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## Prey Item Selection and Prey Delivery of Indian Spotted Eagle during Chick-Rearing Period in Nepal

### Sandesh Gurung

“Himalayan Nature/ Nepalese Ornithological Union”  
Trishakti Marg – 91, 44600 Lazimpat, Kathmandu  
Email: sandeshgurung07@gmail.com

### Tulsi Ram Subedi

“Himalayan Nature/ Nepalese Ornithological Union”  
Trishakti Marg – 91, 44600 Lazimpat, Kathmandu  
Email: tulsi.biologist@gmail.com

### Munir Virani

“The Peregrine Fund 5668”  
West Flying Hawk Lane, Boise, ID 83709 USA  
Email: virani.munir@peregrinefund.org

### Ralph Buij

“The Peregrine Fund 5668”/ Wageningen University and Research Centre  
West Flying Hawk Lane, Boise, ID 83709 USA/ PO Box 47, 6700 AA Wageningen, The Netherlands  
Email: ralph.buij@gmail.com

### Simon Thomsett

“Ornithological Section, Department of Zoology, National Museum of Kenya”  
Nairobi, Kenya  
Email: sthomsett@gmail.com

### Hem Sagar Baral

School of Environmental Sciences, Charles Sturt University/ “Zoological Society of London-Nepal Office”  
Albury-Woodonga, Australia/ PO Box 5867, Kathmandu, Nepal  
Email: Hem.baral@gmail.com

### Dheeraj Chaudhary

“Himalayan Nature”  
Trishakti Marg – 91, 44600 Lazimpat, Kathmandu  
Email: Dheeraz18@gmail.com

## ABSTRACT

The Indian Spotted Eagle (*Clanga hastata*) is a vulnerable species and distributed largely limited within the Indian sub-continent. This species is recently separated from Lesser Spotted Eagle (*Clanga pomarina*) and little information exists on the species' ecology and prey item selection. Here we present the first ever study on the diet of Indian Spotted Eagle during breeding season in lowlands of Nepal. In 2018, we conducted 720 hrs. observation on active nests (n = 3) during chick-rearing period (June – August) to record prey items delivery. In each day, observation was conducted from dawn to dusk that allowed us to record all deliveries of the day. We reported a total of 132 prey deliveries;

frogs contributed the highest (70.3%) proportion among the selected prey items, followed by small mammals (14.41%), birds (7.58%), lizards (0.73%), and a small proportion of unidentified (6.93%) prey items. Male Indian Spotted Eagle delivered most of the prey items (94.70%) and female mostly fed the eaglets. The most preferred feeding time to the eaglet was between 16:00 – 17:00 hrs, followed by 08:00 – 09:00 hrs. Average daily delivery rate of prey was  $2.21 \pm 0.73$  (range = 0 – 3). Binomial test showed no significant difference in the deliverance of prey items before and after the noon time among in all active nests. Although this area is rich on several species of prey items their preference of frogs in a diet during breeding season could have two possible reasons. First, in our study area chick-rearing period of Indian Spotted Eagle occurs in the middle of monsoon season that favors the growth of frogs in the flooded fields making them easier to be hunted. Second, frogs' meat is softer than other prey items and nestlings of Indian Spotted Eagle might have preferred than others.

**Keywords:** Indian Spotted Eagle, Nepal, Chick-rearing period, prey items frogs

## INTRODUCTION

The Indian Spotted Eagle (*Clanga hastata*), formerly considered a subspecies of the Lesser Spotted Eagle (*C. pomarina*) [1], has an estimated population of less than 100 pairs [2], making it one of the world's rarest raptors. The species is largely restricted to Indian-subcontinent, from Bangladesh, Cambodia, Myanmar, India, Pakistan and Nepal, up to 1000 m a.s.l.[3], where it is largely constrained to lowland deciduous dipterocarp forests [4]. Rapid infrastructure development work, deforestation and overall degradation of landscapes of the lowland has huge impact on wild species [5]. The changes is likely to affect all organisms residing in that landscape including Indian Spotted Eagle (*Clanga hastata*), a rare poorly understood apex predator. With a small population along with declining numbers this species has been listed as a globally Vulnerable species on the IUCN Red List [3].

Very little is known about the breeding biology and diet of Indian Spotted Eagle. The species apparently prefers to hunt in open wetlands, marshy areas, within or near the deep forest [6], where it captures a wide range of prey items including small mammals, amphibian, medium-large sized birds, reptiles and insects [6,7]. Study in the southwest of India reported rodents as the main dietary of Indian Spotted Eagle in a breeding season [8]. Several diet studies have been conducted throughout the distribution range of the conspecific Lesser Spotted Eagle [9, 10, 11, 12]. These have shown that wider vertical breeding range (0-1000m a.s.l) of the Lesser Spotted Eagle has led higher diversities on its diet including mammals (88.11%, 19 species), bird (6.25%, 24 species) while amphibians, reptiles and pisces as a whole shared 4.89% [12]. In Georgia nests located at wet land area has a higher proportion of frog as its major dietary [10] while the area with much warmer and drier places has a significantly higher ratios of reptiles [13]. Surprisingly, In 2004 Trienys and Dementavicius recorded switching of major prey (rodents) into alternatives prey (amphibians) when the rodents abundance decreased. The difference in foraging habitat can also give different results [14] while prey base year can be another important factors regarding on the diet study [15]. Here, we quantify for the first time the breeding season diet of Indian Spotted Eagle using observations at three nests in the "Terai" lowlands of Nepal.

## STUDY AREA

This study was conducted in the lowland belt of Nepal at Bhagalpur (26.7142<sup>o</sup>N and 87.0025<sup>o</sup> E) of Koshi Tappu Wildlife Reserve, Dhanusa Dham Community Forest (26.8480<sup>o</sup>N and 86.0527<sup>o</sup>E) of Dhanusa and Lumbini (27.5009<sup>o</sup>N and 83.2788<sup>o</sup>E) at Rupandehi. The weather of the study area is tropical to subtropical, and average monthly rainfall ranged from 682 mm of rainfall in July and 9.5 mm in December and more than 85% of precipitation occurs in the monsoon period between June and September in Koshi and Dhanusa. In Lumbini the average monthly rainfall ranged from 186.36mm in

July and 1.01mm in January. Autumn and spring seasons are shorter while the summer season tends to be longer and winter to be shorter. The daytime temperature ranges between 24 to 40 degrees Celsius in summer and the winter temperature ranges from 27 degree to 9 degree Celsius. The monsoon season starts 7-10 days earlier in Bhagalpur and Dhanusa Dham compared to Lumbini. The daytime temperature ranges from 24 – 40 degree Celsius in summer while the winter temperature ranges from 8 – 25 degree Celsius. The study area is a mosaic of different kinds of habitats, dominated by thin forest of *Dalbergia sissau* where the eagle breeds, surrounded mainly by farmlands habitat and smaller to medium-sized patches of grasslands with perennial sources of water e.g. small rivers.

## MATERIALS AND METHODS

Pair formation and mating in Indian Spotted Eagles generally takes place from the third week of February and the last week of March, which is followed by incubation from March-May; we timed our nest observation to coincide with the nestling phase during June-August [7]. From 2016 and 2017, based on the information from the senior ornithologists, bird guide and local people, the different potential habitat were intensively searched. Later on five nests were discovered in the three different places. Each of the nests discovered were given name, Nest “A”, “B”, and “C” for Lumbini nests, Nest “D” for Dhanusa nest while Nest “E” for the Bhagalpur nest of Indian Spotted Eagle. Nest “C” and “D” failed during incubation. The reason for the nest failure was not known. Hence monitoring of prey delivery during the chick-rearing period was conducted at Nests “A”, “B” and “E”. Observation of prey delivery was conducted from a camouflaged blind placed 40-60 m away from the nest [16]. In 2018, 20 days were spent to monitor prey provision by adults to their eaglet on each active nest (i.e., 60 days in total, or 720 hours). Prey items delivery were monitored on 11<sup>th</sup>-24<sup>th</sup> June and 5<sup>th</sup>-10<sup>th</sup> July for nest “A”, 2<sup>nd</sup>-15<sup>th</sup> July and 1<sup>st</sup>-6<sup>th</sup> August for nest “B” and 14<sup>th</sup>-27<sup>th</sup> July and 7<sup>th</sup>-12<sup>th</sup> August for nest “E”. Prey delivery was monitored continuously from early morning (06:00 h) to evening (18:00 h) by a single observer, using Vortex 10X42 and Opticron 10X42 binoculars, and a Vortex Razor 20-60X spotting scope. In addition, photographs of prey delivery were taken to confirm prey identification at a later stage using a Nikon d5200 DSLR camera with 200-500 mm Nikor lens. The prey items were identified to the most specific taxonomic possible. The delivery time and feeding time was recorded, and whether delivery and nestling feeding was conducted by the male or the female, on the basis of their size (males in Indian Spotted Eagles are about 10-15% smaller than females; Tulusi R. Subedi, Simon Thomsett and Sandesh Gurung personal communication). We recorded the certain characteristics of each individual such as its color, feather plumage, molts to enable proof of identity when only one individual was present in the nest.

## RESULTS

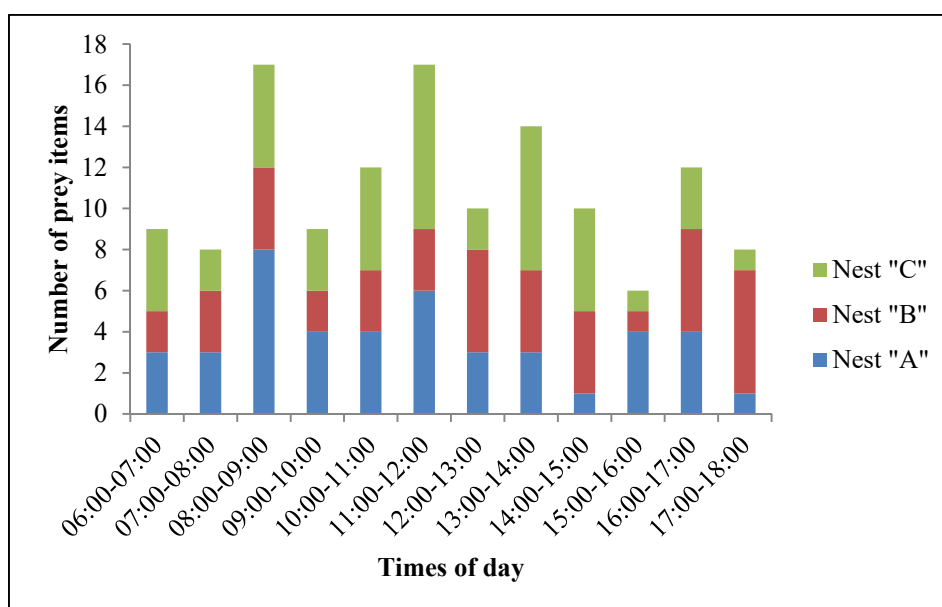
During the study period the five nests were discovered (three nests at Lumbini, one at Dhanusa and one at Koshi). Out of five nests, four were built in the *Dalbergia sissau* tree while nest of Dhanusa at *Shorea robusta*. The height of nesting trees were 15±3.63 meter and nests were 11.28±3.01 SD above the ground. The average distance between the water resources and nesting tree was 78.54 meter. We recorded 132 prey items delivered in the nests (Fig 1). The dominant part of diet was created by Frog (*Rana sp.*) among the prey items (mean = 70.3% ± 8.75 SD). Small mammals (mainly rodents=18 and Five Striped Palm Squirrel *Funambulus penantii* = 1) of order rodentia were the second most important prey item (mean = 14.41% ± 6.58 SD) followed by birds (mean = 7.58% ± 4.28 SD), reptiles (mean = 0.73% ± 1.07 SD) and unidentified prey items (mean = 6.83% ± 3.51 SD). Most frequently detected small mammals were rodents while Five-palm Squirrel was delivered once in Nest “E” (Table 1). Out of 12 avian preys delivered in the nests, only six individuals were identified up to species level (one adult Brahminy Starling *Sturnia pagodarum*, one adult Cattle Egret *Bubulcus ibis* and four chicks

of Bronze-winged Jacana (*Metopidius indicus*) meanwhile other birds were chick of the other wetland birds. Common Garden Lizard (*Calotes versicolor*) was delivered once by adult male of nest “A”.

**Table 1.** Percentage of different prey item delivered to the eaglet in the three different nests

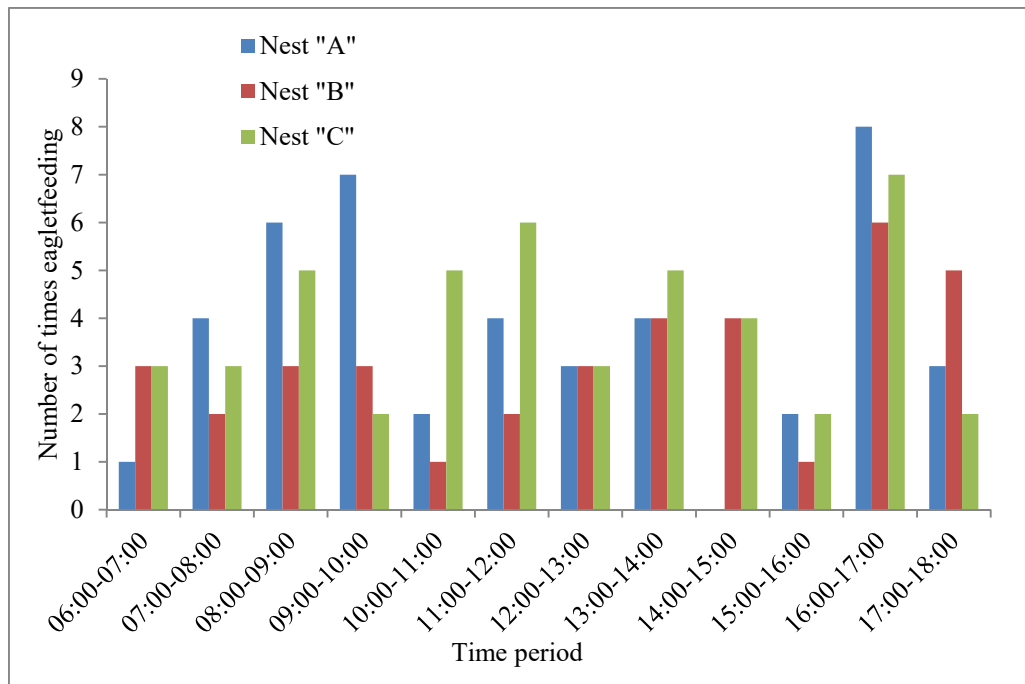
Nest	Frog (%)	Lizard (%)	Bird (%)	Rodent (%)	Squirrel (%)	Unidentified (%)
Nest "A"	59.09	2.27	13.64	20.45	0.00	4.55
Nest "B"	71.43	0.00	4.76	11.90	0.00	11.90
Nest "E"	80.43	0.00	4.35	8.70	2.17	4.35

Males delivered most prey items to the nest (94.70%), however females mostly fed the chick (87.5% of 113 prey items delivered to the nest). Once, an adult male was seen feeding the chicks, on 15<sup>th</sup> of June. The parents fed the eaglet 128 times. Fifteen times the young eaglet of Koshi was seen feeding the prey items by themselves when the eaglet reached about 6 weeks old. Of the total prey delivery, 72 preys were delivered before the noon (54.54%; Fig 1). Prey delivery time (before and after noon) did not show any significance difference in all three nest (nest “A” = 28 vs 16, nest “B” = 17 vs 25 and nest “C” = 27 vs 19, Binomial test,  $P > 0.05$ ; Fig 1).



**Figure 1.** Frequency of the prey items delivered at the three nests (Lumbini and Khosi) by Indian Spotted Eagle as a function of time of day in lowlands of Nepal

The peak feeding time was between 16:00 – 17:00 h, followed by 08:00 – 09:00 h (Fig 2). Single prey items were recorded during each delivery. The average prey delivery was  $2.21 \pm 0.73$  SD/day (range = 0 – 3/day).



**Figure 2.** Frequency of prey items fed to the eaglet at three nests (Lumbini and Khosi) by parent as a function of time of day

## DISCUSSIONS

We found that Frog (*Rana sp.*) as the major dietary followed by small mammals (mainly rodents) of the Indian Spotted Eagle during the breeding season in lowlands of Nepal. Prey items delivered by the Indian Spotted Eagle in our study were very similar to the main food items as described by Naoroji (2006) and Shivprakash et al. (2006). In contrast, Sant and his friends found that rodents (73% of 90 items) dominated the diet at a nest in southwest India [8]. They conducted prey items monitoring to cover entire breeding season (January- July), mostly in spring when wheat is harvested (February to May). Rodents are easily accessible in this season [17, 18]. We covered only the chick-rearing/nestling period that overlapped with the monsoon season (June – August), when frogs are relatively more abundant and conspicuous in rice field, ponds, marshy and swampy area, small rivers and ditches [19]. A study in Langholm moor of Scotland proposed raptors as a limiting factor responsible to halt the increase in the density of the grouse inferring hunting success rate increases as the increase in the abundance of the prey species goes high [20]. If the abundance gets higher the detection rate by predator to prey gets higher. If detected by predators, amphibians are easy to catch by losing lesser amount of energy and have higher profitability to it compared to small mammals and birds [21]. Meanwhile due of the water all over the exposed area the mouse and other reptiles tends to move towards the more drier and safe places, the human settlements. As a consequent the detecting of these prey species in foraging area gets lesser as the abundance gets decreased so then the frequency of such prey delivery gets lowered. On the other hand the frogs meat are much softer compared to other species recorded in the study area. Soft tender fleshes are easier to tear and eat for the eaglet. Due of the softness of the meat, preferences of the frog meat by the eaglet could be another possible reasons. Our study design was different from that of Sant and his friends [8], they mostly conducted observation hours only in the morning (06:30-10:00 h) and afternoon (15:30 -18:30 h), and covered more months of the breeding season that could lead to the different result. As in the spring to early monsoon rice field gets open along with no or very less water in the field might have made eagles much easier to detect field mice than frogs [8]. Since our finding shows that this species shares very



similar dietary needs of its closely related conspecific Lesser Spotted Eagle in Georgia [10] and Belarus [11] however contrast with that of research in Slovakia [12] and in Hungary [9]. One of the possible explanations of obtaining higher percentage of amphibians as main dietary rather than rodents could be related to the alternatives prey hypothesis. The alternative hypothesis inform, predators (raptors) often alter their preferred diet into alternative species when the major prey population goes on decreasing in their hunting area [22]. For instance, the share of voles in the summer diet of North-European vole-eating birds of prey usually differs many times between vole-poor and vole-rich years [22, 23, 24, 25]. The present finding of prey deliverance by adult male (94.70%) and feeding of delivered prey items by adult female (87.5%) to eaglet in the nest makes an agreement with the scientific study conducted on Belgaun [8]. In addition to this, very similar behavior has been recorded on its closely related Greater Spotted Eagle [26]. Similar behavior of task partition with male delivering the prey and female feeding it to eaglet were also recorded in the study of other large eagles such as Spanish Imperial Eagle in central Spain [27], Golden Eagle [28, 29], Black Eagle [30], Mountain Hawk Eagle [16]. Such activities of adult male feeding less to their eaglet could provide them sufficient time for hunting thus optimizing the division of role and parental investment. The most preferred feeding time period was 16:00 – 17:00 h, followed by 08:00 – 09:00 h, Study on breeding biology of Indian Spotted Eagle showed agreement with our finding [7, 8]. Similarly Indian Spotted Eagle closest relatives Greater Spotted Eagle were also proposed to have a similar behavior when it comes about feeding the eaglet [26]. Similar behaviors were recorded among in larger eagles such as Mountain Hawk Eagle [16] feeding mostly at morning, Spanish Imperial Eagle [27]. As the chick rearing period progressed, the chick became more proficient at feeding the prey items delivered in the nest by itself (15 times in nest “E” observed). Similar behavior was recorded in Indian Spotted Eagle studied in Belgaum of India [8], Spanish Imperial Eagle in Central Spain [27], Imperial Eagle studied in Southwest Spain [31], Golden Eagle [28].

## CONCLUSIONS

This study was undertaken to assess prey item selection and delivery of prey items to the eaglet at chick rearing stage in lowlands of Nepal. This research clearly revealed that frog (*Rana sp.*) as a major prey most frequently delivered in the nest, followed by rodentia order of small mammals, birds and the least delivered reptiles in the study area. The parental role of male during the chick rearing period was to provide foods, rarely fed the young ones. Meanwhile the female fed the food delivered by the male and hardly hunted the prey to feed their brood. The result of the investigation pointed out the most preferable time period to feed the eaglet was 16:00 – 17:00 hrs followed by 08:00 – 09:00 hrs however the deliverance of the prey items by parent in the nest before and after the noon didn't show any significant difference. Prey provision to the brood ranged from 0 – 3.

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