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Comparison of Diet Analysis of Eurasian Sparrowhawk, *Accipiter nisus* and Black Kite, *Milvus migrans* (Accipitridae: Accipitriformes) from Southern Punjab, Pakistan

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TH conceived the project. NS and SN executed the experimental work. IA and MA and MR analyzed the data. MA wrote the article. IA and TR supervised the research work.

Key words
Diet analysis, black kite, sparrow hawks.

ABSTRACT

The diets of Eurasian sparrowhawk *Accipiter nisus* and Black kite *Milvus migrans* occupying Lal Sohanra National Park at Bahawalpur, southern Punjab were analyzed. The hawks were more diverse (euryphagous) in feeding habits with maximum feeding during summer while kites were less diverse (stenophagous) in feeding with feeding at peak during autumn. Out of 700 pellets collected from 15 nests of sparrowhawk, 920 prey items were recovered. The hawks preferred birds in their diet (449) followed by rodents (168), fish (102), frogs (67), bats (63), insects (38) and lizards (33). Whereas, 750 pellets collected from 15 nests of kites contained 900 preys items The kites preferred shrew in their diet (378) followed by birds (260), rodents (122), fish (120) and insects (120).

INTRODUCTION

The Eurasian sparrowhawk *Accipiter nisus* and black kite *Milvus migrans* commonly found in open woodlands, marshes, desert grassland, partially cleared lands, and cultivated fields. Both the species are well adapted to subtropical, tropical and temperate areas of world (Roberts, 1991). The Eurasian sparrowhawks from colder regions of northern Asia migrate south for the winter, some to north Africa (some as far as equatorial east Africa) and India; members of the southern populations are resident or disperse. According to Bird Conservation International their status is of least concern. In South Asia especially in India, the population of *Milvus migrans* is particularly large especially in areas of high human population. Here the birds avoid heavily forested regions. Again their status is of least concern according to Bird Conservation International (Roberts, 1991).

The Eurasian sparrowhawk primarily preyed on smaller woodland birds, great tits, house sparrows, tits, finches, buntings, thrushes and starlings. More than 120 bird species have been recorded as prey. Small mammals, including bats, rodents and fish are also consumed (Post and Gotmark, 1996). The reptiles and amphibians are also consumed in summer and rainy season while insects are rarely eaten (Speakman, 1991). The black kite generally snatch small live prey, fish, birds, bats and rodents (Narayanan, 1989). Occasionally they also feed on waterfowl especially during summer to feed their young ones (Veiga and Hiraldo, 1990). Sometime they were seen attacking nests of other pairs. Kites also try to attack the nest of weaver birds in order to obtain eggs and chicks (Wesley *et al.*, 1991).

The hawks and kites also known as bird of prey 'the Raptors'. They take up high trophic level in the food chain and play an important role in terrestrial ecosystems through regulation of prey species. A detailed analysis of diets consumed by the raptors provides important information on niche segregation of sympatric species. Therefore, food habit study is essential for an understanding of raptor biology and community dynamics. Directly observing the prey capture and consumption, monitoring prey delivered to the nests (Simmons *et al.*, 1991), and collecting prey remains (Thrailkill *et al.*, 2000; Rutz, 2003) and pellets (Sharp *et al.*, 2002) are the methods frequently used to study feeding habits of raptors.

The objectives of the present study were to

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analyze the diets composition and feeding niche of two co-existing populations of Eurasian sparrow hawk and black kite at Lal Sohanra National Park, southern Punjab.

MATERIALS AND METHODS

Field survey and sampling

The present study was conducted at Lal Sohanra National Park 29.3167° N, 71.9167° E situated in district Bahawalpur, southern Punjab, Pakistan. It encompasses an area of 127,480 acres, out of which 20,974 acres are green land (irrigated plantations), 101,726 acres are dry land (desert), and 4,780 acres are wet land (ponds and lakes) (Wariss *et al.*, 2014). The climate is tropical and continental, characterized by low and sporadic rainfall (176 – 250mm per annum), high temperatures, low relative humidity, high rate of evaporation and strong summer winds. The soil is classified as saline (pH 8.2-8.4) to sodic (pH 8.8-9.6), respectively (Rafay *et al*.,2015). The vegetation is generally xerophytic and consists of *Dalbergia sissoo*, *Acacia nilotica*, *Azadirachta indica*, *Prospopis cineraria*, *Acacia modesta*, *Capparis decidua*, *Tamarix aphylla*, *Zizyphus mauritiana*, *Zizyphus nummularia*, *Eleusine compressa*, *Panicum antidotale*, and *Calotropis procera* (Wariss *et al.*, 2014). The field work started with the search of pellet remains under the trees used by sparrowhawk and black kite to build nests or roosts. The pellet remnants were also collected from inside the nests when the adult birds were out for daily activities. Majority of the pellets were collected from the vicinity of nests. A total of thirty nests and roosts (fifteen for each species) were observed on fortnight basis for collection of pellet samples of both the species (February, 2013 to January, 2014). The pellet samples were preserved in tagged, labeled, sealed plastic bags and brought to laboratory of Forestry, Range and Wildlife Department. The samples were oven dried at 55ºC for 36 h and preserved for later identification.

Pellet analysis

A vernier calliper and weighing balance was used for measurement of length, width and weight of pellet samples, respectively. A magnifying glass or binocular microscope was used to count and identify the prey items (*viz.*, hairs, feathers, skulls, beaks, claws, body parts of insects etc.) following Dickman *et al*. (1991) and Yalden (2003). The biomass was calculated by multiplying the number of prey items present in the pellets by mean body weight. The mean body weight of the prey species was taken from literature (Roberts, 1991, 1992, 1997). An estimated weight of 1 g was assigned to each insect prey following Leonardi and Arte (2006). Both number and biomass of the prey items were expressed in percentage (Holt, 1993; Denver and Leroux, 1996). The data was also separated on seasonal basis consisting of four seasons round the year. For assessment of diversity among different prey items, Magurran (1988) was followed to calculate species richness (S), Shannon's index (H'), and Peilou's evenness (E) indices. Food overlap was calculated by the percentage similarity (PS); $PS = 1 - 0.5\_[Pi,j - Pi,k]$, where Pi is the proportion of prey species i in the diet of predator j and k respectively (Nilsson, 1984). A value of 0 means no overlap and 1 means complete overlap. One-way ANOVA and student's t-test were used for comparisons between species.

RESULTS

Pellet analysis of two species

Approximately 24 field visits were conducted to different localities of park and a total of 700 pellets of Eurasian sparrowhawk were collected from 15 nests/roosts. These pellets contained 920 different prey items. A mean length of pellet was 33±0.67 mm (range 30-38mm), mean breadth was 30±0.38mm (range 27-33.5mm), while mean weight was recorded as 2.8±0.85g (range 2.5-4.2g). The number of prey items per pellet varied from 1-6 with the mean of 1.02 prey/pellet (Table III). Similarly, a total of 750 pellets of black kite were collected from 15 nests/roosts contained 900 different prey items. A mean length of pellet was 38±0.80 mm (range 37.2-42 mm), mean breadth was 35±0.42 mm (range 33-40.2 mm) while mean weight was recorded as 3.2±0.62g (range 2.9-5.12g). The number of prey items per pellet varied from 1-4 with the mean of 1.10 prey/pellet (Table VI). These parameters were significantly changed round the year (during four seasons) with $F= 6$, $P < 0.05$). The summer pellets were comparatively smaller in size than others.

Diet analysis of two species

A total of 920 prey items were present in 700 pellets of Eurasian sparrowhawk (Table I). Among rodents the *Rattus rattus* (10%) was preferred over *Mus musculus* (8.3%), fish and bats were represented by a single species each *viz.*, *Tilapia mossambicus* 11% and *Rhinopoma* spp. 6.8%, while lizards were 3.6%, frogs/toads 7.2% and insects (grasshopper and bugs) were 4.1%. Among birds, *Columba livia* 21.7% was favourite food item followed by *Passer domesticus* 20.3% and *Ploceus phillipinus* 6.7% of the total number of preys. The overall avian biomass consumed was 77.2% followed by rodents 17.6%, frogs/toads 2%, fish 1.5%, bats 1%, lizards 0.6% and insects 0.05% (Table I).

Table I.- Pellet analysis of Eurasian sparrowhawk *Accipiter nisus:* prey items (%) and their biomass (%). No. of pellets, 700. No. of prey items, 920. Nest observed, 15.

Prey items	MBW (g)	Number (%)	Biomass (%)	Total No.
Rodents				
Mus musculus	12	8.3	1.3	76
Rattus rattus	120	10	16.3	92
			17.6	(168)
Fish				
Tilapia mossambicus	10	11	1.5	102
Bats				
Rhinopoma spp.	10	6.8	1	63
Birds				
Passer domesticus	25	20.3	6.9	187
Columba livia	160	21.7	47.3	200
Ploceus phillipinus	250	6.7	23	62
			77.2	(449)
Lizards	13	3.6	0.6	33
Frogs/Toads	20	7.2	2	67
Insects	1	4.1	0.05	38vi
Total	621	920	67584	920

MBW, mean body weight.

For seasonal comparison, a total of 160 pellets consisted of 174 prey individuals were analyzed in winter diet samples. The birds were high in number 55.1% of the total number of prey followed by rodents 19.5%, fish 12%, bats 8.6% and insects 4.6%. The spring diet consisted of 300 pellets having 336 prey individuals with birds 62.1% in number followed by rodents 15.4%, fish 10.7%, bats 8% and insects 3.6%. In the summer diet, 140 pellets were analyzed having 281 prey individuals. A diversity of preys were identified with birds dominating in number 37% followed by rodents 20%, frogs/toads 13.1%, fish 11.4%, lizard 8.1%, bats 7.1% and insects 3.6%. The autumn diet consisted of 100 pellets having 129 prey individuals with birds 31% in number followed by rodents 20.2%, frog/toads 23.2 %, fish 10%, lizard and insects 7.8% each (Table II). High prey diversity was recorded in Summer and Autumn while evenness index showed that the hawks are not dependent on single specific prey species (Fig. 1).

On contrary, a total of 900 prey items were analyzed in 750 pellets of black kite (Table IV). Among rodents the *Millardia meltada* 7.2% was preferred over *Mus musculus* 6.3%, fish and small mammals were represented by a single species each *viz.*, *Labeo rohita* 13.3% and *Suncus murinus* 42% and insects (grasshopper) 2.2%. Among birds: *Passer domesticus* 16.7% was dominant followed by *Streptopelia decaocta* 10.6% and *Ploceus phillipinus* 1.7% of the total number of preys. The overall avian biomass consumed was 36.29% followed by small mammals 33%, fish 23.03%, rodents 7.53% and insects 0.035% (Table IV).

The diet comparison among different seasons showed that winter sample contained 163 pellets with 171 prey individuals. The small mammals were numerically dominant 49.1% followed by birds 19.88%, fish 15.20%, rodents 14% and insects 1.8%. In the spring diet, 164 pellets were analyzed having 166 prey individuals with

Table II.- Seasonal changes in the prey items (%) of Eurasian sparrowhawk *Accipiter nisus.*

Prey item	Winter	Spring	Summer	Autumn	Total
Mus musculus	8	6.5	10	9.3	76
Rattus rattus	11.5	8.9	10	10.9	92
Tilapia mossambicus	12	10.7	11.4	10	102
Rhinopoma spp.	8.6	8	7.5	-	63
Passer domesticus	27.6	22.3	15.7	15.5	187
Columba livia	21.8	30.3	14.2	15.5	200
Ploceus phillipinus	5.7	9.5	7.1	-	62
Lizards	-	-	8.1	7.8	33
Frogs/ Toads	-	-	13.1	23.2	67
Insects	4.6	3.6	3.6	7.8	38
No. of pellets	160	300	140	100	700
No. of preys	174	336	281	129	920

small mammals numerically dominant 56.6% followed by fish 20.5%, rodents 19.8% and insects 3%. Surprisingly no bird prey was recovered from pellets of spring season. In the summer diet, 195 pellets were analyzed with 200 prey individuals. Again the small mammals were abundant 51% followed by birds 25%, rodents 16.6%, fish 6% and insects 3%. The autumn diet consisted of 228 pellets having 363 prey individuals with birds dominant 48.4% in pellet sample followed by small mammals 27%, fish 13.2%, rodents 9.6% and insects 1.7% (Table V). The highest prey diversity was recorded in the pellet sample of winter and autumn season while evenness index showed that the kites preferred a specific prey species (Fig. 2).

Table III.- Measurements of pellet size (mean and range values) of sparrowhawk.

Parameters	Mean value	Range
Length (mm)	33 ± 0.67	30-38
Width (mm)	30 ± 0.38	27-33.5
Weight (g)	2.8 ± 0.85	2.5-4.2
No. of preys/ pellet	1.02	1-6

Table IV.- Pellet analysis of black kite *Milvus migrans:* prey items (%) and their biomass (%). No. of pellets, 750. No. of prey items, 900. Nest observed, 15.

Prey item	MBW (g)	Number (%)	Biomass (%)	Total No.
Rodents				
Mus musculus	12	6.3	1.05	57
Millardia meltada	65	7.2	6.48	65
Total		13.5	7.53	122
Small mammals				
Suncus murinus	57	42	33.08	378
Fish				
Labeo rohita	125	13.3	23.03	120
Birds				
Passer domesticus	25	16.7	5.75	150
Streptopelia decaocta	170	10.6	24.79	95
Ploceus phillipinus	250	1.7	5.75	15
Total		29	36.29	260
Insects	1	2.2	0.03	20
Total	705	900	65125	900

For abbreviations see Table I.

Comparison of diets of two species

The two avian species *viz.,* Eurashian sparrowhawk and black kite were primarily different in their diet composition, although they belong to same family and prefer more or less similar species but in different ratios. The hawks mainly dependent on birds biomass followed by rodents and fish while kites usually consumed birds biomass in major followed by small mammals and fish. The results of ANOVA and t-test further confirmed the said hypothesis ($t=3.78$, $df=3$, $p<0.05$). The niche breadth was calculated for both the species and a value of 2.8 was observed for hawks indicating a broad feeding niche as compared to 2.3 for kites showing a narrow feeding niche. A low degree of food overlap was recorded for both avain species throughout the year.

DISCUSSION

The pellet size was variable for both the species. The average size of pellet of sparrowhawk was larger than reported in literature (Tornberg and Vitali, 2007). It was observed that a major proportion of diet for the hawks mainly consisted of birds biomass. The presence of feathers in the pellet is also responsible for its large size (Takagi *et al.,* 1995). The average size of pellet of kite was more or less in accordance with the earlier reports (Huang *et al.,* 2004). The size of pellet varied significantly due to composition of diet and nutritive value of prey consumed (Alvarez-Castaneda *et al.,* 2004; Nadeem *et al.,* 2012). The mean number of prey per pellet of the sparrowhawk was higher than that of kites possibly due to presence of more insects in their diet.

During present study the biomass of birds and rodents accounted for 77.2% and 17.6% respectively in the diet of hawks while birds and small mammals shared almost in equal ratios in the diet of kites with 36.29% and 33.08% respectively. Many species of birds breed at the same time as do the sparrowhawks. This synchronization provides an easy access to the food resources as compared to others and the prey is in abundance as well (Thrailkill *et al.,* 2000). The presence of bats in their diets is an indication that they also hunt at dawn and dusk of the day. Most of the raptors are semi-nocturnal feeder and are opportunistic hunters which hunt prey that are easy to catch and provide an optimal reward (Redpath *et al.,* 2001). Presently *Suncus murinus* being the chief component in the food item of kite is in agreement with (Souttou *et al.,* 2012; Beg *et al.,* 1986). Bergier (1982) found that small mammals accounted 48% of the diet of black kite followed by birds 40% and invertebrates 11%. The population of small mammals varied throughout the year and their contribution reached at peak especially in

Table V.- Seasonal changes in the prey items % of black kite *Milvus migrans*.

Prey item	Winter	Spring	Summer	Autumn	Total
Mus musculus	7	9	7	4.4	52
Millardia meltada	7	10.8	9.6	5.2	65
Suncus murinus	49.1	56.6	51	27	378
Labeo rohita	15.20	20.5	6	13.2	120
Passer domesticus	19.88	-	25	18.2	150
Streptopelia decaocta	-	-	-	26.1	95
Ploceus phillipinus	-	-	-	4.1	15
	19.88	-	25	48.4	
Insects	1.8	3.0	3	1.7	20
No. of pellets	163	164	195	228	750
No. of preys	171	166	200	363	900

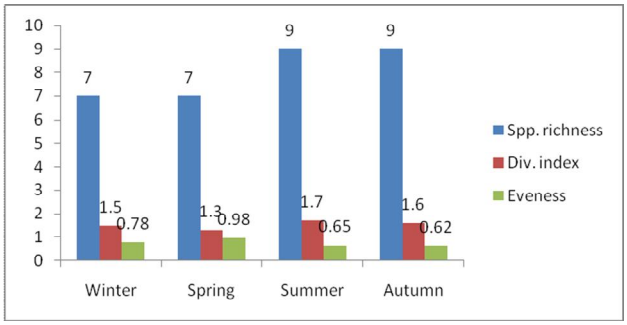

Fig. 1. Diversity of prey items in the pellet samples of Eurasian sparrowhawk.

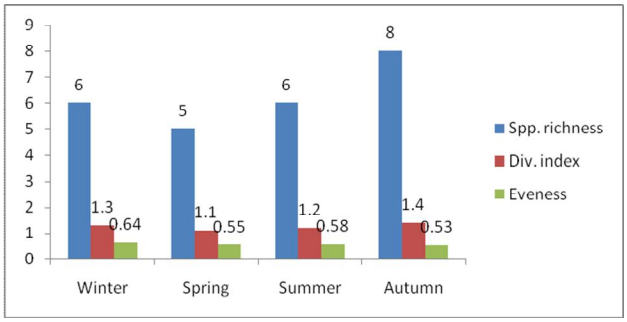

Fig. 2. Diversity of prey items in the pellet samples of black kite.

summer season (Andrew, 1992; Alivizatos *et al.*, 2005). The kite also consumed a variety of birds and the nestlings of family Passeridae are preferred over the others (Manosa, 1994).

The diet composition of sparrowhawk and black kite also varied round the year. The rodents, small mammal and fish were consumed by kite in winter, spring and summer diets while birds mainly *Streptopelia decaocta* and *Ploceus phillipinus* replaced their share in

Table VI.- Measurement of pellet size (mean and range values) of black kite.

Parameters	Mean value	Range
Length (mm)	38 ± 0.80	37.2-42
Width (mm)	35 ± 0.42	33-40.2
Weight (g)	3.2 ± 0.62	2.9-5.12
No. of preys/ pellet	1.10	1-4

autumn diet. On the other hand hawks preyed on rodents, fish, bat, birds, reptiles and amphibians. The rodents, fish, bat and birds were consumed in winter and spring diets while lizard and frog/toad were preferred in summer and autumn diets. Similar pattern of prey consumption was documented by other researchers working on feeding habits of different raptor species. A change in prey composition may be the result of opportunistic hunting strategy directly related to prey availability and abundance (Bose and Guidali, 2001; Debrot *et al.*, 2001; Mahmood-ul-Hassan *et al.*, 2007c). The rodents and small mammals were preferred during winter and spring season probably due to availability of ample food to these preys in this time period. In most parts of Punjab, wheat and fodder are grown in early winter and harvested at early summer. These cultivations were considered to be a favourite food for these mammalian pests (Ruby *et al.*, 2010). Thus, an increase in the raptors diet might be the result of this cultivation impact.

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