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 landscapesit 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 interactionsboth between species and ecosystems (Pimm, 1982; Paine, 1980; Schoener, 1989; Polis, 1991). Herea speciesreacting functionally to the abundance of its preycan 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 particularhabitat (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 observationof 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° 18' N, 73° 10' E) Gujarat, India,Kites were observed feeding at several placesfrom 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° C to removeall 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,undigestableparts of birds *etc.* as describe by Huang *et al.,* (2006). The parts ofinsect 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 theseare compared, the differencesare significantat $P<0.001$ ($F_{3,597}$ 8.76) for length and at $P<0.01$ ($F_{3, 597}$2.30) for width. Differences in weight of pellets isalso highly significantat $P<0.001$($F_{3,597}$ 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 are3.7± 0.22 cm. and 2.08 ± 0.01cm. while that from Railway station are3.52 ± 0.13cm.and1.97 ± 0.01cm. and from Bhutdizapa 3.65± 0.14cm.and1.9±0.2 cm.The differences inlength and width of pelletsare significant at $P<0.001$($F_{3,597}$3.77 and $F_{3,597}$8.15) respectively. Similarly,differences in mean weight of pelletsfrom three sites arealso 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 are4.02± 0.07cm. and 2.09 ± 0.03cm. Those from Railway station are4.0± 0.06 cm. long and2.13 ± 0.05 cm.broad while thosefrom Bhutdizapa are 3.97± 0.01cm. 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.and0.71 ± 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 arenonsignificant at P>0.05 ($F_{3,597}$ 0.06).

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

The mean Length of pellets for summeris 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 threesites are 1.97 ± 0.1, 1.91 ± 0.12 and 1.98 ± 0.01gm., with poultry left over in pelletsat 0.89 ± 0.06, 0.78 ± 0.09 and 0.88 ± 0.03gms., 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 forwidth 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:

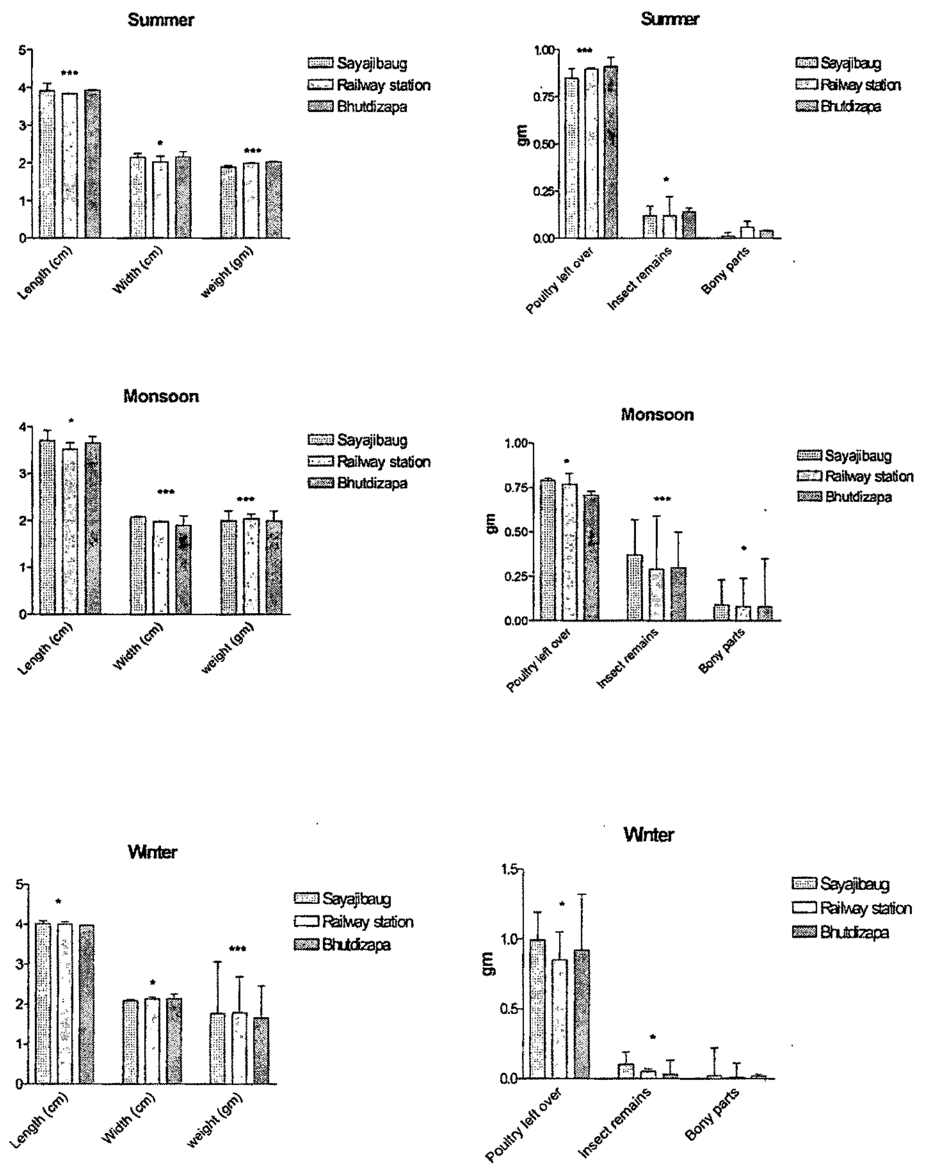
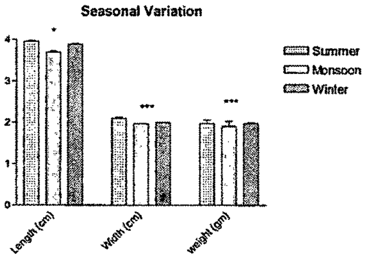
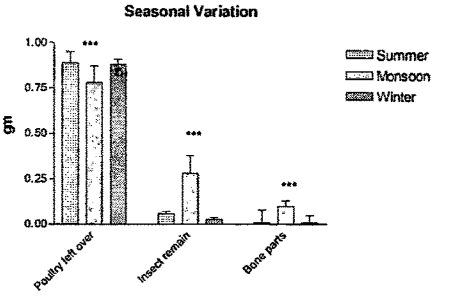


Fig: 2 The overall seasonal variations in Morphometric characteristics of Black Kite pellets.





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:

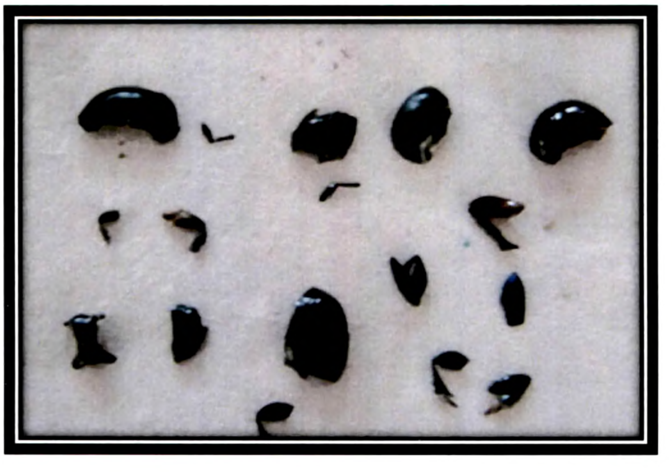
Food and water is the basic need of every individual. Species of birds try to build their nest nearer to feeding sites so they can explore the feeding grounds and also care for the young once. During day time Black Kites are observed foraging nearer to dumping site, poultry farms, surrounding water resources, 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.

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