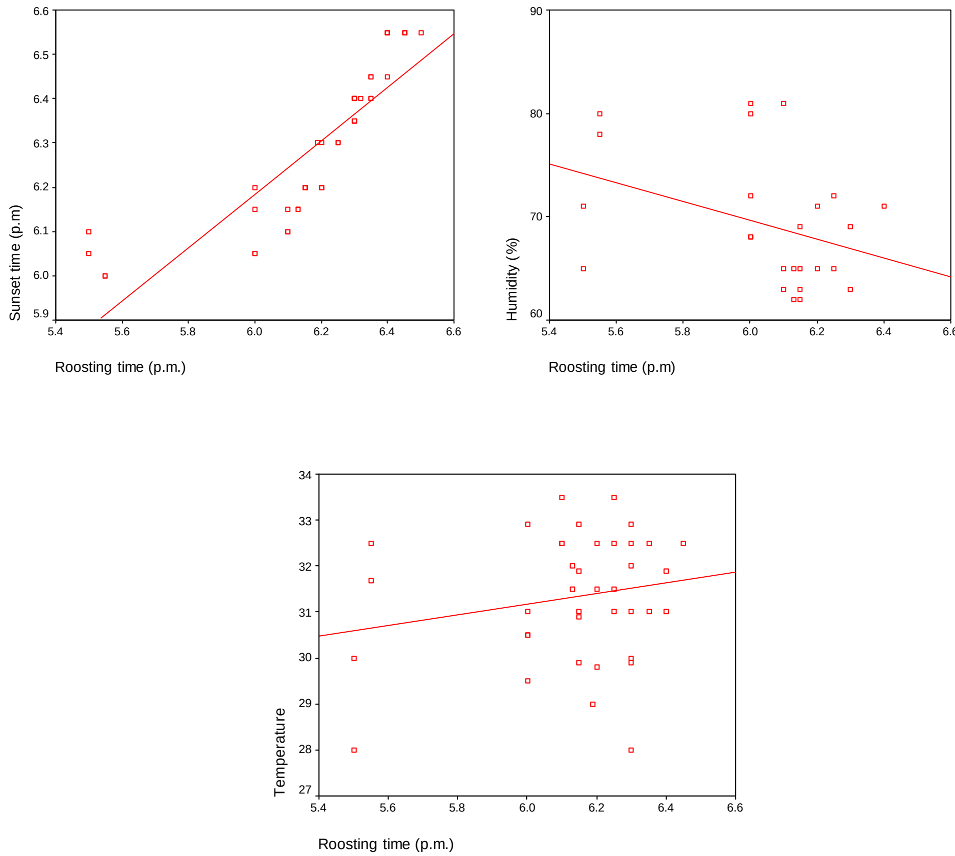


Fig: 4 Relation between roosting time with temperature, sunset time and humidity.



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.

CHAPTER: 2

NESTING ECOLOGY

INTRODUCTION:

Nests of birds have been compared to the mammalian uterus which provides warmth and protection to the developing embryo. Hence, in many species of birds selection of the nest site is often considered as an important determinant of their reproductive success (Coulson, 1968; Ryder and Ryder, 1981; Jackson *et al.*, 1988; Rendell and Robertson, 1989; Li and Martin, 1991; Toumenpuro, 1991; Donazar *et al.*, 1994; 1996). Thus, the nest site selection is an important determinant of the population dynamics of birds. For breeding, habitat selection is also important where the parents can easily get primary requirements such as food (Kushlan 1976; Wilson *et al.*, 2009; Watling *et al.*, 2009, Gamauf *et al.*, 2013). An individual's fecundity and survival is likely to depend upon the choice of nest site which may in turn determine the structure and growth rate of populations, and also the evolution of species (Clark *et al.*, 2004). The poor nest site selection can lead exposure of nest to predation for longer duration when parents are away feeding and hence affect the natural selection of the bird species (Lack, 1954; Ricklefs, 1969; Nillson, 1987).

Knowledge of how individuals disperse and select nest sites remains limited (Walters, 2000). However, the distribution of nesting raptors is not only influenced by nest site but also by food availability (Newton, 1979). Raptors are reported to settle in areas where food is abundant, which significantly influence the selection of nest sites, minimizing the risks of predation (Simmons and Smith, 1985; Mearns and Newton, 1988) and optimize the thermal environment (Skutch, 1976; Mosher and White, 1976). In reality, the choice of nest site represents a compromise between various factors, for *e.g*. Northern harriers show compromise between wet nest site in close proximity to optimum foraging habitat and their females to a mate with a high food provisioning rate (Simmons and Smith, 1985). Relatively little is known about the breeding biology of raptors in tropical regions. Tropical birds of prey have longer breeding seasons and lower reproductive rates than their temperate counterparts (Mader, 1981). Due to stable climatic conditions they can lay eggs almost at any time of the year (Immalmen, 1971; Mader, 1982). However, tropical species may have breeding seasons that are restricted to either the wet or the dry seasons (Benson *et al*., 1971; Mader, 1981; 1982). The duration of some of their stages of the breeding cycle (such as incubation and nesting periods) are generally longer (Newton, 1979; Mader, 1982) with reproductive rates and nest success comparatively lower (Lack, 1968; Skutch, 1976) while, survival of fledglings and adults is as high as in temperate areas due to prolonged parental care (Mader, 1982).

Factors such as inclement weather and proximity to feeding places influence species of bird with small body size while larger species are better equipped to tolerate weather oscillations and can make long distance trips in search of food (Collias and Collias, 1984). Further, avian nest studies also show intraspecific variations in reproduction success in relation to nesting substratum. Nests made at the places not easily accessible to predators, such as cliffs, tall trees, thick vegetation, *etc.* have high breeding success (Li and Martin, 1991; Watson, 1992; Kelly, 1993). Further, nest site selection is also closely related to the individual fitness since it influences the probability of raising offspring successfully (Martin, 1988). As nest sites selection is competitive and strong, the choice of less secure places is very common. The individuals with lesser competitive abilities relegate to suboptimal sites (Li and Martin, 1991; Newton, 1991). In a given species, nest site quality varies in space and time at different scales due to different environmental factors affecting reproductive success (Wiens, 1976). Thus, selection of nesting habitat is of prime importance for the fitness of individual birds (Martin, 1988; Boulinier, 1996). Nest site selection of raptors has been studied by Speiser and Bosakowski, (1987) for Northern Goshawks, Redpath *et. al.*, (2001) for Hen harrier, Ontiveros (1999) for Bonelli's Eagle, Krûger (2002) for Common Buzzard, Serrano *et al.* (2004) for Lesser Kestrel, Orth and Kennedy (2001) for Burrowing owl, Sara and Vittorio (2003) for Egyptian Vultures and Stanevièius, (2004) for Marsh harrier.

However, nesting requirements of the Black Kites is poorly known except brief accounts given by Ali, (1979) and Naoroji, (2007). Hence, nesting ecology of the Black kites was studied to understand the factors affecting selection of nesting habitat and nest tree characteristics and its implications for management of the species for conservation purpose.

MATERIALS AND METHODS:

Study area:

The Breeding season of Black kite is from September to February (Ali, 1979; Mahable and Bastawade, 1984; Naoroji, 2007). In the present study, nesting of Black Kites is investigated in Vadodara city (22^{o} 18'N, 73^{o} 10' E), Gujarat, India from 2009 to 2011. After identification of nests month wise random surveys were conducted from September to February (2009-11) each year to find out active nests (nest with eggs). Once identified the nests were regularly monitored for 2 to 4 days in a week. To study nesting ecology, nest site characteristics like tree species where the nest was built, height of tree, height of nest, canopy cover, sub-branches, trunk diameter at breast height (DBH), number of nests, distance from nearest water body, distance from nearest building (based on Google earth images), are recorded. The percentage of canopy cover is 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 canopy cover 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). Diameter at breast height (DBH) was measured using a standard measuring tape to measure the circumference of a tree and divided by π (3.14). Degree of urbanization and human activities along with differences in habitat composition around each nest tree was noted down.

Statistical analysis:

To analyze the relationship between different nest site characteristics, nest height is correlated with characteristic of the trees studied like canopy cover, height, DBH, distance of the nest from the nearest water body and distance of the nest from the nearest building by using Spearman rank correlation coefficient. Nest site characteristics for successful and unsuccessful nests were analyzed using t-test. Statistical evaluation of the data is carried out using Statistical software package Graph Pad Prism 3.00 and SPSS 7.0. Data values are expressed as mean ± SE and test statistics were considered significant at $P < 0.05$ and $p < 0.01$.

RESULTS:

Total 90 nests of Black Kites are recorded within the study area from 2009 to 2011. Out of these, 83 nests were successful whereas 7 were unsuccessful. As seen in Table1 and Fig.1, majority of nests were found on Neem trees (*Azadiracta indica* 61% of successful nests Plate: 5). The other species of trees used for nesting were Maha neem 13.25% (*Alianthus exelsa* - 12% successful with 2% unsuccessful attempts), Eucalyptus 4.81% (*Eucalyptus* hybrid - 4.% successful nest and 1% unsuccessful nests), three each 3.61% of Gulmohor (*Delonix regia* – successful nests 3%) and Tamarind (*Tamarindus indica* - successful nests 3%), Ashoka 6.2% *(Polyalthia longifolia* with 6% successful and 2% unsuccessful nests), and one each (1.2%) of Piple (*Ficus religeosa* 1% successful nests and 2% unsuccessful nests) and Bahedo (*Terminalia bellirica*- successful nests 1% Plate:5). The mean tree height, nest height, canopy cover and DBH for Neem trees were 20.9 ± 0.12 m, 15.24 ± 0.32 m, 85 ± 0.24 % and 96 ± 0.02 cms. respectively. For the other 6 species, the height of nesting trees with successful attempts were 18.89 ± 0.32, 19.81 ± 0.04, 19.72 ± 0.81, 18.28 ± 0.34, 17.67 ± 0.01, 16.98 ± 0.75 and 20.42 ± 0.3m. for Maha neem, Eucalyptus, Gulmohor, Tamarind, Ashoka, Pipal and Bahedo respectively. The mean height at which nests are constructed are 14.02 ± 0.21, 16.15 ± 0.09, 15.76 ± 0.9, 14.98 ± 0.2, 13.63 ± 0.12, 13.1 ± 0.24, 14.93 ± 0.5m. respectively. The highest canopy cover is noted for Tamarind (87 ± 0.23%) while lowest is of Ashoka (58 ± 0.16%) and Eucalyptus (58 ± 0.4%). The highest mean DBH is noted for Tamarind (90 ± 0.02 cms) while lowest is noted for Ashoka (43 ± 0.4 cm).

Out of 83 successful nesting trees, 45 nest are located near busy roads, 26 near human habitation, 8 nests near dumping area whereas only 3 nests are found in garden and 1 near Industrial area (Table1, Fig.1). Further, for Neem trees mean distance from nearest water body and from nearest building are 370 ± 2.34 m. and 180 ± 13.21m. respectively, while for other species like Maha neem it is 800 ± 14.32 and 100 ± 4.21m, for Eucalyptus it is 400 ± 12.13; 220 ± 9.19m, for Gulmohor it is 500 ± 10.21 and 200 ± 4.1 m, for Tamarind it is 300 ± 8.1 and 300 ± 15.76m, for Ashoka 179 ± 1.02 and 402 ± 12.98 m., for Pipal and Bahedo; 200 and 40 m. and 240 m. and 0 m. respectively as only one tree each are used for nesting.

Characteristics of trees used for nesting by Black kite- *Milvus migrans govinda* in Vadodara city.

As seen in Table 1 the mean height of trees where nesting is successful is 19.08 ± 0.48 m. Their mean height at which nests are constructed is 14.73 ± 0.37 m., the mean difference between tree height and height of nest is 4.23 ± 0.26m., mean canopy cover is 75%, mean DBH of trees is 63.25 ± 6.9 cms., the mean distance from nearest water body is 373 ± 71.93 m. and from nearest building is 180.3 ± 47.07 m.

As seen in table 2 the mean height at which the nesting was successful is 14.23±0.66m., the mean height at which the nest is constructed is 16.62± 1.64m, the mean difference between the tree height and nest height 1.88±2.06 m, the mean canopy cover is 68.5±0.07 %, the mean DBH 52±6.17cm., the mean distance from the nearest water body 394.8 ± 1.44m. and the mean distance from the nearest build is 195.5±78.06. On the other side the mean height at which the nesting was unsuccessful is 11.15 ± 0.61 m., the mean height of the tree is 14.74±1.24m, the mean difference between tree height and height of nest is 2.97 ± 0.9m., mean canopy cover of these trees is 48%, mean DBH of trees 41.75 ± 6.04 cms., the mean distance from nearest water body is 350 ± 120 m. and from nearest building is 190 ± 56.77 m.

In present study, breeding failure was noted in 7 nests. These nests were found on Eucalyptus, Ashoka, Pipal and Maha neem trees. When data of tree species on which both successful and unsuccessful nesting is computed (Table:3) there were significant differences between nest height ($P<0.05$) and percentage of canopy cover ($P<0.05$) of successful and unsuccessful nesting. No significant differences were noted between height of tree ($P>0.05$), DBH of tree ($P>0.05$), distance from nearest water body ($P>0.05$) and distance from nearest building ($P>0.05$).

As noted in Table: 3 highly significant correlation was found between tree height and nest height (0.89, $P<0.1$), tree height and canopy cover

(0.722, $p<0.05$) and, nest height and canopy cover (0.813, $p<0.05$). While DBH, distance from nearest water body and nearest building were non significantly correlated (0.431, 0.487 and 0.559 respectively, $p>0.05$) with each other.

Table: 1 Characteristics of trees used for nesting by Black kite- *Milvus migrans govinda* in Vadodara city.

SN=Successful nest, USN= Unsuccessful nest

		Tree height (m)	Nest height (m)	Difference Between tree and nest height (m)	Canopy cover (%)	DBH (cm)	Distance from nearest water body (m)	Distance from nearest building (m)
Neem tree *Azadiracta indica* **66.26%**	SN=55 61%	20.9±0.12	15.24±0.32	5.66	85±0.24	96±0.02	370±2.34	180 ± 13.21
Maha neem *Alianthus exelsa* **13.25%**	SN=11 12%	18.89±0.32	14.02±0.21	4.87	78±0.02	50±0.09	800±14.32	100±4.21
	USN=2 2%	15.81±0.01	12.62±0.3	3.19	55±0.21	41±0.12	700±10.34	130±8.0
Eucalyptus *Eucalyptus* hybrid **4.81%**	SN=4 4%	19.81±004	16.15±0.09	3.66	58±0.4	70±0.12	400±12.13	220±9.19
	USN=1 1%	15.01	11.21	3.81	45	59	320	200
Gulmohor *Delonix regia* **3.61 %**	SN=3 3%	19.72±0.81	15.76±0.9	3.96	78±0.34	58±0.2	500±10.21	200± 4.1
Tamarind *Tamarindus indica* **3.61 %**	SN=3 3%	18.28±0.34	14.98±0.2	3.3	87±0.23	90±0.02	300±8.10	300± 15.76
Ashoka *Polyalthia longifolia* **6.02 %**	SN=5 6%	17.67±0.01	13.63±0.12	4.04	58±0.16	43±0.4	179±1.02	402 ± 12.98
	USN=2 2%	16.93±1.21	12.23±0.34	4.70	50±0.9	35±0.9	180±4.9	350±9.0
Piple *Ficus religeosa* **1.2%**	SN=1 1%	16.98±0.75	13.1±0.24	3.88	80±0.23	45±0.5	200	40
	USN=2 2%	11.21±0.76	9.53±0.41	2.68	45±0.34	32±0.79	220±3.21	100±4.65
Bahedo *Terminalia bellirica* **SN = 1, 1.2%**	SN=1 1%	20.42±0.3	14.93±0.5	4.49	75±0.01	57±0.8	240	0
Mean	90 (83+7)	19.08 ± 0.48	14.73 ± 0.373	4.23 ± 0.26	74.88 ± 3.93	63.25 ± 6.9	373 ± 71.93	180.3 ± 47.07

Table 2. Nest site characteristics of successful and unsuccessful nests.

Nest site characteristics	Unsuccessful Nest	Successful Nest
Tree height	14.74 ± 1.24	16.62 ± 1.61
Nest height	11.24±0.61	14.23 ±0.66*
Canopy cover	48.75± 2.39	68.50±3.07*
DBH	41.75 ±6.04	52±6.17
Distance from nearest water body	350 ± 120	394 ± 1.44
Distance from nearest building	190±56.77	195. ± 78.06

Table 2. Spearman rank Correlation coefficient between nest height and different characteristics of nesting tree.

Nest site characteristics (N=83)	Nest Height	Canopy cover	DBH	Distance from water body	Distance from nearest building
Height of tree	0.89**	0.722*	0.431	0.487	0.559
Nest Height		0.813*	0.456	0.351	0.510
Canopy cover			0.561	0.510	0.455
DBH				0.461	0.520
Distance from water body					0.623

* P<0.05, ** P<0.01, *** P<0.001

Fig:1 Percentage of trees used for nesting successfully (83 nests) by Black kite- *Milvus migrans govinda* in Vadodara city.

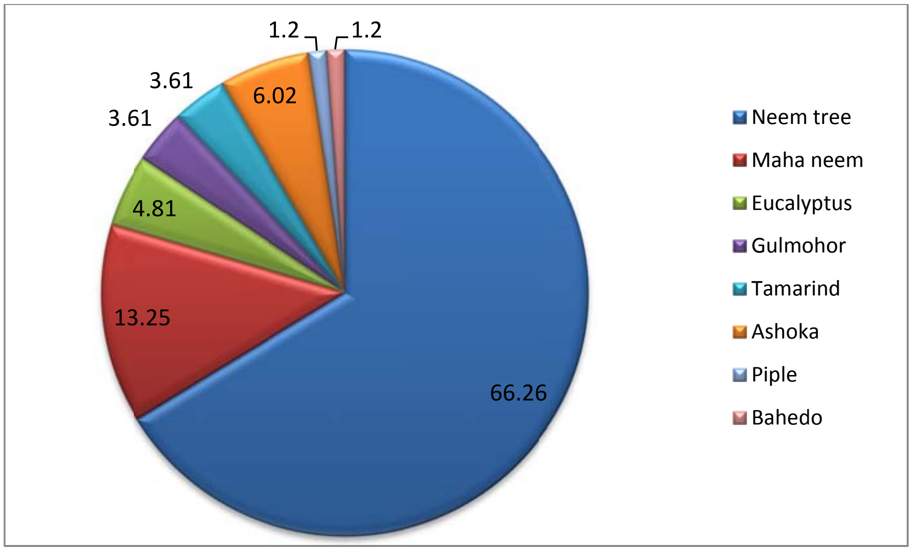
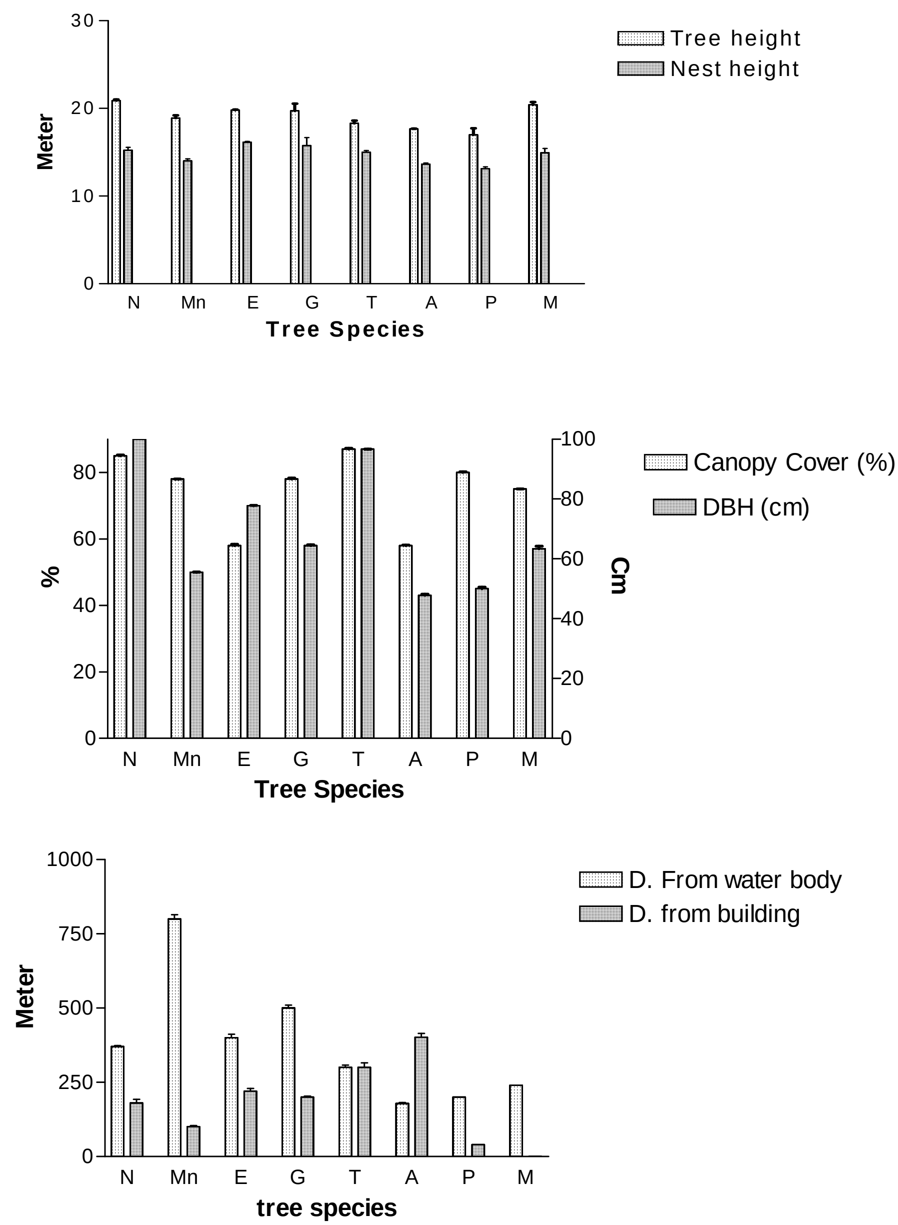


Fig: 2 Tree height, nest height, canopy cover, DBH, distance from nearest water body and distance from nearest building of trees used for nesting of Black kite.



Where, N= Neem tree, Mn=Maha neem tree, E= Eucalyptus tree, G= Gulmohor tree, T= Tamarind tree, A= Ashoka tree, P=Pipal tree, B= Bahedo tree.

Fig 3**. Correlation between Tree height and different characteristics of nesting tree.**

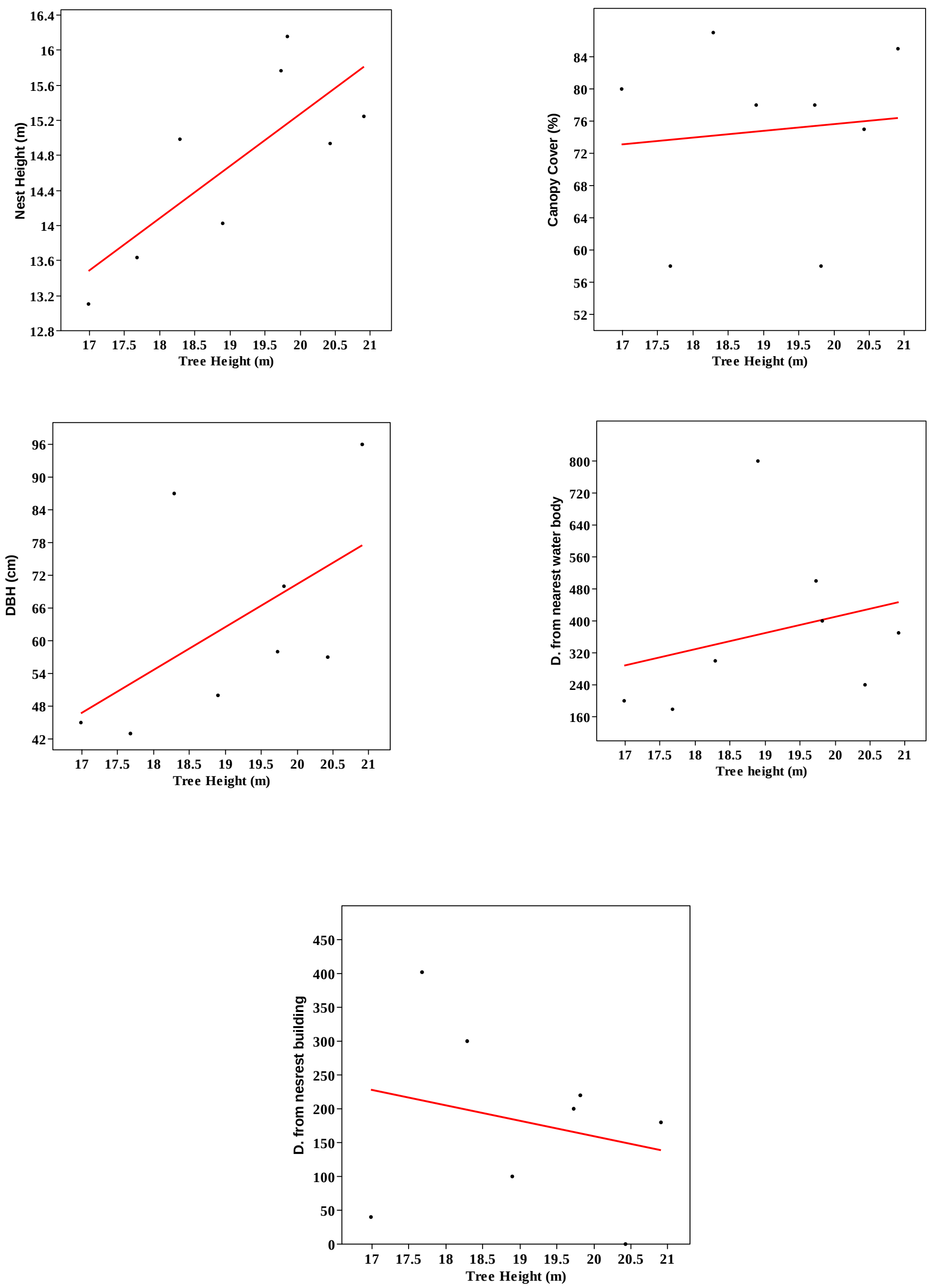
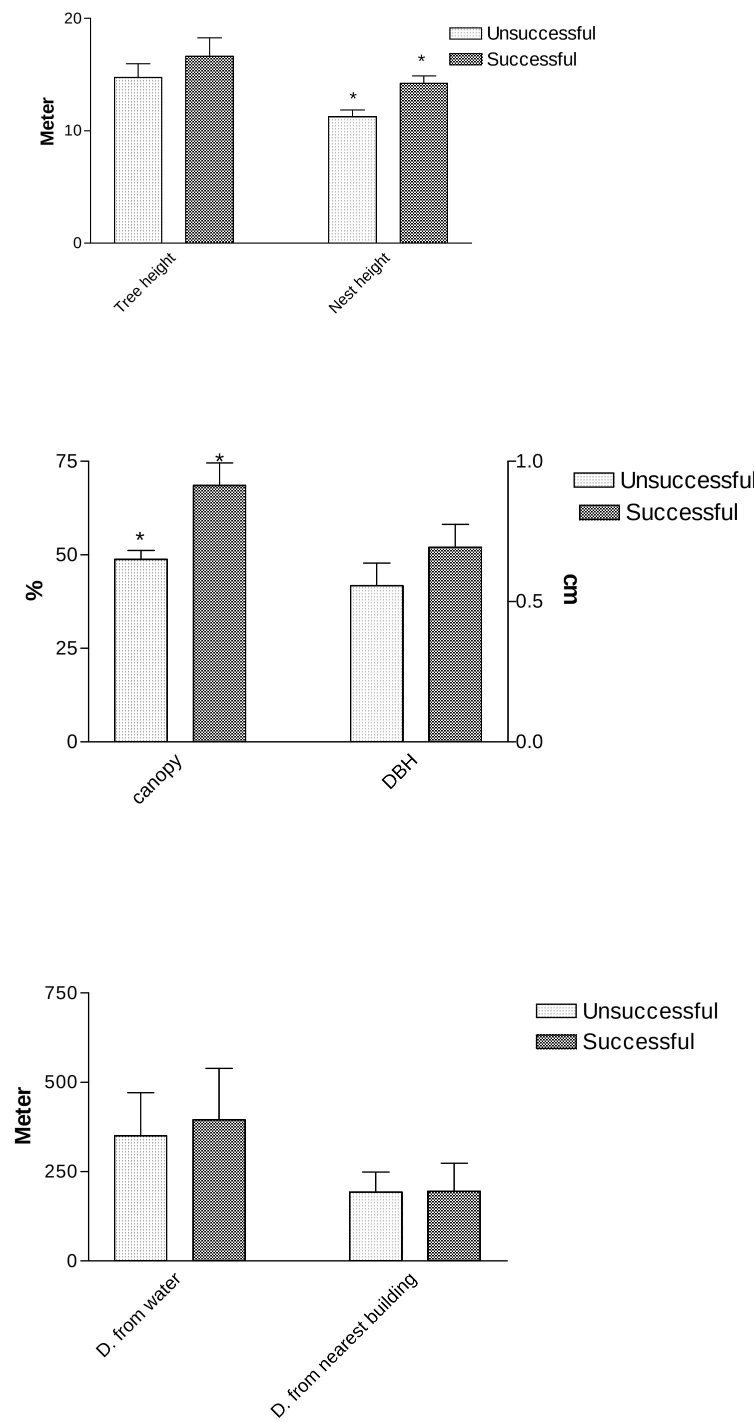


Fig 4. Nest site characteristics of successful and unsuccessful nests.



DISCUSSION:

Identification of the habitat features, that influence reproduction and survival, are essential for the management and long-term viability of bird populations (Davis *et al.*, 2006). As successful nesting is important for later, selection of nesting tree also should be equally important. In the present study it is noted that the Black Kites mainly prefer Neem trees (*Azadiract indica*) for nesting. The reason may be the availability of these trees in large numbers which have suitable height and canopy preferred by these raptors. Neem is the most common tree in the area. Among other trees, Maha Neem (*Alianthus exelsa*) with almost similar canopy covers and height were preferred. They also provide number of crotches to hold the nest properly on the tree. The dense cover of the canopy provides sustained protection by minimizing direct heat loss to the open sky (Morse, 1980) and thermal stress to vulnerable young while provides hide from the predators (Burger and Hahn, 1989) and does not require wing shading provided by parents to their chicks, which considerably reduces energy loss by the parents (Lack, 1968).

However, among these two tree species, 100 % nesting success was noted only on *Azadiracta indica* (55 nests) whereas nesting success for *Alianthus exelsa* is noted to be lower [Successful nest-11 (12%) and Unsuccessful nest-2 (2%)] having comparatively low canopy cover. As noted for Hadada Ibis and Black Ibis (Soni *et.al.*, 2010), Black Kites also prefer nesting on the upper third of the tree. A positive correlation of tree height and canopy with nest height indicates that canopy cover and height of trees are important for nesting by Black Kites. The height and higher nest elevation provide easy access to leave and to land directly on the nest. Majority of bird species choose their nest site with the consideration of climatic pressures such as wind speed, temperature, sudden and heavy rain pour as well as potential predation including human disturbance (Dhinsa *et al.*, 1989). The position of nest on the sub- branch and its proximity to the trunk minimizes exposure, easy flight pathways and escape. Beside the characteristics of the tree and nest vicinity, consideration of the foraging sites is also equally important. The American White ibis (*Eudocimus albus*) are reported to construct their nesting colony depending on the availability of the foraging habitat (Kushlan, 1976). Similarly, Egyptian Vultures (*Neophron percnopterus*) also build their nests at the site where the food availability is abundant (Olga and Jose, 1989). Thus, distance from foraging habitat is crucial to birds to avoid exposure of chicks for long duration to predation (Plate: 6). Though not measured majority of nests found in the present study were found nearer to either garbage dumps or near poultry or mutton shops where plenty of food is available. Food and water are the basic requirements for any individuals. In the case of Black kites, their nests are nearer to waterbodies too.

Birds with food solitarily show nest solitarily too (Lack, 1968). Like, Common Kestrel (*Falcon tinunculus*) (Bustamante, 1994), Black Kites are also solitary nesters. Further, it is a well known fact that availability of food and nesting sites are limiting factor for bird populations including raptors. However, raptors in urban area are equally opportunistic and acquire either of these limited commodities from human source. Though, not observed in Vadodara, Kites have been observed nesting on power poles or high voltage transmission towers in Ahmedabad. Thus, when trees are not available for nesting they use other resources to overcome availability of a second limited source. Acquisition of such limited commodities has increased the urban population of Kites.

Many bird species are reported to occupy previously used nesting area (Greenwood and Harvey, 1976; Newton, 1979; 1982). These researchers noted that breeding site fidelity is more often observed in the successful individuals than the unsuccessful one. Reuse of old deserted nests and taking over of active nests are recorded for many bird species as a consequence of scarcity of nest sites or nest materials (Dusi, 1968; Burger, 1978a; 1978b). Many species also show nesting associations (Welty and Bapista, 1988). Nesting association of Black Kites with crows was recorded in Vadodara. An association with a predatory species is related to protection from potential predators. Such an association is also reported in White Ibis (Donazar *et al.*, 1996). Similar observation was recorded at Ahmedabad. It was also noted that the nests used by Vultures were reused by Black Kites (Personal observation). Stealing of nest material was also recorded occasionally by Black Kites as is also reviewed by Welty and Bapista (1988). Old nest is reused by many species like Cattle egret and Little Blue heron (Dusi, 1968) and Buff necked Ibis (Donazar *et al.*, 1996). Likewise, Black Kites often reuse their conspecific or heterospecific deserted nests. By preferring old nests, the kites could save energy required in exploring safer nest sites and by shortening the period of nidification. Frequent flights are required to gather nest material from nearby area to build a nest. Thus, Black Kites have to invest much time and energy to build a new nest. Therefore, reuse of nest involves apparent benefit of time and energy saving by not building a new nest. It is further supported by the fact that pre-laying period is significantly shortened when a pair reuses old nest. If the same pair reuses the site, then it could minimize the cost of territory establishment too (Soni *et al.*, 2010).

Nest predation is the main cause of nest failure in many bird species (Ricklefs, 1969; Martin, 1993) and nest-predation rates have been shown to vary with nest-site characteristics for a wide range of bird species (Ricklefs, 1969; Collias and Collias, 1984; Martin, 1993). In Black Kites, out of 83 nests only 7 nests are not successful. It is also noted that unsuccessful nests are built on shorter trees which provide lower nest height with a thinner canopy cover and are directly exposed to sunlight. Though the actual reason for nest failure could not be found out in present study, it might be because of selection of inferior nesting sites. Human impact on the environment is one of the major issues in biodiversity conservation (Meffe and Carroll, 1994). As far as an urban adaptor like Black Kite (Rathod, 2009) is concerned, the human presence had no negative influence on its nesting. Distance from nearest building was not correlated with nesting activities as 45 nests were located on busy roads, 26 near building while only 4 in undisturbed area.

In conclusion it may be said that Black Kites *M. m. govinda* prefers nesting in the trees which are tall and have higher canopy cover. The availability of these trees is also important. In Vadodara where large number of old *Azadiracta inidca* with high canopy cover as well as height are present the success of nesting on it is 100%.

CHAPTER: 3

FEEDING ECOLOGY

INTRODUCTION:

In the terrestrial ecosystems predators, the raptors among the birds play the apex role. Occupying a position at high tropic level they play important role by regulating prey species. The concept recorded by Lack (1946) as “density of raptor is limited because of its food supply”. Therefore studying the food habits of raptors is essential for the understanding of raptor biology and its community dynamics. Food availability is one of the most important factors influencing the quality of raptor habitats, which is determined not only by prey density, but also by its accessibility (Widen, 1994). Though, urbanization is reported by many conservationists as one of the major driving force behind the loss of global biological diversity it is also being recognized as a major modified ecosystem (Marzluff, 2001). Several species successfully adapt to urbanization over the time. Black Kite is one such species that is most common raptor inhabiting urban tropical region (Naoroji, 2007, Rathod, 2009). Being common resident around human habitation, it has adapted very well to living in cities. Though strongly associated with urban landscapes it isone of the least studied diurnal bird of prey as its population is very high in the cities. It is one species that has probably got effectively adapted to urban habitat and its modification (Rathod, 2009).

Ecology of this raptor with reference to food habits in the diet is scarce, highly fragmentary and incomplete.

Food is one of the most important factor influencing the abundance and distribution of birds in any ecosystem (Pimm, 1982; Polis, 1991; Begon *et al.,* 1996). In a food web, birds show interactions both between species and ecosystems (Pimm, 1982; Paine, 1980; Schoener, 1989; Polis, 1991). Here a species reacting functionally to the abundance of its prey can be utilized to assess predator prey population dynamics (Andersson and Erlinge, 1977; Korpimaki, 1987; Korpimaki and Norrdahl, 1989, 1991; Hanski *et al.,* 1991; O'Donoghue *et al.,* 2001).

To understand the role of raptors in an ecosystem detailed knowledge of its feeding habits and diet are important (Marti *et al.,* 2007). Diet studies also provide information on abundance of prey species and its distribution (Bontzorlos *et al.,* 2005). Further, for the conservation and management of raptors also, it is necessary to understand their preferred food and feeding ecology in particular habitat (Bakaloudis, 2009, 2010; Birrer, 2010). Diurnal raptors often consume prey large enough to be identified at a distance. Yet, studying raptor diets for many species can be difficult and time consuming given the large home ranges and low rates of prey capture. The most common methods used to study food of raptors are direct observation of prey capture or consumption, monitoring and photographic recording of prey delivered to the nests (Collopy, 1983; Marti, 1987; Simmons *et al*., 1991), and collecting prey remains (Mañosa, 1994; Toyne, 1998; Rutz, 2003). Other methods include stomach content analysis (Marti, 1987). In raptors indigested parts of food such as hair, bone, insect exoskeletons, scales, *etc*. are regurgitated by many species in the form of pellets. Thus, study of pellets (Mañosa, 1994; Toyne, 1998) is non invasive method of food analysis that provides good indication of prey species consumed (Rosenberg and Cooper, 1990). Hence, in the present study pellet analysis is carried out to find out main food of Black Kite *Milvus migrans govinda*. However, this method is likely to overestimate the large and more conspicuous prey items (Real, 1996; Rutz, 2003; Selås *et al.*, 2007; Ruddock *et al.*, 2009).

MATERIAL AND METHODS:

In Vadodara city (22^{o} 18’ N, 73^{o} 10’ E) Gujarat, India, Kites were observed feeding at several places from 2010-2011. These mainly included garbage dumps and poultry/ mutton shops. However, for collecting regurgitated pellets roosting sites were visited (Chapter: I).

The regurgitated pellets under the roosting trees of Black Kites were collected bimonthly during morning hours. Pellets were identified based on their morphological features and collected manually and stored in zip lock bags until analyzed (Plate: 7). For each pellet, information regarding date and place of collection were recorded. Before analysis pellets were dried in hot oven at 60^{o} C to remove all moisture content, cooled and weighted. After drying, to identify different undigested prey items, pellets were teased carefully to separate the indigestible components such as insect body parts, bones of small animals, undigestable parts of birds *etc.* as describe by Huang *et al.,* (2006). The parts of insect exoskeleton were observed under the microscope for identification up to order/family and classified on the bases of standard reference guides (McGavin, 2000). For better identification of the bony parts they were kept in 5% KOH solution overnight for bleaching.

Statistical Analysis:

Total 1800 pellets from three sites (600 each) over three seasons were collected and used for the analysis. Morphometry and composition of pellets were compared between seasons and between sites by using one way analysis of variance (ANOVA).

RESULTS:

Morphometric characteristics of regurgitated pellets of Black Kites: (Table: 1, Fig: 1, Plate: 7)

In summer, mean length and width of pellets collected from Sayajibaug are 3.92 ± 0.2 cm. and 2.14 ± 0.11 cm. while that from Railway station are 3.84 ± 0.01 cm. and 2.02 ± 0.16 cm. and from Bhutdizapa 3.93 ± 0.01 cm. and 2.16 ± 0.14 cm. respectively. When these are compared, the differences are significant at $P<0.001$ ($F_{3,597}$ 8.76) for length and at $P<0.01$ ($F_{3,\ 597}$ 2.30) for width. Differences in weight of pellets is also highly significant at $P<0.001$ ($F_{3,597}$ 18.98), as mean weight of pellets from Sayajibaug, Railway station and Bhutdizapa are 1.89 ± 0.04 gm., 1.99 ± 0.01 gm. and 2.03 ± 0.01 gm. respectively.

In monsoon mean length and width of pellets collected from Sayajibaug are 3.7 ± 0.22 cm. and 2.08 ± 0.01cm. while that from Railway station are 3.52 ± 0.13cm. and 1.97 ± 0.01cm. and from Bhutdizapa 3.65 ± 0.14cm. and 1.9 ±0.2 cm. The differences in length and width of pellets are significant at $P<0.001$ ($F_{3,597}$ 3.77 and $F_{3,597}$ 8.15) respectively. Similarly, differences in mean weight of pellets from three sites are also highly significant at $P<0.001$ ($F_{3,597}$ 26.74) as mean weight of pellets from Sayajibaug, Railway station and Bhutdizapa are 1.99 ± 0.21 gm., 2.04 ± 0.1 gm. and 2.0 ± 0.1 gm. respectively.

In winter, mean length and width of pellets collected from Sayajibaug are 4.02 ± 0.07 cm. and 2.09 ± 0.03cm. Those from Railway station are 4.0 ± 0.06 cm. long and 2.13 ± 0.05 cm. broad while those from Bhutdizapa are 3.97 ± 0.01 cm. and 2.14 ±0.12 cm. long and broad respectively. The differences in the length and width of these pellets are significant at $P < 0.05$ ($F_{3,597}$ 3.67 and $F_{3,597}$ 3.81). However, differences in mean weight of pellets are highly significant at $P<0.001$ ($F_{3,597}$ 30.24) with mean weight of pellets from Sayajibaug, Railway station and Bhutdizapa being 1.77 ± 1.35 gm., 1.79 ± 0.9 gm. and 1.66 ± 0.81 gm. respectively.

When undigested food contents from pellets are analyzed (Table: 1 Fig: 2, Plate: 8). Poultry leftovers (Feathers) are the main components with mean weight 0.85 ± 0.05 gm., 0.9 ± 0.06 gm. and 0.91 ± 0.05 gm., in summer, for the pellets collected from Sayajibaug, Railway station and Bhutdizapa respectively. The insect remains are 0.12 ±0.5 gm., 0.1 ± 0.03 gm. and 0.14 ± 0.02 gm. respectively. Occasionally undigested bones are also noted with mean weight 0.01 ±0.02 gm. at Sayajibaug, 0.06 ±0.03 gm. at Railway station and 0.04 ±0.003 gm. at Bhutdizapa. The differences in the poultry leftovers between the three sites are significant at $P<0.001$ ($F_{3, 597}$ 23.17), for insect parts at $P<0.05$ ($F_{3, 597}$ 3.9) while non significant for bony parts at $P>0.05$ ($F_{3, 597}$ 1.13). Similarly mean poultry leftover for pellet in monsoon are 0.79 ± 0.01 gm., 0.77 ± 0.06 gm. and

0.71 ± 0.02 gm., insect remains 0.37 ±1.8 gm., 0.29 ± 0.9 gm. and 0.3 ± 1.2 gm. from the three sites respectively. While, bony parts are 0.09 ±1.4 gm., 0.08 ±0.16 gm. and 0.08 ±0.27 gm. from the three sites respectively. In monsoon the differences in the weight of poultry left over in the pellets from three sites are significant only at $P<0.05$ ($F_{3,597}$ 3.58), while difference in insect remains are significant at $P<0.001$ ($F_{3,597}$ 33.98) and bony parts at $P<0.05$ ($F_{3,597}$ 6.01). During winter mean poultry leftover in regurgitated pellets are 0.99 ± 1.7 gm., 0.85 ± 1.2 gm. and 0.92 ± 0.02 gm., weight of insects remains 0.1 ±0.9 gm., 0.05 ± 0.02 gm. and 0.03 ± 0.01 gm. respectively while, bony parts 0.02 ± 0.2 gm. at Sayajibaug, 0.01 ±0.2 gm. at Railway station and 0.02 ±0.01 gm. at Bhutdizapa. The difference in poultry left over and insect remains during winter are significant at $P<0.05$ ($F_{3,597}$ 4.30 and $F_{3,597}$ 4.25) respectively, while differences in bony parts are nonsignificant at $P>0.05$ ($F_{3,597}$ 0.06).

The overall Seasonal variation: (Table: 2, Fig: 2)

The mean Length of pellets for summer is 3.96 ± 0.01 cm., for monsoon 3.7 ± 0.02 cm. and for winter 3.89 ± 0.01 cm. while, widths are 2.1 ± 0.03 cm., 1.96 ± 0.01cm. and 2.0 ± 0.01 cm. respectively. Length and width of pellets during three seasons are significantly different at $P< 0.05$ and $P<0.001$ ($F_{3,1797}$ 3.57 and $F_{3,1797}$ 12.75) respectively. The mean weight of the pellets from three sites are 1.97 ± 0.1, 1.91 ± 0.12 and 1.98 ± 0.01

gm., with poultry left over in pellets at 0.89 ± 0.06, 0.78 ± 0.09 and 0.88 ± 0.03 gms., insects remains 0.06 ± 0.01, 0.28 ± 0.1 and 0.03 ± 0.01 gm. and bony parts 0.01 ± 0.7, 0.1 ± 0.03 and 0.01 ± 0.04 gm. in summer, monsoon and winter respectively. Seasonal variations at $P<0.001$ ($F_{3,1797}$ 12.75, 35.22, 12.91, 83.69 and 30.42) are noted for width of pellets, total weight, poultry leftover, insect remains and bony parts respectively while at $P<0.05$ ($F_{3,1797}$ 3.57) for length of the pellets.

Table 1: Morphometric Characteristics Black kite pellets from three sites in three seasons:

	Summer			F Value
Mean value	**Sayajibaug**	**Railway station**	**Bhutdizapa**	
Length (cm)	3.92±0.2	3.84±0.01	3.93±0.01	8.76 ***
Width (cm)	2.14 ± 0.11	2.02 ±0.16	2.16 ±0.14	2.3*
Weight(gm)	1.89± 0.04	1.99 ±0.01	2.03 ±0.01	18.98***
Poultry left over (gm)	0.85±0.05	0.9 ±0.006	0.91±0.05	23.17***
Insects remain (gm)	0.12±0.5	0.1 ± 0.03	0.14 ± 0.02	3.9*
Bony parts (gm)	0.01±0.02	0.06 ±0.03	0.04 ±0.003	1.13
	Monsoon			
Length (cm)	3.70 ± 0.22	3.52 ± 0.13	3.65 ± 0.14	3.77*
Width (cm)	2.08 ± 0.01	1.97 ± 0.01	1.90 ±0.2	8.15***
Weight(gm)	1.99 ± 0.21	2.04± 0.1	2.0 ± 0.2	26.74***
Poultry left over (gm)	0.79 ± 0.01	0.77 ± 0.06	0.71 ±0.02	3.58*
Insects remain (gm)	0.37 ±1.8	0.29 ±0.9	0.30 ±1.2	33.98***
Bony parts (gm)	0.09±0.14	0.08±0.16	0.08±0.27	6.01*
	Winter			
Length (cm)	4.02 ± 0.07	4.0 ± 0.06	3.97 ± 0.01	3.67*
Width (cm)	2.09 ± 0.03	2.13 ± 0.05	2.14 ± 0.12	3.81*
Weight(gm)	1.77 ± 1.35	1.79 ±0.9	1.66 ± 0.81	30.24***
Poultry left over (gm)	0.99 ± 1.7	0.85 ± 1.2	0.92 ± 0.02	4.3*
Insects remain (gm)	0.1 ± 0.9	0.05 ±0.02	0.03 ± 0.01	4.25*
Bony parts (gm)	0.02 ± 0.2	0.01 ± 0.2	0.02 ± 0.01	0.06

* P<0.05, ** P<0.01, *** P<0.001

Table: 2 The overall seasonal variations in Morphometric characteristics of Black Kites pellets.

Mean value	Summer	Monsoon	Winter	F value, P<0.05
Length (cm)	3.96 ± 0.01	3.7 ± 0.02	3.89 ± 0.01	3.57*
Width (cm)	2.1 ±0.03	1.96±0.01	2.0 ±0.01	12.75***
Weight(gm)	1.97 ± 0.1	1.91 ± 0.12	1.98 ±0.01	35.22***
Poultry left over (gm)	0.89 ± 0.06	0.78 ± 0.09	0.88 ± 0.03	12.91***
Insects remain (gm)	0.06 ±0.01	0.28 ± 0.1	0.03 ± 0.01	83.69***
Bone parts (gm)	0.01±0.7	0.1 ±0.03	0.01±0.04	30.42***

* P<0.05, ** P<0.01, *** P<0.001

Fig:1 Morphometric Characteristics Black Kite pellets from three sites in three seasons:

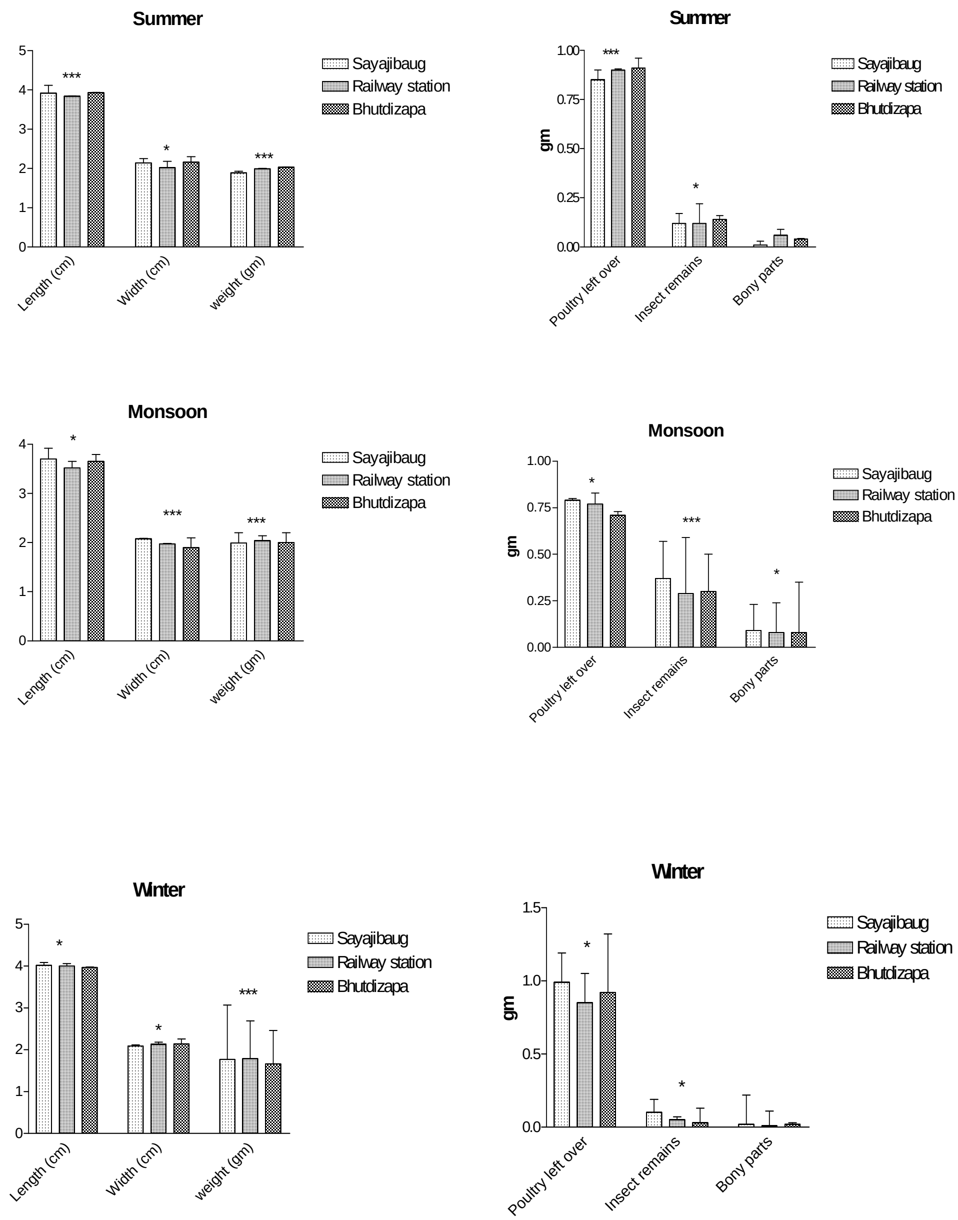
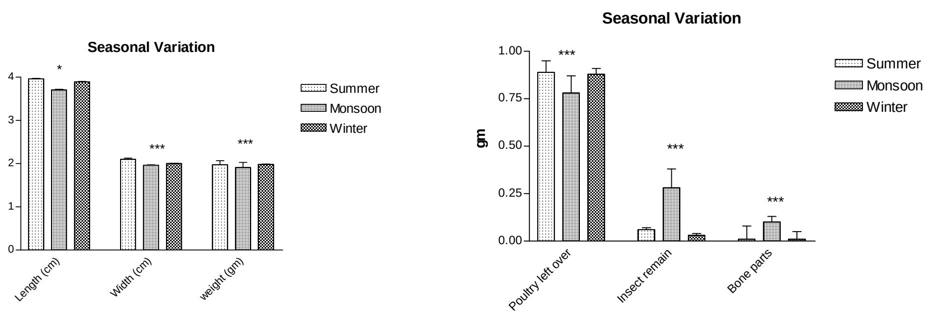


Fig: 2 The overall seasonal variations in Morphometric characteristics of Black Kite pellets.



DISCUSSION:

Environmental quality can affect the size of raptor population through food supply, nest sites and human activities (Newton, 1979). Food habit studies provide the foundation for additional investigations. Besides documenting the existence of certain prey species within the raptor's range, it also documents individual's capability to take such prey, and relative abundance of prey species in the diet (Santhanakrishnan *et al.*, 2010). As in other avian groups, food supply is one of the main factors influencing the ecology of raptors too (e.g., Newton 1979). Black Kite prefers feeding on insects, small animals *etc*. as evidenced by the presence of their bones in the pellet (Ali, 1979; Naoroji, 2007). The occurrence of adequate prey numbers to fulfill energy requirements influences the birds' breeding performance hence; food has direct affect on the breeding success of individuals (Newton, 1979). Therefore, knowledge of the diet of focal species at a location of interest is crucial for appropriate management and conservation action **(**Limiñana *et al.*, 2012). In present study, based on frequency of occurrence it is noted that poultry leftover is the major food item consumed by this species which has adapted to urban environment. In addition, parts of insect exoskeleton with few bony remains are also observed in all of the pellets collected during the study period from all the study sites. On the basis of data collected, the result stresses on heavy dependence of the Black Kites on the poultry leftovers because of their easy availability in urban habitats. To gather small bits of biomass to fulfil nutritional needs in urban environs can be more difficult. However, the attraction of urban men to poultry products has resulted in mushrooming of poultry farms around the cities. Black Kite a sensible species has probably exploited this availability as more than 90% undigested food in the pellets showed presence of feather of White Leghorn, a very common poultry breed grown for both egg and table purpose. Further, Vadodara being located in semi arid zone of India and experiencing monsoon type climate with dry and hot summer and humid and warm in monsoon emergence of insects/amphibians form their dormancy of hot summer, increases their availability in large number. Hence, in monsoon, insects are included in food items by Black Kites. In addition though in small numbers, small amphibians also form prey base for the Black Kites.

The increase in insects in diet during monsoon decrease the length and width of pellets as chitinous parts of insects form a compact structure while poultry feather in summer and winter make the pellet soft and fluffy making them larger in size. Very few bony parts added to this compactness without influencing weight of the pellets. Hence, it can be said that due to poultry leftovers and insects the pellet showed significant difference in the morphometrics of pellets across the seasons.

Investigations of predation have shown that certain prey species are more likely to be eaten than others (Getz, 1961, Marti, 1974; Kolter, 1985). This depends on their easy availability. Occurrence of insects exoskeleton especially (Order: Coloeptera) during monsoon in all the pellets studied indicate their availability at the 3 habitats. The proportion of insects in diet is higher in the pellets collected from Sayajibaug which has rich floral diversity attracting variety of insects while other two areas have comparatively more concrete structures and low insect diversity. In present study majority of insects were from order Coeloptera, families - Carabidae and Scarabidae. These families are common in Sayajibaug area, near Vishwamitri stream, and surrounding and inside the cricket ground in university campus (Naidu, 2008). In Vadodara Black Kites are requently seen near garbage dumping sites as well, where high insect population is expected. The urban landscape shows presence of natural diet like insects as well as amphibians that are consumed whenever available. The relative abundance of any prey species in a particular habitat is further influenced by its own reproductive schedule, vegetation cover, climate and weather (Cameron 2003, Mushtaq-ul-Hassan *et al.*, 2004, Mahmood-ul-Hassan *et al.*, 2007).

Thus, the results suggest that due to availability of poultry leftover in Vadodara, Black Kites get plenty of food to satisfy their energy needs and as discussed in Chapter: I plenty of time to soar in the urban sky with thermals without spending much energy. This helps them to save energy by avoiding hunting and breed successfully (Chapter: II). This may also suggest that the time spent for hunting is less compared to other species which have to rely on obtaining maximum biomass in limited available time.

The current study is an attempt towards understanding the diet composition and food preference of the Black Kites in three habitats in urban landscape and to have a base line data regarding the prey base for these birds. This investigation can be further carried out extensively to have a better understanding of diet composition its availability and food preference spatially and temporally.

General information:

Food and water is the basic need of every individual. Species of birds try to build their nest nearer to feeding sites so they can explore the feeding grounds and also care for the young once. During day time Black Kites are observed foraging nearer to dumping site, poultry farms, surrounding water resources, slaughter houses and nearer mutton shops. The sites from where they can easily get food. At a time after rainy nights in monsoon Kites are observed flying low on large open grounds for feeding on emerging small insects from ground from early morning itself.

CHAPTER: 4

ANALYSIS OF TOXIC AND ESSENTIAL ELEMENTS

INTRODUTION:

Large quantities of pollutants are continuously being introduced into the environments of cities as a consequence of anthropogenic activities such as urbanization, vehicular traffic and industrial processes. Among these heavy metals, due to their high potential to enter and accumulate in food chains, are considered as critical contaminants in the environment, (Olojo *et al.,* 2005; Erdoğrul and Erbilir, 2007). The main sources of heavy metal pollution are industries and mining activities (Singh *et al.,* 2007). At low concentrations arsenic, lead, cadmium and chromium are toxic to living organisms while other metals like copper and zinc are the biologically essential metals that become toxic only at very high concentrations (Cohen *et al.,* 2001; Storelli *et al.,* 2006).

Environmental contamination caused due to anthropogenic activities is a relatively novel concept in ecological times. These stressors negatively affect individuals and entire ecosystems via air and water around the world, even in the areas relatively free of their production (Iwata *et al.,* 1993). However, in the past few decades, more efforts have been made to discuss the monitoring of health of the ecosystem. These discussions concentrate on presence of essential, non essential elements and other pollutants in the environment that cause great risk to all living biota. These elements are frequent waste products of industrial activities and their emission contaminate surrounding environment (Eeva and Lehikoinen, 2000).

Increasing levels of toxic and essential elements in air, soil as well as water are of growing concern for the biota on earth including human being. There are hundreds of sources for these elements like pollution, combustion of coal and natural gases, paper and chloroalkali industries, *etc.* through which these metals end up and accumulate in environment. Their excessive persistence in the environment or their bioaccumulation and biomagnification in food chains are the potential threats leading to undesirable effects in the biota (Zhuang *et al.*, 2009; Dżugan *et al*., 2012). A control of accumulation of these substances in an ecosystem is of great value in context to global environmental pollution. Use of bioindicators in monitoring such pollutants is often easier compared to monitoring abiotic samples (Lebedeva, 1997). Among the bioindicators birds are traditional subjects for monitoring polluted ecosystem, especially in territories adjacent to stationary sources of pollution. The studies on birds with reference to accumulation of heavy metals are extensive and increasing (Dmowski, 1999).

Birds occupy wide range of tropic levels in different food chain. Due to this compared to other species it is very easy to monitor them (Burger *et al.,* 1999; Eens *et al.,* 1999). Among them species that are at the apex of the food web are more commonly used as bio-indicators to evaluate the presence of persistent contaminants. As a result of escalating generation of evidences that bird populations are particularly sensitive to the changes produced by men in the environment, potential use of birds as indicator for environmental pollution has been widely recognized. Most of these species are long-lived, hence pollutant burden in their bodies get integrated in a complex way over the time. Thus, birds are useful biomonitors for studying bioaccumulation. They are visible, sensitive to environmental changes and are at the pinnacle of the food chain. Raptors are amongst the most intensively studied bird species in biomonitoring investigations due to their top position in the food chains and the spatial integration of contaminant levels in their extended home ranges (Altmeyer *et al*., 1991, Esselink *et al.,* 1995, Garcia- Fernandez *et al.,* 1997, Pain *et al.,* 2007).

Their ecology, physiology and behaviour have been well studied and they are of interest to the public (Burger, 1993). Most studies have been conducted on internal tissues, but the number of studies making use of non-destructive methods, like measuring the concentrations of metals in feathers, faeces and eggs have increased over the years. Especially, feathers are considered as valuable tool to monitor exposure to heavy metals. However, many carnivorous birds are foraging over a wide geographical area; due to this it is also very difficult to detect source and site for their toxic ingestion. The effects of heavy metal concentration in the different species have been studies by researchers like Burger (1993), Furness (1993), *etc*. The environmental toxicant can bind to the proteinmolecules in the feather during the short period of feather growth when the feather is connected with the bloodstream in pulp of calamus (Furness, 1993). Compared to blood and other tissues it is easier to detect and quantify heavy metals in feathers (Cahil *et al*., 1998; Tom *et al*., 2002).

The Black Kite (*Milvus migrans govinda*) is a common diurnal scavenger distributed throughout the Paleartic region (Bijlsma, 1997) and also a very common scavenger around towns in India (Galushin, 1971; Ali, 1979; Navroji, 2007). In the present study, while studying ecology of kites in urban area an attempt is made to quantify and assess the impact of various elements from different tissue of Black Kite (*Milvus migrans govinda*) collected from one of the most polluted city Ahmedabad, Gujarat, India.

MATERIALS AND METHODS:

The samples of tissue and feather of kites were collected from Ahemdabad (23.03° N 72.58° E) about 90 Km. North of Vadodara. Gujarat is a cultural state where all festivals are celebrated. One of the most celebrated festival of Gujarat is “Uttraryan-The Kite flying festival” celebrated on 14th and 15th January every year. During this festival thousand of paper kites are flown in the sky with sharp threads and there is an impulsive competition among kite flyers to cut each other’s paper kites. Due to the sharp threads hundreds of birds are injured. These injured birds are brought to bird rescue centres and are treated by several NGOs and Forest Department, Government of Gujarat for recovery. However, some heavily injured birds succumb to the injury. From these dead Black Kites *Milvus migrans govinda* (Plate 9) from Ahmedabad were used for quantification of heavy metals.

Sample collection:-

Ahmedabad being a Metro city with highest human population in Gujarat has larger population of kites too and hence the number of kites getting injured and succumbing to death is also higher.

After taking Permission from Ministry of Environment and Forest Government of India (MOEF), New Delhi (vide letter no.WLP/28/C/396-398 and F.No.1-4/2007 WL-I) for collection of various tissue from dead birds the samples were collected. For heavy metal analysis, liver, kidney, muscles and primary feathers were taken. Each dead Kite was weighed by digital weighing balance, dissected open and tissues were collected and stored in dry ice and transferred to laboratory and stored at -20^0 C till further analysis. Before analysis the tissues were washed alternately with deionized water (Mili-Q) and acetone and then exposed to 60 ^{0}C in dry oven for 24 h to determine dry weight. The dry tissues were digested in a 1:1 mixture of Nitric acid (Qualigen) (70%) and Hydrogen Peroxide (Merck) (30%). For analysing toxic and essential elements in feathers, first three primaries were taken (Plate 9); their calamus was removed and processed in similar way. The digestion was completed with heat destruction procedure described by Blust *et al.* (1988). All the samples were diluted by adding 4 ml deionized water (Milli Q) and stored at -20 ^{o}C until analysed. Analysis was carried out by Inductively Coupled Plasma Atomic Mass Spectrometer (ICPMS) method described by Swaileh and Sansur (2006) at Inductively Coupled Plasma (ICP) Lab, Pawai, Mumbai.

Statistical analysis:

Statistical evaluation of the data was carried out by using statistical software package SPSS 7.5 for Spearman correlation coefficient while Prism 3 for one way ANOVA. To find out relationship between body weights and concentrations of different metals in different organs of male and female, Pearson coefficient was carried out. Concentration of essential and toxic metal in different tissue like Feathers, Kidney, Liver and Muscles were compared by using One way analysis of variance (ANOVA). To reveal the overall variation in the concentration of each element the coefficient of variation (CV) was calculated. Data values are expressed as mean ± SE and test statistics were considered significant at $P < 0.05$, $P < 0.01$, $P < 0.0001$.

RESULTS:

Concentration of toxic elements in Feathers, Liver, Kidney and Muscles of *Milvus migrans govinda*: (Cd, Hg, Ni, Pb, Cr) (Table: 1, Fig: 1)

The mean concentration of toxic metals, cadmium, mercury, nickel, lead and chromium in feathers are 0.05 ± 0.01, 0.03 ± 0.03, 0.1 ± 0.01, 0.4 ± 0.01, 0.25 ± 0.04 µg/g dw respectively. Among other tissues concentration of Cadmium is highest in Liver 2.0 ± 0.01µg/g dw, followed by kidney 0.8 ± 0.03 and muscles 0.2 ± 0.1 µg/g dw. Similarly concentration of Mercury is also high in liver 0.5 ± 0.01 µg/g dw, followed by kidney 0.2 ± 0.02 µg/g dw and low in muscles 0.05 ± 0.01 µg/g dw. The concentration of Nickel is 0.3 ± 0.01, 0.21 ± 0.01 and 0.01 ± 0.01 µg/g dw respectively, while those for Lead and Chromium are also highest 1.0 ± 0.01 and 0.8 ± 0.01 in liver, followed by 0.13 ± 0.01 µg/g dw and 0.15 ± 0.02 µg/g dw in kidney and lowest 0.03 ± 0.01 and

0.04 ± 0.02 µg/g dw in muscles. Accumulation of metals (in µg/g dw) can be summarised as follows: Feathers Pb > Cr > Ni > Cd > Hg, Liver Cd > Pb > Cr > Hg > Ni, Kidney Cd > Hg ≈ Ni > Cr ≈ Pb, Muscles Cd > Hg > Cr > Pb > Ni. The difference in the concentration of toxic elements in tissues studied are highly significant at $P < 0.0001$ with Cadmium- $F_{3,21}$ 64.99, Mercury- $F_{3,21}$ 27.38, Nickel- $F_{3,21}$ 72.21, Lead- $F_{3,21}$ 247.8 and Chromium- $F_{3,21}$ 76.52.

Concentration of essential elements in Feathers, Liver, Kidney and Muscles of *Milvus migrans govinda*: (Zn, Cu, Co) (Table:1, Fig:1)

The mean concentration of essential elements Zinc, Copper and Cobalt in feathers are 26 ± 0.4, 4.0 ± 0.5 and 0.05 ±0.01 µg/g dw respectively. Amongst the tissues also the concentrations of Zinc is highest of all the essential elements and are 85 ± 0.8, 32 ± 0.9 and 2.0 ± 0.05 µg/g dw for liver, kidney and muscles respectively. The concentration of Cobalt is minimum amongst all the tissues with 2.0 ± 0.01, 1.3 ± 0.3 and 2.0 ± 0.3 µg/g dw in the three tissues respectively while the concentration of copper is 15 ± 0.09, 10 ± 0.7 and 13 ± 0.52 µg/g dw respectively. For essential elements also differences in accumulation of elements in tissue are highly significant at $P < 0.0001$ with Zinc- $F_{3,21}$ 255.9, Copper- $F_{3,21}$ 12.02 and Cobalt- $F_{3,21}$ 34.9. Mean concentration of essential elements can be summarise for feather, liver and kidney as Zn > Cu > Co while for muscles as Cu > Zn ≈ Co.

Correlation between body weight and accumulation of heavy metal in different tissues:

As given in Table: 2, Pearson correlation was employed to examine the correlation between body weight and toxic and essential metal accumulation in different tissues. The body weight of Black kites ranged between 300 to 550 gms. with mean body weight 473.8 ± 13.55. Body weight correlated nonsignificantly either positively or negatively. Both the trends are seen in liver (Cd, Pb, Cu - positive and other elements Cr, Hg, Ni, Zn Co - negative). In kidney it is mainly negative (Cd, Hg, Pb, Cr, Cu, Co,) while only Ni and Zn showed positive correlation. In muscles and feather the correlation with body weight are mainly positive (Hg, Pb, Cr, Zn, Cu) while other elements (Cd, Ni, Co) showed negative correlations.

Comparison of heavy metals in Male and Female Black Kites:

For the comparison of heavy metal concentrations in various tissues of male and female Kites t test is employed. The Results are given in Table: 3. As seen in the table no significant difference are observed in concentration of all elements studied in all tissue of male and female Black kites.

Correlation of concentration of toxic and essential elements in various tissues of male and female Kites with body weight:

Fig (2) shows correlation between body weight and concentration of toxic and essential elements in various tissues of male and female Kites *(Milvus migrans govinda)*. When toxic elements in liver of male and female individuals are considered no significant increase with the increase in body weight in the concentration of all toxic elements are noted except for mercury in male which shows significant increase at $P<0.05$ with body weight. While in female liver non significant decline is noted only for Pb and Cr with increase in body weight. However, in kidney of male and female individuals all toxic elements showed a non significant increase with body weight except chromium concentration. Chromium concentrations are negatively and nonsignificantly correlated with body weight of male birds while positively and significantly at $P<0.05$ with body weight of female birds. For muscles, though the concentration of all toxic elements is very low they showed nonsignificant increase with body weight in both the sexes. Feathers showed varied relationship. In male birds non significant positive correlation for all elements except Ni is noted. In feathers from female kites concentration of Cd, Ni and Cr showed nonsignificant increase with the body weight whereas Hg showed significant increase ($P<0.05$) while Chromium showed nonsignificant decline with body weight.

Among essential elements all showed nonsignificantly increase ($P<0.05$) with body weight in liver and kidney of both the sexes. In muscle negative correlation with body weight is noted only for copper in male while for feathers negative correlation is established in Zinc concentrations in both the sexes.

Coefficient of variation of all elements in different tissues:

All toxic and essential elements in tissues studied are compared with the help of coefficient of variation too (Table:5, Fig:3). In the liver, Mercury concentration showed highest coefficient of variation while Cadmium and Zinc showed lowest CV compared to all other elements. In the kidney with Mercury, Copper also showed highest coefficient of variance while nickel showed lowest variations. In muscles and feather, it is Cadmium concentrations which has highest CV while Copper and Nickel respectively showed lowest CV.

Table:1 **Concentration (in µg/g dw) of toxic and essential elements in Feathers, Liver, Kidney and Muscles of *Milvus migrans govinda*: (Cd, Hg, Ni, Pb, Cr)**

	Feather	**Liver**	**Kidney**	**Muscle**	**F value (***)**
Cd	0.05±0.01	2.0 ± 0.01	0.8 ± 0.03	0.2 ± 0.1	64.99
Hg	0.03 ± 0.03	0.5 ± 0.01	0.2 ± 0.02	0.05 ± 0.01	27.38
Ni	0.1 ± 0.01	0.3 ± 0.01	0.21 ± 0.01	0.01 ± 0.01	72.21
Pb	0.4 ± 0.01	1.0 ± 0.01	0.13 ± 0.01	0.03 ± 0.01	247.8
Cr	0.25± 0.04	0.8 ± 0.01	0.15 ± 0.02	0.04 ± 0.02	76.52
Zn	26 ± 0.4	85 ± 0.8	32 ± 0.9	2.0 ±0.5	255.9
Cu	4±0.05	15±0.09	10±0.7	13±0.52	34.9
Co	0.05±0.01	2.0±0.01	1.3±0.3	2.0±0.3	12.02

Table: 2 Overall Correlation of various toxic and essential elements in tissue with body weight (Pearson correlation).

Metals	**Feather**	**Liver**	**Kidney**	**Muscle**
Cd	-0.06	0.77	-0.05	-0.06
Hg	0.16	-0.04	-0.38	0.17
Ni	-0.17	-0.001	0.07	-0.12
Pb	0.16	0.33	-0.06	0.16
Cr	0.61	-0.56	-0.75	0.67
Zn	0.08	-0.06	0.11	0.09
Cu	0.52	0.26	-0.04	0.80
Co	-0.03	-0.05	-0.03	-0.004

Table: 3 A comparison of Toxic and essential elements in various tissue in Male and female *Milvus migrans govinda* (t test)

	Feather		Liver		Kidney		Muscle	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Cd	0.01±0.03	0.05±0.01	0.92 ± 0.07	0.86 ± 0.08	0.92 ±0.09	0.92±0.07	0.48±0.08	0.43±0.10
Hg	0.05±0.01	0.04±0.01	0.51 ± 0.07	0.47 ± 0.06	0.22 ± 0.02	0.20 ±0.02	0.1 ±0.01	0.08±0.07
Ni	0.07±0.01	0.09±0.01	0.3 ± 0.02	0.29 ± 0.03	0.24 ±0.01	0.24 ±0.01	0.03 ±0.08	0.02 ±0.05
Pb	0.41±0.08	0.26±0.05	1.14 ± 0.06	1.13 ± 0.08	0.16 ±0.01	0.15 ±0.01	0.05±0.01	0.06±0.1
Cr	0.22±0.04	0.25±0.06	0.68 ± 0.06	0.61 ± 0.04	0.19 ± 0.006	0.17 ±0.01	0.06±0.007	0.05±0.005
Zn	27.28±4.99	21.83±4.45	81.0±3.27	79.33±2.72	37.5 ±2.79	38.3±1.90	4.88±1.02	4.50±1.057
Cu	1.92± 0.38	3.23±0.477	15.83±1.62	15.67±1.52	13.92±1.55	13.3±1.54	14.83±0.90	14.17±0.70
Co	0.019±0.06	0.049±0.01	1.93±0.133	1.94 ±0.1	1.57±0.11	1.41±0.1	3.45±0.45	3.0±0.365

All p values are Non significant (NS)

Table: 4 Correlation of concentration of toxic and essential elements in various tissues of male and female kites *(Milvus migrans govinda)* with their body weight.

	Liver		**Kidney**		**Muscle**		**Feather**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Cd	0.71	0.41	0.54	0.43	0.65	0.17	0.13	0.38
Hg	0.81*	0.33	0.58	0.44	0.79	0.44	0.63	0.87*
Ni	0.78	0.49	0.52	0.47	0.7	0.7	-0.6	0.47
Pb	0.65	-0.57	0.03	0.23	0.8	0.24	0.01	0.39
Cr	0.64	-0.1	-0.05	0.89*	0.35	0.06	0.62	-0.23
Zn	0.82	0.91	0.44	0.4	0.84	0.49	-0.52	-0.02
Cu	0.81	0.8	0.47	0.23	-0.63	0.14	0.46	0.02
Co	0.75	0.56	0.74	0.05	0.54	0.59	0.50	0.11

*$P < 0.05$

Table: 5 Coefficient of variance (CV) of all elements in different tissues of *Milvus migrans govinda*.

Elements	Feather	Liver	Kidney	Muscle
Cd	101.75	9.03	18.85	56.81
Hg	55.19	30.27	27.96	21.30
Ni	45.84	20.10	13.02	55.82
Pb	54.31	13.05	21.92	45.82
Cr	51.35	22.35	14.62	24.52
Zn	46.47	9.44	14.86	54.84
Cu	47.26	23.91	27.01	11.59
Co	83.86	16.10	17.76	28.42

Fig:1 Concentration of toxic and essential elements in Feather Liver, Kidney and Muscle of *Milvus migrans govinda*:

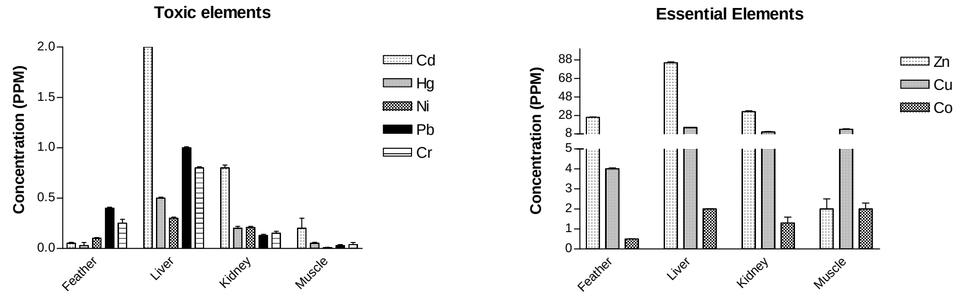
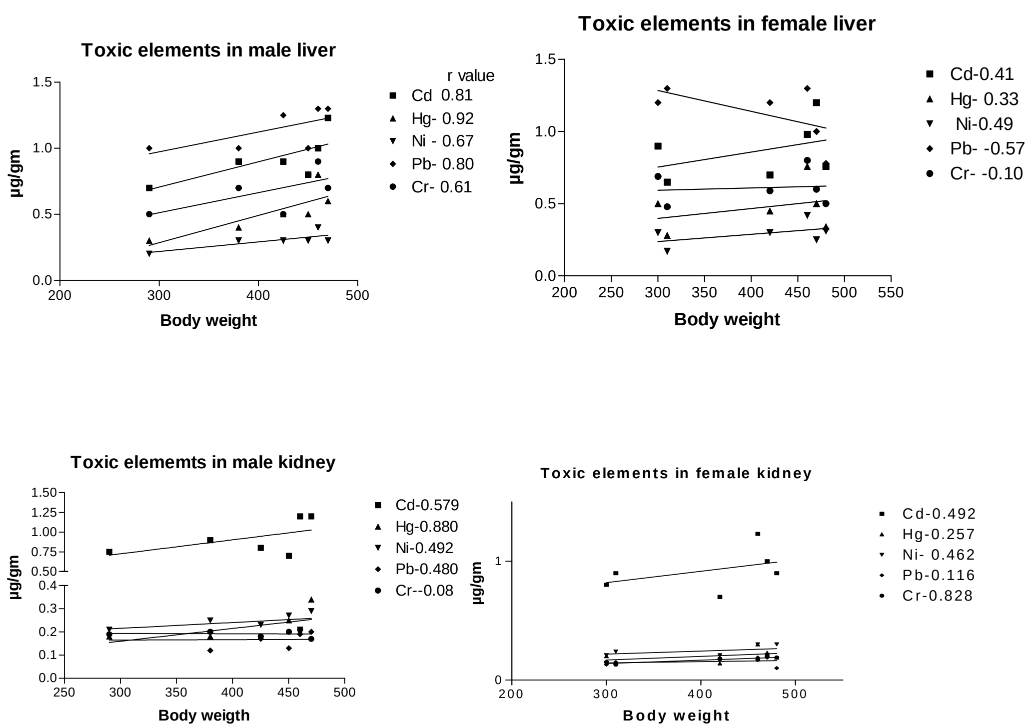
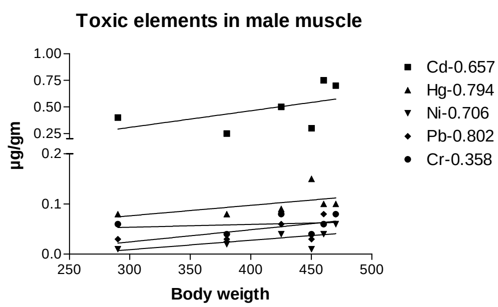
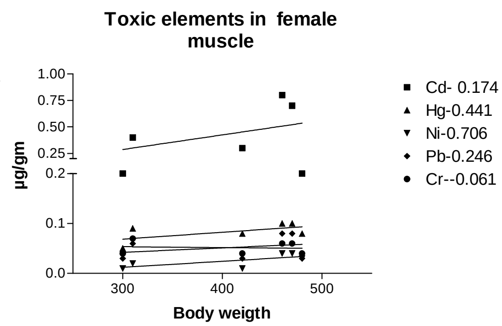
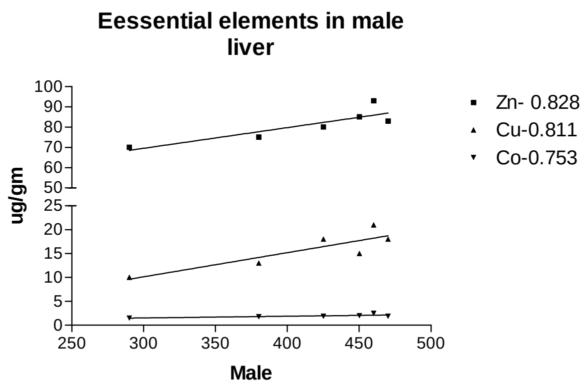


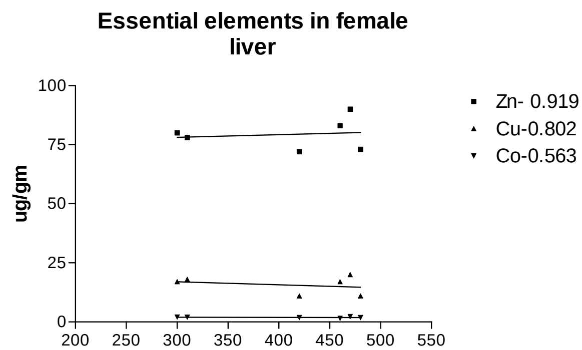
Fig: 2 **Correlation of tissue concentration of male and female Black Kites with Body weight.**

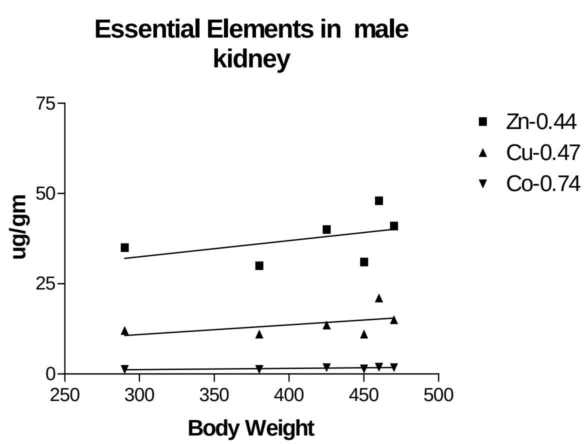


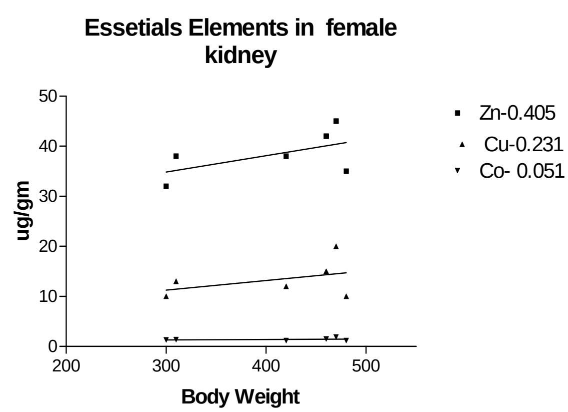

Toxic elements in male muscle
µg/gm
Body weigth
Cd-0.657
Hg-0.794
Ni-0.706
Pb-0.802
Cr-0.358

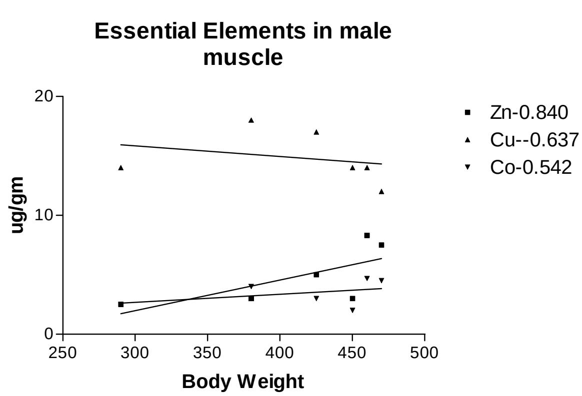

Toxic elements in female muscle
µg/gm
Body weigth
Cd- 0.174
Hg-0.441
Ni-0.706
Pb-0.246
Cr--0.061


Eessential elements in male liver
ug/gm
Male
Zn- 0.828
Cu-0.811
Co-0.753


Essential elements in female liver
ug/gm
Zn- 0.919
Cu-0.802
Co-0.563

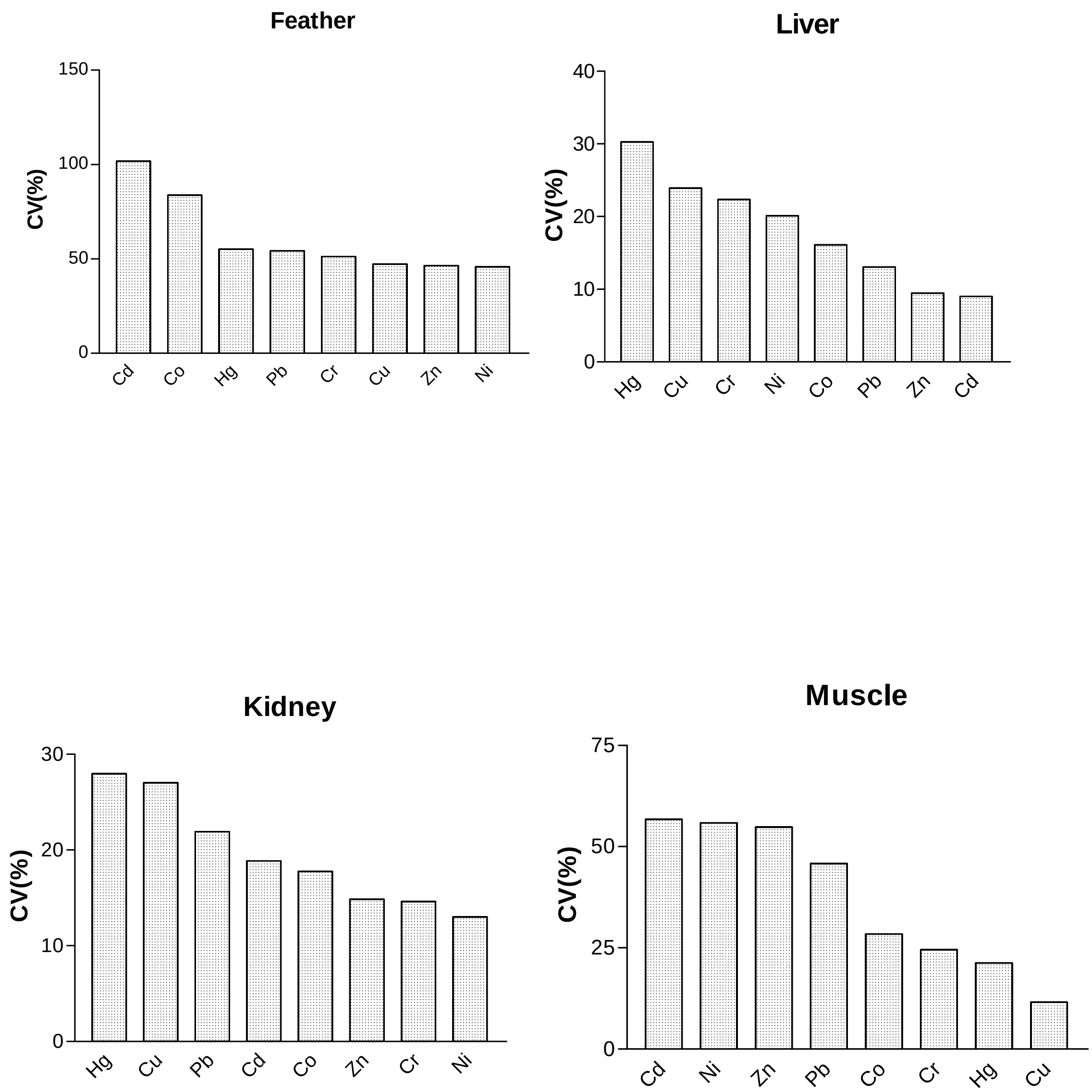

Essential Elements in male kidney
ug/gm
Body Weight
Zn-0.44
Cu-0.47
Co-0.74


Essetials Elements in female kidney
ug/gm
Body Weight
Zn-0.405
Cu-0.231
Co- 0.051


Essential Elements in male muscle
ug/gm
Body Weight
Zn-0.840
Cu--0.637
Co-0.542


Essential Elements in female
ug/gm
Body Weight
Zn-0.492
Cu-0.144
Co-0.597

Fig 3: Coefficient of variance of all elements in different tissue of Black Kite



DISCUSSION:

Avian survivorship in urban areas is influenced by risk of environmental toxicants, collision with man-made objects, changes in the predator assemblage, food supply and diseases (Chace and Walsh, 2006). Among the environmental toxicant metal and elements form major component. Many studies reported on concentration of heavy metals in different groups like Birds and fishes (Licata *et al.*, 2010; Mansouri *et al*., 2012; Binkowski *et al.*, 2013, Begum and Sehrin, 2013, Rajkowsa and protasowicki, 2013, *etc*.). Birds are used intensively for the past 30 years as a biomonitoring tools (Burger, 1993). Among eight elements Studied Cadmium is the toxic element which is showing maximum accumulation among the elements studied in the three tissues. However, its CV was maximum >100% for feathers followed by kidney and liver. Cadmium is known to be nephrotoxic (Gancia- Fernandez *et al*., 1997; Kalisinska *et al.*, 2004). Studies of Binkowski *et al.*, (2013) show highest concentration of Cadmium in kidney of Waterfowls *i.e.* Coots and Mallards indicating similar efficiency of detoxification process. However, in terrestrial raptor *Milvus migrans govinda* highest cadmium concentration are noted in liver. A non significant but positive correlation of hepatic cadmium levels while negatively correlated with kidney, muscle and feather concentration with respect to body weight indicates a possibility of difference in efficiency of detoxification process in water dependent and terrestrial species which needs to be further explored. As high concentration of Cadmium also occurs in liver it has been reported that Liver and Kidney together may accumulate about 75% of Cadmium in an organism (Gunn and Gould, 1957, Nordburg *et al.,* 2007) as it is also true in present studies. Further, as per various studies (Nicholson, 1981, Thompson, 1990) in present study also Cadmium levels in muscles and feathers are low. Singh and Srivastav (2007) state that the tissue concentration of metal content is strictly influenced by availability to animals while those in feathers to the share deposited in growing feathers through blood (Furness *et al*., 1990).

Mercury is one of the most important heavy metal toxicant in the environment originating from both natural cycling in the biosphere as well as anthropogenic activities like industrial emissions, burning of fossil fuels *etc*. As top predators as well as urban exploiters, Black Kites-*Milvus migrans govinda* is likely to accumulate the same in its body. Among the three tissues studied and feathers, maximum Hg concentration occurred in liver, followed by kidney and low in Muscles and feathers. Mercury contents in feathers are the indications of mercury contents in the diet of an individual (Furness *et al.,* 1990). Top predators are known to accumulate high mercury contents in their feather too. Though, Black

Kite is a raptor it mainly scavenges on the poultry left over (Rathod and Padate, 2004, Chapter:III). Hence, the accumulation of the same in feathers can be low. However, in Black kite accumulation of Hg in liver is highest followed by Kidney, indicating presence of the same in the terrestrial urban environment of Ahmedabad. This also indicates that Liver and Kidney of Black kite (*Milvus migrans govinda*) are able to handle the low concentrations of this heavy metal in the environment. However as far as CV is concerned feathers showed 55% variability compared to other tissues which showed CV between 20 to 30 % indicating that in these individuals that are exposed to Hg load accumulation of Hg increases in feather. The liver is preferred organ for metal accumulation. When mercury concentration is correlated with body weight positive correlations are obtained for muscles as well as feathers while negative correlations with liver and kidney. *Milvus migrans govinda* shows higher accumulation of Chromium too in both tissues. With significantly low accumulation in other tissue indicating that liver is able to handle this load of mercury too. However, among other three tissues accumulation of chromium is higher in feathers with 50% CV against 15 to 25% CV of other tissues indicating irregular ingestion of this metal in food by *M. m. govinda*.

Nickel, a ubiquitous metal in the biosphere is introduced in the environment from natural and human sources. It is circulated via chemical as well as physical processes and transported across living organism via biological mechanisms (Sevin, 1980; WHO, 1991). Though useful for normal growth of many microorganisms, plants and several species of vertebrates WHO classify this metal as carcinogenic for humans. Hence, nickel which persist in the environment and has affinity for bioaccumulation is considered as toxic metal (Bubb and Lester, 1996). The data on toxic influence of Nickel on birds is more limited than mammals. Outridge and Scheuhammer (1993) report higher accumulation of nickel in mammals and birds form Ni polluted environment with occasionally kidney showing higher levels than liver. According to these authors higher doses of nickel 300 to 800 µg/g in diet of chicks produces variable effects including death whereas still higher dose in adult show no evidences of systemic or reproductive toxicity. Hence, tissue concentrations of nickel are not reliable indicator of potential toxicity. DeForest *et al.*, (2012) states that the nickel toxicity is likely to occur in animals ingesting food that includes soil that are specifically higher in earthworms. However, concentrations higher than 10 µg/g dw of kidney and 3 µg/g in liver are considered to lead to no toxicity. Aquatic food chains with macrophytes and aquatic organisms like piscivores, or terrestrial food chain like soil earthworm and worm eating mammals, are at risk of secondary poisoning (Technical Guidance Document, 2003). On the basis of very limited data available for correlation of bioavailability of the diet born fraction of nickel in birds, the concentration of nickel in various tissues of Black Kites may be considered as below the toxic levels. Further, Kites do not fall in any of the food chains which are believed to lead to bioaccumulation of this metal leading to its toxic effects. Birds all over the world usually show low accumulation of nickel (Kozulin and Pavluschick, 1993; Hui, 1998; Hui *et al.,* 1998). However, accumulation of nickel is positively correlated with body weight only in kidney while in other three tissue it is negatively correlated. As, Nickel concentration is higher in feathers and muscle with 45- 56% CV against 10 to 20% CV of other tissues it indicates irregular ingestion of this metal in food of *M. m. govinda*.

Lead toxicity in birds is frequently associated with ingestion of lead shots, mistakenly consumed as food particles or grit or from dead prey which has been shot by lead pellets. These shots remaining in muscular gizzard can lead to Lead toxicity (Sanderson and Bellarose, 1986; Pain, 1992; 1996, Scheuhammer and Norris, 1996). Hunting of 1.4 to 2.6 million water birds annually has been estimated by U.S. Fish and Wildlife Services (1986). The status of “Critically Endangered” Callifornia Condor *Gymnogyps califernianus* has been associated with Lead poisoning from such ingested bullets (Wiemeyer *et al.,* 1988; Birdlife international, 2007). This has also been reported to be major obstacle to the reintroduction programs for this species (Meretsky *et al*., 2000). Several other species are also moved to critical and near threatened categories due to lead poisoning. However, as Kites mainly feed on poultry leftover (Rathod and Padate, 2004; Chapter III), there is rare possibility of heavy metal load of lead to this species. Nevertheless, here liver showed maximum concentration followed by feathers, kidney and Muscles. It showed positive increase in liver and muscles as body weight increased. While among other two tissues accumulation of lead is higher in feathers with >50% CV. Clark and Scheuhammer (2003) considered <6 µg/g dw lead in Liver and Kidney of birds as back ground concentration while >6 µg/gm associated with exposure to lead and >20 µg/gm liver and >30 µg/gm as toxic. Hence, the concentration in present study indicates much lower exposure of Black Kites of lead in city of Ahmedabad. The muscles in general are considered to have weak accumulation potential (Erabgrual and Erbilir, 2007; Bervoers and Blast, 2003).

Having multiple valance chromium has dual character. Chromium III plays key role in the metabolism of animals (e.g. formation of glucose tolerance factor), while its hexavalent form Cr VI is related to occupational health hazard (Jeejeebhoy *et al*., 1977; Gad, 1989). Hence, Chromium is known to be essential for human as well as animals (Schwartz and Mertz, 1995). Though homeostatic mechanism regulates chromium uptake as per nutritional requirements of body an increase in chromium concentration is observed when mechanisms are saturated or are less effective in controlling uptake. In such cases Chromium intoxication may be observed. Since the first reports of Cancer in early 1990s, there have been several studies on chromium levels in environment and biota including birds (Mansouri, *et al.*, 2012; Toghyani, 2012; Binkowski, *et al.*, 2013). However, no biomagnifications of chromium has been reported in food chain probably due to ready ability of Cr VI to get converted to Cr III. This ability is likely to protect the higher organisms from the effects of low level of exposure (Eisler, 1986). In present study, among the tissues studied though highest Chromium levels are in liver and lowest in muscles, the overall concentration is low. As said earlier in urban areas of Gujarat, Black Kites get plenty of Poultry left over (Skin with feather, Rathod and Padate, 2004; Chapter:III) where exposure to chromium is expected to be nil. Hence, it can be said that whatever Chromium occurs in tissues of Black Kites has other sources and have not crossed the critical levels to consider as harmful to kites. However, as body weight increases, consumption of food also increases and the accumulation of metal is significant as is evinced by increase in Chromium concentration with increase in body weight in muscles and feathers. Metal level in feather may change and increase with age due to exogenous contamination.

Zinc an essential trace element is having varied functions in body (Welsh *et al.*, 1994). However it is also believed to be harmful to organisms at higher concentrations (Sandstead and Au, 2007). In human Zn accumulation is considered as less toxic. The interaction of Zinc and Copper is considered to be mutually antagonist and hence probably in livestock Zinc supply is raised as a protective measure to reduce Copper toxicity. It also plays important role against Cadmium toxicity (Jacob *et al.*, 1987). Animal flesh is the best source of readily bio available Zinc (Soriano-Santos and Guerrero-Legarreta, 2010) with red meat being richest. Among birds the aviary species are likely to exhibit Zn poisoning due to galvanized irons (Cage wire, cage clips and bird toys). However, toxicity associated to Zn coated food containers has been reported in humans but not in birds (Brown *et al.*, 1964). Toxic level of Zn in liver of different aviary species of psittacine species is reported to range from 95 to 759 µg/g dw (Puschner *et al.*, 1999). Though, higher levels of Zn are recorded compared to other heavy as well as essential elements in the tissue of Black Kites, in present study these levels are nowhere near toxic concentrations. Among essential elements Zinc concentration in tissue studied except liver, increased positively with body weight. While in other three tissues muscles and feathers this increase was with 45-55% CV against 5 to 20 % CV of Liver and Kidney of *M. m. govinda*. Black Kite *Milvus migrans govinda* is neither aviary bird nor it feeds on red meet (it gets plenty of poultry left overs *i.e.* white meat in urban area). Hence, it can be said that the possibility of any zinc toxicity in Black Kite is remote in present environmental conditions.

Copper, the naturally occurring metal in variety of foods like nuts, meat and grains, is one of the important micro nutrient essential to human health. However, being ubiquitous in the environment, it is highly toxic to many freshwater aquatic species including algae and fishes. Terrestrial fauna is exposed to acute and chronic copper toxicity risk due to agricultural pesticides. Because of its role as essential trace element there is uncertainty in establishing its risk to birds and mammals. Many of these have the ability to handle excess copper by storing it in liver and bone marrow. Hence copper deficiency as well as toxicity risk are rare. In accordance to the studies of Szymczyk and Zalewski (2003) and Binkowski *et al* (2013) the copper concentrations in tissues of Black Kites in present study are found to be lower with low concentrations in muscles compared to liver as reported by former ornithologist. As body weight increased concentration of Copper also increased in muscles, followed by feathers and liver. The concentration of Copper in tissues especially liver is regulated below 50 µg/g dw by homeostatic control (Pyle *et al.,* 2005).

Cobalt, a compound of Vitamin B_{12}, in a minute quantity is an accessory element for life mainly in production of erythrocytes and prevention of anaemia. At higher levels of exposure it has been shown to produce mutagenic and carcinogenic effects which may be similar to nickel. Its concentration in body is highly regulated with over 80 % accumulated in the skeletal system. Mean range of Cobalt in different species of sea birds has been shown to be between 0.048 to 0.11 µg/g dw with lowest coefficient of variance (Szefer *et al.,* 1993; Kim *et al.,* 1998). Further, accumulation of cobalt in eggs of tern has shown no change in levels for eleven years (Burger and Gochfeld, 1988). However, in the present study cobalt levels in tissues are found to be much higher from 0.05 in feathers to 2.0 µg/g dw in liver and muscles. However, compared to three tissues accumulation of cobalt is elevated in feathers with >80% CV against 15 to 30% CV of other tissues of *M. m. govinda*. This needs further investigation with reference to its role in terrestrial raptors in one of the highly polluted urban area of India.

Gender Difference:

In present study the accumulation of heavy metals showed no gender difference as is demonstrated in the Red- Billed Gulls (*Larus novaehollandiae scopulinus*) (Furness *et al.*, 1999), Great tit (*Parus major*) and Blue tit (*Parus caeruleus*) (Dauwe *et al*., 2002). However, in present study only Mercury and Chromium concentrations showed significant increase in either of sexes in relation to body weight while, rest of elements showed nonsignificant increase or decrease. Burger and Gochfeld (1997) found significant differences in levels of several metals between male and female ducks, although mercury levels were the same in both the sexes. Hutton (1981) found differences in levels of Zinc and Cadmium between male and female Oystercatchers *Haematopus ostralegus* while Heinz (1976) has reported higher Mercury levels in the livers of males than in those of females in Mallards, after the egg-laying period.

Few studies have examined the effects of gender on the accumulation of heavy metals in feathers and other tissues (Burger, 1995; Gochfeld *et al.*, 1996). In feathers of Bonaparte's Gulls, Braune and Gaskin (1987) found significantly lower levels of Mercury in primary feathers of female when compared with primaries of male birds while in present study no gender difference is found in accumulation of essential and toxic metals in feathers of *Milvus migrans govinda*.

Biological monitoring provides direct qualitative and quantitative assessment of exposure of a group of persons or individual to noxious agents present in the environment (Mehra, 2010). Advantages of using biomonitors are recently acknowledged. To identify pollution in a larger area Bio-indicators that reflect a coarser spatial scale should be used. Birds use different sources of food and water in a relatively large area and thus the levels of trace elements in bird's organs and feathers are expected to reveal the levels of toxic elements in their entire home range. In the present study it is revealed that urbanization in Central Gujarat has very little impact on accumulation of heavy metals in various tissues of Black Kites and hence the lower concentrations of these metals in tissue of Black Kite (*M. m. govinda*) which mainly feeds on poultry leftovers which are expected not to be exposed to heavy metals as poultry is one of the major food item in the diet of urbanized human population. The Black Kite has exploited this food very well and hence is thriving in urban areas due to plenty of food supply, thermals to soar at high levels in the sky with little exposure to polluted diet and air at lower levels.

SUMMARY

Urbanization produces large scale extensions of once continuous natural habitats, causing its intense fragmentation. The increased urbanization usually leads to an increase in the avian biomass with reduction in species richness. This successive increase is reflected as increase in the population of certain species as urban settings are free from persecution and provide adequate food supplies As urban settlements encroach natural habitats, 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.

Black Kite (*Milvus migans govinda)* is a resident urban raptor of Indian sub continent that occurs in huge numbers in Metro cities. As there is lack of information about its ecology in urban area, an attempt is made to document habits of this umbrella species in an urban landscape. The first part of study includes Ecology while second part of study includes essential and toxic elements from different tissue of *Milvus migrans govinda*.

POPULATION AND ROOSTING ECOLOGY:

In Vadodara maximum population of Black Kites was noted during Monsoon (July-September) indicating arrival of migratory kites 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. The number reaches to peak by month of August and/or September before retreating monsoon sets in the area. The fluctuating populations of Black Kites showed positive relationship with environmental variables like temperature in all seasons but with humidity only in monsoon. During study period rainfall was highly significantly correlated with population of kites due to arrival of migratory population from southern regions of India which immigrate to these comparatively drier parts of semiarid zone where Vadodara is located. The understanding of fluctuating population behaviour with environmental variables might be useful pertaining to the management and conservation of such species in an urban landscape. When roosting time is considered highly significant positive correlation is noted with humidity. While, 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 at 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. It was observed that humidity was positively expressed with arrival time at which 50% of the Black Kites arrived. Most of the Black Kites arrived earlier at roost sites when relative humidity was higher.

In Vadodara, Black Kites roosting prefer on aggregations on tall trees with dense canopy cover. 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.

NESTING ECOLOGY:

The nest site selection is important determinant of the population dynamics of birds. In the present study it is noted that the Black Kites mainly prefers Neem trees for nesting. The reason may be the availability of these trees with suitable height and canopy preferred by these raptors. Neem- *Azadiracta indiaca* is one of the most common tree in the area. Among other trees Maha Neem- *Alianthus exelsa* with almost similar canopy covers and height were preferred. These species of tree also provides number of crotches to hold the nest at the proper locations. The dense cover of the canopy provides sustained protection by minimizing the direct heat loss to the open sky and reduces the thermal stress to vulnerable young and also provides hide from the predators. Moreover, a well covered nest does not require wing shading provided by parents to their chicks, which considerably reduces energy loss by the parents. In addition, higher nest elevation provide easy access to leave and land directly on the nest.

Beside the characteristics of the tree and nest vicinity, consideration of the foraging sites is also equally important. The majority of nests were found nearer to either garbage dumps where plenty of food is available or near poultry or mutton shops where skin is thrown away. Hence, availability of food is important factor affecting nest site selection. Food and water are the basic requirement for any individuals. In Black kites, their nests are nearer to waterbodies too.

FEEDING ECOLOGY:

In the terrestrial ecosystems predators -the raptor among the birds, play the apex role. Occupying a position at highest tropic level they play important role by regulating prey species. Black Kite is a diurnal bird of prey mainly feeding on the insect and small sized amphibians as well as other smaller vertebrates. As food is main component for survival of a species, food preference studies are also conducted for Black Kites. Regurgitated pellets from all the study sites mainly contained feather of poultry birds. This shows that the poultry leftover were the most preferred food. The data is supported by the facts that out of three, two study sites are in close vicinity to poultry farms and/or dump yard where poultry leftovers are easily available. In addition parts of insect exoskeleton and amphibian bones are also found in the pellets but at very low levels. Heavy dependence of the Black Kites on the poultry leftovers shows its easy availability and widespread presence in the urban area. The proportion of insects diet is higher during monsoon, especially in the pellets collected from Sayajibaug which has rich undisturbed natural habitat supporting variety of insects while other two areas have comparatively more concrete structures and low insect diversity. Hence, it may be said that Black Kite has adapted to urban, environment and the easy food supply that has help the population thrive in the region.

ESSENTIAL AND TOXIC ELEMENTS:

Birds use different sources of food and water in a relatively large area and thus the level of trace elements in bird's organs and feathers may reveal the levels of toxic elements in their entire home range. Tissues of raptors are known to be potentially appropriate biomonitors for environmental heavy metal contamination. Hence, the other aspect of current study was preliminary assessment of toxic (Cd, Hg, Ni, Pb and Cr) and essential (Zn, Cu and Co) elements in the various tissues like liver, kidney, muscles and feathers of *Milvus migrans govinda*. Black Kites generally exhibited low to moderate concentrations of these elements in tissues. Based on these results, metal pollution does not appear to be an immediate risk to these birds. Black Kites may be particularly well-adapted to survive in urban areas as they mainly feed on poultry leftover where possibility of heavy metal contamination is expected to be rare. In the present study it is revealed that urbanization has very little impact on accumulation of heavy metals in Black Kite as it mainly feeds on poultry leftover and prefers soaring high in the sky during evening hours as its energy requirement are fulfilled and hence the median concentrations of these metals were lower in tissue of Black kite (*M. m. govinda*) in Central Gujarat.

GENERAL CONSIDERATION

The urban landscapes asses a broad spectrum of variable environments ranging from patches of land to highly modified streetscapes that house a large proportion (~ 50%) of the world's human population. This proportion is increasing rapidly, particularly in the developing world (World Resources Institute, 1996) and by 2030 no space is expected to be available in cities. Such processes of urbanization promote extensive changes in the landscape, especially when urban sprawl produces large scale extensions of once continuous natural habitats, causing its intense fragmentation. Large proportions of birds are known to adjust to such changes. Even though patterns of avian responses to urbanization are emerging, most of the studies have been carried out in the temperate regions.

In the present study, we have made an attempt to understand the ecology of a raptor- Black Kite *(Milvus migrans govinda),* a species well adapted to urban ecosystem in the metropolitan cities of India *i.e.* including Vadodara, Gujarat, along with assessment of environmental toxicant in various tissues of this species.

Vadodara is located at 22.30°N 73.19°E in western India at an elevation of 39 metres. The city sits on the banks of the River Vishwamitri, in central Gujarat. Divided into two aspects: behavioural and laboratory study, Behavioural part includes Population fluctuations, Roosting, Nesting and Feeding ecology while, laboratory study includes quantification of trace elements from various tissue of Black kite.

Three roosting sites observed during study period namely Sayajibaug, Railway Station and Bhutdizapa all together support hundreds of Black kites with seasonal fluctuations in number above the noise of daily variability. Number increases during Monsoon due to arrival of migratory populations from southern parts of India.

Birds settle down at roosts sites during evening. Among the different environmental parameters like humidity, temperature and sunset time, the last one is most important to bring individuals back to the roost with temperature and humidity playing little effect. The roost sites selected are aggregations of trees either monospeciefic or multispcific. However, in the later only two species are used for roosting. For understanding the characteristics of roosts, tree species, its canopy cover, DBH, number of birds per tree, shape index *etc*. are counted at each roost sites. From this it can be said that Black kites select taller trees for roosting with greater canopy cover which will provide protection against wind, sunlight as well as predators.

Roosting time of Black kite is positively correlated with sunset time and temperature. Birds settled down at roosting place before sunset time around 8- 15 minutes earlier than sunset. Temperature and humidity provide cles for arriving at roost earlier mainly during monsoon and winter.

Black kite (*Milvus migans govinda)* is one such resident urban raptor of Indian sub continent that occurs in huge numbers in Metro cities. During study hundreds of Black Kites migrated at each site arriving mostly between end of April and beginning of May, when a significant percentage of immature birds are observed. On the onset of pre monsoon the population size further increases with the arrival of migratory populations and temporary roosts are also formed. Population density is the major ecological characteristics pertaining to the ecosystem level energy use by the species.

During study period, when the migratory species mix with the resident species they show local movements from one roost to another roost. After some time some birds from that roost again come to the original roost. In Ahmedabad city these Black kites are observed roosting on the ground near dumping sites. Occasionally during full moon *M. m. govinda* shows some typical flying behaviour.

Reproduction is necessary process to produce a new generation of living individuals similar to themselves. In Birds, especially Raptors both male and female take part in nesting. For nest site selection tree height, canopy cover, and distance from feeding ground and water sources are important. Almost all observed nests of the Black Kites were found to be located on the third sub branch of the trees. Black kite is a solitary breeder. Therefore, only one nest was found on a tree but occasionally two nests are found in Ahmedabad city. Kites do not use roosting trees for nesting. In study period majority of nests were observed on Neem tree. In city of Ahmedabad where tree density is low Kites build their nest on electrical poles and sometimes at the top of building too. Once a crow was also observed disturbing parents while feeding their young.

Feeding plays a critical role in biological adaptation. Food and water both are essential for parents as well as young once. On the basis of study on regurgitated pallets of Black Kites it is observed that in the urban areas poultry leftover is the main component of food with very less insects and small vertebrates. Consumption of later two items increases in monsoon when they emerge from their dormancy of summer after first rains. Kites may be seen foraging in the afternoon at dumping sites or in monsoon early in the morning on open grounds to catch emerging insects.

Environmental stressors like metal contamination, pesticides and pollutants are found in air and water in urban areas. Vehicular traffic, industrial exhaust and other pollutants are basic sources of toxic contamination including heavy metals and essential elements which disturb balanced in environmental biota. These pollutants also affect plants as well as animals. Among animals birds are considered as bio indicators as changes in environment directly affect them. Raptors placed at the top of food chain are the umbrella species. Bioaccumulation of stressors in top predators can produce several adverse effects. As far as Black Kites in urban areas are concerned, as they mainly feed on poultry leftovers, biomagnifications of stressors in their body is not observed. However, on the bases of lessons learnt from *Gyps* species, it is necessary to monitor Black Kites which are thriving in urban areas and feeding on the leftover food produced by men for himself.

The present study provides baseline data for a species of raptor whose population is thriving in urban areas. Among raptors Vultures are considered highly sensitive towards the environmental change. Vultures are classified under Critically Endangered species in the world. By learning from vultures before anything happens to Black Kites care should be taken and planning its conservation and management are suggested.

REFERENCES

Agostini, N. (2002). La migrazione dei rapaci in Italia. Brichetti, P. and Gariboldi, A. [Eds]. *Manuale di Ornitologia.* Edagricole, Bologna, pp 157-182.

Agostini, N. and Duchi, A. (1994). Water-crossing behavior of Black Kites (*Milvus migrans*) during migration. *Bird Behavior,* **10 (1.4)**:45-48.

Agostini, N. and Panuccio, M. (2010). Western Marsh Harrier (*Circus aeruginosus*) migration through the Mediterranean Sea: a review. *Journal of Raptor Research,* **44(2)**: 136-142.

Agostini, N., Lucia, G., Mellone, U., Ashton booth, J., Wilson, S., Chiatante, G.and Todisco, S. (2007). Le Serre Catanzaresi: Important Bird Area (IBA) per la migrazione autunnale dei rapaci. Page 68 in Proceedings of the XIV Italian Ornithological Congress.

Alberti, M.A., Marzluff, J.M., Shulenberger, E., Bradley, G., Ryan, C. and Zumbrunnen, C. (2003). Integrating humans into ecology: opportunities and challenges for urban ecology. *BioScience,* **53**: 1169-1179.

Ali, S. (1979). *The book of Indian Birds*.11th Edition. Bombay Natural Society, Bombay.

Altken, E. H. (1947). *The common birds of India.* Thacker and Co. Ltd, Bombay.

Altmeyer, M., Dittman, J., Dmowski, K., Wagner, G. and Muller, P. (1991). Distribution of elements in flight feathers of a white tailed eagle. *Science of Total Environment*, **105**: 157-164.

Anderson, D. L. (2001). Landscape heterogeneity and diurnal raptor diversity in honduras: the role of indigenous shifting cultivation. *Biotropica*, **33**: 511–519.

Andersson, M. and Erlinge, S. (1977). Influence of predation on rodent populations. *Oikos*, **29**: 591-597.

Bakaloudis, D. E. (2009). Implications for conservation of foraging sites selected by Short-toed Eagles (*Circaetus gallicus*) in Greece. *Ornis Fennica*, **86**: 89-96.

Bakaloudis, D. E. (2010). Hunting strategies and foraging performance of the Shorttoed Eagle in the Dadia-Lefkimi-Soufli National Park, north-east Greece. *Journal of Zoology*, **281**: 168-174.

Beale, C. M., and Monaghan, P. (2004). Behavioral responses to human disturbance: a matter of choice? *Animal Behaviour*, **68**:1065–1069.

Begon, M., Harper, J. L. and Townsend, C. R. (1996). *Ecology - Individuals, Populations and Communities*. 3rd Edition. Blackwell, Oxford, UK.

Begum, A. and Sehrin, S. (2013). Levels of Heavy Metals in Different Tissues of Pigeon (*Columba livia*) of Bangladesh for Safety Assessment for Human Consumption. *Bangladesh Pharmaceutical Journal*, **16(1):** 81-87.

Benson, W., Brooker, R. K., Dowsett, J. and Irwin M. P. (1971). *The birds of Zambia*. London, Collins Publishing Co. **65:** 148-164.

Bervoets, L. and Blust, R., (2003). Metal concentrations in water, sediment and gudgeon (*Gobio gobio*) from a pollution gradient: relationship with fish condition factor. *Environmental Pollution*, **126**: 9-19.

Bijlsma, R.G. (1997). Black Kite. W.J.M Hagemeijer and M.J. Blair [Eds], The EBCC atlas of European breeding birds, their distribution and abundance. T. and A.D. Poyser London, U.K. pp 132-133.

Binkowski, Ł.J., Stawarz, R. M. and Zakrzewski, M. (2013). Concentration of cadmium, copper and zinc in tissue of mallard and coot from southern Poland. *Journal of environmental science and Health, Part:B.* **48**: 410-415.

Bird Life International (2009) "*Milvus migrans*", IUCN Red List of Threatened Species. Version 2009.2. International Union for Conservation of Naure. Retreived 2010-02-15.

Bird, D. M., Varland, D. E. and Negro, J. J. (1996). *Raptors in Human Landscapes: Adaptations to Built and Cultivated Environments*. Academic press, London.

Bird Life International. (2007). Bird Life's online world bird database. BirdLife International, Cambridge, United Kingdom. Available from http://www.birdlife.org/datazone/index.html.

Birrer, S. (2010). Synthesis of 312 studies on the diet of the Long Eared Owl *Asio otus*. *Ardea,* **97**: 615- 624.

Blair, R. B. (1996). Land use and avian species diver-sity along an urban gradient. *Ecological Applications*, **6**:506-519.

Blake, J. G and Loiselle, B. A. (1991). Variation in resource abundance affects capture rates of birds in three lowland habitats in Costa Rica. *Auk*, **108**: 114-130.

Blust, R., Van der Linden, A., Verheyen, E. and Decleir, W. (1988). Evaluation of microwave heating digestion and graphite furnace atomic absorption spectrometry with continuum source background correction for the determination of Fe, Cu and Cd in brine shrimp. *Journal of Analytical Atomic Spectrometry*, **3**: 387-393.

Boag, P. T and Grant, P. R. (1984). Darwin’s finches (Geospiza) on Isla Daphne Major, Galapagos: Breeding and feeding ecology in a climatically variable environment. *Ecological Monograph*, **54**: 463- 489.

Bolger, D. T., Alberts, A. C., Sauvajot, R. M., Potenza, P., McCalvin, C., Tran, D., Mazzoni, S., Soulé, M. E. (1997). Response of rodents to habitat fragmentation in coastal southern California. *Ecological Applications*, **7**: 552–563.

Bontzorlos, V. A., Peris, S. J., Vlachos, C. G. and Bakaloudis, D. E. (2005). The diet of Barn Owl in agricultural landscapes of Central Greece. *Folia Zoologica*, **54**: 99-110.

Boulinier, T. (1996). On breeding performance, colony growth and habitat selection in Buff Necked Ibis. *Condor*, **98:** 440-441.

Bourquin, J. D. (1983). MortaliteÂ des rapaces le long de l'autoroute GeneÁve-Lausanne. *Nos Oiseaux*, **393**: 149-169.

Bowman, R. and Woolfenden, G. E. (2001). *Nest success and timing of nest failure of Florida ScrubJays in suburban and wildland habitats*. Kluwer Academic Publishers, Boston, MA. pp 383- 402.

Bradley, M., Johnstone, R., Court, G. and Duncan, T. (1997). Influence of weather on breeding success of Peregrine Falcons in the Arctic. *Auk*, **114**: 786–791

Braune, B. M., and David E. G. (1987): A mercury budget for the Bonaparte's gull during autumn moult. *Ornis Scandinavica,* **18:** 244-250.

Brown, L. R., Gardner, G. and Halweil, B. (1998). *Beyond Malthus: 16 dimensions of the population problem*. World watch Paper 143. Worldwatch Institute, Washington, DC.

Brown, M. A. (1964). Food poisoning involving zinc contamination. *Archives of Environmental Health.* **8(5):** 657-660.

Brown, T., Dawson, C. and Miller, R. (1979). Interest and attitudes of metropolitan New York residents about wildlife. *North American Wildlife Nature Resource Conference*. **44**: 289-297.

Bubb, J. M and Lester, J. N. (1991). The impact of heavy metal on lowland river and the implication for man and the environment. *The science of the total environment*, **100**: 207-233.

Burger, J. (1978a). The pattern and mechanism of nesting in mixed species heronries. New York. pp 45-48.

Burger, J. (1978b). Competition between Cattle Egret and native North American herons, egrets and ibises. *Condor*, **80:** 15-23.

Burger, J. (1993). Metals in avian feathers: bioindicatiors of environmental pollution. *Review of Environmental Contamination and Toxicology*, **5**: 203-311.

Burger, J. (1995). A risk assessment for lead in birds. *Journal of Toxicology Environmental Health*, **45**:369- 396.

Burger, J. and Gochfeld, M. (1988). Nest-site selection and temporal patterns in habitat use of Roseate and Common terns. *Auk*, **105**: 433-438.

Burger, J. and Gochfled, M. (1997). Age differences in metals in the blood of Herring gull (*Larus pipixcan*). *Archieves of Environmental Contamination and Toxicology*, **18**: 673- 678.

Burger, J. and Hahn, C. (1989). Crow predation on Black-crowned Night Heron eggs. *Wilson Bulletin*, **89:** 350-351.

Burger, J., Woolfenden, G. E. and Gochfeld, M. (1999). Metal concentrations in the eggs of endangered Florida scrub jays from central Florida. *Archieves of Environmental Contamination and Toxicology*, **37**: 385-388.

Bustamante, J. (1994). Behaviour of colonial common kestels (Falcon tinunculus) during the post-fledging dependece period in southwestern Spain. *Journal of Raptor Research*, **28(2):** 79-83.

Cahil, T. M., Anderson, D. W., Elbert, R. A., Perley, B. P. and Johnson, D. R. (1998). Elemental profiles in feather samples from a mercury- contaminated lake in central California. *Archieves of Environmental Contamination and Toxicology*, **35**: 75-81.

Cameroon, G. N. (2003). Prey use by a pair of barn owl (*Tyto alba*) in Texas coastal habitat. *Texas Journal of Science*, **55**: 219–224.

Carney, K.M., and Sydeman, W. J. (1999). A review of human disturbance effects on nesting colonial waterbirds. *Waterbirds,* **22**:68–79.

Carrete, M. and Donázar, J. A. (2005). Application of central place foraging theory shows the importance of Mediterranean dehesas for the conservation of the cinereous vulture, *Aegypius monachus*. *Biological Conservation*, **126**: 582–590.

Carrete, M.A., Jose, L., Tella, A., Blanco, B. and Beretellotti, C. (2009). A Effects of habitat degradation on the abundance, richness and diversity of raptors across Neotropical biomes. *Biological Conservation*, **142(10):** 2002-2011.

Catterall, C. P., Green, R. J., Jones, D. N. (1991). *Habitat use by birds across a forest-suburb interface in Brisbane: implications for corridors*. Saunders, D. A. and Hobbs, R. J. [Eds.], Nature Conservation 2: The Role of Corridors. Surrey Beatty and Sons, Chipping Norton, pp 247–258.

Chace, J. F. and Walsh, J. J. (2006). Urban effects on native avifauna: a review. *Landscape Urban Planning*, **74**: 46–69.

Chace, J. F., Walsh, J. J., Cruz, A., Prather, J. W. and Swanson, H. M. (2003). Spatial and temporal activity patterns of the brood parasitic Brown-headed Cowbird at an urban/wildland interface. *Landscape and Urban Planning,* **64**:179-190.

Clark, A. J., and Scheuhammer, A. M. (2003). Lead poisoning in upland-foraging birds of prey in Canada. *Ecotoxicology*, **12**: 23-30.

Clark, R. G., Hobson, K. A., Nichols, J. D. and Bearhop, S. (2004). Avian dispersal and demography: scaling up to the landscape and beyond. *Condor*, **106**:717–719.

Clergeau, F. and Quenot, F. (2007). Roost selection flexibility of European starlings aids invasion of urban landscape. *Landscape and Urban Planning,* **80**: 56 -62.

Clergeau, P., Jokimäki, J. and Savard, J. (2001). Are urban bird communities influenced by the bird diversity of adjacent landscapes? *Journal of Applied Ecology,* **38**: 1122–1134.

Cohen, T., Hee, S. and Ambrose, R. (2001). Trace metals in fish and invertebrates of three California coastal wetlands. *Marine Pollution Bulletin*, **42**: 224-232.

Collias, N.E. and Collias, E.C. (1984). *Nest building and bird behaviour*. Princeton University Press, Princeton, NJ.

Collopy, M. W. (1983). A comparison of direct observations and collections of prey remains in determining the diet of Golden Eagles. *Journal of Wildlife Management*, **47**:360- 368.

Cooper, D. S. (2002). Geographic associations of breeding bird distribution in an urban open space. *Biological Conservation*, **104**: 205– 210.

Corlett, R. (1992b). The changing urban vegetation. Gupta, A.J., Pitts, J. [Eds.], *Physical Adjustments in a Changing Landscape: The Singapore Story*. Singapore University Press, Singapore, pp 190–214.

Coulson, J.C. (1968). Differences in the quality of birds nesting in the centre and on the edge of a colony. *Nature*, **217:** 478-479.

Crooks, K. R., Suarez, A.V., Bolger, D. T. and Soule. M. E. (2001). Extinction and colonization of birds on habitat islands. *Conservation Biology*, **15**: 159-172.

Dauwe, T., Bervoets, L., Janssens, E., Pinxten, R., Blust, R. and Eens, M. (2002). Great and blue tit feathers as biomonitors for heavy metal pollution. *Ecological Indicators*, **1**: 227-234.

Davis, S. K., Brigham, R. M., Shaffer, T. L., and James, P. C. (2006). Mixed-grass prairie passerines exhibit weak and variable responses to patch size. *The Auk*, **123(3):** 807-821.

DeForest, D. K., Schlekat, C. E., Brix, K. V. and Fairbrother, A. (2012). Secondary poisoning risk assessment of terrestrial birds and mammals exposed to Nickel. *Integrated environmental assessment and management*, **8(1)**:107-119.

DeSante, D. F. and Geupel. G. R. (1987). Land bird productivity in central coastal California: The relationship to annual rainfall, and a reproductive failure in 1986. *Condor,* **89**: 636-653.

Dhinsa, S.M., Peter, E.K. and David, A.B. (1989). Nest height of Black-Billed Magpies: Is it determined by human disturbance or habitat type? *Canadian Journal of Zoology,* **67:** 228-232.

Dmowski, K. (1999). Birds as bioindicators of heavy metal pollution: review and examples concerning European species. *Acta Ornithologica,* **34(1):** 1-25.

Donazar, J.A., Ceballos, O., Travaini, A., Rodriguez, A., Funes, M., and Hiraldo, F. (1994). Breeding performance in relation to nest site substratum in a Buff-necked Ibis (*Theristicus caudatus*) population in Patagonia. *Condor, **96*****:** 994- 1002.

Donazar, J.A., Travaini, A., Rodriguez, A., Ceballos, O. and Hiraldo, F. (1996). Nesting association of Raptors and Buff-necked Ibis in the Argentinean Patagonia. *Colonial Waterbirds*, **19**: 11-115.

Dusi, J. L. (1968). The competition between Cattle Egrets and Little Blue Herons. *Alabama Birdlife*, **16:** 4-6.

Dżugan, M., Zielińska, S., Hęclik, J., Pieniążek, M. and Szostek, M. (2012). Evaluation of heavy metal environmental contamination based on their concentrations in tissues of wild Pheasant *(Phasianus colchicus*). *Journal of Microbiology, Biotechnology and Food Sciences*, **2(1)**: 238-245.

Eens, M., Pinxten, R., Verheyen, R. F., Blust, R. and Bervoets, L. (1999). Great and blue tits as indicators of heavy metal contamination in terrestrial ecosystems. *Ecotoxicology and Environmental Safety*, **44**: 81-85.

Eeva, T. and Lehikoinen, E. (2000). Recovery of breeding success in wild birds. *Nature*, **403**: 851-852.

Eiserer, L. A. (1984). Communal roosting in Birds. *Bird Behaviour*. **5**: 61 - 80.

Eisler, R. (1986). *Chromium hazards to fish, wildlife, and invertebrates: a synoptic review*. Patuxent Wildlife Research Center, Laurel, MD (USA).

Elkin, N. (1988). *Weather and bird behaviour*, 2nd Edition. TandA D Poyser, Calton.

Ellison, L. N., and Cleary. L. (1978). Effects of human disturbance on breeding of double crested cormorants. *The Auk*, **95**:510-517

Emlen, J.T., (1974). An urban bird community in Tucson, Arizona: derivation, structure, regulation. *Condor*, **76**: 184–197.

Erdoğrul, Ö. and Erbilir, F. (2007). Heavy metal and trace elements in various fish samples from Sir Dam Lake, Kahramanmaraş, Turkey. *Environmental Monitoring and Assessment*, **130**: 373-379.

Esselink, H., Van der Geld, F. M., Jager, L.P., Posthuma- Trupie, G.A., Zoun, P. and Baars, A. J. (1995). Biomonitoring heavy metals using the Barn Owl (*Tylo alba guttata*): sources of variation specially relating to body condition. *Archieves of Environmental contamination and toxicology*, **28**: 471-486.

Esselink, H., Van der Geld, F. M., Jager, L.P., Posthuma- Trupie, G.A., Zoun, P. and Baars, A.J. (1995). Biomonitoring heavy metals using the Barn Owl (*Tylo alba guttata*): sources of variation specially relating to body condition. *Archieves of Environmental contamination and toxicology*. **28**: 471-486.

Estrella, R. R., Donázar, J.A. and Hiraldo, F. (1998). Raptors as Indicators of Environmental Change in the Scrub Habitat of Baja California Sur, Mexico. *Conservation Biology*, **12(4):** 921–925.

Everding, S. E. and Jones, D. N. (2006). Communal roosting in a suburban population of Torresian crows (*Corvus orru*). *Landscape and Urban Planning*, **74**: 21 -33.

Faulkner, S. (2004). Urbanization impacts on the structure and function of forested wetlands. *Urban Ecosystems*, 7: 89-106.

Fernandez-Juricic, E. (2000). Avifaunal use of wooded streets in an urban landscape. *Conservation Biology,* **14**:513-521.

Fernández-Juricic, E. and Tellería, J. L. (2000). Effects of human disturbance on Blackbird *Turdus merula* spatial and temporal feeding patterns in urban parks of Madrid, Spain. *Bird Study,* **47**: 13–21.

Fetterolf, P. M. (1983). Effects of investigator activity on Ring-billed Gull behavior and reproductive performance. *Wilson Bulletin,* **95**:23-41.

Finlayson, C. (1992). *Birds of the Strait of Gibraltar*. London, Poyser. Forsman.

Fowler, G. S. (1999). Behavioral and hormonal responses of Magellanic penguins (Spheniscus magellanicus) to tourism and nest site visitation. *Biological Conservation*, **90**:143–149.

Fretwell, S. D. (1972). *Populations in a seasonal environment*. Princeton University Press, Princeton, NJ.

Furness, R. W. (1996) Cadmium in birds. Beyer, W. N., Heinz, G. H., Redmon-Norwood, A. W. [Eds.] *Environmental contaminants in wildlife*. CRC Press, Boca Raton. pp 389–404.

Furness, R.W. (1993). *Birds as monitors of pollutants.* Furness, R. W., Greenwood, J. J. D. [Eds.] Chapman and Hall, New York, pp 86–143.

Furness, R.W., Lewis, S.A. and Mills, J. A. (1990). Mercury Levels in the Plumage of Red Gulls *Larus novaehollandiae scopulinus* of known Sex and Age. *Environmental Pollution,* **63**: 33-39.

Gad, S. C. (1989). Acute and chronic systemic chromium toxicity. *Science of the Total Environment,* **86 (1)**: 149-157.

Galushin, V. M. (1971). A huge urban population of birds of prey in Delhi, India. *Ibis*, 113: 552.

Gamauf., A., Tebb, G. and Nemeth, E. (2013). Honey Buzzard *Pernis apivorus* nest-site selection in relation to habitat and the distribution of Goshawks *Accipiter gentilis*. *Ibis*, **155**: 258–270.

Garcia- Fernandez, A.J, Motas-Guzman, M., Navas, I., Maria-Mojica, P., Luna, A. and Sanchez-Garcia, J.A. (1997). Environmental exposure and distribution of lead in four species of raptors in southern eastern Spain. *Achieves of Environmental Contamination and Toxicology,* **33**: 76-82.

Gardner, J. E.,Garner, J. D. and Hofmann, J. E. (1991). Summer roost selection and roosting behavior of Myotis sodalis (Indiana bat) in Illinois. Illinois Natural History Survey/Illinois Department of Conservation, Champaign, USA.

Getz, L. (1961). Hunting areas of the long-eared owl. *The Wilson Bulletin*, **1**:79-82.

Giese, M. (1996). Effects of human activity on Adélie penguins Pygoscelis adeliae breeding success. *Biological Conservation,* **75**:157–164.

Gill, J. A., Norris, K. and Sutherland, W. J. (2001). The effects of disturbance on habitat use by black-tailed godwits, Limosa limosa. *Journal of Applied Ecology,* **38**:846– 856.

Gillett, W. H., Hayward, J. L. and Stout, J. F. (1975). Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony. *Condor*, **77**: 492-495

Gochfeld, M., Belant, J., Shulka, T., Benson, T. and Burger, J. (1996). Heavy metals in laughing gulls: gender, age and tissue differences. *Enviornmental Toxicology and Chemistry*, **15**: 2275-2283.

Götmark, F. (1992). Blue eggs do not reduce nest predation in the song thrush, Turdus philomelos. *Behavioral Ecology and Sociobiology*, **30**:245–252

Green, R.E., Newton, I., Shultz, S., Cunningham, A.A., Gilbert, M., Pain, D.J., Prakash, V. (2004). Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. *Journal of Applied Ecology* **41**: 793–800.

Greenberg, R. (1981). Frugivory in some migrant tropical forest wood warblers. *Biotropica,* **13**: 215- 223.

Greenwood, P.J. and Harvey, P.H. (1976). The adaptive significance of variation in breeding Area fidelity in Black Bird (*Turdus merula*). *Journal of Animal Ecoogy*, **45:** 887-898.

Gunn, S. A. and Gould, T. C. (1957). Selective accumulation of Cd115 by cortex of rat kidney. *Experimental Biology and Medicine,* **96(3)**: 820-823.

Hanski, I., Hansson, L. and Henttonen, H. (1991). Specialist predators, generalist predators, and the microtine rodent cycle. *Journal of Animal Ecology*, **60**: 353-367.

Heinz, G. (1976). Methylmecury: second-year feeding effects on mallard reproduction and duckling behavior. *Journal of Wildlife Management*, **40**: 82-90.

Hernandez, M. (1988). Road mortality of the little owl (Athene noctua) in Spain. *Journal of Raptor Research*, **22**: 81-84.

Holmes, R. T., Marra, P. P. and Sherry, T. W. (1996). Demographic responses of breeding Blackthroated Blue Warblers (*Dendroica caerulescens*) to a heterogeneous habitat: implications for population dynamics. *Journal of Animal Ecology*, **65**:183–195.

Holmgren, J. (2004) Roosting in tree foliage by Common Swift *Apus apus*. *Ibis*, **146**: 404 -416.

Hostetler M. (2001). The importance of multi-scale analyses in avian habitat selection studies in urban environments, In J. M. Marzluff, R. Bowman, and R. Donnelly [Eds.], Avian ecology and conservation in an urbanizing world. Kluwer Academic Publishers, Boston, MA. pp 139-154.

Huang, K.Y., Lin, Y.S., Severinghaus, L.L., (2006). Comparison of three common methods for studying the diet of nestling of two Accipiter species. *Zoological Studies*, **(45):** 234 - 243.

Hui, A., Takekawa, J., Baranyuk, V. and Litvin, K. (1998). Trace element concentrations in two subpopulations of lesser snow geese from Wrangel Island, Russia. *Archives of Environmental Contamination and Toxicology*, **34**: 197-203.

Hui, C. (1998). Elemental contaminants in the livers and ingest of four subpopulations of the American coot (*Fulica americana*): an herbivorous winter migrant in San Francisco Bay. *Environmental Pollution,* **101**: 321-329.

Hutton, M. (1981). Accumulation of heavy metals and selenium in three seabird species from the United Kingdom. *Environmental Pollution*, **26** : 129-145.

Illner, H. (1992). Road deaths of Westphalian owls: methodological problems, influence of road type and possible effects on population levels. In: Galbraith, C. A., Taylor, I. R., Percival, S. [Eds.], The Ecology and Conservation of European Owls. Joint Nature Conservation Committee, Peterborough UK, pp 94-100.

Imhoff, M. L., Bounoua, L., Defries, R., Lawrence, W.T., Stutzer, D., Tucker, C.J. and Ricketts, T. (2004). The consequences of urban land transformation on net primary productivity in the United States. *Remote Sensing of Environment*, **89**:434-443.

Immelmam, K. (1971). Ecological aspects of periodic reproduction. Farner, D. S. and King, J. R. [Eds.] *Avian biology*. Vol. 1. Academic Press, New York, pp 342-390.

IUCN. (2002) 2002 IUCN red list threatened species. Available from: http://www.redlist.org.

Iwata, H., Tanabe, S., Sakai, N. and Tatsukawa, R. (1993). Distribution of persistent organochlorines in oceanic air and surface seawater and the role of ocean in their global transport and fate. *Environmental Science and Technology*, **27**: 1080-1098.

Jackson, S. L., Hik, D. S. and Rockwell, R. F. (1988). The influence of nesting habitat on reproductive success of Lesser Snow Geese. *Canadian Journal of Zoology*, **66:** 1699-1703.

Jacob, R. A., Skala, J. H., Omaye, S. T. and Turnlund, J. R. (1987). Effect of varying ascorbic acid intakes on copper absorption and ceruloplasmin levels in young men. *Journal of Nutrition*, **117**:2109-2115.

Janicke, T. and Chakarov, N. (2007). Effect of weather conditions on the communal roosting behaviour of common ravens *Corvus corax* with unlimited food resources. *Journal of Ethology*, **25**: 71-78.

Jayson, E.A. and Mathew, D.N. (1995) Roosting behaviour of common Indian Mayna (*Acridotheres tristis*) at Trichur, Kerala. *Pavo*, **33 (1 and 2)**: 41-46.

Jeejeebhoy, K. N. (1999). Chromium and parenteral nutrition. *The Journal of Trace Elements in Experimental Medicine*, **12(2)**: 85-89.

Jokimäki, J., Clergeau, P., Kaisanlahti-Jokimäki, M. L. (2002). Winter bird communities in urban habitats: a comparative study between central and northern Europe. *Journal of Biogeography*, **29**: 69–79.

Jokimäki, J., Suhonen, J. (1998). Distribution and habitat selection of wintering birds in urban environments. *Landscape Urban Planning*, **39**: 253–263.

Jumber, J. F. (1956) Roosting Behaviour of the Starling in Central Pennsylvania. *The Auk*, **73(3):** 411-426.

Kalisinska, E., Salicki, W., Myslek, P., Kavetska and K., Jackowski, A. (2004). Using the Mallard to biomonitor heavy metal contamination of wetlands in north-western Poland. *Science of the Total Environment*, **320(2)**: 145-161.

Kang, N. and Yei, V.Y.Y. (1956) Roost site selection and waking and roosting behaviour of mynas in relation to light intensity. *Malayan Nature Journal*, **46**:255-263.

Kark, S., Iwaniuk, A., Schalimtzek, A., Banker, E. (2007). Living in the city: can anyone become an "Urban exploiter?". *Journal of Biogeographical research*, **34**: 638-651.

Karr, J. R. (1982). Population variability and extinction in the avifauna of a tropical land bridge island. *Ecology*, **63**: 1975-1978.

Karr, J. R. and Freemark, K. E. (1983). Habitat selection and environmental gradients: Dynamics in the "stable" tropics. *Ecology*, **64**: 1481- 1491.

Karr, J. R., Schemskean, D. W., Brokaw, D. N. (1982). Temporal variation in the undergrowth bird community of a tropical forest.

The ecology of a tropical forest [Eds.] Leigh, E. G., Rand, A. S., and Windsor, D. M. Smithson. Inst. Press, Washington, D.C. pp. 441-453

Kelly, J. P. (1993). The effect of nest predation on habitat selection by dusky flycatchers in limber pine juniper woodland. *Condor*, **95:** 83- 93.

Kim, E. Y., Ichihashi, H., Saeki, K., Atrashkevich, G., Tanabe, S., and Tatsukawa, R. (1996). Metal accumulation in tissues of seabirds from Chaun, Northeast Siberia, Russia. *Environmental Pollution,* **92**: 240–252.

Klopfer, P. (1963). Behavioural aspects of habitat selection: the role of early experience. *Wilson Bulletin*, **75:** 15-22.

Knight, R. L., and Cole, D. N. (1991). Effects of recreational activity on wildlife in wildlands. Transactions of the North American Wildlife and Natural Resources Conference **56**:238–247

Korpimaki, E and Norrdahl, K. (1991). Numerical and functional responses of Kestrels, Short eared Owls, and Long-eared Owls to vole densities. *Ecology,* **72**: 814-82.

Korpimaki, E. (1987). Dietary shifts, niche relationships and reproductive output of coexisting Kestrels and Long-eared Owls. *Oecologia*, **74**: 277-28.

Korpimaki, E. and Norrdahl, K. (1989). Avian predation on mustelids in Europe 2: Impact on small mustelid and microtine dynamics - a hypothesis. *Oikos,* **55**: 273-276.

Kostrzewa, A. and Kostrzewa, R. (1990). The relationship of spring and summer weather with density and breeding performance of the buzzard *Buteo buteo*, goshawk *Accipiter gentilis* and kestrel *Falco tinnunculus*. *Ibis*, **132**: 550-559.

Kotler, B. P. (1985). Owl predation on desert rodents which differ in morphology and behavior. *Journal of Mammalogy*, **66(4)**: 824-828.

Kozulin, A. and Pavluschick, T. (1993). Content of heavy metals in tissues of mallards Anas platyrhynchos wintering in polluted and unpolluted habitats. *Acta Ornithologica*, **28**: 55-61.

Kraaijeveld, K. (2008). Non-breeding habitat preference affects ecological speciation in migratory waders. *Naturwissenschaften,* **95**: 347-354.

Kruess A, and Tscharntke, T. (1994). Habitat fragmentation, species loss, and biological control. *Science,* **264**: 1581-1584.

Krûger, O. (2002). Analysis of nest occupancy and nest reproduction in two sympatric raptors: common buzzard *Buteo buteo* and Goshawk *Accipiter gentilis*. *Ecography,* **25**: 523–532.

Kurta, A., Williams, K. J. and Mies. R. (1996). Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis)*. [Eds.] Barclay, R. M. R. and R. M. Brigham, *Bats and forests. British Columbia Ministry of Forests*. pp 102-117

Kushlan, J. A. (1976). Site selection for nesting colonies by the American White Ibis *Eudocimus albus* in Florida. *Ibis*, **118:** 590-593.

Lack, D. (1946). Competition for food in birds of prey. *Journal of Animal Ecology*, **15**: 123-129.

Lack, D. (1954). *The natural regulation of animal numbers*. Oxford University Press, Oxford. pp 343.

Lack, D. (1968). *Ecological adaptations for breeding in birds*. Methuen and Co., London. pp 409.

Lambeck, R. J. (1997). Focal species: a multi-species umbrella for nature conservation. *Conservation Biology*, **11**: 849–856.

Lancaster, R. K., Rees, W. E. (1979). Bird communities and the structure of urban habitats. *Canadian Journal of Zoology*, **57**: 2358–2368.

Lande, R., Engen, S. and Saether, B.E. (2003). *Stochastic Population Dynamics in Ecology and Conservation*. Oxford University Press, Oxford.

Levey, D. J. (1988). Spatial and temporal variation in Costa Rican fruit and fruit-eating bird abundance. *Ecological Monograph,* **58**: 251-269.

Li, P. and Martin, T. E. (1991). Nest site selection and nesting success of cavity nesting birds in high elevation forest drainages. *Auk,* **108:** 405-418.

Licata, P., Naccari, F., Lo Turco, V., Rando, R., Di Bella, G. and Dugo, G. (2010). Levels of Cd (II),Mn (II), Pb (II), Cu (II), and Zn (II) in Common Buzzard (*Buteo buteo*) from Sicily (Italy) by Derivative Stripping Potentiometry. *International Journal of Ecology*, **1**: 1-7.

Limiñana, R., Javaloyes, T. and Urios, V. (2012). Diet of the Montagu's Harrier *Circus pygargus* nesting in natural habitat in Eastern Spain. *Ornis Fennica,* **89**:74–80.

Lundberg, P. (1988). The evolution of partial migration in birds. *Trends in Ecology and Evolution*, **3**: 172–175.

Lyon, L.A. and Caccamise, D.F. (1981). Habitat selection by roosting blackbirds and starlings: management implications. *Journal of Wildlife Management,* **45**: 435 - 443.

McGavin, G. C. (2000). *Insects, Spinders and other terriestrial arthropods*. A Dorling Kindersley Limited, 80 Strand, London.

Mader, W. J. (1981). Notes on nesting raptors in the Llanos of Venezuela. *Condor*, **84**: 48-51.

Mader, W. J. (1982). Ecology and breeding habits of the Savanna Hawk in the Llanos of Venezuela. *Condor*, **84**: 261-271.

Maeda, T. (1998). Bird communities and habitat relationships in a residential area of Tokyo. *Journal of Yamashina Institute of Ornithology*, **30**: 83–100.

Mahabal A. and Bastawade, D. B. (1987). Population ecology and communal roosting behavior of lack kite *Milvus migrans govinda* in Pune (Maharastra). Jouranal *of Bombay Natural History Society*. **82**: 337-346.

Mahmood-ul-Hassan, M., Beg, M. A. and Ali, H. (2007). Seasonal variation in the diet of the barn owl *Tyto alba* stertens in central Punjab, Pakistan. *Acta Zoologica Sinica*, **53(3)**: 431–436.

Makarieva, Anastassia M., Victor G. Gorshkov, and Bai-Lian Li. (2005). Why do population density and inverse home range scale differently with body size? Implications for ecosystem stability. *Ecological Complexity*, **2(3)**: 259-271.

Mañosa, S. (1994). Goshawk diet in a Mediterranean area of Northeastern Spain. *Journal of Raptor Research*, **28**: 84-92.

Mansouri, B., Babaei, H., Hoshyari, E., Khodaparast, S. H. and Mirzajani, A. (2012). Assessment of Trace-Metal Concentrations in Western Reef Heron (*Egretta gularis*) and Siberian Gull (*Larus heuglini*) From Southern Iran. *Archieves of Environmental Contamination and Toxicology*, **63**:280–287.

Margules, C. R. and Pressey, R.L. (2000). Systematic conservation planning. *Nature*, **405**: 243–253.

Marti, C. D. (1974). Feeding ecology of four sympatric owls. *Condor*, **76(1)**: 45-61.

Marti, C. D., Bechard, M. and Jacksic, F. M., (2007). *Food habits.* Bird, D.M., Bildstein, K.L. [Eds.], Raptor Research and Management Techniques. Hancock House Publishers, Surrey, BC., pp 129-149.

Marti, C.D. (1987). *Raptor food habit studies* National Wildlife Federation, Washington, D.C.

Martin, T. E. (1988). Habitat and area effects on forest bird assemblages: is nest predation an influence? *Ecology*, **69(1)**:74-84.

Martin, T. E. (1993). Nest predation among vegetation layers and habitat types: revising the dogmas. *American Naturalist*, **141**: 897–913.

Martinez, J. A , Martinez, J. E. Zuberogotitia, I., Garcia, J. T., Caarbonell, R., de Lucas, M. and Diaz, M. (2003). Environmental impact assessment on raptor populations: difficulties in implementation and a search for solution. *Ardeola*, **50:** 85-102.

Marzluff, J. M, Bowman, R., Donnelly, R. (2001). *Avian ecology and conservation in an urbanizing world.* Kluwer Academic Publ. Boston.

Marzluff, J. M. (2001). Worldwide urbanisation and its effects on birds. Marzluff, J. M., Bowman, R., Donnelly, R. [Eds.], Avian Ecology and Conservation in an Urbanizing World. Kluwer Academic Publishers, Boston, pp 19–47.

Marzluff, J. M. and Ewing, K. (2001). Restoration of fragmented landscapes for the conservation of birds: a general framework and specific recommendations for urbanizing landscapes. *Restoration Ecology*, **9**: 280–292.

Marzluff, J. M. and Hamel, N. (2001). Land use issues. Levin, S. A. [Eds.], *Encyclopedia of biodiversity*. Academic Press, San Diego, CA. **3**: 659-673

Matlack, G. R. (1993). Sociological edge effects: spatial distribution of human impact in suburban forest fragments. *Environmental Management*, **17**: 829-835.

May, C. A., Petersburg, M. L. and Gutierrez, R. J. (2004) Mexican spotted owl nest and roost site habitat in northern Arizona. *Journal of Wildlife Management*, **68**: 1054- 1064.

May, R. (1999). Unanswered questions in ecology. Philosophical Transactions: *Biological Sciences*, **354:** 1951–1959.

Mearns, R. and Newton, I. (1988). Factors affecting breeding success of Peregrines in south Scotland. *Journal of Animal Ecology*, **57**: 903-916.

Meffe, G. K. and Carroll, C. R. (1994). Principles of Conservation Biology. Sinauer Associates, Sunderland, Massachusetts.

Mehra, R., Thakur, A. S. and Bhalla, S. (2010). Trace level analysis of chromium, manganese, cobalt and iron in human hair of people residing near heavy traffic area by biomonitoring. *International Journal of Pharma and Bio Science*, **1 (4)**: 57- 61.

Melles , S., Glenn, S. and Martin, K. (2003). Urban bird diversity and landscape complexity: species-environment associations along a multi-scale habitat gradient. *Ecology and Society*, **7(1):** 5-11.

Mellone U., Agostini N., Panuccio M., Gustin M. (2007). Spring raptor migration over the Eolian archipelago. Proceeding -XIV Italian Ornitholical Congress: **67**.

Menge, B. A., Berlow, E. L., Blanchette, C. A.,. Navarrete, S. A. and Yamada. S. B. (1994). The keystone species concept: variation in interac- tion strength in a rocky intertidal habitat. *Ecological Monographs*, **64**:249–286

Meretsky, V. J., Snyder, N. F., Beissinger, S. R., Clendenen, D. A. and Wiley, J. W., (2000). Demography of the California condor: implications for reestablishment. *Conservational Biology*, **14**: 957–967.

Meyer, W. B and Turner, B.L. (1992). Human population growth and global land-use/cover change. *Annual Review of Ecology and Systematics*, **23**:39-61.

Middleton J. (1994). Effects of urbanization on biodiversity in Canada. In: Biodiversity in Canada: A Science Assessment for Environment Canada. Environment Canada, Ottawa, pp. 15-20

Miller, J. R., and Hobbs, R. J. (2002). Conservation where people live and work. *Conservational biology.* **16**: 330–337.

Mills, G. S, Dunning, J. B. and Bates, J.M. (1989). Effects of urbanisation on breeding bird community structure in southwestern desert habitats. *Condor,* **91**: 416–429.

Morneau, F., Décarie, R., Pelletier, R., Lambert, D., DesGranges, J. L., Savard, J.P. (1999). Changes in breeding bird richness and abundance in Montreal parks over a period of 15 years. *Landscape Urban Plann*ing, **44**: 111–121.

Morse, D. H. (1980). *Behavioural mechanisms in ecology*. Harvard University Press, Cambridge, Massachusetts. pp 383.

Mosher, J. A. and White, C. M. (1976). Directional exposure of golden eagle nests. *Candian Field Naturalist*, **90**: 356.359.

Munyenyembe, F., Harris, J. and Hone, J. (1989). Determinants of bird populations in an urban area. *Australian Journal of Ecology*, **14**: 549–557.

Mushtaq-ul-Hassan, M., Raza, M. N., Shahzadi, B. and Ali. A. (2004). The diet of Barn Owl from canal bank, canal rest house and graveyard of Gogra. *Journal of Research (Science)*, **15(3)**: 291–296

Naidu, B. (2008). *Diversity, Ecology and Conservation of Insect: A habitat Approach.* Ph.D. Thesis submitted to The M. S. University of Baroda. Vadodara, India.

Naoroji, R. (2007). *Birds of prey of the India Subcontinent.* Om books international. Delhi.

Natuhara, Y. and Imai, C. (1999). Prediction of species richness of breeding birds by landscape level factors of urban woods in Osaka Prefecture, Japan. *Biodiversity and Conservation*, **8**: 239–253.

Newton, I. (1979). *Population ecology of Raptors*. Poyser, Berkhamsted. pp 399.

Newton, I. (1982). Fidelity to breeding area and mate in Sparrow Hawks (*Accipiter nisus*). *Journal of Animal Ecoogy,* **51:** 327-341.

Newton, I. (1991). Habitat variation and population regulation in Sparrow Hawks. *Ibis,* **133:** 76- 88.

Newton, I. (2004). Population limitation inmigrants. *Ibis*, **146**: 197–226.

Nicholson, J. K. (1981). The comparative distribution of zinc, cadmium and mercury in selected tissues of the herring gull (*Larus argentatus*). *Comparative Biochemistry and Physiology Part C: Comparative Pharmacology,* **68 (1)**: 91-94.

Niemelä, J. (1999a). Ecology and urban planning. *Biodiversity and Conservation*, **8**: 119–131.

Nillson, S. G. (1987). Limitation and regulation of population density in the Nuthatch *Sitta europaea* breeding in natural cavities. *Journal of Animal Ecoogy*, **56:** 921-937.

Nordberg, G.F, Nogawa, K., Nordberg, M. and Friberg, L. (2007). *Cadmium. In: Handbook on The Toxicology of Metals* [Eds.] Nordberg, G. F., Fowler, B. F., Nordberg, M. and Friberg, L. Amsterdam: *Elsevier,* pp 445-448.

Norris, D. R. and Marra, P. P. (2007). Seasonal interactions, habitat quality, and population dynamics in migratory birds. *Condor*, **109**: 535–547.

O'Donoghue, M., Boutin, S., Murray, D. L., Krebs, C. J., Hofer, E. J. and Breitenmoser, U. L. (2001). Coyotes and lynx. C. J. Krebs, S. Boutin & R. Boonstra [Eds.], *Ecosystem dynamics of the boreal forest.* New York: Oxford University Press.

Olga, C. and Jose, A. D. (1989). Factors influencing the breeding density and nest site selection of the Egyptian Vulture *Neophron percnopterus*. *Journal of ornithology,* **130(5):** 353-359.

Olojo, E. A. A., Olurin, K. B., Mbaka, G. and Oluwemimo, A. D. (2005). Histopathology of the gill and liver tissues of the African catfish *Clarias gariepinus* exposed to lead. *African Journal of Biotechnology,* **4**: 117-122.

Olsen, P. D. and Olsen, J. (1989a). Breeding of the Peregrine Falcon *Falco peregrinus*. II. Weather, nest quality and the timing of egg laying. *Emu,* **89**: 1–5.

Ontiveros, D. (1999). Selection of nest cliffs by bonelli's eagle (*hieraaetusfa sdatus*) in southeastern spain. *Raptor Research,* **33 (2)**:110-116.

Orth, P. B. and Kennedy, P. L. (2001). Do land-use patterns influence nest-site selection by Burrowing owls (*Athene cunicularia hypugaea*) in northeastern Colorado? *Canadian Journal of Zool*ogy, **79:** 1038–1045.

Outridge, P. M., and Scheuhammer, A. M. (1993). Bioaccumulation and toxicology of chromium: implications for wildlife. *Reviews of environmental contamination and toxicology*, **130**: 31-77.

Pain, D. J, Carter, I., Sainsbury, A.W., Shore, R.F., Eden, P., Taggert, M. A., Konstantions, S., Walker, L. A., Meharg, A. A. and Raab, A. A. (2007). Lead contamination and associated disease in captive and reintroduced red kite *Milvus milvus* in England. *Science of the Total Environment*, **376**: 116-127.

Pain, D. J. (1992). Lead poisoning in waterfowl: a review. Pain D. J. [Eds.]. *Lead Poisoning in Waterfowl.* Proceedings of an IWRB Workshop, Brussels, Belgium, 13–15 June 1991. International Waterfowl and Wet- lands Research Bureau Special Publication 16, Slimbridge, UK. pp 7–13.

Pain, D. J. (1996). Lead in waterfowl. Beyer, W. M., Heinz, G. H. and Redman-Norwood, A. W. [Eds.] *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. Lewis Publishers, Boca Raton, Florida, USA. pp 251– 262.

Pain, D. J., Carter, I., Sainsbury, A.W., Shore, R.F., Eden, P., Taggert, M. A., Konstantions, S., Walker, L. A., Meharg, A. A. and Raab, A. A. (2007). Lead contamination and associated disease in captive and reintroduced Red Kite *Milvus milvus* in England. *Science of the Total Environment*, **376**: 116-127.

Paine, R. T. (1980). Food webs: road maps of interactions or grist for theoretical development? *Ecology,* **69**: 1648-1654.

Paletto, A. and Tosi V. (2009). Forest canopy cover and canopy closure: comparison of assessment techniques *European Journal of Forest Research*, **128**:265–272.

Palomino, D. and Carrascal, L. M. (2007). Threshold distances to nearby cities and roads influence the bird community of a mosaic landscape. *Biological Conservation*, **140(1)**: 100-109.

Panasci, T. A. and Whitacre, D. F. (2002). Roadside hawk breeding ecology in forest and farming landscapes. *Willson Bulletin*, **114:** 114–121.

Panuccio M., Agostini N. and Massa B. (2004). Spring raptor migration at Ustica, southern Italy. *British Birds,* **97**: 400-403.

Panuccio, M., Agostini, N. and Mellone, U. (2005). Autumn migration strategies of Honey Buzzards, Black Kites, Marsh and Montagu's Harriers over land and over water in the Central Mediterranean. *Avocetta*, **29**: 27-32.

Panuccio, M., Agostini, N., D'Amicis, B., Canale, E., and Roccella, A. (2005). Sex and age ratios of Marsh Harriers Circus aeruginosus wintering in central-southern Italy. *Avocetta,* **29**:13–17

Park, C. R and Lee, W. S. (2000). Relationship between species composition and area in breeding birds of urban woods in Seoul, Korea. *Landscape Urban Planning*, **51**:29–36.

Park, C. R., Lee, W. S. (2000). Relationship between species composition and area in breeding birds of urban woods in Seoul, Korea. *Landscape Urban Plannning*, **51:** 29–36.

Peh K. S. H. (2002) Roosting behaviour of House crow (*Corvus splendens*) in relation to envriornmental variables. *The Raffles Bulletin of Zoology*, **50(1):** 257-262.

Penland, S. (1987). Attitudes of urban residents toward avian species and species' attributes. Adams, L.W. and Leedy, D.L. [Eds.] *Integratineg Man and Nature in the Metropolitan Environment*, Chevy Chase, New York, pp 77-82.

Pickett, S. T., Cadenasso, M. L., Grove, J. M., Nilon, C. H., Pouyat, R. V., Zipperer, W. C. and Rcostanza. A. (2001). Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics*, **32**:127-157.

Pimm, S. L. (1982). *Food Webs*. Chapman and Hall, London.

Pimm, S. L., Gilpin, M. E. (1989). Theoretical issues in conservation biology. In: May, R.M., Levin, S.A., Roughgarden, J. [Eds.], Perspective in Ecological Theory. Princeton University Press, Princeton, New Jersey, pp 287-305.

Polis, G. A. (1991). Complex desert food webs: an empirical critique of food web theory. *American Naturalist*, **138**:123-155.

Porneluzi, P., Bednarz J. C., Goodrich L. J, Zawada N. and Hoover, J. (1993). Reproductive performance of territorial Ovenbirds occupying forest fragments and a contiguous forest in Pennsylvania. *Conservation Biology*, **7**:618–622.

Porter, E. E., Forschner, B. R. and Blair, R. B. (2001). Woody vegetation and canopy fragmentation along a forest-to-urban gradient. *Urban Ecosystem*, **5**: 131–151.

Powell, G. N. and Bjork, R. D. (1994). Implication of altitudinal migration for conservation strategies to protect tropical biodiversity: A case study of the Resplendent Quetzal *Pharomacrus mocinno* at Monteverde, Costa Rica. *Bird conservation international*, **4:** 161-174.

Prakash V., Pain D. J., Cunningham A. A., Donald P. F., Prakah N., Verma A., Gargi, R., Shivakumar S. and Rahmani A. R. (2003).

Catastrophic collapse of Indian White-backed *Gyps bengalensis* and Long-billed *Gyps indicus* vulture population. *Biological Conservation* **109**: 381-390.

Probst, J. R., and Hayes, J. P. (1987). Pairing success of Kirkland's Warblers in marginal vs. suitable habitat. *Auk*, **104**:234–241.

Pulido, F. (2007). The genetics and evolution of avian migration. *BioScience,* **57**: 165–174.

Puschner, B., J., Leger, S. T. and Galey, F. D. (1999). Normal and toxic zinc concentrations in serum/plasma and liver of psittacines with respect to genus differences. *Journal of Veterinary Diagnostic Investigation*, **11 (6)**: 522–527.

Pyle, G. G., Rajotte, J. W. and Couture, P. (2005). Effects of industrial metals on wild fish populations along a metal contamination gradient. *Ecotoxicology and Environment Safety*, **61:** 287-312.

Rajkowska, M. and Protasowicki, M. (2013). Distribution of metals (Fe, Mn, Zn, Cu) in fish tissues in two lakes of different trophy in Northwestern Poland. *Environment Monitoring Assessment*, **185**: 3493–3502.

Rathod, J. and Padate, G. (2004). *Feeding adaptation of Black kite (Milvus migrans govinda) in urban area of Vadodoara*. Paper presented at International conference of Birds and Enviornment Organized by Gurukul Kangri University, Haridwar, India.

Rathod, J. Y. (2009). *Avifauna of Urban areas: its significance and implication under various human disturbances.* Ph.D. Thesis submitted to The M. S. University of Baroda. Vadodara, India.

Real, J. (1996). Biases in diet study methods in the Bonelli's Eagle. *Journal of Wildlife Managemen*, **60:** 632–638.

Redpath, S. M., R. Clarke, M. Madders and S. J. Thirgood. (2001). Assessing raptor diet: comparing pellets, prey remains, and observational data at Hen Harrier nests. *Condor*, **103**: 184-188.

Reebs, S. G. (1986). Influence of temperature and other factors on the daily roosting times of black-billed magpies. *Canadian Journal of Zoology*, **64:** 1614 -1619.

Rendell, W. B. and Robertson, R. J. (1989). Nest site characteristics, reproductive success and cavity availability for tree swallows breeding in natural cavities. *Condor*, **91:** 875-885.

Ricklefs, R. E. (1969). An analysis of nesting mortality in birds. *Smithson Contributions to Zoology*, **9:** 1-48.

Rodríguez-Estrella, R., Donázar, J.A., Hiraldo, F., 1998. Raptors as indicators of environmental change in the scrub habitat of Baja California Sur, Mexico. *Conservation Biology*, **12**: 921–925.

Root, T. (1988). Energy constraints on avian distributions and abundance. *Ecology*, **69**: 330-339.

Rosenberg, K. V. and Cooper, R. J. (1990). Approaches to avian diet analysis. *Avian Biology*, **13**: 80- 90.

Rosenzweig, M. L. (2003). *Win-win ecology*. Oxford University Press, Oxford, UK.

Roshier, D. A., Robertson, A. I., Kingsford, R. T. (2002). Responses of waterbirds to flooding in an arid region of Australia and implications for conservation. *Biological Conservation*, **106**: 399–411

Ruddock, M., Wells, J. H., Smith, J. P. and Montgomery, I. W. (2009). The biases in raptor diet studies; resolving conservation and sporting conflicts. Sielicki, J. and Mizera, T. [Eds.], *Peregrine Falcon Populations Status and Perspectives in the 21st Century*. Turul/Poznan University of Life Sciences Press, Warsaw Pozna. pp 567-580.

Rutz, C. (2003). Assessing the breeding season diet of Goshawks *Accipiter gentilis*: biases of plucking analysis quantified by means of continuous radio-monitoring. *Journal of Zoology*, **259**: 209-217.

Ryder, P. L. and Ryder, J. R. (1981). Reproductive performances of Ring billed Gulls in relation to nest location. *Condor*, **83:** 57-60.

Sánchez-Zapata, J. and José, F. (1999). Raptor distribution in relation to landscape composition in semi-arid Mediterranean habitats. *Journal of Applied Ecology,* **36(2):**254-262

Sánchez-Zapata, J.A., Carrete, M., Gravilov, A., Sklyarenko, S., Ceballos, O., Donázar, J.A., Hiraldo, F. (2003). Land use changes and raptor conservation in Steppe habitats of Eastern Kazakhstan. *Biological Conservation,* **111**: 71–77

Sanderson, G. C. and Bellrose, F. C. (1986). A review of the problem of lead poisoning in waterfowl. *Linois Natural History Survey, Special Publication,* **4**:1–34.

Sandstead H. H and Au, W. (2005). *Handbook on Toxicology of metals*. 3rd Edition. Academic Press, Denmark. pp 925 – 946.

Sandvik, H. and Barrett. R. T. (2001) Effect of investigator disturbance on the breeding success of the black-legged kittiwake. *Journal of Field Ornithology,* **72**:30–42.

Santhanakrishnan, R., Ali, M. S. and Anbarsan, U. (2010). Diet Variations of the Barn Owl *Tyto alba* in Madurai district, Tamilnadu, Southern India. *Podoces,* **5(2)**:95-103.

Sarà, M., and Vittorio, M. (2003). Factors influencing the distribution, abundance and nest-site selection of an endangered Egyptian

Vulture (*Neophron percnopterus*) population in Sicily. *Animal Conservation*, **6(4):** 317-328.

Sarasola, J. H. and Negro, J. J. (2006) Role of exotic tree stands on the current distribution and social lbehaviour of Swainson's Hawk, *Buteo swainsoni* in the Argentine. *Journal of Biogeography*, **33: (6)**: 1096-1101.

Sauvajot, R. M., Buechner, M., Kamradt, D. A. and Schonewald, C.M. (1998). Patterns of human disturbance and response by small mammals and birds in chaparral near urban development. *Urban Ecosystems*, **2**: 279– 297.

Savard, J. P., Clergeau, P. and Mennechez, G. (2000). Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning*, **48**: 131-142.

Scheuhammer, A. M., and. Norris, S. L. (1996). The ecotoxicology of lead shot and lead fishing weights. *Ecotoxicology*, **5(5)**: 279-295.

Schoener, T. W. (1989). Food webs from the small to the large. *Ecology*, **70**:1555-1559.

Schreiber, R.W. (1967) Roosting Behavior of the Herring Gull in Central Maine. *Wilson Bulletin*, **79 (4):** 421-431.

Schwartz, K., and Mertz, W. (1959). Chromium (III) and glucose tolerance factor. Archieves of Biochemistry and Biophysics, **85**: 292–295.

Selås, V. (1993). Selection of avian prey by breeding Sparrowhawks *Accipiter nisus* in south Norway: the importance of size and foraging behaviour of prey. *Ornis Fennica*, **70:** 144-154.

Selås, V., Tveiten, R. and Aanonsen, O. M. (2007). Diet of Common Buzzards (*Buteo buteo*) in southern Norway determined from prey remains and video recordings. *Ornis Fennica*, **84**: 97-104.

Sergio, F., Caro, T., Brown, D., Clucas, B., Hunter, J., Ketchum, J., McHugh, K. and Hiraldo, F. (2008). Top predators as conservation tools: ecological rationale, assumptions and efficacy. *Annual Review of Ecology Evolution and Systematics*, **39**:1-19.

Sergio, F., Newton, I., Marchesi, L. and Pedrini, P. (2006). Ecologically justified charisma: Preservation of top predators delivers biodiversity conservation. *Journal of applied ecology*, **43**:1049-1055

Serrano, D., Forero, M.G., dona´ zar, J.A. and Tella, J. L. (2004). Dispersal and social attraction affect colony selection and dynamics of lesser kestrels. *Ecology*, **85(12):**3438–3447.

Sevin, I. F. (1980). *Nickel- Metals in the environment.* HA Waldron. pp 263-291.

Simberloff, D. (1988). The contribution of population and community biology to conservation science. – *Annual review of ecology, evolution and systematic*, **19**: 473-511.

Simmons, R. and Smith, P.C. (1985). Do Northern Harriers (*Circus cyaneus*) choose nest sites adaptively? *Canadian Journal of Zoology*, **63:** 494-498.

Simmons, R. E., Avery, D. M. and Avery, G. (1991). Biases in diets determined from pellets and remains: correction factors for a mammal and bird-eating raptor. *Journal of Raptor Research*, **25(3)**: 63-67.

Sinclair, K. E., Hess, G. R., Moorman, C. E. and Mason, J. M. (2005). Mammalian nest predators respond to greenway width, landscape context, and habitat structure. Landscape *and Urban Planning*, **71**:277-293.

Singh, A. P. and Srivastava, P. C. (2007). Relationships of heavymetals in natural lake waters with physic chemical characteristics of waters and different chemical fractions of metals in sediments.*Water, Air, and Soil Pollution*, **188**: 181–193.

Singh, R. K., Chavan, S. L. and Sapkale, P. H. (2007). Heavy metal concentrations in water, sediments and body tissues of red worm (Tubifex spp.) collected from natural habitats in Mumbai, India. *Environmental Monitoring and Assessment*, **129**: 471-481.

Skutch, A.F. (1976). *Parent Birds and Their Young*. University of Texas.

Sodhi, N. S., Briffet, C., Kong, L. and Yuen, B. (1999). Bird use of linear areas of a tropical city: implications for park connector design and management. *Landscape Urban Planning*, **45**:123–130.

Soni, K. C., Sharma, A. N. and Soni, V. C. (2010). Nesting Ecology, Interspecific Interaction and Nesting Association of Indian Black Ibis (*Pseudibis papillosa*) Inhabiting the Arid Zone of Rajasthan. *Our Nature*, **8**: 12-25.

Soriano-Santos, J., & Guerrero-Legarreta, I. (2010). Chemical Composition and Nutritional Content of Raw Poultry Meat. *Handbook of Poultry Science and Technology,* John Wiley and Son, Inc, Hoboken, New Jersey.

Speiser, R. and Bosakowski, T. (1987). Nest site selection by northern goshawks in northern new Jersey and Southeastern New York. *Condor,* **89**:387-394.

Stanevièius,V. (2004). Nest-site selection by Marsh Harrier (*Circus aeruginosus*) in the shore belt of helophytes On large lakes. *Acta Zoologica Lituanica*,**14(3)**: 47-53.

Steenhof, K., Kochert, M. N., Carpenter, L. B. and Lehman, R. N. (1999) Long term prairie falcon population changes in relation to prey abundance, weather, land uses, and habitat conditions. *Condor*, **101**: 28–41

Storelli, M. M., Barone, G., Storelli, A. and Marcotrigiano, G. O. (2006). Trace metals in tissues of mugilids (*Mugil auratus, Mugil capito, and Mugil labrosus*) from the Mediterranean Sea. *Bulletin of Environmental Contamination and Toxicology*, **77**: 43-50.

Swaileh, K. M and Sansur, R. (2006). Monitoring urban heavy metal pollution using the House Sparrow (*Passer domesticus*). *Journal of Environmental Monitoring*, **8**: 209–213.

Swingland, I. R. (1976) The influence of Light intensity on the roosting times of the rook (*Corvus frugilegus*). *Animal Behaviour*, **24**: 154 -158.

Szefer, P., Czarnowski, W., Pempkowiak, J. and Holm, E. (1993). Mercury and major essential elements in seals, penguins, and other representative fauna of the Antarctic. *Archived Environmental Contamination Toxicology*, **25**: 422–427.

Szymczyk, K. and Zalewski, K. (2003). Copper, zinc, lead, and cadmium content in liver and muscle of Mallards (*Anas platyrhyc*) and other Hunting Fowl Species in Warmia and Mazury in1999- 2000. *Polish Journal of Environmental Studies*. **12(3)**: pp 381-386.

Technical Guidance document on Risk Assessment. (2003). European Commission Joint research Centre.

Tella, J.L., Forero, M.G., Hiraldo, F., Donázar, J.A., (1998). Conflicts between lesser kestrel conservation and European agricultural policies as identified by habitat use analyses. *Conservation Biology,* **12**: 593–604.

Tester, J.R. (1987) Changes in daily activity rhythms of some free-ranging animals in Minnesota. *Canadian Field Natauralist,* **101**: 13-21.

Thiollay, J M. (1989). Area requirnment for the conservation of rain forest raptors and game birds in French Guiana. *Conservation biology,* **3**: 128-137

Thorington, K. K. and Bowman, R. (2003). Predation rates on artificial nests increases with human housing density in suburban habitats. *Ecography,* **26**:188-196.

Tom, D., Bervoets, L., Blust, R. and Eens, M. (2002).Tissue levels of lead in experimentally exposed Zebra finches (*Taeniopygia guttata*) with particular attention on the use of feathers as biomonitor. *Archived Environmental Contamination Toxicology,* **42**: 88-92.

Tomialojc, L. (1998). Breeding bird densities in some urban versus non-urban habitats: the Dijon case. *Acta Ornitholgica*, **33**: 159–171.

Toumenpuro, J. (1991). Effect of nest site on nest survival in the Dunnock, *Prunella modularis*. *Ornis Fennica*, **68:** 49-56.

Toyne, E. P. (1998). Breeding season diet of the Goshawk *Accipiter gentilis* in Wales. *Ibis*, **140**: 569-579.

Tree, A. J. (2001). Kittlitz's Plover as an intra-African migrant. *Honeyguide*, **47**: 10–16.

Tree, A.J. (1973). Ageing the Kittlitz's Plover. *Safring News*, **2(2):** 23–25.

U. S. Fish and Wildlife Service (1996). Canadian Wildlife Service. 1986.*North American waterfowl management plan: a strategy for cooperation. US Fish and Wildlife Service, Washington, DC*.

Underhill, L.G., Tree, A.J., Oschadleus, H.D., Parker, V. (1999). *Review of ring recoveries of Waterbirds in southern Africa*. Cape Town: Avian Demography Unit, University of Cape Town.

Urban, E.K. (1986). "Charadriinae, plovers" *The birds of Africa,* 2: 225-246.

Wackernagel, M. and Rees, W. (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth*. The New Catalyst Bioregional Series, New Society Publishers.

Walsh, C. T., Sandstead, H. H., Prasad, A. S., Newberne, P. M. and Fraker, P. J. (1994) Zinc: health effects and research priorities for the 1990's. *Environment Health Perspecive*. **102(2)**: 5–46.

Walters, J. R. (2000). Dispersal behavior: an ornithological frontier. *Condor*, **102**:479–481.

Watling, J.I., Nowakowski, J.A., Donnelly, M.A. and Orock, J. L. (2009). Meta-analysis reveals their importance of matrix composition for animals in fragmented habitat. *Global Ecology and Biogeography,* **20**: 209–217.

Watson, J. (1992). Nesting ecology of the Seychelles Kestrel *Falco araea* on Mahe, Seychelles. *Ibis,* **134:** 259-267.

Welty, J. C and Baptista, L. F. (1988). *The life of birds,* 4th Edition. WB Saunders, New York.

Whellwright, N. T. (1983). Fruits and the ecology of resplendent Quetzal. *Auk*, **100**: 286-301.

White, J. G., Amos, M. J., Fitzsimons, J. A. and Palmer, G. C. (2005). Non-uniform bird assemblages in urban environments: the influence of streetscape vegetation. *Landscape and Urban Planning,* **71**: 123-135.

White, T.C.R. (2008). The role of food, weather and climate in limiting the abundance of animals. *Biological Reviews,* **83**: 227–248.

Widen, P. (1994). Habitat quality for raptors: a field experiment. *Journal of Avian Biology*, **25**: 219–223.

Wiemeyer and Stanley N. (1988). Environmental contaminants in California condors. *The Journal of Wildlife Management*, **52**: 238-247.

Wiens, J. A. (1976). Population responses to patchy environments. *Annual Review of Ecology, Evolution and Systematic*, **7:** 81-120.

Wild life Protection Act. (1972). Amendment, 2008.

Wilson, M.W., Irwin, S., Norriss, D.W., Newton, S.F., Collins, K., Kelly, T.C. and O′Halloran, J. (2009). The importance of pre-thicket conifer plantations for nesting Hen Harriers *Circus cyaneus* in Ireland. *Ibis*, **151:** 332–343.

Wilson, R. P. and Culik, B. (1995). Penguins disturbed by tourists. *Nature*, **376**:301–302.

World Health Organization. (1991). *International programme on chemical safety*. Environmental health criteria: Nickel. WHO, O'Day, P. A., Chisholm Brause, C. J., Towle, S.N., Parks, G. A. and. Geneva. G. E.

World Resources Institute. (1996). World Resources 1996–1997. Oxford University Press, Oxford.

Xu, Y, Ran. J, Zhou. X, Yang. N., Yue. B. and Wang. Y. (2008) The effect of temperature and other factors on roosting times of Szechenyi Monal Partridges *Tetraophasis szechenyii* during the Breeding season. *Ornis Fennica*, **85**: 126-134.

Zammuto, R.M. and Franks, E.C. (1981) Environmental effects on roosting behaviour of Chimney Swifts. *Wilson Bulletin*, **93**: 77-84.

Zhuang, P., Zou, H., and Shu, W. (2009). Biotransfer of heavy metals along a soil, plant, insect, chicken food chain: Field study. *Journal of Environmental Science.*, **21(6)**: 849–853.

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

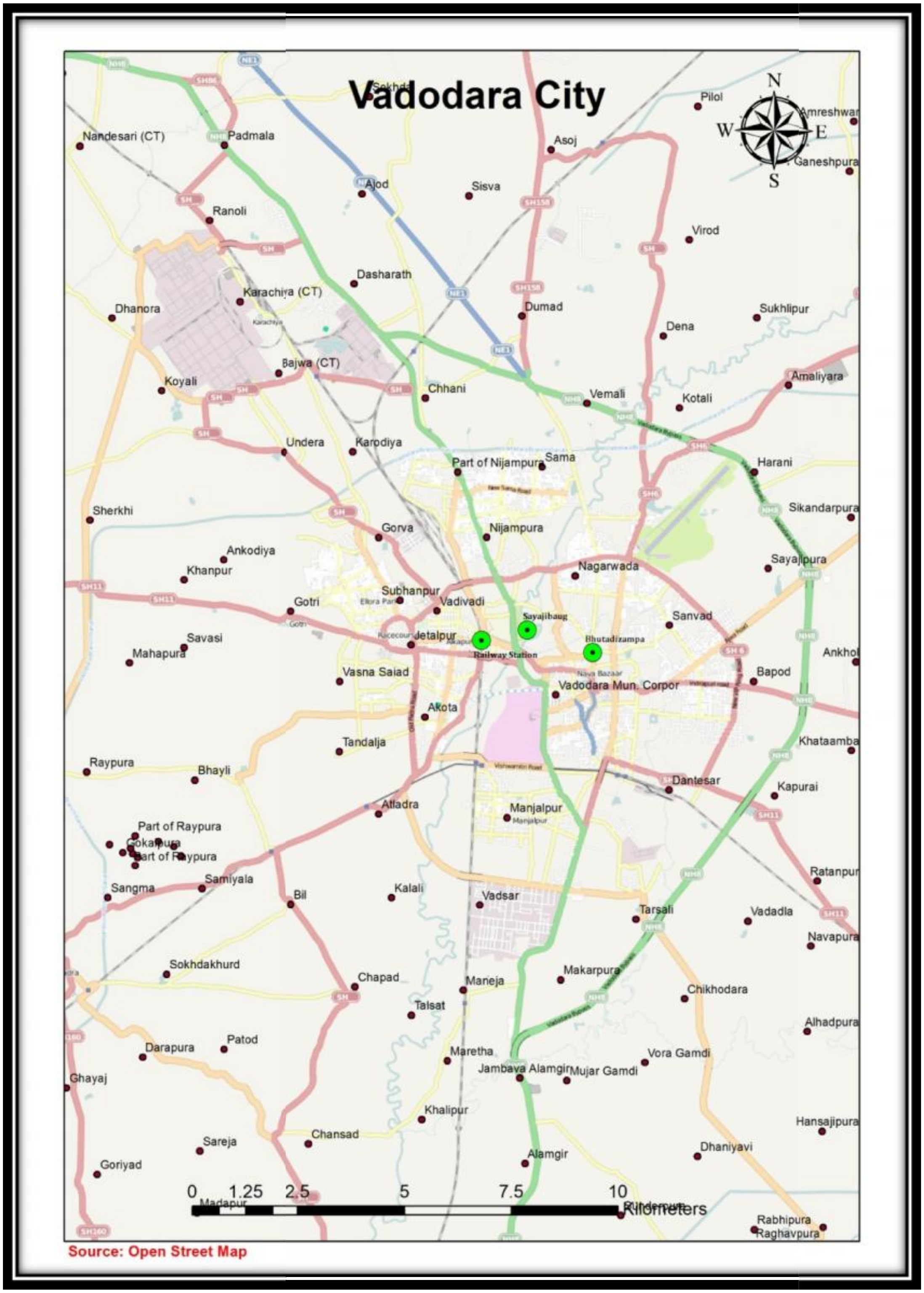


Plate 3. Google Earth Image of three roosting sites of Vadodara City

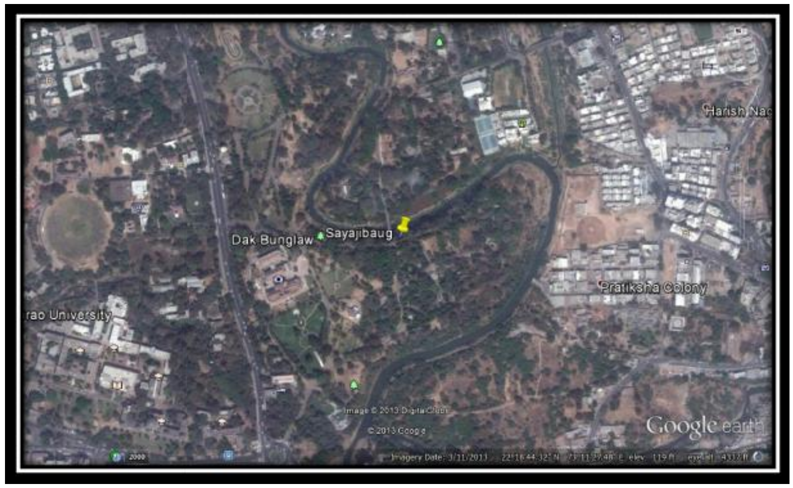


Plate 4. Pre roosting Behaviour of Black Kite *(Milvus migrans govinda)*

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

Plate 5 Nest of Black Kite (*Milvus migrans govinda*) on Neem

Nest of Black Kite on *Terminalia bellirica*

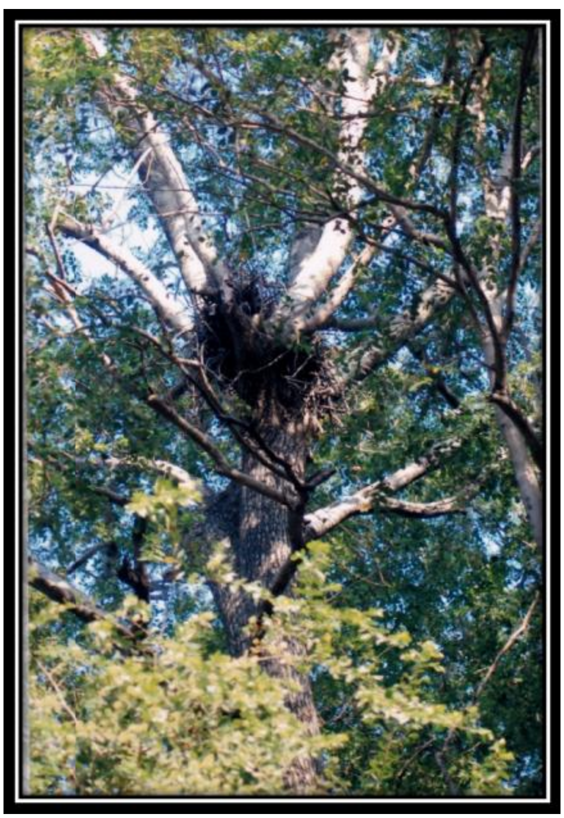


Plate 6

Young once of Black Kites (*Milvus migrans govinda*)

Juvenile Black Kite (*Milvus migrans govinda)* with Parent

Plate: 7 Adult Black Kite (*Mivus migrans govinda*) with food

Regurgitated Pellet of Black Kite (*Milvus migrans govinda)*

Plate: 8 Poultry left over from Regurgitated Pellet of Black Kite (*Milvus migrans govinda)*

Parts of insect exoskeleton from regurgitated pellet of Black Kite

Bony parts of amphibians from regurgitated pellet of Black Kite