

Population and Distribution of Raptors in Keoladeo National Park, Bharatpur, India

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ABSTRACT

A raptor census was carried out twice a month from September 1985 to August 1986. The birds were counted directly by walking/cycling down the roads and dykes which criss-cross the park. The sightings were marked on maps. Systematic nest surveys were also carried out throughout the period.

Owls and vultures were not considered. Twenty-six species of *Accipitridae* and four *Falconidae* were recorded. Five were new records for the park. Ten species of *Accipitridae* and four species of *Strigidae* were recorded nesting.

The raptor population was the highest in December (79) and lowest in July (23). The Shannon-Weiner Index of species diversity was maximum in October and minimum in June, 2.7802 and 1.2 respectively. These populations were more steady in June ($J=.83$) and more fluctuating during December ($J=.429$). A significant positive correlation ($r=.95$, $P<0.001$) was seen between the numbers of raptors and waterfowl.

The marshes (8.5 km²), along with the adjoining forest, were the preferred habitat for 20 raptor species, while savanna-type grasslands were for 6 species. Two species were dependent exclusively on aquatic areas and one on woodlands.

INTRODUCTION

Although information on the distribution of various species of raptors in the Indian subcontinent is available (Ali & Ripley 1983), their population and habitat requirements have not been studied in detail. Raptors are valuable indicators of environmental problems, and their density and diversity often reflect the health of a given ecosystem. The present study formed part of an ongoing multidisciplinary project by the Bombay Natural History Society (Ali & Vijayan 1986) on the ecosystem of Keoladeo National Park, a world heritage site, famous for its wintering Palearctic waterfowl and as the only proven wintering ground of the Siberian Crane in India (Ali & Vijayan 1986).

Extending from September 1985 to August 1986, this study is concerned with the numbers, distribution and habitat requirements of various raptor species inside the park. Vultures and owls were excluded from regular monitoring, although their nesting distribution was studied.

STUDY AREA

The Keoladeo National Park, situated at 27°7.6'-27°12.2'N and 77°29.5'-77°33.9'E is 2 km south-east of Bharatpur City and 180 km south of Delhi (Fig. 1). It covers about 29 km² of flattish terrain sloping to a slight depression of about 8.5 km² in the centre. This forms the main submersible area of the park and has been divided into several unequal compartments by dykes (Ali & Vijayan 1986). The average elevation of the area is 174 m. Extremes of climate are experienced in the area, with temperatures varying between 1°C and 50°C.

Apart from the wetland, the park has ca. 20 km² of woodlands, savanna-type grasslands and savanna with thickets. In some of the compartments the marshes have scattered mounds planted with *Acacia nilotica*, and are also bordered with these acacias, the other tree species being *Mitragyna parvifolia*, *Sizygium cumini* and *Prosopis spicigera*.

METHOD

Counts were made in the mornings every fortnight while walking/cycling down the roads and dykes. The exact position of each bird was marked on a map. The roads and bunds criss-cross the park in such a way that the aquatic and grassland areas could be fully covered during a census. Part of the forest area was left uncovered. It is unlikely that any birds were missed, except for the secretive Accipiters.

Perch-trees were classed according to their appearance:-

1. Green: tree in full leaf.
2. Dry: bare or with dry leaves.
3. Dry-top: top branches bare, the rest with green leaves.

At every sighting, the species of perch-tree was noted, together with the type and height, and the height at which the bird was located. The population of prey species, mainly waterfowl, was estimated twice monthly by counting them in 200 x 200 m plots located in areas of maximum concentration.

Figure 1. Map of Keoladeo National Park, showing the major habitat preferences of raptors.

(A) Marsh with adjoining forest

- 1) *Milvus migrans lineatus*
- 2) *Accipiter nisus*
- 3) *Accipiter virgatus*
- 4) *Buteo rufinus*
- 5) *Hieraaetus fasciatus*
- 6) *Hieraaetus pennatus*
- 7) *Aquila heliaca*
- 8) *Aquila rapax vindhiana*
- 9) *Aquila rapax nipalensis*
- 10) *Aquila clanga*
- 11) *Aquila pomarina*
- 12) *Haliaeetus leucoryphus*
- 13) *Circus cyaneus*
- 14) *Circus macrourus*
- 15) *melanoleucos*
- 16) *Spilornis cheela*
- 17) *Falco peregrinus*
- 18) *Falco severus*
- 19) *Falco subbuteo*

(B) Woodland

- 1) *Pernis ptilorhynchus*

(C) Marsh

- 1) *Circus aeruginosus*
- 2) *Pandion haliaetus*

(D) Savanna-type grassland

- 1) *Elanus caeruleus*
- 2) *Milvus migrans govinda*
- 3) *Accipiter badius*
- 4) *Accipiter gentilis*
- 5) *Butastur teesa*
- 6) *Circaetus gallicus*
- 7) *Falco tinnunculus*



The nesting distribution of raptors was studied by systematically searching for nests over the whole park throughout the year.

RESULTS AND DISCUSSION

Twenty-six species of *Accipitridae* and 4 of *Falconidae* were recorded. Five were recorded for the first time from the park.

The species diversity index ($H' = -\sum_{i=1}^S P_i \ln P_i$) was highest in October (-2.78) and lowest in June (-1.15) (Table 1). The high diversity in September (-2.32) and October coincided with the onset of the autumn migration, while the increase in diversity in February and March was probably due to the transient population on return migration. In summer, only the resident species (9 out of 30) were seen in the park, which explains the lower density and diversity in that period.

POPULATION

The raptor population in Keoladeo National Park in the peak season comprises 53% migrants, 30% residents, 6% local migrants, 3% stragglers, 3% breeding migrants and 3% having two populations - one resident and the other migratory (Table 2). The highest population (79) was recorded in December and the lowest (23) in July (Table 3). Two species of *Accipitridae* and four of *Stridigae* nested in the park (Table 4).

A significant positive correlation was found between the numbers of waterfowl-dependent raptors and the numbers of waterfowl ($r=0.95$ $P<0.001$) (Fig. 2). Such correlations between the populations of raptors and their prey species have already been recorded between insectivorous raptors and insects (Thiollay 1978; Newton 1979) and between Bald Eagle and salmon (Cassidy 1986).

A positive correlation was found between the raptor population and water depth ($r=0.79$ $P<0.01$). This link, however, may not be a direct one. The majority of the raptors are migrants and their arrival - and departure - coincides with those of the waterfowl, which in turn depend on water-depth.

DISTRIBUTION

The habitat diversity attracts a large number of raptors to this small area. The marshes with the adjoining forest areas were the most preferred habitat for 20 species (70%), while savanna-type grassland and adjoining deciduous forest were preferred by 6 species. Two species depended exclusively on aquatic areas and one on woodland. Red Kite was sighted only once, near the marsh (Fig. 1).

Table 1. Shannon-Weiner Species Diversity Index for raptors in Keoladeo National Park.

MONTH	SPECIES DIVERSITY INDEX
September	-2.32
October	-2.78
November	-2.28
December	-2.18
January	-2.18
February	-2.21
March	-2.48
April	-2.16
May	-1.75
June	-1.55
July	-2.03
August	-2.38

Table 2. Status of raptors at Keoladeo National Park.

SPECIES	RESIDENT	LOCAL MIGRANT	WINTER MIGRANT	BREEDING MIGRANT	STRAGGLER	MIGRANT/ BREEDING
<u>Elanus caeruleus</u>	X					
<u>Pernis ptilorhynchus</u>	X					
<u>Milvus migrans govinda</u>	X					
<u>Milvus milvus</u>					X	
<u>Milvus migrans lineatus</u>			X			
<u>Accipiter gentilis</u>			X			
<u>Accipiter badius</u>	X					
<u>Accipiter nisus</u>			X			
<u>Accipiter virgatus</u>			X			
<u>Buteo rufinus</u>			X			
<u>Butastur teesa</u>	X					
<u>Hieraaetus fasciatus</u>	X					
<u>Hieraaetus pennatus</u>			X			
<u>Aquila heliaca</u>			X			
<u>Aquila rapax vindhiana</u>	X					
<u>Aquila rapax nipalensis</u>			X			
<u>Aquila clanga</u>						X
<u>Aquila pomarina hastata</u>	X					
<u>Haliaeetus leucoryphus</u>				X		
<u>Circus cyaneus</u>			X			
<u>Circus macrourus</u>			X			
<u>Circus aeruginosus</u>			X			
<u>Circus melanoleucos</u>			X			
<u>Circaetus gallicus</u>	X					
<u>Spilornis cheela</u>		X				
<u>Pandion haliaetus</u>			X			
<u>Falco peregrinus</u>			X			
<u>Falco subbuteo</u>			X			
<u>Falco severus</u>		X				
<u>Falco tinnunculus</u>			X			
TOTAL	9	2	16	1	1	1

Table 3. The population of raptors in December 1985.

SPECIES	NO.
<u>Elanus caeruleus</u>	5
<u>Pernis ptilorhynchus</u>	1
<u>Milvus migrans govinda</u>	1
<u>Accipiter nisus</u>	1
<u>Accipiter virgatus</u>	1
<u>Hieraaetus pennatus</u>	1
<u>Hieraaetus fasciatus</u>	1
<u>Aquila heliaca</u>	9
<u>Aquila rapax</u>	-
<u>Aquila rapax nipalensis</u>	12
<u>Aquila clanga</u>	24
<u>Aquila pomarina</u>	2
<u>Haliaeetus leucoryphus</u>	3
<u>Circus aeruginosus</u>	10
<u>Circaetus gallicus</u>	-
<u>Spilornis cheela</u>	6
<u>Falco peregrinus</u>	2
TOTAL	<u>79</u>

The habitat preferences of 10 dominant species were studied in detail. The 4 species of *Aquila* (*A. heliaca*, *A. rapax nipalensis*, *A. clanga*, *A. pomarina*), *Haliaeetus leucoryphus* and *Spilornis cheela* preferred the marsh and forest around it; *Circus aeruginosus* depended mainly on marsh; *Pernis ptilorhynchus* preferred woodland; while *Elanus caeruleus* and *Circaetus gallicus* were seen in savanna and nearby dry deciduous forest.

Table 4. Raptors found nesting in the park.

ACCIPITRIDAE		
S.NO.	SPECIES	NO. OF NESTS
1.	<u>Elanus caeruleus</u>	5
2.	<u>Pernis ptilorhynchus</u>	5
3.	<u>Butastur teesa</u>	1
4.	<u>Aquila clanga</u>	1
5.	<u>Aquila pomarina</u>	1
6.	<u>Haliaeetus leucoryphus</u>	1
7.	<u>Sarcogyps calvus</u>	3
8.	<u>Neophron percnopterus</u>	5
9.	<u>Gyps bengalensis</u>	244
10.	<u>Circaetus gallicus</u>	4
STRIGIDAE		
1.	<u>Otus bakkamoena</u>	2
2.	<u>Bubo coromandus</u>	12
3.	<u>Athene brama</u>	10
4.	<u>Strix ocellata</u>	2

Figure 2. Relationship between numbers of raptors and waterfowl.

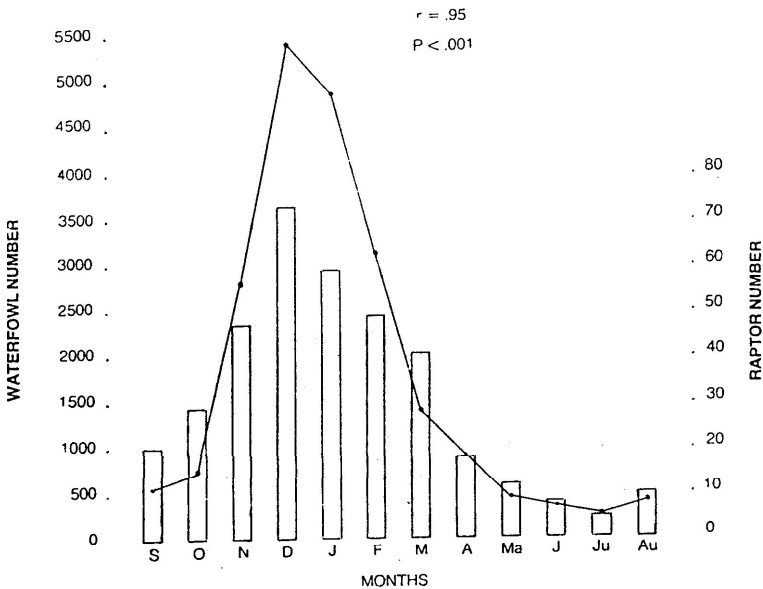
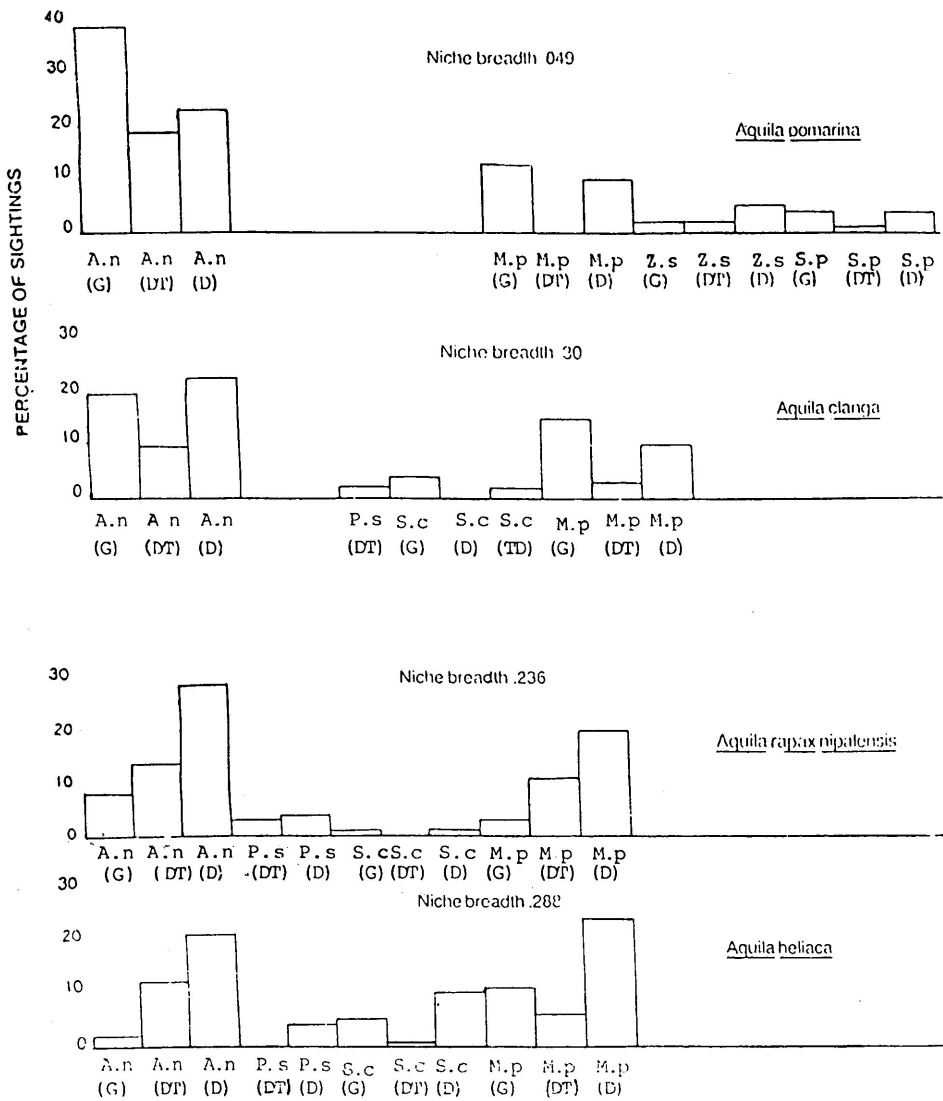


Table 5. Tree usage (%) by major raptor species.

SPECIES	TREE SPECIES									χ^2
	Acacia nilotica	Acacia leucophloea	Prosopis spicigera	Prosopis juliflora	Mitragyna parvifolia	Syzygium cumini	Zizyphus jujuba	Tamarix aphylla	Savadora persica	
Black-winged Kite	14.5	9.11	30.2	1.56	13.8	2.00	17.70	-	10.9	180.86
Honey Buzzard	26.37	-	-	-	21.97	25.27	13.18	-	13.18	7.49
Imperial Eagle	35.41	-	6.5	-	40.57	17.17	-	.30	-	407.33
Steppe Eagle	51.55	-	10.6	-	35.23	2.07	-	.519	-	970.22
Greater Spotted Eagle	52.60	-	4.03	-	28.42	6.04	-	8.8	-	423.70
Lesser Spotted Eagle	58.82	-	-	-	22.63	-	8.9	9.6	-	369.08
Pallas' Fishing Eagle	53.97	-	8.42	-	23.13	13.76	-	.71	-	233.84
Marsh Harrier	39.02	-	7.3	-	36.58	4.8	12.1	-	-	222.50
Short-toed Eagle	22.27	-	54.40	-	17.61	2.5	-	-	3.1	172.00
Crested Serpent Eagle	40.00	-	-	-	-	24.28	21.42	14.28	-	9.8

Figure 3. Niche breadth for sympatric *Aquila* species.



Tree species and classes:

A.n. *Acacia nilotica*

P.s. *Prosopis spicigera* G Greeb

S.c. *Syzgium cumini* DT Dry top

M.p. *Mitragnya parvifolia* D Dry

Table 6. Perch preferences among sympatric *Aquila* species.

TREE SPECIES	% usage by				G. VALUE
	<i>Aquila</i> <i>heliaca</i>	<i>Aquila</i> <i>nipalensis</i>	<i>Aquila</i> <i>clanga</i>	<i>Aquila</i> <i>pomarina</i>	
<i>Acacia nilotica</i> (green)	2.4	7.7	20.56	39.5	200.54
<i>Acacia nilotica</i> (dry)	12.15	14.24	9.8	8.9	60.29
<i>Acacia nilotica</i> (dry-top)	20.82	29.52	22.8	13.36	153.47
<i>Prosopis spicigera</i> (green)	1.97	3.6	2.4	-	15.7
<i>Prosopis spicigera</i> (dry)	.75	3.1	-	-	19.81
<i>Prosopis spicigera</i> (dry-top)	3.7	3.8	1.6	-	20.46
<i>Syzygium cumini</i> (green)	5.31	1.2	4.03	-	12.24
<i>Syzygium cumini</i> (dry)	1.5	-	-	-	75.4
<i>Syzygium cumini</i> (dry-top)	10.33	.83	2.01	-	25.35
<i>Mitragyna parvifolia</i> (green)	10.6	3.1	15.12	12.8	86.2
<i>Mitragyna parvifolia</i> (dry)	5.6	11.33	3.22	-	152.54
<i>Mitragyna parvifolia</i> (dry-top)	24.3	20.3	10.08	9.8	47.94
<i>Tamarix aphylla</i> (green)	.3	.51	7.2	-	-
<i>Tamarix aphylla</i> (dry)	-	-	-	1.6	-
<i>Tamarix aphylla</i> (dry-top)	-	-	-	-	-
<i>Zizyphus</i> SP (green)	-	-	-	1.7	-
<i>Zizyphus</i> SP (dry)	-	-	-	2.1	-
<i>Zizyphus</i> SP (dry-top)	-	-	-	4.9	-
<i>Salvadora persica</i> (green)	-	-	-	3.9	-
<i>Salvadora persica</i> (dry)	-	-	-	1.2	-
<i>Salvadora persica</i> (dry-top)	-	-	-	4.4	-

In all, 9 tree species were used as perches. Most of these were the tallest in the local area. Significant differences in preference were evident between species (Table 5). The sympatric marsh-loving species of *Aquila* (Imperial Eagle, Steppe Eagle, Greater Spotted Eagle) shared almost similar habitats with reference to tree species (Friedman two-way analysis of variance (Lehner 1979) X^2 $r=1.2$, not significant). However there was a significant difference in the utilisation of different classes of trees by the 4 sympatric *Aquila* species (Table 6) (G-Test, $P < 0.001$). The Imperial Eagle preferred dry-top *Mitragyna parvifolia* (24.3%), whereas the Steppe Eagle had almost equal preference for green (20.56%) and dry *Acacia nilotica* (22.1%). The fulvous phase of Greater Spotted Eagle was seen more often on green *Acacia nilotica*, as was the Lesser Spotted Eagle.

The 'niche breadth' (Levins 1968) with respect to perch-trees was the highest in Greater Spotted Eagle (0.30), followed by Imperial Eagle (0.288), Steppe Eagle (0.236) and Lesser-Spotted Eagle (0.0493) (Fig. 3). This could have been due to the more even utilisation of tree classes by the Greater Spotted. Imperial and Steppe Eagles had the highest niche overlap (Hurlbert 1978) ($\alpha = 0.72$), followed by Imperial and Greater Spotted ($\alpha = 0.86$) and then Greater Spotted and Steppe ($\alpha = 0.66$). Lower values were found for Imperial and Lesser Spotted Eagles (0.047), for Steppe and Lesser Spotted Eagles (0.273), and for Greater Spotted and Lesser Spotted (0.078).

The population increased in winter owing to the influx of migrants, 53% of raptors being migratory. The habitat around the marsh and adjoining forest was utilised by the majority of species (66%). There was a high positive correlation between the prey species and the raptor population, and between the raptor population and water-depth. Thirty species of *Accipitridae* were recorded in Keoladeo National Park, among which 5 were new records. Almost all had a significant difference in tree species preference. The water-loving species of *Aquila* shared similar habitats. There was a significant difference in the utilisation of different classes of trees by *Aquila* spp.

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