

## Foraging and nesting behavior of Pallas's fish eagle, *Haliaeetus leucoryphus* (Pallas, 1771) in the Himalayan Bhutan

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### Abstract

Pallas's fish eagle, *Haliaeetus leucoryphus* (Pallas), is listed as endangered (EN) in the IUCN Red List of Threatened Species with a global population of 2,500 to 9,999 individuals. It is one of the least known species in Bhutan and assessing its foraging and nesting behavior will be one of the best conservation measures to monitor its status, ecology and conservation threats. Therefore, the nesting behavior of the eagle was observed for two months and chick feeding activities for sixteen weeks at 21 vantage points along a 75 km highway in the Punatshangchu River Valley, Bhutan. Fifty households residing 500 m from the river were interviewed using structured questionnaires to examine their perception towards the eagle. A total of 92% (n= 46) of respondents were aware of the presence of *H. leucoryphus* in their locality and 78% felt that it is a rare and endangered fishing eagle. However, 84% (n= 42) of respondents were not aware of nesting within their vicinity. The sexes of *H. leucoryphus* can be differentiated by their plumage and the fledgling was observed approximately one week after the end of the incubation period. It took 112 days for the fledging to leave the nest. The study revealed that the eagle preferred foraging between 7 and 9 AM in the morning and in the afternoon from 1 to 3 PM. The maximum foraging attempts occurred in a pool habitat 54% (n= 37) with a success rate of 78% (n= 54). The hunting and feeding of the fledgling was done by the male and prey delivery in the first two months consisted of 78.5% fish and 19.5% rodents. However, the feeding of fish declined by 35% in the next two months and its diet mainly consisted of small birds. Attacks on the fledgling were done by the crested serpent eagle (*Spilornis cheela* Latham) (48%), followed by the black eagle *Ictinaetus malaiensis* (Temminck) (33%).

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### Introduction

Pallas's Fish Eagle, *Haliaeetus leucoryphus* (Pallas), is considered to be a poorly studied fish eagle across its entire range (Tingay and Katzner, 2010). The species was formally considered to be locally common across central and southern Asia, however, during the 20<sup>th</sup> century, the species range has retracted significantly and is believed to be largely absent from its former

stronghold areas such as the Caspian and Kazakhstan areas (Sourav et al., 2011; Gilbert et al., 2014; Birdlife International, 2016). Due to declining population size, it has been classified as "Vulnerable" by the International Union for Conservation of Nature [IUCN] (IUCN, 2016). The conservation status was further downgraded to "Endangered" in 2021 (IUCN, 2023). The number of mature individuals in the wild is estimated from 2,500 to 9,999 individuals (Birdlife International, 2016).

In countries where the species exists, the population is likely to be declining, although quantifiable data is lacking as only a few formal surveys have targeted this species (Barua and Sharma, 1999). The population decline is believed to be due to degradation of wetland habitats, loss of potential nesting trees, pollution from agricultural and human persecution (IUCN, 2016). The main breeding populations of *H. leucoryphus* are believed to be in China, Mongolia and South Asia and nests are most often placed on the highest point of forked tree branches which overlook water and lakes (Lahkar, 2000). The diet primarily consists of freshwater fish, rodents (Chowdhury et al., 2020) and various water birds (Sourav et al., 2011).

In 1988, Bhutan was identified as one of the ten biodiversity hotspots of the world. Bhutan is a repository of more than 700 species of birds, including 221 global endemic birds, 18 of which are globally threatened, 4 Critically Endangered (CR) and 16 Near-threatened (NT) (BBSAP, 2014). The Pallas's fish eagle, *H. leucoryphus* is a globally threatened fish eagle that occurs in four major rivers of Bhutan and its breeding sites are reported from the Punatshangchu, Mangdichhu, and Kurichhu valleys (Spierenburg, 2005). However, there is a paucity of information on foraging and nesting behavior of *H. leucoryphus*.

Currently, conservation priority has been given to the critically endangered White-bellied heron, *Ardea insignis* Hume, while other globally threatened species such as *H. leucoryphus* has not received any local priority. Therefore, information on this species in Bhutan, as well as elsewhere in the world, is very limited. It is crucial to have adequate information on foraging and nesting areas for effective conservation and management of this rare bird both at local and global levels.

## Material and Methods

### Study area

Punatsangchu is one of the major rivers in Bhutan that flow across the western region, through the six administrative districts of Gasa, Punakha, Wangdiphodrang, Tsirang, Dagana and Sarpang. Phochu and Mochu rivers are its major tributaries contributing more than 80% of the flow volume. The study area along the Punatsangchu basin lies at latitude 27°34'13.92" N and longitude 89°52'16.82" E, with an altitude variation from 485 to 1375 meters above sea level (m a.s.l.) (Sherub, 2004).

### Study design

For this study, the Punatsangchu River was divided into three sections; Mochu, Phochu and Punatshangchu. In total, a 75 km stretch of the river was covered for the survey (Fig. 1). Keeping the river as the transect, a motor vehicle was used to monitor along the existing Punakha-Samdengkha farm road

and Punakha-Gasa highway. At 500 m intervals a 10-min stop was made to scan for perching, roosting and foraging *H. leucoryphus* using Adorrgon 12x42 HD binoculars and a Canon 7D Mark II DSLR camera with a Canon 600 mm lens. A hand-held GPS (Garmin) was used to record the distance travelled at each site. The maps were prepared using ArcGIS 10.2.2 version. An additional transect survey was made in areas that were vehicle inaccessible. Transects walk were carried out during the 1<sup>st</sup> and 3<sup>rd</sup> week of the month using same method used in vehicle transect and vantage point observations was made during the 2<sup>nd</sup> and 4<sup>th</sup> week of the same month (Fig. 1). Data on feeding, roosting and nesting sites of *H. leucoryphus* were collected from the transect survey and vantage observation points and the social survey was conducted using questionnaires.

### Foraging behavior

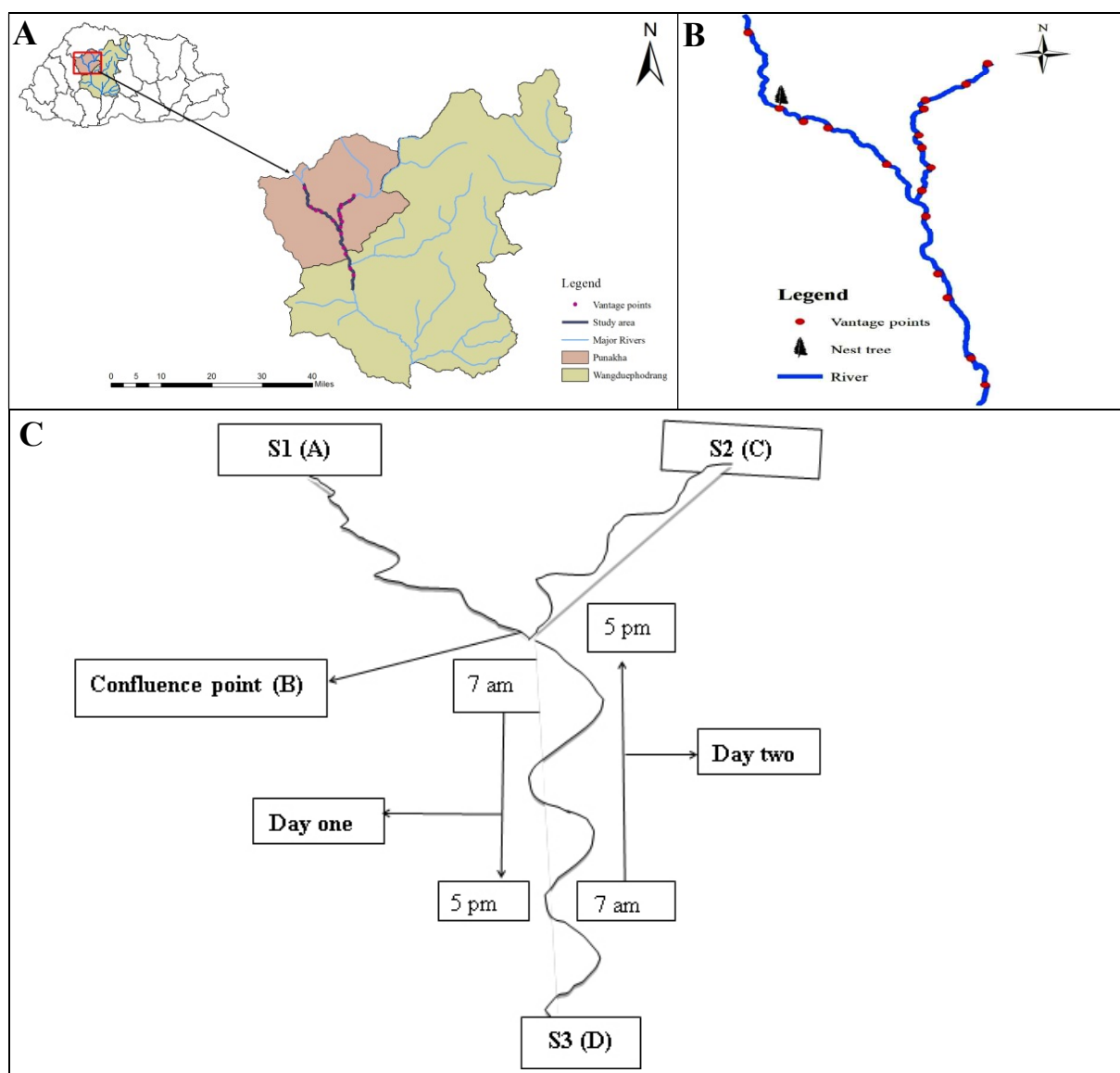
For each foraging attempt, details on habitat type, foraging time and attacks, prey type, and success/unsuccessful attempts were recorded. Foraging habitats were classified as: Run (a section of the river where the water is relatively deep and fast-moving, with a smooth surface and no obstructions); Riffle (a section of the river where the water is shallower and flows over a gravel or rocky bottom, creating a riffled or broken surface); and Pool (a section of the river where the water is deep and slow-moving, often found in areas where the river widens or deepens due to an obstruction or bend in the channel) (The Healthy Headwaters Lab, 2023). Foraging behavior was classified as: perching, when *H. leucoryphus* forages from a tree; flapping, when the eagle flaps its wings in the air; soaring, when the eagle soars or rises high in the air without flapping; and hovering, when the eagle remains stationary in the air by flapping. To determine active foraging times, observations were done in four periods; morning (0700 – 0900 hours), mid-day (0900 – 1100 hours), afternoon (1300 – 1500 hours) and evening (1500 – 1700 hours) (Fig. 1).

### Nest and perch tree characteristics

Trees used by *H. leucoryphus* for perching and nesting had the following parameters recorded: tree species name, diameter-at-breast-height (DBH), height, growth form, and distance from river, road and settlements. Geographical information such as GPS coordinates, elevation and slope were also recorded.

### Nesting behavior

Nest observations were made once a week from a vantage point about 600–800 m from the nest. Only observations which could ascertain the gender of the individual were used when analyzing the data. Feeding activities were observed from 0700 to 1700 hours. A total of 160 daylight hours (16 days with 10 observation hours per day over 16 weeks) of data was collected from nesting sites.



**Figure 1:** Study area map of *Haliaeetus leucoryphus*. A. Map of Bhutan showing position of the Punatsangchu River and its two tributaries Mochu and Phochu Rivers; B. Observation vantage points on the Punatsangchu River; C. River sections for transect walk and data collection.

### Male and female identification

During the study period distinct plumage differences between male and female *H. leucoryphus* was observed and confirmed using a dead specimen of *H. leucoryphus* that was encountered on 14/09/2017. To confirm the gender of this individual, a postmortem was conducted by an ornithologist from Ugyen Wangchuck Institute for Conservation and Environmental Research and a veterinary doctor from the College of Natural Resources (CNR), Bhutan. The intent was to determine and confirm the plumage differences between the male and female, as definitive information on this was lacking. Breeding pairs of eagles at Phochu River and other pairs at Mochu River were also monitored for this study.

### Questionnaire survey

All households within 500 m of the Punatsangchu River were selected for interviews using ArcGIS

10.2.2. The questionnaire survey was conducted to get local people's perception of *H. leucoryphus*. The door-to-door interviews of the households were conducted from December 1–30, 2016. A total of 50 households were interviewed. The questions were set to get specific information on the occurrence, emerging threats to the species, and general perceptions of the local people.

### Data analysis

SPSS version 23 was used for data analysis. Cross tabulation was used to calculate foraging and feeding percent. Chi-square test was used to determine the significant differences between male and female foraging.

### Results and Discussion

The gender of *Haliaeetus leucoryphus* usually differentiated using a morphometric method based on

body weight. Females weigh 2.1–3.7 kg which is slightly larger than males at 2.0–3.3 kg (The Eagle Directory, 2016). However, such methods are typically inaccurate, especially if the traits used for sex discrimination show geographical variation, which is known to occur in many bird species (Shephard et al., 2004). Through this study, the sex distinction could be made through physical appearance based on plumage differences.

It was found that there is a distinct plumage difference between male and female *H. leucoryphus*. Adult males have dark brown plumage with a whitish head (Fig. 2A) but the upper mantle and neck are covered with buffish brown plumage (Fig. 2B). The male description was confirmed through a postmortem report (Fig. 2C, D). This sexual dimorphism was observed throughout the year.

In the female, the head, neck and upper mantle are more whitish when compared to the male. The plumage coloration is also slightly different with the presence of white feathers on the dark brown greater coverts of the wings (Fig. 3A, B). Both the male and female of *H. leucoryphus* have a black tail with a distinctive white band. Juveniles are overall darker in color with no band on the tail (Fig. 3C, D).

#### Foraging frequency in different habitats

Figure 4 compares foraging attempts in pool, riffle and run river habitats for *H. leucoryphus*. The most frequent fishing spot used by *H. leucoryphus* was the pool habitat with 64% (n= 44), followed by riffle 25% (n= 17) and then run at 11% (n= 8). Similar results were reported for the Madagascar fish eagle, *Haliaeetus vociferoides* Des Murs, by Berkelman (1997) and in the Bald eagle, *Haliaeetus leucocephalus* (Linnaeus), by Kaltenecker et al. (1998). In the current study area, owing to low river volume during winter, it is likely that pools had higher fish abundance. Fish species tend to look for pools, or areas of low stream velocity, to conserve energy during the winter season (Cunjak and Power, 1986; Hillman et al., 1987).

The maximum foraging success was observed in pool habitat compared to riffle and run (Fig. 5). Maximum unsuccessful attempts were in riffle, whereas in run habitats both successful and unsuccessful attempt were equal. The same observation was made for *H. vociferoides* by Watson et al. (1991) and *H. leucocephalus* by Brown (1993), where maximum foraging success was in pools, and success depends largely on fish abundance. Although measuring fish abundance was beyond the scope of this study, it is presumed that abundant fish and low river volume in winter would have contributed to the success of fishing in the pool habitat.

#### Active foraging time

The active foraging activities like fishing and hunting and feeding times for chicks at nest site for *H.*

*leucoryphus* were observed during the morning and afternoon hours (Fig. 6). A similar result was reported for the Osprey, *Pandion haliaetus* (Linnaeus), by Flemming and Smith (1990) and *H. vociferoides* by Nadjafzadeh et al. (2016). Berkelam (1997) reported that early morning peak foraging hours must have resulted from hunger after fasting overnight, for the Madagascar fish eagle, *Haliaeetus vociferoides*. It could also be due to eagles taking advantage of greater fish availability and calmer weather during early morning hours. During the mid-day hours, fishing activity appears to be less when the riverbank seems occupied with human disturbances. The afternoon search rate peak may be because eagles may have digested their morning food and are hungry again (Whitfield and Blaber, 1979). The results of fledgling feeding times at the nest site also indicate that foraging activities and prey delivery to the nest were highest during morning and afternoon hours (Fig. 6).

#### Nest tree description

From the one nest site, it was observed that *H. leucoryphus* used a tall and large Chirpine (*Pinus roxburghii*) tree with more unobstructed branches and a greater arc of accessibility than the nearby trees. The substantial differences observed between this nest tree and surrounding trees suggest that *H. leucoryphus* selects a nest tree from among the largest trees available nearby. This may be because of their substantial body size and the need to construct large nests to support their weight and that of any fledglings.

A tall nest could also provide a good vantage point to maximize the accessibility and visibility for foraging and territorial defense. It is also assumed that a tall nest would allow the fledgling to glide as they learn to fly. Placing the nest at a lower height would expose it to wild predators and human disturbance.

#### Hunting frequency

A comparison of the hunting frequency during each week of the breeding season indicates that males hunt considerably more compared to females (Fig. 7). The frequency of male hunting was 57% (n= 66) followed by females at 28% (n= 33) and combined hunting constituted only 15% (n= 16). Hunting by the female is therefore comparatively low. This could be because during early on the female was continuously guarding the young fledgling against predators, but as the fledgling grows, the female starts to join the male for hunting. In the final month when the fledgling became independent (self-feeding and safe from attack by other eagles) both parents start hunting and feeding the fledgling at the nest. Significant differences were found between male and female hunting frequency ( $\chi^2 (2) = 33.722, p < .05$ ).

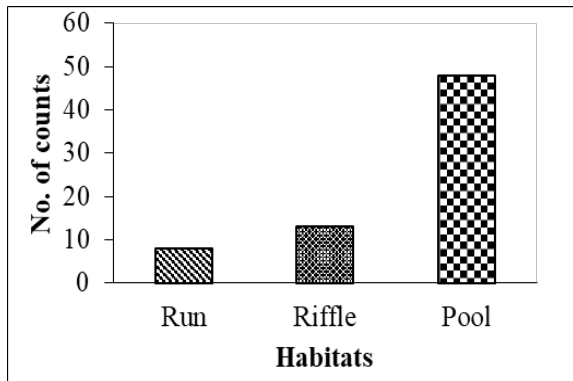
This finding is in contradiction to the report by Brodin et al. (2003) who reported that in some raptor species, like *Pandion Haliaeetus*, both parents take part in bringing food to the nest.



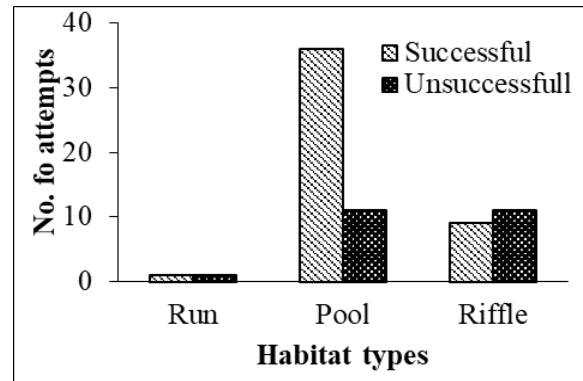
**Figure 2:** Adult male of *Haliaeetus leucoryphus*. (A) Adult male, (B) upper mantle and neck with buffish brown color, (C) dead body, and (D) dissected male genitals.



**Figure 3:** *Haliaeetus leucoryphus*. (A and B) Two females from different areas with whitish neck and mantle, (C) a juvenile with missing white pattern in its tail, and (D) a juvenile at the nest site.



**Figure 4:** Foraging frequency of *Haliaeetus leucoryphus* in different river habitats.



**Figure 5:** Successful and unsuccessful foraging attempts of *Haliaeetus leucoryphus* in different river habitats.

**Fledgling feeding by parents**

The fledgling was fed by both parents up to the 9<sup>th</sup> week, which is until the end of January after hatching in December and the maximum feeding was done by the male ( $\chi^2(2) = 15.096, p < 0.05$ ) (Fig. 8). Feeding frequency by both parents declined as the nestling matured and became proficient at self-feeding from the 9<sup>th</sup> week onwards. Maximum self-feeding was done during the 11<sup>th</sup>, 12<sup>th</sup> and 13<sup>th</sup> weeks (February). This pattern may be due to the chicks' greater energetic requirements, lower investment in nest attendance and reduction in the requirements of protection, which allowed the parents to devote more time for hunting and feeding themselves (Steyn, 1972; Brown et al., 1977; Collopy, 1984).

The overall feeding record over the 16 weeks indicated that maximum feeding was done by the male 44% (n= 51) compared to the female 17% (n= 19) and nestling self-feeding was 39% (n= 45). The average feeding frequency, considering both the male and female, was  $7 \pm 2$  times per day. The result also showed that parental tasks (feeding and hunting) during the nesting period were not shared equally between pairs. The role of male was higher than that of female. Similar observations were documented for other large eagles like *H. leucocephalus* and *H. vociferoides* (Collopy, 1984; Boshoff et al., 1991; Watson, 1991), with the Imperial eagle, *Aquila heliaca* Savigny, being an exception (Meyburg, 1989).

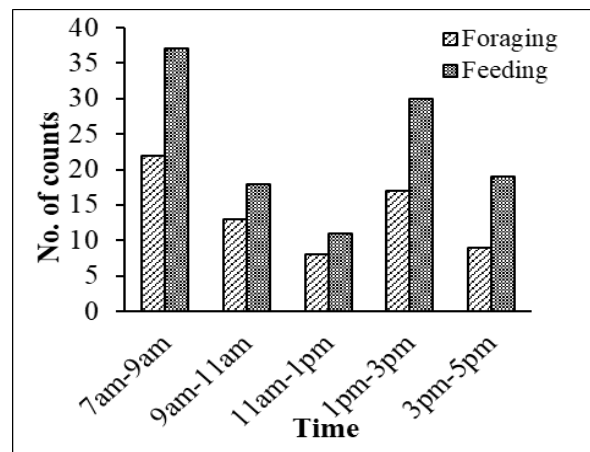
**Fledgling development**

Fledgling development at the early stages could not be recorded because the fledgling was obscured by the nest. However, during later stages, the fledgling became visible enough to record its development stages. At one month old (December) the body of the fledgling is covered with white downy plumes and the wings, with dark covert feathers and remiges, are in development. Occasionally, the fledgling was observed standing up, stretching and exercising its wings and performing small jumps (Fig. 9A). At two months old (January), some downy plumes on the top of the head, neck, ventral surface of wings and thighs are still present, however, dark and pale brown covert feathers have already covered the greater part of the body. It became aggressive to our human presence,

keeping its beak open and calling to the parents (Fig. 9B). Three months after hatching (February), the parents stopped feeding and the fledgling started self-feeding. The only downy plumes still visible were those on the ventral surface of the wings. The chick already has the appearance of a young *H. leucoryphus* (Fig. 9C). By March, when the fledgling is four months old, all the adult feathers are fully developed and the young bird took short flights (Fig. 9D). The first soaring flights were observed at 112 days.

**Prey delivery**

In total, 115 prey items were brought to the nest, of which 57% (n= 65) were fish, 20% (n= 24) were rodents and 23% (n= 26) birds. The average number of fish delivered per day to the nest was 4, followed by 1.5 rodents and 1.6 birds. Prey deliveries in the first two months (December and January) consisted mostly of fish (78.5%) followed by rodents (19.5%). However, towards the last two months (February and March), fish feeding declined to 35% and 47% of the diet consisted of birds (Fig. 10). This change in prey item delivery could be because feeding on birds would enable the fledgling to learn the skill of ripping flesh and feathers. The same observation was reported in the golden eagle, *Aquila chrysaetos* (Linnaeus) chicks by Collopy (1984).



**Figure 6:** Foraging and feeding activities of *Haliaeetus leucoryphus*.

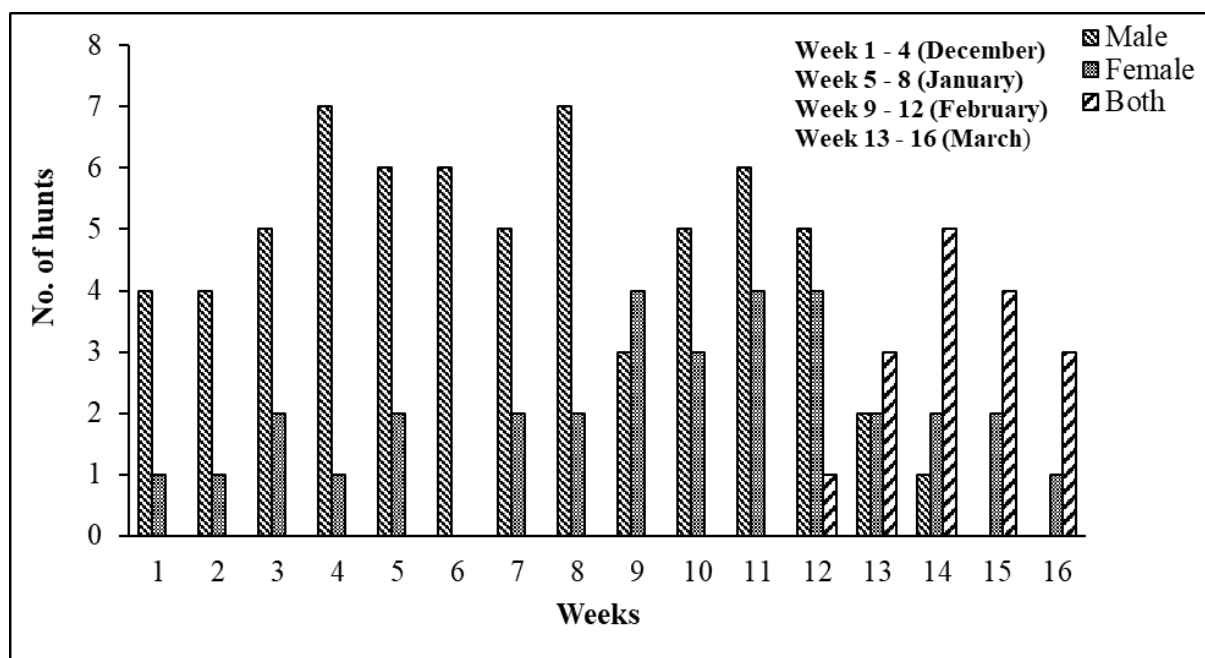


Figure 7: Frequency of hunting by parents in *Haliaeetus leucoryphus*.

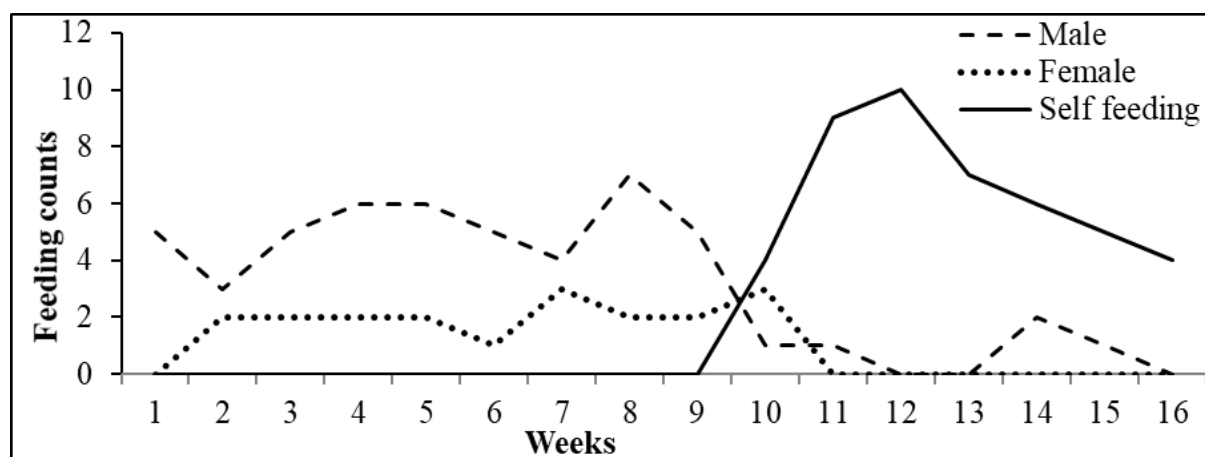


Figure 8: Feeding frequency of *Haliaeetus leucoryphus* during the nesting period.

### Fledgling attacks

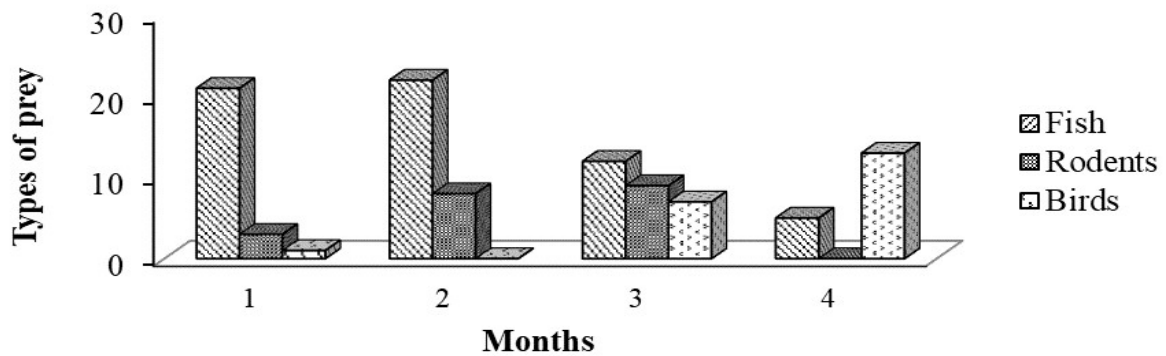
Through 27 direct observations made on a nest, the fledgling was attacked by *Spilornis cheela* 48% of the time and *Ictinaetus malaiensis* attacked 33%. The rest of the attacks were observed from other eagle species. The highest number of attacks were observed during the second month 38%, (n= 10), compared to the first month with 31%, (n= 8). This could be because predators were not fully aware of the fledgling's existence at the beginning and moreover that both parents were guarding the fledgling during the first month. However, as the fledgling matured, the frequency of attack declined, where only 19% (n= 5) and 12% (n= 3) of attacks occurred in the third and fourth months, respectively (Fig. 11). This indicates that predators may take advantage during early stages when the fledgling lack skills for self-defense.

### People's perception towards *Haliaeetus leucoryphus*

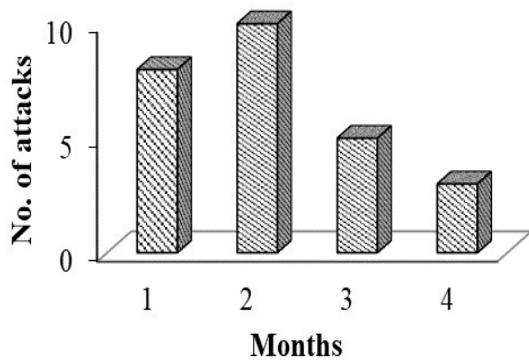
Most respondents were aware of the presence of *H. leucoryphus* in their locality. Out of 50 respondents, 92% (n= 46) were aware of the species being present in their area. The majority of respondents, 80% (n= 40), knew through personal observation, where 11% (n= 6) were informed by the government and 9% (n= 4) by neighbors (Fig. 12). This indicates that *H. leucoryphus* live or forage close to the proximity of villages. About 78% (n= 39) of the respondents felt that the species is a common fishing eagle that lives in the vicinity of their village. Only 13% (n= 7) felt that it is a rare bird species. Therefore, it is crucial to create awareness on the threatened status of *H. leucoryphus* to gain public support for its effective conservation in the study area. However, 84 % (n= 42) of the respondents were not aware of the existence of the nest in their vicinity. This could be because the nests of *H. leucoryphus* are generally located far from settlements.



**Figure 9:** Fledgling development of *Haliaeetus leucoryphus*. (A) One-month old (December), (B) two months old (January), (C) three months old (February) and (D) four months old (March).



**Figure 10:** Different prey delivery to a fledgling *Haliaeetus leucoryphus*.



**Figure 11:** Fledgling attacks at nest site of *Haliaeetus leucoryphus*.

Within a five-year period (2012–2017), 22% (n= 11) of the respondents felt that the population of the eagle in their locality has decreased. Only 4% (n= 2) of the respondents felt that the population of *H. leucoryphus* had increased. Half of the respondents, 50% (n= 25), could not confirm the population trend as they hardly care about the wildlife near their villages. Regarding the need for conservation of *H. leucoryphus*, 16% (n= 8) of the respondents strongly agreed, whereas 60% (n= 30) did not agree. Therefore, it is deemed crucial to provide an educational awareness program to those residents residing in close proximity to habitats of *H. leucoryphus*, so that the public will get more information about the current conservation status



and importance of this endangered bird. Some 24% (n= 12) of the respondents did not reveal any conservation need, as they were not aware of the presence of *H. leucoryphus*.

## Conclusion

On the basis of the research results, the sexes of Pallas's fish eagle can now be differentiated from their color plumage. However, further studies are recommended in other distributional range countries of *H. leucoryphus* to validate these findings. *Haliaeetus leucoryphus* prefers fishing in calm, pool-like stretches of rivers and successful prey acquisition largely depends on the type of river habitat. The peak foraging times were observed during morning and afternoon hours. During the mid-day hours the eagles roost when the river bank appears to be occupied with human disturbance. Trees used by the eagles for perching were among the tallest trees present on the riverbank and are mature trees with less canopy coverage. Therefore, trees like mature *P. roxburghii* with large girth have the best potential for nesting and should be exempt from rural timber harvesting, especially along the river.

During the period for rearing a fledgling, hunting and feeding tasks were not shared equally between the sexes. The male *H. leucoryphus* was the main and almost exclusive food provider during the whole nestling period while the female involvement in providing prey to the fledgling was comparatively low. Further studies, examining a larger number of nests and investigating these same factors, are necessary to better understand the parental care and foraging activity of *H. leucoryphus* over its extensive distribution range.

The majority of the local human population living within 500 m of the river were aware of *H. leucoryphus* occurrence in their localities. Local people viewed this bird as a rare and endangered

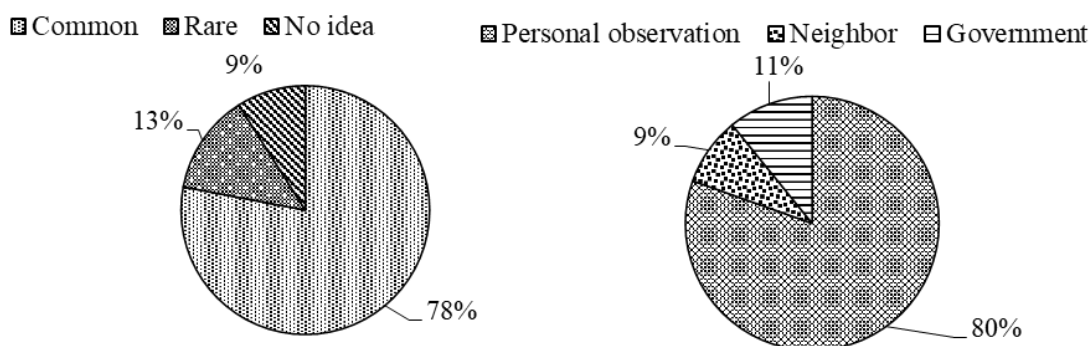
water bird. The population trend is hard to ascertain, but local people have found its numbers declining, based on the frequency of observation from the past. The presence of human fishing activities in the rivers used by *H. leucoryphus* is seen as a significant threat to its food availability, which might bring adverse impacts on the conservation of this fishing eagle in the future. This study forms a basis for future researchers to carry out long-term monitoring on the nesting ecology, population status, distribution and home range of this species to better understanding this eagle.

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## Authors contribution

S.J. conceived and designed the research. S.J., S.P., T.D., and L.T., performed the survey. S.J. analyzed the data. S.J., S.P., T.D., and L.T., wrote the draft and reviewed the article and S.J. wrote the final article.



**Figure 12:** Perception and awareness of people about *Haliaeetus leucoryphus* in Punakha District.

## Conflict of interest

All the authors declare that there is no conflicting issue related to this research article.

## References

- Barua, M. and Sharma, P. (1999). Birds of Kaziranga National Park, India. *Forktail*, 15: 47–60.
- BBSAP, Bhutan Biodiversity Strategic Action Plan (2014). Bhutan Biodiversity Strategic Action Plan, National Biodiversity Centre, Ministry of Agriculture, Royal Government of Bhutan. Thimphu, Bhutan. pp. 11–15.
- Berkelman, J. (1997). Habitat requirements and foraging ecology of the Madagascar Fish-eagle Ph.D. thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.
- Bird Life International. (2016). Species factsheet. Pallas's Fish Eagle. <http://www.birdlife.org> (Accessed 09 September 2016).
- Boshoff, A. F., Palmer, N. G., Avery, G., Davies, R. A. G. and Jarvis, M. J. F. (1991). Biogeographical and topographical variation in the prey of the Black Eagle in the Cape Province, South Africa. *Ostrich: Journal of African Ornithology*, 62 (1–2): 59–72. <https://doi.org/10.1080/00306525.1991.9639642>
- Brodin, A. Ingemar, J. K. and Holmgren, N. (2003). Optimal energy allocation and behavior in female raptorial birds during the nestling period. *Ecoscience*, 10 (2): 140–150. <https://doi.org/10.1080/11956860.2003.11682760>
- Brown, B. T. (1993). Winter foraging ecology of bald eagles in Arizona. *The Condor*, 95 (1): 132–138. <https://doi.org/10.2307/1369394>
- Brown, L. H., Gargett, V. and Steyn, P. (1977). Breeding success in some African eagles related to theories about sibling aggression and its effects. *Ostrich: Journal of African Ornithology*, 48 (3–4): 65–71. <https://doi.org/10.1080/00306525.1977.9634083>
- Chowdhury, S. U., Foysal, M. and Khan, N. U. (2020). Using community-based interviews to determine population size, distribution and nest site characteristics of Pallas's fish eagle in north-east Bangladesh. *Oryx*, 56 (4): 627–63. <https://doi.org/10.1017/S0030605321000314>
- Collopy, M. W. (1984). Parental care and feeding ecology of Golden Eagle nestlings. *The Auk*, 101 (4): 753–76. <https://doi.org/10.2307/4086902>
- Cunjak, R. A. and Power, G. (1986). Winter habitat utilization by stream resident brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*). *Canadian Journal of Fisheries and Aquatic Sciences*, 43 (10): 1970–1981. <https://doi.org/10.1139/f86-242>
- Flemming, S. P. and Smith, P. C. (1990). Environmental influences on osprey foraging in northeastern Nova Scotia. *Journal of Raptor Research*, 24 (3): 64–67.
- Gilbert, M., Tingay, R., Losolmaa, J., Sureda, N., Gilbert, C., Batmunkh, D. and Gombobaatar, S. (2014). Distribution and status of the Pallas's Fish Eagle *Haliaeetus leucoryphus* in Mongolia: A cause for conservation concern. *Bird Conservation International*, 24 (03): 379–388. <https://doi.org/10.1017/S0959270913000543>
- Hillman, T. W., Griffith, J. S. and Platts, W. S. (1987). Summer and winter habitat selection by juvenile Chinook salmon in a highly sedimented Idaho Stream. *Transactions of the American Fisheries Society*, 116 (2): 185–195. [https://doi.org/10.1577/1548-8659\(1987\)116<185:SAWHSB>2.0.CO;2](https://doi.org/10.1577/1548-8659(1987)116<185:SAWHSB>2.0.CO;2)
- IUCN, International Union for Conservation of Nature (2016). The IUCN Red list of Threatened Species. <https://www.iucnredlist.org> (Accessed 09 September 2016).
- IUCN, International Union for Conservation of Nature (2021). The IUCN Red list of Threatened Species. <https://www.iucnredlist.org> (Accessed 10 July 2021).
- Kaltenecker, G. S., Steenhof, K., Bechard, M. J. and Munger, J. C. (1998). Winter foraging ecology of bald eagles on a regulated river in southwest Idaho. *Journal of Raptor Research*, 32 (3): 215–220.
- Lahkar, B. P. (2000). Pallas's fish eagle pirates fish from an otter *Lutra lutra*. *Journal of the Bombay Natural History Society*, 97 (3): 425–425.
- Meyburg, B.-U. (1989). The Spanish Imperial Eagle *Aquila (heliaca) adalberti*: its biology, status and conservation, In: Meyburg, B.-U. and Chancellor, R. D. (Eds.), *Raptors in the Modern World*. World Working Group on Birds of Prey and Owls, Berlin, London and Paris. pp. 255–268.
- Nadjafzadeh, M., Hofer, H. and Krone, O. (2016). Sit-and-wait for large prey: foraging strategy and prey choice of White-tailed Eagles. *Journal of Ornithology*, 157 (1): 165–178. <https://doi.org/10.1007/s10336-015-1264-8>
- Shephard, J. M., Catterall, C. P. and Hughes, J. M. (2004). Discrimination of sex in the White-bellied Sea-Eagle, *Haliaeetus leucogaster*, using genetic and morphometric techniques. *Emu*, 104 (1): 83–87. <https://doi.org/10.1071/MU03043>
- Sherub. Using Habitat Models to Predict the Distribution of Birds in Bhutan: Implications for Future Research and Conservation. PhD diss., University of Wisconsin-Madison, 2004.
- Sourav, S. H., Ahmed, B. and Thompson, P. (2011). Pallas's Fish Eagle *Haliaeetus leucoryphus* in Bangladesh. *Birding ASIA*, 16: 101–105.

- Spierenburg, P. (2005). *Birds in Bhutan: status and distribution*. Oriental Bird Club, United Kingdom, 400 pp.
- Steyn, P. (1972). Further observations on the brown snake eagle. *Ostrich: Journal of African Ornithology*, 43 (3): 149–164.  
<https://doi.org/10.1080/00306525.1972.9632594>
- The Eagle Directory. (2012). Pallas's Fish Eagle - *Haliaeetus leucoryphus*. [http://www.eagledirectory.org/species/pallas\\_fish\\_eagle.html](http://www.eagledirectory.org/species/pallas_fish_eagle.html) (Accessed 09 September 2016).
- The Healthy Headwaters Lab. (2023). Great lakes Institute for Environmental Research University of Windsor, Canada. <https://www.healthyheadwaterslab.ca> (Accessed 14 June 2023).
- Tingay, R. E. and Katzner, T. E. (2010). *The eagle watchers: observing and conserving raptors around the world*. Comstock Publishing Associates, Cornell University Press, Ithaca, NY, U.S.A. 234 pp.  
[https://doi.org/10.1111/j.1557-9263.2011.00326\\_2.x](https://doi.org/10.1111/j.1557-9263.2011.00326_2.x)
- Watson, J. W., Garrett, M. G. and Anthony, R. G. (1991). Foraging ecology of bald eagles in the Columbia River estuary. *The Journal of Wildlife Management*, 55 (3): 492–499.  
<https://doi.org/10.2307/3808981>
- Whitfield, A. K. and Blaber, S. J. M. (1979). Feeding ecology of piscivorous birds at Lake St Lucia, part 3: swimming birds. *Ostrich: Journal of African Ornithology*, 50 (1): 10–20.  
<https://doi.org/10.1080/00306525.1979.9633525>