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WORLD OWL CONFERENCE
उलूक
PUNE - INDIA - 2019

Proceedings of the 6th World Owl Conference, Pune, India, 2019

Ela Foundation

Savitribai Phule Pune University
Dept. of Env. Scn. & Dept. of Zoology

महाराष्ट्र वन विभाग

DISCOVER OWLS

Global OWL PROJECT

OENSL

This special issue is dedicated to the
Late Anant Gokhale
whose tireless efforts made the
WOC, Pune, India 2019
a great success

Editorial

The 6th World Owl Conference started at Pune, Maharashtra, India on 29th November 2019. During the 5th World Owl Conference held at Evora, Portugal, I had requested the WOC managing committee to give Ela Foundation, our organization, an opportunity to host the 6th World Owl Conference in India. I was happy and felt highly honored that the managing committee unanimously granted my request. I express my gratitude to Dr. David Johnson and other dignitaries of WOC managing committee for their support.

Owls are shrouded in superstitious beliefs and are misunderstood all over the world, and our country is not an exception. It was therefore very important that the owl conference was held in India. The congregation of international experts on owls would attract the much needed public and media attention towards our owls. The hosting of an owl conference for the first time in Asia, at Pune, India, where I stay, and where we have been conducting research on owls for over three decades, would also inspire further research on these nocturnal and secretive birds that are very difficult to study.

I accepted the responsibility of Organizing Secretary of the 6th WOC and I am happy that the one of the oldest universities in the country, Savitribai Phule Pune University gladly agreed to be the co-hosts with Ela Foundation and Maharashtra Forest Department. I must express my sincere gratitude to Prof. Nitin Karmalkar, Hon. Vice Chancellor of SPPU and Mr. Nitin Kakodkar, IFS, Chief Wildlife Warden and PCCF, Maharashtra Forest Department for their support. Prof. Karmalkar offered the heritage venue of Sant Dnyaneshwar Hall with its scintillating chandeliers and adjacent complex for hosting the conference. We had the main conference hall, poster presentation hall, exhibition hall and photographic gallery to showcase the photographs of owls taken in the natural habitats. A special student conference was also conducted. Food was served in the marble hall where owl artefacts, books, and other shop items were displayed.

Prof. Reuven Yosef from Eilat, Israel and Dr James Duncan from Manitoba, Canada, unconditionally offered their expertise as members of the scientific committee. The tireless efforts of Ela Foundation volunters made the conference a great success. Excellent research papers were presented in the 6th WOC, Pune, India. The conference was attended by owl researchers from 17 countries.

The WOC, Pune, India was followed by a vist to Ela Habitat, Pingori, taluka Purandar, Pune, the field research station of Ela Foundation which is 61 km from Pune. Researchers from the international community visited the 2nd Indian Owl Festival which was hosted there, back to back with the WOC. This two-day festival, which is aimed to create public awareness and education about owls to promote their conservation and protection, was attended by atleast 15,000 students, teachers, farmers, housewives, academicians, artists, and others from various professions. Paintings, sculptures, book marks, masks, book marks, and several other artefacts created by students and artists were displayed. All visitors were offered owl tattoos, owl mehdi paintings on hands and owl face painting. The 6th WOC, Pune, India and the 2nd Indian Owl Festival received generous press and TV coverage.

I look forward to the 7th World Owl Conference that aims to share and expand research frontiers and knowledge about owls for their saftey and conservation.

Prof. Dr. Satish A. Pande
MD, DNB, PhD, FMASci., FLS
Organizing Secretary, 6th WOC, Pune, India
Director, Ela Foundation, Pune, India

6th World Owl Conference, Pune, India : Photo Feature

Savitribai Phule Pune University, Pune, the venue of the 6th World Owl Conference, Pune, India.

The inaugural session of the 6th World Owl Conference, Pune, India, 29th November - 2nd December 2019.

Participants of the 6th World Owl Conference, Pune, India.

6th World Owl Conference, Pune, India : Photo Feature

Participants of the 6th World Owl Conference, Pune, India.

The 6th World Owl Conference, Pune, India, address by the Hon. Vice Chancellor, Prof. N. Karmalkar. Hon. VC with Prof. Dr. Satish Pande, Organizing Secretary, WOC, Pune, India at the photo exhibition.

Cultural program (dance and Mallakhamb) and lighter moments at the 6th World Owl Conference, Pune, India.

WORLD OWL CONFERENCE 2019 PUNE-INDIA

29, 30 November, 1, 2 December 2019

Patron:
- Prof. Nitin Karmalkar, Hon. Vice Chancellor, SPPU

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Dr. Satish A. Pande,
MB, MD, DNB,PhD, F.M.A.Sci., FLS
Director, Ela Foundation and OENSL,
Pune, India.

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2nd Indian Owl Festival, Ela Habitat, Pingori
(3 - 4 December 2019)

Volunteers

- Rajkumar Pawar
- Rahul Lonkar
- Faiyaz Shaikh
- Avishkar Bhujbal
- Pandurang Madane
- Akram Inamdar
- Zaid Attar
- Tausif Attar
- Abhiram Rajandekar
- Vaibhav Gandhe
- Vishal Hingane
- Rajendra Lambate
- Avadhoot Belsare
- Umaji Khomane
- Shamrao Gaikwad
- Rahul Choudhary
- Sachin Zagade
- Mayur Shinde
- Mayuri Shinde
- Suresh Shinde
- Shubhada Bhujbal
- Harshada Bhujbal
- Sana Shaiikh
- Vrushali Mhaske
- Radhika Bhosale
- Prajakta Thopte
- Divya Bhujbal
- Rutuja Shinde
- Pallavi Pawar
- Pratiksha Bhujbal
- Shubhangi Bardade
- Samruddhi Pawar
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- Sanket Ghate
- Shubham Kadam
- Sanjay Khatavkar
- Shabbir Lokhandwala
- Pramod Deshpande
- Banda Pednekar
- Amol Shinde
- Baba Shinde
- Atmaprakash Sahu
- Sudhanawa Rajurkar
- Manasi Pathak
- Sanjeewani Wad
- Vrushali Gambhir
- Priyamvada Gambhir
- Hema Rao
- Dr. Satish Pande
- Dr. Suruchi Pande

Opening Remarks: A Brief Overview of the Previous Five World Owl Conferences

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Keywords:
World Owl Conferences; Owl Research and Conservation; India; Canada; Australia; Netherlands; Portugal.

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On the morning of 29 November 2019 during the inaugural session of the World Owl Conference, Pune, India, I had an opportunity to deliver a brief oral presentation on the history of the previous five World Owl Conferences. The following is a written account of that presentation:

In March 2018, I had the pleasure, on behalf of the World Owl Conference Organizing Committee, to inform Professor Dr. Satish Pande that the committee had approved India's proposal for the ELA Foundation to host the 6th World Owl Conference in beautiful Pune, India, in 2019.

This series of international owl conferences, started in Winnipeg, Manitoba, Canada in 1987, brings together scientists and others from around the world to share their owl expertise, knowledge, and wisdom to further the study, appreciation and conservation of owls.

The location of the international owl conferences has varied, as has the attendance which has ranged from 130 to 193 delegates from a variety of countries as follows:

- 1987 – 150 delegates – 10 countries – 52 papers – Manitoba Wildlife Branch, Winnipeg, Manitoba, Canada
- 1997 – 180 delegates – 15 countries – 91 papers – Manitoba Wildlife Branch, Winnipeg, Manitoba, Canada
- 2000 – 130 delegates – 10 countries – 51 papers – Australasian Raptor Association, Canberra, Australia
- 2007 – 193 delegates – 32 countries – 86 papers – Worldwide Owl Conference 2007, Groningen, Netherlands

- 2017 – 155 delegates – 30 countries – 89 papers – Universidade de Evora, Evora, Portugal

It is noteworthy that each conference has produced a proceedings containing peer-reviewed published papers that serve as a continuing legacy and source of knowledge to further the conservation of owls around the world. These proceedings include:

- Nero, R.W., Clark, R.J., Knapton, R.J. and R.H. Hamre (Eds.). 1987. Biology and Conservation of Northern Forest Owls: Symposium proceedings. 3-7 February 1987. Winnipeg, Manitoba. USDA Forest Service Gen. Tech. Report RM 142. 309 p.
- Duncan, J.R., Johnson, D.H. and T.H. Nicholls (Eds.). 1997. Biology and Conservation of Owls of the Northern Hemisphere: 2nd International symposium, 5-9 February 1997. Winnipeg, Manitoba. USDA Forest Service Gen. Tech. Rep. NC-190. 635 p.
- Newton, I., Kavanagh, R., Olsen, J. and I. Taylor (Eds.). Ecology and Conservation of Owls. Symposium proceedings from Owls 2000: The biology, conservation and cultural significance of owls. 19-23 January 2000, Manning Clark Centre, Australian National University, Canberra, Australia. Csiro Publishing, Collingwood, Australia. 363 p.
- Johnson, D.J., Van Nieuwenhuyse, D. and J.R. Duncan (Eds.). 2009. Owls – Ambassadors for the Protection of Nature in their Changing Landscapes. Proceedings of the fourth World Owl Conference. 31 October – 4 November 2007, Groningen, The Netherlands. Ardea 97(4): 395-649.
- Roque, I.M.F., Duncan, J.R., Johnson, D.H. and Van Nieuwenhuyse, D. (Eds.). 2021. Proceedings of the 2017 World Owl Conference. Evora, Portugal. Airo 29.

Many of us here are assisting with the 2019 World Owl Conference and will be helping to prepare the follow-up proceedings. This rich history of international collaboration and support from many sponsors has culminated in bringing us to this historic point in time and will guarantee to make the 2019 World Owl Conference a success.

Marie Jaworski

Saw-whet Owl

Small mammal prey and owl predator population dynamics over a 20-year period (1991-2010) in Manitoba, Canada and adjacent Minnesota, USA, and an evaluation of a citizen science project.

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Keywords: Small mammal monitoring; owl monitoring; predator prey dynamics; citizen science; Manitoba; Canada
[Keynote oral presentation submitted as a research article for the Proceedings for the 2019 WOC]

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Abstract

From 1986 to 2010 annual small mammal relative abundance indices were obtained by a snap-trapping program in southeastern Manitoba, Canada and adjacent Minnesota, USA. From 1991 to 2015 owl populations were surveyed extensively across Manitoba by volunteers in a citizen science program. Thus, both small mammal prey and owl predator populations were sampled concurrently for 20 years (1991-2010) enabling an exploration of predator-prey dynamics in North America's boreal forest and adjacent ecosystems. Pooled relative abundance indices for 11 owl species varied significantly with those for 9 small mammal species ($R^2 = 0.514$, $p = 0.0004$) and generally fluctuated synchronously over time. Further analysis of owl and small mammal prey species indices revealed that only the two most common species of owls detected, the Great Horned Owl *Bubo virginianus* and the Northern Saw-whet Owl *Aegolius acadicus*, varied significantly with pooled small mammal prey abundance. Conversely only microtine rodents (voles, subfamily Arvicolinae), but not shrews (Family Soricidae) or mice (suborder Myomorpha), varied significantly over time with changes in the relative abundance indices for pooled owl species, Great Horned Owl, Northern Saw-whet Owl, and the Great Gray Owl *Strix nebulosa*. Akaike Information Criterion analysis corrected for small samples (AICc) selected Meadow Vole *Microtus pennsylvanicus* and pooled small mammal indices as frequent model predictors of owl species abundance indices and had best approximating models consistent with significant linear regression

results for only three of eight owl species. These analyses indicate that the Manitoba citizen science owl monitoring program provided valuable time series data for at least three commonly and/or regularly detected owl species in relation to prey population changes over time. This conclusion can be used to encourage continued participation in this citizen science project.

Introduction

Long-term wildlife monitoring programs are costly and time consuming but help define ecological processes, assess the conservation status of species, and inform management action planning (Takats et al. 2001; Manley et al. 2004; Holthausen et al. 2005; Witmer 2005; Duncan et al. 2009). Such programs are typically either intensive (i.e., conducted by scientists at small spatial scales) or extensive (i.e., conducted by volunteer citizens over large areas) but rarely, if ever, both (Bonney et al. 2009; Proença et al. 2017). Such divergent approaches to monitoring have relative strengths and weaknesses regarding sample sizes and geographic relevance for extrapolation over areas and through time (Manley et al. 2004; Quinn and Keough 2002; Proença et al. 2017). This study examined two independent, concurrent, and sympatric monitoring programs (one intensive and one extensive) in Manitoba, Canada and adjacent Minnesota, USA (Fig. 1) to determine if they informed each other in an ecologically meaningful manner. Of specific interest was assessing if and how extensively collected citizen science owl population abundance indices related to intensively collected small mammal prey population indices over a 20-year period.

Methods – Owl Survey

Owl species scientific names followed Handbook of the Birds of the World and BirdLife International (2019). The Manitoba Nocturnal Owl Survey methods were described in detail in Duncan (2021) and are therefore only briefly summarized herein. Survey participants were provided resources to learn the territorial calls of the 12 Manitoba owl species, instructions, and data sheets (https://www.researchgate.net/project/Manitoba-Nocturnal-Owl-Survey). Their ability to identify owl species was not tested. Survey routes (Fig. 2) were assigned in a non-random manner as access to roads in early spring was limited due to thick snow cover and/or spring flooding. Volunteers surveyed at least one survey/route per year between mid-March to mid-April starting at least 30 min after sunset. At each survey stop individual owls detected (heard or seen) and the owl's estimated distance and direction from the stop were recorded. Some individual owls could be heard from multiple stops. Therefore, surveyors recorded if an owl detected was also detected at a previous stop or stops to prevent the same owl from being counted more than once. Additional information recorded at each stop included time, an odometer reading, noise interference and the number of passing cars.

The estimated number of individual owls detected per route were pooled annually and used to calculate total annual owl species indices (number of individuals of a given species detected/km surveyed/year) to standardize variable annual survey effort. An overall annual owl abundance index was calculated by pooling all individuals of all species detections/km surveyed/year. The owl survey expanded over time and the survey protocol changed as follows (see also Duncan 2021).

- 1991 – 1999: Survey stops were 0.8 km apart and took a minimum of 3 min and 40 s to complete: 1 min of listening, 20 s playback of Boreal Owl *Aegolius funereus* or Northern Saw-whet Owl *Aegolius acadicus* territorial calls, 1 min of listening, 20 s playback of Great Gray Owl *Strix nebulosa* or Eastern Screech Owl *Megascops asio* territorial calls, 1 min of listening. No standard survey route length (number of stops) was prescribed. Boreal Owl and Great Gray Owl playback was used in Boreal Forest habitats, whereas Northern Saw-whet Owl and Eastern Screech Owl playback was used in other habitats.
- 2000 – 2015: A standardized Canadian volunteer owl survey protocol was developed in 1999 and implemented in 2000 (Takats et al. 2001) where a survey route consisted of 10 survey stops spaced 1.6 km apart. Surveyors listened for owls passively (no playback used) for 2 min at each stop.

In general, the survey method change did not preclude the comparison of the long-term data sets herein as the owl survey indices are relative and not absolute abundance estimates. However the implications of the change in owl survey methods for owl detection rates has been reviewed and discussed in Duncan (2021) and addressed in the methods and results section below.

Methods – Small Mammal Survey

Small mammal scientific names follow the Integrated Taxonomic Information System (http://www.itis.gov) accessed 1 October 2020. Small mammals were trapped annually (late September to mid-October 1986–2010) at two study areas 80 km apart in southeastern Manitoba and adjacent Minnesota (Fig. 3). The annual trapping effort at each study area consisted of six trap lines, in three pairs, with 50 trap stations (spaced 10 m apart) per line for a total of 300 stations per study area (Fig. 4). One Museum Special snap-trap (Woodstream Corp., Lititz, Pennsylvania, USA), baited with peanut butter, rolled oats and bacon fat, was set at each station (Fig. 5). The traps were set for three nights and checked each morning. Trapped mammals were removed and identified, and traps were reset or re-baited as required. In each study area a pair of trap lines sampled a Tamarack *Larix laricina* dominated forest stand, while the other two pairs sampled open habitats with numerous perches used by hunting owls such as open treed muskeg, burned over areas, or cleared roadsides and adjacent drainage areas (Duncan 1987, Fig. 6). The annual trapping effort was quantified as the number of trap stations available times the number of nights (# trap nights); occasional missing or broken traps were not counted, reducing the annual total effort slightly each year (Fig. 7). Indices (# mammals caught / # trap nights) estimated the relative abundance of mammal prey categories (see below) and pooled mammal prey abundance for each year to standardize variable annual survey effort. Total annual index values were used for regression and other analyses.

Trapped small mammals were grouped into four prey categories for analysis as follows:

Red-backed Voles: Southern Red-backed Vole *Myodes gapperi*

Meadow Voles: Meadow Vole *Microtus pennsylvanicus* and Northern Bog Lemming *Synaptomys borealis*. The latter species was rarely caught and occupied similar habitats as Meadow Voles therefore the two species were pooled for this analysis.

Shrews: Masked Shrew *Sorex cinereus*, American Pygmy Shrew *Sorex hoyi*, Arctic Shrew *Sorex arcticus*, Northern Water Shrew *Sorex palustris*, and Northern Short-tailed Shrew *Blarina brevicauda*.

Other: Deer Mouse *Peromyscus maniculatus*, Woodland Jumping Mouse *Napaeozapus insignis*.

Methods – Data Analysis

Data analyses were prepared using 2016 Microsoft Excel Data Analysis Tool Pack and Daniel's XL Toolbox version 7.2.13 (http://www.xltoolbox.net) and Statistix 10 (www.statistix.com, Analytical Software).

More owls were detected in the earlier survey period (1991-1999), when playback was used, than in the later period (2000-2010) when no playback was used (Duncan 2021). This 'trend' was likely the result of the change in methods, rather than a change in owl abundance, and the indices were 'detrended' as in Duncan et al. (2009) and as follows. For each of the two owl survey periods, the residuals of a linear regression of observed and expected index values were calculated. Since the residuals are larger (in absolute terms) for larger indices, the residuals in the two periods were made comparable by converting them into residual ratios (dividing each residual by the mean index for that period). Hereafter owl indices expressed as residual ratios will be referred to simply as owl indices.

General linear models were used for modelling owl – prey relationships and these were contrasted with the results of simple linear regression analysis (Kassambara 2018; Bevans 2020). A series of general linear models were fit using pooled and select different owl species as responses, and pooled and different small mammal indices as predictors. Candidate models were ranked using Akaike Information Criterion analysis corrected for small samples (AICc) to identify the relative influence of small mammal prey category abundance indices on owl abundance indices. The models were fit using PROC MIXED in SAS version 9.4 (SAS Institute Inc.) with an auto-regressive order 1 error correlation structure. This allowed for temporal correlation among the residuals of adjacent years.

No models were run for Burrowing Owl *Athene cunicularia*, Snowy Owl *Bubo scandiacus* or Barn Owl *Tyto alba* as their indices were zero for 20, 17, and 14 of 20 years, respectively. Due to the small sample size (20 years), model forms were restricted to maximum of two additive predictors. A total of 12 Candidate Model Sets included all one and two factor combinations of each of the four small mammal prey categories, a null model and a pooled small mammal index model. Best approximating models and competing models (within 2 AICc units of the top model) were identified. If null or intercept only models were best approximating or highly competitive, this indicated that there were no sufficiently strong linear relationships with small mammal predictor models.

Results – Owl Surveys

An estimated 6,335 individual owls of 11 species were detected on a total of 32,549 km of linear point count surveys over 25 years (1991 to 2015) by ca. 900 surveyors (Duncan 2021). Northern Saw-whet Owls, Great Horned Owls *Bubo virginianus*, and Boreal Owls were detected every year and accounted for 75% of all detections (Duncan 2021). Other owl species detected every year included the Great Gray Owl, Long-eared Owl *Asio otus*, and Barred Owl *Strix varia*. The Northern Hawk Owl *Surnia ulula*, Eastern Screech Owl, Short-eared Owl *Asio flammeus*, Barn Owl, and Snowy Owl were detected at an order of magnitude lower and were not detected every year. The Burrowing Owl was the only Manitoba owl species not detected. Owl species relative abundance varied annually (Fig. 8).

Results – Mammal Surveys

A total of 6,733 small mammals were trapped during a total of 44,587 trap nights over 25 years. For analysis, trapped mammals were tallied into the following four small mammal categories (see methods): Southern Red-backed Voles (3,916), Meadow Voles (1,429), Shrews (1,161) and Other (227). The number of small mammals trapped varied considerably from year to year (Fig. 9).

Results – Owl and Mammal Comparisons

The intensive prey and extensive owl data sets overlapped for 20 years from 1991-2010. The following tests ensured that the assumptions of simple linear regression analysis were met. Both the mammal indices ($W = 0.9701$, $n = 20$, $P = 0.756$) and owl indices ($W = 0.9193$, $n = 20$, $P = 0.165$) were normally distributed (Wilkes - Shapiro normal residuals). The owl – mammal linear regression error terms were not correlated (Durbin-Watson test $P > 0.345$) and there were no significant autocorrelations (Runs Test) for either the mammal indices nor for the owl indices and the data sets were considered independent. The owl and mammal data sets were time lagged in either direction, but there were no significant predator-prey lags.

Pooled owl indices and pooled small mammal indices showed generally synchronized fluctuations over time (Fig. 10) and their regression was significant (Fig. 11, Table 1). There were also significant linear regressions for both Great Horned Owls and Northern Saw-whet Owls indices with pooled small mammal indices (Table 1). Linear regressions were significant between each of the Red-backed Vole and Meadow Vole small mammal prey category indices and pooled owl abundance indices (Table 1). Lastly, linear regressions were significant for the indices of four other owl species – mammal prey category pairs (Table 1).

A sample of the AICc analysis results for Northern Saw-whet Owl is presented in Table 2 and Figure 12. In this case the best approximating model was the Red-backed Vole index model indicating that it had the strongest linear relationship with the Northern Saw-whet Owl index; the pooled small mammal index was the best competing model (Table 2). A summary of all the AICc model output for owl species indices with small mammal prey category indices as model predictors is presented in Table 3. A comparison of linear regressions and AICc model results are discussed below. In decreasing order, Meadow Vole, Other, or All Mammals were the most frequent best approximating model predictors followed by Red-backed Vole and Shrews; one null best approximating model was selected (Short-eared Owl; Tables 3, 4). The selected null model indicates that there were no sufficiently strong linear relationships identified between the Short-eared Owl and any small mammal indices.

Discussion

The significant predator-prey relationship between many owl species and small mammals is well known (Duncan 2003, Konig and Weick 2009). Owl species detected in this study eat small mammals as prey to varying degrees depending on body size and behaviour; some like the Great Gray Owl are vole specialists (Duncan 1992) while others like the Great Horned Owl are diet generalists (Duncan 2013). It is generally recognized that small mammal prey populations regulate northern owl numbers (Lehikoinen et al, 2011) by affecting their survival, reproduction and dispersal (Cheveau et al. 2004, Bowman et al. 2010, Confer et al. 2014). The demonstration of significant relationships between owl and mammal indices in this study documents that extensively collected Manitoba owl survey data has an ecological connection to intensively collected small mammal prey data, thereby validated the ability of citizen scientists to collect meaningful owl population data, at least for relatively abundant and regularly detected owl species.

Pooled small mammals and more commonly trapped small mammal prey species had a significant influence on pooled owl abundance indices over time based on linear regression analyses (Fig. 11, Table 1). Furthermore, linear regression demonstrated significant relationships between more commonly trapped small mammal prey species and three of six regularly detected owl species (Table 1). One of these, the Great Gray Owl, is a diet specialist that in Manitoba eats primarily Meadow Voles (Duncan 1992). While Meadow Voles were not the most frequently trapped small mammal prey (Fig. 9) their unique influence on the detection rates of Great Gray Owls was corroborated by these results (Table 1).

The AICc analysis frequently selected more common small mammal prey category (Meadow Vole, pooled small mammals and Red-backed Vole) indices as model predictors of owl indices (Table 3, 4). These included best approximating models for all six regularly detected owl species, pooled owls and two less frequently and irregularly detected owl species, the Northern Hawk Owl and the Eastern Screech Owl (Table 3). Only two of these (Great Horned Owl and Northern Saw-whet Owl) and the pooled owl index were consistent with significant linear regression results (Table 1). The AICc results therefore identified some potentially important predator-prey models or relationships identified as not significant by the linear regression analysis and they tended (for 6 of 9 owl indices) to pick best approximating model predictors that matched the lowest, sometimes nearly significant, probabilities generated for the corresponding linear regressions (i.e., Barred Owl – Pooled or All Mammals, $P = 0.071$; Tables 1, 3).

Both linear regression and AICc analyses were valuable approaches to assessing the Manitoba citizen science owl survey but the AICc identified best approximating predator – prey models relative only to other models considered, and not in an absolute sense. More analyses of these and similar data sets is encouraged, including the use of simulations and Bayesian Information Theory (Brewer et al. 2016).

The significant relationship between the dependent (pooled owl) and the independent (pooled small mammal) abundance indices is evidence that the owl data collected extensively by citizen scientists is ecologically valid. This conclusion held true for the two most frequently detected owls, the Northern Saw-whet Owl and Great Horned Owl, but, except for the Great Gray Owl, not for less commonly or irregularly detected species (Table 1). The are various reasons some owl species were detected less frequently. The Eastern Screech Owl has a limited, largely urban distribution in Manitoba (Taylor 2003) and the Northern Hawk Owl is thought to be an irregular and irruptive migrant and predominantly calls diurnally (Duncan & Duncan 1998). The Short-eared Owl is relatively rare in the province in most years, and most likely migrates quickly through Manitoba to the tundra to breed (Taylor 2003). The Barn Owl is rare and accidental in Manitoba and the majority of Snowy Owls depart southern Manitoba for their Arctic breeding range prior to the survey period (Taylor 2003). Lastly, the endangered Burrowing Owl was never detected due to its arrival in Manitoba as a late spring migrant (Taylor 2003) after the survey period ended. It also has an exceedingly small range in extreme southwestern Manitoba where few owl surveys took place. Duncan (2021) concluded that these five species require species-specific targeted survey methods to adequately monitor their populations in Manitoba. In general, less common species need other means of monitoring their populations (Manley et al. 2004; Holthausen et al. 2005).

Recruiting and retaining volunteer citizen scientists for extensive owl or wildlife monitoring programs is important (Bonney et al. 2009). Volunteer citizen scientists were mainly motivated to participate in the Manitoba owl survey for social reasons, i.e., having fun with family and friends (Ng et al. 2018). The results of this current study can be used to reassure and educate volunteers that they are collecting ecologically relevant data that is valuable to help manage and conserve owls.

Acknowledgements

Thanks to my wife and colleague, Patricia Duncan, for her support and assistance with our research on owls. My former professor Robert W. Nero continues to be an inspiration for engaging the public in owl research and conservation. Steve Wilson of Minnesota generously shared his owl survey protocols that were then adapted to start the Manitoba owl survey. Llwellyn Armstrong with Ducks Unlimited Canada assisted with the AICc analysis. Llwellyn Armstrong, Dean Berezanski, Patricia Duncan, Riki Kerbrat, and Prachi Mehta kindly reviewed and greatly improved this manuscript. Financial and other support came from Bird Studies Canada's James Baillie Memorial Fund, the University of Manitoba's Alumni Fund, and the Government of Manitoba. Bird Studies Canada's Beaverhill Bird Observatory and Nature Saskatchewan enabled Colin Murray to kindly prepare the owl survey map. Thanks to the over 900 hundred volunteer owl surveyors for participating in the owl survey and to Dr. Satish Pande, the ELA Foundation and many volunteers for hosting the 2019 World Owl Conference.

	All Mammals		RBV		MV		Shrews		Other	
Owl Species	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P
All Owls	0.514	0.0004	0.433	0.002	0.633	0.00003	0.072	0.251	0.054	0.323
Great Horned Owl *Bubo virginianus**	0.238	0.029	0.115	0.144	0.339	0.007	0.124	0.127	0.021	0.541
Northern Saw-whet Owl *Aegolius acadicus**	0.228	0.033	0.263	0.021	0.229	0.033	0.005	0.761	0.005	0.763
Barred Owl *Strix varia**	0.170	0.071	0.104	0.165	0.126	0.125	0.134	0.113	0.028	0.480
Boreal Owl *Aegolius funereus**	0.108	0.157	0.113	0.147	0.114	0.146	0.022	0.531	0.057	0.312
Barn Owl *Tyto alba*	0.081	0.225	0.029	0.470	0.119	0.137	0.073	0.248	0.015	0.607
Northern Hawk Owl *Surnia ulula*	0.029	0.476	0.006	0.742	0.044	0.373	0.033	0.440	0.000	0.947
Great Gray Owl *Strix nebulosa**	0.084	0.216	0.079	0.229	0.207	0.044	0.004	0.788	0.167	0.073
Eastern Screech Owl *Megascops asio*	0.021	0.544	0.006	0.740	0.004	0.802	0.123	0.129	0.000	0.982
Long-eared Owl *Asio otus**	0.055	0.321	0.071	0.257	0.116	0.142	0.015	0.607	0.059	0.304
Short-eared Owl *Asio flammeus*	0.001	0.880	0.003	0.810	0.054	0.325	0.172	0.069	0.000	0.967
Snowy Owl *Bubo scandiacus*	0.041	0.392	0.071	0.257	0.033	0.447	0.023	0.526	0.067	0.271

Table 1. Simple linear regression of owl abundance indices as residual ratios and small mammal prey abundance indices from Manitoba, Canada and adjacent Minnesota, USA (1991-2010). See text for details on abundance indices. Owl species regularly detected on owl surveys each year are denoted with an asterix (*). P = probability and yellow shading denotes significance ($P < 0.05$). All Mammals = pooled small mammal data; RBV = Southern Red-backed Vole *Myodes gapperi*; MV = Meadow Vole *Microtus pennsylvanicus* and Northern Bog Lemming *Synaptomys borealis*; Shrews = Masked Shrew *Sorex cinereus*, American Pygmy Shrew *Sorex hoyi*, Arctic Shrew *Sorex arcticus*, Northern Water Shrew *Sorex palustris*, and Northern Short-tailed Shrew *Blarina brevicauda*; Other = Deer Mouse *Peromyscus maniculatus* and Woodland Jumping Mouse *Napaeozapus insignis*.

Ken Stewart

Great horned Owl

Model Predictors	k	-2 log Likelihood	AICc	Delta AICc	AICc weight
RBV	4	-94.54	-83.87	0.00	0.43
All Mammals	4	-92.75	-82.09	1.79	0.17
RBV + Shrews	5	-94.72	-80.43	3.44	0.08
MV	4	-91.06	-80.40	3.48	0.07
RBV + MV	5	-94.65	-80.37	3.50	0.07
RBV + Other	5	-94.58	-80.29	3.58	0.07
NULL	3	-87.09	-79.59	4.28	0.05
Shrews	4	-87.82	-77.16	6.72	0.01
MV + Other	5	-91.30	-77.02	6.85	0.01
MV + Shrews	5	-91.06	-76.78	7.09	0.01
Other	4	-87.25	-76.58	7.29	0.01
Shrews + Other	5	-87.85	-73.56	10.31	0.00

Table 2. Sample AICc model output for Northern Saw-whet Owl *Aegolius acadicus* and various small mammal prey indices as model predictors. The best approximating model (RBV) is highlighted in yellow and the best competing model (All Mammals) in orange. All Mammals = pooled small mammal data; RBV = Southern Red-backed Vole *Myodes gapperi*; MV = Meadow Vole *Microtus pennsylvanicus* and Northern Bog Lemming *Synaptomys borealis*; Shrews = Masked Shrew *Sorex cinereus*, American Pygmy Shrew *Sorex hoyi*, Arctic Shrew *Sorex arcticus*, Northern Water Shrew *Sorex palustris*, and Northern Short-tailed Shrew *Blarina brevicauda*; Other = Deer Mouse *Peromyscus maniculatus* and Woodland Jumping Mouse *Napaeozapus insignis*. k = number of model parameters.

Predictors Appearing in Best Approximating and Top Competing Models			
Dependent Variable	**Best Approximating Model form**	**1st Competing Model form***	**2nd Competing Model form***
All Owl Index	Meadow Vole		
Short-eared Owl	NULL		
Northern Saw-whet Owl[1]	Red-backed Vole	All Mammals	
Northern Hawk Owl	Meadow Vole		
Long-eared Owl[1]	Other	NULL	
Great Horned Owl[1]	All Mammals	Meadow Vole	Shrews
Great Gray Owl[1]	Other		
Eastern Screech Owl	Shrews	NULL	
Boreal Owl[1]	Meadow Vole	NULL	
Barred Owl[1]**	All Mammals	Red-backed Vole - Other	Meadow Vole - Other

* within 2 AICc units
[1] Owl species regularly detected on owl surveys each year
** Barred Owl with three additional successive Competing Models: Other; Red-backed Vole; and Shrews

Table 3. Summary of AICc model output for owl species (see Table 1 for owl scientific names) and various small mammal prey indices as model predictors. Null indicates that there were no sufficiently strong linear relationships identified between owl and any small mammal indices. All Mammals = pooled small mammal data; Red-backed Vole = *Myodes gapperi*; Meadow Vole = *Microtus pennsylvanicus* and Northern Bog Lemming *Synaptomys borealis*; Shrews = Masked Shrew *Sorex cinereus*, American Pygmy Shrew *Sorex hoyi*, Arctic Shrew *Sorex arcticus*, Northern Water Shrew *Sorex palustris*, and Northern Short-tailed Shrew *Blarina brevicauda*; Other = Deer Mouse *Peromyscus maniculatus* and Woodland Jumping Mouse *Napaeozapus insignis*.

Independent Variable	Frequency in Best Approximating AICc Model	Frequency in Competing AICc Model	Frequency in Best Approximating or Competing AICc Model
Meadow Vole	3	2	5
Other	2	3	5
All Mammals	2	1	3
NULL	1	3	4
Red-backed Vole	1	2	3
Shrews	1	2	3

Table 4. Frequency of small mammal prey independent model variables in the best approximating or a competing model in all AICc model sets for owl abundance indices. Null indicates that there were no sufficiently strong linear relationships identified between owl and any small mammal indices. All Mammals = pooled small mammal data; Red-backed Vole = *Myodes gapperi*; Meadow Vole = *Microtus pennsylvanicus* and Northern Bog Lemming *Synaptomys borealis*; Shrews = Masked Shrew *Sorex cinereus*, American Pygmy Shrew *Sorex hoyi*, Arctic Shrew *Sorex arcticus*, Northern Water Shrew *Sorex palustris*, and Northern Short-tailed Shrew *Blarina brevicauda*; Other = Deer Mouse *Peromyscus maniculatus* and Woodland Jumping Mouse *Napaeozapus insignis*.

Figure 1. Location of Manitoba (red outline) in association with major ecosystems in Canada. Source: https://prosfa.vn/wp-content/uploads/2017/08/515bfe84-d6e7-40c2-b645-44a6bc714c95.jpg accessed 5 October 2020.

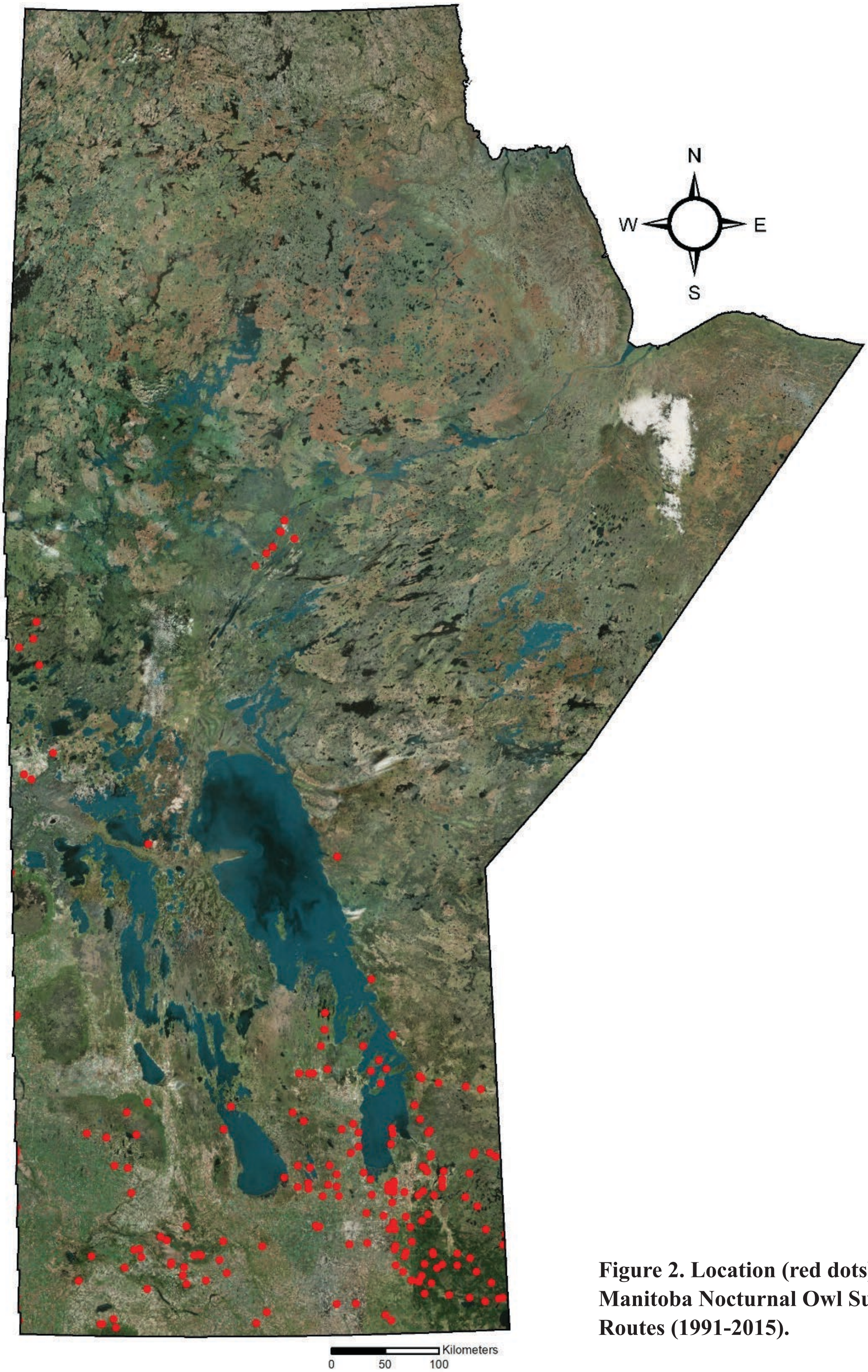

Figure 2. Location (red dots) of Manitoba Nocturnal Owl Survey Routes (1991-2015).

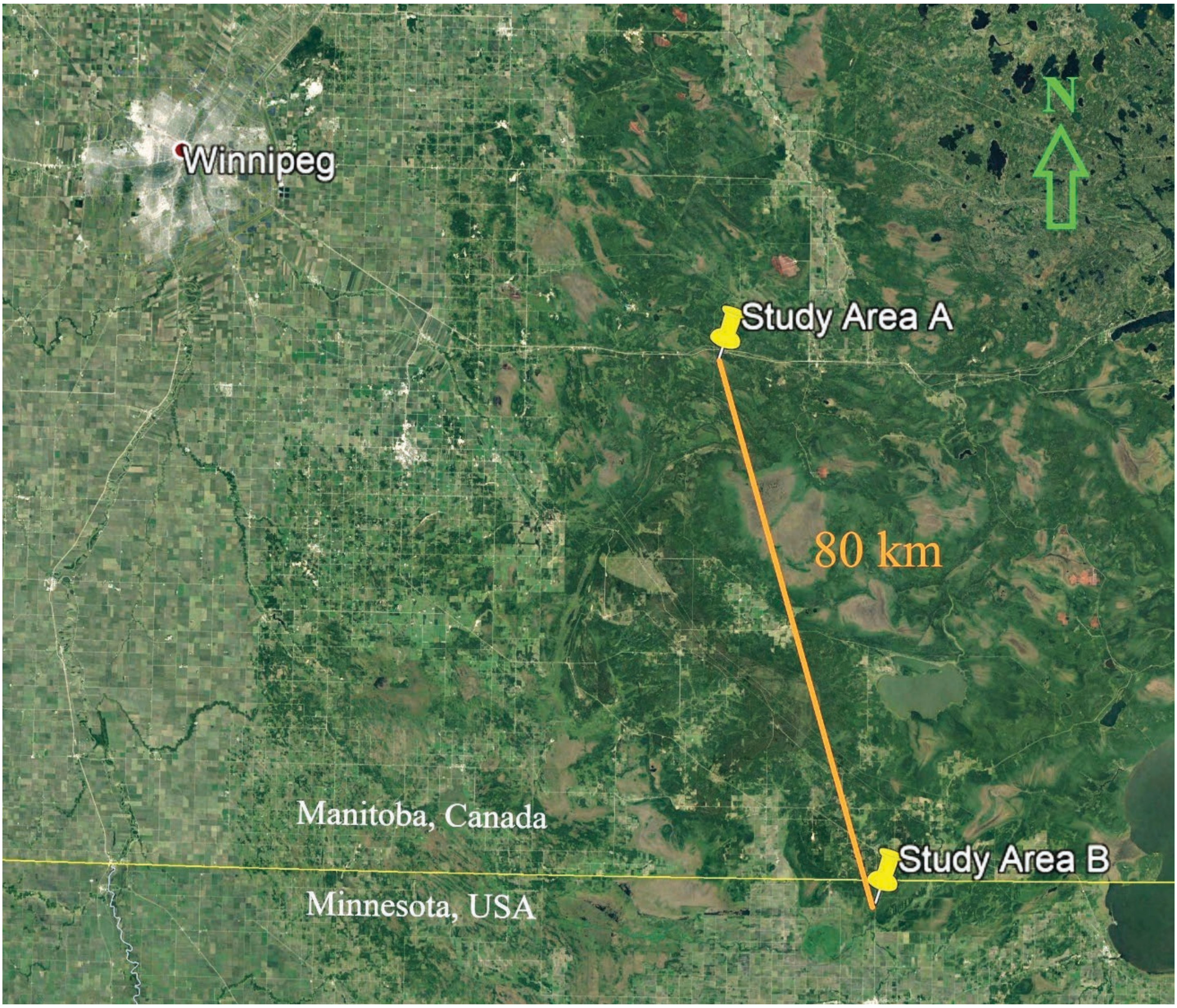

Figure 3. Location of small mammal survey areas (1986 to 2010) in southeastern Manitoba, Canada (A) and adjacent Minnesota, USA (B). Figure image source: Google Earth accessed 5 October 2020.

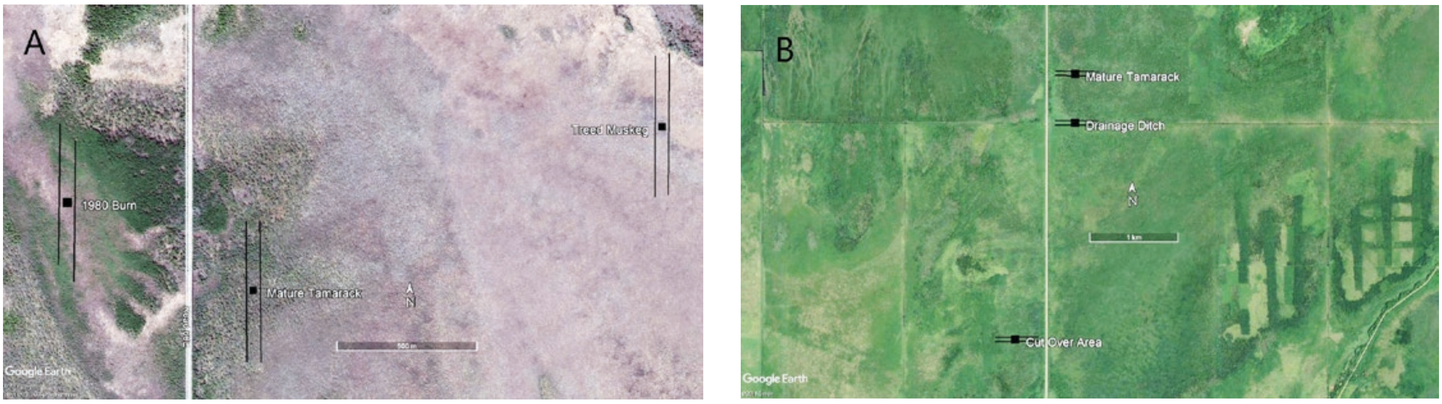

Figure 4. Location of small mammal survey lines in two study areas (1986 to 2010) in southeastern Manitoba, Canada (A) and adjacent Minnesota, USA (B). Google Earth imagery dates were 1 May 2016 (left) and 9 July 2015 (right) accessed 5 October 2020.

Figure 5. Examples of small mammals trapped, including Southern Red-backed Vole *Myodes gapperi* (Left) and Masked Shrew *Sorex cinereus* (Right), in southeastern, Manitoba and adjacent Minnesota, USA.

Figure 6. Examples of habitats surveyed for small mammals in southeastern, Manitoba and adjacent Minnesota, USA. Upper left: Mature Tamarack *Larix laricina* Forest; Upper right: Treed Muskeg; Lower left: Cut Over and Burned Areas; Lower right: Drainage Ditch.

Spruce Siding Study Area					
Small Mammal Snap Trap Census Data Form					
8-11 October 1999					
		Old Burn	100%Tam	TreeMus	Total
DAY 1	RBV's	25	34	15	74
	MV's	20	12	28	60
	Shrews	3	1	6	10
	Other	0	0	0	0
	Total	48	47	49	144
	# TN's	101	98	102	301
DAY 2	RBV's	10	30	9	49
	MV's	15	8	13	36
	Shrews	5	3	7	15
	Other	0	0	0	0
	Total	30	41	29	100
	# TN's	101	96	100	297
DAY 3	RBV's	5	9	7	21
	MV's	7	9	8	24
	Shrews	2	1	2	5
	Other	0	0	0	0
	Total	14	19	17	50
	# TN's	100	95	99	294
TOTAL	**RBV's**	40	73	31	144
	MV's	42	29	49	120
	Shrews	10	5	15	30
	Other	0	0	0	0
	Total	92	107	95	294
	# TN's	302	289	301	892

Roseau Bog Study Area					
Small Mammal Snap Trap Census Data Form					
16-19 October 1999					
		Clark's	Ditch	Tam	Total
DAY 1	RBV's	4	5	42	51
	MV's	1	7	0	8
	Shrews	4	3	1	8
	Other	0	0	3	3
	Total	9	15	46	70
	# TN's	99	105	101	305
DAY 2	RBV's	2	3	12	17
	MV's	5	12	2	19
	Shrews	7	7	4	18
	Other	0	0	0	0
	Total	14	22	18	54
	# TN's	98	104	97	299
DAY 3	RBV's	2	1	12	15
	MV's	1	7	1	9
	Shrews	4	5	3	12
	Other	0	0	3	3
	Total	7	13	19	39
	# TN's	99	104	98	301
TOTAL	**RBV's**	8	9	66	83
	MV's	7	26	3	36
	Shrews	15	15	8	38
	Other	0	0	6	6
	Total	30	50	83	163
	# TN's	296	313	296	905

Figure 7. Small mammal survey sample field data sheets. See text for explanation of prey and habitat category abbreviations. "# TN's" = number of total trap nights.

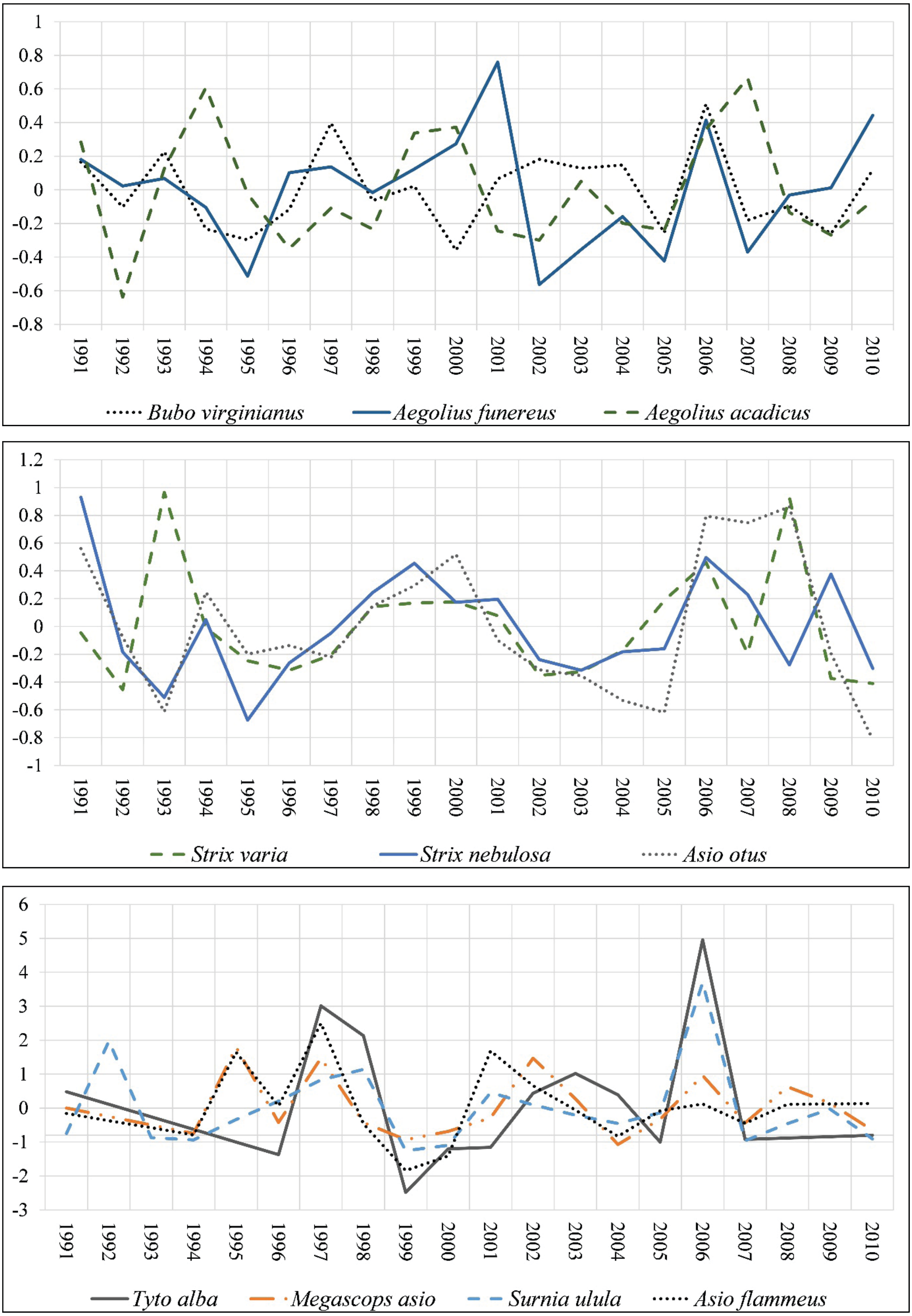

Figure 8. Owl species survey abundance indices as residual ratios by year in Manitoba, Canada.

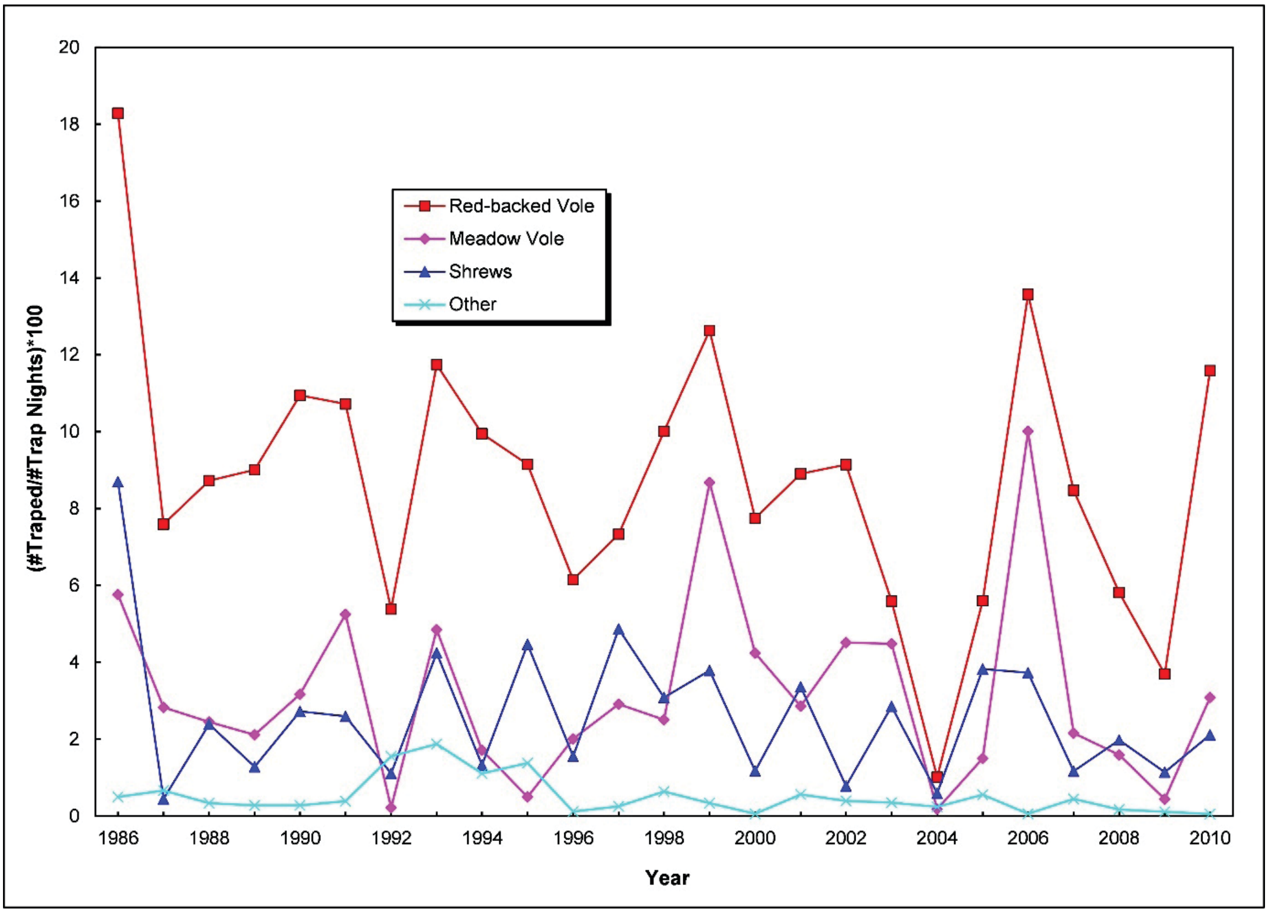

Figure 9. Small mammal prey category indices by year in southeastern Manitoba, Canada and adjacent Minnesota, USA. See text for explanation of prey categories.

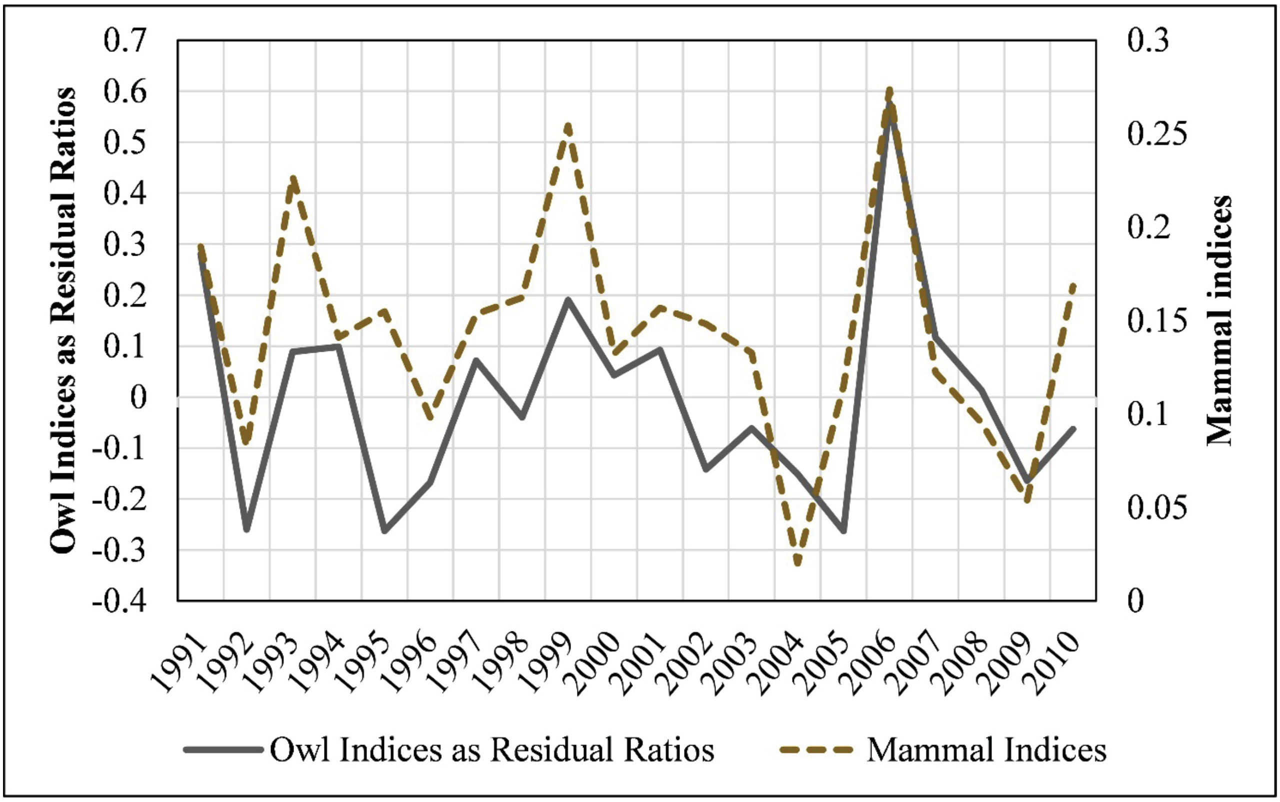

Figure 10. Pooled owl relative abundance indices as residual ratios and pooled small mammal relative abundance indices (see text) by year in Manitoba, Canada and adjacent Minnesota, USA.

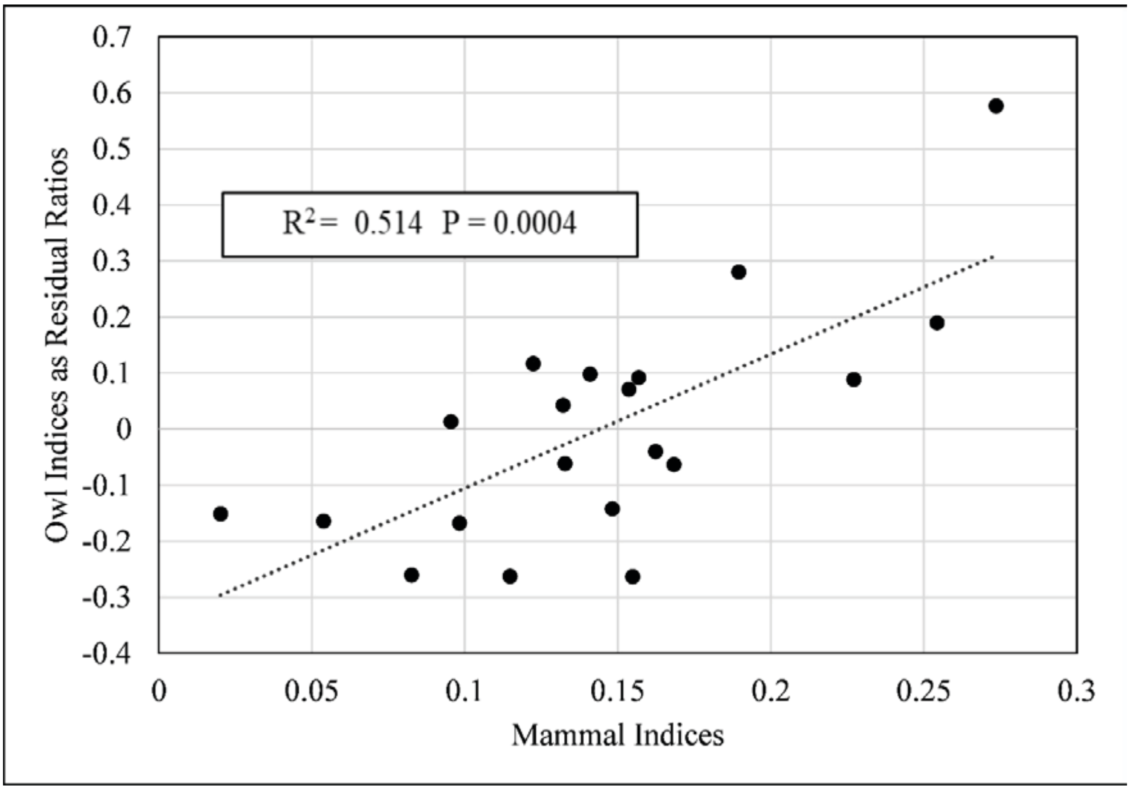

Figure 11. Scatter plot and linear regression of pooled owl relative abundance indices as residual ratios and pooled small mammal relative abundance indices (see text) in Manitoba, Canada and adjacent Minnesota, USA, from 1991 to 2010.

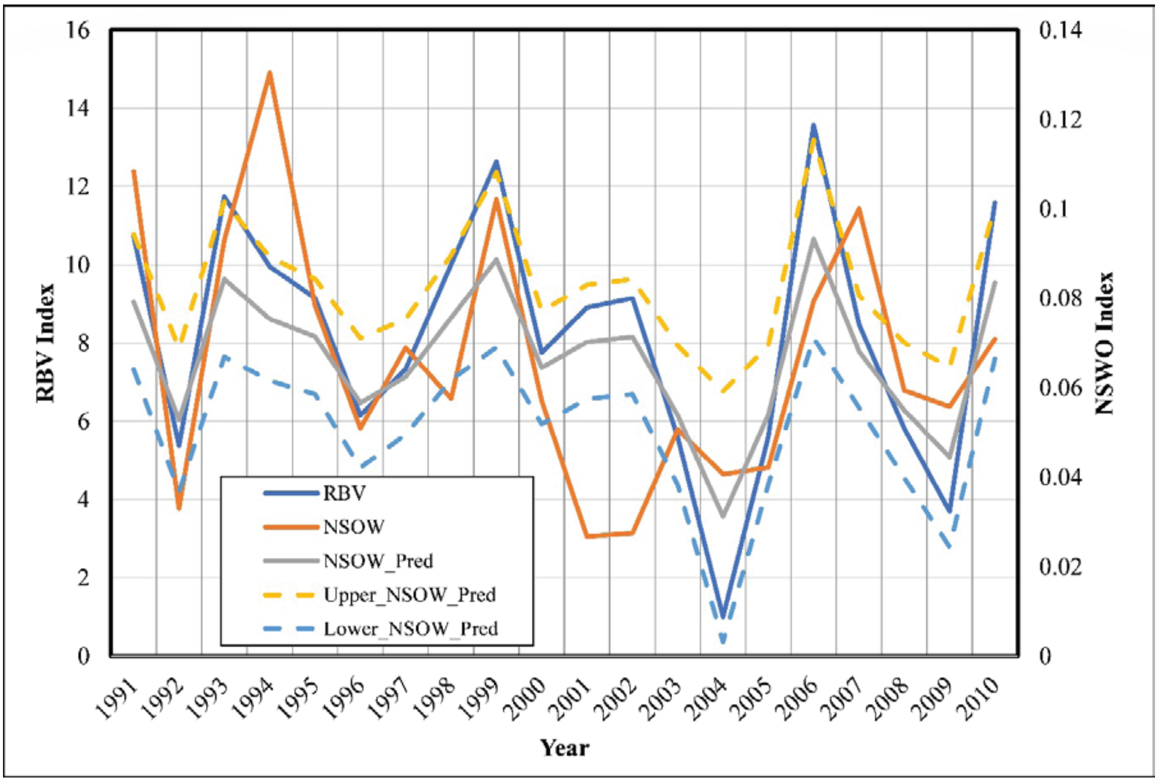

Figure 12. Northern Saw-whet Owl *Aegolius acadicus* (NSWO) and Red-backed Vole *Myodes gapperi* (RBV) relative abundance indices by year in Manitoba, Canada and adjacent Minnesota, USA, including model-predicted NSWO values and 95% confident limits.

References

- Bevans, R. 2020. *An introduction to the Akaike information criterion*. https://www.scribbr.com/statistics/akaike-information-criterion/. Accessed 6 June 2020.
- Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J. 2009. Citizen science: a developing tool for expanding scientific knowledge and scientific literacy. *BioScience* 59: 977–984.
- Bowman, J., Badzinski, D.S. and Brooks, R.J. 2010. The numerical response of breeding Northern Saw-whet Owls Aegolius acadicus suggests nomadism. *Journal of Ornithology* 151: 499–506.
- Brewer, M.J., Butler, A. and Cooksley, S.L. 2016. The relative performance of AIC, AICC and BIC in the presence of unobserved heterogeneity. *Methods in Ecology and Evolution* 7: 679–692.
- Cheveau, M., Drapeau, P., Imbeau, L. and Bergeron, Y. 2004. Owl winter irruptions as an indicator of small mammal population cycles in the boreal forest of eastern North America. *Oikos* 107: 190-198.
- Confer, J.L., Kanda, L. and Li, I. 2014. Northern Saw-whet Owl: regional patterns for fall migration and demographics revealed by banding data. *Wilson Journal of Ornithology* 126: 305-320.
- Duncan, J.R. 1987. Movement strategies, mortality and behaviour of radio-marked great gray owls in southeastern Manitoba and northern Minnesota. Pp. 101-107 in Nero, R.W., Clark, R.J., Knapton, R.J. and Hamre, R.H. (eds.). *Biology and Conservation of Northern Forest Owls: Symposium proceedings.* February 3-7, 1987. Winnipeg, Manitoba. USDA, Forest Service, Gen. Tech. Report RM-142. 309p.
- Duncan, J.R. 1992. *Influence of prey abundance and snow cover on great gray owl breeding dispersal.* Ph.D. Thesis. Zoology Department, University of Manitoba, Winnipeg, Manitoba. 127p.
- Duncan, J.R. and Duncan, P.A. 1998. Northern Hawk Owl (Surnia ulula). In: Poole, A. & Gill, F. (eds.). *The Birds of North America*, No. 356. The Birds of North America, Inc., Philadelphia, PA. 28p.
- Duncan, J.R. 2003. *Owls of the World.* Key Porter Books, Ltd. Toronto, ON. 310p.
- Duncan, J.R., Swengel, S.R. and Swengel, A.B. 2009. Correlations of Northern Saw-whet Owl (*Aegolius acadicus*) calling indices from surveys in southern Wisconsin, USA with owl and small mammal surveys in Manitoba, Canada, 1986-2006. Pp. 489-496 in Johnson, D.J., Van Nieuwenhuyse, D. and Duncan, J.R. (eds.). *Owls – Ambassadors for the Protection of Nature in their Changing Landscapes.* Proceedings of the fourth World Owl Conference. 31 October – 4 November 2007, Groningen, The Netherlands. *Ardea* 97: 395-649.
- Duncan, J.R. 2013. *The Complete Book of North American Owls.* Thunder Bay Press. San Diego, CA. 192p.
- Duncan, J.R. 2021. An Evaluation of 25 Years of Volunteer Nocturnal Owl Surveys in Manitoba, Canada. Pp xx-xx in Roque, I.M.F., Duncan, J.R., Johnson, D.H. and Van Nieuwenhuyse, D. (eds). *2017 World Owl Conference Proceedings.* Evora, Portugal. *Airo 29:66-82.*
- Handbook of the Birds of the World and BirdLife International (2019). *Handbook of the Birds of the World and BirdLife International digital checklist of the birds of the world. Version 4.* Available at:http://datazone.birdlife.org/userfiles/file/Species/Taxonomy/HBW-BirdLife_Checklist_v4_Dec19.zip. Accessed 1 October 2020.
- Holthausen, R., Czaplewski, R.L., DeLorenzo, D., Hayward, G., Kessler, W.B., Manley, P., McKelvey, K.S., Powell, D.S., Ruggiero, L.F., Schwartz, M.K., Horne, B.V. and Vojta, C.D. 2005. *Strategies for monitoring terrestrial animals and habitats.* General Technical Report RMRS-GTR-161. Department of Agriculture, Forest Service. Rocky Mountain Research Station, Fort Collins. 34p.
- Kassambara, A. 2018. *Regression Model Validation - Regression Model Accuracy Metrics: R-square, AIC, BIC, Cp and more.* http://www.sthda.com/english/articles/38-regression-model-validation/158-regression-model-accuracy-metrics-r-square-aic-bic-cp-and-more/. Accessed 1 September 2020.
- Konig, C. and Weick, F. 2009. *Owls of the World, 2nd ed.* Yale University Press. New Haven, Connecticut. 528p.
- Lehikoinen. A., Ranta, E., Pietiäinen, H., Byholm, P., Saurola, P., Valkama, J., Huitu, O., Henttonen, H. and Korpimäki, E. 2011. The impact of climate and cyclic food abundance on the timing of breeding and brood size in four boreal owl species. *Oecologia* 165: 349–355.
- Manley, P.N., Zielinski, W.J., Schlesinger, M.D. and Mori, S.R. 2004. Evaluation of a multiple-species approach to monitoring species at the ecoregional scale. *Ecological Applications*. 14: 296-310.
- Ng, C.S., Duncan, J.R. and Koper, N. 2018. Who's "hooting"? Motivations and scientific attitudes of Manitoban citizen science owl surveyors. *Avian Conservation and Ecology* 13: Art. 9. https://doi.org/10.5751/ACE-01265-130209.
- Proença, V., Martin, L.J., Pereira, H.M., Fernandez, M., McRae, L., Belnap, J., Böhmg, M., Brummitt, N., García-Moreno, J., Gregory, R.D., Honrado,

J.P., Jürgens, N., Opige, M., Schmeller, D.S., Tiago, P. and van Swaay, C.A.M. 2017. Global biodiversity monitoring: From data sources to essential biodiversity variables. *Biological Conservation* 213: 256–263.
- Quinn, G.P. and Keough, M.J. 2002. *Experimental Design and Data Analysis for Biologists.* Cambridge University Press. 537p.
- Takats, D.L., Francis, C.M., Holroyd, G.L., Duncan, J.R., Mazur, K.M., Canings, R.J., Harris, W. and Holt, D. 2001. *Guidelines for Nocturnal Owl Monitoring in North America.* Beaverhill Bird Observatory and Bird Studies Canada, Edmonton, Alberta. 32p.
- Taylor, P. (ed.). 2003. *The Birds of Manitoba.* Manitoba Avian Research Committee, Manitoba Naturalists Society. Winnipeg, Manitoba. 504p.
- Witmer, G.W. 2005. Wildlife population monitoring: some practical considerations. *Wildlife Research* 32: 259–263.

Leroy Miller

Long-eared Owl

Long-eared Owl *Asio otus* behaviour, prey provisioning and diet during the nestling period using a camera trap in 2015 in Manitoba, Canada.

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Abstract

A camera trap was set up at a Long-eared Owl *Asio otus* nest in Manitoba, Canada in 2015. This was the first time this nocturnal species has been studied in this manner. An analysis of 128,694 images collected over 15 d during the nestling period revealed new information on Long-eared Owl behaviour and diet. Initially, the male delivered prey to the female brooding nestlings and the female rarely left the nest. The female often performed a raised wing display with erect body plumage when receiving prey from the male reminiscent, in part, of a male precopulatory display. Two unsuccessful nestling predation attempts were recorded. When the oldest nestling was 16-17 d old the female spent less time on the nest which coincided with the inferred onset of thermoregulation and observed ability of nestlings to feed themselves. Prey deliveries increased up to fledging in response to increased nestling energy requirements and to expedite fledging and maximizing nestling survival. Prey provisioning at the nest then decreased as successive nestlings fledged and were fed directly outside the view of the camera. The majority (92.5%) of 106 prey deliveries were small mammals, especially voles (Cricetidae), which was consistent with other diet studies derived from pellet analysis. Only 48.1% of delivered prey were identified to species. Nestling diet did not significantly change with time. Results from this study demonstrate the potential and limitations of camera traps for future research on the behaviour and diet of nesting Long-eared Owls and other nocturnal species.

Introduction

Studying animal behaviour enhances our understanding of a species' biology including habitat use, interactions with other species and feeding ecology (Sutherland 1998; Rogers et al. 2005). This understanding is important to develop species management and conservation plans to mitigate increased anthropogenic induced changes to the environment and climate (Jordan 2005; Berger-Tal et al. 2011; Caravaggi et al. 2017; Gaglio et al. 2017). Yet for many species such basic information such as diet is either non-existent, limited, or biased (Jordan 2005), especially for nestlings where diet influences growth, development, and fitness (Robinson et al. 2015).

Directly observing wildlife is time-consuming, can influence behaviour, produce observer bias and fatigue, yield small sample sizes, and may be not be logistically feasible (Rogers et al. 2005; Reif and Tornberg 2006; Caravaggi et al. 2017). Indirect methods, such as the identification of prey remains in nests and pellet analysis, may also yield limited data and biased results, especially for raptors (Marti 1974; Marti 1987; Jordan 2005; Rogers et al. 2005; García-Salgado et al. 2015; Robinson et al. 2015).

To overcome the challenges noted above, researchers have used simple and affordable non-intrusive camera traps to continuously document nesting bird diet, behaviour and predation through high quantity and quality recorded video or images (Cutler and Swann 1999; Lewis et al. 2004; Cox et al. 2012; García-Salgado et al. 2015; Caravaggi et al. 2017). Difficult to observe and rare events or behaviours can be documented while minimizing disturbance to species during sensitive times, during inclement weather, and at night (Cutler and Swann 1999; Lewis et al. 2004; Reif and Tornberg 2006; Caravaggi et al. 2017). Continuously recorded video and/or image files can be viewed repeatedly by many reducing observer bias, increase sample sizes and more accurately estimate prey provisioning rates and nestling diets (Cutler and Swann 1999; Lewis et al. 2004; Rogers et al. 2005; Reif and Tornberg 2006; García-Salgado et al. 2015). Nonetheless cameras may affect bird behaviour, are subject to mechanical or battery failure and may bias diet estimates, i.e., blurry images of prey items, colourless images taken at night, or images with prey hidden from view (Cutler and Swann 1999; Lewis et al. 2004; García-Salgado et al. 2015; Caravaggi et al. 2017). Despite these limitations, nest camera traps remain an effective tool for studying raptor behaviour and diet (García-Salgado et al. 2015).

The Long-eared Owl is notoriously elusive during the nesting season and, as with other nocturnal owl species, unbiased detailed information on its breeding biology is sparse (Glue 1977). It is found in a variety of open forested habitat in North America, Eurasia, and northern Africa between 30° and 65°N latitude (Cramp 1985; Marks et al. 1994). It is a widespread and regular migratory breeding bird in Manitoba (Holland et al. 2003; Artuso 2019; Duncan 2020). While its diet and some aspects of its breeding biology have been studied using pellet analysis, radio-telemetry, and direct observation it can be sensitive to disturbances making detailed and unbiased research on its nesting behaviour challenging (Craig et al. 1988, Marks et al. 1994). This study is the first time this species has been studied with nest camera trap technology to document its breeding behavior and feeding ecology. Because determining the limitations of camera trap technology is important, especially for species active at night, our assessment examined the degree to which delivered prey could be identified from black and white images taken at night.

Methods

Study Area

The nest site we monitored was located within a small forest patch near Balmoral, Manitoba, Canada (50.2406168°, -97.3027412°) at 254 m asl in a highly fragmented agriculture-dominated landscape (Fig. 1). Mean annual temperature ranges from 2-3°C with a mean 16°C summer temperature and a mean -12.5°C winter temperature. Mean annual precipitation range is 450-700 mm (Environment Canada 2020). This area is within the Lake Manitoba Plain Ecoregion in the Prairies Ecozone (Wiken et al. 1996) and was originally characterized as mixed-grass aspen parkland. It is now a mix of dispersed remnant native and non-native grasslands and forest patches within a dominant mosaic of forage and cereal crops.

The nest was in a forested patch dominated by trembling aspen (*Populus tremuloides*) mixed with some burr oak (*Quercus macrocarpa*) and Manitoba maple (*Acer negundo*). Introduced tree species included scots pine (*Pinus sylvestrus*), white birch (*Betula papyrifera*), jack pine (*Pinus banksiana*), tamarack (*Larix laricina*), balsam fir (*Abies balsamea*), northern-white cedar (*Thuja occidentalis*), and white spruce

(*Picea glauca*). The stick nest used by the owls was 5.5 m above ground in a white spruce and was built by American crows (*Corvus brachyrhynchos*) prior to 2015. The nest tree was ca. 50 m north of an occupied farmhouse (Fig. 1).

Observations of Long-eared Owls at the nest and in the area helped interpret some behaviours obtained from camera images and enabled the young to be aged accurately (Table 1). This included setting up an observation blind 10 m north of the nest from which to infrequently observe the nest without flushing the owls.

Data Collection

On 2 June 2015, a Reconyx PC900 HyperFire Professional High Output Covert IR Trail Camera (www.reconyx.com) was mounted just above and 1 m from the centre of the nest using a steel angled bracket attached to the nest tree (Fig. 2) to optimize the collection of images to document behaviour and identify prey. Steen et al. (2016) determined that <1 m missed behaviours and >1 m made prey identification more difficult. Cameras placed >1 m from nests were triggered excessively by moving branches, wasted limited image memory storage space, and depleted batteries faster (R. Steen pers. comm.). The camera was focused to 1 m by the manufacturer at purchase to maintain the warranty. The camera settings used were: motion sensor = on; sensitivity = high; pictures per trigger = 3; picture interval = rapid fire; quiet period = no delay; and night mode = fast shutter. Images included an image number, time (hh:mm:ss), date (yyyy-mm-dd) and temperature (^{o}C) stamp. Time was set for the Central Daylight Saving Time Zone. The 3 images/second capture/motion setting was a compromise between likelihood of identifying prey to species level and limits of memory and battery capacity (R. Steen pers. comm.). Reducing the frequency of camera memory and battery maintenance also reduced disturbance to the nesting owls (Caravaggi et al. 2017). The camera's SD card and batteries were replaced three times and 128,694 images were recorded from 08:08 hrs on 2 June 2015 to 15:13 hrs on 18 June 2015 (Table 2). The camera was removed after the last of the young fledged from the nest. Because Long-eared Owls have an asynchronous hatch (Marks et al. 1994) and are only moderately sexually size dimorphic (Earhart and Johnson 1970) we assumed that the largest nestling, readily identifiable in images (Fig. 3), was also the oldest.

Reviewing Camera Trap Images

All camera trap images collected were reviewed and behaviours such as prey deliveries were transcribed into a spreadsheet. The time, date and number of prey delivery images were recorded to determine their duration and peak periods. Changes in the number and type of prey items delivered to the nest as nestlings aged was assessed by clustering images into three time periods (see below). The sex of the adult delivering prey was noted to see if changed as nestlings aged. While Long-eared Owls exhibit moderate reverse sexual size and facial disk colour dimorphism (Earhart and Johnson 1970; Marks et al. 1994; Holt 2016) these differences or any other differentiating characteristics (i.e., plumage pattern) were not distinguishable on images. We presumed that only the female Long-eared Owl incubated and brooded as only they develop a brood patch (Marks et al. 1994). Therefore, we noted the male as delivering prey to the nest when the female was in the nest. The female was identified as delivering prey only if she remained in the nest afterwards and if she subsequently fed or preened the young. Otherwise, the adult delivering the prey was noted as unknown sex.

Identification of Prey from Camera Trap Images

All prey items delivered to the nest were identified to the finest taxonomic level possible from images by consensus of both authors to estimate the contribution of prey type to the nestlings' diet. Small mammal prey were identified using a combination of one or more visible features including relative tail or hind leg length, ear and/or eye size, and uniform vs contrasting pelage shading (Fig. 3). There were few pellets recovered from in and around the nest after the young fledged. No additional prey species were identified from pellets to avoid double counting them. Bird prey were likewise identified by bill, head, body, wing and tail shape and size and plumage appearance to the extent possible and by consultation with three bird experts. Images with bird prey were also posted on iNaturalist (https://www.inaturalist.org/) to see if yielded crowd-sourced identification suggestions.

Low lighting, movement resulting in blurring or a partially blocked field of view resulted in prey delivery or handling images (Fig. 3) from which prey were assigned to one of six possible categories: unidentified, unidentified mammal, unidentified rodent, unidentified mouse, unidentified vole, or unidentified passerine. The proportion of prey items that comprise the nestlings' diet was summarized in three equal time segments to determine if proportion changed as nestlings aged as follows: week one (June 02-07), week two (June 08-13), and week three (June 14-18). A chi-square test ($\alpha = 0.05$, Statistical Function, Excel for Microsoft 365 updated April 2020) was used to determine if diet composition changed over time. The oldest nestling was 12 d old on 2 June and was 28 d old on 18 June.

The duration of time spent by the female in the nest was also recorded to assess whether the level of parental care changed as nestlings aged. The difference in the date and time associated with the first and last images in which the female arrived, stayed, and then left the nest was recorded as time spent in the nest. A selection of other behaviours observed in recorded images were noted and are described herein.

Results

In total, 128,694 camera images were collected (Table 2). Although the camera was frequently checked, a battery failure caused the camera to malfunction on 9 June at 01:04 hrs until it was reset on 11 June at 07:29 hrs resulting in an image and data gap when the oldest nestling was between 19 and 21 d old. The oldest nestling fledged from the nest the following day at 22 d old.

From 2 to 17 June 2015 the average time of sunset was 21:35:11 hrs (21:29:00 to 21:40:00 hrs) and sunrise was 05:20:53 hrs (05:19:00 to 05:24:00 hrs) with 7 h and 46 min from sunset to sunrise. The times that the nest camera switched from colour (day) to black and white (night) mode varied depending on light levels affected by cloud cover and vegetation density but averaged 21:03:24 hrs or 32 min before sunset. Likewise, the times that the camera switched from black and white to colour mode averaged 05:56:03 hrs or 35 min after sunrise (Fig. 4).

Prey Deliveries

From the 128,694 camera images collected, 106 prey deliveries were documented. Most (89.6%) prey deliveries occurred after sunset and before sunrise with the two largest peaks about 22:00 and 01:00 hrs and a smaller peak about 03:00 hrs (Fig. 4). The frequency of prey deliveries generally increased as nestlings aged until the camera's batteries failed a few days prior to when the oldest nestling fledged (Fig. 5). From this point on, the frequency of prey deliveries declined as subsequent nestlings fledged from the nest (Fig. 5) and fledged young received prey away from the nest.

For the 15-d period the camera recorded images the mean prey delivery rate was 7.1 prey/d (n=106, se = 1.04, range 2-16) for an average of 1.8 prey/nestling/d. However, as mentioned above, some prey deliveries occurred away from the nest after the oldest nestling fledged. The mean prey delivery rate was 8.4 prey/d (n = 76, se = 1.44, range 2-16) for the 9 days all four nestlings were present for an average of 2.1 prey/nestling/d.

Of the 106 prey deliveries, 31 were by the male, 20 by the female, and 55 by an unknown adult whose sex could not be determined. The male initially delivered most of the prey (Fig. 6) while the brooding female rarely left the nest (Fig. 7). During this period, the female accepted and tore up prey to feed the nestlings. When the oldest nestling was 15 d old the female began to spend less time at the nest, and this trend decreased further as the nestlings aged (Fig. 7). At this time, the arrival of the female became increasingly indistinguishable from that of the male and more prey deliveries were noted as being by an "unknown" adult (Fig. 6). Toward the end of the nestling period, nearly all prey delivered to the nest was by an unknown adult as the nestlings no longer required assistance in consuming prey and duration of time spent at the nest by the female neared zero (Figs. 6, 7).

Prey Identification and Diet

There was limited consensus or specificity among the three bird experts we asked to independently identify bird prey from select images (i.e., Fig. 4); one suggested all five bird prey were recently fledged Chipping Sparrows *Spizella passerina* while two thought that some of them were either Savannah Sparrows *Passerculus sandwichensis* or "unidentified sparrow" (Passerellidae). The habitat around the owl nest supported healthy populations of Savannah, Clay-coloured *Spizella pallida* and Chipping Sparrows in spring and summer (J. Duncan unpubl. data). The same images of bird prey posted on iNaturalist (https://www.inaturalist.org/) on 9 June 2020 failed to produce additional identifications from website bird expert moderators over a three-week period. Therefore, we considered all bird prey to be unidentified small passerines, likely sparrows.

Of the 106 prey items delivered to the nest, 98 were small mammals, 6 were sparrows (Passerellidae) or small passerine birds, and 2 were unidentifiable to class (Table 3). In total, 48.1% of prey items were identified to one of five species: Deer Mouse *Peromyscus maniculatus*, Meadow Vole *Microtus pennsylvanicus*, Arctic Shrew *Sorex arcticus*, Red-backed Vole *Myodes gapperi* and Northern Short-tailed Shrew *Blarina brevicauda* (Table 3). The remaining prey were identified as a chipmunk (*Tamius* spp.), three jumping mice (Zapodinae) and one of six other groupings (Table 3).

Voles (Cricetidae) made up most (65.1%) of the nestling diet; of the 69 voles, 28 were unidentified, 26 were Meadow Voles, and 15 were Red-backed Voles (Table 3). Unidentified rodents (Rodentia) made up 11.3% of the nestlings' diet followed by mice (Muridae) comprised 10.4% of nestling diet including seven Deer Mice, three jumping mice, and one unidentified mouse (Table 3). The remainder of nestling diet was composed of sparrows (Passerellidae), unidentified mammals, shrews (Soricidae), and unidentifiable prey (Table 3). Voles consistently made up the greatest proportion of delivered prey as nestlings aged (Fig. 8, Table 3). Changes in composition of nestling diet by week did not change significantly as nestlings aged ($x^2 = 3.946$, $p = 0.684$, Table 3).

Other Notable Behaviours and Events

When the male delivered prey to the female brooding young his arrival was immediately preceded by the female erecting her body plumage, especially those on her back, while raising her wings up such that the wing tips almost touched over her back, and tilting her body forward (Fig. 9). This represents a new ritualized display for this species as the closest similar behaviour has only been described as a precopulatory male calling posture (Mikkola 1983). This display has also been seen repeatedly only in spring when feeding a captive human-imprinted female Long-eared Owl (J. Duncan unpublished data).

On several occasions the camera captured nest sanitation behaviour by the female where she inspected the nest and used her bill to pick up and either eat or dispose uneaten prey or pellets over the side of the nest (Fig. 10). This was consistent with observations made by others (Murphy 1992; Scott 1997). Images of the female removing saclike nestling feces, a behaviour reported by Murphy (1992), were not recorded.

We considered an adult Cooper's Hawk *Accipiter cooperii* landing near the nest on 4 June 2015 to be a predation attempt, as this species is known to kill and eat Long-eared Owls (Bloom 1994). Immediately after the hawk's arrival the female owl exhibited an exaggerated inverted wing display with erected body feathers while swaying left to right after which the Cooper's Hawk dispersed (Fig. 11) after 1 m and 8 s.

Another predation attempt involving a Short-tailed Weasel *Mustela erminea* was documented whereby the weasel appeared to attempt to take a nestling at 06:27 hrs on 12 June 2015 (Fig. 12). This mammal regularly climbs trees to the nests of even large birds for prey (King 1989). This event was concurrently and independently photographed by Skip Shand (Fig. 12) which documented that both the male and female participated in the successful defence of the nestlings. This incident appears to be the first documented predation attempt by a weasel on a Long-eared Owl nest. A week earlier, at 05:08 hrs on 5 June 2015, the brooding female peered intently at some stimulus below the nest, but the object of her attention was not visible (Fig. 12).

Discussion

This effort is the first camera trap study of Long-eared Owl nesting behaviour and analysis of temporal changes in prey provisioning rates and nestling diet composition. Prey deliveries for this nocturnal species (Marks et al. 1994) were expected to largely occur at night (Fig. 4). The peak prey delivery times we observed (Fig. 4) were generally consistent with, but started an hour earlier than, those observed by Craig et al. (1988) where nesting Long-eared Owls were most active between 22:00 to 05:00 hrs. The Long-eared Owls we observed perhaps had to start hunting earlier as they had less time (7 h and 45 min) to do so between sunset and sunrise than those studied in Idaho (9 h and 45 min; Craig et al. 1988).

Craig et al. (1988) also reported lulls in prey deliveries from 20:00 to 22:00 hrs and from 05:00 to 06:00 hrs whereas the first lull we detected was an hour later at 23:00 hrs (Fig. 4). The occasional day-time prey deliveries we recorded (Fig. 4) were likely opportunistic, energy efficient prey captures close to the nest. The prey deliveries just prior to sunset (Fig. 4) were consistent with Bayldon's (1978) observation that Long-eared Owls begin hunting before sunset, especially during brood-rearing.

The observed increase in prey provisioning as nestlings aged (Fig. 5) correlated with an inferred increase in their energy needs (Steen et al. 2012) and represents a means by which adults increase nestling fledging success and survival (Ricklefs 1968). The provisioning rate we obtained (8.4 prey/d) was higher than that reported for two nests in Utah, USA, (3.5-4 prey/d) by Delong (1982) but the number of young present in these nests was not given. We nor Delong (1982) measured prey availability in our respective study areas, which likely influence prey delivery rates.

As expected, the subsequent progressive decline in prey provisioning (Fig. 5) coincided with the successive fledging of nestlings as adults increasingly fed young owls outside of the nest and the camera detection range; fledged Long-eared Owls are fed by the female until the young are 6.5-8 weeks old and 2-3 weeks afterwards by the male (Marks et al. 1994). The observed daily fluctuations in prey delivery rates (Fig. 5) may relate to weather as other have reported that rain and wind reduced Long-eared Owl hunting success to only one capture for every six or more attempts (Cramp 1985).

Most raptors have asymmetric parental roles in which the female incubates, broods and feeds the nestlings, while the male hunts for prey and is usually assisted by the female for the latter part of the nestling period (Sonerud et al. 2014). This study found similar results as the male was the main provider of prey during the beginning of the nestling stage (Fig. 6). As the nestlings aged toward the latter part of the nestling period the female also delivered prey and ultimately spent little time at the nest (Figs. 6, 7), however, the extent to which she captured prey was unknown. One of many hypotheses for the evolution of reversed size dimorphism in owls is that the larger female is better able to defend eggs or nestlings from predators (Mueller 1986). The female was observed playing a primary and immediate role in defending the nestlings on at least two separate occasions, therefore it is assumed that she also remained close to the young in the latter part of the nestling and post-fledgling periods and had fewer opportunities than the male to forage for prey. This conjecture is supported by Ulmschneider's (1990) observation that radio-marked males made 2.5 times more food deliveries than did similarly marked and more protective female Long-eared Owls during the post-fledgling period.

The decrease in the duration of time on the nest and increase in prey delivery by the female was similar to, but more delayed than, that inferred by Craig et al. (1988) from the movements of two radio-marked breeding female Long-eared Owls. This decrease was influenced by two non-mutually exclusive factors, the ontogeny of thermoregulation and self-feeding ability of the nestlings. While away from the nest, the female presumably perched and hunted opportunistically nearby. Female absence from the nest varied with the age of the nestlings: when the oldest nestling was 13-14 d old, the female was away from the nest <10% of the time; when it was 15-16 d old, she was away for 26-29% of the time; and when it was 17-18 d old she was away for 76-90% of the time (Fig. 7). Barn Owl *Tyto alba* nestlings can maintain their own body temperature when 15-20 d old and the absence of the female on the nest before this date has adverse consequences for the young (Durant et al. 2004). Similarly, nestling Eastern Screech Owls *Megascops asio* achieved thermoregulation when 14-16 d old (Lohrer 1985). Older and larger nestlings able to thermoregulate can transfer heat to younger and smaller nestlings (Durant et al. 2004). Therefore, we infer that Long-eared Owl nestlings can thermoregulate when they are 15-18 d old based on the female's behaviour (Fig. 7) which is much later than what Singer (1988) observed in Idaho (11–12 d old) based on behavioural observations of young. Singer (1988) did not observe brood or group homeothermy at an earlier age to individual homeothermy and considered that their results were influenced by relatively mild ambient temperatures.

As the female spent less time on the nest, the behaviours that distinguished her from the male (i.e., remaining on the nest and feeding young) also decreased, thereby increasing the number of prey deliveries denoted as "unknown adult" (Fig. 6). Capturing and marking a breeding adult could mitigate this limitation (Craig et al, 1988; Ulmschneider 1990).

Identifying delivered prey to class (mammal or bird) from camera trap images was successful but more specific identifications were often challenging (Fig. 3, Table 3). Challenges included harsh shadows or low lighting, movement resulting in blurred images, or the prey item was partially or wholly blocked by an owl (Fig. 3). In many cases, prey were identified from one or more of a series of images taken after prey delivery, such as feeding events. In addition, almost all deliveries occurred at night while the camera was in black and white mode, which prevented the use of colour in prey identification.

The diet of the Long-eared Owl nestlings in this study was dominated by small mammals, especially voles, while birds made up a relatively small portion, and parallels other studies in North America, Eurasia and Africa (Marti 1976; Klippel and Parmalee 1982; Marks 1984; Marks et al. 1994; Birrer 2009; Mori and Bertolino 2015). Voles may have been the most common or available prey in our study area, as raptors often select prey relative to their availability (Boshoff et al. 1994). The composition of nestling Long-eared Owl diet did not significantly change with age (Table 3) suggesting that the adults captured and delivered prey opportunistically and that relative prey availability did not change over the same period. This interpretation is consistent with other research which state that Long-eared Owls feed opportunistically on available prey rather than being a specialized vole predator (Marks 1984; Craig et al. 1988; Marks et al. 1994). In contrast, one study (Ulmschneider 1990) noted a gradual increase in pocket mice (*Perognathus* spp.) in Long-eared Owl nestling diets but also concluded that this increase was related to an increase in this prey type's availability.

Birds may contribute to a limited portion of nestling diet as they may be less active at night or parents may avoid feeding them to nestlings as they may take longer for nestlings to handle and eat (Sonerud et al. 2014). Bird prey may also be more dangerous for nestlings to eat. Duncan and Nero (1998) documented that a recently fledged Eastern Screech-owl choked on and died while eating an intact red-breasted nuthatch *Sitta canadensis*; the wedged bill of the nuthatch pierced the upper pallet and skull of the owlet.

Camera traps are an innovative way to study animal behaviour (Steen 2009; Trolliet et al. 2014; Caravaggi et al. 2017). Their use, and other new sources of images and data, such as internet forums and social media (Lourenço 2019), are yielding new data on wild species. The camera trap as used in this study was useful in obtaining a better understanding of key aspects of the breeding ecology of the Long-eared Owls such as provisioning rates, diet, nest sanitation, predation attempts, and one new ritualized display behaviour. These results would be logistically difficult or impossible to obtain by direct observation or pellet analysis for this nocturnal owl species. The female stayed away from the nest for nearly an hour after the initial camera set-up during a time when she rarely left the nest. However, we concluded that overall, the camera trap was non-intrusive and all four nestlings fledged from the nest at approximately 22 days old.

The camera trap was an efficient way to capture images for subsequent study. Images can be reviewed by multiple researchers or experts, enhancing the accuracy of the results, and archived for later access. We recommend that the same methods be used at other Long-eared Owl nest sites to determine the generality of our findings (Johnson 2002). Camera trap research should use standard research and reporting methods (Meek et al. 2014; Robinson and Prostor 2017). Camera traps are subject to malfunctions, such as the battery failure we experienced, creating data gaps. Additional limitations included difficulties in the identification of prey to species. However, we conclude that the benefits of using camara traps outweighed their limitations and that they compliment more traditional methods to study animal behaviour. Camera traps provide detailed results which positively impact conservation management and research efforts.

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Table 1. Chronology of observed and estimated* events at a Long-eared Owl *Asio otus* nest in Manitoba, Canada in summer 2015.

Date	Event or Observation
29 March	Long-eared Owls detected in adjacent areas during nocturnal owl surveys
05 April	Male Long-eared Owl courtship call heard 130 m W of nest site
22-28 April	Estimated range of dates eggs that hatched were laid
09 May	Six eggs observed in nest 5.5 m above ground in a 11 m high White Spruce *Picea glauca* tree
14-16 May	Observation blind erected 10 m N of nest site over a 3-d period
17 May	Spring snow blizzard with an overnight low of -4 °C, 60 kph NNE winds and 12 cm snow cover likely froze two of six eggs positioned on north side of the stick nest
21 May	Estimated first egg hatch
25 May	Three eggs and three nestlings observed
27 May	Estimated date fourth egg hatches
30 May	Two eggs and four nestlings observed
02 June	Two eggs and four nestlings observed and camera mounted
04 June	Cooper's Hawk *Accipiter cooperii* predation attempt at 10:51 hrs
11-12 June	Oldest nestling fledged at estimated 22 d old
12 June	Short-tailed Weasel *Mustela erminea* predation attempt at 06:27 hrs
14 June	Oldest nestling (fledged 11-12 June) observed 22 m ESE of nest tree
15 June	Third oldest nestling fledged at estimated 23 d old to branch 1.3 m above nest
17-18 June	Last two of four nestlings fledged, the youngest at estimated 21-22 d old

* Estimated based on observations and 2 d egg laying intervals and 28 d incubation (Marks et al. 1994).

Table 2. Summary of camera trap recorded image files at a Long-eared Owl *Asio otus* nest in Manitoba, Canada in summer 2015.

Date and Time Checked	Date/Time Range of Recorded mages		Number of Days	Number of Images
	Start	End		
7 June at 18:00*	2 June at 08:08	7 June at 05:00**	5	38,019
11 June at 07:29	7 June at 18:03	9 June at 01:04**	<2 days	24,580
14 June at 16:50	11 June at 07:29	14 June at 16:50	>4 days	38,529
18 June at 19:53	14 June at 16:50	18 June at 19:53	~4 days	27,566
		Totals	~15 days	128,694

* Times (hrs)

** Two gaps in coverage due to camera battery exhaustion and/or secure digital card ran out of storage space.

Table 3. Summary of prey delivered by week derived from camera trap images at a Long-eared Owl *Asio otus* nest in 2015 in Manitoba, Canada.

	Week 1	Week 2	Week 3	Totals
Date Range	2-7 June	8-13 June	14-18 June	
Age (days) of Oldest Nestling	12-17 d	18-23 d	24-28 d	
Prey Item Identification	Number of Prey Items			
Passerine (Passerellidae)	3	1	2	6
Unidentified Mammals	2			2
Unidentified Rodent (Rodentia)	8	2	2	12
Unidentified Mouse (Muridae)	1			1
Deer Mouse *Peromyscus maniculatus*	4	3		7
Jumping Mouse (Zapodinae)	1	1	1	3
Unidentified Vole (Cricetidae)	20	7	1	28
Meadow Vole *Microtus pennsylvanicus*	6	12	8	26
Red-backed Vole *Myodes gapperi*	1	8	6	15
Arctic Shrew *Sorex arcticus*			1	1
Northern Short-tailed Shrew *Blarina brevicauda*	1	1		2
Chipmunk (*Tamias* spp.)			1	1
Unidentified Prey		2		2
Totals	47	37	22	106

Figure 1. Location of the 2015 Long-eared Owl *Asio otus* nest site within a highly fragmented agriculture-dominated forest-grassland landscape in the Lake Manitoba Plain Ecoregion (left) and located north of an occupied farmhouse (right) in Manitoba, Canada.

Figure 2. The Reconyx Hyperfire Trail Camera positioned just above and 1m from the centre of the Long-eared Owl *Asio otus* nest (left), and a motion-triggered image it captured (right), in 2015 in Manitoba, Canada.

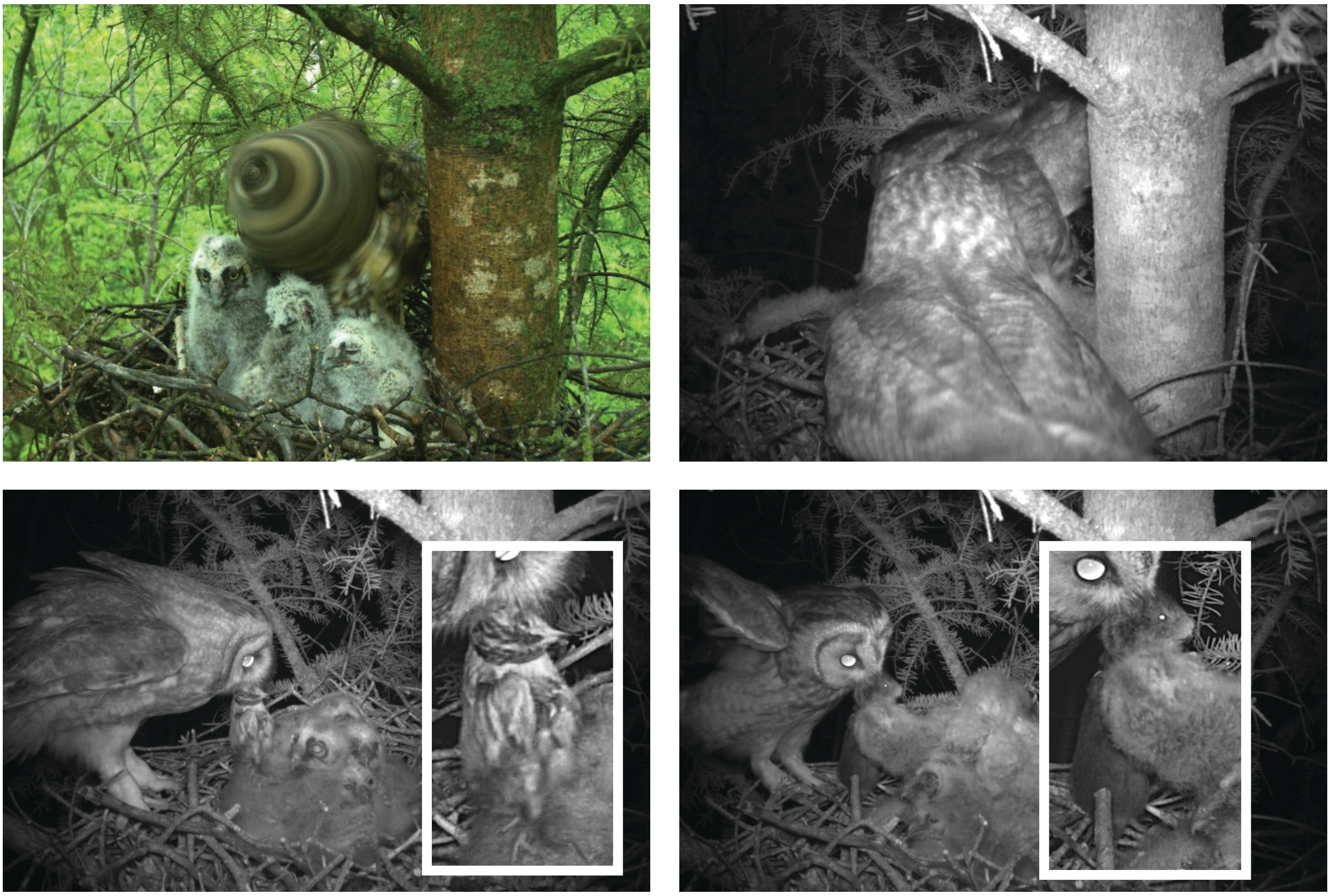

Figure 3. Nest camera images captured at a Long-eared Owl *Asio otus* nest in 2015 in Manitoba, Canada. **Upper left:** Relative nestling size (and assumed age) was apparent in images. Some motions (female head shake) were too fast for the camera to capture and were blurred. **Upper right:** Relatively few prey deliveries were not initially visible due to camera position and angle. **Lower left:** Most prey were delivered at night making it harder to identify them due to a lack of colour. Magnification and sharpening of images helped (inset). Bird experts consulted did not reach consensus on bird prey delivered but agreed they were sparrows (Passerellidae). **Lower right:** Meadow Vole *Microtus pennsylvanicus* prey delivery; small mammal prey were identified by the relative size of features, i.e., tail and/or hind leg length or ear and/or eye size, and uniform vs contrasting pelage shading.

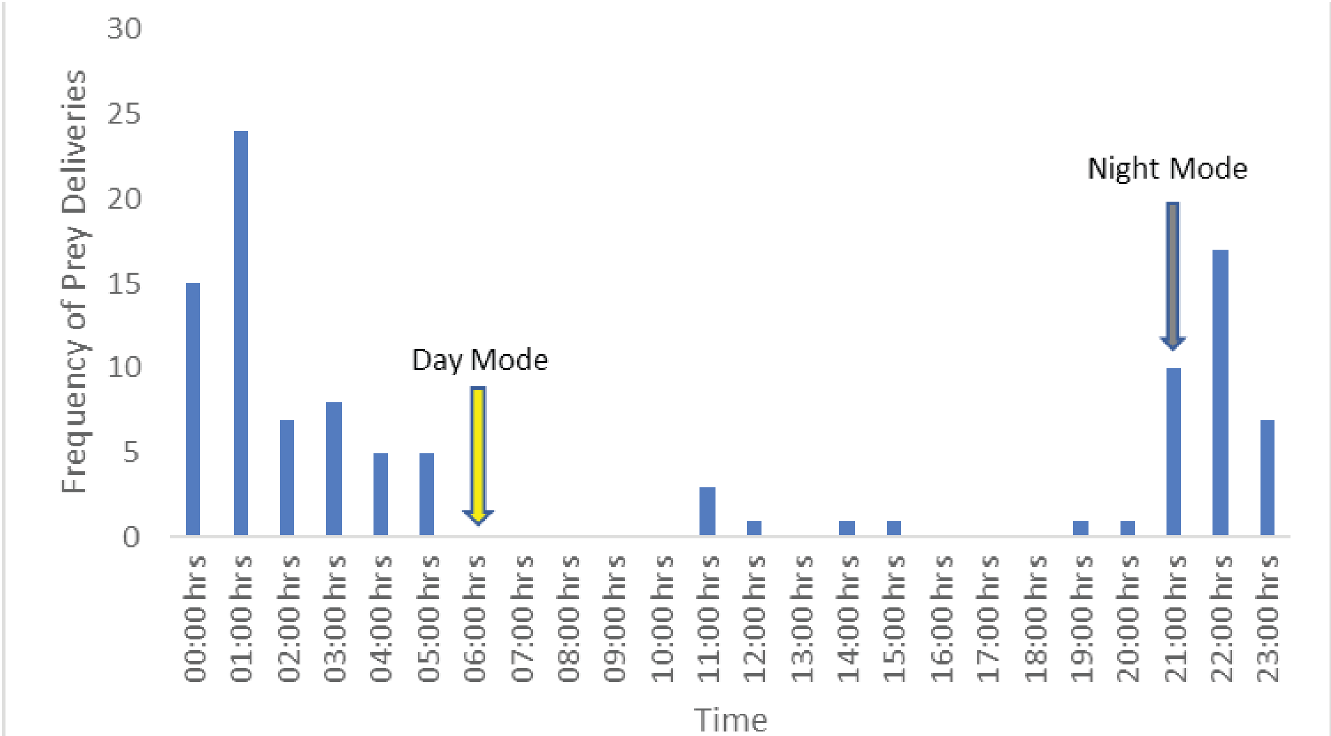

Figure 4. Timing of Long-eared Owl *Asio otus* prey deliveries (n=106) derived from nest camera images from 2-18 June 2015 in Manitoba, Canada. Arrows indicate average times camera switched between day mode (colour) and night mode (black and white). Average sunrise and sunset were 05:20:53 and 21:35:11 hrs, respectively.

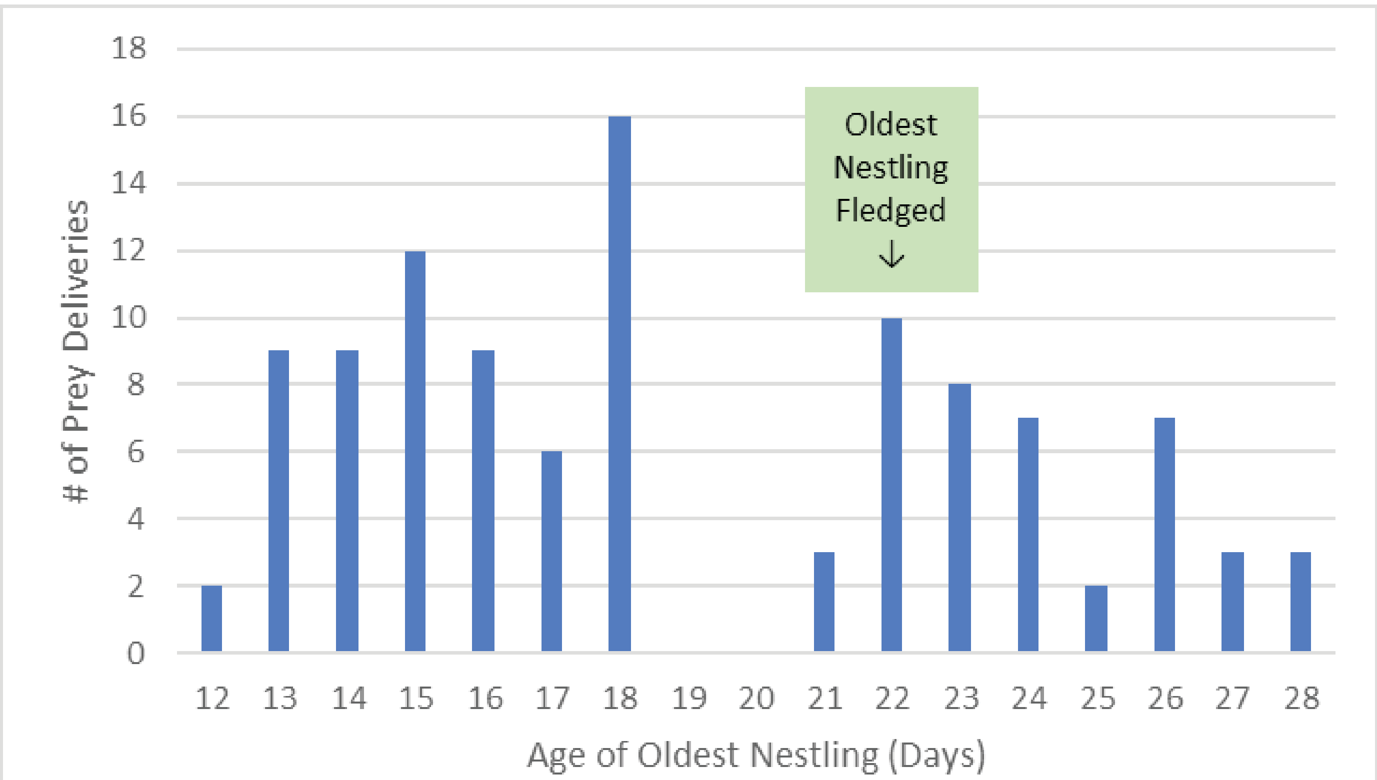

Figure 5. Total occurrences of prey deliveries (n=106) derived from nest camera images from 2-18 June 2015 when the oldest Long-eared Owl *Asio otus* nestling was 12-28 d old, in Manitoba, Canada. The gap in prey deliveries (19-20/21 d old) was due to camera battery failure.

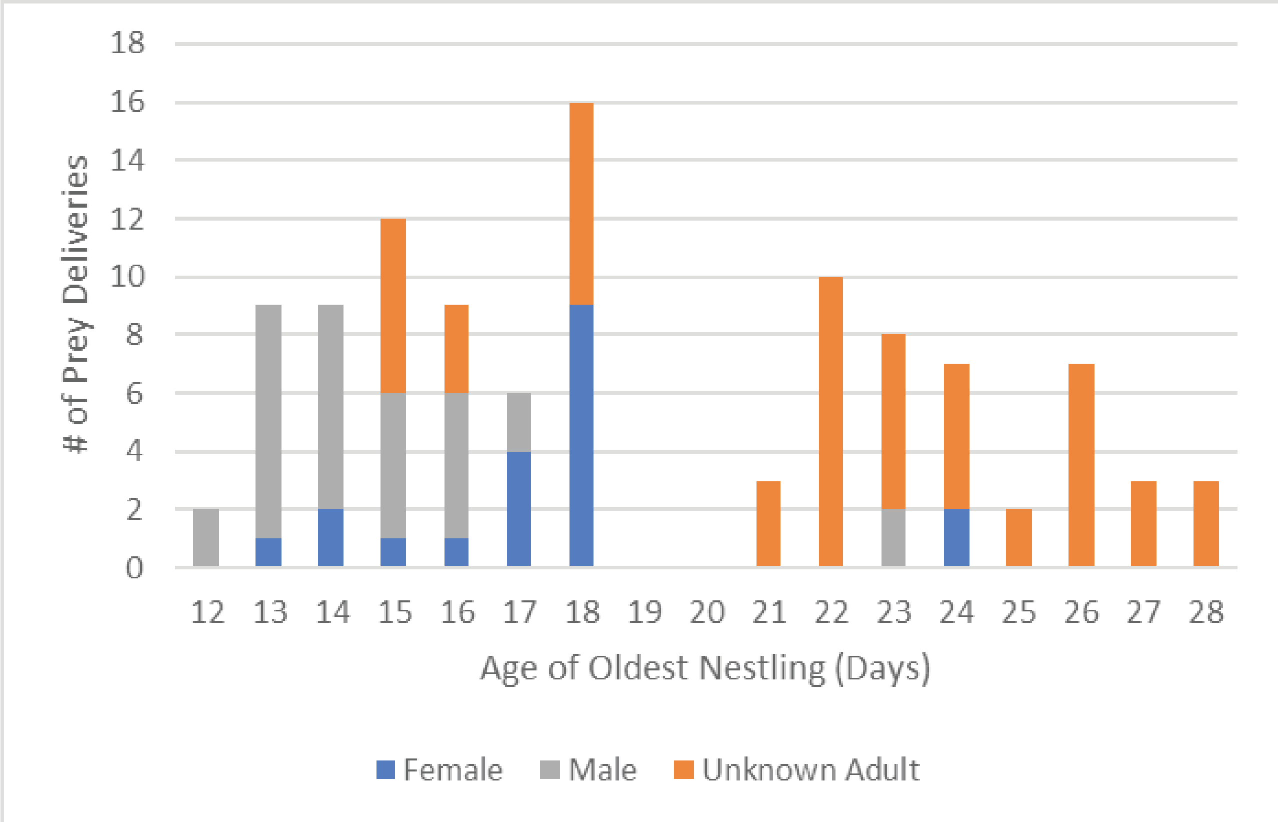

Figure 6. Frequency of prey delivered by the female, male, and unknown adult Long-eared Owl *Asio otus* derived from nest camera images from 2-18 June 2015 relative to the age of the oldest nestling, in Manitoba, Canada. The gap in prey deliveries (19-20/21 d old) was due to camera battery failure.

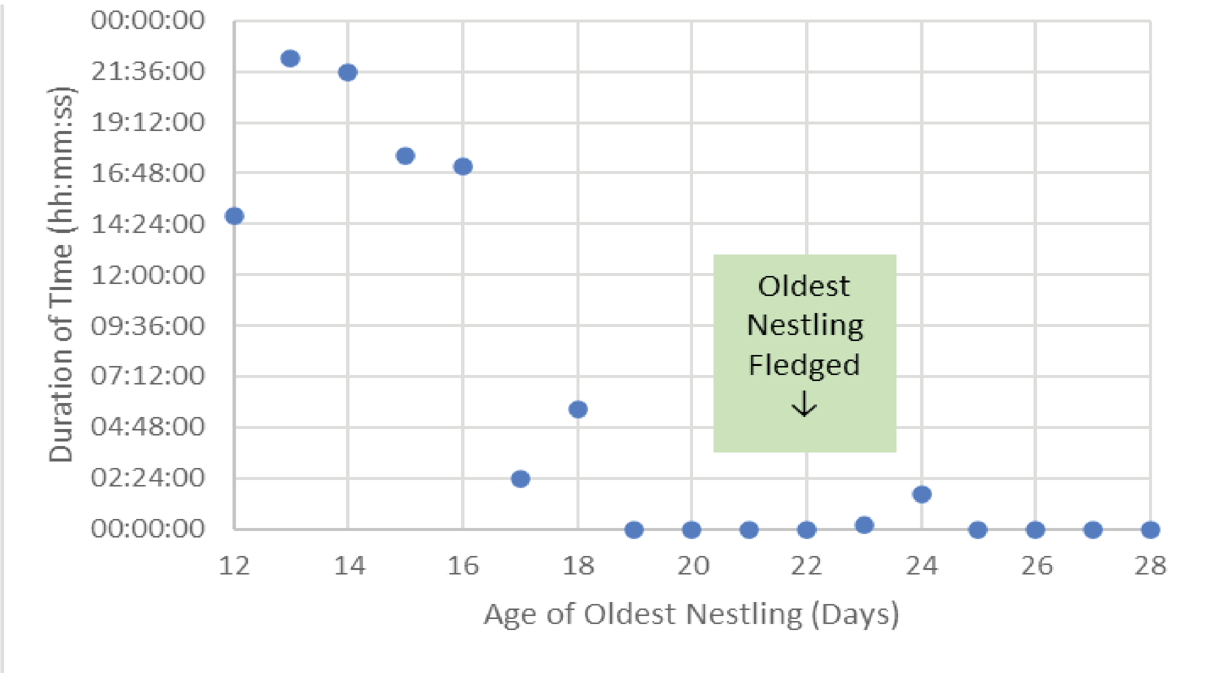

Figure 7. Duration of time spent on the nest by the female Long-eared Owl *Asio otus* derived from nest camera images from 2-18 June 2015 relative to the age of the oldest nestling, in Manitoba, Canada. There was a camera battery failure from 19-20/21 d old.

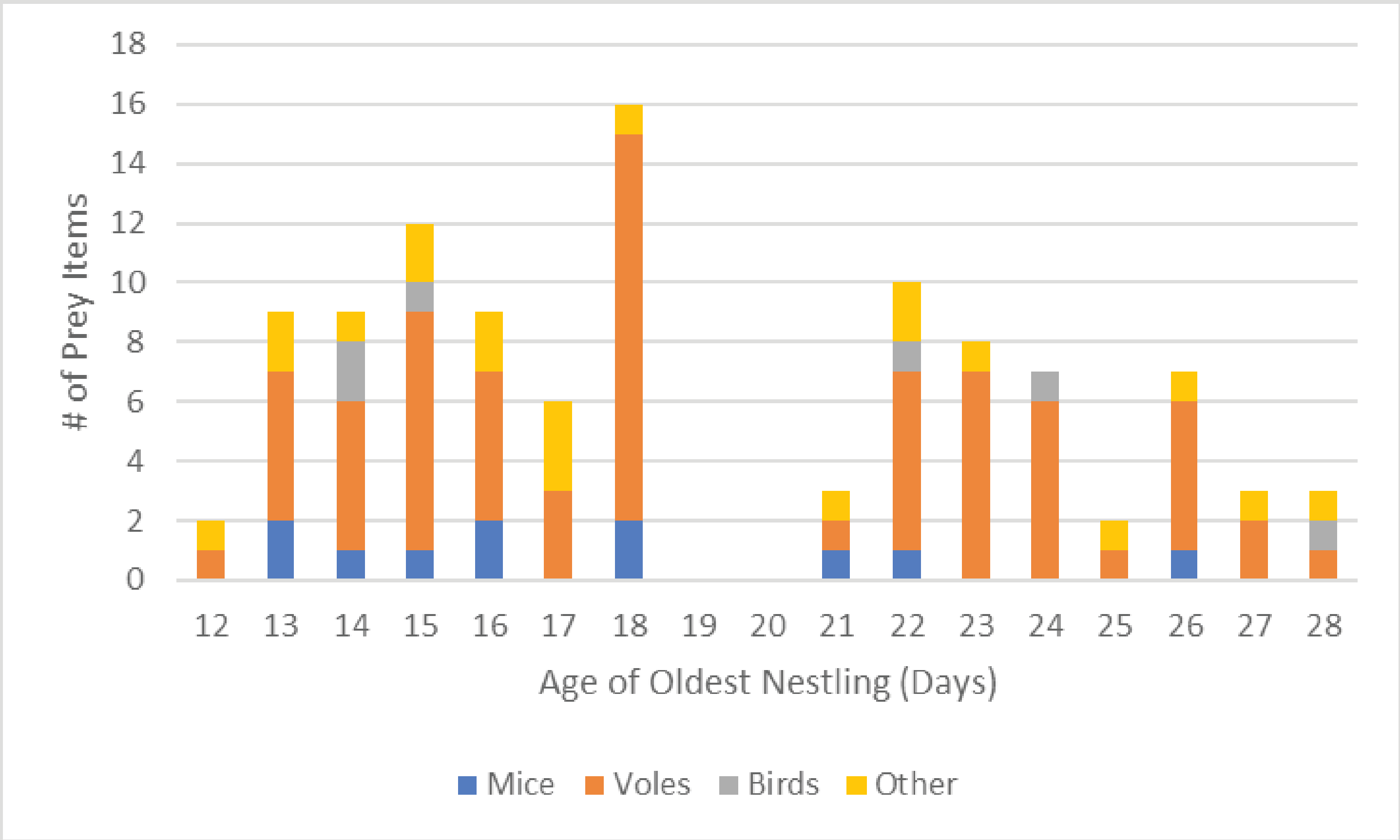

Figure 8. Major prey categories comprising the diet of nestling Long-eared Owls *Asio otus* relative to age of the oldest nestling and derived from nest camera trap images from June 2015 in Manitoba, Canada. There was a camera battery failure from 19-20/21 d old.

Figure 9. Female Long-eared Owl *Asio otus* performing a raised wing tip display on the nest before (left) and after (right) receiving prey from the male in 2015 in Manitoba, Canada. This display is reminiscent of the male precopulatory calling position display (Mikkola 1983) and has not been described in this context before.

Figure 10. Adult female Long-eared Owl *Asio otus* nest camera three image sequence showing nest sanitation (pellet removal) in 2015 in Manitoba, Canada: Pellet in nest below the female's head (left), pellet in air after female grabbed and flung it outwards (middle), and pellet on its way out past the outer rim of nest (right).

Figure 11. Female Long-eared Owl *Asio otus* inverted wing display nest defence in response to predation attempt by an adult Cooper's Hawk *Accipter cooperii* at 10:52 hrs on 4 June 2015 in Manitoba, Canada. The entire sequence from the hawk's arrival to departure lasted 1 m and 8 s.

Figure 12. Nestling predation attempts on 5 and 12 June 2015 by a Short-tailed Weasel *Mustela erminea* at a Long-eared Owl *Asio otus* nest in Manitoba, Canada. **Upper Left:** Female peering intently downward over the right side of the nest at possible predator at 05:09 hrs on 5 June 2015. **Upper Right:** Weasel attempting to predate nestling from right side of nest at 06:27 hrs on 12 June 2015. **Lower Left and Right:** Female ready to attack the weasel which had retreated immediately below the nest after previous attacks by the male and female Long-eared Owls at approximately 06:30 hrs on 12 June 2015 (photos by Skip Shand).

References

- Artuso, C. (2019). Long-eared Owl in Artuso, C., Couturier, A.R., De Smet, K.D., Koes, R.F., Lepage, D., McCracken, J., Mooi, R.D. and Taylor, P. (eds.). *The Atlas of the Breeding Birds of Manitoba, 2010-2014*. Bird Studies Canada. Winnipeg, Manitoba. http://www.birdatlas.mb.ca/accounts/speciesaccount.jsp?sp=LEOW&lang=en [23 Sep 2019]
- Bayldon, J.M. (1978). Daylight hunting by Long-eared Owls. *British Birds* 71:88.
- Berger-Tal, O., Polak, T., Oron, A., Lubin, Y., Kotler, B.P. and Saltz, D. (2011) Integrating animal behavior and conservation biology: A conceptual framework. *Behavioral Ecology* 22: 236–239.
- Birrer, S. (2009) Synthesis of 312 Studies on the Diet of the Long-Eared Owl *Asio otus*. *Ardea*, 97: 615–624.
- Bloom, P.H. (1994). The biology and current status of the Long-eared Owl in coastal southern California. *Bulletin of the Southern California Academy of Sciences* 93:1-12.
- Boshoff, A.F., Palmer, N.G., Vernon, C.J. and Avery, G. (1994) Comparison of the diet of crowned eagles in the Savanna and Forest Biomes of south-eastern South Africa. *South African Journal of Wildlife Research* 24: 26–31.
- Caravaggi, A., Banks, P.B., Burton, A.C., Finlay, C.M.V., Haswell, P.M., Hayward, M.W., Rowcliffe, M.J. and Wood, M.D. (2017) A review of camera trapping for conservation behaviour research. *Remote Sensing in Ecology and Conservation* 3: 109–122.
- Cox, W.A., Pruett, M.S., Benson, T.J., Chiavacci, S.J. and Thompson III, F.R. (2012) Development of Camera Technology for Monitoring Nests. Pp 185-210. In: Ribic, C.A., Thompson III, F.R. and Pietz, P.J. (eds), *Video Surveillance of Nesting Birds*. Studies in Avian Biology (no 43), University of California Press, Berkeley, CA. 240p.
- Craig, E.H., Craig, T.H. and Powers, L.R. (1988) Activity Patterns and Home-Range Use of Nesting Long-Eared Owls. *The Wilson Bulletin* 100: 204–213.
- Cramp, S. (1985). *The birds of the western Palearctic. Volume 4. Terns to Woodpeckers.* Oxford University Press, Oxford. 722p.
- Cutler, T.L. and Swann, D.E. (1999) Using remote photography in wildlife ecology: A review. *Wildlife Society Bulletin* 27: 571–581.
- Delong, T.R. (1982). Effect of ambient conditions on nocturnal nest behavior in Long-eared Owls. Master's Thesis, Brigham Young Univ., Provo, UT.
- Duncan, J.R. and Nero, R.W. (1998) Juvenile Eastern Screech-Owl Dies Eating A Red Breasted Nuthatch. *Blue Jay* 56: 209–212.
- Duncan, J.R. (2021). An Evaluation of 25 Years of Volunteer Nocturnal Owl Surveys in Manitoba, Canada. In Roque, I., Duncan, J.R., Johnson, D.H. and Van Nieuwenhuyse, D. (eds). Proceedings of the 2017 World Owl Conference. Evora, Portugal. Airo 29: 66-82.
- Durant, J.M., Gendner, J.P. and Handrich, Y. (2004) Should I brood or should I hunt: A female barn owl's dilemma. *Canadian Journal of Zoology* 82: 1011–1016.
- Earhart, C.M. and Johnson, N.K. (1970). Size Dimorphism and Food Habits of North American Owls. The Condor 72: 251-264.
- Environment Canada. (2020). *The Ecological Framework of Canada*. Environment Canada, Ottawa, Ontario http://ecozones.ca/english/region/162.html. Accessed 20 June 2020.
- Gaglio, D., Cook, T.R., Connan, M., Ryan, P.G., and Sherley, R.B. (2017) Dietary studies in birds: testing a non-invasive method using digital photography in seabirds. *Methods in Ecology and Evolution* 8: 214–222.
- García-Salgado, G., Rebollo, S., Pérez-Camacho, L., Martínez-Hesterkamp, S., Navarro, A. and Fernández-Pereira, J.-M. (2015) Evaluation of trail-cameras for analyzing the diet of nesting raptors using the Northern Goshawk as a model. *PLoS ONE* 10: 1–15.
- Glue, D.E. 1977. Breeding biology of Long-eared Owls. *British Birds* 70: 318-331.
- Holt, D.W. (2016). Sex Differences in Long-eared Owl Plumage Coloration. *Journal of Raptor Research* 50: 60-69.
- Holland, G.E., Curtis, C.E. and Taylor, P. (2003). Long-eared Owl. Pp. 234 *in* Taylor, P. (ed). *The Birds of Manitoba*. Manitoba Avian Research Committee. Manitoba Naturalists Society. Winnipeg, Manitoba. 504p.
- Johnson, D.H. (2002). The Importance of

Replication in Wildlife Research. *The Journal of Wildlife Management* 66: 919–932.
- Jordan, M.J.R. (2005) Dietary analysis for mammals and birds: A review of field techniques and animal-management applications. *International Zoo Yearbook* 39: 108–116.
- King, C.M. (1989). *The natural history of weasels.* Christopher Helm Ltd. And Cornell University Press. Ithaca, New York. 253p.
- Klippel, W.E. and Parmalee, P.W. (1982) Prey of a Wintering Long-Eared Owl in the Nashville Basin, Tennessee. *Journal of Field Ornithology* 53: 418–420.
- Lewis, S.B., DeSimone, P., Titus, K. and Fuller, M.R. (2004) A Video Surveillance System for Monitoring Raptor Nests in a Temperate Rainforest Environment. *Northwest Science* 78: 70–74.
- Lohrer, F.E. (1985) Ontogeny of Thermoregulation in the Eastern Screech-Owl. *Journal of Field Ornithology* 56: 65–66.
- Lourenço, P.M. (2019). Internet photography forums as sources of avian dietary data: bird diets in Continental Portugal. *Airo* 26: 3-16.
- Marks, J.S. (1984) Feeding ecology of breeding long-eared owls in southwestern Idaho. *Canadian Journal of Zoology* 62: 1528–1533.
- Marks, J.S., Evans, D.L. and Holt, D.W. (1994) Long-eared Owl (*Asio otus*), version 2.0. In Poole, A.F. and Gill, F.B. (eds). *The Birds of North America*. Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.133
- Marti, C.D. (1974) Feeding Ecology of Four Sympatric Owls. *The Condor* 76: 45–61.
- Marti, C.D. (1976) A Review of Prey Selection by the Long-eared Owl. The Condor 78: 331–336.
- Marti, C.D. (1987) Raptor food habits studies, pp 67–80. In: Giron, B.A., Pendleton, B.A., Millsap, B.A., Cline, K.W. and Bird, D.M. (eds), *Raptor Management Techniques Manual.* National Wildlife Federation Scientific and Technical Series No. 10, Washington, D.C. 420p.
- Meek, P.D., Ballard, G., Claridge, A., Kays, R., Moseby, K., O'Brien, T., O'Connell, A., Sanderson, J., Swann, D.E., Tobler, M. and Townsend, S. (2014). Recommended guiding principles for reporting on camera trapping research. *Biodiversity and Conservation* 23: 2321–2343.
- Mikkola, H. (1983). *Owls of Europe.* Buteo Books, Vermillion, South Dakota. 397p.
- Mori, E. and Bertolino, S. (2015) Feeding ecology of Long-eared Owls in winter: An urban perspective. *Bird Study* 62: 257–261.
- Mueller, H.C. (1986). The Evolution of Reversed Sexual Dimorphism in Owls: An Empirical Analysis of Possible Selective Factors. *Wilson Bulletin* 98: 387-406.
- Murphy, R. K. (1992). Long-eared Owl ingests nestlings' feces. *Wilson Bulletin* 104: 192-193.
- Reif, V. and Tornberg, R. (2006) Using time-lapse digital video recording for a nesting study of birds of prey. *European Journal of Wildlife Research* 52: 251–258.
- Ricklefs, R. E. (1968) Patterns of growth in birds. *Ibis* 110: 419–451.
- Robinson, B.G., Franke, A. and Derocher, A.E. (2015) Estimating nestling diet with cameras: quantifying uncertainty from unidentified food items. *Wildlife Biology* 21: 277–282.
- Robinson, B.W. and Prostor, M. (2017). Guidelines for conducting a camera study of nesting raptors. Pp. 283-298. In: Anderson, D.L., McClure, C.J.W., and Franke, A. (eds). *Applied raptor ecology: essentials from Gyrfalcon research.* The Peregrine Fund, Boise, Idaho, USA. 298p.
- Rogers, A.S., DeStefano, S. and Ingraldi, M.F. (2005) Quantifying Northern Goshawk Diets Using Remote Cameras and Observations from Blinds. *Journal of Raptor Research* 39; 303–309.
- Scott, D. (1997). *The Long-eared Owl*. The Hawk and Owl Trust, London. 128p.
- Singer, L.D. (1988). *Thermoregulation in nestling owls: its development and implications.* Master's Thesis, Idaho State University, Pocatello, Idaho. 162p.
- Sonerud, G.A., Steen, R., Løw, L.M., Røed, L.T., Skar, K., Selås, V. and Slagsvold, T. (2014) Evolution of parental roles in raptors: Prey type determines role asymmetry in the Eurasian kestrel. *Animal Behaviour* 96: 31–38.
- Steen, R. (2009). A Portable Digital Video Surveillance System to Monitor Prey Deliveries at Raptor Nests. *Journal of Raptor Research* 43:

69-74.

- Steen, R., Sonerud, G.A. and Slagsvold, T. (2012) Parents adjust feeding effort in relation to nestling age in the Eurasian Kestrel (*Falco tinnunculus*). *Journal of Ornithology*, 153: 1087–1099.
- Steen, R., Miliou, A., Tsimpidis, T., Selås, V. and Sonerud, G.A. (2016) Nonparental Infanticide in Colonial Eleonora's Falcons (*Falco eleonorae*). *Journal of Raptor Research* 50: 217–220.
- Sutherland, W.J. (1998) The importance of behavioral studies in conservation biology. *Animal Behaviour* 56: 801–809.
- Trolliet, F., Huynen, M.-C., Vermeulen, C. and Hambuckers, A. (2014). Use of camera traps for wildlife studies. A review. *Biotechnology, Agronomy and Society and Environment* 18: 446-454.
- Ulmschneider, H. (1990). *Post-nesting ecology of the Long-eared Owl (Asio otus) in southwestern Idaho.* Master's Thesis, Boise State Univ., Boise, ID.
- Wiken, E.B., Gauthier, D., Marshall, I., Lawton, K. and Hirvonen, H. (1996) *A Perspective on Canada's Ecosystems. An Overview of the Terrestrial and Marine Ecozones.* CCEA Occasional Papers NO. 14. Canadian Council on Ecological Areas, Ottawa, Ontario. 99p.

Nest-box breeding ecology of the endemic Cyprus Scops Owl *(Otus cyprius)*

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Abstract

Recent studies have shown that the endemic Cyprus Scops Owl (*Otus cyprius*) is monotypic and can be separated from Eurasian Scops Owl (*O. scops*) and other *Otus* species, by mtDNA, plumage, and vocalizations. Due to its uncertain population status, and evidence that it is hunted, we decided to initiate a nest box program in and adjacent to the Paphos Forest nature reserve. Here we present the breeding data (2015-2018) from 238 nest boxes placed over a four year period at an average (±SD) height of 5.8 m (±1.5) and at least 250 m apart with no line of sight between nest boxes. We documented detailed parameters of 94 of 96 nesting attempts. Clutch size averaged 2.5, an average of 2.1 eggs hatched and an average of 1.99 young fledged per nesting attempt. Egg-laying date fluctuated significantly between seasons, from an average of 15 May in 2015 (N = 18) to an average of 25 April in 2018 (N = 25), (Kruskal-Wallis test, $H_3 = 35.4$, $n = 77$, $P < 0.0001$). We have demonstrated that the Cyprus Scops Owl readily adapts to artificial nest boxes.

Keywords: Cyprus Scops Owl, *Otus cyprius*, nest-box, breeding ecology, Cyprus.

1. Introduction

The Cyprus Scops Owl (*Otus cyprius*) was split from the Eurasian Scops Owl (*O. scops*) by the IOC (International Ornithological Committee) in 2016 (Gill and Donsker 2016) and by Clements in 2021 (eBird https://ebird.org/news/2021-ebird-taxonomy-update, Birds of the World https://birdsoftheworld.org/bow/species/eursco3/cur/introduction?login#simspecies), based on mtDNA, plumage, and vocalizations (Flint et al. 2015). It is believed to be an endemic resident; however, it is possible that some migrate away from Cyprus in winter so it remains unclear if this is an "endemic" or a "breeding endemic" species. Large numbers of Eurasian Scops Owl of both the nominate and the *cycladum* subspecies pass through Cyprus on migration, especially during spring (Iezikel 2021). Flint (2017) suggested that a behavioral isolating mechanism, the single-note song as opposed to the double-note song in Eurasian Scops Owl forms a reproductive barrier. At present, the Cyprus Scops Owl is considered "Least Concern" by the IUCN with an estimated breeding population of 10,000-24,000 individuals (Birdlife International 2021). The species' abundance and breeding ecology have never been studied until recently (Iezikel 2021). Local ornithologists report migration and a possible population decline (Horner and Hubbard 1982) perhaps due to a lack of suitable cavities (Hadjisterkotis 2003). For many years the policy of the Cyprus Department of Forests was to fell old trees located in state forests for wood production. Olive (*Olea europaea*) and Carob (*Ceratonia siliqua*) trees also provided cavities; however, carob trees are no longer planted because they are not economically profitable and old trees are felled for wood or to clear the land for other crops. Although we have observed Cyprus Scops Owls nesting in old stone houses in villages, modern architectural and renovation techniques are reducing the number of such artificial cavities (Hagan 2001, Surya 2016).

Artificial nest boxes may help in the recovery of certain avian populations and in the research of species that naturally nest in cavities (Lambrechts et al. 2012). They bolster existing populations (van Nieuwenhuyse et al. 2008, Arlettaz et al. 2010, Bobek et al. 2018, Braziotis et al. 2017, Bakaloudis et al. 2020 but see Semel et al. 1988, Klein et al. 2007), are used for environmental education (Gal and Yosef 2018 but see Abd Rabou 2020), and can establish populations for biological control in agricultural landscapes (Meyrom et al. 2009).

Marcel et al. (2012) lamented the fact that many nest box studies lack nest box details, maintenance procedures, and information on the breeding biology of species in artificial structures. We present such details (Fig. 1) herein for the Cyprus Scops Owl for four breeding seasons (2015-2018). Our nest box program, initiated under the auspices of the Department of Forests, continues to date.

2. Methods

The study area (16.7 km^2) covered the Paphos Forest and adjacent areas. The Paphos Forest is a 62,000 ha state-owned nature reserve on the western side of the Cyprus Island, Republic of Cyprus (Fig. 2). It mostly covers the Troodos Mountains and ranges from sea level to > 1300 m above sea level. It is a Mediterranean type forest with coniferous (Brutia Pine *Pinus brutia*, Cyprus Cedar *Cedrus brevifolia*) and broadleaf (Golden Oak *Quercus alnifolia*, Plane Tree *Platanus orientalis*) trees.

Unless stated otherwise, measurement data is presented below as an average (±SD). Over a four-year period (2015 to 2018) 238 nest boxes (Fig. 3) were mounted at an average height of 5.8 m (± 1.5) and at least 250 m apart with no line of sight between next boxes (Iezikel et al. 2021). Nest boxes were placed in shade and on, or adjacent to, a large branch. A thin layer of wood chips was added as nesting substrate. All boxes were checked before each breeding season to remove wasps and bees and to clean out debris from the previous breeding season.

We classified a nest box as occupied if we observed both adults in the vicinity, and/or heard courtship calls. Further, all nests included in the study were checked with the help of a camera mounted on a telescopic pole (Fig. 4). We followed all breeding pairs through the complete breeding cycle (early April to early June) from courtship to the fledging of young.

During each of the four breeding seasons (2015-2018) each nest box was checked on average 4.1 (±1.6) times. We defined a breeding attempt as at least one egg in the nest and subsequent brooding by a parent, hatching success as the percent of eggs hatched, and fledging success as the percent of young that fledged. Breeding success was the number of pairs that successfully fledged at least one young divided by the number of females that laid at least one egg. All dates were converted to Julian days for calculations. Julian day is expressed as consecutive days of the year, starting on 1 January = 1 and 31 December = 365. We also calculated the nearest-neighbor-distance between the occupied nest boxes. Adults or nestlings were not ringed or otherwise marked for individual identification.

2.1. Statistical analysis

All nesting variables deviated from the normal distribution (Shapiro-Wilk test $P < 0.05$) thus nonparametric statistics were used, with median as the descriptive statistics. Median variation was measured using the Median Absolute Deviation (MAD) expressed as:

$$\frac{1}{n}\sum_{i=0}^{n}|x_i - m(X)|$$

where: $m(X)$ = median

Kruskall-Wallis ANOVA with Dunn test (Dunn 1964) as post-hoc was used to test differences between years.

We employed a General Additive Model (GAM) fitted with restricted maximum likelihood estimation (REML, Zuur et al. 2009) implemented in the R package "mgcv" (Wood 2013) to investigate the effect of longitude, latitude, altitude, height of nest box, orientation, distance to the nearest neighbor, and distance to the three closest neighbors, on the: (1) date of egg-laying and (2) number of nestlings. We did not develop models for clutch size, number of eggs hatched, and number of young fledged because these reproductive parameters were highly correlated with number of nestlings ($r = 0.81$, $r = 0.79$, $r = 0.78$ resp. all $p < 0.001$). The GAM is an extension of the Generalized Linear Model (GLM) and provides a flexible non-linear relationship between the response variable and the independent variables (Austin and Meyers, 1996; Guisan et al., 2002). The model was defined as Poisson distribution with the log-link function. We develop one model for date of egg-laying and number of nestlings according with equation.

$$\log(bp) = \beta_0 + s(longitude) + s(latitude) + s(altitude) + s(high) + s(orientation) + s(distance_1) + s(sistance_2)$$

Where: β_0 – intercept, bp – breeding parameters (i.e., first model - date of egg-laying and second model - the number of nestlings).

3. Results and Discussion

3.1. Nest box occupancy rate

Over the four year period nest boxes were used 96 times and annual nest box use varied from year to year (Table 1).

3.2. The density of breeding pairs and distance among nests

The mean density of breeding pairs was 1.43 pairs/km^2 (Table 2). Nest boxes were placed at least 250 m apart and the mean distance to the nearest neighbor was 564 m. There was no difference in either the mean nearest-neighbor-distance or the three nearest neighbours between years (one-way ANOVA, $F_{3,82}$ = 0.43, P = 0.72; $F_{3,77}$ = 1.09, P = 0.35; resp., Table 2).

3.3. Time of breeding.

The median ± MAD Julian date of laying the first egg was 127.0 ± 8.9 (7 May; n = 107, range 101 – 142) and was significantly different between years (Kruskal-Wallis ANOVA, $H_3 = 48.9$, $P < 0.0001$). According to the Dunn test, these medians were significantly different between all years, except 2016 *vs.* 2017 (Fig. 5A). Our results indicate that the Cyprus Scops Owl laid eggs, on average, up to 4 days earlier each year of our study.

The earliest hatching was on Julian day 122 (i.e., 2 May) (median ± MAD = 150 ± 11.86) and differed between years (Kruskal-Wallis ANOVA, $H_3 = 35.4$, n = 77, $P < 0.0001$, Fig. 5B). The median of hatching was significantly different between the years (Dunn tests, $P < 0.05$) except 2016 *vs*. 2017 (P = 0.06).

The average incubation period for the four study years was 22.3 ± 2.5 days. First fledging occurred on Julian day 144 (24 May; 169 ± 9.64) and differed between years (Kruskal-Wallis ANOVA, H = 26.9, $P < 0.0001$, Fig. 5C). We found incubation period differences between all year pairs except 2015 and 2017, and 2016 and 2017. The average nestling period (first hatched to last fledged) for the four study years was 22 ± 4.0 days.

3.4. Clutch size, hatching and breeding success

For 96 nesting attempts, a total of 231 eggs were laid, an average (±SD) of 2.35 ± 0.96 per nest. The most common clutch sizes were 2 (N = 49, 44.9%) and 3 eggs (N = 30, 27.5%, Table 3). We found significant differences in the mean clutch size among years (Kruskal-Wallis ANOVA, $H_3 = 9.87$, P = 0.01, Fig. 6A).

A total of 218 eggs hatched (94.3%) and mean hatching success was 0.91 and did not vary significantly among years ($\chi^2_3 = 0.54$, P = 0.16).

Mean breeding success expressed as the proportion of successful nests (i.e., with at least one juvenile fledged) to all visited nests was 0.86 and did not differ significantly between years ($\chi^2_3 = 0.84$, P = 0.41). A total of 185 juveniles fledged for a mean of 2.05 (95% CL: 1.03 - 1.38) fledglings per nests. The number of fledglings per nest differed between years (Kruskal-Wallis ANOVA, $H_3 = 8.41$, N = 90, $P < 0.038$, Fig 6B).

3.5. Factors affecting on time of breeding and number of fledglings

Only altitude was a significant predictor for the first laying date GAM ($R^2 = 0.14$, Table 4, Fig. 7A) whereas only distance to the nearest neighbor was a significant predictor for the number of fledgings ($R^2 = 0.19$, Table 4, Fig. 7B).

A lack of research on the endemic Cyprus Scops Owl precludes a comparison of our data with that from natural nest cavities and therefore knowing the effects of nest boxes on this species.

Clutch size of the Cyprus Scops Owl is similar to that of the Lanyu Scops Owl (*O. elegans botelensis*) in Taiwan (Severinghaus 2017) but is lower than for the European Scops Owl (range 4-6 eggs, average 3-4) (Snow and Perrins 1998, Hardouin et al. 2009, Ivajnšič et al. 2020). The Cyprus Scops Owl lays eggs earlier than the European Scops Owl in Italy (Trento Region, central-eastern Alps, 65-3764m ASL) where the median laying date was 29 May, and which decreased with altitude (Marchesi and Sergio 2005).

Note that we found other birds used the nest boxes including the Common Kestrel (*Falco tinnunculus*, N = 8), European roller (*Coracias garrulus*, N = 2), and Barn Owl (*Tyto alba*, N = 2). This suggests that the nest-box entrance should be smaller to prevent their use by competitors and predators and such that only the Cyprus Scops Owl can use them. Future studies should determine whether the presence of breeding large raptors, including their use of nest-boxes, influences Cyprus Scops Owl occupancy rates and territory establishment in the Paphos Forest.

In conclusion, our study demonstrates that the endemic Cyprus Scops Owl will breed in nest-boxes placed in and near the Paphos Forest Reserve. The effects of the nest-box placement (location on the tree, distance between boxes) along with its breeding biology in natural/urban/rural nesting sites should be studied to refine our understanding of the true conservation status of the species.

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5. Literature Cited

- Abd Rabou, A. F. N. 2020. On the owls (Order Strigiformes) inhabiting the Gaza Strip – Palestine. JOJ Wildlife and Biodiversity 3:555603.
- Arlettaz R, Schaub M, Fournier J, Reichlin TS, Sierro A, Watson J, Braunisch V. 2010. From publications to public actions: when conservation biologists

bridge the gap between research and implementation. Bioscience 60:835–842.

- Austin M.P., Meyers J.A. 1996. Current approaches to modelling the environmental niche of eucalypts: implication for management of forest biodiversity. Forest Ecol. Manage. 85:95–106.
- BirdLife International 2019. *Otus scops*. *The IUCN Red List of Threatened Species* 2019: e.T155019839A155215276. Downloaded on 15 March 2020.
- https://dx.doi.org/10.2305/IUCN.UK.20193.RLTS.T155019839A155215276.en.
- Bobek O., Gal A., Saltz D., Motro U. 2018. Effect of nest-site microclimatic conditions on nesting success in the Lesser Kestrel *Falco naumanni*, Bird Study, 65:4:444-450. DOI: 10.1080/00063657.2018.1522294
- Bakaloudis D. E., Papakosta M. A. Guy-Yosef M. Kosicki J. Goutner V. Vlachos C. G. Yosef R. 2020. Sibling competition affects allostatic load in the colonial nesting Lesser Kestrel (*Falco naumanni*). Journal of Vertebrate Biology. 69:In Press.
- Braziotis S., Liordos V., Bakaloudis D. E., Goutner V., Papakosta M. A., Vlachos C. G. 2017. Patterns of postnatal growth in a small falcon, the lesser kestrel *Falco naumanni* (Fleischer, 1818)(Aves:Falconidae). The European Zoological Journal 84:277-285.
- Dunn O.J. 1964. Multiple comparisons using rank sums. Technometrics 6:241-252.
- Flint P. 2017. Unusual song of an individual Cyprus Scops Owl *Otus cyprius* (Aves: Strigidae). Zoology in the Middle East 63:291-295. DOI: 10.1080/09397140.2017.1375191
- Flint P., Whaley D., Kirwan G.M., Charalambides M., Schweizer M., Wink M. 2015. Reprising the taxonomy of Cyprus Scops Owl *Otus* (*scops*) *cyprius*, a neglected island endemic. *Zootaxa* 4040:301–316.
- Gal A., Yosef R. 2018. Importance of Citizen Science to Conservation: a case study of the Lesser Kestrel (*Falco naumanni*) in Israel. Journal of Raptor Research 52:511-515.
- Gill F., Donsker D. (Eds). (2016) *IOC World Bird List* (v.6.3). http://worldbirdnames.org/http://dx.doi.org/10.14344/IOC.ML.6.3.
- Guisan A., Edwards T. C., Jr., Hastie T., 2002. Generalized linear and generalized additive models in studies of species distributions: setting the scene. Ecol.Model. 157:89–100.
- Hadjisterkotis E. 2003. The effect of Corvid shooting on the population of owls, kestrels and cuckoos in Cyprus, with notes on Corvid diet. Z. Jadgwiss. 49:50-60.
- Hagan S. 2001. Taking shape - a new contract between architecture and nature. Architectural Press, Oxford, UK, 214 pp.
- Hardoiun L. A., Bretagnolle V., Tabel P., Bavoux C., Burneleau G., Reby D. 2009. Acoustic cues to reproductive success in male owl hoots. Animal Behaviour 78:907-913.
- Horner K. O., Hubbard J. P. 1982. An analysis of birds limed in spring at Paralimni, Cyprus. Cyprus Ornithological Society (1970) 7th Bird Report 1976:54-104.
- Iezikel, S., R. Yosef, C. Themistocleous, D. Bakaloudis, C. Vlachos, A. Antoniou, E. Iezikel, M. Papakosta, and J. Z. Kosicki. 2021. Endemic Cyprus Scops Owl *Otus cyprius* readily breeds in artificial nest boxes. Animals 11:1775. https://doi.org/10.3390/ani11061775.
- Ivajnšič, D., D. Denac, K. Denac, N. Pipenbaher, M. Kaligarič. 2020. The Scops owl (*Otus scops*) under human-induced environmental change pressure. Land Use Policy 99:104853. https://doi.org/10.1016/j.landusepol.2020.104853.
- Klein A, Nagy T, Csorgo T, Mátics R. 2007. Exterior nest boxes may negatively affect barn owl *Tyto alba* survival: an ecological trap. Bird Conservation International 17:263–271
- Lambrechts M. M., Wiebe K. L., Sunde P., Solonen T., Sergio F., Roulin A., Møller A. P., Lopez B. C., Fargallo J. A., Exo K.-M., Dell'Omo G., Costantini D., Charter M., Butler M. W., Bortolotti G. R., Arlettaz R., Korpimaki E.. 2012. Nest box design for the study of diurnal raptors and owls is still an overlooked point in ecological, evolutionary and conservation studies: a review. Journal of Ornithology 153:23–34. DOI 10.1007/s10336-011-0720-3
- Marchesi L., Sergio F. 2005. Distribution, density, diet and productivity of the Scops Owl *Otus scops* in the Italian Alps. Ibis 147:176-187.
- Meyrom K, Motro Y, Leshem Y, Aviel S, Izhaki I, Argyle F, Charter M. 2009. Nest box use by the barn owl *Tyto alba* in a biological pest control program in the Beit She'an valley, Israel. Ardea 97:463–467.
- Semel, B., Sherman, P. W., Byers, S. M. 1988. Effects of brood parasitism and nest-box placement on wood duck breeding ecology. Condor 90:920-930.

- Sergio F., Marchesi L., Pedrini P. 2009. Conservation of Scops owl *Otus scops* in the Alps: relationship with grassland management, predation risk and wider biodiversity. Ibis151:40–50.
- Severinghaus, L. L. 2017. The reproductive success of Lanyu Scops Owl *Otus elegans botelensis*. Abstract World Owl Conference, Evora, Portugal.
- Snow, D. W., Perrins C. M. (Eds). 1998. The birds of the Western Palearctic, concise edition. Oxford University Press, Oxford.
- Surya, S. 2016. Biodiversity and bird-friendly design in urban areas for sustainable living. Indian J. Sci. Technol. 9:1–7.
- Wood, S., 2013. mgcv:Mixed GAM Computation Vehicle with GCV/AIC/REML smoothness estimation. R package version 1.7-22. http://cran.r project.org/web/packages/mgcv.
- Van Nieuwenhuyse D., Genot J-C., Johnson DH. 2008. The Little Owl. Cambridge University Press, Cambridge.
- Zuur A.F., Ieno E.N., Walker N.J., Saveliev A.A., Smith G.M. 2009. Mixed effects models and extensions in Ecology with R. Springer, New York. pp. 574.

Table 1. Annual nest-box occupancy rates of Cyprus Scops Owl (*Otus cyprius*).

Year	Number of available nest boxes	Number of Nest Boxes Used	% of Nest Boxes Used
2015	50	18	36.0%
2016	110	20	18.2%
2017	170	32	18.8%
2018	236	26	11.0%

Table 2. The number of Cyprus Scops Owl (*Otus cyprius*) nests, densities of breeding pairs and mean distance [m] to the nearest neighbor (distance_1) in 2015-2018. CL denotes 95% confidence limits.

Year	No. of nests	Pairs/ km^{2*}	Mean distance_1 (95% CL)
2015	18	1.07	626.7 (820.6-1676.9)
2016	20	1.19	695.2 (797.5-1560.8)
2017	32	1.91	570.3 (646.9-1138.7)
2018	26	1.55	410.6 (322.9-582.8)
Mean	24.0	1.43	564.4 (739.2-1000.2)

*Based on 16.7 km^2 study area

Table 3. Clutch sizes of Cyprus Scops Owl (*Otus cyprius*) in 2015-2018.

	2015		2016		2017		2018		Total	
N	18	%	20	%	32	%	26	%	96	%
1-egg	2	11.1	8	40	0	0.0	7	26.9	17	15.5
2-egg	9	50	7	35	15	46.8	5	19.2	49	44.9
3-egg	5	27.8	5	25	16	50.0	4	15.4	30	27.5
4-egg	2	11.1	0	0	1	3.1	10	38.5	13	11.9

Table 4. Results of Generalized Additive Model examining the effect of independent variables (Predictors) on date of egg-laying and number of nestlings of the Cyprus Scops Owl (*Otus cyprius*) in 2015-2018.

Model	Predictors	F	p
date of egg-laying	Longitude	0.439	0.133
	Latitude	0.387	0.093
	Altitude	**2.750**	**0.027**
	Nest-box Height	0.041	0.839
	Distance	0.626	0.284
number of nestlings	Longitude	0.010	0.869
	Latitude	0.001	0.588
	Altitude	0.014	0.475
	Nest-box Height	0.015	0.912
	Distance	**0.498**	**0.021**

Figure 1. Measurements of nest boxed used to study the breeding biology of the Cyprus Scops Owl (*Otus cyprius*) in 2015-2018 on Cyprus (See Iezekiel et al. 2021).

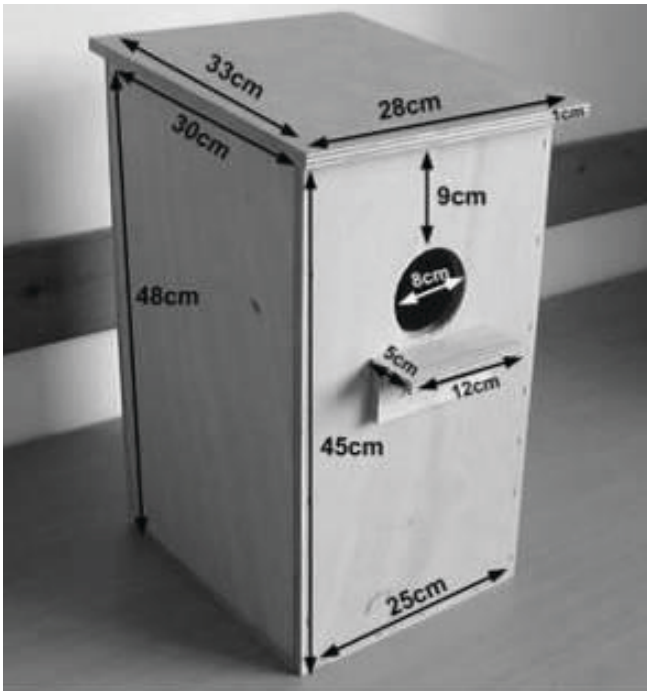


Figure 2. The location of the Paphos Forest Reserve on Cyprus where most of the Cyprus Scops Owl (*Otus cyprius*) nest-boxes were placed from 2015 to 2018. See Iezekiel et al. 2021 for nest box locations.

Figure 3. A Cyprus Scops Owl *(Otus cyprius)* at a nest box.

Figure 4. Thermal camera video image showing Cyprus Scops Owl (*Otus cyprius*) nocturnal activity at a nest box during the 2015 breeding season.

Figure 5. Kruskall-Wallis with Dunn tests as post-hoc for time of three breeding parameters of the Cyprus Scops Owl (*Otus cyprius*).

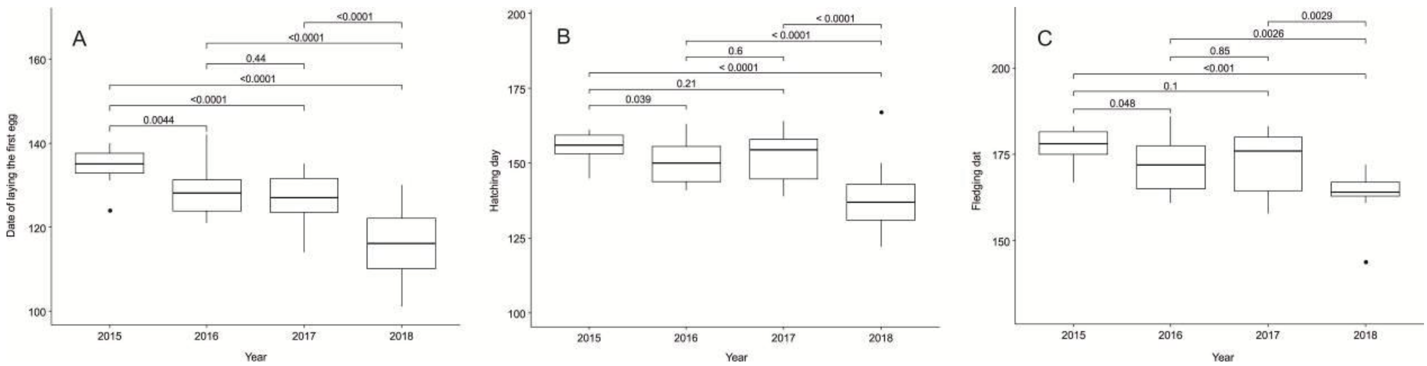


Figure 6. Annual Differences in mean clutch size (A) and the number of nestlings (B) of Cyprus Scops Owl (*Otus cyprius*) in 2015-2018.

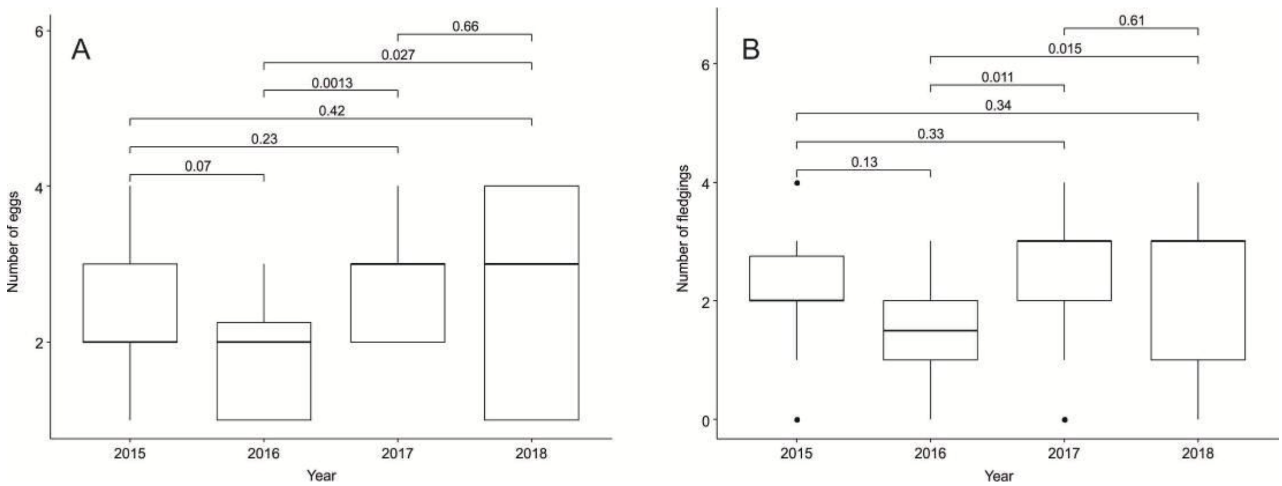
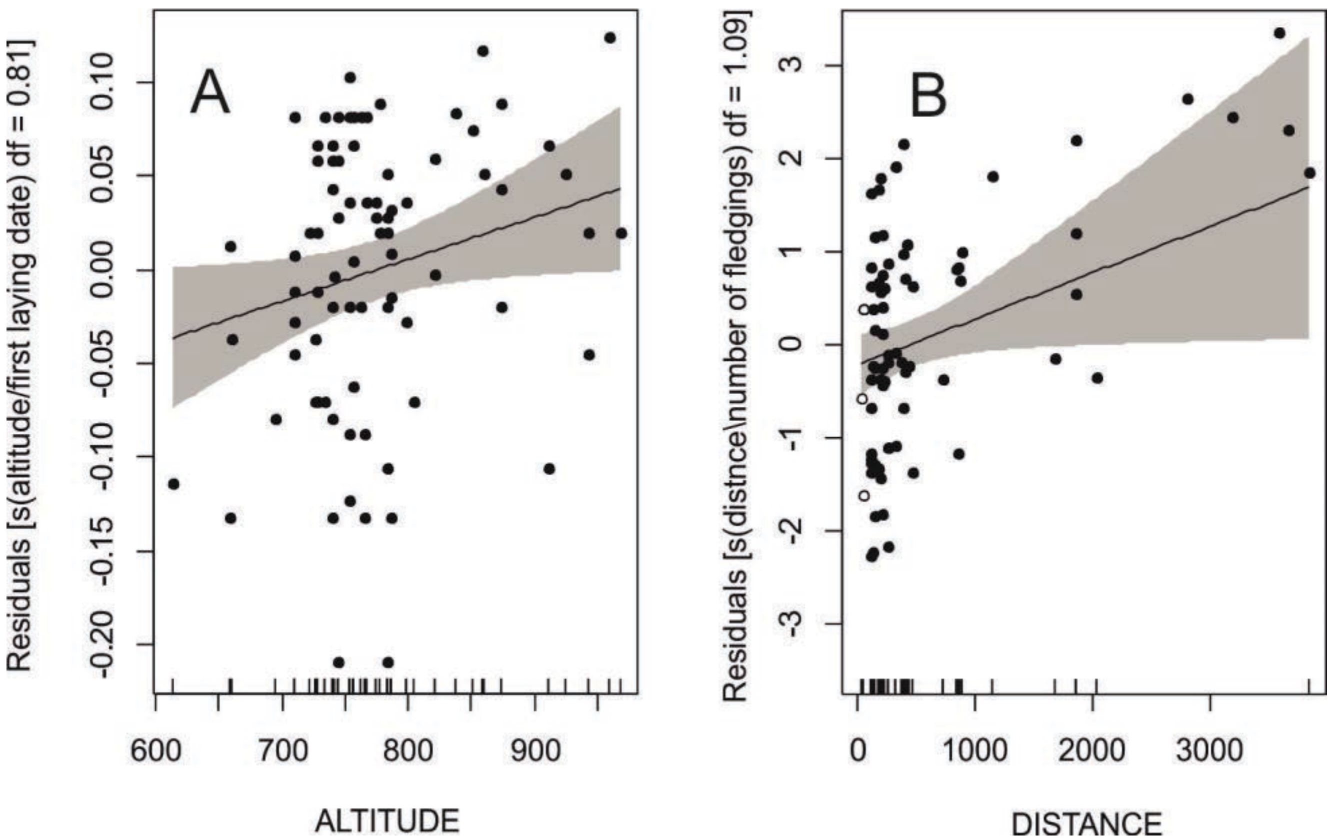


Figure 7. General Additive Model fit for (A) date of egg-laying and (B) the number of fledglings of Cyprus Scops Owl (*Otus cyprius*) in 2015-2018.



First long-term monitoring of reproduction parameters and mortality of the Indian Eagle Owl *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

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Introduction:

The Indian Eagle Owl (*Bubo bengalensis*) is a breeding resident of Maharashtra state, India (Ali and Ripley 1969; Wink and Heidrich 1999; Pande et al. 2008). It is endemic to the Indian subcontinent and inhabits the Deccan Plateau Bio-geographic Zone of India (Pande et al. 2011). The habitat comprises of hills, scrubland, cropland, edges of water body and fringes of human habitation. It is a generalist carnivore subsisting on small mammals including rodents and mice, birds, reptiles and large insects and plays an important role in controlling agronomic pests (Pande and Dahanukar 2011a). Its vocalization (Ramanujam 2000), breeding parameters (Pande and Dahanukar 2011b) and nestling growth (Pande and Dahanukar 2011c) have been studied. Here I report on first long-term monitoring of reproduction and mortality of the elusive nocturnal Indian Eagle Owl in western Maharashtra, India (2008 to 2019).

Key words: Indian Eagle Owl; Bubo bengalensis; long term study, declining population; India.

Methods:

The Study area was Western Maharashtra, and the breeding period lasted from late October to late March. Forty-nine nests were studied but some nests were not visited each year. Nests were visited four times each breeding season. The number of nesting attempts, nesting success, fledging success and the number of injured or sick Indian Eagle Owls encountered were recorded from 2008 to 2019.

A nesting attempt was considered when a pair was seen at the nest during the breeding period or when nuptial display was observed or when eggs were laid. A nest was considered successful when at least one young

Table 1. Causes of sickness or death of Indian Eagle Owls *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

Cause of sickness or death	Number of owls
Electrocution *	4
Poisoning *	4
Prickly awn in wings and unable to fly	1
Road traffic accident *	2
Starvation in cold weather	5
Wet wings in monsoon and unable to fly	1
Trapped in a snare *	1
Mobbing by crows	1
Predation by mongoose	1
Total	**20**

*Anthropogenic causes

Table 2. Summary of five breeding parameters for the Indian Eagle Owl *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

Breeding parameter	Average (range; SD)
Number of nesting attempts/year	39.3 (33-44; ±4.7)
Number of successful nests/year	30.5 (18-43; ±8.9)
%Breeding success/year	76.4% (52.9-97.7; ±14.6)
Number of fledglings/nest/year	1.7 (1.1-2.2; ±0.3)

fledged from the nest. Breeding success was defined as the number of young that fledged the nest or walked out of the nest prior to taking flight (Steenhoff 1987).

Averages and SD were calculated for four breeding parameters and linear regression analysis was used to analyzing their trends. The null hypothesis was that there was no change in the breeding parameters over the 11-year period; it was rejected for $p < 0.05$ and the regression slope would determine the direction of the trend.

Results:

Twenty Indian Eagle Owls were found either sick or dead and consisted of 15 adults and five juveniles (Table 1.). Of these, five adults and five juveniles survived and were released to the wild.

On average, 76.4% of 39.3 nesting attempts per year were successful fledging 1.7 young per nest per year (Table 2). While there was a significant decrease in the number of nesting attempts, nesting success and breeding success over time, there was no significant change in the average number of fledglings per nest per year (Table 3, Figs. 1, 2).

Human altered habitats were associated with nest site abandonment (Table 4). These changes resulted from habitat destruction and degradation including construction of roads, increase in croplands, earth moving equipment, human habitation and use of old unused buildings.

Conclusions:

The number of Indian Eagle Owl nesting attempts, nesting success, and breeding success showed a significant decline from 2008 to 2019 in Western Maharashtra, India. The average number of fledglings/nest/year was constant during the 11 year study period and was comparable with earlier observations (Pande and Dahanukar 2011b). The main reasons behind the decline of the Indian Eagle Owl breeding parameters were anthropogenic and habitat related as noted by Penteriani et al. (2002) for *Bubo bubo*. This conclusion highlights the need for public education and public participation for effective conservation of Indian Eagle Owl.

The stronghold of the Indian Eagle Owl is in our rural areas and educating farmers about the important ago-economic role of this owl can go a long way in its conservation. Through our NGO, the Ela Foundation, we have been doing this from our Ela Habitat field station for the past seven years. To educate youth, we have hosted India's first Indian Owl Festivals with overwhelming response for two consecutive years

Table 3. Regression analysis of breeding parameters for the Indian Eagle Owl *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

Parameter	Equation	Slope	Calculated P value	α	Null Hypoth.
Nesting Attempts	y = -1.3091x + 47.127	-1.3091	3.4626E-05	0.05	Rejected
Nesting Success	y = -2.5182x + 45.655	-2.5182	2.923E-05	0.05	Rejected
Breeding Success	y = -3.8782x + 99.696	-3.8782	0.00035936	0.05	Rejected
Fledglings per nest	y = -0.0442x + 90.746	-0.0442	0.10864664	0.05	Not Rejected

Table 4: Habitat associated with abandoned nest sites for the Indian Eagle Owl *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

Nest site habitat	Number of nest sites abandoned
Cropland	9
Hilly area	3
Cavity in ravine	3
Earth cutting near water body	3
Quarry	2
Old building	1

Figure 1. Trend of breeding parameters for the Indian Eagle Owl *Bubo bengalensis* in western Maharashtra, India (2008 to 2019).

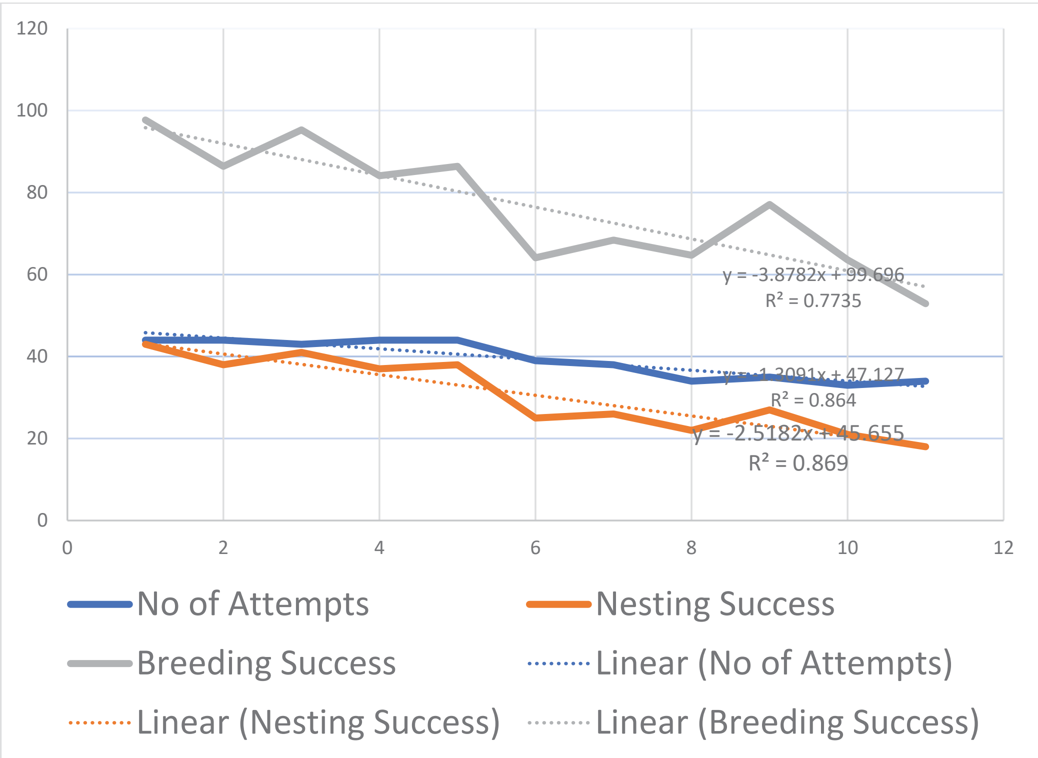
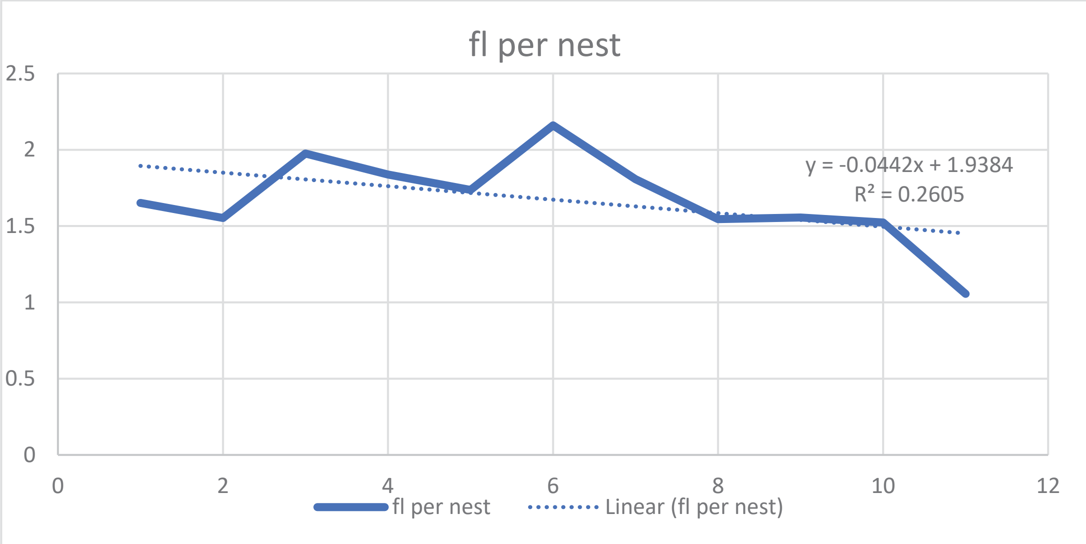


Figure 2. Trend in average number of Indian Eagle Owl *Bubo bengalensis* fledglings (fl)/nest/year in western Maharashtra, India (2008 to 2019).



(2018-19 and 2019-20). This event had to stop during the Covid-19 pandemic, but we plan to resume it starting in 2022. In conclusion, although long-term monitoring of closely related owls (*Bubo bubo*) has occurred (Olson 1979), to the best of our knowledge, this is the first long-term study spanning 11 years documenting the declining breeding parameters of the Indian Eagle Owl in India.

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References:

- Ali, S. and Ripley, S.D. (1969) Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka, Vol. 3. Oxford Univ. Press, New Delhi, India.
- Olsson, V. (1979) Studies on a population of eagle owls *Bubo bubo* (L.), in south Sweden. *Swedish Wildlife Research (Viltrevy)* 11:1–99.
- Pande, S., Sant, N., Vishwasrao, V. and Deshpande, P. (2008) *Birds of Lonavla and Khandala* (including some butterflies, reptiles, amphibians and mammals.). Published by Ela Foundation.
- Pande, S., Deshpande, P. and Sant, N. (2011) *Birds of Maharashtra.* Ela Foundation, Pune. Pages 1-330.
- Pande, S. and Dahanukar, N. (2011a) The diet of Indian Eagle Owl *Bubo bengalensis* and its agronomic significance. *Journal of Threatened Taxa* 3(8): 2011–2017.
- Pande, S. and Dahanukar, N. (2011b) Breeding Biology, Nesting Habitat, and Diet of the Rock Eagle-Owl (*Bubo bengalensis*) *Journal of Raptor Research* 45(3):211-219. 2011. doi: 10.3356/JRR-10-53.1.
- Pande, S. and Dahanukar, N. (2011c) Ecological effects on morphometric development of the Indian Eagle Owl *Bubo bengalensis. Journal of Threatened Taxa* 3(4): 1677-1685.
- Penteriani, V., Gallardo, M. and Roche, P. (2002) Landscape structure and food supply affect eagle owl (*Bubo bubo*) density and breeding performance: a case of intra-population heterogeneity. *Journal of Zoology* (London) 257:365–372.
- Ramanujam, M.E. (2000) On the 'long call' of the Indian great horned owl *Bubo bengalensis* (Franklin). Zoos' Print Journal 18:1131–1134.
- Steenhof, K. (1987) Assessing raptor reproductive success and productivity. Pages 157–170 in Pendleton, B.G., Millsap, B.A., Cline, K.W. and Bird, D.M. [EDS.], Raptor management techniques manual. Natl. Wildl. Fed., Washington, DC U.S.A.
- Wink, M. and Heidrich, P. (1999) Molecular evolution and systematics of the owls. (Strigiformes). Pages 39–57 in Konig, C, Weick, F. and Becking, J.H. [EDS.], A guide to the owls of the world. Yale Univ. Press, New Haven, CT U.S.A

Time distribution of nesting Mottled Wood Owl *(Strix ocellata)* in Western Maharashtra, India

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Abstract

Camera trap analysis has emerged as a successful non-invasive method for collecting a wide range of biological data on diverse taxa of animals. We deployed camera traps on two nests (Nest 1, Pingori, Tal. Purandar and Nest 2, Supe, Tal. Baramati, both in Dist. Pune, Maharashtra) of Mottled Wood Owl (*Strix ocellata*). The study duration for Nest 1 was 7 January to 18 February 2019, and for Nest 2 was 7 February to 8 March 2019. Bushnell and Reconyx cameras were used. Nest 1 was monitored from 5 days prior to hatching of first egg until the fledging (branching) of last chick (49 days) and Nest 2 was monitored from hatching of first egg until one day prior to branching of last chick (29 days). Total of 65,269 images (Nest 1- 29,822, Nest 2- 35447) were eyeballed and scrutinized. Two eggs were laid in each nest with hatching interval of 2 days. Three chicks walked out of the nest at an average of 35 days after hatching and one chick in Nest 1 died on day 17 after hatching.

Time budget analysis of parents over the duration of 77,431 minutes showed that 56% (43,410 minutes) time was spent attending the nest (12% incubation, 33% warming the chicks, 9% feeding, 2% guarding). Total 170 food items were brought to the nest by both parents of which 57% were birds (Red vented bulbul (*Pycnonotus cafer*), Large Grey Babbler (*Turdoides malcolmi*), Prinia sp., House sparrow (*Passer domesticus*), Baya weaver, Indian Silverbill (*Euodice malabarica*) and Common Tailorbird (*Orthotomus sutorius*)), 7% were rodents (Mouse, Rat, Gerbil), 2% reptiles (Garden calottes), 1% each amphibians and insects and 32% were unidentified.

Fig: 1 Study Area **(Image source: Google Earth)**

Average food delivery per night at Nest 1 was 2.8 items (Range 1-7; ± 1.73 SD) and at Nest 2 3.13 items (Range 0-15; ± 4.37 SD). Caching was seen at Nest 2 and no delivery of food at nest was recorded up to 2 days after caching. Nest 1 was visited by 11 visitors of four species (Red-vented bulbul, Large Grey Babbler, Five-striped Palm Squirrel and South Western Langur), but nest was undisturbed. The food was delivered continually from 7 pm to 6 am with average of 7 (Range 5.5 to 11.5; ± 1.66 SD) food items per hour. The maximum food delivery was between 11 pm to 1 am (17 items). Chicks were mostly inactive from 6 am to 6 pm. Chicks started wing flapping 1 week prior to branching.

Thus, our study utilizes camera trap analysis in better understanding of the secret in nest behavior of this endemic Mottled Wood Owl (*Strix ocellata*) for the first time for this species.

Introduction

The Mottled Wood Owl (*Strix ocellata*) is a poorly studied owl, endemic to the Indian subcontinent (Pande et al. 2018). There is very scanty information available on the ecology of the species. Lesson (1839) first identified the species and it was later separated into three subspecies (Baker 1927, Ali 1935, Koelz 1950, Aliand Ripley 2001). The distribution of this species is restricted to the Indian subcontinent (Jathar and Rahmani2006), though this species was described as common and widely distributed in the avian literature (Boyer and Hume 1991, Grimmett et al. 1999, Ali and Ripley 2001, Ko¨nig and Weick2008, Holt et al. 2017) but, owing to lack of information is classified as a "Species of Least Concern' (International Union for Conservation of Nature 2016). Holt et al. (2017) reported the species to be uncommon to scarce. Several local authors have indicated the presence of the Mottled Wood-Owl in different regions of India (Jose and Zacharias2003, Chandra and Singh 2004, David and Vinoth 2016), presented anecdotal information (e.g. Baviskar and Baviskar 2015, Kumar et al. 2017), or called for conservation of the habitats in which the species is present (Jaysonand Sivaram 2009, Pattanaik et al. 2009). Mottled Wood Owl (*Strix ocellata)* Family: Strigidae is endemic to Indian subcontinent. It is a tree dwelling carnivorous owl and nests in tree hollows open to sky. Breeding season is December to March.

Figure 2: Nest Site 1

Material and Methods

The study was carried out in Pingori village (Tal: Purandar, Dist: Pune) and Supe village (Tal: Baramati, Dist: Pune) (fig. 1). Two Mottled wood owl nests were identified and studied during the study period i.e January to March 2019 for 49 days and 29 days respectively.

Two Camera traps namely Reconyx and Bushnell were deployed on the Mottled wood owl nest. Total 65269 images (Nest 1: 29822, Nest 2: 35447) were collected during the study period for the both the nests. Total nest observation time recorded was 77431 minutes. Batteries and memory cards were changed as per camera settings, 7 to 10 days interval.

Results and Discussions:

Time Analysis

Two nests were observed for total 77431 minutes and 65269 images (Nest 1: 29822 & Nest 2: 35447) were scrutinized. The time budget analysis of parents is showed in (Fig. 3).

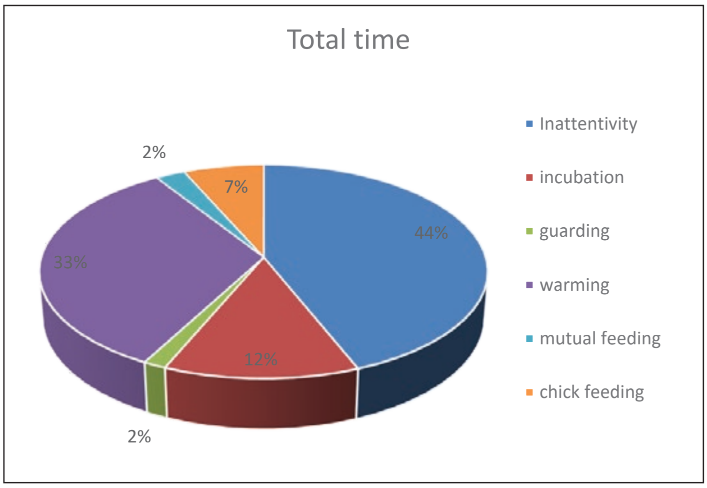


Figure 3: Time Budget Chart

It was observed that 56% of time was given for nest attention by parents which includes incubation 12%, warming the chicks 33%, feeding 9% and nest guarding 2%. It was observed that for remaining 44% the nest was unattended by the parents.

Prey items

During the study period prey items bought by parents to feed the chicks were also analyzed. It was observed that total 170 food items were brought to the nest in which 89 % were birds, 7 % were rodents, 2 % reptiles and 1% amphibian and insects (Fig. 4).

Out of 89 % birds 32% birds were unidentified and remaining 57 % of bird species were Red vented bulbul

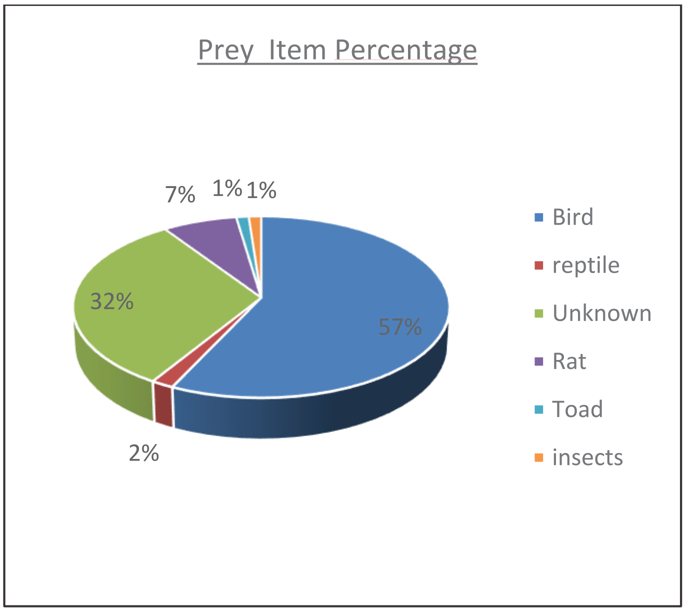


Figure 4: Prey item percentage

(*Pycnonotus cafer*), Large Grey Babbler (*Turdoides malcolmi*), Prinia sp., House sparrow (*Passer domesticus*), Baya weaver, Indian silverbill (*Euodice malabarica*) and Common tailor bird (*Orthotomus sutorius*) (Fig. 5).

Prey Delivery

Statistical analysis was performed to calculate the average food delivery by parents per night per nest. It was found that average food delivery per night was 2.8 items and 3.13 items at nest 1 (Fig. 6) and nest 2 (Fig. 7) respectively. The range of items in nest 1 varies from 1 to 7 with standard deviation (SD) of ± 1.73 and in nest 2 range of items was 0 – 15 with SD of ± 4.37.

Prey Delivery Time

Through the camera trap data it was observed that the food was continually delivered from 7 pm to 6 am every night in both the nests with average of 7 (range 5.5 to 11.5; ± 1.66 SD) food items per hour (Fig. 8). The maximum food delivery was between 11 pm to 1 am. Chicks were found inactive mostly from 6 am to 6 pm.

Nest visitors

Only Nest 1 was visited by various other animals like Red-vented Bulbul (*Pycnonotus cafer*), Large Grey Babbler (*Turdoides malcolmi*), Five-striped Palm Squirrel (*Funambulus pennant*) and South Western Langur (*Semnopetheus hypoleucos*) (fig. 9). Total 11

Figure 5: Various prey items brought by parents in nest

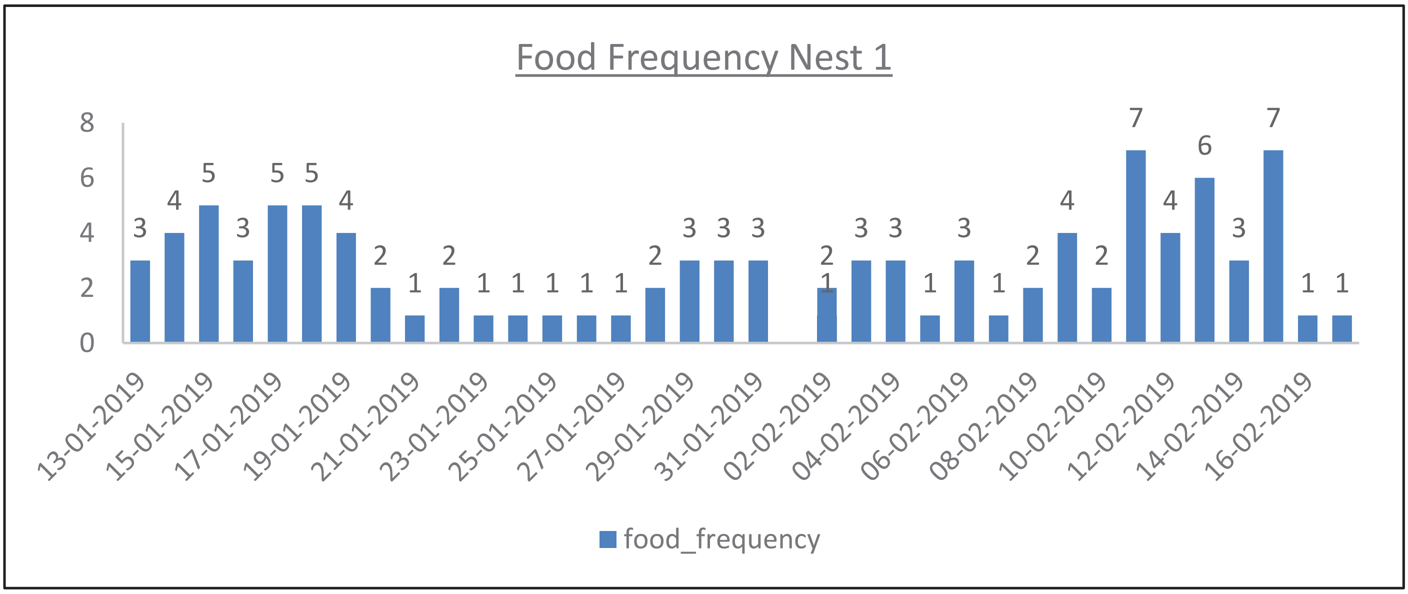
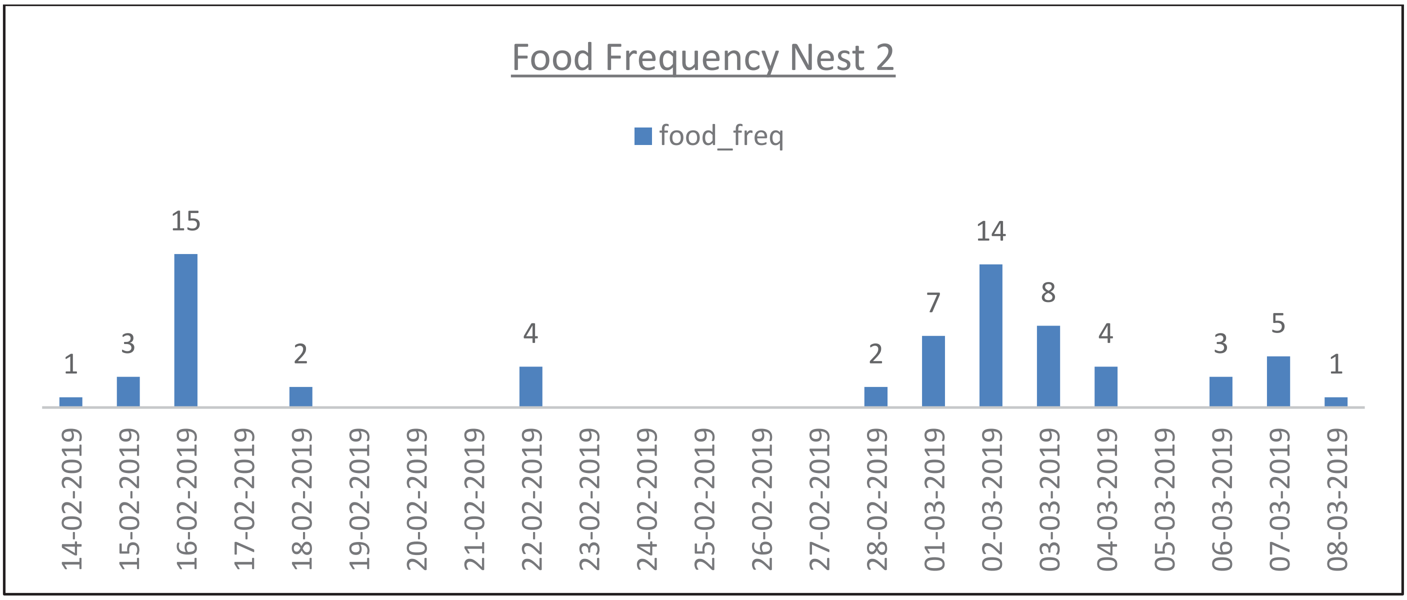


Figure 6: Food Frequency at Nest 1



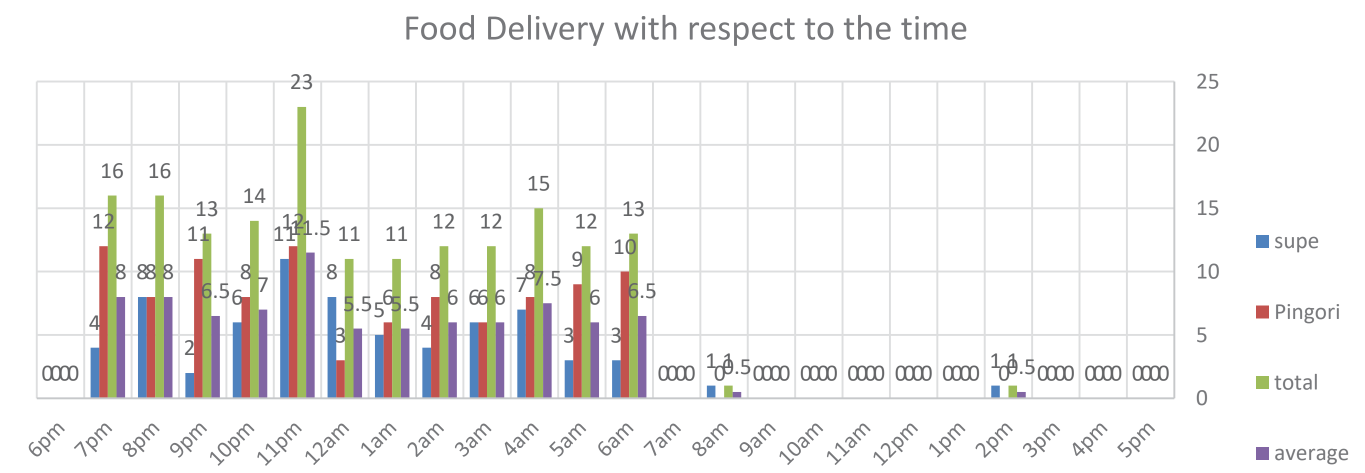


Figure 8: Food delivery with respect to the time

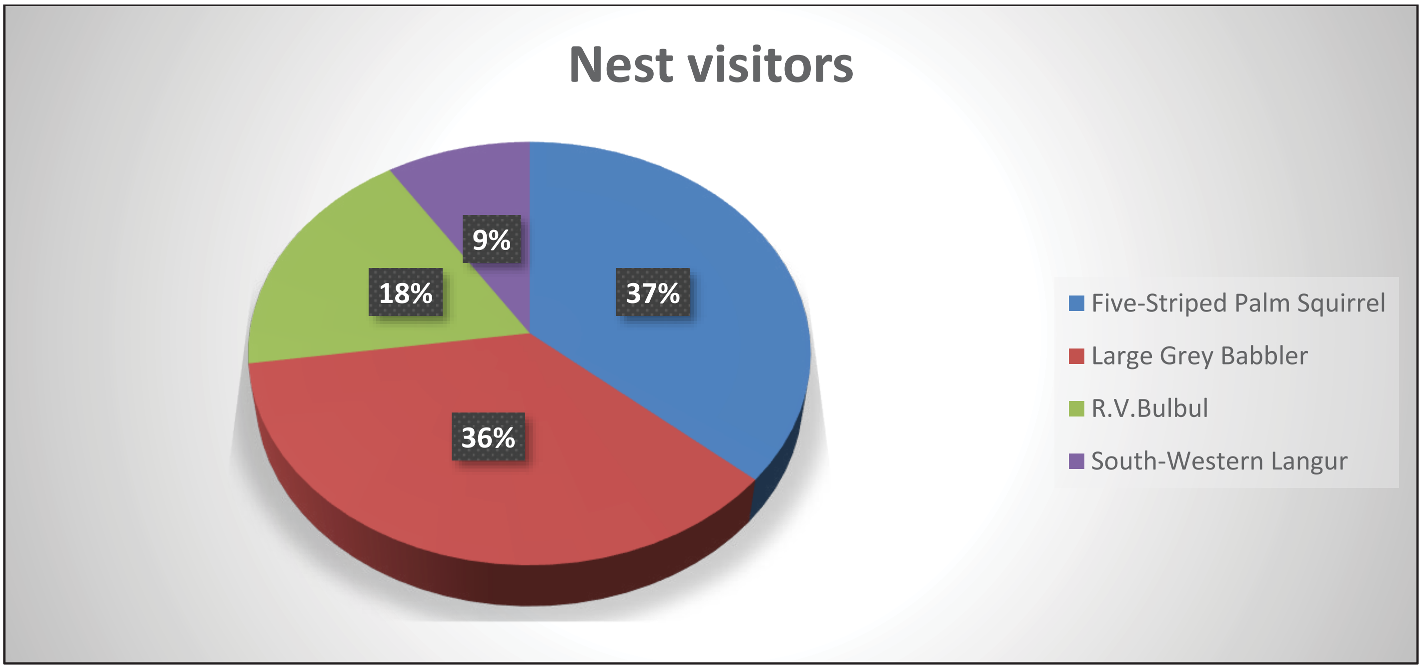


Figure 9: Ratio of Nest visitors

visitors were recorded in the camera trap (fig. 10).

Acknowledgement:

We are grateful to Maharashtra Forest Department for necessary permissions. Field work was assisted by Rajkumar Pawar, Dr. Omkar Sumant, Dr. Satish Karmalkar, Avadhoot Belasare, Abhiram Rajandekar and Anant Gokhale. The study was facilitated by ELA Foundation, Pune. We are thankful to local villagers for providing the information about the nest and for protection of nesting trees and their valuable cooperation throughout the study period.

References:

- Ali, S. (1935). Mottled Wood Owl. Journal of the Bombay Natural History Society 137:140.
- Ali, S., and S. D. Ripley (2001). Handbook of the Birds of India and Pakistan, Third edition. Vol. 3. Oxford Univ. Press, New Delhi, India.
- Baker, S. (1927). The fauna of British India, Ceylon, and Burma. Birds 4:441.
- Baviskar, B. S., and P. B. Baviskar (2015). A report of Hyalomma tick infestation in Mottled Wood Owl Strix ocellata from Nagpur, Maharashtra. Ela Journal of Forestry and Wildlife 4:6–7.
- Boyer, R., and T. Hume (1991). Owls of the World. Dragon's World Ltd., Surrey, UK.
- Chandra, K., and R. K. Singh (2004). Avifauna of Madhya Pradesh and Chhattisgarh. Zoos' Print Journal 19:1534–1539.
- David, J. P., and B. Vinoth (2016). Nocturnal birds in the Eastern Ghats of Tamil Nadu. Indian Birds 11:39–41.
- Grimmett, R., C. Inskipp, and T. Inskipp (1999). Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka and the Maldives. Princeton University Press, Princeton, NJ, USA.
- Holt, D. W., R. Berkley, C. Deppe, P. Enr´ıquez Rocha, J. L. Petersen, J. L. Rangel Salazar, K. P. Segars, K. L. Wood and J. S. Marks (2017). Mottled Wood-Owl (Strix ocellata). In Handbook of the Birds of the World Alive (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Lynx Edicions, Barcelona, Spain. http://www.hbw.com/node/55032.
- International Union for Conservation of Nature (2016). Strix ocellata. The IUCN Red List of Threatened Species 2016:e.T22689066A93216851.
- Jathar, G.A., and A.R. Rahmani (2006). Endemic birds of India. Buceros 11:20-21.
- Jayson, E. A., and M. Sivaram (2009). Ecology and Behavior of the Forest Owls in the Western Ghats and Developing a Habitat Model for their Conservation. Kerala Forest Research Institute Report 343. Kerala Forest Research Institute, Peechi, Kerala, India.

- Jose, B., and V. J. Zacharias (2003). Distribution of birds in relation to vegetation in the Calicut University Campus, Kerala. Zoos' Print Journal 18:1187–1192.
- Ko¨nig, C., and F. Weick (2008). Owls: A Guide to the Owls of the World, Second edition. Yale University Press, New Haven, CT, USA.
- Koelz, W. (1950). New subspecies of birds from southwestern India. American Museum Novitates 1452:1–10.
- Kumar, D., S. Kushwaha, A. Kumar, and A. Namdev (2017). Rescue of Mottled Wood Owl (Strix ocellata) in Jhansi district, Uttar Pradesh. Spring 6/7:1–9.
- Pande, Satish, Reuven Yosef, Prashant Deshpande, Rajkumar Pawar, and Murlidhar N. Mahajan (2018). Breeding Biology of the Mottled Wood-Owl (*Strix Ocellata*) In West-Central India. *J. Raptor Res.* 52(2):240–244.
- Pattanaik, C., S. N. Prasad, and C. S. Reddy (2009). Need for conservation of biodiversity in Araku Valley, Andhra Pradesh. Current Science 96:11–12.


Mottled Wood Owl Nest site visitors: Large Grey Babblers and Red-vented Bulbul

Mottled Wood Owl Nest site visitors: Parent Mottled Wood Owl and Five-striped Palm Squirrel

Mottled Wood Owl Nest site visitors: Hanuman Langur

Vocalizations of the endemic Mottled Wood Owl *Strix ocellata* in Western Maharashtra, India.

Anant Gokhale, Abhiram Rajandekar, Rahul Lonkar, Kumar Pawar, Omkar Sumant, Vaibhav Gandhe, Satish Pande[1]

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Keywords: Mottled Wood Owl; *Strix ocellata*; vocalizations; call types.

Abstract

The Mottled Wood Owl *Strix ocellata* is a poorly studied endemic owl of the Indian subcontinent. A characteristic vocalization is a duet of hoots uttered by paired males and females and the repetitive call *chuhua-aa* in breeding season. Four adult and one nestling calls, and differences between male and female vocalizations, are described in detail.

Introduction

The Mottled Wood Owl *Strix ocellata* is a poorly studied endemic owl of the Indian subcontinent (Ali 1935; Pande et al. 2018). It inhabits deciduous forests adjacent to dry thorn forests, in sparsely occupied human rural habitations, groves and croplands (Kumar et al. 2020; Rasmussen and Anderton 2005). Its presence is detected by the distinctive tremulous eerie calls at dawn and dusk (Pande et al. 2018). Some examples of their calls can be heard on the xeno-canto website (https://xeno-canto.org/species/Strix-ocellata). Their courtship starts in October/November and breeding season ends in February/March.

Nests are typically found in old tamarind *Tamarindus indicus*, mango *Mangifera indica*, peepal *Ficus religiosa* trees. Although its breeding biology has been detailed, scanty information is available on its vocalizations (Pande et al. 2018). We recorded and describe a variety of Mottled Wood Owl calls during the breeding season and highlight differences between male and female vocalizations.

Materials and Methods

Call recordings of Mottled Wood Owl were made during 20 visits during the breeding season from October 2018 to March 2019 at three nest sites in old tamarind trees in the villages of Pingori, Supe and Waghdarwadi, Pune district, Western Maharashtra, India. A pair of owls were present at each site and one site had one nestling present.

Mottled Wood Owls start to call at dusk prior to leaving the nest site to hunt. We visited nest sites one hour prior to sunset to record them using Zoom H1 or H5 recorders. Only calls with minimal or no background noise were analyzed using Raven Pro Software (Cornell Lab of Ornithology).

A temporal and spectral analysis of calls was conducted using the following parameters: Minimum Frequency (Fmin), Maximum Frequency (Fmax), Peak Power Frequency, Hoot Duration, Inter-Hoot Duration, Number of Hoots and the timing of the start of vocal activity relative to sunset. Averages, range and standard deviation were calculated for all parameters.

Results

The following Mottled Wood Owl calls were recorded when owls became active after dusk.

Initiation of Calling Relative to Sunset

Mottled Wood Owls started calling an average 23.83 min after sunset (11-46 min, SD +/- 12.36 min, n = 12, Fig. 1).

Hoots

Mottled Wood Owl hoots had an average peak power frequency of 518.8 Hz, an average hoot duration of 414 milliseconds, and an average maximum and minimum hoot frequency was 570 Hz and 348 Hz, respectively (Table 1). The Average time between two successive hoots was 34 seconds (n=47, i.e., Fig. 2). The average peak power frequency of male hoots was 520 Hz (n=212 calls of 3 individuals) and of females was 619 Hz (n=42 calls of 2 individuals) (i.e., Fig. 3).

Courtship Calls

Courtship calls (Figs. 4, 5) had average peak power frequency of 550.9 Hz, an average minimum and maximum frequency of 387 and 682 Hz, respectively, and an average call duration of 930 milliseconds (Table 2).

Alarm Calls

The alarm call consisted of four short hoots uttered in rapid succession (Fig. 6) during the presence of an intruder such as a raptor, human approaching the nest. An alarm call sequence lasted an average of 128 milliseconds and had a peak power frequency 529.5 Hz (Table 3).

Nestling Calls

Nestling calls (Fig. 7) had an average peak frequency of 931 Hz. This and other parameters measured are presented in Table 4.

Discussion

Four clearly distinguishable types of Mottled Wood Owl calls given during the breeding season are herein described in detail for the first time for this species. The nocturnal nature of this species is supported by the delay in calling behaviour until after sunset. The peak power frequency of recorded calls were similar to that described earlier (Pande et al. 2018). There were differences between male and female vocalizations and the peak power frequency of nestling calls were higher than adult calls. Further research is needed to understand the vocal behavior of this species over the entire year.

Acknowledgment

We thank Pramod Deshpande and Dr. Nivedita Pande for assistance in the field. The Ela Foundation provided support for the study. We thank the Forest Department for their support and necessary permissions. We thank Dr. James Duncan and an anonymous referee for constructive suggestions on the earlier drafts of the manuscript. We are also grateful to Cornell Lab of Ornithology for providing us Raven Pro Software.

Author Contributions: AR, AG, RL, KP conducted field study. AR and AG performed statistical analysis. AR and AG rote the paper. SP formulated and supported the study.

References:

- Ali, S. (1935). Mottled Wood Owl. *Journal of the Bombay Natural History Society* 137:140.
- Kumar, D., Kushwaha, S., Kumar, A. and Namdev, A. (2020). Rescue of Mottled Wood Owl (*Strix ocellata*) in Jhansi district, Uttar Pradesh. *Species*

21:316-324.

- Pande, S., Yosef, R., Deshpande, P., Pawar, R. and Mahajan, M.N. (2018). Breeding Biology of the Mottled Wood-Owl (*Strix Ocellata*) In West-Central India. *Journal of Raptor Research.* 52:240–244.
- Rasmussen, P.C. and Anderton, J.C. (2005). Birds of South Asia. The Ripley Guide. Volume 2. Smithsonian Institution and Lynx Edicions. p. 242.

Table 1. Acoustic parameters of Mottled Wood Owl *Strix ocellata* hoots in Western Maharashtra, India. Fmin = Minimum Frequency and Fmax = Maximum Frequency.

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Peak Power Freq.(Hz)	431	680	518.8	61	254
Fmin.(Hz)	217	501	348	50	254
Fmax.(Hz)	488	738	570	65	254
Single Hoot Duration (millisecond)	283	893	414	80	254

Table 2. Acoustic parameters of Mottled Wood Owl *Strix ocellata* courtship calls in Western Maharashtra, India. Fmin = Minimum Frequency and Fmax = Maximum Frequency.

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Peak Power Freq.(Hz)	422	668	550.9	79	70
Fmin.(Hz)	265	495	387	75	70
Fmax.(Hz)	540	836	682	93	70
Single Hoot Duration (millisecond)	700	1227	930	111	70

Table 3. Acoustic parameters of Mottled Wood Owl *Strix ocellata* alarm calls in Western Maharashtra, India. Fmin = Minimum Frequency and Fmax = Maximum Frequency.

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Peak Power Freq.(Hz)	344	646	529.5	86	180
Fmin.(Hz)	219	488	361.7	62	180
Fmax.(Hz)	396	738	607.4	98	180
Single Hoot Duration (millisecond)	85	175	128	20	180

Table 4. Acoustic parameters of Mottled Wood Owl *Strix ocellata* nestling calls in Western Maharashtra, India. Fmin = Minimum Frequency and Fmax = Maximum Frequency.

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Peak Power Freq.(Hz)	785	1043	931	68	28
Fmin.(Hz)	663	896	760	53	28
Fmax.(Hz)	908	1121	1023.9	64	28
Single Hoot Duration (millisecond)	550	952	758	99	28

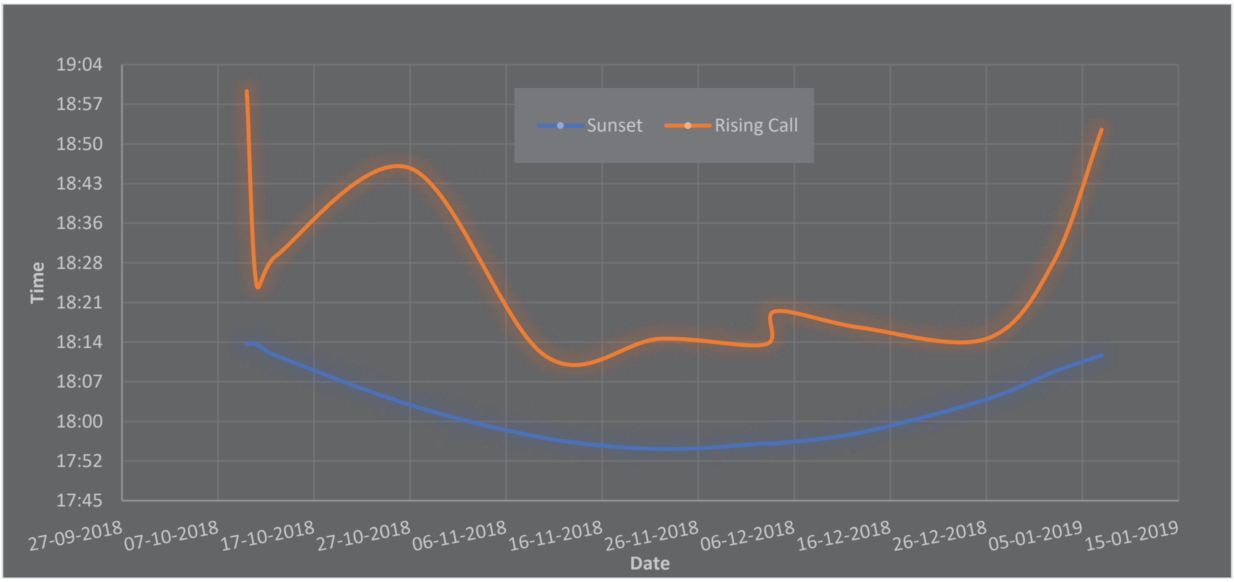

Figure 1. The time of Mottled Wood Owl *Strix ocellata* call initiation relative to sunset in Western Maharashtra, India.

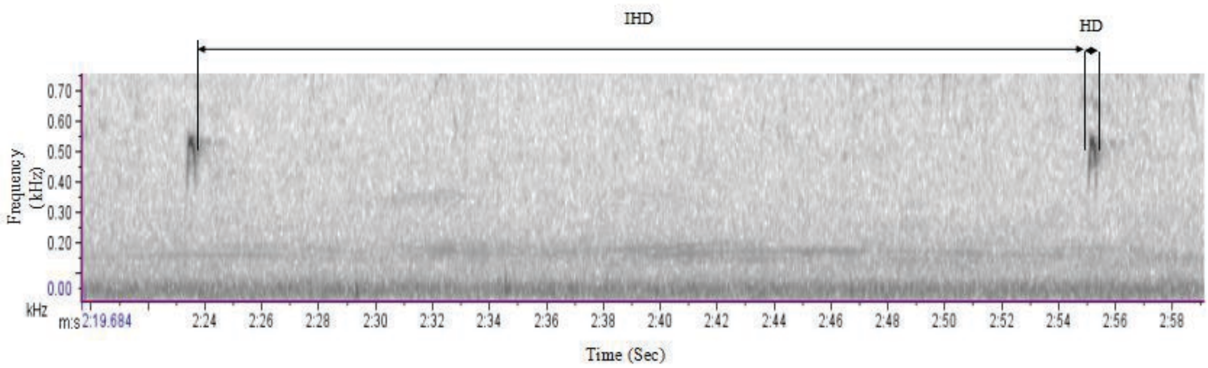

Figure 2. Spectrograms of a Mottled Wood Owl *Strix ocellata* hoot sequence in Western Maharashtra, India. IHD = Inter-Hoot Duration and HD = Hoot Duration.

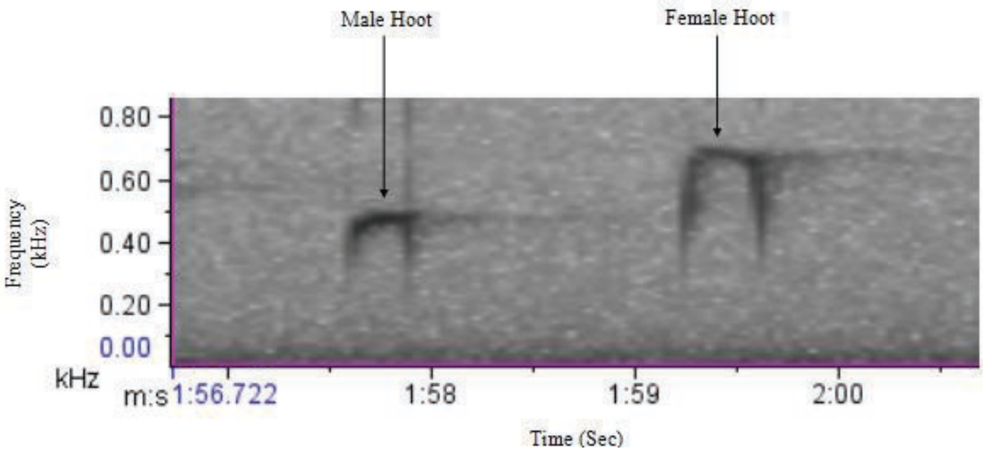

Figure 3. Spectrogram of hoots of a pair of Mottled Wood Owls *Strix ocellata* in Western Maharashtra, India.

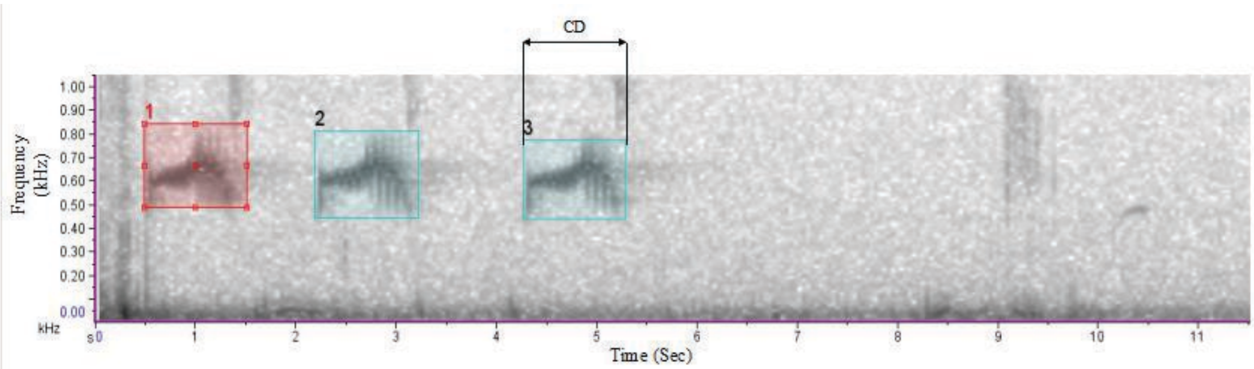

Figure 4. Courtship call spectrograms of Mottled Wood Owl *Strix ocellata* in Western Maharashtra, India. CD = call duration. [1, 2 and 3 represent duet calls]

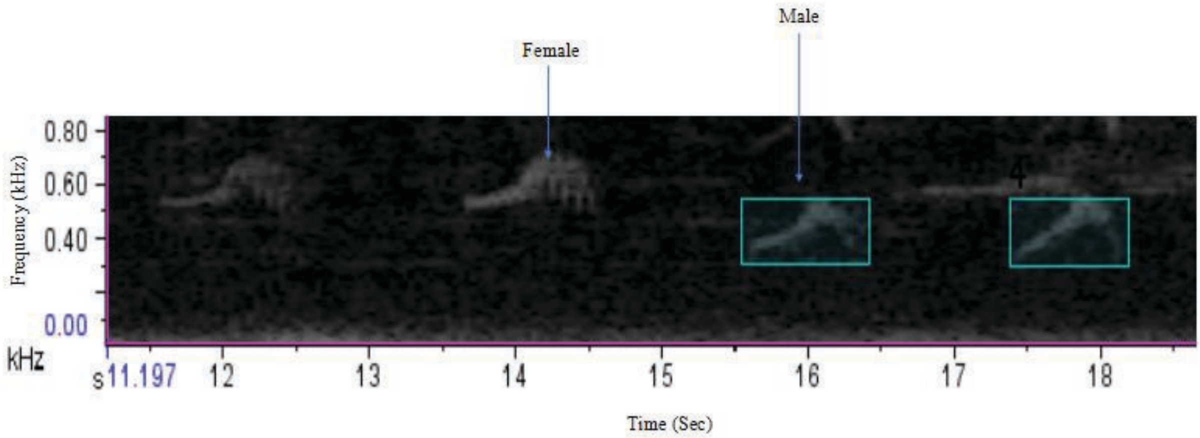

Figure 5. Male and female courtship call spectrogram of the Mottled Wood Owl *Strix ocellata* in Western Maharashtra, India.

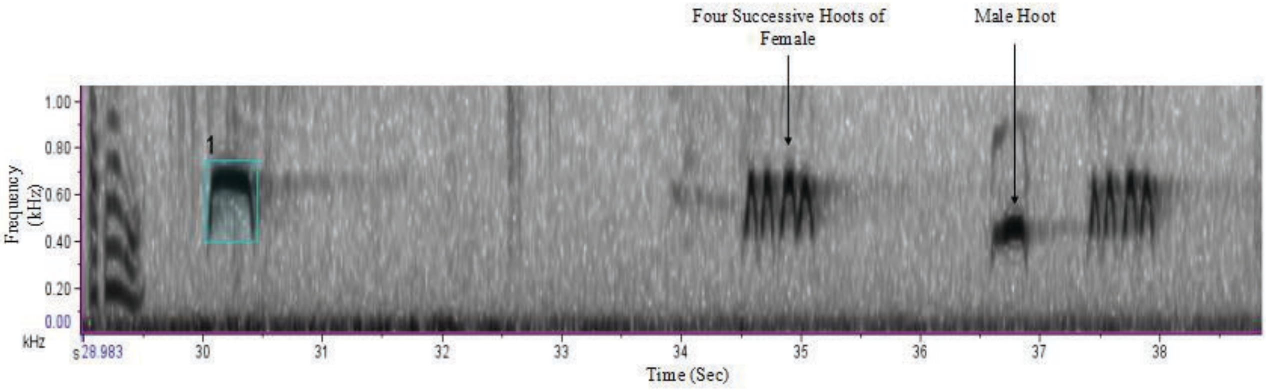

Figure 6. Alarm call spectrogram of the Mottled Wood Owl *Strix ocellata* in Western Maharashtra, India. [1-male hoot]

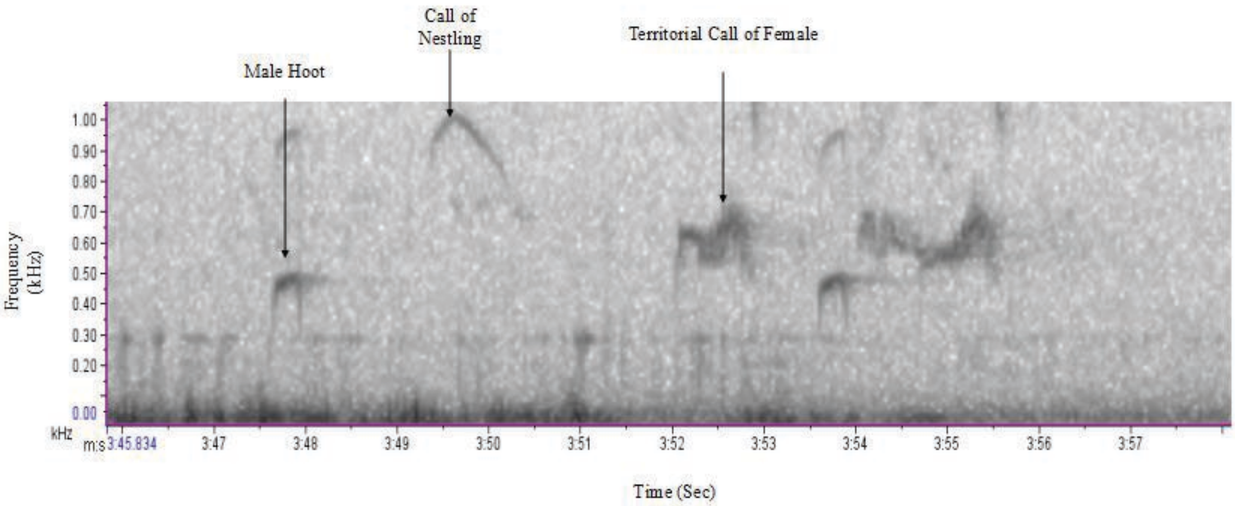

Figure 7. Spectrogram of calls of a Mottled Wood Owl *Strix ocellata* male, female and nestling in Western Maharashtra, India.

Comparison of vocalization of Spotted Owlet *Athene brama* between urban and rural populations in Western Maharashtra, India

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Abstract: There is scanty information about the vocalization of Spotted Owlets *Athene brama*. We hypothesized that there was no difference in vocalizations between urban and rural populations. Rising call was recorded and analyzed during the study period. We compared both the populations by conducting Student's T test. Null hypothesis was rejected indicating that a statistically significant difference was present between the two.

Keywords: Spotted Owlet, *Athene brama,* vocalization, urban, rural, statistical difference

Introduction:

The Spotted Owlet (*Athene brama*, Aves: Strigidae) is a common owlet found across India. Spotted Owlet *Athene brama* is a common resident of open habitats including farmland and human habitation (Mahabal, Pande, Pandit et al 2011). This owlet is vocal and its call can be heard during dawn and dusk (Pande et al. 2011). Work has been done on some aspects of Spotted Owlet including hybridization (Pande et al 2011a), biometry and growth of nestlings (Pande et al 2011b), diet (Pande et al 2004) and breeding behavior (Pande et al 2005, 2007).

The existence of biological clock is a widely known phenomenon and has been studied in relation to numerous organisms but vocal behavior of this species is poorly studied. The daily screeching time during emergence in the evening has been documented under natural conditions (Pande et al. 2011). In the current study we have focused on rising call patterns of the Spotted Owlet. Calls were then analysed using dedicated software for spectogram generation (Raven Pro Software of Cornell Lab of Ornithology).

Materials and Methods:

We did passive field call (with no playback) recordings of Spotted Owlets in their natural habitats.

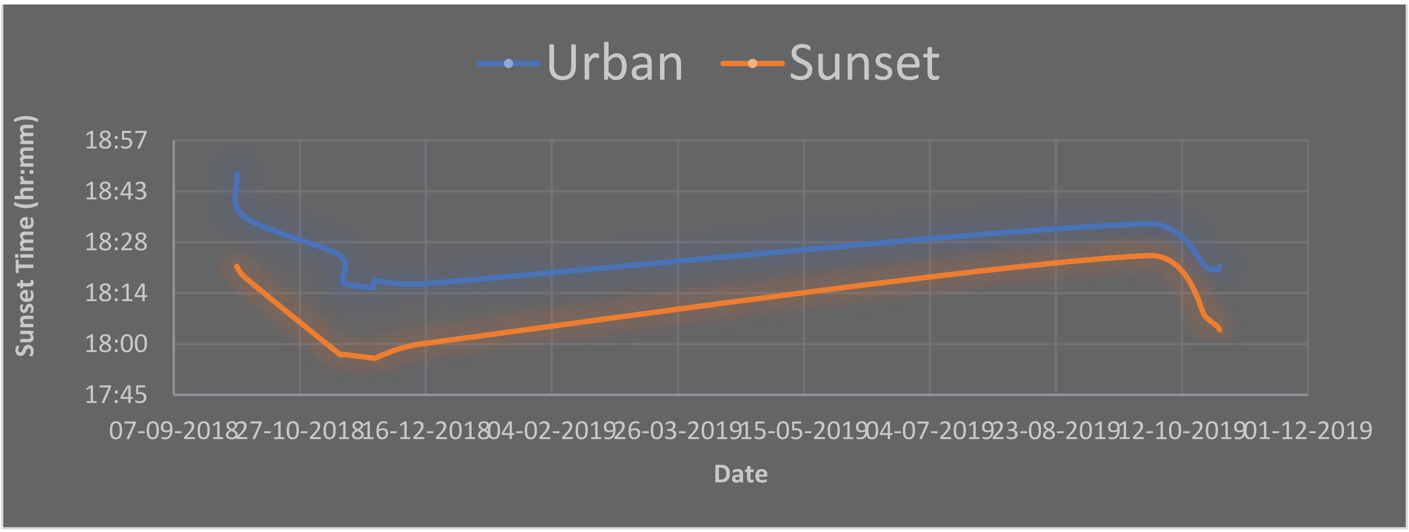

Fig.1: Co-relation of rising call time with sunset in Urban population (Range = 14 ~ 28 minutes, SD +/- 4.07 minutes, n = 11). In rural areas average time of rising call after the sunset time was 9.5 minutes.

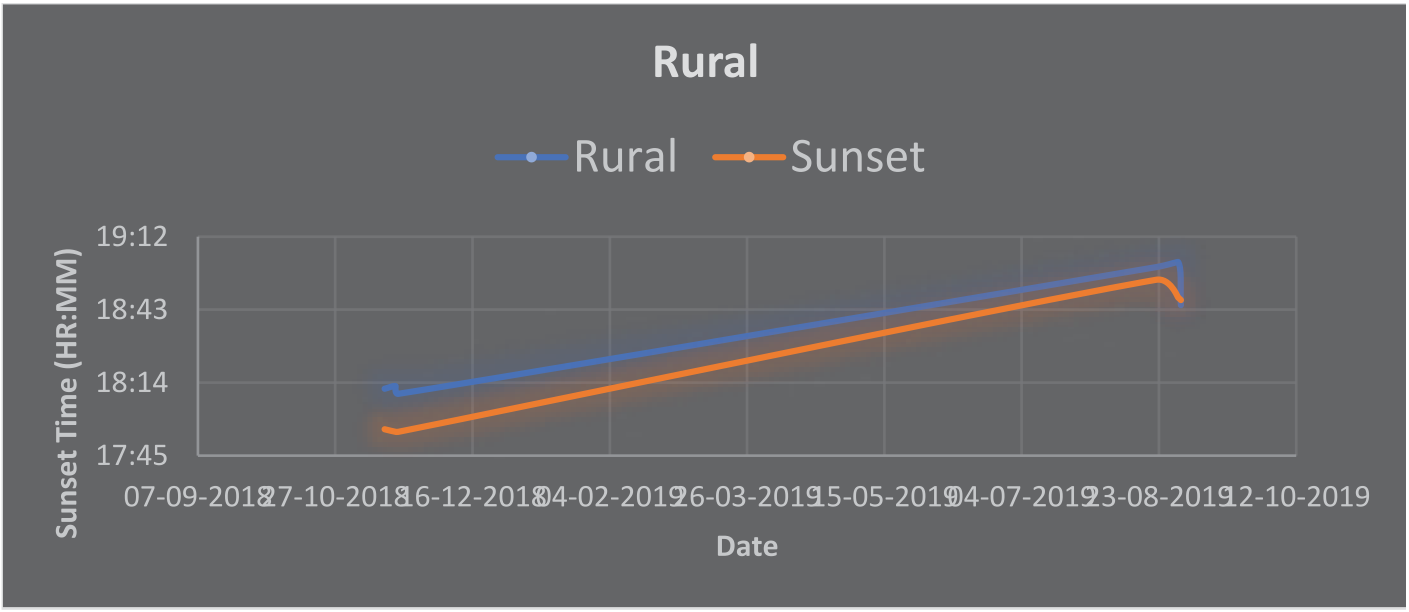

Fig.2: Co-relation of rising call time with sunset in Rural population (Range= 5 ~ 18 minutes, SD +/- 5.51 minutes, n = 5). Analysis revealed that the phrase in rising call from urban areas had an average peak power frequency of 2625 Hz

The study period was between October 2018 and September 2019. We made recording in urban and rural populations in Purandar taluka, Pune district of Western Maharashtra, India. Roosting sites of Spotted Owlet both in urban and rural areas were identified for call recording. The entire call was recorded but only rising calls were used for analysis. Spectograms consisting of minimal or no background noise were analysed.

We compared the following vocalization parameters between the two populations. Parameters like: 1) Fmin, 2) Fmax, 3) Peak Power Freq., 4) Phrase duration, 5) Inter-phrase duration 6) Number of phrases, 7) Co-relation of rising call time with sunset.

Mean and standard deviation were calculated for all parameters. We also performed Student's T-test to test our Null hypothesis.

For urban population we did recording in of four

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Avg. Peak Power Freq.(Hz)	2063	3656	**2625**	398	58
Fmin.(Hz)	1221	1877	**1591**	137	58
Fmax.(Hz)	2549	4881	**3394**	589	58

Table 1. Average peak power frequency of rising call in Urban Area. (Range= 2063 ~ 3656 Hz, SD +/- 398 Hz, n = 58). Same call from rural areas had an average peak power frequency of 2349 Hz (Table 2).

Parameter	Min Value	Max Value	Average	Standard Dev.	n
Avg. Peak Power Freq.(Hz)	1312	3750	**2349**	562	59
Fmin.(Hz)	563	2177	**1146**	310	59
Fmax.(Hz)	1539	4055	**2881**	558	59

Table 2. Average peak power frequency of rising call in Rural Area (Range = 1312 ~ 3750 Hz, SD +/- 562 Hz, n = 59).

pairs in Pune city including ARAI Hill, Sinhgad Road area, Sahakar Nagar area, and BMCC college premises. For rural localities we included Ela Habitat (Pingori), Shinde Nagar (Pingori), Wadkar Dara (Kavdewadi), Khomne Wasti (Kavdewadi), Kolvihire, Morgaon and Nimgaon Ketki.

We used Zoom H1, Zoom H5 recorders. Sound files were analyzed using Raven Pro Software ~~from~~ (Cornell Lab). We have done temporal and spectral analysis of calls.

Results:

Interestingly, in spite of being an *Athene*, Spotted owlet does not utter hoots both in the rural and urban localities, We observed that this species utters complex phrases while calling. We studied the rising call (*Chirurr Chirurr*), a common and clearly distinguishable call (consisting of 2 ~ 19 phrases) recorded at all localities. When multiple individuals vocalized complex recording patterns were obtained. The co-relation of rising call time with sun set time was sought.

The average time of rising call in the urban areas was 18.22 minutes (Fig.1).

Average minimum frequency in call from urban areas was 1591 Hz (1221 ~ 1877 Hz, SD +/- 137 Hz, n = 58). Average maximum frequency in call from urban areas was 3394 Hz (2549 ~ 4881 Hz, SD +/- 589 Hz, n = 58). Average minimum frequency in call from rural areas was 1146 Hz (563 ~ 2177 Hz, SD +/- 310 Hz, n = 59). Average maximum frequency in call from rural areas was 2881 Hz (1539 ~ 4055 Hz, SD +/- 558 Hz, n = 59).

Average phrase duration from urban areas was 0.38 sec (0.22 ~ 0.62 sec, SD +/- 0.065 sec, n=58) and from rural areas was 0.34 Sec (0.09 ~ 0.61 sec, SD +/- 0.115 sec, n=59). Inter-phrase duration from urban areas was 0.40 sec (0.15 ~ 0.76 sec, SD +/- 0.177 sec, n=46) and from rural areas was 0.32 sec (0.12 ~ 0.88 sec, SD +/- 0.176 sec, n=41). Average number of phrases in a call from urban areas was 10 (6~19 , SD +/- 6.35, n=5) while from rural areas was 10.5 (2 ~ 19, SD +/- 6.73, n=5). Average call duration from urban areas was 7.71 sec (3.56 ~ 17.43 sec, SD +/- 6.20, n = 5) while from rural areas was 8.66 sec (1.25 ~ 14.12 sec, SD +/- 4.86, n = 5).

Discussion:

We hypothesized that there was no difference in vocalizations between urban and rural populations of Spotted Owlet. We performed student's T test to test our Null hypothesis. We tested three parameters namely peak power frequency, Minimum Frequency, and Maximum frequency in the data set of Rural and Urban recordings. Students T test analysis gave the P value for three parameters as 6.28E-18, 1.44E-13, 2.85E-06 respectively. The p values were < 0.05, hence the Null hypothesis was rejected, indicating that a significant statistical difference. Such differences have been described for diurnal song birds. This is the first such study on crepuscular and nocturnal Spotted Owlet from India and further work can help us understand the vocalization behavior of this species. Comparative analyses between both the populations clearly gives us vocalization differences between the two populations (Fig.4).

Because of the presence of obstacles like houses & buildings in urban areas, the urban owlet uttered high frequency calls with shorter phrases to reach shorter distances; with a smaller number of phrases and less average call duration, due to exhaustion coupled with higher inter-phrase duration. Hence, this is an ecological adaptation. Whereas in rural areas, lower frequency calls were uttered which reach longer distances. No account of lack of obstacles it had less number of calls with more phrases and longer average call duration. It translated into less energy expenditure.

Again, such differences have been described for diurnal song birds, this is the first such study on crepuscular and nocturnal Spotted Owlet from India. It was interesting to see that populations of Spotted Owlet in urban and rural areas have adapted their vocalization to suit different ecological conditions

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Author Contributions: AR, AG, RL, KP conducted field study. AR and AG performed statistical analysis. AR and AG wrote the paper. SP guided.

References:

- Pande, S., Pawashe, A., Bastawade, B., Kulkarni, P. 2004. Scorpions and molluscs as new dietary record of Spotted Owlet *Athene brama brama*. *Newsletter for Ornithologists*.
- Satish Pande, Amit Pawashe , M. N. Mahajan & Anil Mahabal (2005) Changing nest site preference for holes in earth cuttings in Spotted Owlet – *Athene brama brama. Indian Birds.*
- Satish Pande, Amit Pawashe, Murlidhar Mahajan, Anil Mahabal and Charu Joglekar (2007) Differential effect of habitat and food on breeding success in rural and urban populations of Spotted Owlet (*Athene brama*) *Journal of Raptor Research* 41 (1): 26-36.
- Pande, S.A., A.P. Pawashe, R. Kasambe & R. Yosef (2011a). Discovery of a possible hybrid of the Critically Endangered Forest Owlet *Athene blewitti* and Spotted Owlet *Athene brama* (Aves: Strigiformes) from northern Maharashtra, India. *Journal of Threatened Taxa* 3(4): 1727–1730.
- Pande S, Pawashe A, Mahajan MN, Mahabal A, Yosef R, Dahanukar N (2011b) Biometry based ageing of nestling Indian Spotted Owlets (*Athene brama brama*). *ZooKeys* 132: 75–88. doi: 10.3897/zookeys. 132.1346.
- Mahabal, Anil, Satish Pande, Pranav Pandit and Aditya Ponkshe. (2011). Zool. Surv. India. *Fauna of Maharashtra, State Fauna Series*, 20(Part 1) : 147-188.

Ecological factors influencing site occupancy of the Forest Owlet *(Athene blewitti)* in East Kalibhit Forests, Madhya Pradesh, India

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ABSTRACT

The critically endangered forest owlet (*Athene blewitti*) is endemic to Central India. We carried out a survey of the forest owlet in East Kalibhit forests, in Khandwa District of Central India using call broadcast surveys, in 367 grid cells admeasuring 500 x 500 m each, and assessed potential ecological factors in the same cells. We carried out selectivity analysis to study the response of the forest owlet occurrence to ecological factors. We carried out occupancy analysis to estimate the occupancy of the forest owlet in the surveyed cells, and to assess the influence of various ecological factors on occupancy. Of the six ecological factors under consideration, distance from agriculture, percentage of teak (*Tectona grandis*) trees in the cell, elevation, and average girth of the trees, were found to be strong predictors of occupancy. Forest owlet occupancy was negatively influenced by distance from agriculture and elevation, and positively influenced by percentage of teak trees in the cell. Occupancy had an inverse quadratic relationship with average girth of trees in the cell. Logging affected the selectivity of forest owlet for logged sites negatively, but the sites recovered in four to six years. We suggest that the adverse impact of timber logging can be reduced by exempting nest and roost sites of the forest owlet from logging. The forest owlet has adapted to living in forests interspersed with agricultural fields but cannot survive in areas devoid of forests. It is important to protect the forests for its long-term survival.

INTRODUCTION

Understanding spatial distribution of biodiversity is one of the central themes of ecological studies. It is also crucial for conservation and management of species of special conservation concern such as forest-dwelling raptors (Henneman et al. 2007). Often species, especially those that are endemic, display specialized habitat requirements, which causes them to be restricted to a narrow geographical range. A well-designed survey becomes an important tool to assess the distribution, abundance and population trends in case of endemic species (Petitot et al. 2014). The standard survey techniques that help to assess the abundance of the target species include line-transects, point counts and breeding season surveys (Anderson and Ohmart 1981; Pyke and Recher 1985). However, such surveys can be expensive, time-consuming, and difficult to accomplish (Andersen et al. 2004), especially in the case of forest-dwelling raptors, because meaningful estimates of density or population trends require intensive surveys over large geographic areas (Henneman et al. 2007).

Site-occupancy is increasingly used to describe the presence of a species in a quantitative manner (MacKenzie et al. 2002). It is defined as the probability of presence of a species in a particular site or habitat patch, and is also described as proportion of area occupied by the species. Occupancy theory was developed to account for imperfect detection of species, to estimate the true occupancy based on repetitive sampling of the survey sites (MacKenzie et al. 2002). The occupancy estimation technique is a low-cost and resource-efficient alternative to estimating species abundance. Occupancy theory enables estimation of detection probability on the basis of capture history of the species, and also incorporates habitat covariates such as habitat type, forest type, vegetation composition and biotic influences, to account for variation in detectability. Occupancy theory can model for variations in occupancy as a function of habitat covariates.

Broadcast surveys are one of the most widely used techniques to locate and census owls (Fuller and Mosher 1981, Johnson et al. 1981, Smith 1987). Call broadcast surveys were used by Todd et al. (2018) to locate multiple nocturnal bird species and estimate their occupancy. Broadcast surveys have also been used to detect the presence of diurnal forest-dwelling raptors such as the red-shouldered hawk (*Buteo lineatus*) (Henneman et al, 2007). In their study, they argue that broadcasting conspecific vocalizations can increase the probability of detecting forest-dwelling raptors.

The use of site-occupancy framework is not limited to raptors. It has been used to model detection non-detection data of Amphibians in Mediterranean region (Petitot et al. 2014). Large-scale site occupancy surveys have led to the discovery of new Adelie penguin breeding sites (Southwell and Emmerson 2013). In India, occupancy modelling framework has been extensively used to monitor large carnivore populations from sign surveys in South India by Karanth et al. (2011) and Punjabi et al. (2017).

The forest owlet (*Athene blewitti)* is a small (19-21 cm, 160-180 g, Mehta et al. 2021) diurnal owl, endemic to Central India. Until 1884 there were only seven confirmed records of the forest owlet from the Central Indian highlands (Rasmussen and Collar 1998). The lack of authentic records after 1884 led to the belief that it was possibly extinct (Ripley 1952, 1976). In 1997 the forest owlet was rediscovered in the Shahada forests in northern Maharashtra (King and Rasmussen 1998).

Owing to its small and isolated populations, and discontinuous distribution, the Forest Owlet is placed in the Endangered category of the Red Data list by IUCN (Birdlife International 2020). Habitat loss, due to forest felling, forest fires, forest encroachment, and hunting, have been identified as the major threats to forest owlet populations in North-western Maharashtra (Jathar and Rahmani 2004; Jathar and Patil 2011; Mehta et al. 2017b), and Central India (Mehta et al. 2008, Mehta et al 2017a).The present study was carried out with the object of identifying the main ecological factors governing the site occupancy of the forest owlet, in forests of Central India.

Materials And Methods

Study area

The study was carried out in East Kalibhit Reserved Forests (N21.90, E77.00) in Khandwa District of Madhya Pradesh state in Central India. The size of our study area was about 26 km x 20 km. The region is characterised by flat and gently sloping terrain interspersed with small hills, and the elevation ranged from 300 to 700 m asl. The climate of the area is tropical, with three well-defined seasons. The rainy season lasts from mid-June to September. During this season, the area receives more than 80% rainfall due to south-west monsoon. The forests in the study area are government forests, maintained primarily for timber production and environmental functions. These are of the type southern dry deciduous teak-bearing forests, raised in the past by artificial plantation of teak (*Tectona grandis*), an important timber species. Teak is the dominant species with associates such as *Anogeissus latifolia, Lannea coromandelica, Terminalia alata, Butea monosperma, Diospyros melanoxylon, Boswellia serrata,* and *Garuga pinnata*. Bamboo is found mainly in the hilly parts of the study area. *Wrightia tinctoria, Helicteres isora,* and *Zizyphus rugosa* are the main species in the understorey (Shukla 2013).

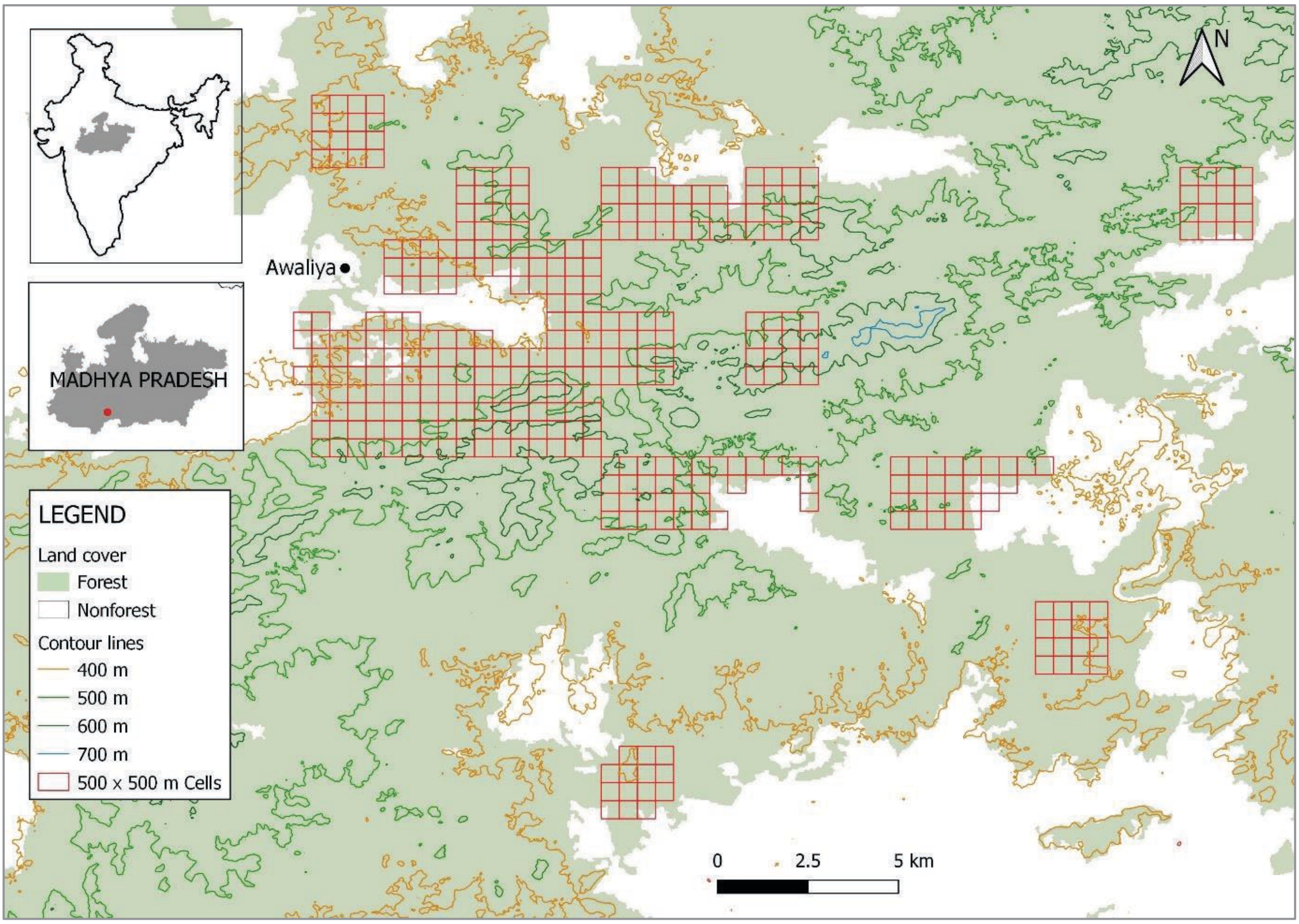
Within and around the study area there are seven villages of indigenous residents, with populations in the range of 700 to 1600. The inhabitants belong mainly to the Korku tribe. Monsoon crops include rice, corn and cotton, while winter crops include wheat, soyabean, gram, and pulses.

The forests in the study area are managed for timber production by the Forest Department. Timber logging is carried out according to the selection cum improvement silvicultural system, wherein mature trees of harvestable girth are extracted selectively. The forests are also used by the local communities for collecting firewood, grazing their cattle, and for collecting non-timber forest produce. There is some degradation pressure on the forest adjacent to villages, due to tree cutting for firewood, livestock grazing, and due to forest fire.

Occupancy Survey Design

The study area was overlaid with a grid of cells admeasuring 500 m x 500 m (25ha). Each survey unit had a georeferenced central coordinate termed "survey station" (Johnson et al. 2007). Totally 367 cells were selected to assess the forest owlet presence in the study area. Of these, 212 cells were in a compact cluster, and

Figure 1: Location map of study area



were selected because of known presence of the forest owlet in the area. Additionally, 155 cells in 8 clusters were selected to assess the impacts of timber logging on forest owlet occupancy.

Survey Techniques

The survey was carried out from November 2013 to May 2014. Owls were located by broadcast survey. A call broadcast survey carried out during the breeding season would elicit a response from the breeding owl pair in that cell, indicating its presence in the area. However, owls may be present at the site but not respond for various reasons, for example, if they are incubating, or due to the presence of a predator. In that case, lack of response may be recorded as false absence. It is therefore desirable that occupancy or distribution survey should consist of repeated visits in the area in the breeding season (Johnson et al. 2007).

At each survey station, the contact call was broadcasted for a period of 2 minutes, followed by a 3-minute response time. This cycle was repeated twice or sometimes thrice (Johnson et al. 2007). In the summer season, surveys were carried out from 0600 to 1000 hrs. and 1500 to 1800 hrs. During winter months, surveys were carried out from 0700 to 1100 hrs, and 1500 to 1800 hrs. The selected cells were visited from 1 to 5 times, though most cells were visited four times. There were totally 1194 sampling occasions. Since occupancy analysis is robust to missing data, incomplete sampling in a few cells would not substantially affect the results, though there may be loss of precision (McKenzie et al. 2002). The result of the survey on each occasion was recorded as a matrix of 0s and 1s, where 0 indicates non-detection and 1 indicates detection.

Measurement of Habitat covariates

Habitat assessment was carried in each 500 x 500 m cell of the study area. For each cell, we used a combination of remotely sensed variables, field-based covariates and data from secondary sources (Table 1). For quantifying the percentage of teak, we marked a 20 m x 20 m (0.04 ha) quadrat (James and Shugart 1970, Belthoff and Ritchison 1990) at the center of the cell, and counted the number of trees of each species. Potential collinearity between covariates was ruled out by testing that Pearson's r value did not exceed 0.7 for any pairs of covariates.

Occupancy analysis

We used the software PRESENCE version 10.5 (Hines 2006) to analyse the occupancy patterns of the forest owlet. This software fits the occupancy models to the detection/non-detection data using maximum likelihood techniques. The software then ranks the candidate models according to Akaike's Information Criterion (AIC) value. A lower AIC value corresponds to a better fitting and more parsimonious model. The occupancy analysis was carried out according to the

Table 1: Description of candidate habitat covariates and their source

Covariate	Description	Source of data
FA	Proportion of forest area in the cell	Digitized from Google Earth
DISTAGRI	Distance from the centre of the cell to nearest agricultural field (km)	Measured from Google Earth
ELEV	Average elevation of the cell (m)	Averaged from Aster DEM raster data
TEAK	Proportion of teak trees in the cell	From 20 x 20 m quadrat at centre of each cell
MXDEN	Maximum canopy cover (fraction) in the cell of the various forest patches in the cell	From forest stock map of the Forest Department
GBH	Average girth at breast height (cm) of trees in the cell	From forest stock map of the Forest Department
LOG	Years since last logging	Forest Department logging records

general model ψ(*covariates*).p(*covariates*) where ψ represents occupancy and p represents detection probability of the forest owlet.

Selectivity analysis

A preliminary analysis of the response of the occupancy to each covariate was done using selectivity analysis. In order to do this, the range of values of each covariate was divided into four or five equal intervals. Selectivity was calculated using Jacobs selectivity index (Jacobs 1974),

$$S_i = \frac{r_i - p_i}{r_i + p_i - 2r_i p_i} \quad (1)$$

where r_i is proportion of cells wherein forest owlet was detected in the i^{th} interval, out of the total number of cells in which the forest owlet was detected, and p_i is the proportion of available cells in the i^{th} interval out of the total number of cells. The value of the selectivity index ranges from -1 to 1. A positive value of selectivity indicates preference for that interval, with a value of 1 indicating highest level preference while a negative value indicates avoidance, with a value of -1 indicating highest level of avoidance. A 0 value of selectivity indicates neutral response (Jacobs 1974).

Results

Habitat requirements of forest owlet

Table 2 summarises the habitat covariates observed in the surveyed cells, which were considered for occupancy modelling. In the study area the forest owlet occurs in a narrow elevation range (377 to 504 m asl). It was not found at elevations higher than 504 m asl in the surveyed cells, though the elevation extended to 674 m asl. The average GBH in the cells where the forest owlet was detected ranged between 13 to 97 cm, and was slightly lower than the average GBH in the study area. The average teak percentage in the cells where

Table 2: Range and average values of habitat parameters considered in this study

Covariate	In the entire study area		In the cells where Forest Owlet was detected		t-test p (same mean)
	Range	Average Value (±SD)	Range	Average Value (±SD)	
FA	0 – 1	0.824 (±0.338)	0 – 1	0.783 (±0.308)	t= -2.9056 p=0.0039
DISTAGRI (km)	0 – 4.468	1.093 (±1.011)	0 – 2.157	0.537 (±0.620)	t=3.333 p=0.0009
ELEV (masl)	349 – 660	459 (±64.7)	375 – 531	425 (±33.1)	t=3.1506 P=0.0017
TEAK	0 – 100 %	56.8 (±24.0) %	30 – 100 %	70.7 (±22.0) %	t= -2.9056 p=0.0039
MXDEN	0.3 – 0.8	0.649 (±0.077)	0.3 – 0.8	0.660 (±0.091)	t=-0.8477 p=0.3987
GBH (cm)	40-110	86.3 (±9.82)	70-105	84.7 (±7.72)	t=1.015 p=0.3106
LOG (years)	0-12	5.79 (±4.62)	0-12	5.25 (±4.46)	t=0.6431 p=0.5205

the forest owlet was found, was slightly higher than the study area. The forest owlet was found in cells whose forest cover ranged from 0 to 100% forest area with an average of 82.4% forest area. The distance of the cells, where the forest owlet was detected, from agriculture, ranged from 0 to 2157 m. The average distance from agriculture of the cells with forest owlet presence (537 m) was less than the average distance of all cells in the study area (1093m).

Selectivity Analysis

For each covariate the selectivity values were plotted against the covariate values to understand the response of species occurrence to covariate values for each covariate (Figure 1A to 1F). The selectivity analysis carried out by us is based on forest owlet detections, which is an index of its abundance. Gaston et al. (2000) have demonstrated that species abundance is positively related to occupancy. Hence, we assert that the selectivity patterns based on number of forest owlet detections also apply to forest owlet occupancy.

The selectivity of the forest owlet for the proportion of forest area in the cell (FA), and the girth at breast height (GBH) showed a peak in the middle of the range, indicating a preference by the forest owlet for middle ranges of these two covariates (Figure 2A, 2F). A linear negative relationship was observed for two habitat covariates, distance from agriculture (DISTAGRI) and elevation (ELEV), where selectivity decreased with increase in these covariate values (Figure 2B & 2C). An increase in selectivity was observed with increase in percentage of teak (TEAK) and maximum canopy density (MAXDEN) (Figure 2D & 2E). An increase in selectivity was observed with increase in number of years since the last logging operation (LOG), tending to plateau after a few years (Figure 2G).

Occupancy modelling

For the occupancy analysis, it was assumed that forest owlet occupancy followed the same trend as selectivity with each covariate, i.e. linear increasing, linear decreasing, or inverted quadratic. Occupancy modeling is carried out based on a logistic model for occupancy according to the equation

$$\psi = \frac{\exp(XB)}{1+\exp(XB)} \qquad (2)$$

where X is the covariate vector and B is the coefficient vector (MacKenzie 2002). The vector X consists of all the candidate covariates. Two additional pseudocovariates FASQ and GBHSQ, which are the square of FA and GBH respectively, were introduced in the covariate vector X, to account for the quadratic relationship of occupancy with FA and GBH respectively. These two covariates were always modeled in combination with their squares, i.e. FA-FASQ and GBH-GBHSQ, keeping in mind the quadratic relationship of occupancy with these habitat factors observed from the selectivity analysis (Figure 2). The validity of this assumption was later confirmed by the occupancy modelling where the quadratic relationship for GBH received more support than the linear model.

Considering the large number of potential predictor models, a two-step approach was adopted in the analysis. Initially a model of the nature ψ(<u>*covariates*</u>).p(*covariates*) was considered for determining the structure of the model for detection

Table 3: The candidate models for ψ(all covariates).p(covariate) and their AIC values

Model	AIC	ΔAIC	AIC weight	Model likelihood	No. of parameters	-2*Log Likelihood
ψ(DISTAGRI,TEAK), p(.)	272.02	0	0.3097	1.0000	4	264.02
ψ(DISTAGRI,TEAK), p(FA)	273.71	1.69	0.1330	0.4296	5	263.71
ψ(DISTAGRI,TEAK), p(TEAK)	273.86	1.84	0.1234	0.3985	5	263.86
ψ(DISTAGRI,TEAK), p(ELEV)	273.89	1.87	0.1216	0.3926	5	263.89
ψ(DISTAGRI,TEAK), p(GBH)	273.92	1.90	0.1198	0.3867	5	263.92
ψ(DISTAGRI,TEAK), p(MXDEN)	273.99	1.97	0.1156	0.3734	5	263.99

Figure 2: Forest Owlet selectivity in response to various habitat covariates

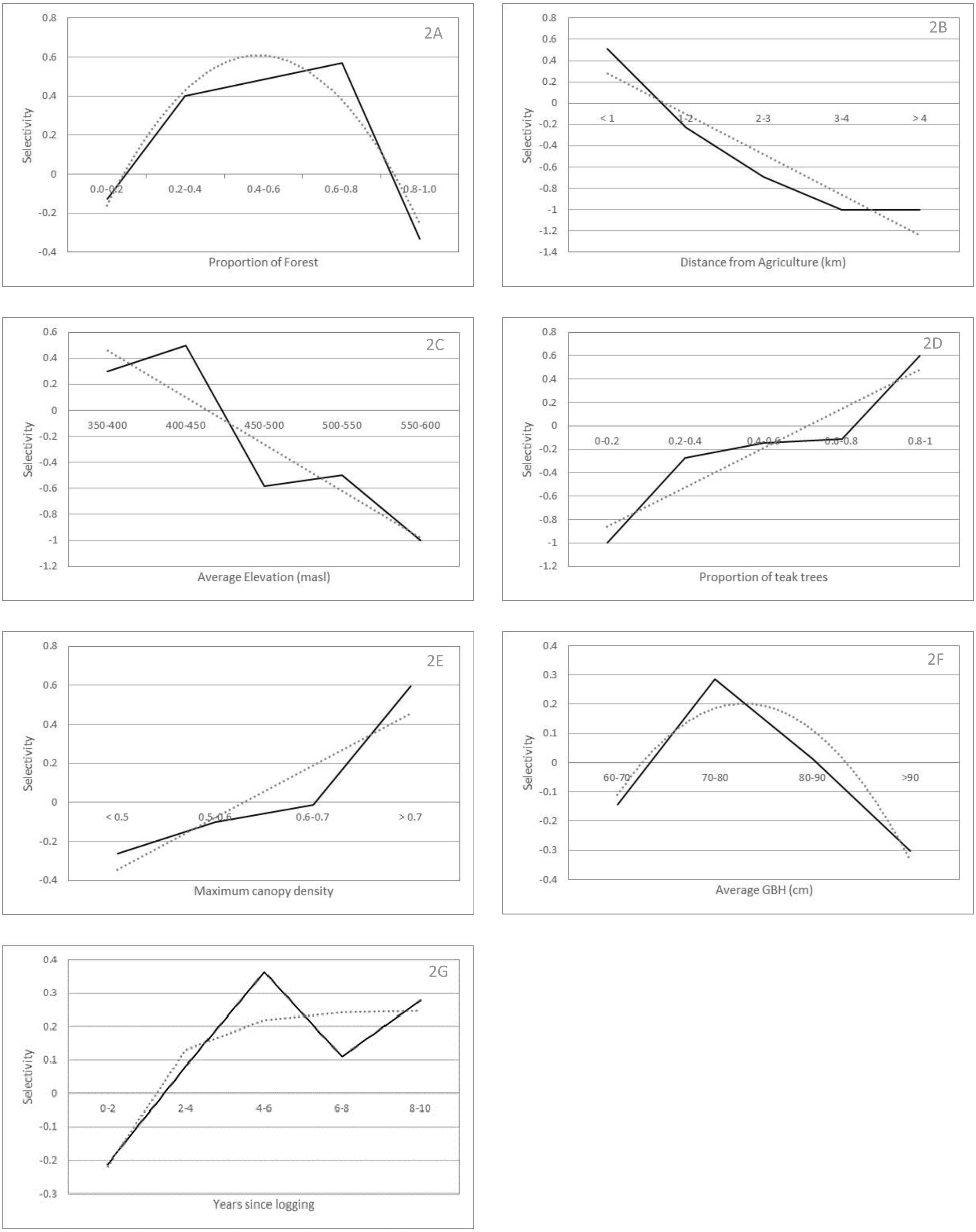


Table 4: The candidate models for ψ(covariates).p(.) and their AIC values

Model	AIC	ΔAIC	AIC weight	Model likelihood	No. of parameters	-2*Log Likelihood
ψ(DISTAGRI,TEAK,ELEV,GBH,GBH SQ), p(.)	266.74	0.00	0.4901	1	7	252.74
ψ(DISTRAGRI,TEAK,ELEV),p(.)	267.60	0.86	0.3188	0.6505	5	257.60
ψ(DISTRAGRI,TEAK,GBH,GBHSQ),p(.)	270.23	3.49	0.0856	0.1746	6	258.23
ψ(TEAK,ELEV),p(.)	271.25	4.51	0.0514	0.1049	4	263.25
ψ(DISTRAGRI,TEAK),p(.)	272.02	5.28	0.035	0.0714	4	264.02
ψ(DISTRAGRI,ELEV),p(.)	274.46	7.72	0.0103	0.0211	4	266.46
ψ(DISTAGRI,ELEV,GBH,GBHSQ),p(.)	274.78	8.04	0.0088	0.018	6	262.78

Table 5: β coefficients of the selected covariates in the top seven occupancy models

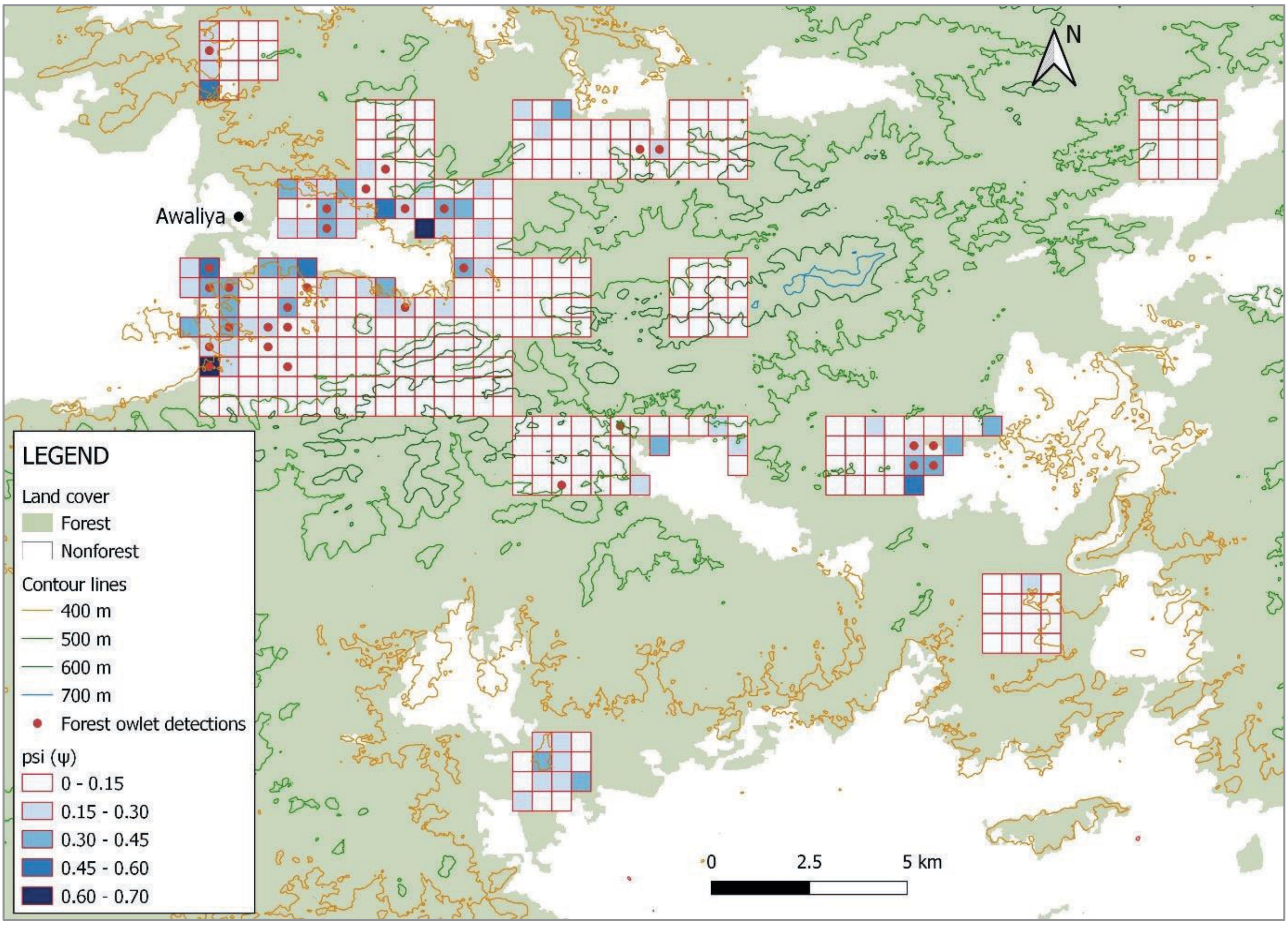
Model	CONST	DISTAGRI	TEAK	ELEV	GBH	GBHSQ
ψ(DISTAGRI,TEAK,ELEV,GBH,GBH SQ), p(.)	-29.23	-0.82	3.54	-0.014	79.22	-48.77
ψ(DISTAGRI,TEAK,ELEV),p(.)	3.35	-0.86	3.22	-0.015	-	-
ψ(DISTAGRI,TEAK,GBH,GBHSQ),p(.)	-29.7	-1.13	3.36	-	67.4	-42.34
ψ(TEAK,ELEV),p(.)	4.80	-	3.36	-0.02	-	-
ψ(DISTAGRI,TEAK),p(.)	-2.97	-1.18	3.06	-	-	-
ψ(DISTAGRI,ELEV), p(.)	4.85	-0.94	-	-0.013	-	-
ψ(DISTAGRI,ELEV,GBH,GBHSQ),p(.)	-21.5	-0.92	-	-0.013	64.5	-39.8

probability, where *covariates* was a constant set of covariates, while the covariates for modelling p were variable (Table 3). The model ψ(DISTAGRI, TEAK).p(.) was found to be the most parsimonious with an AIC value of 272.02. Hence the null model for p was selected for further occupancy analysis.

In the next step ψ was modelled for all possible combinations of the covariates using the model ψ(*covariates*).p(.) The model support was assessed based on ΔAIC values, , where ΔAIC is the difference in AIC with respect to the top model that has the lowest AIC. Models with ΔAIC ≤ 2 were considered to be very credible; models with ΔAIC ≥ 3 but ≤ 7 were considered to be less credible; and models with ΔAIC ≥ 10 were considered to be unlikely (Burnham and Anderson, 2002).

Seven occupancy models were considered in all, which had ΔAIC ≤ 10. Of these, the top three models accounted for 89% of the AIC weight. Of the seven models considered, DISTAGRI occurred in six models, TEAK occurred in five models, ELEV occurred in five models, and the GBH-GBHSQ combination occurred in three models. Therefore DISTAGRI, TEAK, and ELEV appear to be the most important covariates for forest owlet occupancy. The GBH-GBHSQ combination also appears to be important as it occurs in two of the top three models (Table 4). Based on the β coefficients (Table 5), occupancy showed a negative relationship with DISTAGRI, a positive relationship with TEAK, and negative relationship with ELEV, confirming the inferences made through selectivity analysis. Forest owlet occupancy had an inverted quadratic relationship with the covariate combination GBH-GBHSQ, indicating higher occupancies in the intermediate range of GBH, which also confirms the inferences made through selectivity analysis.

Figure 3: Forest Owlet Occupancy Map in the Study Area



The naïve occupancy forest owlet was found to be 0.0742, i.e., 7.42% of the sampled landscape was detected to have the presence of forest owlet. The average detection probability was found to be 0.3750. In comparison, the model-averaged occupancy estimate, averaged for all 334 sites, was estimated to be 0.1031.

Understanding the response of forest owlet occupancy to various habitat covariates was an important aim of this study. Exploratory analysis using selectivity was found to be a useful tool as a criterion for shortlisting potential covariates and understanding the response of forest owlet occupancy to various habitat factors. A monotonously increasing or decreasing relationship is generally assumed between occupancy and the covariates. However, species preference for habitat factors may be more complex. In our analysis we found that the forest owlet preferred intermediate values of GBH, and proportion of forest area, FA, in the cell (Figure 2), which points to a quadratic model. While the covariate combination FA-FASQ did not occur in any of the top models of ψ, the combination GBH-GBHSQ occurred in three of the top seven models (Table 4), indicating its importance as a covariate for forest owlet occupancy. Selectivity analysis can help to a priori identify such relationships of occupancy with covariates and help in selection of more appropriate models of ψ.

Discussion

After its rediscovery, several systematic studies were initiated by researchers to understand the ecology and distribution of forest owlet (King and Rasmussen 1998; Ishtiaq and Rahmani 2000; Mehta et al. 2008; 2015; 2017b; Laad and Dagale 2015; Raha et al. 2017; Patel et al. 2015; 2017). However much remains to be understood about the general habitat requirement of this species. In this study, for the first time we used selectivity analysis (Jacobs 1974), as well as occupancy analysis in the site occupancy framework described by MacKenzie (2002), to study the occupancy of the forest owlet in a previously undescribed area.

Ibarra et al. (2014) carried out an occupancy study for the austral pygmy owl (*Glaucidium nana*), a habitat generalist, and the rufous legged owl (*Strix rufipes*), a threatened forest specialist, in temperate forests of Southern Chile, using the call playback technique. They reported detection probabilities ranging from 0.39 to 0.65 for rufous-legged owls, and 0.17 to 0.62 for the austral pygmy owls. They found that moonlight increased detectability, while environmental noise decreased detectability. Since both covariates were not factors in our study, a null model for detection probability, which was found to be the best model in our analysis, is quite reasonable.

The importance of the covariate "Distance from Agriculture" in the occupancy analysis is consistent with findings of recent studies on the forest owlet in Nandurbar District (Jathar & Rahmani 2004; Kulkarni and Mehta 2020) and in Central India (Mehta et al. 2015), where the forest owlet also prefers sites closer to agriculture. Preference of forest owlet for edge habitat near agriculture is likely to be due to availability of rodents, which are important prey of the forest owlet (Mehta et al. 2018), in agricultural fields.

Our finding that forest owlet occupancy increased with increase in percentage of teak trees in a cell is also supported by recent studies. The forest owlet is known to prefer teak forests and teak-bearing miscellaneous forests (Rasmussen and Collar 1998; Ishtiaq and Rahmani 2000; Jathar and Rahmani 2004, Kulkarni and Mehta 2020). However, the reason for the Forest owlet's preference for teak dominated forest remains unclear and needs further study.

Records of forest owlet presence in literature help in interpreting the negative correlation of the forest owlet's occupancy with the average elevation, which indicates that their range is restricted to lower elevations in the study area. Earlier records have reported forest owlet's presence in the elevation ranging between 400-600 m asl (King and Rasmussen 1998; Ishtiaq and Rahmani 2000; Jathar and Rahmani 2004; Mehta et al. 2015). Kulkarni and Mehta (2020) report, as well, a preference of the forest owlet for the elevation range from 250 to 550 m asl in Nandurbar District. Other studies have reported the forest owlet's preference for an elevational range of 400-500 m asl (Ishtiaq and Rahmani 2000; Jathar and Rahmani 2004). In the coastal region in Tansa Sanctuary the forest owlet is found at elevations as low as 50 m asl (Mehta et al. 2017b). In our study area, it is possible that the forest owlet prefers lower elevations because of the availability of agricultural fields, which are generally present here at lower altitude. Other factors may be unsuitability of habitat at higher elevations due to higher slope, higher rainfall, lower temperatures, and change in structure and composition of forest.

The preference for intermediate aged forests indicated by the inverted quadratic relationship observed between occupancy of the forest owlet and average girth at breast height (GBH), with a peak observed in the girth glass 70-80 cm (Fig. 2F) has a parallel in other owl species. In North America, the persistence of the northern spotted owl (*Strix occidentalis caurina*) is closely linked with old growth forests. However, their favourite prey, the dusky-footed wood rat (Neotoma fuscipes) is found in higher density in seral forests, so the owls are often found foraging in seral forests (Franklin 1997). The preference of the forest owlet for intermediate age forest may have to do with higher prey availability in these forest stands. Studies on rodent availability in middle-aged forests are needed to confirm this.

However, two ecological factors, proportion of forest area and maximum forest density in a cell, which were found to be important in the selectivity analysis, were not found to be important covariates of forest owlet occupancy.

Through selectivity analysis we found that the occurrence of forest owlet was influenced by the maximum canopy density of a forest patch within a cell (MXDEN, Figure 2E). However MXDEN did not occur in the top occupancy models (Table 4), hence it is concluded that the MXDEN is not a strong predictor of forest owlet occupancy.

Similarly, though the inverted quadratic relationship of the forest owlet occurrence with the proportion of forest area in the cell (covariate FA, Figure 2A), showed a preference for intermediate values of proportion of forest area in the cell, this covariate did not occur in the top occupancy models, and is therefore not a strong predictor of forest owlet occupancy. We conclude that the forest owlet is able to survive in patches with varying proportions of forest interspersed with non-forest. Viter (2019) found that sites close to logged areas became hunting grounds of raptors due to the influx of passerine birds and rodents. It is possible that a similar mechanism may exist in our study site, wherein rodent density is higher in open areas, which primarily consist of agriculture, allowing continuity of the forest owlet in cells with partial forest cover.

On the other hand, unsustainable agriculture and logging are identified threats to raptors, leading to massive depletion of nesting sites (McClure et al. 2018, Viter 2019). In fact, timber logging near the nest site of the forest owlet can result in the owls abandoning the nest (Mehta et al. 2022), and we found that forest owlet shows negative selectivity for cells where logging has taken place recently. However, the selectivity increases within four to six years and then becomes almost constant (Figure 2G), so it appears that there is a transient impact due to logging on forest owlet occupancy, as the logged sites recover within a few years. This explains why the covariate for number of years since logging was not found to be a strong predictor of forest owlet occupancy.

Logging practices in the study area follow selection felling practices, wherein a small percentage of mature trees are harvested and the remaining trees are left standing. The felling cycle adopted in this region by the Forest Department is 20 years, wherein each block, known as a coupe, is logged once in 20 years. The felling blocks are small - about 75-150 ha in extent (Shukla 2013) - and are surrounded by unlogged forest, so the birds have refuge areas where they can retreat when the coupe is logged. In areas where a matrix of logged and unlogged forests is available, birds recolonize the logged areas if their nest and roost trees are not disturbed by logging (Mehta 2000). In East Kalibhit forests, the conservative logging practices explains the quick recover of logged sites recover in 4 to 6 years (Figure 2G).

We conclude that the forest owlet has adapted to living in areas with interspersion of forest and non-forest, and presence of agriculture. However, forests are still critical for its existence and it cannot survive in places devoid of forest. Forested areas near the agricultural fields should be protected from encroachment for conservation of forest owlet in human-dominated landscape. Timber logging may result in abandoning the site by the forest owlet but the logged sites are likely to be recolonized in a few years. Protection of nest trees and cavity-bearing trees in areas to be logged could help to mitigate the impact. Another practice that we recommend is identifying a buffer zone around nest and roost sites of the forest owlet, and exempting it from logging. Such practices need to be incorporated in the working plan - the management document of the Forest Department that regulates logging.

Campioni et al. (2013) studied the habitat preference of the ferruginous pygmy owl (*Glaucidium brasilianum*) in xerophytic forests of central Argentina. They found that ferruginous pygmy owls selected mature vegetation with higher dbh, probably for nesting cavities, whereas the forest owlet was found to prefer vegetation with intermediate dbh. They also found that the ferruginous pygmy owl showed a preference for heterogenous habitat, which they suggested provided the owl with different resources. We observed a similar habitat preference by the forest owlet, which showed a preference for edge habitat in proximity to agriculture.

Presence/absence surveys in an occupancy framework enable the estimation of the site occupancy of rare and endangered species, and help to identify the habitat preferences of the species. This is especially important in managed forests, and forests with anthropogenic pressures, to ensure that the basic habitat and resource requirements of the species are protected.

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References

- Andersen, D.E., DeStefano, S., Goldstein, M.I., Titus, K., Crocker- Bedford, D.C., Keane, J.J., Anthony, R.G. and Rosenfield R.N. (2004). The status of northern goshawks in the western United States. Wildlife Society Technical Reviews 04-1. The Wildlife Society, Bethesda, Maryland, USA.
- Anderson, B.W. and Ohmart, R.D. (1981). Comparisons of avian census results using variable distance transect and variable circular plot techniques. pp. 186–192. In: Ralph, C.J. and Scott, J.M. (eds), *Estimating Numbers of Terrestrial Birds*. Cooper Ornithological Society: Kansas.
- Belthoff, J.R. and Ritchison, G. (1990). Nest-Site Selection by Eastern Screech-Owls in Central Kentucky. The Condor 92 (4): 982-990
- BirdLife International (2020). Species factsheet: Heteroglaux blewitti. Downloaded from http://www.birdlife.org on 05/10/2020. Recommended citation for factsheets for more than one species: BirdLife International (2020) IUCN Red List for birds. Downloaded from http://www.birdlife.org on 05/10/2020.
- Campioni Letizia, José Hernán Sarasola, Miguél Santillán and Marcos Matías Reyes (2013). Breeding season habitat selection by Ferruginous Pygmy Owls *Glaucidium brasilianum* in central Argentina. *Bird Study* 60 (1): 35–43. http://dx.doi.org/10.1080/00063657.2012.733336
- Franklin, Alan B. (1997). Factors Affecting Temporal and Spatial Variation in Northern Spotted Owl Populations in Northwest California. *PhD Thesis, Department of Fisheries and Wildlife Biology,* Colorado State University, Fort Collins, Colorado. X+185pp.
- Gaston Kevin J., Tim M. Blackburn, Jeremy J. D. Greenwood, Richard D. Gregory, Rachel M. Quinn and John H. Lawton (2000). Abundance-occupancy relationships. *Journal of Applied Ecology* 37 (Suppl. 1): 39-59
- Henneman C., McLeod, M.A. and Andersen, D.E. (2007). Red-Shouldered Hawk Occupancy Surveys in Central Minnesota, USA. *Journal of Wildlife Management* 71(2): 526–533. https://doi.org/10.2193/2006-013
- Hines, J.E. (2006). PRESENCE – Software to estimate patch occupancy and related parameters. Version 10.5. USGS-PWRC. http://www.mbr-pwrc.usgs.gov/software/presence.html.
- Ibarra, J.T., Martin, K., Altamirano, T.A., Hernánvargas, F. and Bonacic, C. (2014). Factors associated with the detectability of owls in South American temperate forests: Implications for nocturnal raptor monitoring. *The Journal of Wildlife Management* 78(6): 1078–1086. https://doi.org/10.1002/jwmg.740
- Ishtiaq, F. and Rahmani, A.R. (2000). Further information on status and distribution of Forest Owlet *Athene blewitti*. *Forktail* 16: 172–173.
- Jacobs, J. (1974). Quantitative measurement of food selection. A modification of the forage ratio and Ivlev's electivity index. *Oecologia* 14: 413–417.
- Jathar, G.A. and Patil, D.N. (2011). Reassessment of status of Forest Owlet in its known distribution and evaluation of conservation issue. Final report. Published by Watershed Organization Trust. Pp. 1–48.
- Jathar, G.A. and Rahmani, A.R. (2004). Ecological studies of the Forest Spotted Owlet *Athene* (*Heteroglaux*) *blewetti* in Toranmal Reserved Forest, India. Final report. Bombay Natural History Society, Mumbai. Pp. 1–77.
- Johnson, D.H., Nieuwenhuyse, D. Van and Génot, J-C. (2007). Survey Protocol for the Little Owl (*Athene noctua*). Ardea 97 (4): 403-411.
- Karanth, K.U., Gopalaswamy, A.M., Kumar, N.S., Vaidyanathan, S., Nichols, J.D. and MacKenzie, D.I. (2011). Monitoring carnivore populations at the landscape scale: occupancy modelling of tigers from sign surveys. *Journal of Applied Ecology* 48(4): 1048–1056. https://doi.org/10.1111/j.1365-2664.2011.02002.x
- King, B. and Rasmussen, P.C. (1998). The rediscovery of the Forest Owlet *Athene* (*Heteroglaux*) *blewitti*. *Forktail* 14: 53–55.
- Kulkarni, J. and Mehta P. (2020). Habitat selectivity by the Forest Owlet *Athene blewitti* in Nandurbar District, Maharashtra, India. *Indian Birds* 16(2): 33-39.
- Laad, S. and Dagale, R. (2015). First report of Forest Owlet *Heteroglaux blewitti* from Tansa Wildlife Sanctuary (Western Ghats), Maharashtra, India. *Journal of Bombay Natural History Society* 111(2): 134.
- MacKenzie D.I., Nichols, J.D., Lachman, G.B.,

Droege, S., Royle, J.A. and Langtimm. C.A. (2002). Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83(8): 2248–2255. https://doi.org/10.1890/0012-9658(2002)083[2248:ESORWD]2.0.CO;2

- McClure, C.J.W., Westrip, J.R.S., Johnson, J.A., Schulwitz, S.E., Virani, M.Z., Davies, R., Symes, A., Wheatley, H., Thorstrom, R., Amar, A., Buij, R., Jones, V.R., Williams, N.P., Buechley, E.R. and Butchart S.H.M. (2018). State of the Worlds Raptors: Distributions, Threats, and Conservation Recommendations. *Biological Conservation* 227: 390–402. https://doi.org/10.1016/j.biocon.2018.08.012
- Mehta, Prachi (2000). The Effect of Forestry Practices on Bird Species Diversity in Satpura Hill Ranges. *PhD Thesis*. Wildlife Institute of India, Science Faculty, Saurashtra University. Pp. 1-203.
- Mehta P., Kulkarni, J. and Patil, D. (2008). A survey of critically endangered Forest Owlet (*Heteroglaux blewitti*) in Central India. *Birding Asia* 10: 77–87.
- Mehta, P., Prasanna, N.S., Nagar, A.K. and Kulkarni, J. (2015). Occurrence of Forest Owlet *Heteroglaux blewitti* in Betul District, and the importance of its conservation in the Satpura landscape. *Indian BIRDS* 10(6): 157–159.
- Mehta, P., Anand, A. and Kulkarni, J. (2017a). A Study on Population, Demography and Ecology of Forest Owlet in East Kalibhit Forests, Khandwa District, Madhya Pradesh. Final Technical Report submitted to Raptor Research and Conservation Foundation, Mumbai. Wildlife Research and Conservation Society. Pp 1–139.
- Mehta, P., Anand A., Kulkarni, J., and Rao, M. 2022. Nest-cavity and nest site characteristics of three sympatric owls in central India. Proceedings of World Owl Conference 2019,
- Mehta, P., Anand, A., S, Sangeeth and Kulkarni J. 2021. Investigating Reversed Sexual Size Dimorphism in the Endangered Forest Owlet *Athene (Heteroglaux) blewitti. Journal of Asian Ornithology* 37: 60-65.
- Mehta, P., Kulkarni, J., Mukherjee, S., Chavan, S. and Anand, A.V. (2017b). A distribution survey of the Forest Owlet *Heteroglaux blewitii* in north-western Maharashtra. *Indian BIRDS* 13(4): 103–108.
- Patel, J., Vasava, A. and Patel, N. (2017). Occurrence of the Forest Owlet *Heteroglaux blewitti* in Navsari and Valsad Districts of Gujarat, India. *Indian BIRDS* 13(3): 78–79.
- Patel, J.R., Patel, S.B., Rathor, S.C., Patel, J.A., Patel, P.B. and Vasava, A.G. (2015). New distribution record of the Forest Owlet *Heteroglaux blewitti* Hume, 1873, (Aves: Strigiformes: Strigidae) in Purna Wildlife Sanctuary, Gujarat, India. *Journal of Threatened Taxa* 7(12): 7940–7944.
- Petitot, M., Manceau, N., Geniez, P. and Besnard, A. (2014). Optimizing occupancy surveys by maximizing detection probability: application to amphibian monitoring in the Mediterranean region. *Ecology and Evolution* 4(18): 3538–3549. https://doi.org/10.1002/ece3.1207
- Punjabi, G.A., Edgaonkar, A., Srivathsa, A., Ashtaputre, S. and Rao, M.K. (2017). Distribution of the dhole in its northern range limits in the Western Ghats, India. *Canid Biology & Conservation* 20(3): 7–13. http://www.canids.org/CBC/20/dhole_in_western_ghats.pdf.
- Pyke, G.H. and Recher, H.F. (1985). Estimated forest bird densities by variable distance point counts. *Australian Wildlife Research* 12(2): 307–319. https://doi.org/10.1071/WR9850307
- Raha, B., Gadgil, R. and Bhoye, S. (2017). Sighting of the Forest Owlet *Heteroglaux blewitti* in Harsul, Nashik District, Maharashtra. *Indian BIRDS* 13(3): 80–81.
- Rasmussen, P.C. and Collar, N.J. (1998). Identification, distribution and the status of the Forest Owlet *Athene* (*Heteroglaux*) *blewitti*. *Forktail* 14: 43–51.
- Ripley, S.D. (1952). Vanishing and extinct bird species of India. *Journal of Bombay Natural History Society* 50 (4): 902–906.
- Ripley, S.D. (1976). Reconsideration of *Athene blewitti* (Hume). *Journal of Bombay Natural History Society* 73(1): 1–4.
- Shukla, S. (2013) Working Plan of Khandwa Division (2013–2023). Madhya Pradesh Forest Department, India.
- Southwell, C. and Emmerson, L. (2013). Large-scale occupancy surveys in East Antarctica discover new Adélie penguin breeding sites and reveal an expanding breeding distribution. *Antarctic Science* 25(4): 531–535. https://doi.org/10.1017/S0954102012001174

- Todd, M.K., Kavanagh, R.P., Penman, T.D., Bell, P. and Munks, S.A. (2018). The relationship between environmental variables, detection probability and site occupancy by Tasmanian nocturnal birds, including the Tasmanian masked owl (*Tyto novaehollandiae castanops*). *Australian Journal of Zoology* 66: 139–151. https://doi.org/10.1071/ZO17069
- Viter, S.G. (2019). Forestry activities and their influence on the Raptor's populations in the Southern Forest-Steppe Zone and Steppe Zone (on the example of the Kharkiv Region of Ukraine). *Raptors Conservation* 38: 156–178. https://doi.org/10.19074/1814-8654-2019-38-156-178

Author Contribution

Jayant Kulkarni: design of the study, data analysis, and manuscript preparation.

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Sajan Sheikh: survey and data collection

Nest-cavity and nest-site characteristics of three sympatric owls in Central India

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Abstract:
From 2013 to 2017, we studied nest-site and nest selection by the Forest Owlet (*Athene blewitti,* n =16), Spotted Owlet (*Athene brama,* n=10) and Jungle owlet (*Glaucidium radiatum,* n=11) in East Kalibhit Reserved Forests of Madhya Pradesh, Central India. Active nests were located by monitoring the behaviour of the birds and listening to the calls of the chicks. Vegetation in nest-site was quantified in 0.04 ha plot per plot and nest-cavity dimensions were measured after the breeding season of the owls was over. Multivariate analysis was used to test for the differences in nest-site, nest- tree and nest - cavity characteristics among three owl species. Cavity-bearing trees of *Tectona grandis, Bridelia retusa, Madhuca latifolia, Butea monosperma* are selected by the Forest, Jungle and Spotted Owlet for nesting. These species should be protected during timber logging operation. Differences in the breeding season and selection of different type of nest cavities enables the Forest Owlet to co-exist with Spotted Owlet and the Jungle Owlet in the East Kalibhit Forests.

Key Words:
Athene blewitti, conservation, Forest Owlet, India, Jungle Owlet, Glaucidium radiatum, nest-cavity selection, nest-site characteristics, protection, spotted owlet

Cavity-bearing trees in forests have a key ecological role in supporting a gamut of life forms (Haartman 1957). Decayed or excavated tree cavities are used by several species of birds for roosting, nesting, foraging, prey caching, and as a refuge from inclement weather and predators (Cody 1985; Erckmann et al. 1990; Newton 1994; Goodburn and Lorimer 1998). Macro-habitat associations such as slope, altitude (Poirazidiz et al. 2007), stand basal area (Stauffer and Best 1980), stand density, snag density, and presence of overstory and understory (Raphael and White 1984; Swallow et al. 1988; Sedwick and Knopf 1986; Martin 1993), distance of nest tree from foraging sites (van Balen et al. 1982; Nilsson 1984; 1986), nest tree species, nest tree height and nest tree diameter (Martin and Li 1992; Steeger and Dulisse 2002; Politi et al. 2009; 2010) can influence nest site selection by birds. At micro-habitat level, cavity height (Nilsson 1984; Li and Martin 1991), cavity depth (Belthoff and Ritchison 1990a), cavity entrance width (Politi et al. 2009, 2010; 2012), cavity orientation (Radford and Du Plessis 2003; Goodenough et al. 2010) and cavity shape (Martin et al. 2004; Zhu et al. 2012) are important attributes for enhancing breeding success of cavity-nesting bird species. Among non-habitat factors, life-history traits of nesting species (Collias 1964; Katzner et al. 2003), nest predation (Selas 1997), body size of a bird species, (Carlson et al. 1998), food availability, weather and disease (Li and Martin 1991; Selas 1997; Sanchez et al. 2007) can impact the breeding success of cavity-nesting species.

For secondary cavity nesting species such as passerines and small owls, acquiring suitable natural and excavated cavities is very crucial for ensuring safe breeding (Kostrezwa 1991; Mezquida 2004). Factors that influence cavity availability are rates of cavity creation, inter and intra-specific competition for nest sites, levels of nest depredation ((Holt and Martin 1997; Aitken et al 2002; Martin et al. 2004; Hutto and Gallo 2006; Cockle et al. 2011; Constantini 2016) and human-induced alterations such as timber logging, post fire salvage operations and tree cutting(Mannan et al. 1980; Brawn and Balda 1988; Du Plessis 1995; Martin and Eddie 1999; Saab et al. 2004; Cockle et al. 2015; Nyirenda et al. 2016). To avoid inter and intra-specific competition for cavities, the species may adopt different strategies, such as spatial and temporal separation by breeding at different locations and seasons (Koenig 2003), choose to narrow their niche by displaying tree preference, cavity dimension or orientation (van Balen et al. 1982; Korpimäki 1986; Li and Martin 1991, Gerhardt 2004), or extend their niche breadth to breed in less optimal habitats (Collwell and Fuentes 1975).

The Forest Owlet *Athene (Heteroglaux) blewitti* is a small sized (19 - 21 cm, 150 -170 g (Mehta et al, 2021) cavity-nesting owl endemic to India (Ali and Ripley 1987). Owing to its isolated and small population, it is listed in the endangered category by the IUCN (Birdlife International 2020) and included in Schedule I under the Indian Wildlife (Protection) Act, 1974, making it a high-priority species for conservation. Currently, there are twelve confirmed populations of the Forest Owlet, distributed in Maharashtra, Madhya Pradesh and Gujarat states of Central India (Mehta et al. 2017a). As a part of the long-term ecological project on the endangered Forest Owlet in Central India, we studied the nest and nest-site characteristics of the Forest Owlet in East Kalibhit Reserved Forest in the State of Madhya Pradesh in Central India (Mehta et al. 2017b). Along with the Forest Owlet, we also studied the nest-sites of sympatric Spotted Owlet *Athene brama* (17-19 cm, 110 -115 g) and the Jungle Owlet *Glaucidium radiatum* (18-20 cm, 88 -114 g) both widely distributed in the country (Ali and Ripley 1987; Konig and Weick 2009), to understand the underlying patterns of co-existence.

Nest-site characteristics of four Forest Owlet pairs has been studied in the Reserved Forests of Toranmal in northern Maharashtra (Ishtiaq and Rahmani 2005; Jathar and Rahmani 2011). The study reported maximum nests to be located close to the road and stream with majority of the nests found on *Soymida febrifuga* (Indian Red-wood) in natural cavities (Ishtiaq and Rahmani 2005; Jathar and Rahmani 2011). Substantial work has been carried out on the nest and nest-site characteristics of Spotted Owlet from various parts of India (Kumar 1985; Pandey et al. 2007; Santhanakrishnan et al. 2011; Vanitha et al. 2014; Ali and Santhanakrishnan 2015; Gaba and Vashistha 2018). There is no published information on the nest-site characteristics of the Jungle Owlet.

In this paper, we describe (a) species-specific nest-site characteristics of the Forest Owlet, Spotted Owlet and the Jungle Owlet and (b) species-specific nest-cavity selection by the three owlets. The information obtained from this study can be used to formulate forest management guidelines for retaining cavity trees used by these three owl species in human-dominated landscapes, with special reference to the endangered Forest Owlet.

Study Area

The East Kalibhit Reserved Forests (21.8887 N, 76.9673 E) are located in Khandwa district of Madhya Pradesh in Central India (Fig. 1). . The topography in East Kalibhit area is gently sloping with elevation ranging from 300 to 700 masl. During hot dry summers from March to June, the temperature soared above 45° C while during the winters in October to February, the temperatures dropped to 5° C. The area received rains during June to the mid-September and the average annual precipitation was 820 mm. The forests are dominated by teak (*Tectona grandis*) and had associated species such as *Anogeissus latifolia*, *Bridelia retusa, Madhuca latifolia*, *Terminalia alata*, *T. arjuna*, *Boswellia serrata*, and *Diospyros melanoxylon*, interspersed with clumps of bamboo *Dendrocalamus strictus* (Shukla 2013). The East Kalibhit Reserved Forests are being managed under Selection cum improvement system of timber logging by the State Forest Department. As per the provision of the Selection felling, every twenty years, selected areas having mature teak and miscellaneous tree species with 120 cm girth are logged along with trees having large cavities and standing dead. We chose an intensive study area of 100 km^2 which had a mix of recently logged (logged in last two to five years) and old-logged (logged ten or more years ago) areas (Fig. 1). The study area comprised largely of forest interspersed with agricultural lands. Within the study area, there are three villages, local communities mostly practiced sustenance cultivation of wheat, soybean, grams, and pulses. Often, large cavity-bearing trees are felled and girdled by the villagers for firewood and for commercial sale.

Field Methods

The study was carried out from January 2013 to April 2017. We carried out the survey of owls year-round to determine the breeding season for each species. During their respective breeding seasons, active nests were located by monitoring the breeding pairs and observing signs of white-wash and regurgitated pellets below probable tree cavities. Active nests were confirmed by listening to begging calls by the chicks, and deploying camera-traps near the cavity to confirm the use of cavity by the owl species. Endoscope camera was used in the initial stage to confirm incubation by the female. Camera-trap footage provided vital information on prey deliveries by male and emergence of juvenile from the nests. Once the fledglings were out of the nests, nest site parameters and nest cavity dimension were measured.

Nest-site Characteristics

We measured seventeen variables at each nest site (Table 1). The vegetation around each nest was measured in a 20 m x 20 m (0.04 ha) plot centered around the nest tree and in four plots located 150 m away from the nest tree in four cardinal directions (James and Shugart 1970; Belthoff and Ritchison 1990a). Inside each plot, we recorded species, girth, and height of all trees greater than 10 cm in diameter. The shrub cover was measured using the line intercept method in which we used two perpendicular ropes from north to south and east to west and counted all woody stems touching the transect (James and Shugart 1970). A sum of the count was presented as shrub cover. Canopy cover was measured using a 96-point densitometer in all four corners of the plot. We recorded the altitude of nest tree using the hand-held GPS, and the distance of nest trees from the nearest village, water source, road and farm or crop field (Titus and Mosher 1981).

Nest-tree and nest-cavity Characteristics

We recorded nest tree species and measured the nest tree girth using a meter tape and the nest tree height using a laser range finder. We measured the tree girth at nest cavity, cavity entrance height and width, depth of the cavity and orientation of the cavity in degrees using the methods described in literature (Belthoff and Ritchison 1990a;1990b; Politi et al. 2009). We also recorded the presence of branches (access branch) near the cavity opening which may serve to conceal the nest and/or as a perch while entering or exiting the nest.

Data Analysis

We tested for the normality of seventeen independent variables (Table 1) using Kolmogorov–Smirnov one-sample tests and found the distribution not to be normal. We used log-transformations to normalize the variables, Univariate ANOVA's were conducted for nest site and nest variables for the three-owl species. One-way ANOVA was used to test for the differences among three owl species in nest-site, nest- tree and nest -cavity characteristics. To determine which species showed the difference, we performed multiple pairwise comparison using Gabriel's post-hoc test (SPSS ver 3.0, Zar 1996). To assess orientation of the nest cavity, we calculated the mean as well as angular distribution. We then tested for significance of the calculated mean using Rayleigh's Z test (Batschelet 1981; Zar 1996). We used Jacob's selectivity index (Jacob 1974) to examine nest tree preference by owls. This index is used by ecologists to understand habitat selection among animals (Bolboaca et al. 2013; Gavrilov et al. 2015).

The selectivity index calculates selectivity for the i^th^ tree species for j^th^ owl species by the formula $S_{ij} = \frac{r_{ij} - p_i}{r_{ij} + p_i - 2 r_{ii}\, p_i}$ (Jacobs, 1974). The fraction of the i^th^ nest tree species (r_{ij}) was calculated by dividing the nest trees of the i^th^ tree species of that owl by total number of nest trees found in the habitat plot of the owl species. Similarly, the fraction of the i^th^ tree species available in the forest (p_i) was determined from tree enumeration data collected from vegetation quadrats by dividing the number of trees of that species by total number of trees. The selectivity for the i^th^ tree species (S_{ij}) was calculated for each tree species for each owl species. The selectivity of each tree species combined for all owls, S_i was also calculated, where r_i was calculated by adding the nest trees of the i^th^ tree species of all the three owl species divided by total number of nest trees. The value of the selectivity index ranges from -1 to 1. A positive value of selectivity indicates highest preference while a negative value of -1 indicating highest level of avoidance (Jacob 1974). Pearson's correlation matrix was used to detect collinearity among seventeen variables. We selected one of the variables from the pair that showed high correlation ($r > 0.6$) and performed Principal Component Analysis (PCA) with varimax rotation to ordinate variables for three owl species. Further reduction in dimensionality of the same variables used in the PCA was achieved by using the step-wise discriminant function analysis (DFA, Cooley and Lohnes 1971) to determine which variables contributed most to the differences between owls for selection of nest sites (Pielou 1984). All tests were carried out using SPSS (version 3.0) and the significant differences were set at 0.05 (Zar 1996).

Results

Description of nest and nest-site characteristics

In our study area, the breeding season of the Forest Owlet was from October to March, while that of the Spotted Owlet was from February to May and the Jungle Owlet breeding season was between March to June . If any of the owl species attempted a second clutch, then the breeding season would extend by two months for the owl species respectively (Prachi Mehta, pers. observation). We located thirty-seven owl nests of which 16 nests were of the Forest Owlets, 10 nests were of the Spotted Owlets and 11 nests were of the Jungle Owlets. Mean altitude of nest site was 447 masl and no nest was located below 380 m or above 580 masl. The nests were located in forests having a mean canopy height of 10.59 m (SD ±4.84, range 4.49-29.25) and mean tree girth of 126.07 cm (±117.28, 25.59-496). Mean altitude, mean canopy height and mean tree girth was not significantly different among the nest sites of three owlets (Table 2).

Sixty-three percent of the Forest Owlet nests were located on forest edge while the remaining nests were located inside the forest. Ninety-three percent nests of the Spotted Owlets were in areas logged five years ago and only one nest was located in the old logged forest. All the Spotted Owlet nests were located on the edge or inside the crop fields. All the Jungle Owlet nests were located in old logged forests. Of these, 63 % of the nests were located inside the forests (near the stream) and remaining were on the edge of the forests (Fig.1.) The nests of Spotted Owlets were located closest to the village (One-way ANOVA, F= 7.73, P < 0.05)) and crop fields (F= 2.20, P < 0.05) compared to the nests of the Forest Owlets and Jungle Owlets (Table 2).

Species-specific nesting tress, nest-sites and nests

We recorded twenty-six species of trees in the plots. Although teak was the dominant tree species (59%) in all the nest-site plots, only 22 % nests of the owls were located on teak trees. Nests of Forest Owlet were found mainly on *Bridelia retusa* (43.75%) and teak (31.25%), Spotted Owlet nests were on *Butea monosperma* (40 %) and *Madhuca latifolia* (30 %) while the Jungle Owlet nests were found on *Bridelia retusa* (36.36 %), *Terminalia arjuna* (27.27%) and teak (18.18 %). All the nests of the Forest and Jungle Owlets were in excavated cavities while the nests of the Spotted Owlet were in decayed cavities (60 %) and broken tree tops (40 %).

All nest cavities were located on the main branch of the nest tree. The presence of access branch was observed in 93 % of the nests of Forest Owlet.

The Jungle Owlet nests were located on taller trees compared to the other two owls (Table 2). The nests of Spotted Owlet were lowest in height from the ground compared to the Forest Owlet and the Spotted Owlet. The entrance of Spotted Owlet nests was wider and longer compared to the nest entrance of both the other owls. The direction of nest cavity orientation was not specific for any of the owls and the cavity orientation was not found to be significantly different between the owls (Table 3).

Based on the results of Pearson's correlation matrix (Table 4), from the seventeen variables, we considered 11 variables for the PCA using varimax rotation (Table 5). Four components explained 76.36 % of variance. PC1 explained 26 % variance and accounted for nest girth, nest entrance height, and nest entrance width, PC 2 explained 24 % variance which was correlated with nest tree height and nest height, PC 3 accounted for 13 % variance and explained the width of the nest cavity, while PC 4 accounted for 9 % variability and was correlated negatively with cavity depth.

We performed a stepwise DFA on the nest sites of three owlets. The first discriminate function explained 86.0% of the variance (eigenvalue 2.81, canonical correlation 0.86) and the second function 14.0% (eigenvalue 0.46, canonical correlation 0.56, Table 6). The first discriminant function was related to cavity depth, entrance height and entrance width while function 2 was related to nest tree height and nest height (Fig. 2). Along discriminant function I, there was considerable overlap between the nests of Forest Owlet and Jungle Owlet while the Spotted Owlet nests showed no overlap with nests of the other two owls. For function II, the overlap was observed between the Forest and Spotted Owlet nests while the Jungle Owlet nests partially overlapped with the other two species. On multivariate analysis, the nests of three owl species were separated by differences in cavity entrance height, cavity entrance width, nest tree height and nest height. DFA selected cavity dimension and nest tree height as most important variables in differentiating the nests between the owl species (Fig. 2; Table 6). To measure the power of the discriminating variables in achieving group separation, the number of correct classifications of the individual cases was determined. The overall correct classification of species was 81.2 %. The selectivity analysis revealed that the Forest Owlet and Jungle Owlet display selection for *Bridelia retusa* while Spotted Owlet appears to display high selection for *Butea monosperma*. *Terminalia elliptica* had a slightly lower selectivity while selectivity for teak was found to be lowest indicating that owl species select cavities in trees other than teak in the study area (Table 7).

Discussion

Nest-site selection by the three owl species

We could detect totally 37 nests of all the three owlets in the study area. Though it could be considered a small dataset, it compares well the results from other studies. In East Kalibhit Forests, maximum nests of the Forest Owlet were located in the forests while one nest was by the road side and another was by the stream. Our study reports mean values for the Forest Owlet nest tree height (12.96 m), nest tree girth (157.93 cm) and nest height (7.57 m) which are comparable with those reported from the Toranmal study. However, the mean values for the cavity entrance height (8.56 cm), cavity entrance width (7.45 cm) and cavity depth (31.75 cm) from our study is lower than those reported from Toranmal study. This difference can be explained on the basis that Forest Owlet nests in East Kalibhit Forests were in excavated cavities while in Toranmal Forests, the nests were in naturally decayed cavities having large cavity dimensions. Comparing the results from East Kalibhit and Toranmal, it appears that the Forest Owlet selects nest trees having medium height and girth and the cavities located at mid-height of the nesting trees. Previous studies on nest sites of the Spotted Owlets have been carried out in human dominated landscapes (Kumar 1985; Pande et al. 2007; Santhanakrishnan et al. 2011; Ali and Santhanakrishnan 2015). These studies reported Spotted Owlet nests located on *Palmyra* palms, *Ficus religiosa, F. bengalensis*, *Mangifera indica* and *Tamarindus indica* which are large evergreen trees found around human habitations and cultivations. In East Kalibhit, the Spotted Owlet nests were mainly found on excavated cavities in *Butea monosperma* and *Madhuca longifolia*, both deciduous species. Previous studies on Spotted Owlet nests have reported the average nest tree height between 8 to 13 m and nest height between 7 to 9 m. In our study area, the average height for Spotted Owlet nest trees was at 10 m while the nest height was lower at 3. 95 m. Also, we report average values of entrance height, entrance width and cavity depth to be 22, 18 and 54 cm respectively, which is lower than the values (34, 24 and 82 cm) reported by previous studies (Kumar 1985; Santhanakrishnan et al. 2011; Ali and Santhanakrishnan 2015). In East Kalibhit, the Jungle Owlet nests were located on tall trees (17.81 m) with higher girth (233.90 cm) and the nest were located higher up (8.48 m) in the trees. The Jungle Owlet nests were located in dense forests close to the riverine area which had tall and mature trees. Since there is no published information on Jungle Owlet nest site, our results cannot be compared with findings from other studies.

Till date, no attempt has been made to compare the nest-site and nest characteristics of the Forest Owlet with similar sized cavity-nesting owls from areas of their sympatry in Central India. In our study area, the nest-site characteristics among the three owlets did not show significant difference except the Spotted Owlet nests were located closest to the villages compared to the nests of other two owls. Nests of all three owl species were close (50m – 1.5km) to crop fields. In the study area, the crop fields had standing crops from October to April. There is a good abundance of rodents and shrews in the crop fields during the cropping season (Agarwal 2000). Our study on comparative diets of the Forest, Spotted and Jungle Owlet in East Kalibhit Forest has reported that all the three owl species prey upon rodents, shrews and insects (Mehta et al. 2018). Having nest sites in close proximity to foraging grounds is safer for breeding birds which can explain the selection of nest sites close to crop fields by the study species.

Differences in nest tree and nest cavity selection by three owls

The East Kalibhit forests are primarily teak dominant forests but majority of the Forest Owlet nests were found on *Bridelia retusa* trees. Since teak is removed during timber logging operation, cavities made in other tree species were selected by the owl species for nesting. The wide nest dimensions of the Spotted Owlet and narrow nest dimensions of Forest and Jungle Owlets may be explained by the number of individuals that roost in the cavity. Some owl species such as the Eastern Screech Owl *Otus Asio* (Belthoff and Ritchison 1990b), Great Horned Owls *Bubo virginanus* (Robinson and Davis 2014), Barn Owl *Tyto alba*, Indian Scops Owl *Otus sunia* and the Spotted Owlet have post-fledgling juveniles who stay with parents prior to dispersing (Ali and Ripley 1987). To accommodate more individuals in the same cavity, the nest needs to be wider and deeper. In the study area, we have observed up to six individuals of Spotted Owlets using the same nest cavity while presence of more than two individuals was not observed in the nests of Forest and Jungle Owlet (Prachi Mehta, personal observation). The dimensions of the nest- cavity also determines the internal microclimate and protection level of the eggs and hatchlings from predators (Belthoff and Ritchson 1990a). Narrow cavity entrance provide safety against cold wind which may be helping the Forest Owlet breeding during colder months of October to February when the temperature dips to 5° C. The Spotted Owlet starts nesting from March onwards when the temperature ranges from 40° C at midday to 18° C at night. Inhabiting deeper cavities may be offering better protection from large temperature fluctuations outside (Kumar 1985). The Jungle Owlet begins its breeding season towards the end of the summer which continues to the beginning of the monsoon. During this time temperature are high but the bird prefers cavities higher up on trees where the ambient temperature potentially might not affect the internal microclimate of the nests drastically. The Forest Owlet nests had a presence of a branch above, below or adjacent to the cavity. We observed that the bird would perch on the branch for a briefly before entering or after exiting the nest. Due to the smaller cavity entrance dimensions, the Forest Owlet may be using this branch to easily access the cavity.. Presence of this branch was not observed in the Jungle Owlet and Spotted Owlet nests. We did not see any indication that suitability of a nest was based on the orientation of the cavity opening. The nests were almost equally distributed around the 360°.

During our study, we could study the impact of timber logging at Jirpa site. Prior to logging, we had observed a pair of Forest Owlet using the area. When timber logging started in Jirpa, the pair was not seen in the area. After 2 years, we saw one Forest Owlet visiting the area briefly. During our study period, no other area was logged therefore we do not have further information on logging and its impact on the Forest Owlet. However, logging operations is likely to cause adverse impact on the Forest Owlet as the timber logging activity coincides with the breeding season of the species. Presence of Forest Owlet nests in old logged sites indicates that the Forest Owlet will return to logged sites after a few years. Jungle Owlet nests were also located in old logged sites but the Spotted Owlet nests were found in recently logged sites. Since the Spotted Owlet has adapted to live in urban and rural areas, they may be more tolerant of human presence than the Forest Owlet and the Jungle Owlet.

Temporally the breeding seasons of three owls is varied and inherently this reduces competition for nest sites among the three owls. Even though they have different breeding seasons, we did not observe Forest Owlet nest being occupied by Jungle Owlet or Spotted Owlet or vice versa. Our study reports that the Forest Owlet, Spotted Owlet and the Jungle

Owlet are able to nest in the same area due to their non-overlapping breeding season and specific nesting requirement.

Conservation Implications

Previous ecological studies on the Forest Owlet have reported uncontrolled illegal tree cutting and timber logging as one of the causes for its small and declining population (Ishtiaq and Rahmani 2005; Jathar and Rahmani 2012; Mehta et al. 2008; 2015; 2017; Kulkarni and Mehta 2020). Though there is a lot of discussion about conservation of wildlife in Reserved Forests, it is difficult to implement it in absence of specific management guidelines that are backed by scientific studies. For a developing country like India, forest is a major renewable resource which provides timber for commercial and domestic use. However, removal of mature and cavity bearing trees during timber logging is known to impact breeding bird densities in the area (Johns 1992; 1996; Mehta 2000). We observed that Forest, Spotted and Jungle Owlets reuse their nests in subsequent years. Therefore, it is of vital importance to protect the existing cavities which are used by the three owl species. Timber logging operations coincide with the breeding season of the all three owl species. Considering the endangered status of the Forest Owlet, areas having the nests of Forest Owlet should be exempted from timber logging. In East Kalibhit Reserved Forests, cavity-bearing trees of *Tectona grandis, Bridelia retusa, Terminalia elliptica, T. tomentosa, Madhuca latifolia, Butea monosperma, Albizzia lebbeck and Soymida febrifuga* are selected by the owls for nesting. These species should be protected from timber logging and tree cutting. Apart from the nest tree, we have also identified regular roost trees of the Forest Owlet in a radius of 20 m around the nest tree. During our study, we organised field visits and workshops for senior forest officers and field staff to demonstrate the importance of cavity bearing trees as well as roost trees in the Forest Owlet habitat. In response to this exercise, the State Forest Department issued guidelines to protect existing nest trees as well as the roost trees of the Forest Owlet in the study area. This was done by painting all the identified trees with a green band so that these trees can be exempted from timber logging. Since these are Reserved Forests, it is not possible to completely stop timber harvesting. We recommend that prior to timber logging, it is essential to carry out a survey to identify nest, roost and refuge cavities of the Forest Owlet and other owls so that such trees can be protected. This will also help in preventing illegal tree cutting. We involved local communities in nest protection program by offering incentives for protecting cavity-bearing trees. Backed by scientific data on nesting requirements, and with the support of the Forest Department and local communities, it should be possible to implement an economically and ecologically viable model of owl conservation, even in the Reserved Forests.

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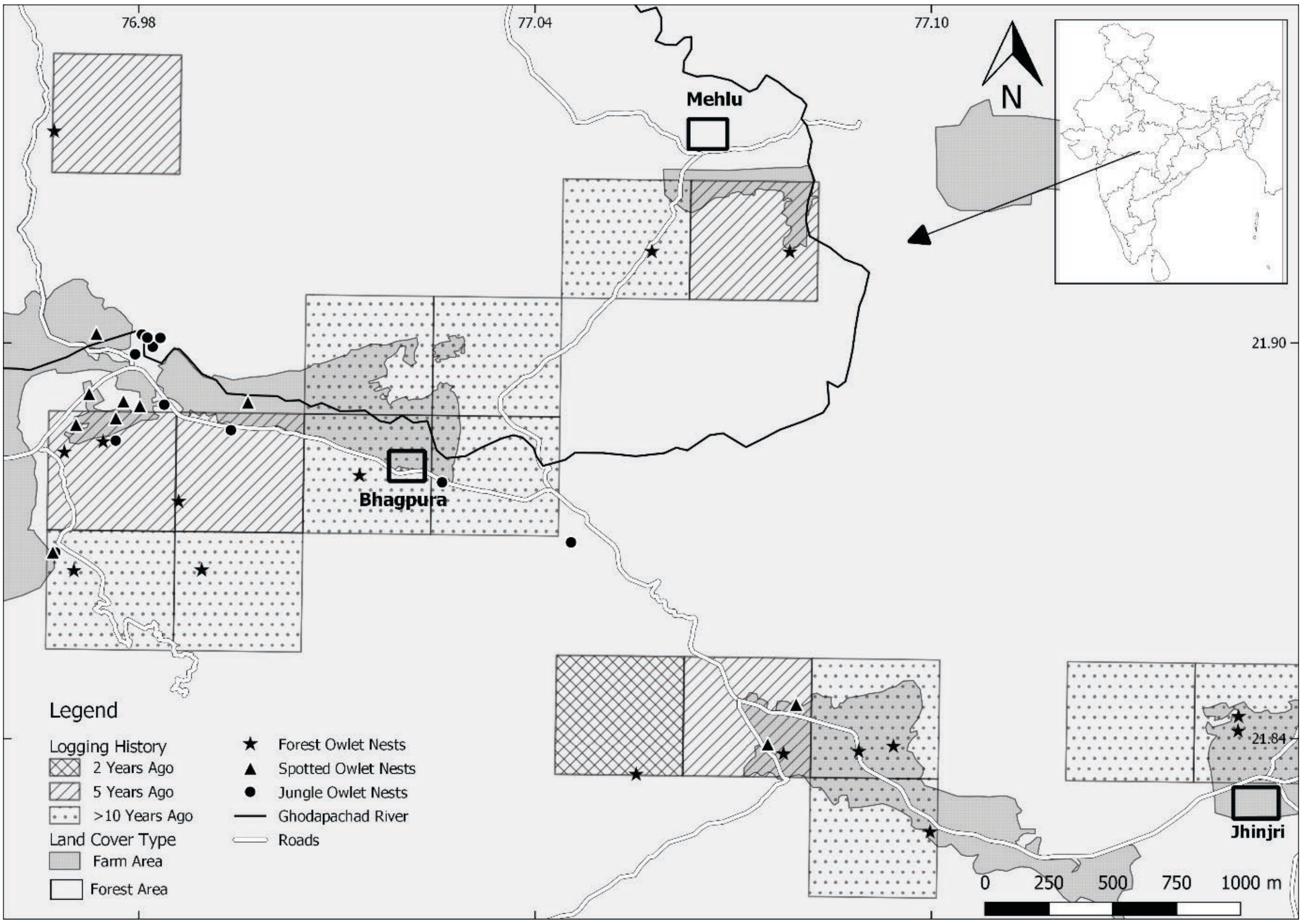

Fig. 1. Location of nests of the Forest Owlet, Spotted Owlet and Jungle Owlet in East Kalibhit Forests in Madhya Pradesh, Central India.

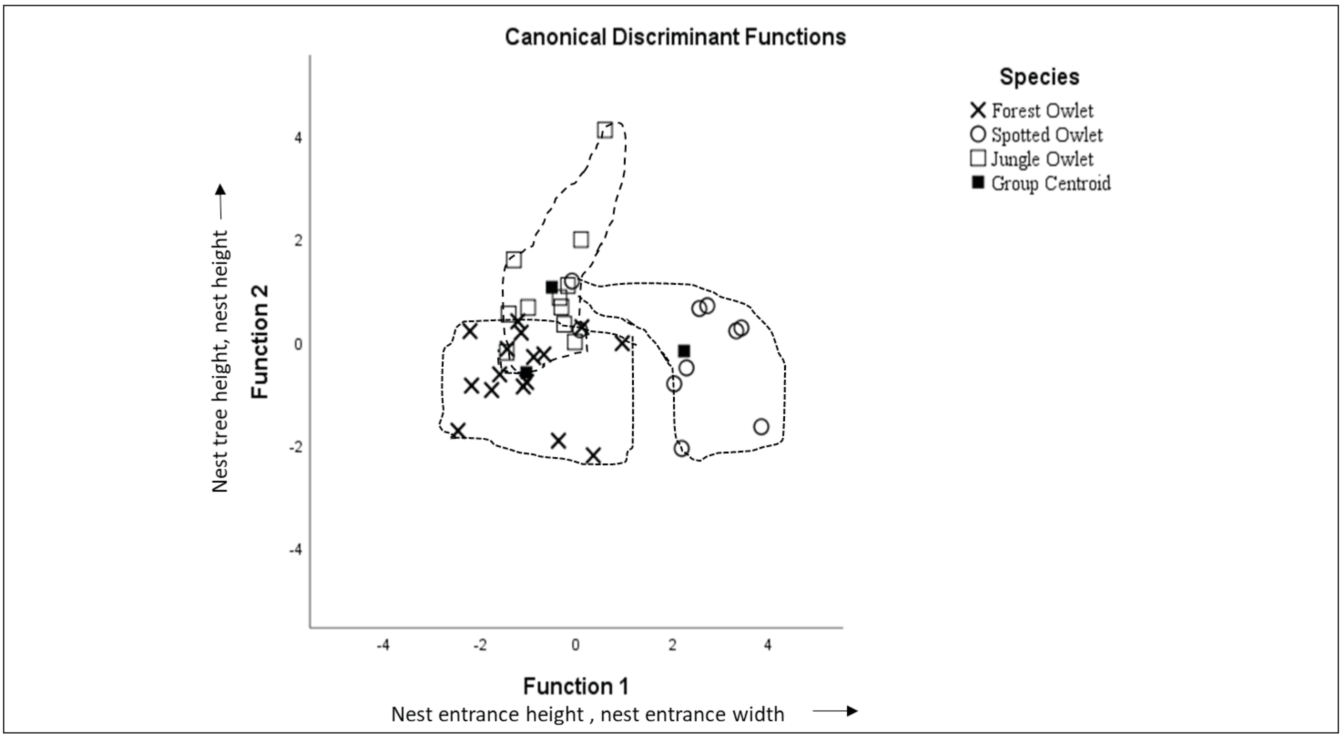

Fig. 2 Two-dimensional plot of discriminant scores indicating the nest distributions among three species of owls in East Kalibhit Forests in Madhya Pradesh, Central India.

Table 1. Description of quantitative nest site characteristics measured for nest sites of three sympatric owls in East Kalibhit Forest in Madhya Pradesh, Central India in 2017.

Sr. no	Mnemonic	Description	Method of Measurement
1	Alt	Altitude of the Nest Tree	Hand-held GPS
2	NTHT	Nest Tree Height	Height of the nest tree measured with a laser range-finder (m)
3	NTGH	Nest Tree Girth	Girth of the nest tree measured with a meter tape (cm)
4	NHT	Nest Height	Height of the nest cavity measured with a laser range-finder (m)
5	NGH	Nest Girth	Girth of the tree at the cavity measured with a tape (cm)
6	CEHT	Cavity Entrance Height	Height of the cavity entrance measured with a scale (cm)
7	CEWH	Cavity Entrance Width	Width of the cavity entrance (cm)
8	CDH	Cavity Depth	Depth of the nest cavity (cm)
9	CWH	Cavity Width	Width of the cavity from entrance to the back wall (cm)
10	APTHT	Average Plot Tree Height	Average height of trees measures in 20x 20 m plot
11	APTGH	Average Plot Tree Girth	Average girth of trees measures in 20x 20 m plot
12	APSC	Average Plot Shrub Cover	Average shrub cover measured in 20 x 20 m plot
13	APCC	Average Plot Canopy Cover	Average canopy cover measured in 20 x 20 m plot
14	DVG	Distance from Village	Distance of the nest tree from the nearest village (m)
15	DWR	Distance from Water	Distance of the nest tree from the nearest water source (m)
16	DRD	Distance from Road	Distance of the nest tree from the nearest road (m)
17	DCF	Distance from Crop Field	Distance of the nest tree from the nearest crop field (m)

Table 2: Sample means, (±) standard deviations, and One-way Analysis of Variance (ANOVA), F values testing for significant differences in nest site and nest variables among three sympatric owl species in East Kalibhit Forests in Madhya Pradesh, Central India in 2017

Variables	Forest Owlet	Spotted Owlet	Jungle Owlet	F value Among Three Owls	Forest owlet Vs. Spotted owlet	Spotted owlet Vs. Jungle owlet	Forest owlet Vs. Jungle owlet
	n=16	n=10	n=11				
Alt	431.40 ±31.06	410.11±41.30	403.50±70.12	1.40	2.03	0.07	2.67
NTHT	12.96 ± 2.96	10.20 ±3.73	17.81 ±6.11	10.15**	0.28	0.58**	0.38**
NTGH	157.93 ±97.78	200.5±81.88	223.90±114.96	2.10	0.27	0.05	0.33
NHT	7.57 ±2.73	3.95±2.59	8.48±3.67	10.36**	0.78**	0.89**	0.11
NGH	101.31 ±23.59	127.80 ±36.03	115±26.43	2.84	0.22	0.09	0.13
CEHT	8.56±2.50	22.10±13.48	10.09±3.08	16.10**	0.83**	0.67**	0.17s
CEWH	7.45±1.10	18.20±10.57	10.36±5.02	15.11**	0.76**	0.50**	0.27
CDH	31.75±7.54	54.70±30.22	41.45±10.75	1.60	0.33	0.06	0.27
CWH	41.66±65.67	28.30±16.58	28±7.74	0.05	0.07	0.08	0.01
APTHT	9.59±3.55	8.09±3.24	13.91±6.50	2.84	0.07	0.37	0.30
APTGH	82.88 ±111.45	140.25±99.33	175.99±126.31	4.72*	0.61	0.17	0.78*
APSC	8.81±5.66	8.09±5.13	8.62±7.79	0.10	0.05	0.11	0.17
APCC	42.59±30.89	38.07±29.00	67.74±22.44	2.20	0.11	1.14	1.03
DVG	1653.62±1936.39	1000±471.40	1254.54±873.05	7.73**	0.20	1.30**	1.50**
DWR	159±249.78	392.10±647.02	33.54±44.10	3.06	0.34	1.96	1.61
DRD	442.50±735.22	202.50±212.20	111.81±140.27	1.16	0.45	0.46	0.91
DCF	1170.93±2109.59	21(±20.78)	166.36±175.22	5.26*	2.50	2.20*	0.31

**.Significant at $P < 0.01$, * $P < 0.05$

	Reyleigh's *Z*	Critical *U*
Forest Owlet	1.21	2.92
Spotted Owlet	0.39	2.91
Jungle Owlet	0.61	2.92
	Mann-Whitney *U*	Critical *U*
Forest vs. Spotted Owlet	0.17	0.19
Spotted Vs. Jungle Owlet	0.08	0.18
Forest Vs. Jungle Owlet	0.04	0.18

Table 3. Rayleig's Z test and critical U values for testing for average nest-cavity orientation and Mann-Whitney U test for detecting differences in cavity orientation among three sympatric owls in East Kalibhit Forests in Madhya Pradesh, Central India in 2017.

Table 4. Pearson's correlation coefficient matrix between nest site and nest tree variables for three sympatric owl species in East Kalibhit Forests, Madhya Pradesh, Central India in 2017.

	NTHT	NTGH	NHT	NGH	CEHT	CEWH	CDH	CWH	APTHT	APTGH	APSC	APCC	DVG	DWR	DRD	DFM
NTHT	1	0.48**	0.56**	0.11	-0.09	-0.03	-0.33*	0.16	0.70**	0.45**	-0.04	0.08	-0.22	-0.28	-0.20	-0.13
NTGH		1	0.17	0.19	0.05	0.18	0.77**	0.84**	0.59**	0.58*	-0.43**	-0.08	-0.24	-0.17	-0.28	-0.26
NHT			1	-0.24	-0.31	-0.16	-0.27	-0.00	0.37*	0.88**	0.12	0.16	-0.01	-0.30	-0.10	0.04
NGH				1	0.55**	0.41*	0.02	0.16	0.31	0.27	-0.19	-0.00	-0.12	0.17	-0.15	-0.13
CEHT					1	0.50**	-0.15	-0.05	0.07	0.12	-0.09	-0.20	-0.17	0.08	-0.10	-0.19
CEWH						1	0.33*	-0.05	0.06	0.21	-0.08	0.16	-0.17	0.56**	-0.10	-0.17
CDH							1	-0.17	-0.19	0.00	-0.01	0.08	-0.10	0.40*	-0.07	-0.20
CWH								1	0.33*	0.57**	-0.28	-0.29	-0.14	-0.14	-0.08	-0.11
APTHT									1	0.77**	-0.42*	-0.17	-0.19	-0.28	-0.19	-0.08
APTGH										1	-0.48**	-0.17	-0.23	-0.17	-0.18	-0.21
APSC											1	0.34*	0.25	0.04	0.30	0.32
APCC												1	0.12	0.05	0.03	0.16
DVG													1	-0.07	0.70**	0.91**
DWR														1	0.00	-0.07
DRD															1	0.72**
DCF																1

Variables name as in Table 1. **.Significant at $P < 0.01$, * $P < 0.05$ (2-tailed)

Table 5: Summary statistics of the Principal Component Analysis for nest site and nest variables of three sympatric owl species in East Kalibhit Forests Madhya Pradesh, Central India in 2017.

		PC1		PC2		PC3		PC4	
Variables	Communalities	r	C	R	C	R	C	r	C
NTHT	0.90	0.36	-0.15	0.40	0.40	-0.18	-0.18	0.03	0.03
NTGH	0.67	0.33	0.06	0.23	0.23	0.20	0.21	-0.05	-0.04
NHT	0.80	-0.66*	-0.19	0.30	0.38	-0.12	-0.12	-0.11	-0.11
NGH	0.65	0.55	0.30	0.02	0.02	-0.12	-0.12	0.30	0.30
CEHT	0.76	0.83*	0.34	0.00	0.00	-0.02	-0.02	0.07	0.07
CEWD	0.80	0.80*	0.37	0.16	0.16	-0.18	-0.18	-0.23	-0.23
CDH	0.70	0.05	-0.02	-0.31	0.07	-0.66*	-0.06	0.40	-0.61
CWH	0.84	0.19	-0.18	0.54*	-0.11	0.56*	0.63	-0.63*	0.20
APTHT	0.60	0.54	0.04	0.75*	0.21	0.20	0.07	-0.05	0.21
DCF	0.80	-0.66*	-0.11	-0.04	-0.30	0.31	0.01	0.17	0.27
DVG	0.52	-0.27	-0.04	-0.52	0.07	0.24	-0.42	-0.32	0.24
Eigenvalue		2.87		2.76		1.43		1.01	
Percentage of Variance Explained		23.62		21.58		15.01		12.87	

r - Pearson's correlation coefficient; C - factor score coefficient; *Correlation significant at $P \leq 0.05$.

Table 6. Summary of stepwise discriminant function analysis on three owl species nest variables in East Kalibhit Forests, Madhya Pradesh, Central India in 2017.

	Discriminant Functions	
	I	II
Eigenvalues	2.81	0.46
Percentage of variance	86	14
Canonical Correlation	0.86	0.56
Chi Square	56.63	12.46
Significance	P < 0.001	P < 0.05
Degrees of Freedom	6	2
Standardized Discriminant Function Coefficient		
Entrance height	0.49	-0.08
Entrance width	0.29	0.29
Nest tree height	-0.25	0.84
Nest height	-0.22	0.7
Cavity depth	0.32	0.22

Table 7. Nest-tree selectivity (S) by three sympatric owls in East Kalibhit Forests Madhya Pradesh, Central India in 2017.

Tree species	Number of nest trees				Fraction of nest tree species, r				Fraction of tree species in the forest	Selectivity (S)			
	Forest Owlet	Spotted Owlet	Jungle Owlet	All	Forest Owlet	Spotted Owlet	Jungle Owlet	All	*P*	Forest Owlet	Spotted Owlet	Jungle Owlet	All
Albizzia lebbeck	1	0	1	2	0.06	0.00	0.09	0.054	0.00	0.84	-1	0.89	0.82
Butea monosperma	0	4	0	4	0.00	0.40	0.00	0.10	0.02	-1	0.93	-1	0.66
Bridelia retusa	7	1	4	12	0.44	0.10	0.36	0.32	0.00	0.98	0.93	0.98	0.98
Madhuca latifolia	0	2	0	2	0.00	0.20	0.00	0.05	0.01	-1	0.90	-1	0.63
Soymida febrifuga	1	0	0	1	0.06	0.00	0.00	0.02	0.00	0.97	-1	-1	0.94
Terminalia arjuna	1	1	3	5	0.06	0.10	0.27	0.13	0.00	0.87	0.92	0.97	0.94
Terminalia elliptica	1	1	1	3	0.06	0.10	0.09	0.08	0.04	0.19	0.42	0.37	0.32
Tectona grandis	5	1	2	8	0.31	0.10	0.18	0.21	0.58	-0.50	-0.84	-0.71	-0.66

Author Contributions

Prachi Mehta: Original Idea, Design of the Study, Data Analysis and Manuscript Preparation

Akshay Vinod Anand: Field data Collection and Manuscript Preparation

Jayant Kulkarni: Original Idea, Design of the Study, Data Analysis

Megha Rao: Field Data Collection

Literature Cited

- Aitken, K. E. H., Wiebe, K. L. and Martin, K. (2002). Nest-site reuse patterns for a cavity-nesting bird community in interior British Columbia. *The Auk 119*(2): 391–402. doi:10.1093/auk/119.2.391
- Ali, A. H. M. S. and Santhanakrishnan, R. (2015). Nest trees, habitat and breeding biology of the Spotted owlet *Athene brama Brama* (Temminck, 1821) in human habitation and agricultural landscape of India. *Zoology and Ecology* 25(3): 211–219. doi:10.1080/21658005.2015.1061248
- Ali, S. and Ripley, S. D. (1987). *Compact handbook of the birds of India and Pakistan*. Oxford University Press, London, UK.
- Batschelet, E. (1981). *Circular statistics in biology*. Academic Press, London.
- Belthoff, J. R. and Ritchison, G. (1990a). Nest-site selection by Eastern Screech-Owls in central Kentucky. *Condor* 92(4): 982–990. doi:10.2307/1368734
- Belthoff, J. R. and Ritchison, G. (1990b). Roosting behaviour of post fledging Eastern Screech-Owls. *The Auk* 107, 567–579.
- Birdlife International. (2020). Species factsheet: *Heteroglaux blewitti*. http://www.birdlife.org.
- Bolboaca, L., Baltag, F., Pocora, V. and Constantin, I. (2013). Habitat selectivity of

sympatric tawny owl (Strix aluco) and Ural owl (Strix uralensis) in hill forests from North-Eastern Romania. *Biologie animală* 14: 69–76.
- Brawn, J. D. and Balda, R. P. (1988). Population biology of cavity nesters in northern Arizona: Do nest sites limit breeding densities? *Condor* 90(1): 61–71. doi:10.2307/1368434
- Carlson, A., Sandström, U. and Olsson, O. (1998). Availability and use of natural tree holes by cavity nesting birds in a Swedish deciduous forest. *Ardea* 86: 109–119.
- Cockle, K. L., Bodrati, A., Lammertink, M., and Martin, K. (2015). Cavity characteristics, but not habitat, influence nest survival of cavity-nesting birds along a gradient of human impact in the subtropical Atlantic Forest. *Biological Conservation* 184: 193–200. doi:10.1016/j.biocon.2015.01.026
- Cockle, K. L., Martin, K. and Wesołowski, T. (2011). Woodpeckers, decay, and the future of cavity□nesting vertebrate communities worldwide. *Frontiers in Ecology and the Environment* 9(7): 377–382. doi:10.1890/110013
- Cody, M. (1985). An Introduction to habitat selection in birds. In M. L. Cody (Ed.), *Habitat selection in birds*. Academic Press, New York. pp. 4–46.
- Collias, N. E. (1964). The Evolution of nests and nest-building in birds. *American Zoologist* 4(2): 175–190. doi:10.1093/icb/4.2.175
- Colwell, R. K. and Fuentes, E. R. (1975). Experimental studies of the niche. *Annual Review of Ecology and Systematics* 6(1): 281–310. doi:10.1146/annurev.es.06.110175.001433
- Cooley, W. W. and Lohnes, P. R. (1971). *Multivariate data analysis*. John Wiley and Sons, New York.
- Costantini, D., Edwards, D. P. and Simons, M. J. P. (2016). Life after logging in tropical forests of Borneo: A meta-analysis. *Biological Conservation* 196: 182–188. doi:10.1016/j.biocon.2016.02.020
- Du Plessis, M. A. (1995). The effects of fuel wood removal on the diversity of some cavity-using birds and mammals in South Africa. *Biological Conservation* 74(2): 77–82. doi:10.1016/0006-3207(95)00016-W
- Erckmann, W. J., Beletsky, L. D., Orians, G. H., Johnsen, T., Sharbaugh, S. and D'Antonio, C. (1990). Old nests as cues for nest-site selection: An experimental test with red-winged blackbirds. *Condor* 92(1): 113–117. doi:10.2307/1368389
- Gaba, Y. and Vashishat, N. (2018). Roosting ecology of Spotted owlet (Athene brama) and barn owl (Tyto alba) in agroecosystem of Punjab. *Journal of Entomology and Zoological Study* 6: 829–833.
- Gavrilov, G., Zlatanova, D., Spasova, V., Valchev, K. D. and Dutsov, A. A. (2015). Home range and habitat use of brown bear in Bulgaria: The first data based on GPS-telemetry. *Acta Zoologica Bulgarica* 67: 493–499.
- Gerhardt, R. P. (2004). Cavity nesting in raptors of Tikal National Park and vicinity, Petén, Guatemala. *Ornitologia Neotropical* 15: 477–483.
- Goodburn, J. M. and Lorimer, C. G. (1998). Cavity trees and coarse woody debris in old-growth and managed northern hardwood forests in Wisconsin and Michigan. *Canadian Journal of Forest Research* 28(3): 427–438. doi:10.1139/x98-014
- Goodenough, A. E., Maitland, D. P., Hart, A. G. and Elliot, S. L. (2008). Nest-box orientation: A species-specific influence on occupation and breeding success in woodland passerines. *Bird Study* 55(2): 222–232. doi:10.1080/00063650809461526
- von Haartman, L. V. (1957). Adaptations in hole-nesting birds. *Evolution* 11(3): 339–347. doi:10.1111/j.1558-5646.1957.tb02902.x
- Martin, K. (1997). Landscape modification and patch selection: The demography of two secondary cavity nesters colonizing clearcuts. *The Auk* 114(3): 443–455. doi:10.2307/4089245
- Hutto, R. L. and Gallo, S. M. (2006). The effects of postfire salvage logging on cavity-nesting birds. *Condor* 108(4): 817–831. doi:10.1093/condor/108.4.817
- Ishtiaq, F. and Rahmani, A. R. (2005). The Forest owlet *Heteroglaux blewitti*: Vocalization, breeding biology and conservation. *Ibis* 147(1): 197–205. doi:10.1111/j.1474-919x.2004.00389.x
- Jacobs, J. (1974). Quantitative measurement of food selection. A modification of the forage ratio

and Ivlev' selectivity index. *Oecologia* 14(4): 413–417. doi:10.1007/BF00384581
- James, F. C. and Shugart, H. H. (1970). A quantitative method of habitat description. *Audubon Field Notes* 24: 727–736.
- Jathar, G. A. and Rahmani, A. R. (2012). Habitat utilization by Forest owlet Heteroglaux blewitti in Toranmal Reserve Forest, India. *Journal Care4Nature* 1: 18–30.
- Johns, A. D. (1992). Vertebrate response to selective logging. Implications of designs of logging systems. *Philosophical Transactions of the Royal Society of London. Series B* 335(1275): 437–442. doi:10.1098/rstb.1992.0035
- Johns, A. G. (1996). Bird Population persistence in Sabahan logging concessions. *Biological Conservation* 75(1): 3–10. doi:10.1016/0006-3207(95)00044-5
- Katzner, T. E., Bragin, E. A., Knick, S. T. and Smith, A. T. (2003). Coexistence in a multispecies assemblage of eagles in Central Asia. *Condor* 105(3): 538–551. doi:10.1093/condor/105.3.538
- König, C. and Weick, F. (2009). *Owls of the world* (2nd ed). Christopher Helm Publishers/A and C Black Publisher Ltd, London, UK.
- Koenig, W. D. (2003). European Starlings and their effect on native cavity-nesting birds. *Conservation Biology* 17(4): 1134–1140. doi:10.1046/j.1523-1739.2003.02262.x
- Korpimäki, E. (1986). Niche relationships and life-history tactics of three sympatric Strix owl species in Finland. *Ornis Scandinavica* 17(2): 126–132. doi:10.2307/3676861
- Kostrzewa, A. (1991). Interspecific interference competition in three European raptor species. *Ethology Ecology and Evolution* 3(2) 127–143. doi:10.1080/08927014.1991.9525379
- Kulkarni, J. and Mehta, P. (2020). Habitat selectivity by the Forest owlet Athene (Heteroglaux) blewitti in Nandurbar District, Maharashtra, India. *Indian Birds* 16(2): 33–39.
- Kumar, T. S. (1985). *The life history of the Spotted owlet (Athene brama brama Temminck) in Andhra Pradesh*. Monograph of the Raptor Research Centre, Hyderabad.
- Li, P. and Martin, T. (1991). Nest-site selection and nesting success of cavity-nesting birds in high elevation forest drainages. *The Auk* 108: 405–418.
- Mannan, R. W., Meslow, E. C. and Wight, H. M. (1980). Use of snags by birds in Douglas-fir forests, western Oregon. *Journal of Wildlife Management* 44(4): 787–797. doi:10.2307/3808306
- Martin, K. and Eadie, J. M. (1999). Nest webs: A community-wide approach to the management and conservation of cavity-nesting forest birds. *Forest Ecology and Management* 115(2–3): 243–257. doi:10.1016/S0378-1127(98)00403-4
- Martin, K., Aitken, K. E. H. and Wiebe, K. L. (2004). Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: Nest characteristics and niche partitioning. *Condor* 106(1): 5–19. doi:10.1093/condor/106.1.5
- Martin, T. E. (1993). Nest predation and nest sites. *BioScience* 43(8): 523–532. doi:10.2307/1311947
- Martin, T. E. and Li, P. (1992). Life history Traits of Open- vs. Cavity-Nesting Birds. *Ecology* 73(2): 579–592. doi:10.2307/1940764
- Mehta, P. (2000). *The effect of forestry practices on bird species diversity in Satpura Hill ranges* [PhD Thesis]. Saurashtra: Wildlife Institute of India, Saurashtra University.
- Mehta, P., Kulkarni, J., Mukherjee, S., Chavan, S. and Anand, A. (2017a). A distribution survey of the Forest owlet Heteroglaux blewitti in north-western Maharashtra. *Indian Birds* 13: 103–108.
- Mehta, P., Anand, A, V. and Kulkarni, J. (2017b). A Study of Population, Demography and Ecology of the Forest Owlet Athene (Heteroglaux) blewitii in East Kalibhit Forests, Khandwa District, Madhya Pradesh. Final Technical Report. Wildlife Research and Conservation Society. doi: 10.13140/RG.2.2.36601.39521
- Mehta, P., Kulkarni, J., Talmale, S. and Chandarana, R. (2018). Diets of sympatric Forest Owlets, Spotted Owlets, and Jungle Owlets in East Kalibhit Forests, Madhya Pradesh, India. *Journal of Raptor Research* 52(3): 338–348. doi:10.3356/JRR-17-00002.1
- Mehta, P., Prasana, N., Nagar, A. K. and Kulkarni, J. (2015). Occurrence of Forest owlet *Heteroglaux blewitti* in Betul District, and the importance of its conservation in the Satpura

landscape. *Indian Birds* 10: 157–159.

- Mezquida, E. T. (2004). Nest site selection and nesting success of five species of passerines in South American open Prosopis woodland. *Journal of Ornithology* 145(1): 16–22. doi:10.1007/s10336-003-0002-9
- Newton, I. (1994). The role of nest sites in limiting the numbers of hole nesting birds: A review. *Biological Conservation* 70(3): 265–276. doi:10.1016/0006-3207(94)90172-4
- Nilsson, S. G. (1984). The evolution of nest-site selection among hole-nesting birds: The importance of nest predation and competition. *Ornis Scandinavica* 15(3): 167–175. doi:10.2307/3675958
- Nilsson, S. G. (1986). *Evolution of hole-nesting in birds: On balancing selection pressures*. *The Auk* 103(2): 432–435.
- Nyirenda, V. R., Chewe, F. C., Chisha-Kasumu, E. and Lindsey, P. A. (2016). Nest sites selection by sympatric cavity-nesting birds in miombo woodlands. *Koedoe* 58(1): 13–59. doi:10.4102/koedoe.v58i1.1359
- Pande, S., Pawashe, A., Mahajan, M. N., Joglekar, C. and Mahabal, A. (2007). Effect of food and habitat on breeding success in Spotted Owlets (*Athene brama*) nesting in villages and rural landscapes in India. *Journal of Raptor Research* 41(1): 26–34. doi:10.3356/0892-1016(2007)41[26:EOFAHO]2.0.CO;2
- Pielou, E. C. (1984). *The interpretation of ecological data: A primer on classification and ordination*. John Wiley and Sons, New York, USA.
- Poirazidis, K., Goutner, V., Tsachalidis, E. and Kati, V. (2007). Comparison of nest–site selection patterns of different sympatric raptor species as a tool for their conservation. *Animal Biodiversity and Conservation* 30: 131–145.
- Politi, N., Hunter, M. and Rivera, L. (2010). Availability of cavities for avian cavity nesters in selectively logged subtropical montane forests of the Andes. *Forest Ecology and Management* 260(5): 893–906. doi:10.1016/j.foreco.2010.06.009
- Politi, N., Hunter, M. and Rivera, L. (2012). Assessing the effects of selective logging on birds in Neotropical Piedmont and cloud montane forests. *Biodiversity and Conservation* 21(12): 3131–3155. doi:10.1007/s10531-012-0358-3
- Politi, N., Hunter, M. and Rivera, L. (2009). Nest selection by cavity-nesting birds in subtropical Montane Forests of the Andes: Implications for sustainable forest management. *Biotropica* 41(3): 354–360. doi:10.1111/j.1744-7429.2008.00481.x
- Radford, A. N. and Du Plessis, M. A. (2003). The importance of rainfall to a cavity-nesting species. *Ibis* 145(4): 692–694. doi:10.1046/j.1474-919X.2003.00198.x
- Raphael, M. G. and White, M. (1984). Use of snags by cavity-nesting birds in the Sierra Nevada. *Wildlife Monographs* 1–86.
- Robinson, B. and Davis, C. (2014). A communal roosting of the great horned owl (Bubo virginianus). *Journal of Raptor Research* 48(1): 88–89. doi:10.3356/JRR-13-47.1
- Saab, V. A., Dudley, J. and Thompson, W. L. (2004). Factors influencing occupancy of nest cavities in recently burned forests. *Condor* 106(1): 20–36. doi:10.1093/condor/106.1.20
- Sanchez, S., Cuervo, J. J. and Moreno, E. (2007). Suitable Cavities as a scarce resource for both cavity and non-cavity nesting birds in managed temperate forests. A case study in the Iberian Peninsula. *Ardeola* 54: 261–274.
- Santhanakrishnan, R., Ali, M. S. and Anbarasan, U. (2011). Breeding biology of the Spotted owlet (*Athene brama*) in Madurai district, Tamil Nadu, India. *International Journal of Environmental Sciences* 1: 1682–1691.
- Selas, V. I. D. A. R. (1997). Nest-site selection by four sympatric forest raptors in southern Norway. *Journal of Raptor Research* 31: 16–25.
- Sedgwick, J. A. and Knopf, F. L. (1986). Cavity-nesting birds and the cavity-tree resource in Plains cottonwood Bottomlands. *Journal of Wildlife Management* 50(2): 247–252. doi:10.2307/3801906
- Shukla, S. (2013). *Working plan of Khandwa division (2013–2023)*. India: Madhya Pradesh Forest Department.
- Stauffer, D. F. and Best, L. B. (1980). Nest-site selection by cavity-nesting birds of riparian habitats in Iowa. *Wilson Bulletin* 94: 329–337.

- Steeger, C. and Dulisse, J. (2002). *Characteristics and dynamics of cavity nest trees in Southern British Columbia* [Technical report]. USDA Forest Service.
- Swallow, S. K., Howard, R. A. and Gutierrez, R. (1988). *Snag preferences of woodpeckers*.
- Titus, K. and Mosher, J. A. (1981). Nest-site habitat selected by woodland hawks in the Central Appalachians. *The Auk* 98: 270–281.
- Van Balen, J. H., Booy, C. J. H., Van Franeker, J. A. and Osieck, E. R. (1982). Studies on hole-nesting birds in natural nest sites. *Ardea* 70: 1–24
- Vanitha, V., Kumar, C. and Thiyagesan, K. (2014). Roost and diet selection by southern Spotted owlet Athene brama brama (Temminck, 1821) in the Cauvery Delta of Nagapattinam District, Southern India. *Journal of Threatened Taxa* 6(6) 5845–5850. doi:10.11609/JoTT.o3805.5845-50
- Zar, J. H. (1996). *Biostatistical analysis* (3rd ed). Prentice Hall, Upper Saddle River, NJ.
- Zhu, X., Srivastava, D. S., Smith, J. N. M. and Martin, K. (2012). Habitat selection and reproductive success of lewis's woodpecker (*Melanerpes lewis*) at its northern limit. *PLOS ONE* 7(9): e44346. doi:10.1371/journal.pone.0044346

Owls and cemeteries: owls are not ghosts

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Background:

Owls, (family Strigidae) are fascinating birds, but are also one of the most misunderstood taxa all around the world. In our part of India, there are several superstitions around owls including: owls hear what ghosts speak, owls are witches, seeing or hearing an owl is an ill omen, owls catch stones thrown at them and as they rub them the person who has thrown the stone slowly dies. Owls are globally incorrectly associated with death and bad omen. In some areas of Maharashtra, India, the owl is known as '*Madhe Pakhru*' (in local Marathi language), literally meaning a 'corpse bird'.

Owls are seen as ill omen or messengers of it in some parts of Africa, Middle East and among some Native American tribes and they believe owls kidnap and predate on children. Owing to these superstitions, people may try to harm them.

To investigate the cause behind this uncomfortable association of owls with human death, we undertook a pilot survey of human cemeteries. The reason of choosing this unique study area is attributed to association of cemeteries and death.

Methods:

Our study area included cemeteries in two bio-geographic zones, Deccan Plateau, Pune District, Maharashtra and the Western Ghats, Haveli and Purandar Taluka, Maharashtra, India. The study period was August to mid November 2019. We visited 57 cemeteries. These belonged to three religious' communities, Hindu (n=48), Muslim (n=7) and Christian (n=2).

Each cemetery was visited three times at dawn and dusk. We documented the time since the cemetery was in use, the distance of the cemetery from human habitation, the distance of the cemetery from water source, the tree species and the girth at breast height of the trees in the locality of the cemetery, the status of maintenance of the cemetery and any undergrowth, and the presence or absence of owls in the cemetery and the owl species when present.

Results and Discussion:

Age of cemeteries: The cemeteries were in use for an average of 100 years (10 to 200+ years; sd±30 years).

Most of the cemeteries were traditional and undisturbed with no alterations. The cemeteries were briefly visited by humans only for performing the last rites on the dead. They were otherwise not frequented by humans. The average distance of the cemeteries from nearest human habitation was 435 m (0 to 2000 m; ± 474 m).

Distance from human habitation: Cemeteries being distant from human habitation and undisturbed, promoted wild undergrowth and quietness, with abundance of rodents. They appeared to be useful habitats for owls.

The possible reason behind this significantly high occurrence of 6 species of owls in cemeteries could be lack of human disturbance, presence of big trees. Although tree felling is quite common in the study area, trees in the cemeteries are usually protected and not fell.

Proximity to water source: Cemeteries were located near a source of water in 48 localities (84.2%). The various water sources near cemeteries were:

- pond (n=1)
- lake (n=1)
- well (n=1)
- irrigation canal (n=2)
- stream (n=18)
- stream and well (n=13)
- river (n=12)

Presence of a water body near cemeteries could increase local rodent populations and other biodiversity - a source of food for owls. Food offerings are often kept at the cemeteries during the performance of last rites and this attracts rodents and birds.

Trees in cemetery:

The average number of trees in cemeteries was 25 (2 to 110; ± 25). The average girth of trees at breast height (GBH) was 214 mm (60 to 550 mm; ± 115). This indicated that trees were old. Trees found in cemeteries included:

- Tamarind (Tamarindus indicus)
- Pipal (Ficus religiosa)
- Banyan (Ficus benghalensis)
- Karnja (Millettia pinnata)
- Raintree (Samanea saman)
- Neem (Azadirachta indica)

Trees are commonly planted in cemeteries for shade and serenity.

Maintenance:

Several old cemeteries are not regularly maintained. Vegetation, grass, shrubs, climbers were observed to grow in abundance and provided favourable habitat to reptiles, rodents, and birds, which in turn were food for owls. We found that such cemeteries attracted owls.

Presence of Owls in Cemetery:

Owls were seen in 53/57 (92.9%) cemeteries. The various owl species recorded were:

- Spotted Owlet *Athene brama* (n=144),
- Barn Owl *Tyto alba* (n=30),
- Indian Eagle Owl *Bubo bengalensis* (n-13),
- Mottled Wood Owl *Strix ocellata* (n= 8),
- Brown Wood Owl *Strix leptogrammica* (n=2) and
- Barred Jungle Owlet *Glaucidium radiatum* (n= 2).

Absence of Owls in Cemetery:

Owls were not seen in only 4 cemeteries (7% incidence of owl absence in cemeteries).

Conclusions

We found that owls were present in 93% of cemeteries in the study area. Based on our observations we conclude that owls inhabit cemeteries, because of the favourable conditions existing in cemeteries. We found that owls are correctly associated with cemeteries but were wrongly associated with death. It is obvious that whenever people visited cemeteries, they were likely to observe an owl either by site or vocalization. People visited cemeteries only when their kith or kin had died and owls inhabited cemeteries at all times because of the appropriate habitat that they offered. People wrongly associated owls with death since owls were present in the cemeteries at all times. We feel that educational programs should be undertaken at grass root levels, to remove superstitious beliefs about owls. A larger survey of cemeteries should be conducted in the near future. Without wider grass root level education about owls, wrong perceptions shall continue to trouble both humans and owls. Younger generation should be the target population for this education programs so that they can spread the education to the next generations.

Morbidity and Mortality in Owls in Western Maharashtra, India

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Abstract

We evaluated the causes of morbidity and mortality for three owl species in Purandar taluka, Pune district, Western Maharashtra, India. *Tyto alba* (n=8), *Bubo bengalensis* (n=3) and *Strix ocellata* (n=1) specimens were examined between October 2017 and August 2019. We measured morphometry, examined feathers, and conducted dissections for histopathological and subsequent ecotoxicology study.

The average biomass of *Tyto alba*, *Bubo bengalensis* and *Strix ocellata* specimens was 304 g, 865 g and 281 g respectively. Missing feathers included one secondary in two *Bubo bengalensis* and one *Tyto alba* specimens, eight secondaries in one *Tyto alba* specimen, and one primary in the *Strix ocellata* specimen. Molt was underway in the *Strix ocellata* (all feathers) and two *Tyto alba* specimens.

In the liver organ, extensive hepatic necrosis was seen in the *Strix ocellata* specimen, sinusoidal congestion in one *Tyto alba* specimen, and a foreign body giant cell reaction with granulomas and parasite in one *Tyto alba* specimen. The kidney of one *Bubo bengalensis* specimen showed acute tubular necrosis. Hemorrhages and congestion were noticed in the lungs of specimens of all three species. One parasite was observed in the lungs of one *Tyto alba* specimen. Hypoxic changes were seen in the brains of two *Tyto alba* specimens.

Organochlorine pesticide (OCPs) residues were found in liver tissues of all owl specimens. Extremely high concentrations (6.901 mg/kg) were detected in the *Strix ocellate (n=1)* specimen followed by an average of 0.042 mg/kg for *Bubo bengalensis* specimens and 0.024 mg/kg *for Tyto alba* specimens. The observed pattern of accumulation of organochlorine pesticides in owl specimens was, in declining order, DDT > Dieldrin > Lindane. Among various pesticides analyzed a form of Dichlorodiphenyldichloroethylene noted as p,p'-DDE contributed maximum towards the total OCPs.

Introduction

Although populations of all owl species have declined in India during the present century, there is no consensus on underlying causes. Changes in agriculture, notably the loss or degradation of rough grassland, which supports a diversity of rodents and shrews, have probably greatly reduced the food supply of many owl species. In some regions, the concurrent loss of old trees and farm buildings that provided nest sites for some owl species and mortality from vehicle collisions and pesticides further exacerbates the reduction of owl numbers below the level that remaining prey populations might otherwise support (Bunn et al. 1982; Shawyer 1987; de Bruijn 1994; Taylor 1994). In this paper, we evaluated the causes of morbidity and mortality for three owl species in Pune district, Western Maharashtra, India (Fig. 1). *Tyto alba* (n=8), *Bubo bengalensis* (n=3) and *Strix ocellata* (n=1) specimens were examined between October 2017 and August 2019 Table 1). We focus on organochlorine pesticides as a major cause of morbidity and mortality during our study.

Materials and Methods

People were requested to inform us when they found dead or injured owls. Owls were frozen (< -20 °C) if they could not be obtained promptly. Fresh or thawed owl specimens were examined externally and then dissected. Permission from the Maharashtra Forest Department was procured to carry out the study.

Owl specimen data collected

Owl specimen data obtained included species name, location, circumstances of death, gender and date of death (Table 1). Body mass, wing chord, stretched wing, wing width, wingspan, number of primaries, secondaries, and rectrices, alula length, tail length, spread claw length, middle toe, middle talon, tarsus length, gape (width), ear opening (width), eye diameter were obtained from external examinations (Fig. 2). Total intestine length and mass, and mass of heart, liver, gizzard and one kidney were then obtained by dissection (Fig. 3).

Histopathology

Dissected liver, heart, kidney, lungs and brain were preserved in a formaldehyde solution for histopathological study. Haematoxylin was the basic dye used to stain nuclei and Eosin was the acidic dye used to stain cell cytoplasm. The staining process (Suvarna et al. 2018) was carried out on tissue samples mounted on slides as follows:

Step 1: - Deparafinisation using a LG microwave set at medium-high for 7-10 min.

Step 2: - Clearing and Rehydration

STEP	SOLUTIONS	DURATION
Clearing	Xylene I	5 min.
	Xylene II	5 min.
	Xylene III	5 min.
Rehydration	Absolute alcohol	3 min.
	70% alcohol	3 min.

Slides were thoroughly washed with running tap water until clear.

Step 3: - Staining

NUCLEUS STAINNG	Haematoxylene	2-8 min.
Decolourisation	1% Acid alcohol	1 dip
Bluing	1% Ammonia water	3-4 dips
	Running tap water	3 min.
Cytoplasmic staining	Eosin	1-2 min.
Dehydration	70% alcohol	1 Dip
	Absolute alcohol	1 Dip
Clearing	Xylene I	1 Dip
	Xylene II	1 Dip

Pesticide residue analysis

Extraction: Liver tissues were dissected and frozen at -20 ^{0}C until processing. A whole laboratory sample was crushed in a mixture and grinder until the sample was homogenized. About 5 gm (±0.1 gm) of homogenized sample was transferred to a 50 ml centrifuge tube and 10 ml of Acetonitrile (1% Acetic acid) was added and vortexed. One g sodium chloride and four g $MgSO_4$ were added and mixed for 5 min. The solution was then centrifuged at 7,000 rpm for 5 min.

Clean-up procedure and Instrumental analysis by Gas Chromatography - Mass Spectrometry (GCMS): A two ml supernatant was taken from the centrifuged extract and placed in a test tube containing 150 mg $MgSO_4$ + 50 mg PSA + 50 mg C18 and was vortex for 30 s. The supernatant was then taken out and filtered through a 0.22µ membrane filter. This supernatant was injected into GCMS-MS and readings were taken.

Clean-up procedure and Instrumental analysis by Liquid Chromatography - Tandem Mass Spectrometry (LCMS-MS): A two ml supernatant from the centrifuged extract was placed in a test tube containing 150 mg $MgSO_4$ + 50 mg PSA + 50 mg C18 and was vortex for 30 s. One ml extract was taken and evaporated to dryness under N22 evaporator, then the volume was made up with 1 ml of reconstitution solvent (1:1, methanol + 20 ml ammonium formate solution in water). The solution was then sonicated for 1 min. and vortexed for 30 s before injecting into the LCMS-MS.

All samples were analyzed for Dieldrin, p,p'-DDD, p,p'-DDE, p,p'-DDT and Lindane. The column used for GCMS-MS was DB-5MS (Or Equivalent), Length-30mtr. I.D.-0.25 mm, Film thickness-25µm and for LCMS-MS was Agilent zorbax C-18, 100 mm L x 4.6 mm i.d. x 5 µm. The detection limit of the instrument was 0.005 mg/kg. Pesticide analysis was carried out according to AOAC Official Method 2007.01 (Lehotay et al. 2007).

Result and Discussion

The average biomass of *Tyto alba* (n = 8), *Bubo bengalensis* (n = 3) and *Strix ocellata* (n = 1) were 304.4 g, 865.3 g and 281.0 g, respectively. Examination of plumage revealed a missing secondary feather in two *Bubo bengalensis* specimens and eight secondaries in one *Tyto alba* specimen and a missing primary feather in the *Strix ocellata* specimen. Evidence of molt was seen in the *Strix ocellata* (all feathers) and in two *Tyto alba* specimens.

Extensive hepatic necrosis was seen in the liver of the *Strix ocellata* specimen, sinusoidal congestion in one *Tyto alba* specimen, and a foreign body giant cell reaction with granulomas and parasite in one *Tyto alba* specimen (Fig. 6). The kidney of one *Bubo bengalensis* specimen showed acute tubular necrosis (Fig. 7). Hemorrhages (Fig. 5) and congestion (Fig. 9) were commonly noticed in lungs of all three species. One parasite was observed in a lung of a *Tyto alba* specimen. Hypoxic changes were seen in the brain of two of *Tyto alba* specimens (Fig. 8).

In previous studies many birds showed signs of hemorrhaging (Newton et al. 1997). Some organochlorine victims showed hemorrhaging of certain internal organs including brain, lungs, heart, kidney and liver (Newton et al. 1982).

Organochlorine pesticide residues (OCPs) were found in liver tissues of all owl species (Fig. 10). Very high concentrations were detected in *Strix ocellata* (6.901 mg/kg) followed by *Bubo bengalensis* (0.042 mg/kg) and *Tyto alba* (0.024 mg/kg) (Fig. 10). The accumulation pattern of organochlorine pesticides in owls was, in declining order, DDT > Dieldrin > Lindane. Among various pesticides analyzed p,p'-DDE contributed maximum towards the total OCPs.

The present study results indicate higher accumulation load of p,p'-DDE. Similarly, elevated concentrations of DDE were reported in migratory and resident waterfowl from South India (Tanabe et al. 1998). Concentrations of DDT and metabolites detected in the present study species are higher than the concentrations reported in various species of water birds (Dhananjayan 2012) in India. The high frequency of occurrence of p,p'-DDE confirms the presence of DDT and its metabolites in the environment (Dhananjayan et al. 2011b). Castillo et al. (1994) reported that the p,p'-DDE concentration exceeding 0.5 µg/g impacted many species of wild bird and proposed threshold levels. The predominant occurrence of pesticides in birds has been previously reported (Dhananjayan et al. 2010, b; Dhananjayan 2012) and in other biological samples (Dhananjayan and Murlidharan 2010).

Conclusion

This study documented the reported reasons for owl mortality included traffic accidents, collisions, electrocutions, and accidents such as falling from nests, but that the underlying reason was the ingestion of pesticides in owl prey leading to neuromuscular, renal, hepatic or pulmonary pathologies. Environmental contamination is therefore an important cause of owl mortality in study area. Still there is high risk of exposure of chemical to the birds in India. Hence, regular monitoring of persistent chemicals is recommended.

Acknowledgements

Authors are thankful to Maharashtra Forest department for providing all necessary help and support. I am also grateful to Ela foundation for their backing. I am thankful to the anonymous referees for their valuable comments and suggestions on the manuscript. I would also express my sincere gratitude to the peoples who informed us about the dead birds.

References

- Bunn, D.S.; Warburton, A.B.; Wilson, R.D.S. (1982) The Barn Owl. Calton: Poyser.
- Castillo J, Thybaud E, Caquet T, Ramade F (1994) Organochlorine contaminants in common tern (Sterna hirundo) eggs and young from the river Rhine area (France). Bulletin of Environmental Contamination and Toxicology 53:759–764.
- de Bruijn, O. (1994) Population ecology and conservation of the Barn Owl Tyto alba in farmland habitats in Liemers and Achterhoek (The Netherlands). Ardea. 82: 1-109.
- Dhananjayan V, Muralidharan S (2010) Organochlorine pesticide residues in inland wetland fishes of Karnataka, India and their implications on human dietary intake. Bulletin of Environmental Contamination and Toxicology 85:619–623.
- Dhananjayan V, Muralidharan S, Jayanthi P (2010) Distribution of persistent organochlorine chemical residues in blood plasma of three species of vultures from India. Environmental Monitoring and Assessment 173:803–811.
- Dhananjayan V, Muralidharan S, Ranapratab S (2011b) Organochlorine pesticide residues in eggs and tissues of house sparrow, *Passer domesticus*, from Tamil Nadu, India. Bulletin of Environmental Contamination and Toxicology 87:684–688.
- Dhananjayan V (2012) Organochlorine pesticides and polychlorinated biphenyls in various tissues of water birds in Nalabana bird sanctuary, Chilika Lake, Orissa, India. Bulletin of Environmental Contamination and Toxicology 89:197–201.
- Lehotay SJ, Tully J, Garca AV, Contreras M, Mol H, Heinke V, Poulsen ME, (2007) Determination of pesticide residues in foods by acetonitrile extraction and partitioning with magnesium sulfate: collaborative study. J AOAC Int. 90 (2):485–520.
- Newton I, Wyllie I, Dale L (1997) Mortality causes in British Barn Owls (Tyto alba), based on 1,101 carcasses examined during 1963-1996.
- Newton I, Bell A, Wyllie I (1982) Mortality of Sparrow hawks and Kestrels. British Birds. 75: 195-204.
- Shawyer, C.R. 1987. *The Barn Owl in the British Isles. Its past, present and future.* London: The Hawk Trust.
- Suvarna, K., Layton, C. and Bancroft, J. 2018. *Bancroft's Theory and Practice of Histological Techniques. 8th edition.* Elsevier- Saunders, Mosby and Churchill Livingstone, 584 pages.
- Tanabe S, Senthilkumar K, Kannan K, Subramanian AN (1998) Accumulation features of polychlorinated biphenyls and organochlorine pesticides in resident and migratory birds from South India. *Archives of Environmental Contamination and Toxicology* 34: 387-397.
- Taylor, I. 1994. Barn Owls. *Predator-prey relationships and conservation*. Cambridge:

Table 1: Information collected on owl specimens Pune district, Western Maharashtra, India.

Common Name	Scientific Name	Date	Gender	Age	Location	Weight (gm)	Circumstances
Barn Owl	*Tyto alba*	18-Oct-17	Female	Adult	Nimgaon Ketki	320	Collision
Barn Owl	*Tyto alba*	7-May-18	Male	Adult	Bhosari	398	Collision
Barn Owl	*Tyto alba*	7-May-18	Female	Adult	Pimple Gurav	280	Immobile
Barn Owl	*Tyto alba*	25-Oct-18	Male	Adult	Mulshi	300	Immobile
Barn Owl	*Tyto alba*	26-Oct-18	Female	Adult	Alfa Laval	430	Collision
Barn Owl	*Tyto alba*	27-Oct-18	Male	Juvenile	Kothrud	203	Immobile
Barn Owl	*Tyto alba*	02-Jan-19	Male	Juvenile	Pune	232	Felled from nest
Barn Owl	*Tyto alba*	02-Feb-19	Male	Juvenile	Jaysinghpur, Sangli	272	Found dead
Indian Eagle Owl	*Bubo bengalensis*	11-Jan-19	Female	Adult	Jejuri	996	Electrocution
Indian Eagle Owl	*Bubo bengalensis*	12-Jan-19	Male	Adult	Kawadewadi	900	Suspected for OC, OP
Indian Eagle Owl	*Bubo bengalensis*	10-Aug-19	Female	Adult	Kodit	700	Electrocution
Mottled Wood Owl	*Strix ocellata*	05-Feb-19	Female	Juvenile	Pune University	281	Immobile

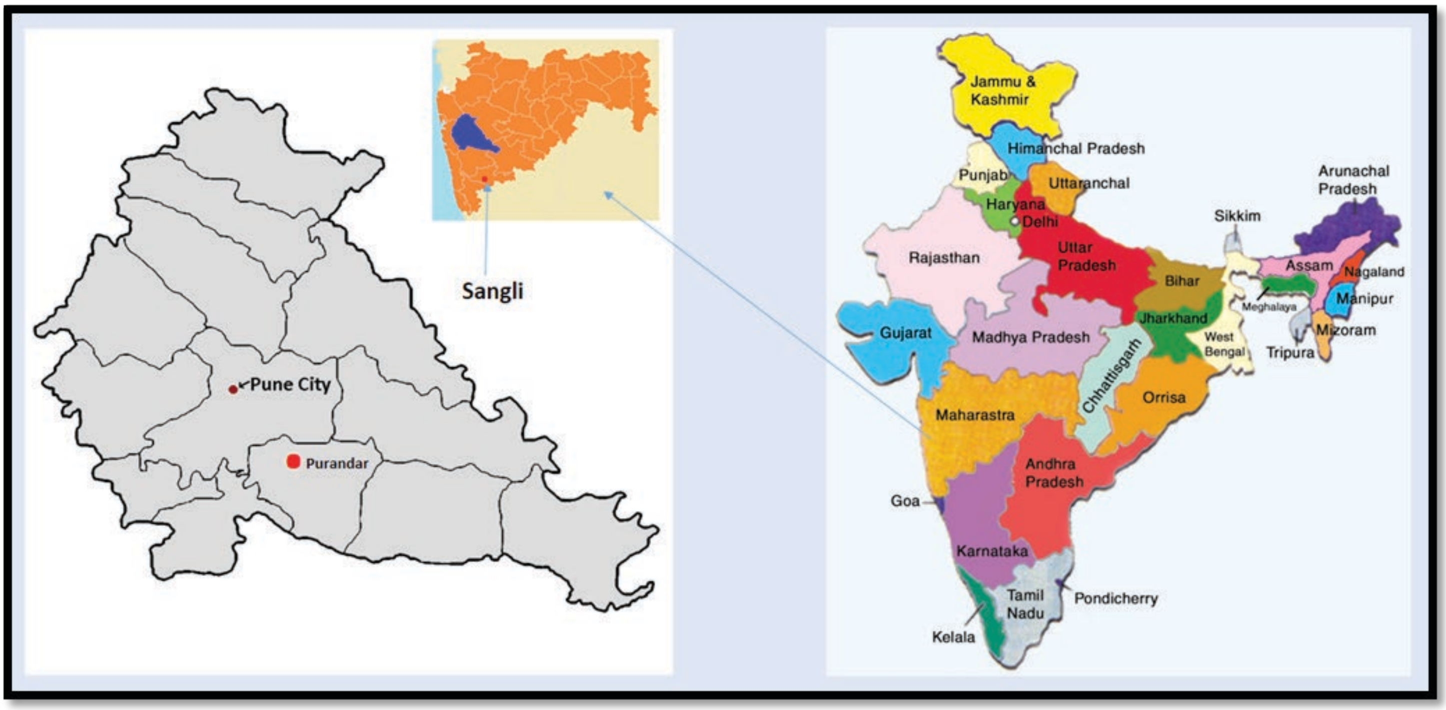

Figure 1: Study area in Western Maharashtra, India.

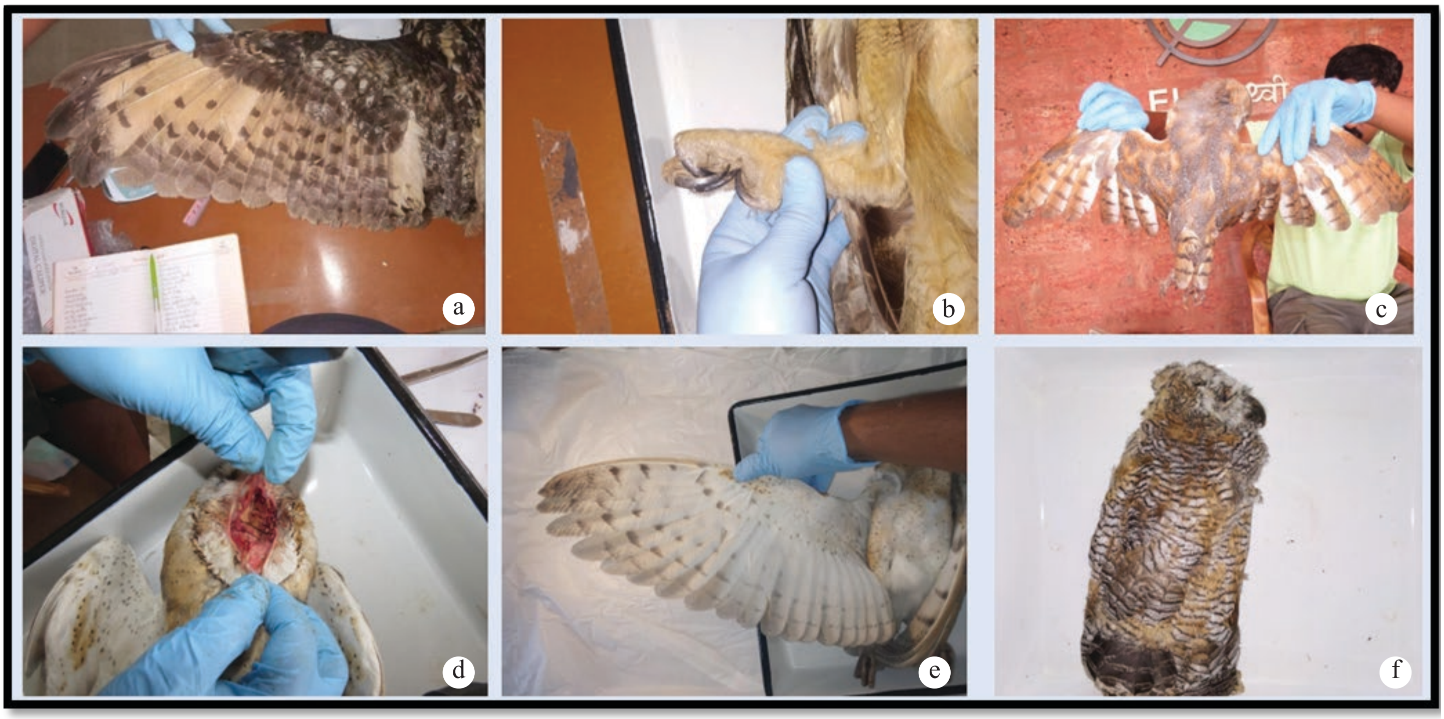

Figure 2: Images of the external examination of owl specimens obtained from Pune district, Western Maharashtra, India. a) Molt pattern of stretched wing; b) Talons; c) Wingspan; d) Gape; f) Side view of whole specimen.

Figure 3: Images of the internal examination of owl specimens obtained from Pune district, Western Maharashtra, India. a) Kidneys; b) Digestive track; c) Heart.

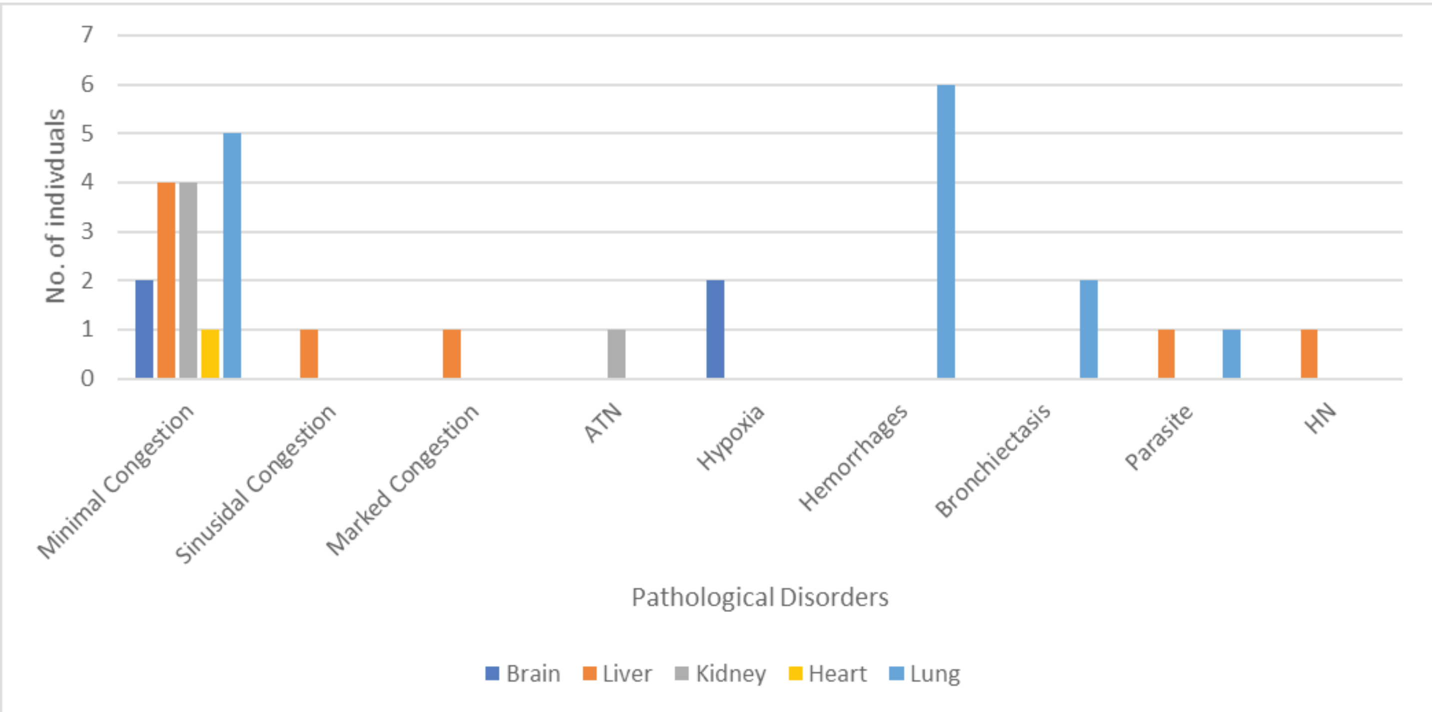

Figure 4: Histopathological disorders in selected organs of owl specimens from Pune district, Western Maharashtra, India.

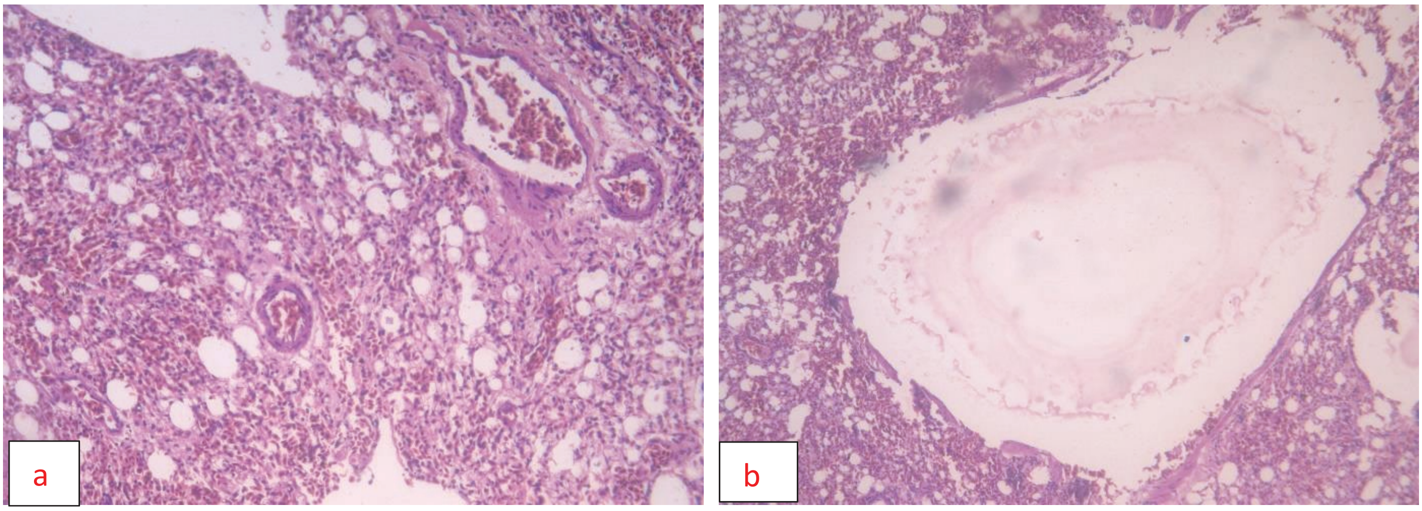

Figure 5: a) Hemorrhages; b) Bronchiectasis in lung tissue of a *Tyto alba* specimen from Pune district, Western Maharashtra, India.

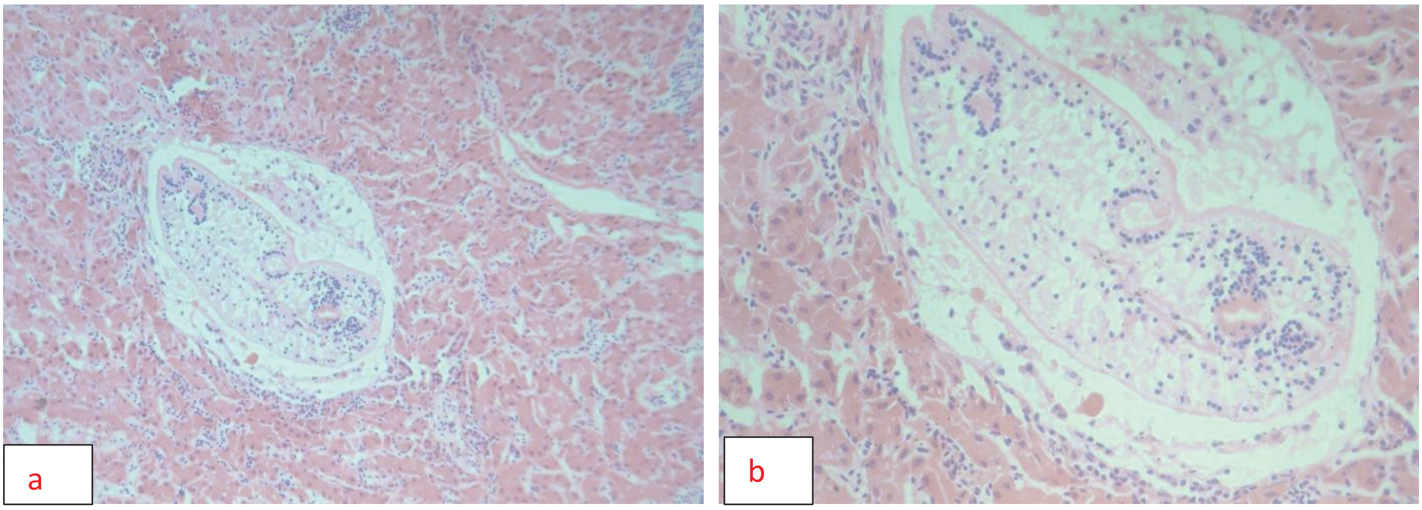

Figure 6: Parasite in Liver tissue of a *Tyto alba* specimen from Pune district, Western Maharashtra, India. a) 20x zoom; b) 40x zoom.

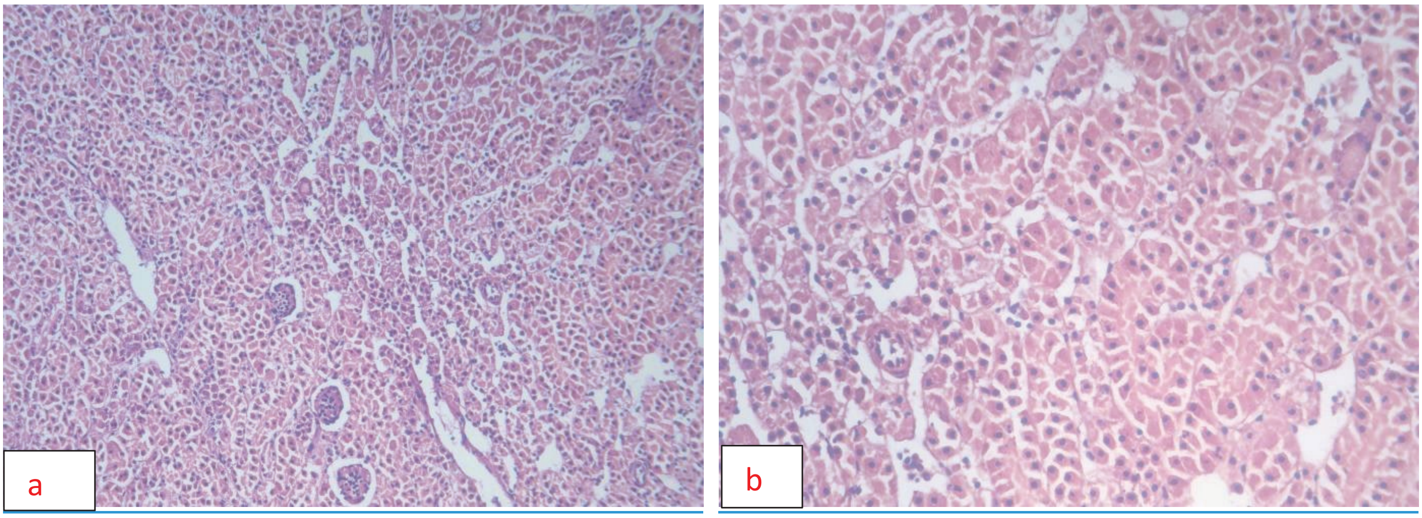

Figure 7: Acute Tubular Necrosis in kidney tissue of *Bubo bengalensis* specimen from Pune district, Western Maharashtra, India. a) 20x zoom; b) 40x zoom.

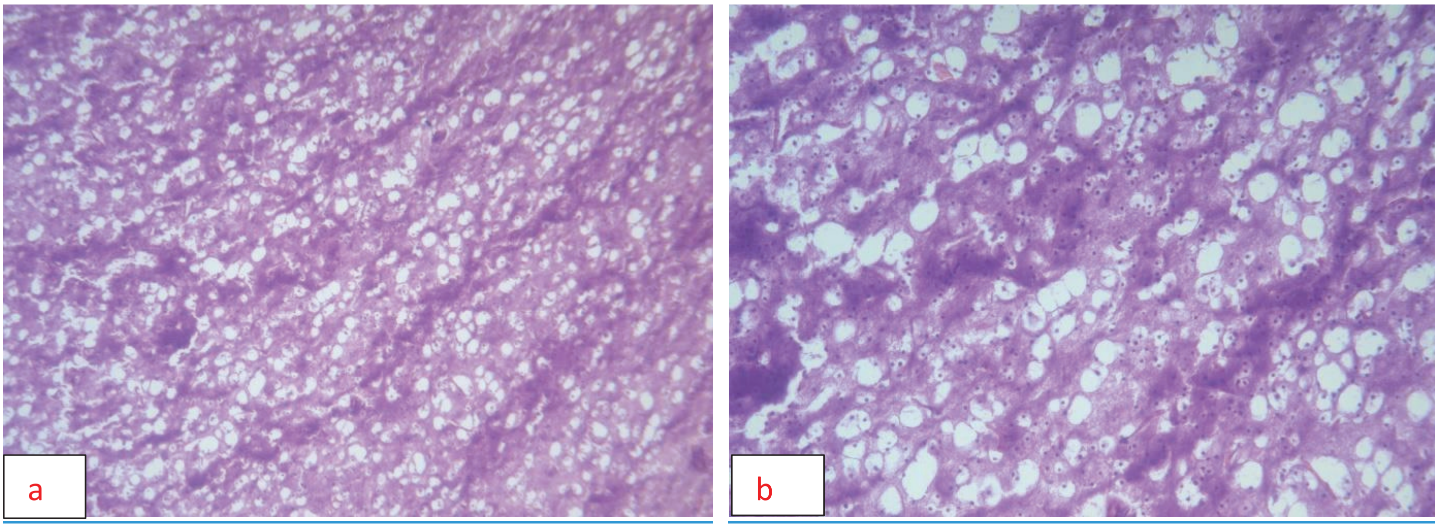

Figure 8: Hypoxic changes in brain tissue of a *Tyto alba* specimen from Pune district, Western Maharashtra, India. a) 10x zoom; b) 20x zoom.

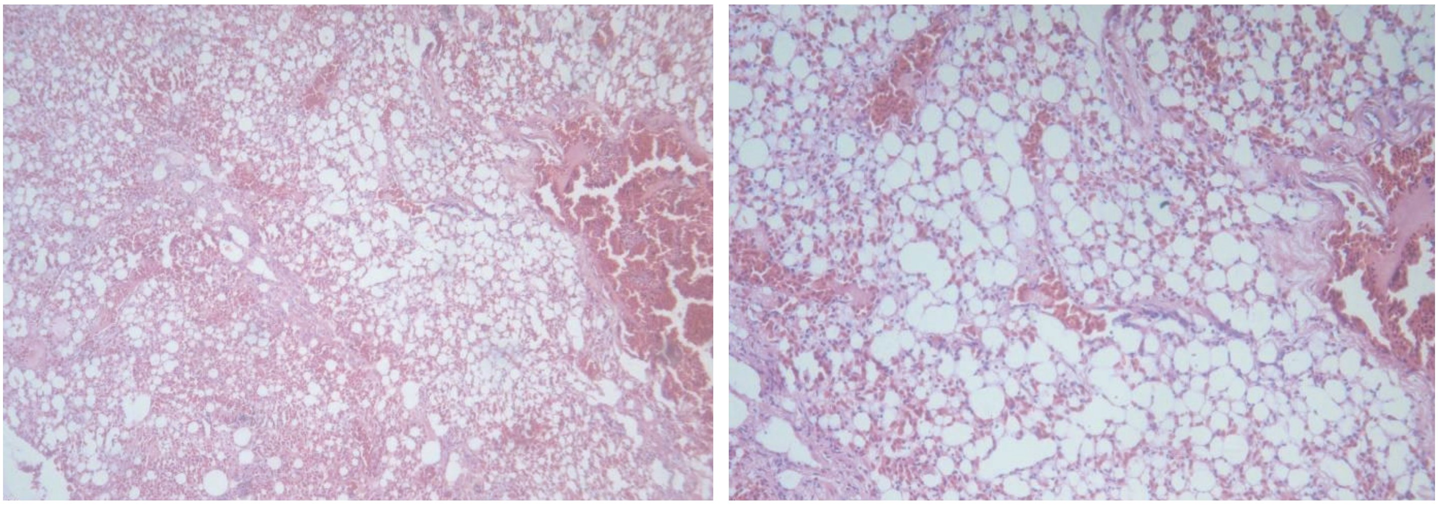

Figure 9: Congestion in lung tissue of *Bubo bengalensis* specimen from Pune district, Western Maharashtra, India. a) 10x zoom; b) 20x zoom.

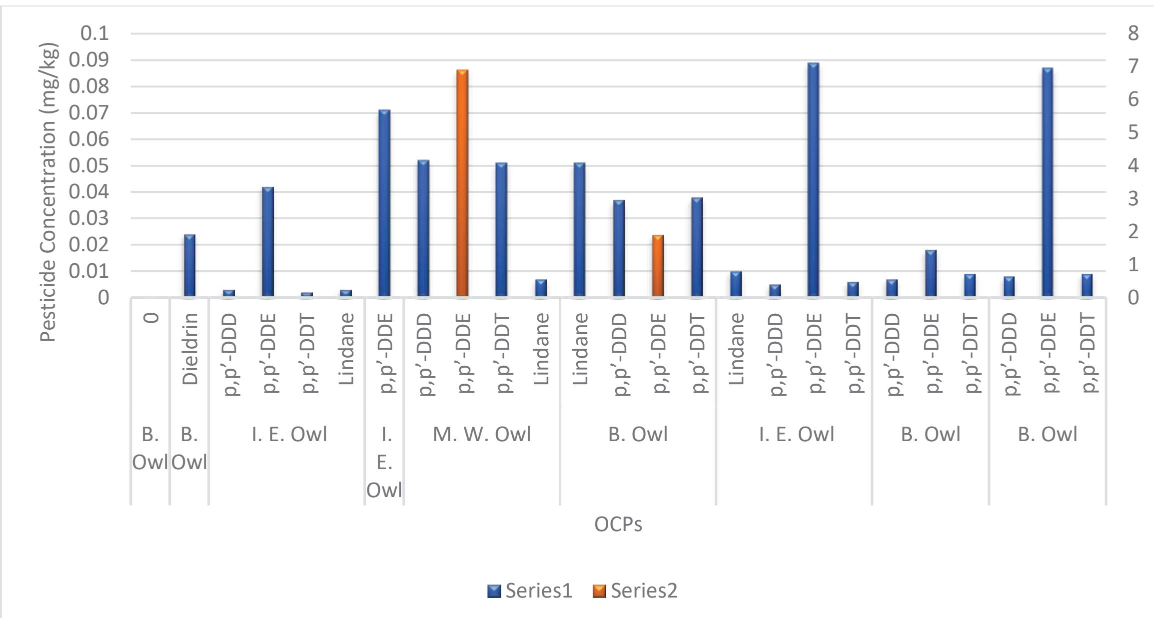

Figure 10: Concentration of various Organochlorine pesticide residues (OCPs) in owl specimens from Pune district, Western Maharashtra, India. B. Owl = Barn Owl (Tyto alba), I. E. Owl = Indian Eagle Owl *(Bubo bengalensis)*, M. W. Owl = Mottled Wood Owl (*Strix ocellata*). Series 1 indicates 0 to 0.1 mg/kg, Series 2 indicates 0 to 8 mg/kg.

Current perceptions of owls held by residents of rural Western Maharashtra, India

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Keywords: Owls; superstition; perception

Introduction:

Owls are nocturnal birds of prey which are not easily seen but are heard. Owls are associated with good and bad omen. Owls continue to be trapped and killed for black magic in India[1]. According to this report around 78000 owls were killed in India for superstitious beliefs, black magic, pet trade and zoo trade.

The survival of flora and fauna is not only associated with their environmental issues but also deeply associated with cultural beliefs. Utilizing cultural beliefs for their conservation has been in vogue lately[2].

Detailed accounts of owls in folklore have been presented[3]. Folklore also tries to associate why owls have been commonly associated with ill omen, their preference to stay solitary and why they prefer to reside in ruins and near grave yards or crematoriums. It is also quite likely that owls were among the first birds noticed by ancient man taking into consideration their vocalization in the night and their association with eerie night[4].

Owls also hold a position where they are considered wise and scholarly[5]. They are also seen as worshippers of God; detached from worldly pleasure[3]. Hence, a mix of perceptions has been cited in the literature.

Indian scenario is no different. Ancient texts depict owl as a wise bird and has over 20 synonyms devoted to owls. Owls belong to order Strigiformes and are sub divided into two families, Tytonidae and Strigidae. 3 from Tytonidae and 27 from Strigidae are known from India[6]. From which one species from Tytonidae and 12 from Strigidae are seen in Western Maharashtra, India[7].

The current perspective on owls in India remains unknown. The aim was to elucidate the knowledge and current perception about owls in rural population of Western Maharashtra, India. The study was conducted from conducted from 'The Center for Ornithology', Ela

Habitat, Pingori, taluka Purandar, Pune.

Materials and Methods:

A questionnaire-based study was undertaken with 233 rural participants. An 8-point questionnaire was used for this first of its kind study. Questions were asked regarding their demographic details, whether they had seen owls, locations of citing, whether they had heard owl calls, and their perceptions when saw or heard an owl. Knowledge about cultural beliefs, superstitions was also asked. Lastly, they were asked if they were willing to help owls.

People from various walks of life participated in this study. They were students, farmers, businessmen, servicemen and housewives.

Paper questionnaires were distributed to the participants and the data was entered in Excel sheet. The questionnaire was administered in Marathi, a vernacular language spoken in Maharashtra, India.

Results and Discussion:

The response rate was 100%. The demographic data revealed that the majority of the population (55%) was under 20 years, followed by 21-49 years (31%) and 14% were over 50 years (Figure 1). The gender wise distribution showed that males (71%) were predominant as compared to females (29%). Based on occupation-wise comparison students predominated over other occupations (Figure 2).

Considering whether the participants had seen owls, 86% had seen them. From the ones who had seen owls, 53.5% saw them either at dusk or at night. Owls were spotted at various locations, like trees, tree hollow, grasslands, residential areas, in wells, cemeteries/crematoriums, under bridges, on power lines, in zoos or in flight. Maximum (n=133) reported that they sighted owls on trees and least (n=1) reported to have sited owls either under the bridge, in flight or in cemeteries or crematoriums (Figure 3). When asked about how they perceived owl sighting; 47% reported that they were neutral, 39% were afraid and only 14% felt good (Figure 4). Among those who were afraid seeing the owls, maximum were students (38.8%) followed by farmers (32.2%) and least were housewives (4.4%) (Figure 5).

From all the participants, 63.5% had heard owl calls. From those who had heard owl calls, 56% were afraid and only 2% were amazed. 27% were neutral and only 15% felt good (Figure 6). Out of those who were afraid listening to the owl, maximum 45.1% were students and 2% were housewives (Figure 7).

To know the general knowledge regarding owls, the participants were asked about which owls were they aware of. 75.5% participants did not know which owl they saw. From those who knew the owl, a decreasing order with the number of species was noticed. 19.7% mentioned knew at least one (either a Barn owl or a spotted owlet), 4.2% knew two species and only 0.4% knew three or more (Barn owl, Spotted owlet, Indian Eagle owl or a Mottled Wood owl).

When asked about cultural awareness regarding owls, 52% had no idea, 23% and 25% associated positive and negative cultural significance respectively (Figure 8). Prevalence of superstitious beliefs was 39.4%. When asked about their superstitious beliefs, they answered that owls are death birds, they hear whispering of ghosts, consuming their eyes gives you divine vision to seek treasure or attain divinity, owls catch the stone human throw at them and rub them against their feathers thus causing the stone pelter to wither and die, owls are ghosts, beliefs of medicinal properties from owl's parts and eggs.

Despite, all of this when asked about willingness to help conserve owls, 90.9% participants were willing to do so. The study confirmed that majority of the participants had seen owls. Regarding the gender wise distribution, males saw owls more than the females did. This could be possibly due to more outdoor activities as compared to females in the rural areas. Based on the age-wise distribution younger individuals saw owls more than did the elderly possibly again due to frequently being outdoors.

The reason why farmers and students sighted more owls may be two-fold. Inquisitiveness of students and the occupational routine of farmers made them sight owls. Farmers spend most of the time in their fields. Perception of fear which was high in students was astonishing and can be due to lack of awareness programs / owls tend not to feature in discussions. They may have harboured fear because of superstitions conveyed to them by the word of mouth from their family.

Similarly, association of fear with owl call cannot be attributed to any single factor. It is partly possible because, majority of owls were sighted and heard at dusk or night. Owls have eerie calls which are not frequently heard and presence of poor electric lighting conditions in farmlands.

Considering that the majority of participants sighting the owl on trees, they saw owls in their natural habitats. Similar finding was noted from another study undertaken in Costa Rica and Malawi[8]. Regarding the locations of owl sighting, wells hold a special position in the rural scenario in the study area. The wells are not lined by concrete but are lined with earth. The upper part is fortified with stones or bricks but the lower part provides niches for residence of owls like the Barn owls.

Regarding the knowledge about owl names, majority of the participants were owl illiterate, meaning they were ignorant either of the owl species or their names. Similar finding has been noted in a study whether participants had abundant knowledge, but it was incorrect and owls still remain to be least understood species[9]. This needs attention and urgent efforts to educate masses via community programs to raise awareness. Owls are till date associated with superstitions. This is congruent with few other studies also[10,8].

Regarding the cultural awareness about 50% was present either way (that is in a positive or negative manner), indicating that the respondents were confused. This provides us with a hope that the population still is amenable to be instilled with positive aspects about owls.

This study emphasizes the need to combine cultural aspects for conservation and education of masses regarding owls. This was also found from another study that it is imperative to consider people's beliefs which in turn affect their actions towards wildlife[11].

This study concludes that till date people have fear associated with both owl sighting and their calls. People lacked knowledge of owl names and their cultural significance. Students and farmers were predominant in both above categories.

Based on our study we would like to recommend:

The responsiveness of the respondents could be positively put to use by providing:

- Education about owls
- Rural outreach programs to address and eliminate superstitions
- Involve cultural (Ethno-Ornithological) perspective, which connects the rural folk to owls more than just providing scientific information.
- A multi centric study with a larger sample size is warranted to substantiate our results.
- Farmers and students need to be sensitized for owl conservation.
- Farmers are associated with the environment and spend more time in the field and can make a positive impact.
- Students are curious to learn and are the flag bearers for a better future.

Literature cited:

1. Ahmed A. Imperilled custodians of the night: a study of the illegal trade, trapping, and utilization of Owls in India. TRAFFIC India/WWF-India; 2010.
2. Raval, S. 1994. Wheel of life: perceptions and concerns of the resident peoples for Gir National Park in India. Society and Natural Resources. 4: 305-320.
3. Modi JJ. The Owl in Folklore.
4. Freethy, R. 1992. Owls: a guide for ornithologists. Hildenborough, England: Bishopsgate Press. 134 p.
5. Cenzato, E.; Santopietro, F. 1991. Owls: art, legend, history. Toronto, Canada: Little, Brown & Co. 112 p.
6. Ali, S. (1996). The book of Indian birds. Oxford University Press, Mumbai.
7. Pande S, Deshpande P, Sant N. Birds of Maharashtra. Ela Foundation; 2013.
8. Enríquez Rocha PL, Mikkola H. Comparative study of general public owl knowledge in Costa Rica, Central America and Malawi, Africa. Biology and conservation of owls of the Northern Hemisphere. General Technical Report NC-190/JR Duncan, DH Johnson, TH Nicholls, eds. p. 160-166.
9. Clark, R.; Smith, D.W.; Kelso, L.H. 1978. Working bibliography of owls of the world. Tech. Ser. 1. Washington, DC: National Wildlife Federation. 319 p.
10. Mikkola, H. 1995. Owls in African superstitions.
11. Holl, K.D.; Daily, G.C.; Ehrlich, P.R. 1995. Knowledge and perceptions in Costa Rica regarding environment, population, and biodiversity issues. Conservation Biology. 9 (6): 1548-1558.

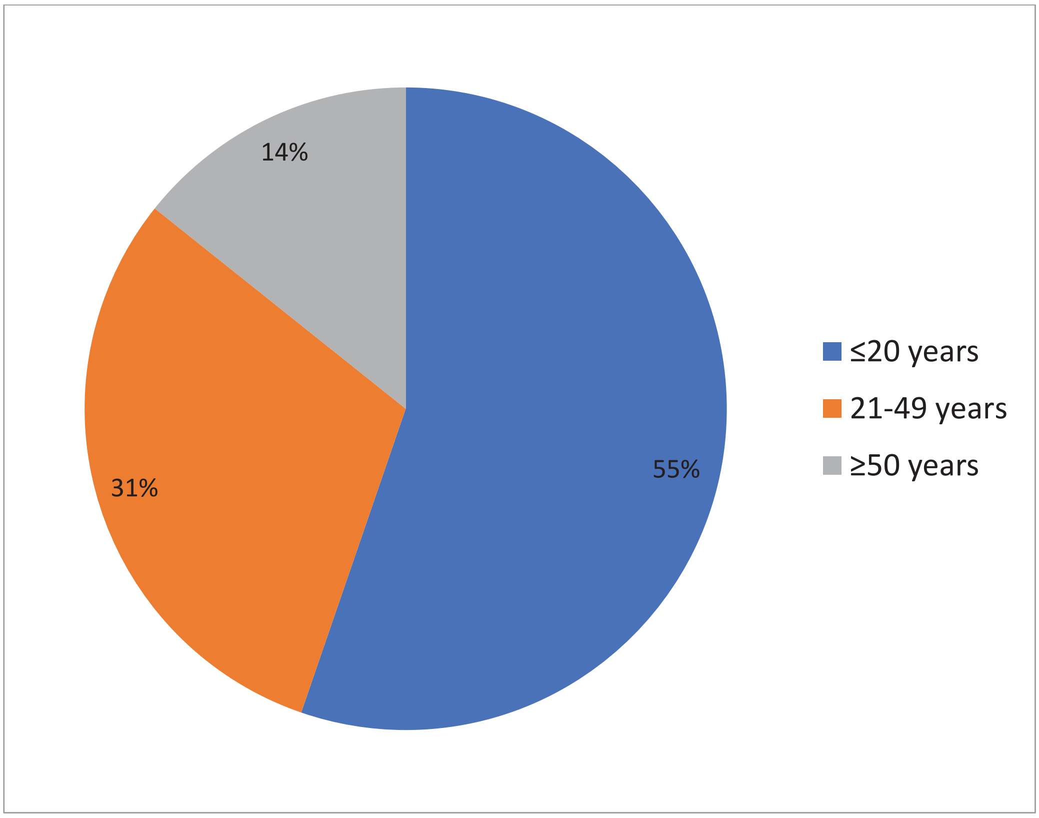

Figure 1. The age of respondents to a questionnaire on perceptions of owls held by rural residents of rural Western Maharashtra, India.

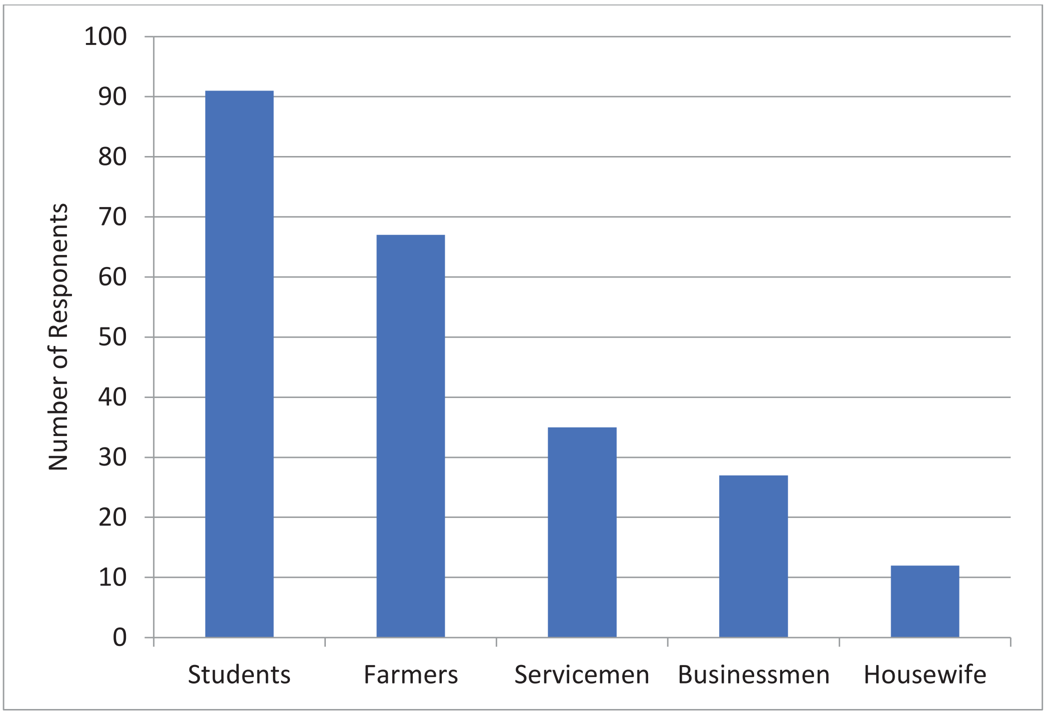

Figure 2. The occupation of respondents to a questionnaire on perceptions of owls held by rural residents of rural Western Maharashtra, India (N=233)

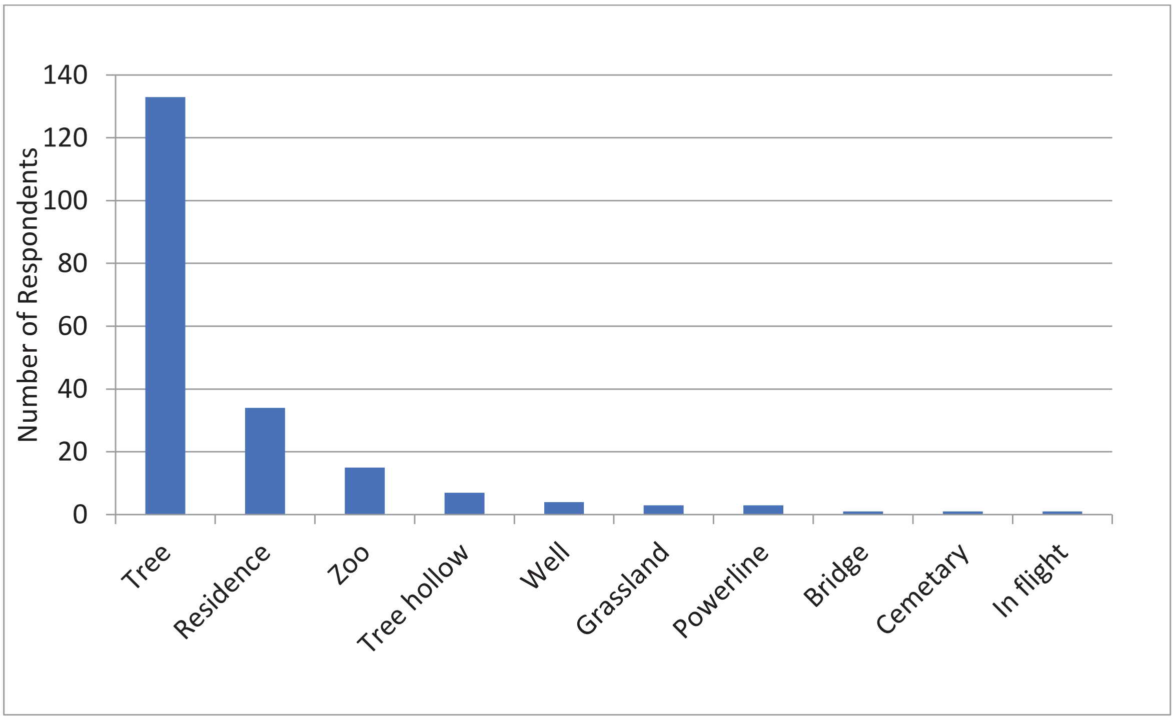

Figure 3. Frequency of locations of where people reported seeing owls (n=202) in rural Western Maharashtra, India

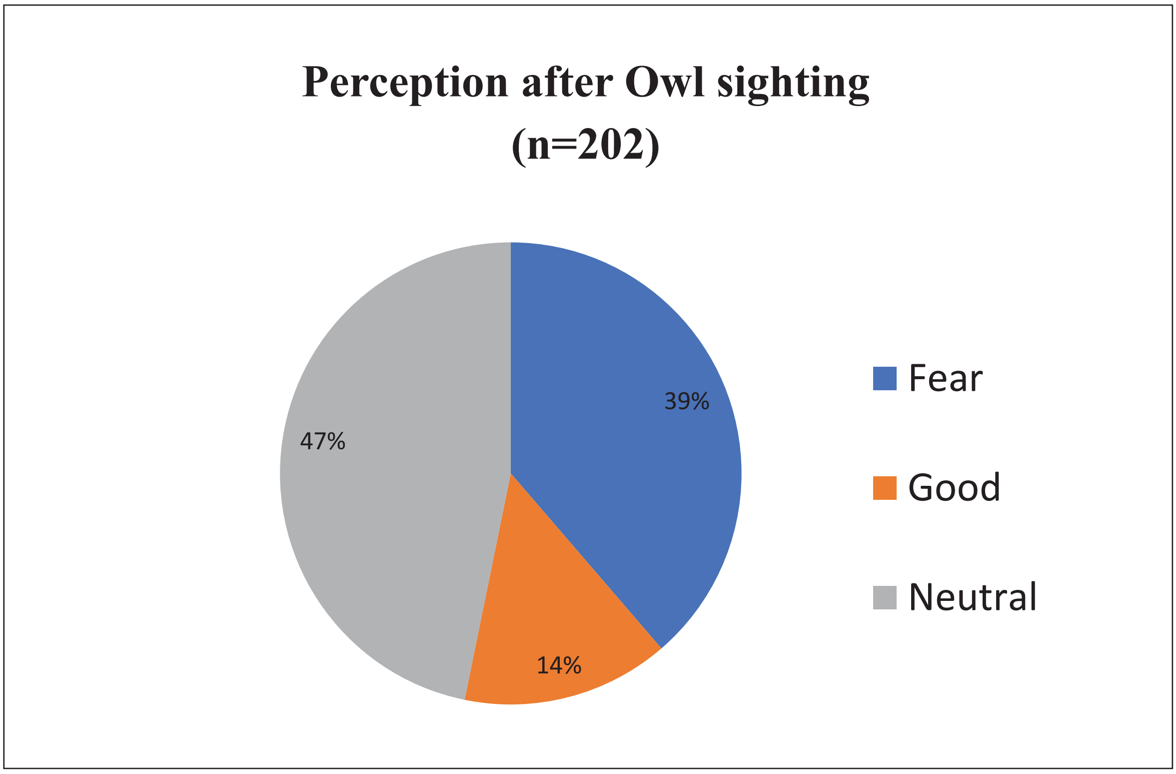

Figure 4. Proportion of types of perceptions after owl sighting held by rural residents of rural Western Maharashtra, India (n=202)

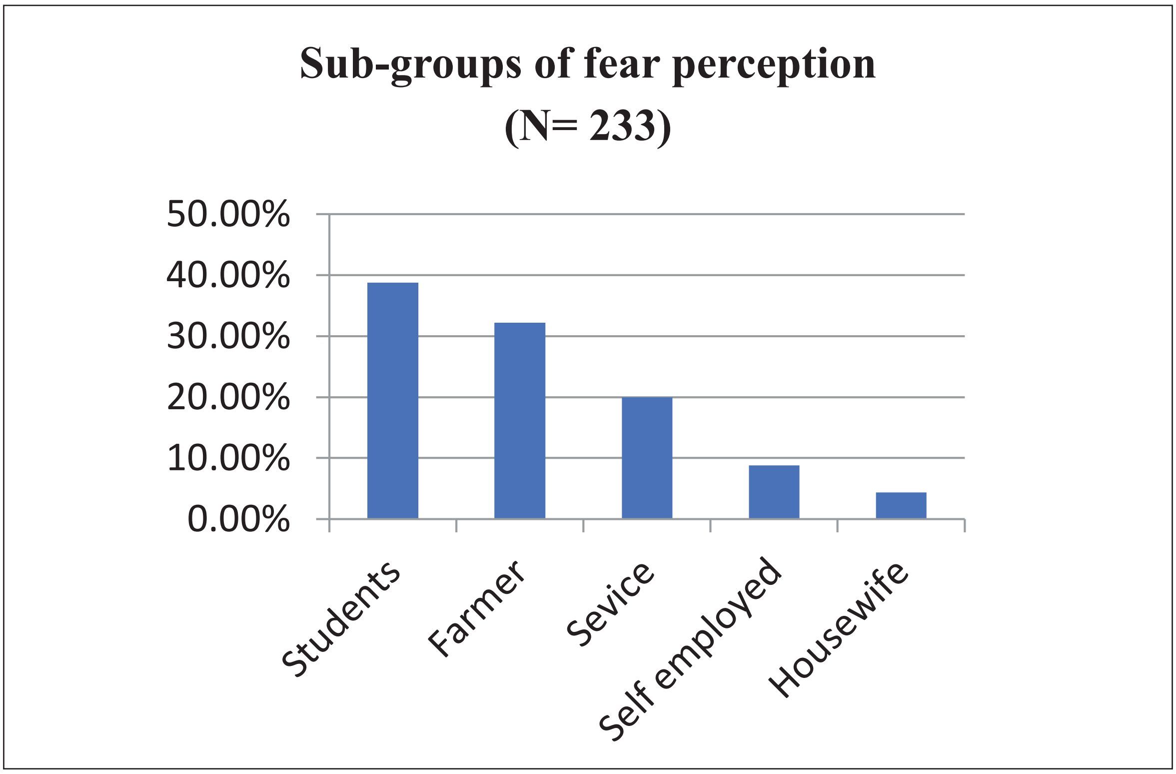

Figure 5. Proportion of sub groups having fear perceptions amongst rural residents of rural Western Maharashtra, India (N=233)

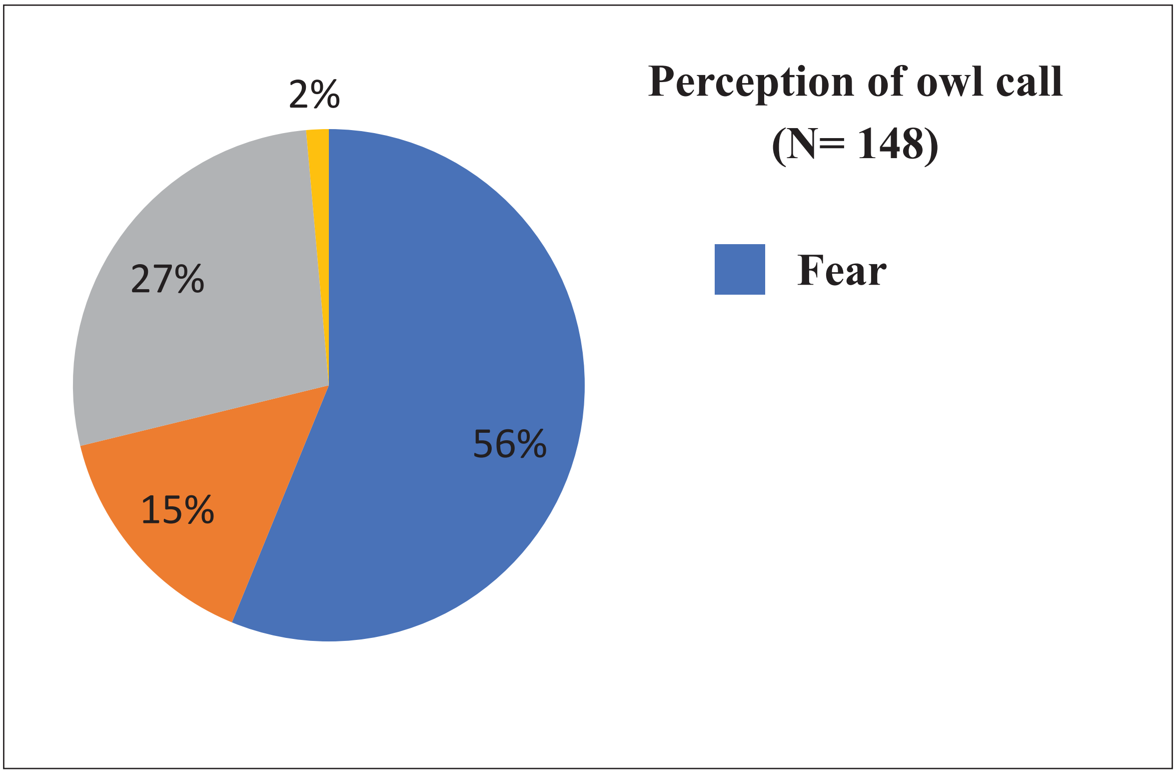

Figure 6. Proportion of perception of owl call amongst rural residents of rural Western Maharashtra, India (n=148)

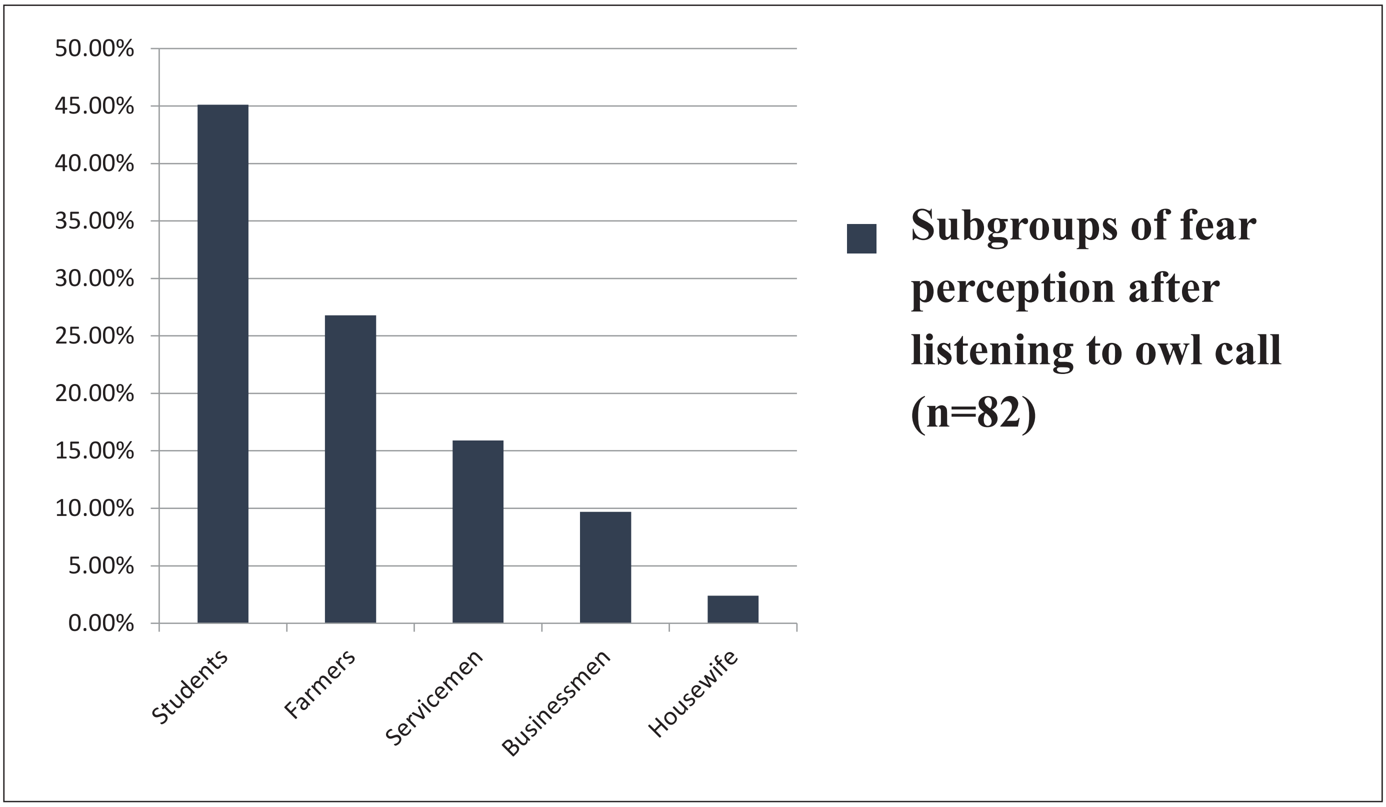

Figure 7. Proportion of sub groups of fear perception of owl call amongst rural residents of rural Western Maharashtra, India (n=82)

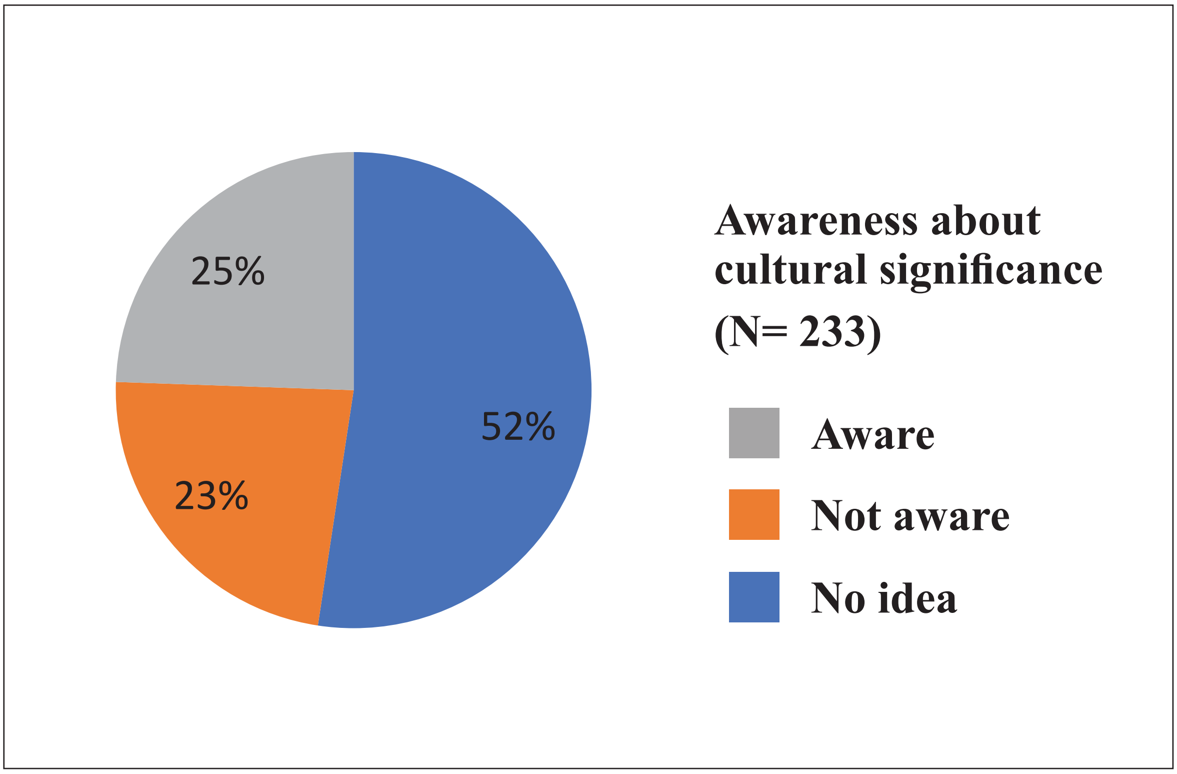

Figure 8. Proportion of awareness about cultural significance amongst rural residents of rural Western Maharashtra, India (N=233)

Owl in Indian Culture

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Goddess Chamunda riding an owl. Odisha.

Introduction:

To the world Sanskrit is an important language because it has a long and rich tradition of literature and has a unique position as an indisputable, reliable means of understanding the life, mind and culture of ancient Indians. The traditions of linguistics and philosophy continue to influence and inspire people all over the world. Sanskrit has nurtured Indian mind, speech and culture. It is a symbol of Indian unity. Sanskrit is one of the oldest languages in the world. It continues to play an important role in the life, thought and expression of Indian people. Sanskrit is a window to our ancient knowledge. It helps us understand how our ancestor viewed nature in general and bird life in particular. It is even more important today to understand our compassionate heritage. Vedic philosophy tries to explain man-nature relationship. Glimpses of our bio-diversity are seen in Sanskrit literature.

Indian ethno-ornithological perspective can be studied from various angles like references from the lexicons, mythology, medicine, superstition and augury, religion, culture, architecture, mysticism, migratory routes etc.

Right from the *Vedas*, we come across numerous references to birds – their descriptions and their habits. Birds have been a part of daily life of Vedic people and their sacrificial rituals. The *Upnishadas* mention birds, mainly figuratively, to describe the philosophical concepts such as non-attachment and so on. In the *Mahabharata*[1], we have an interesting reference to a bird:

Shakuninamivakashe jale vaaricharasya va |
Yatha gatirna drushyeta tathaiva sumahatmanaha ||
Mbh. 12.231.24a

It means 'as the speed of the birds in the sky is not seen so also the (speed or track) of noble persons cannot be seen.'

Materials:

In this paper I shall present a few references to owls from the Sanskrit literature. Sanskrit is shortlisted because it is one of the oldest languages in the world; it is prominent language in the family of Indo-European languages; it is the root language of many regional languages in India and is a language of knowledge, philosophy and cultural heritage. So also, Sanskrit has influenced cultural perceptions in India. I have cited examples from at least twenty one Sanskrit texts that are cited in the references section and at appropriate places where they are mentioned in the results.

Results:

Owl in Buddhist literature

In the Buddhist literature owl appears in mystical context where it is one of the birds that meditated on the discourse of the Buddha. In a Tibetan text titled '*The Bhuddha's law among the birds*'[2], the owl has expressed highly philosophical thoughts such as,

"The hour of death without insight from meditation, - what misery!

A priest without morals, - what misery!

An old lama without judgement, - what misery!

A chieftain without judgement, - what misery! - - - - -

- - - - - - Knowing the misery that all these things can bring, - avoid them!"

Several beliefs and superstitions are associated with the owl.

Oldest references to the owl

From the *Rigveda* onwards '*uluka*' is the general word for the owl. The bird was noted for its cry or the shrill voice and was deemed to be the harbinger if ill fortune.

"May the cruel female fiend after discarding the concealment of her person, wander about at night like an owl, fall headlong down into the unbounded caverns: may the stones grind the Soma destroy *Rakshasas* by their noise." (*Rigveda* 7.104.17)[3]. This verse also occurs in the *Atharvaveda* (8.4.17)[4] with some minor variants.

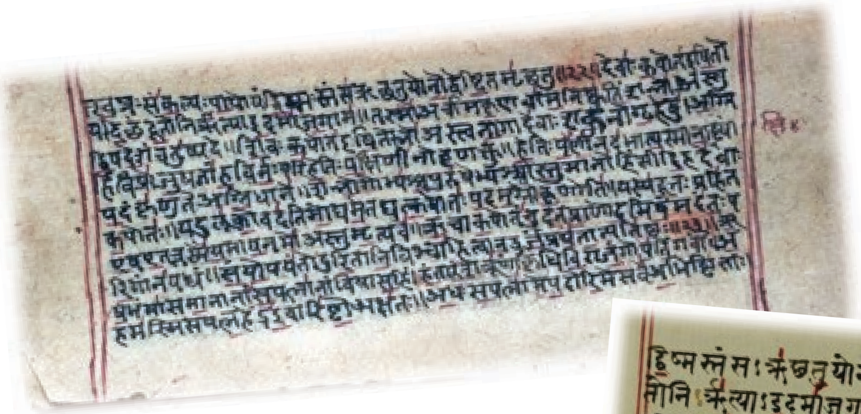
The word *ulukayaatu* occuring in the *Rigveda* and in the *Atharvaveda* refers to a kind of black magic. It may have these aspects –

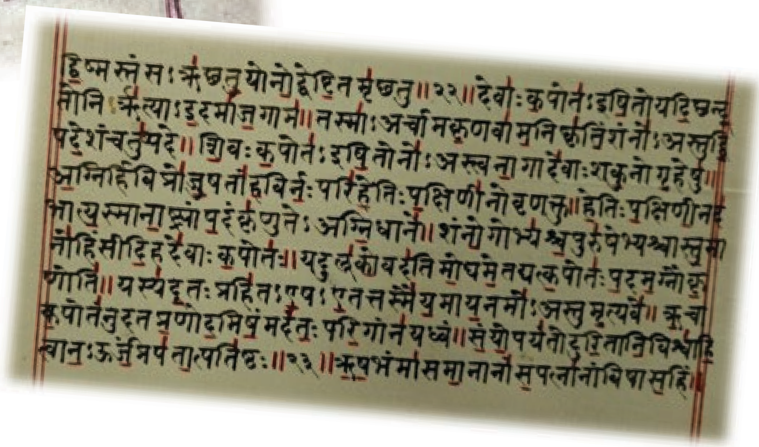
1) One, which moves like an owl.
2) One, which attacks in the night by hiding oneself.

Manfred Mayrhofer[5] explains the word *uluka* as follows-

"*Ululih*" means crying aloud or noisy. (*Ululare heulen*). This word is shown to be onomatopoetic and *uluka* is an owl. According to the Sanskrit dictionary (M.Monier-Williams)[6], the word '*ululi*' means an outcry indicative of prosperity. The reasons for associating the owl with Goddess of wealth can be found in this meaning.

The *Vajasaneyi Samhita* (24.23)[7] refers to the owls as the offering to the forest trees at the horse sacrifice (perhaps because they roosted there).





An old Sanskrit manuscript mentioning the owl

Goddess Laxmi riding an Owl from various states of India

Synonyms for the owl

Here are the descriptive synonyms given in the *Amarkosha* (2.5.15)[8], *Kalpadrukosha* (11. 99-101)[9]

1. *Uluka* is one, which makes shrill outcry.
2. *Vayasaari* is one, which is an enemy of the crow.
3 *Pecaka* is a kind of an owl. (In Bengali language an owl is called as *Lakshmi pecha*.)
4 *Divandha* is one, which cannot see during the day.
5 *Kaushika* is one, which resides in *kusha* (grass) or one, which resides in holes (*kosha*).
6 *Ghuka* is one, which makes a sound like *ghu, ghu.* – an onomatopoetic word. (in Marathi language an owl is called *Ghubada*).
7 *Divabhita* is one, which is afraid of light of the day.
8 *Nishatana* is one, which wanders during the night.
9 *Tamasa* is one who is bad-tempered.
10 *Ghoradarshana* is one who looks fierce.
11 *Ghargharaka* is one who utters the sound as 'ghar' 'ghar'.
12 *Kaushika* is one who resides in the kusha grass.
13 *Piyu* is an owl. (The meaning is not clear.)
14 *Naktanchara* is one who is nocturnal.
15 *Kakati* is one who is the enemy of the crows.
16 *Divandha* is one who cannot see during the day. (Bit this is a wrong notion.)
17 *Kudhi* is one who has ill intellect.
18 It is said that the owl eats flesh by using its nails.
19 *Divasvapi* is one who sleeps during the day.
20 *Vaktravishtha* is one who throws out the pellets through its mouth.

Mythological references to the owl

The *Valmiki Ramayana*[10] says that *Kraunchi* is the mother of owls. (3.14.18). The origin of animal tales is found in the *Mahabharata*. In the *Mahabharata* (3.191.4), there is a story of an owl staying on the mountain called *Himavat*. The name of this owl is *Pravarakarna*-"the owl having tufted ears". The king *Indradyumna* fell from heaven as his share of good deeds came to an end. Sage *Markandeya* advised the king to go and meet the owl to find out the reasons behind his downfall. The owl helped the king to get answers of his queries. In this story, the word "*Pravarakarna*" is important. It means "the cloak-eared". This species may be identified as a horned owl. A similar reference is found in the *Kakolukiyam* section of the *Panchatantra* (III.34,35).

In the *Uttarakanda* of the *Valmiki Ramayana*, there is a story of a vulture and an owl fighting for the nest. They are said to have gone to Lord *Rama* for justice. *Rama* said that the owl was residing in the nest from the time of origin of trees and creepers. The vulture was residing in the nest from the origin of the human beings. This implied that the owl was present before the

Atraditional tribal India owl painting

scavenging vulture, because the trees came into being earlier than the human beings. This story is included in canto no.13 which is supposed to be an interpolation.

Another mythological story is found in the *Adbhuta-Ramayana*[11]. In the sixth canto of this *Ramayana* there is story where the owl is appreciated for its musical calls. There was a king named *Bhuvanesha*. He ordered his citizens to praise only deities by reciting Vedic mantras, and the king himself be praised by singing. There was a *Brahmin* named *Harimitra* who was a great devotee of Lord *Vishnu*. He offered his prayers to his favorite deity by his sweet melodious songs. So, the king got irritated and he harassed *Harimitra*. Due to this injustice, the king was born as an owl and was forced to eat his own dead body when he felt hungry. This owl happened to come to the caves near *Manasa* where he met *Harimitra*. A large-hearted *Harimitra* felt sympathy for the owl. This owl became a great master in the art of music. The owl came to be known as *Ganabandhu* and taught music to sage *Narada*. (The calls of the Forest Owlet are actually very melodious.)

In the *Puranic* period owl was considered as auspicious and was believed to be the carrier vehicle of goddess *Lakshmi* - the goddess of wealth. Owls (*Tyto alba*) feed on various small animals, particularly the squirrels and mice that cause damage to crops and are thus beneficial to agriculture. Perhaps for this reason this owl is associated with *Lakshmi* as well as to Chamunda. In Ellora an owl is depicted as the vehicle of Chamunda.[12]

In Bengal[13] this owl is regularly worshipped with Goddess *Lakshmi* and it is depicted in several pictures as her vehicle. In the iconographical references there are images of Goddess *Lakshmi*.

Bengali folk story[14] of a young boy named Bilu and owl chicks. Bilu a village boy developed friendship with owl chicks living in the hollow of a tree near his hut. He always shared his food with owl chicks. By seeing poverty and hardships of Bilu and his mother, owl chicks request their parents to help Bilu. Every morning owl parents used to visit the garden of goddess of wealth and meet Her.

Owl parents requested the goddess and asked for a boon for the sake of Bilu. The Goddess did not offer wealth in the form of money; but she gave a small packet of sesame seeds for Bilu and told that he should sow these seeds which would bring fortune for the poor family. Bilu accepted the sesame seeds, worked hard and reaped a good crop. Thus, the folklore gave rise to the tradition of worshipping *Lakshmi* – goddess of wealth with sesame seeds in the Hindu months of Bhadrapada (Aug.-Sept. in Gregorian calendar), Kartik (Oct.-Nov.) and Chaitra (mind march). The Goddess is necessarily depicted with an owl.

Some superstitions about the owl

From the *Rigvedic* times, there seems to be a tendency to condemn owls. There are some references implying the belief that the owls are inauspicious.

In the *Bhagavata-Purana* (1.14.14)[15], the owl is said to be fearful. In the *Mahabharata* also it is said that one who steals a cake of flour is born as an owl. (MBh. 13.112.98a). The *Yajnavalkya Smruti* states that the students should take a break in their studies if they hear an outcry of the owl. This was because of the inauspicious character of the owl. (Snataka Dharma Prakarana 148).[16]

The text '*Vasantarajashakunam*'[17] has discussed various predictions or augury associated with the owlet (*pingala*). The text devotes a chapter (no.13) to describe the *Pingalaruta* which means 'an outcry of the owlet'. It is interesting to note that he has particularly talked about the owlets. The reason is simple because they are frequently seen. The author *Bhatta Vasantaraja*, has described elaborately the differences between the calls of owlets. According to him, there are five types of calls. The '*Vasantarajashakuna*' states predictions indicating either misfortune or good luck. For example, if the owlet flies away from the branch of a tree in search of food and if it again comes back and rests on the same branch, it suggests that a traveler will be successful in his journey. His purpose of his journey or pilgrimage will be served. It implies that the owlets were not totally condemned every time.

References to the owl in classical literature

In the *Kumarasambhava*[18] of *Kalidasa* the nocturnal habit of the owl is highlighted. The caves in the Himalayas are said to be offering shelter to the '*divabheeta*' bird. It is said (I.12) -

"*Divakaradrakshati yo guhasu leenam divabheetamivandhakaram* |

The *Raghavapandaveeya* (I.83)[19] contains reference to the jungle that is full of calls of the owls.

References to the owl in the *Mrigapakshishastra*[20] and *Manasollasa*[21]

The text called '*Mrugapakshishastra*' was composed by *Hamsadeva* – a Jaina Muni in 13th c. He has tried to classify the species of many birds and animals. He has described the owls as *Uluka*, *Vayasaraati*, *Pechaka*, *Kaushika, Ghuka*, *Divabheeta* and *Nishaatana*. (*Shreni* no. 28). In the verse no. 341, the author says that trees look beautiful because of the perching owl chicks (when they are in branching stage of their early life).

The huge encyclopedic treatise named "*Manasollasa*" or the "*Abhilashitarthachintamani*" was created by the scholarly Chalukya king Somesvara (third) (12th c AD). The treatise has a chapter no. 13 titled '*pingala shakunam*' on the worship of spotted owlets which has 56 verses. It is interesting to note that the author has documented and transcribed calls of spotted owlets.

References:

1. *Mahabharata*. Vol. I-V, (1971-1976), Poona: Bhandarkar Oriental Research Institute.
2. *The Buddha's law among the birds*. Edward Conze, (1996), Delhi: Motilal Banarsidass, p.27.
3. *Rigveda*. Rigveda samhita with the commentary of Sayanacharya, ed. V.K. Rajwade et.al, Vol.I-V (1972,1984, 1978, 1983, 1951), Pune: Vaidik Samshodhan Mandal.
4. *Atharvaveda*. tr. by Whitney W.D., (1962), Vol I & II, Delhi: Motilal Banarsidass.
5. *Etymologisches Worter buch des Altindoa rischen*. Mayrhofer Manfred, (1953), Band I, Lieferung 1, Heidelberg: Carl Winter Universitatsverlag. P.111.
6. *The Sanskrit-English Dictionary***.** M. Monier-Williams, 1899 (1999), Delhi: Motilal Banarsidass.
7. *Shukla Yajurveda*. Shukla Yajurveda (Vajasaneyi Madhyandina Samhita), tr. By Dhundiraj Shastri Ganesh Dikshita Bapat, Vol. I, II, (Shaka 1862), Aundh: Shrimanta Raajesaheb.
8. *Amarkosha*. Amarasimha, Ed. By Hargovind Shastri, (1957), Varanasi: Chaukhamba Sanskrit series Office.
9. *Kalpadrukosha*. Keshava Ed. By Ramavatara Sharma 1928. 1932)., Baroda, Gaikwad Oriental Series.
10. *Valmiki Ramayana*. The Valmiki Ramayana, Vol. I-VII, ed. G.H. Bhatt et al. (1960-1972), Baroda: Oriental Institute.
11. *Adbhuta Ramayana*. tr. by Dr. Smt. U.J. Surati & Dr. Smt. J.S. Dave, (1983-84) Lucknow: Bhuvanvani Trust.
12. *Bharatiya Murtishastra*. Joshi N.P., (1979), Nagpur, Maharashtra Vidyapith Grantha Nirmiti Mandal. P. 297.
13. *Deva devi o tader vahan*. Swami Nirmalananda. Bharat Sevashram Sangha, Kolkata, sixth edition; 2003.
14. *Loka sanskriti gaveshana*. A quarterly, a special issue on an owl and goddess Lakshmi, Loka sanskriti gaveshna parishad, Kolkata, 2004.
15. *Bhagavata mahapurana*. Geeta press, Gorakhpur, Vol. I and II, 1954.
16. *Yajnyavalkya Smriti*. Bis Smritiyan, ed. By Shriram Sharma Acharya, (1974), Bareli: Sanskriti Sansthan.
17. *Vasantarajashakuna*. Bhatta Vasantaraja, (1940), Mumbanagri: Jagadishvara Shilayantralaya.
18. *Kumarasambhava*. Kalidasa, Kalodasa granthavali, Hindi translation by Sitaram Chaturvedi, third edition, Bharat Prakashan Mandir Aligadh, 1962.
19. *Raghava pandaveeya*. Kaviraj Pandit, edited by Damodar Jha, Choukhamba Vidyabhavan, Varanasi, 1965.
20. *Mrigapakshishastra*. Hamsadeva, ed. By Chitampalli M. & Bhatkhande N. (1993), Mumbai: Maharashtra Rajya Sahitya aani Sanskriti Mandal.
21. *Manasollasa*. Someshwara. Edited by G. K. Shrigondekar. Central Library; Baroda; 1925.

Book Review: All About Owl Diet: A Technical Manual for Identification of Prey Remains from Owl Pellets in Central India

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Book Review, Owl Diet, Pellets, Prey Remains Identification, India.

Have you ever wondered about what the owls living in your area are eating? Have you just found some owl pellets, the regurgitated undigested prey remains, under the perch of a local owl but you are not sure how to proceed? Well the manual called "All About Owl Diet" has come to your rescue!

While attending the Sixth World Owl Conference in Pune, India, 29 November – 2 December 2019, I was presented with an early printed copy of this book by author Dr. Prachi Mehta and Mr. Kiran Srivastava, Chief Operating Officer of the Raptor Research and Conservation Foundation (RRCF) when the forthcoming book was announced (Fig. 2). I was subsequently asked to edit the book. It was a pleasure to do so, and I was subsequently compelled to write this book review for inclusion in the afore-mentioned conference proceedings.

The recommended citation for this book is: Mehta, P., Talmale, S., Kulkarni V., and Kulkarni J. 2020. All About Owl Diet. A Technical Manual for Identification of Prey Remains from Owl Pellets in Central India. Published by Raptor Research and Conservation Foundation, Mumbai, and Wildlife Research and Conservation Society. Pune. 216 p. ISBN 978-93-5391-691-6. The digital version of the book is now available at the WRCS (https://www.wrcsindia.org/publications-1) website.

This invaluable resource book is now a gold standard that future references of this type will aspire to. Its 216 pages are packed with information on owls and their prey (Chapter 1), pellet analysis (Chapter 2), the mammals, reptiles, birds, amphibians, and arthropods eaten by owls (Chapters 3-7), identification keys and bone charts (Chapter 8), and methods and statistical procedures (Chapter 9). Lavish illustrations and a plethora of relevant references complete this readily accessible book. These important aspects are described more fully below.

I was impressed with the authors' attention to detail and devotion to promoting owl research and conservation in India and around the world. This book also includes wisely worded forwards by Mr. David H. Johnson, Director of the Global Owl Project, and research wildlife biologist Dr. Bruce G. Marcot, U.S. Forest Service, which highlight the international context and value of the coverage of the subject matter. The authors duly and eloquently note in the acknowledgement section the extensive help they received from so many to make this reference possible.

Before I begin a brief chapter by chapter review of this valuable book, I would like to address two suggested shortcomings. Although fish are perhaps less likely to be encountered in the pellets of most

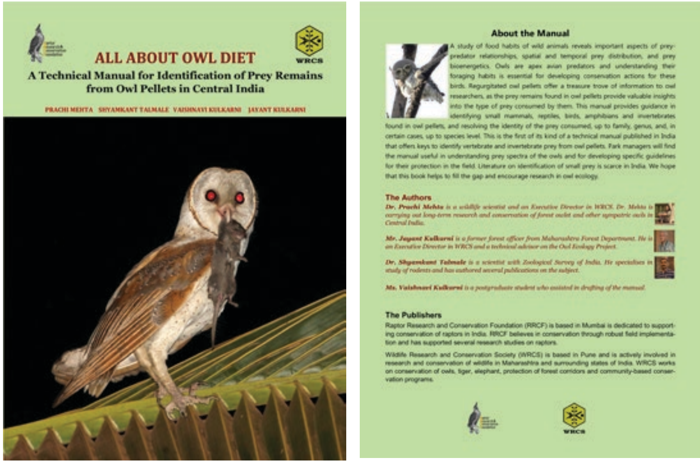

Figure 1. Front and Back Book Covers from "All About Owl Diet: A Technical Manual for Identification of Prey Remains from Owl Pellets in Central India." (Photo credit: Jayant Kulkarni).

owls in India there was a relative lack of detailed information on this prey group in this book. Some fish bones, such as pharyngeal bones and gill rakers, are helpful to identifying fish prey to species. Secondly, while the table of contents can be used to locate the relative chapter and their major sections of interest, the addition of a subject and species taxonomic index would be especially useful. Perhaps the authors can address these points in an expanded future edition of the digital version of this reference book.

The first chapter entitled "Owls and Their Prey" comprised over 10% of the book and covers the reasons why the study of owl diet is critically important to their conservation. A review of owls in India (including a summary table) and the ecological role they have is brief but thorough. The accurately illustrated overview of prey groups, i.e., mammals, birds, etc., and the occurrence of their remains in owl pellets is a great set up for the more detailed chapters, one for each prey group, that follows. Pictures of the main prey species provides a field guide level of information that is both interesting and relevant. This and other chapters end with a thorough list of relevant references, including online open access sources, that enable the reader to dive deeper into the science and natural history of owl diet analysis and prey species.

Chapter two covers pellet analysis methods including pellet collection, identification, and storage but also presents a foundation to understand the anatomy and physiology of owl digestion processes that result in the formation of pellets. This understanding is essential to appreciate the data derived from pellet analysis and its limitations for diet studies. Detailed descriptions and illustrations of pellet analysis methods will help both new and veteran naturalists and scientists.

Chapters three through seven each cover, with welcome detailed information, identification keys, tables, and figures (drawings and specimen photographs) on major prey groups (mammals, birds, etc.) at multiple taxonomic levels down to species. These chapters then expand to include specific anatomical parts of prey found in remains that are important in the identification of species (i.e., key features of various bones and dentition).

Chapter eight is short and sweet, and perhaps a good place for beginners to start reading after they have picked apart some owl pellets and are unsure to which prey group a particular prey remain is from. A quick identification key consisting of tables and pictures comparing specific bones or exoskeleton fragments from major prey groups or taxon is useful to people, especially students, from all parts of the world due to the high taxonomic level of the keys.

The last chapter (nine) is devoted to the last step of diet study, with encouraging and wise words regarding the benefit of reaching out for help from others, especially experts. The reader is also advised to create a reference prey remains collection, a recommendation I can vouch for personally as I have referred to my own owl prey specimen collection frequently over the years while researching owl diets. Chapter nine also presents different ways of summarizing and analyzing diet data. Such standardized reporting methods facilitates subsequent comparisons with other similar published studies and enable our collective knowledge of owl diets and biology to grow and advance. The recognition of the value of such knowledge to owl conservation is the perfect ending to this book. This book will be a valuable reference book for anyone interested in owls and owl conservation.

Thanks to Patricia Duncan for reviewing and improving this manuscript.

Abstracts

World Owl Conference
Pune, India, 2019

In Indian culture owl is the vehicle of Lakshmi, the goddess of wealth.
Owl devours crop pest like rodents and protects the wealth of farmers.

Plenary

Nocturnal raptors in Indian Culture: Owl-Education and Conservation in India

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I present interesting owl perceptions and aspects relevant to conservation from the Indian ethno-ornithological perspective. The subject has immense potential to win public support in owl conservation. Deeply imbibed aspects and species mentioned in any given culture are respected and generally not harmed. India is not an exception. India has a rich cultural heritage of several thousands of years. The conservative estimate of the Vedic period is ca. 7000 BC. Sanskrit is an important language and it has a long and rich tradition of literature and has a unique position as an indisputable, reliable means of understanding the life, mind and culture of ancient Indians. This includes the then existing wildlife. Unique references to owls are also available in Sanskrit literature. I gleaned knowledge from the four Vedas, various Upanishadas, Aranyakas, Puranas, Epics (Ramayana and Mahabharata) and lexicons. They help us to understand the reasoning behind the positive and negative aspects regarding owls in human psyche. Usually superstitions arise either due to misinterpretation of fleeting/ sporadic observations related to wildlife ormisinterpretation of ancient texts which consequently lead to augury. In India, nocturnal raptors are one of the most misunderstood, ill treated and neglected species, and which has not been included in the main stream of scientific research. Though there are a few wrong beliefs regarding owls, Indian religion and culture also confer a position of respect and veneration to owls. Owl is connected to *Dhanya lakshimi* - goddess of grains and goddess *Kali* or *Chamunda* who symbolizes the power of time in its all-destroying incarnation. I present the basis behind such correlations and analyze some of the ornithological references related to owls in Sanskrit. I present conservation related references that can be used to attain public support.

Owls in Myth and Culture in Austria

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Keywords:
ethnobiology, owls, culture, Austria,
interviews, beliefs

The work presented here is part of a larger "Owls in Myth and Culture" effort by the Global Owl Project. Personal interviews have been conducted in 30 countries, with the interview questionnaire translated into 22 languages. During 2019, we conducted interviews with 225 Austrian residents (ages 6 to 83 yrs) to ask them about their ecological and cultural beliefs about owls. The most common names for owls were "Eule", "Kauz" and" Uhu". Of the interviewees, 90% had heard an owl call, and 99% had seen an owl; 76% stated that there were owls near where they lived. The vast majority correctly classified the main prey of the owls, as well as the owls' nesting habitat and nesting places. Predominant among their beliefs about owls were that owls were 'powerful spirits', 'wise', 'helpful or bring good luck', or were 'just birds.' Six respondents (3%) viewed owls as being 'scary/dangerous', four respondents (2%) as being 'helpful for medicine' and two respondents (1%) as 'bad omens or bring bad luck.' Four interviewees (2%) stated to have or to know somebody who killed an owl. Some 26% stated that they knew a story or legend about owls (49% did not know of any stories or legends; 15% were not sure), but only 8% believed that they were true (50% said that did not believe the stories/legends; 10% were unsure). Interestingly, 92% said that owls were important for the environment, and 92% stated that owls should be protected.

The predominant view was that owls were beneficial, harmless, and important. Overall, Austrian citizens seem aware about the presence of owls, their ecological needs, and had a positive view of owls. Owl-themed items (e.g., clothing, jewelry) are commonly found in the marketplaces now. While the majority of the area of Austria consists of steep topography of the Alps and mountain forests with a diversity of 10 owl species, owl populations have been affected by habitat degradation, loss of old forests and breeding cavities through intensive forestry, unconscious hunting, pesticides, poisonings, dense human habitation and anthropological factors. Results from this study found evidence that the substantial majority of people interviewed had a general understanding of owl ecology and positive cultural perspectives supportive of owl protection and conservation.

Plenary

Small mammal prey and owl predator population dynamics over a 20-year period (1991-2010) in Manitoba, Canada.

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Keywords:
Small Mammal Monitoring, Owl Monitoring, Predator Prey Dynamics, Citizen Science, Canada

Long-term wildlife monitoring programs are costly and time consuming but valuable as they can potentially shed light on ecological processes and inform the assessment of the conservation status of species and management action planning. Monitoring programs can include intensive but not extensive sampling efforts such as small mammal trapping by research scientists and extensive but less intensive efforts such as citizen science monitoring programs. This study examined two such different monitoring programs and concluded that they complimented and informed or validated the other. From 1986 to 2010 annual small mammal relative abundance indices were obtained by a snap-trapping program in southeastern Manitoba, Canada and adjacent Minnesota, USA. From 1991 to 2015 owl populations were monitored extensively across Manitoba by volunteers by a citizen science program. Thus, both small mammal prey and owl predator populations were sampled concurrently for 20 years (1991-2010) enabling an exploration of predator-prey dynamics in North America's Boreal Forest and adjacent ecosystems. Pooled relative abundance indices for owls (n = 11 species) and those for small mammals (n = 9 species) were significantly correlated (r2 = 0.395, p = 0.003) and fluctuated synchronously over time. Further analysis of owl and small mammal species indices revealed that only the two most common species of owls detected, the Great Horned Owl *(Bubo virginianus)* and the Northern Saw-whet Owl *(Aegolius acadicus)*, covaried significantly with small mammal abundance. Conversely only microtine rodents (voles, subfamily Arvicolinae), but not shrews (Family Soricidae) or other rodents (i.e., mice, suborder Myomorpha), varied significantly with changes in owl relative abundance over time. The results of this analysis indicate that broad scale citizen science monitoring programs for nocturnal avian predators have value for providing time series data that is related to important ecological variables such as prey population changes over time. The relationship of small mammal prey indices to other owl population data sources will also be explored.

Plenary

Airbnb in Owls: Sharing Space and Time for Co-existence

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Keywords:
central India, diet, Forest Owlet, Jungle Owlet, Owl conservation, niche-separation, nest selection, Spotted Owlet

Ecological and environmental factors influence survival and population dynamics of a species. The Forest Owlet *(Athena brama)* is the only owl species endemic to main land in India. It is found in small isolated population in Central and parts of Western India. However, there is little understanding of how different environmental and ecological factors affect the demography, distribution and population dynamics of the Forest Owlet. Here we present data on habitat use, foraging and nesting requirements of Forest Owlet and two similar sized and widely distributed Spotted Owlet *(Athene brama)* and Jungle Owlet *(Glaucidium radiatum)* in Central India. Although the three owls share the same habitat, their diet differed significantly. The Forest Owlet consumed a wider array of prey (food-niche breadth [FNB]¼0.40) compared to the Spotted Owlet (FNB¼0.13) and the Jungle Owlet (FNB ¼0.06). The dietary overlap was highest between the Forest Owlet and Spotted Owlet (56%), lower between the Spotted and Jungle Owlet (28%), and lowest between the Forest and Jungle Owlet (22%). Nest site selection among three owls also differed. The jungle owlet nests were located on tallest trees (17.81 m) compared to those of the forest owlet (12.96 m) and spotted owlets (10.20 m, $P < 0.05$). The spotted owlet nests were lowest in height (3.95 m) compared to the forest owlet (7.57 m) and jungle owlet (8.48 m, $P < 0.05$). The entrance of spotted owlet nests was widest (18.10 cm) compared to forest owlet (7.45 cm) and jungle owlet (10.36 cm, $P < 0.05$). Nest cavity dimensions and nest height were the main differentiating features among the nests of the 3 owls. The three owls are able to co-exist as they are selecting different prey types, prey size and nest trees. However, the habitat of the owls is facing severe pressure due to illegal tree cutting, timber logging operations, forest fires and possible nest predation for eggs and chicks. It is imperative to protect the existing nest trees and incentivize owl conservation by involving local communities for long-term conservation of owls in the area.

Current perception of owls in rural western Maharashtra, India

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Introduction: Owls are nocturnal birds of prey that are popularly associated with wisdom and good omen in several countries, including India, where it is also associated with Laxmi, the Goddess of wealth. However, there also exist superstitious people who consider the owl as a harbinger of ill omen. This questionnaire based study was undertaken to assess the knowledge and current perception of people about owls.

Aim: To elucidate the knowledge and current perception about owls in rural population of Western Maharashtra.

Methodology: We administered an 8 point questionnaire to 233 people. Data pertaining to demographics was collected. Questions assessed knowledge about place and time of owl sighting, owl names, calls and perception about sighting and listening to their calls. The categorical variables were represented as proportions.

Results: The participants of this study were students (91), farmers (67), business owners (27), employed persons (35) and housewives (12). The response rate was 100%. Our results show that 86.7% had seen owls; maximum sighting was by students (42%) and farmers (27.7%). Most participants (53.4%) sighted owls either at dusk/night. Many (63.5%) had heard owl calls and 55.4% associated it with fear (45.1% students, 26.8% farmers). Almost 52.3% of the participants had no idea about the cultural significance of owls. A third of the respondents (39.4%) held superstitious beliefs. However, most of the participants (90.9%) are willing to help owls.

Conclusion: This study concludes that to date people have fear associated with both owl sighting and their calls. However, people lacked knowledge of owl names and their cultural significance. A multi centric study with a larger sample size is warranted to substantiate our results.

Recommendation: The results of this study show that a public awareness program for farmers and students is needed for enhancing owl conservation. These two are primarily important because farmers are deeply associated with the environment and spend more time in the field. Also, students need to be educated because they are curious to learn and are the flag bearers for a better future.

The agony of the so-called fortune bearers; the owl situation in Bangalore!

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Keywords:
Urbanization, Wildlife, Habitat, Manja, Black magic.

Owls are enigmatic birds, by turns mysterious, adorable, or eerie, depending on whom you ask. They play an important role in the food chain in nature and the urbanized areas. Being carnivores, they feed on 3-4 rodents nocturnally thanks to their high metabolic rate. Hence, they play a significant role in rodent control,thereby reducing the risks to crops and spread of zoonotic diseases such as leptospirosis and plague etc.

People for Animals wildlife hospital and rescue center at Bangalore is specialized in rescue, rehabilitation, and release of the urban wildlife and has been involved in more than eleven thousand avian rescue missions, of which owls are only second to kites in the figures. Barn Owls and Spotted Owlets are the most common species rescued. The escalating unplanned urbanization of Bangalore is the prime reason behind this debacle. Deprived of their habitat, these birds take refuge in man-made structures increasing their conflict with humans.

Manja entanglement,assaults from other species,unscrupulous practices like black magic, head injuries,orphans and displacement due to human conflicts are the major causes for this misfortune. Manja being a glass glazed cotton thread used to fly kites causes severe fractures and patagium tears in owls. The misconception of owls as fortune bearers has taken a heavy toll in their well-being especially in rural areas. Consequently they are hunted and traded for huge amount of money.

PFA is committed in its intent of conserving urban wildlife and provides meticulous management and treatment for these owls.. Initial care is given to the them after rescue by our facility which includes minimization of stress, providing adequate rest, heat and medication. This is followed by observation to ascertain the level of injury and condition. The prospect of further treatment or surgery is scrutinized by the vets and is carried out. The birds are kept under observation during the recovery period and its socializing and surviving skills are closely monitored. A flight test is held before releasing them to their natural habitat.PFA also holds various community outreach programs to spread awareness among students and citizens.We aim at stimulating a peaceful coexistence among humans,owls and other wildlife.

Quaternary Climatic Fluctuations and Resulting Climatically Suitable Areas for Eurasian Owlets

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Aim: The nested pattern in the geographical distribution of three Indian owlets, resulting in a gradient of endemicity, is hypothesized to be an impact of historical climate change. In current time, the Forest Owlet *Athene blewitti* is endemic to central India, and its range is encompassed within the ranges of the Jungle Owlet *Glaucidium radiatum* (distributed through South Asia) and Spotted Owlet *Athene brama* (distributed through Iran, South and Southeast Asia). Another phylogenetically close species, Little Owl *Athene noctua,* which is mainly Palearctic in distribution, is hypothesized to have undergone severe range reduction during the Last Glacial Maximum, showing a postglacial expansion. The present study tests hypotheses on the possible role of Quaternary climatic fluctuations in shaping geographical ranges of owlets.

Methods: We used primary field observations, open access data, and climatic niche modeling to construct climatic niches of four owlets for four periods, the Last Interglacial (~120–140 Ka), Last Glacial Maximum (~22 Ka), Mid-Holocene (~6 Ka), and Current (1960–1990). We performed climatic niche extent, breadth, and overlap analyses and tested if climatically suitable areas for owlets are nested in a relatively stable climate.

Results: Climatically suitable areas for all owlets examined underwent cycles of expansion and reduction or a gradual expansion or reduction since the Last Interglacial. The Indian owlets show significant climatic niche overlap in the current period. Climatically suitable areas for Little Owl shifted southwards during the Last Glacial Maximum and expanded northwards in the post-glaciation period. For each owlet, the modeled climatic niches were nested in climatically stable areas.

Main Conclusions: The study highlights the impact of Quaternary climate change in shaping the present distribution of owlets. This is relevant to the current scenario of climate change and global warming and can help inform conservation strategies, especially for the extremely range-restricted Forest Owlet.

Keywords: citizen science, comparative biogeography, Forest Owlet, geographical range, last glacial maximum, little owl, quaternary climatic fluctuations

Plenary

Owls and cemeteries: a haunting association

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Owls are shrouded in superstitions and a popular global misconception with human death. A hooting owl or perched near one's house is considered an ill omen. In some areas in Maharashtra, India, the owl is known as '*Madhe-Pakhru*' (in Marathi), literally meaning 'corpse bird'. To investigate the cause behind this uncomfortable association we undertook a pilot survey of human cremation grounds in Purandar taluka, Pune district Maharashtra in two bio-geographic zones of Western Ghats and Deccan Plateau from August to mid November 2019. We visited 57 cemeteries of three religious communities, Hindu (n=48), Muslim (n=7) and Christian (n=2). The cemeteries were in use for an average of 100 yr (10 to 200+ yr; ±30 yr). The average distance of the cemeteries from nearest human habitation was 435 m (0 to 2000m; ± 474). cemeteries were located near a source of water in 48 localities (84.2%). The various water sources included pond (n=1), lake (n=1), well (n=1), Irrigation canal (n=2), stream (n=18), stream and well (n=13), and river (n=12). The average number of trees in cemeteries was 25 (2 to 110; ± 25). The average girth of trees at breast height was 214 mm (60 to 550 mm; ± 115). Owls were seen in 53 (92.9%) cemeteries. The various owl species recorded were Spotted Owlet *Athene brama* (n=144), Barn Owl *Tyto alba* (n=30), Indian Eagle Owl *Bubo bengalensis* (n-13), Mottled Wood Owl *Strix ocellata* (n= 8), Brown Wood Owl *Strix leptogrammica* (n=2) and Barred Jungle Owlet *Glaucidium radiatum* (n= 2). The Spotted Owlet was the most common owl to be noticed.

The possible reason behind this significantly high occurrence of 6 species of owls in cemeteries could be lack of human disturbance and presence of big trees. Tree felling is quite common in the study area but trees in the cemeteries are usually protected. People do not routinely visit cemeteries and most of them in our study were located away from human habitation. Presence of a water body near cemeteries could be a source of food for owls. In some instances food offerings are kept at the cemeteries during the performance of last rites and this attracts rodents. Though owls inhabit trees in cemeteries for most part of the year, people visit them only after the demise of their kith or kin. Curious people can locate owls in canopy even during the day time, but if the time of cremation or burial is at dawn or dusk, when owls give rising calls, peoples' attention is drawn towards owls and, hence we assume, that they are linked with death. Owls are misunderstood and unless educational programs are undertaken at grass root levels, these superstitious beliefs shall continue to trouble both humans and owls. The consequences of which will be that the owls will have to pay the price in terms of their survivability. A larger survey should be conducted in the near future to understand the beliefs and connections of owls and humans.

Ecological determinants of Malabar Jungle Owlet *Glaucidium radiatum malabaricum* in the southern Western Ghats, India

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Goal: To identify the factors that influence the distribution of Malabar Jungle Owlet *Glaucidium radiatum malabaricum* (MJO) in southern Western Ghats.

Methods: Point count method with 100m radius at 276 points in southern Western Ghats (SWG) to count the MJO. Within each point, four survey protocols (Dusk watch, spontaneous calls, playback, spotlight searches) were followed. At each census point, habitat covariates were quantified at local (tree structural and understory characteristics) and spatial scales (Vegetation composition, terrain, disturbance variables). Univariate (Mann-Whitney U Test) and multivariate analysis (Classification tree and Logistic Regression model) were performed to identify the key factors that influence the distribution of MJO in SWG.

Results: Of the 276 points, 125 points (45%) had sightings of MJO. Seven variables including four tree (tree height, tree girth at breast height, tree canopy height, tree canopy cover) and two understory variables (Herb cover, Grass cover) were significantly higher in the presence sites than the absence ones. At spatial scale, owlet was strongly associated with deciduous patches close to human habitation that occur in high altitudes of greater precipitation. Classification tree model produced the most parsimonious model than the logistic regression model.

Discussion: At local scale, occurrence sites of MJO were characterised by low tree density and high values of canopy height, tree height, girth at breast height (GBH), grass cover and dead logs. Distribution model of MJO in SWG suggests that (1) rainfall pattern across the ghats is the main driver of the occurrence of MJO, (2) evenly spaced deciduous forests (including dry and moist) are the preferred vegetation types for the species, and (3) distance to human settlement have positive impact on the MJO *i.e.,* it prefers forest edges at spatial scale. Conservation of mature deciduous forest and hole-bearing trees in the SWG is suggested.

Mortality in owls in Western Maharashtra, India

Mahesh Bilaskar#*, Rahul Lonkar*, Aparna Joshi^ and Satish Pande*#
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We evaluated the causes of mortality in three owl species (N = 12) in Purandar taluka, Pune district, Western Maharashtra, India. Barn Owl *Tyto alba* (n=8), *Bubo bengalensis* (n=3), and *Strix ocellata* (n=1) were found dead between October 2017 to August 2019. We measured morphometry, examined feathers, and conducted dissections for histopathological study followed by ecotoxicology study.

The average biomass of *Tyto alba* (08)*,* *Bubo bengalensis* (03)*,* and *Strix ocellata* (01) was 304.4 gm, 865.3 gm, and 281.0 gm respectively. Feather study showed absence of 01 secondary feather in *Bubo bengalensis* (02) and *Tyto alba* (01), 08 secondary feather in *Tyto alba* (01) and 01 primary in *Strix ocellata* (01). Molting was seen in *Strix ocellata* (all feathers) and *Tyto alba* (02).

In histopathological study extensive hepatic necrosis was seen in the liver of *Strix ocellata* (1), sinusoidal congestion in *Tyto alba* (01), foreign body giant cell reaction with granulomas and parasite in *Tyto alba* (01). Kidney of *Bubo bengalensis* (01) showed acute tubular necrosis. Hemorrhages and congestion was commonly noticed in lungs of all three species. One parasite was observed in lung of *Tyto alba* (01). Hypoxic changes were seen in the brain of *Tyto alba* (02).

Organochlorine pesticide (OCPs) residues were found in liver tissues of all owls. Very high concentrations were detected in *Strix ocellata* (6.901 mg/kg) followed by *Bubo bengalensis* (0.042 mg/kg) and *Tyto alba* (0.024 mg/kg). Accumulation pattern of organochlorine pesticides in owls was in declining order DDT > Dieldrin > Lindane. Among various pesticides analyzed p,p' DDE contributed maximum towards the total OCPs.

Plenary

The barn owl diplomat

Alexandre Roulin*
(Professor of biology at the University of Lausanne, Switzerland.)

The barn owl is a fascinating bird that I am studying for more than 25 years. It is cosmopolitan, its plumage varies in coloration and this bird shows remarkable behaviour including cooperation between young siblings. In this talk I will highlight some key results our research group obtained on the study of

(1) colour polymorphism: barn owls vary in the degree of melanin-based coloration from white to reddish and from spotless to heavily marked with black spots. The degree of reddish coloration is important in the context of natural selection (predator-prey interaction), whereas the size of black feather spots is important in the context of sexual selection (male mate choice).
(2) reproductive behaviour: barn owls have interesting sexual behavior such as extra-pair copulation and divorce.
(3) social interactions between family members: The barn owl is exceptionally peaceful. Nestlings preen each other, they feed each other and they vocally negotiate which individual will have priority access to food instead of fighting.

The barn owl is thus an inspiration for us as human. We thus use this bird to bring Israeli, Jordanian and Palestinians at the same table. Farmers spread poison to kill rodents that devastate their agricultural fields. This is an ecological disaster because predators that consume poisoned rodents accumulate poison and die. We thus motivate farmers to use barn owl as environmentally-friendly biological pest control agent. To implement this project in the three regions we organize workshops with Israeli, Jordanian and Palestinians. This approach is of interest to diplomats, farmers, state leaders and even the Pope received us to explain the relevance of our ecological project in reconciliation between communities in war.

*[*Alexandre Roulin is 49 and a full professor of biology at the University of Lausanne, Switzerland. His main scientific interests are the adaptive function of melanin-based coloration and negotiation processes taking place in animal societies using the barn owl as a model organism. He actively participates in the project of promoting cooperation between the Israeli, Palestinian and Jordanian communities using nature conservation as a tool. His ambition is to reconcile human with nature and to use this inter-disciplinary approach to promote peace and respect to our environment.]*

Plenary

Declining breeding performance of Indian Eagle Owl (*Bubo bengalensis*) in Western Maharashtra, India: A 11 year study

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Indian Eagle Owl (*Bubo bengalensis*) is a breeding resident of Maharashtra state, India. I monitored the breeding performance (breeding success, fledging success, number of breeding attempts) for each year in 49 nests of the Indian Eagle Owl in Western Maharashtra for the past eleven consecutive years, 2008 to 2019. Four visits were made per nest in each breeding season. Though I made every attempt to monitor all nests during the breeding period from late October till late March, some nests were not visited each year. I also kept a record of injured or sick Indian Eagle Owls encountered during the study period in the study area. A nest was considered successful when at least one young fledged from the nest. Fledging success is defined as the number of young that fledged the nest.

I hypothesized that there was no decline in the breeding parameters (number of nesting attempts, nesting success, breeding success and average number of fledglings per nest per year) over 11 years. Data were analyzed using linear regression analysis for all four breeding parameters. The plot of each parameter over 11 years showed a negative slope, indicating a negative correlation between breeding parameters with time. Data were considered significant when p value was more than 5 %. The p value was < 0.05 for number of nesting attempts, nesting success and breeding success, rejecting the null hypothesis. However, for average number of fledglings per nest per year there was no correlation between time (p value = 0.1).

Further, twenty Indian Eagle Owls including 15 adults and 5 juveniles were found either dead or sick during the study period (10 in first phase of study and 10 in the second phase). Ten survived and were rewilded (5 adults and 5 juveniles); 8 in the first phase and 2 in the second phase. The causes for sickness or death were electrocution (n=4), road traffic accident (n=2), poisoning (n=4), starvation in cold weather (n=5), prickly awn in wings and unable to fly (n=1), wet wings in monsoon and unable to fly (n=1), trapped in a snare (n=1), mobbing by crows (n=1), and predation by mongoose (n=1).

Plenary

Owl Education and Conservation in South Africa – Successes of 20 Years (Owlproject.org)

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In 1998, Owlproject.org was founded and has been working with 75 schools and about 200,000 children so far. Owlproject.org works with a variety of activities, simple and highly effective ways to teach children the importance of owls in the ecosystem and to break the power of myths. Through education - especially for children and in schools - myths, some of them thousands of years old, are juxtaposed with biological facts. Owlproject.org has established pellet dissecting projects, owl naming projects in the Zulu languages, owl art projects and owl releasing projects in schools (e.g. Barn Owls Tyto alba, Spotted Eagle Owl Bubo africanus) as part of owl education and as a method for controlling rat populations and forgoing rat poison. Owlproject.org is making a significant difference socially, in society, for owl conservation, with poison free methods and for the environment. A survey with 4,000 questionnaires – for 2,000 children and 2,000 adults - has shown the changes of the attitude and the ecological understanding about owls, after children and adults got in touch with the work of Owlproject.org. Owlproject.org made their owl education methods international. A visit of Owlproject.org in two Austrian schools in March 2019 - as well as two Owlproject.org evenings with presentation and a programme for children in the Wilderness Area region and at the University of Vienna - started an international owl education collaboration. In collaboration with the Dürrenstein Wilderness Area, the owl projects have been carried out with the School NMS Göstling close to the Wilderness Area and the SSND School Center Friesgasse in Vienna. The teachers and children have worked in the owl projects with enthusiasm, love and dedication. The international owl education collaboration - with skype calls between the schools in South Africa and Austria as highlights - started international friendships among the children, across continents, gave them unforgettable experiences, insights into other cultures and let them learn a lot about owls, the environment and conservation. Next to owl pellet dissection and creating owl posters and paper owls, biscuits in owl shape were made by the children. In two bake sales the children sold their biscuits, cakes and muffins to support Owlproject.org. Next to collaborating with international partner schools, Owlproject.org enjoys international recognition, has international collaboration partners and is part of the worldwide study "Owls in Myth and Culture" of the Global Owl Project (GLOW). Jonathan Haw, founder of Owlproject.org and EcoSolutions.co.za, is Special Achievements Award winner of the World Owl Hall of Fame. With the expertise of Owlproject.org, the Dürrenstein Wilderness Area is planning to establish long-term Owl Education and Predator Education for children and adults, an Owl Exhibition in the planned Visitor Center "House of the Wilderness" as well as Owl Education in nature in and around the Wilderness Area.

Home ranges and philopatry of Snowy Owls wintering on the Canadian prairies

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Keywords:
home range, snowy owl, migration, telemetry, food supply

In parts of North America, Snowy Owls *Bubo scandinavica* are irruptive and highly nomadic in winter, being found hundreds of km south of their breeding grounds in the high Arctic only in some years. In contrast, some individuals seem to migrate long distances south every year to spend the winter months predictably on the Canadian prairies. I was interested in the winter movements and home range sizes of such owls with regular migration and the extent to which home ranges of an individual overlapped in subsequent years: “winter philopatry”. I fitted 23 wintering owls in central Saskatchewan with backpack GPS/GSM transmitters, 12 of which returned to the prairies in at least two subsequent winters. Movement patterns were diverse with some individuals maintaining a single home range all winter and others moving between up to three home ranges during a winter season. Home range size and the distance moved did not differ between sexes in winter. Between years, the tracks of some owls overlapped locations they had visited in the previous year but home ranges where they eventually settled (95% MCP) did not overlap. Hence, philopatry is scale-dependent. Some Snowy Owls in central North America migrate along similar pathways each year to winter in the same geographic region, the central Canadian prairies. But establishment of smaller-scale home ranges on the prairies likely depends on the winter abundance of deer mice and voles which do not have regular cycles but are patchy and unpredictable between years.

Plenary

Long-eared Owl *(Asio otus)* nesting behaviour documented using a camera trap in 2015 in Balmoral, Manitoba, Canada.

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Keywords:
Long-eared Owl, *Asio otus*, Nesting Behaviour, Camera Trap, Canada

Observational studies of animal behaviour provide information that is an important part of the scientific method. Sometimes a single observation can shed new light on species' natural history. In turn this information can inform conservation action planning needed to sustain populations of species, especially those of conservation concern. However, many species of wildlife are difficult to observe directly without affecting their behaviour, especially those active mainly at night and those sensitive to disturbance, such as nesting owls. Camera traps that record images or video files of nesting birds are increasingly used to address these logistical challenges, but the methods used to quantify bird behaviour from image or video files, and assessments of the effectiveness of camera traps, are still being developed and explored. A camera trap was set up to record images at a nest site of a breeding pair of long-eared owls (*Asio otus*) in Manitoba, Canada in 2015. An analysis of 128,694 camera trap images collected over 15 days during the nestling period until the nestlings fledged was conducted. The ability to quantify nesting behaviour and identify prey delivered to the nest was assessed. A time activity/behaviour analysis, such as prey provisioning rates, and a summary of identifiable prey species delivered to the nest will be presented. This is the first time this owl species has been studied with this increasingly popular technology.

Diet, Nesting Ecology and Conservation Challenges of Endangered Forest Owlet *Athene blewitti* and sympatric Spotted Owlet *Athene brama* and Jungle Owlet *Glaucidium radiatum* in Central India

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Keywords:
central India, diet, Forest Owlet, Jungle Owlet, owl conservation, niche-separation, nest selection, Spotted Owlet

Ecological and environmental factors influence survival and population dynamics of a species. The Forest Owlet (Athena brama) is the only owl species endemic to main land in India. It is found in small isolated population in Central and parts of Western India. However, there is little understanding of how different environmental and ecological factors affect the demography, distribution and population dynamics of the Forest Owlet. Here we present data on habitat use, foraging and nesting requirements of Forest Owlet and two similar sized and widely distributed Spotted Owlet (Athene brama) and Jungle Owlet (Glaucidium radiatum) in Central India. Although the three owls share the same habitat, their diet differed significantly. The Forest Owlet consumed a wider array of prey (food-niche breadth [FNB]¼0.40) compared to the Spotted Owlet (FNB¼0.13) and the Jungle Owlet (FNB ¼0.06). The dietary overlap was highest between the Forest Owlet and Spotted Owlet (56%), lower between the Spotted and Jungle Owlet (28%), and lowest between the Forest and Jungle Owlet (22%). Nest site selection among three owls also differed. The jungle owlet nests were located on tallest trees (17.81 m) compared to those of the forest owlet (12.96 m) and spotted owlets (10.20 m, $P < 0.05$). The spotted owlet nests were lowest in height (3.95 m) compared to the forest owlet (7.57 m) and jungle owlet (8.48 m, $P < 0.05$). The entrance of spotted owlet nests was widest (18.10 cm) compared to forest owlet (7.45 cm) and jungle owlet (10.36 cm, $P < 0.05$). Nest cavity dimensions and nest height were the main differentiating features among the nests of the 3 owls. The three owls are able to co-exist as they are selecting different prey types, prey size and nest trees. However, the habitat of the owls is facing severe pressure due to illegal tree cutting, timber logging operations, forest fires and possible nest predation for eggs and chicks. It is imperative to protect the existing nest trees and incentivize owl conservation by involving local communities for long-term conservation of owls in the area.

Distribution changes and current status of Owls in Ukraine

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Eleven breeding species are known from the Ukraine, and Hawk Owl (*Surnia ulula*) and Snowy Owl (*Bubo scandiacus*) invasions occur mainly in the autumn or winter period. Tawny Owl (*Strix aluco*) and Long-eared Owl (*Asio otu*s) are the most numerous and widespread owl species in the Ukraine. Tawny Owl is a common species of old mixed and deciduous woodlands; its quantity is stable and fluctuates in relation to prey density. Little Owl *(Athene noctua*) was common, and uncommon in human settlements. In the city of Lviv, it averaged 0.6-0.8 calling males per km². A decreasing trend was noted in the past decade, probably caused by the disappearance of large farms, which were suitable breeding sites. Long-eared Owl is a rather common breeding and wintering species with winter aggregations of up to 100 birds observed in settlements. They are strongly dependent on climate conditions and prey- base richness.Short-eared Owl (*A. flammeus*) was a common species in the past. Currently they are considered as very rare breeding (northern and western parts) and rare breeding and wintering species (in the south). The breeding density of the species consists about 0.5 pairs/km² on same meadows of the western part of Ukraine. Some owl species showed an increase during the past decade both in their numbers and distribution.

The Barn Owl *(Tyto alba*) was a common breeding species in the western Ukraine and not numerous in the central and eastern ones in mid-20th century. A significant decrease occurred during the second half of the century. This species is now very rare in the Western Ukraine, and mainly occurs in the southern Ukraine, where an increase in numbers was noted in the past decade. Eagle Owl (*Bubo bubo*) and Scops Owl (*Otus scops*) were characterized by stable populations during the second part of the last century. *Bubo bubo* was not a numerous breeding species at the beginning of the 20 century. Currently it is rare as a result of degradation of the natural habitats and a decrease of the prey base. The *Otus scops* is a common breeding species and occurrs in the southern parts of Ukraine but is rare in the west. It shows an increase in numbers and appears more often at the northern border of its area.

Two species display positive quantitative trends during the past decade: Great Grey Owl (*Strix nebulosa*) in northern Ukraine and Ural Owl (*Strix uralensis*) in the western part of the country. *Strix nebulosa* was a rare breeding species and occurred in the Polissya area (northern Ukraine) only. South- and southwestwards expansion of the species has been observed in recent years. Current population consists of ca. 65 breeding pairs, and depends significantly on the prey base.

Strix uralensis was rare in the mountain and foothill parts of the Carpathian region and a very rare vagrant in the plain areas about 30 years ago. Breeding range has expanded rapidly to the east- and northeast during the last years. The process of range expansion was noted in all the sub-Carpathian and neighboring areas. The density reached 1.7-2.2 pairs/10 km² in some of the new occupied habitats (e.g., in forests in the vicinity of Lviv). Nowadays the species occurs in about 200 km from the Carpathian Mountains and the process of expansion is on-going.

Because of low numbers, population trends of Boreal (*Aegolius funereus*) and Eurasian Pygmy Owl (*Glaucidium passerinum*) are unknown. *Aegolius funereus* is rare and poorly studied. Majority of observations are from the coniferous and mixed forests of the Ukrainian Carpathian Mountain areas and northern Ukraine. *Glaucidium passerinum* is a typical boreal species, which prefers coniferous forests. It occurs in the Ukrainian Carpathians and in the northern and north-western forests of the country.

Eight owl species are included to the Red Data Book of Ukraine (2009) - *Bubo bubo, Aegolius funereus, Glaucidium passerinum, Strix uralensis, Strix nebulosa, Tyto alba, Otus scops* and *Asio flammeus.*

Multi-annual patterns of moult of flight feathers (retrices and remiges) from two captive Great Gray Owls (*Strix nebulosa*) and two captive Long-eared Owls (*Asio otus*) in Manitoba, Canada.

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Keywords:
Moult, Captive Owls, Long-eared Owl, Great Gray Owl

Moulting, breeding and migration are three major energy demanding annual life cycle processes in birds. Owls often occur at low densities and can be hard to capture, and as a result knowledge of their annual moult cycle is limited by studies with small sample sizes and incomplete phenology. While the energy budgets of captive non-breeding birds are dramatically different from wild birds, their availability for study creates an opportunity to learn about moult when food is not limited. Studying the feathers of captive birds that are dropped in the process of moulting is a non-invasive way of studying this important aspect a bird species' life history. Multi-annual patterns of the moult of major flight feathers (retrices and remiges) were derived from moulted feathers collected and labelled from two captive non-breeding Great Gray Owls (*Strix nebulosa*) and two captive non-breeding Long-eared Owls (*Asio otus*) in Manitoba, Canada. The results will be summarized and compared with existing limited knowledge from studies of wild individuals of these species. The value and limitations of obtaining similar information from other captive owls will be discussed.

Evolution in Gene Sequences Responsible for Hearing, Sight, and Digestion in 99 species of Owls, Raptors, and Passerines

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Keywords:
gene sequences; hearing; vision, digestion; owls

Owls are typically nocturnal hunters equipped with great capabilities for night vision, hearing and the digestion of mammal prey, but the relevant genetic basis for this remains largely unknown. In this project, we examined the sequences of 286 genes responsible for hearing, vision, and digestion. At the time of abstract submission, we had evaluated the adaptive evolution of the genes related to vision, hearing and digestion in 47 bird species including owls, raptors and passerines through the gene capture of coding sequences of our focal genes. Positive selection gene analyses of the 47 species together with other published bird gene sequences reveal the positive selection of genes related to vision, hearing and digestion. Preliminary results indicate: 1) 1) two hearing genes are under positive selection in owls, which may suggest their increased sensitivity to sounds; 2) for digestion in owls, some genes related to the digestion of carbohydrate, protein and fat are under positive selection, 3) for vision genes in owls, both night vision genes and bright light vision genes show positive selection, consistent with the crepuscular and night vision of owls. The finding of these positively selected genes suggest their functional enhancement in the adaptation to nocturnal hunting. Comparative analyses of the genes between owls, raptors and passerines, along with a review of their diel activity patterns and aspects of silent flight, suggest their evolutionary adaptation to different lifestyles.

Serious declines in grassland owl species in the Great Plains of North America

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Keywords:
grassland owls, population declines, Great Plains, North America

Goals: To examine the population declines of grassland owls (Burrowing Owl *Athene cunicularia*, Barn Owl *Tyto alba*, Short-Eared Owl *Asio flammeus*) inhabiting the Great Plains of North America in summer and winter, with a focus on the eastern portions of the Great Plains (east of the 100th meridian).

Methods: Utilizing BBS and CBC data, two well-recognized long-term databases, as well as data from state and provincial wildlife agencies, citizen science efforts, and the published literature.

Results: both BBS and CBC data reveal significant declines in all three grassland owl species, with the sharpest declines occurring in the prairie provinces of Canada, and in the US and Canada east of the 100th meridian. State and provincial data indicate the same trend; grassland owl distribution and numbers are greatly reduced in the eastern grasslands (tallgrass and mixed-grass prairies), but also in the short-grass prairie just west of this.

Discussion: Grassland ecosystems are among the most endangered of our global ecosystems, and the loss of grasslands is among the most pressing of conservation issues in the world. Owls in general, and grassland owls in this case, can serve as sensitive bioindicators of environmental quality – veritable canaries in the proverbial coal mine. In North America, BBS and CBC data reveals that grassland birds in general have declined more than any other bird group. Reasons for this decline include grassland habitat loss/fragmentation due to urbanization, conversion to agriculture (including mowing, grazing, burning, etc.), human disturbance, pesticide use, and climate change (drought, etc.), among others. Grasslands are among the easiest lands to develop, and among the most undervalued for their ecological (ecosystem services) and aesthetic values. The steep declines of grassland owls (and other birds) are telling us that there are serious ecological problems in our grasslands, and substantial and serious measures are required immediately to address these problems before they negatively impact human well-being

Biometry based ageing of Mottled Wood Owl (*Strix ocellata*) nestlings and ecological correlation with differential resource allocation

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Biometric analysis helps in sex differentiation, understanding development, ecological studies and survivorship. We suggest that biometry, a non-invasive technique, can also be a reliable, practical and inexpensive tool to determine the age of nestlings in the field. We performed serial biometry of nestling Mottled Wood Owl ((*Strix ocellata*) from day 1 of life till fledging (34 to 36 days from hatching. We targeted two nests in Purandar taluka and Baramati taluka in Western Maharashtra, India. Two nestlings were present in each nest located in a tree hollow open to the sky. Necessary permissions were taken and measurements were taken during the period of female inattentiveness. We measured wing chord, tail length, culmen, tarsus, middle toe, middle talon and body mass to the nearest mm and gram respectively. Data of growth pattern was analyzed using logistic growth model, discriminant analysis and CHAID (Chi-squared Automatic Interaction Detection) based decision tree. We found that the 90% growth of tarsus (Avg 37.4 mm, ±SD 10.8) and beak (Avg 24.6 mm, ±SD 5.9) occurred by 36 days first phase, when the nestlings left the nest by walking out to adjacent branches. Mottled Wood Owls use this strategy to survive because the nests get soiled and smelly due to the fecal droppings and pellets of nestlings over a period of time and can potentially attract predators. After the nestlings survive this crucial first phase of life and become branchers and enter the second phase of life, resources were allocated to the growth of wings (Avg 90.3 mm, ±SD 62.3) and tail (Avg 27.6 mm, ±SD 22.3), which had attained only 50% growth in the first phase. Thus we see that there is an excellent correlation between ecological need and differential resource allocation to tarsus and beak in the first phase and to the growth of wings and tail in the second phase. The growth of toes, talons and biomass was seen to be exponential throughout the growth period. The third phase is when the nestling fledges and takes flight. For this the flight formula (the ratio of wing chord and the biomass) has to reach a specific value of 0.47 (determined by morphometry of adult birds). In the last week of nestling stage, the reduction in biomass is seen to achieve the correct value of flight formula.

The biometry of Mottled Wood Owl nestlings can be used in the field to accurately determine the age of nestling, assess growth rate and understand ecological correlation with differential resource allocation to assist survival. Serial biometry of Mottled Wood Owl nestling, an Indian endemic, is presented here for the first time for this species and we hope that it shall be a useful tool in the hands of biologists and managers for conservation of this species.

Plenary

Cyprus Scops Owl (*Otus cyprius*) nest-box breeding program 2015-2018

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Recent studies have proved that the endemic Cyprius Scops Owl (CSO) on the island of Cyprus can be differentiated from the nominate and other species and sub-species, on the basis of mtDNA, plumage and vocalizations. However, it remains unknown as to whether the species is sedentary, partially or completely migratory. Also, in face of the uncertainty of the status of the endemic species, and past evidence that quite a few are hunted when returning to the island in the spring, and our unpublished data on the decrease in numbers in Paphos Forest, we decided to initiate a nest box program in the Paphos Forest in the framework of the Forestry Department, and it continues to date. Here we present the breeding data for the four breeding seasons of 2015-2018. In 2015 we placed 50 nest boxes, added another 10 in 2016, 2 in 2017 and 64 in 2018. Most were placed on *Pinus brutia* (56, 85%) at an average height of 5.8 m ($\pm$ 1.5). In 2015 - 18 of the boxes were occupied by CSO, in 2016 - 20, in 2017 - 43 and in 2018 - 26 for an average occupancy rate of 44%. Nest boxes were also occupied by Common Kestrel (*Falco tinnunculus*, N = 4), Barn Owl (*Tyto alba*, N = 1) and European Roller (*Coracias garrulous*, N = 1). Of the 96 breeding attempts by CSO, we successfully documented the breeding parameters in 94. Average clutch size for all 4 years was 2.5 (1-4, 0.96 SD, N = 91) and was statistically different between years ($F_{3,87} = 3.82$, $p = 0.012$); of which 2.1 (1-4, 1.26) hatched and also differed between years ($F_{3,87} = 3.67$, $p = 0.015$), as were the average 1.99 (1-4, 2.18) young fledged per breeding pair ($F_{3,87} = 2.96$, $p = 0.038$). A total of 17 (16%) pairs laid a 1-egg clutch, 37 (35%) had 2-egg clutch, 40 (37%) had 3-egg clutch, and 13 (12%) had 4-egg clutch. We found that location did not influence breeding success, only the year ($F_{3,85}=3.71$, $p = 0.014$). However, pairs that breed in the forest or in rural areas took 3-days longer to fledge their young as compared to those boxes placed at the ecotone of the forest edge. Further we noted that all boxes (N = 24 attempts) that were oriented to the south, southwest or west failed; and at present we are unable to explain the reason behind this.

Ural Owls *Strix uralensis* in the Dürrenstein Wilderness Area, Austria *(IUCN Category I, UNESCO World Heritage Site)*

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Keywords:
Ural Owl, reintroduction, deadwood, primeval forest, Austria

The Ural Owl *Strix uralensis* became extinct in Austria in the first half of the 20th century. In 2008, a project was started to reintroduce the owl to Austria to close the distribution gap between Slovenia and the Bohemian Forest. The Dürrenstein Wilderness Area (IUCN Category I, UNESCO World Heritage Site), including Spruce-Fir-Beech Primeval Forest Rothwald, is a natural mountainous forest, rich in deadwood and rich in natural breeding cavities for owls. Therefore, it was chosen as one of two release sites next to the Wienerwald Biosphere Reserve. In the Wilderness Area, long-term telemetry has been used to monitor success and to learn about habitat selection, foraging preferences, breeding success and dependence on beech mast and rodent cycles. From 2009 to 2019, 175 owls were released in the Wilderness Area region. In the first ten years, 14,210 daily owl positions and 16,800 kilometers of movement (by 2018) have been registered by 114 transmitters of three telemetry systems and five main models: two radio telemetry models (n = 64), one satellite telemetry model (n = 3) and two GPS-GSM-telemetry models (n = 47). The ideal GPS-GSM-telemetry transmitter model was developed together with the Polish company ECOTONE. Experiences with telemetry are shared in an international community to develop minimal standards for owls and birds of prey. After the first ten years of the project, 15 territories and 10 breeding pairs have been established in the Wilderness Area region, breeding in larch nest boxes and natural tree holes in beech trees and maple trees. For the release the ideal age of around 90 days was determined. Movement routes of up to 150 km, survival rates of about 75% in the first year after release, and various causes of death (e.g., predation by Golden Eagle) were recorded. The owls are supported by a nest box network. However, first priority is raising awareness for the importance of deadwood and natural breeding holes for biodiversity and breeding success of owls.

How owls impact the prey population structure: is their prey choice selective?

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Keywords: Long-eared Owl, selective predation, Strigiformes, Microtus, voles

It is widely known that predators prey upon poor quality individuals, such as those that are injured, old or juvenile, socially subordinate and inexperienced. Moreover, predators may differentially take individuals of different ages and sexes within a population of prey species. In this way, selective predation can significantly impact the structure of prey populations. Thus, our study aimed to: (1) estimate the size and sex of prey in the diet of Long-eared Owls and (2) compare them with the size and sex of prey in the field. We studied the sex ratio and size of Root Voles and Common Voles in the diet of Long-eared Owls and in the field. The study was conducted in 2016 and 2017 in the Moscow Region of Russia (56º45ʾN 37º45ʾE). Our results showed that Long-eared Owls more often caught individuals of a specific size, species and sex. In general, individuals of two main prey species in the pellets of Long-eared Owls were significantly smaller than the trapped animals. Moreover, the body mass of prey varied in different years of the study. In favourable years, or in phases with increased voles, owls caught larger animals. Long-eared Owls more often caught females of both species of voles. However, the proportion of females in the owls' diets varied in different years.

Plenary

Owl Education and Conservation in India: Ela Foundation Experience

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Ela Foundation is involved in Owl Conservation for more than 20 years. Intensive education and public-outreach programs are conducted for rural and urban communities. The target audience includes students, teachers, farmers, corporate houses, NGO's and also enforcement agencies like forest, police, and revenue departments. We give talks, multi-media presentations, screening of video films made by Ela Foundation based on first hand research, conferences, exhibitions and Owl Festivals. A new method adopted by Ela Foundation is the online publication of a series of six Owl Podcasts which has an international outreach. The podcasts can be heard on several renowned platforms with listeners from >30 countries. We focus on the need for owl conservation; explain about habitat requirements, biology and ecology, threats and reasons behind superstitious beliefs in a simplified manner. Conservation measures that can be undertaken by laymen are explained. The importance of working with the Forest Department is conveyed. To date we have reached > 2, 50, 000 public and programs are ongoing. The involved persons become ambassadors for owl conservation. We include in our program several Indian states including Maharashtra, Goa, Karnataka, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand and Gujarat. We also create owl souvenirs for distribution to the public. These include stickers, T-shirts, caps, pins, and other items. We also publish owl species 'Life Fact Files'. These include Barn Owl, Spotted Owlet, Brown Fish Owl, Indian Eagle Owl, and Mottled Wood Owl. The publications are periodically uploaded to our website for free viewing and download (www.elafoundation.org). To augment our understanding about secretive and nocturnal owls we conduct original research by working closely with the Forest Department. Our education programs are continuously backed and strengthened by insights obtained through research on owls through extensive field work. In addition to educating the public to the importance of protecting owl habitats, we also publish our research in scientific journals and present our findings at national and international conferences.

Plenary

Owls in Myth and Culture – Exploring Options for Conservation and Societal Change

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Keywords:
ethnobiology, owls, culture, beliefs, laws; education; grandmothers

Owls figure prominently in human culture and mythology, and this relationship goes very deep in time (e.g., 30,000 yrs). Owls are found on every continent except Antarctica, and are intertwined to a greater or lesser degree with nearly all human societies. It follows that beliefs and attitudes about owls should have a fundamental role in the protection and conservation (or lack thereof) for owls. It is easy to find a wild array of myths/legends about owls, but what do people *really* believe about owls now? This presentation draws from 6000+ personal interviews conducted in 30 countries to obtain information about the interviewees, their ecological knowledge about owls, and their understanding of owl myths and legends. In addition to the interviews, we also did an extensive literature search, and reviewed archeological, anthropological, art, and religious aspects of the human-owl relationship. Results were rich, illuminating, sometimes startling, and varied tremendously across societies. Owls are viewed across the spectrum as being very dangerous spirits who are associated with death, to a sacred Creator Being (who started the earth), to realistic (predatory species within ecosystems). Interestingly, we found that beliefs about owls have not changed in some countries since the late 1800's, while beliefs in other societies are changing rapidly. Importantly, as part of this effort, we also discovered significant illegal trade in live and dead owls, and owl eggs. The majority of educational programs are focused on owl biology; results of interviews and insights from some long-term programs (e.g., Belize) note the lack of cultural "traction" in creating conservation change.

From a conservation perspective, we wish owls to have "respect", "equality", and to be "valued". In support of owl conservation, what does 'success' look like? Are there any particular owl species with positive cultural attributes? How can we move the cultural dial to one more beneficial to owls? How do societies learn? Examples of 'success' in positive cultural attributes are reviewed in this presentation.

Nesting and roosting habitat characteristics of Asian Barred Owlet (*Glaucidium cuculoides*) in Raghuganga, Myagdi district, Nepal

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Keywords: Asian Barred Owlet, playback, nest, roost, roosting height, IVI.

Nepal has 23 owl species including the Asian Barred Owlet. No specific study has been conducted to reveal information on their distribution as well as nesting and roosting habitats. Thus, this study explored nest and roost sites characteristics of this species. Listening/playback surveys were conducted at dawn and dusk during their breeding season (February-April of 2019) in Raghuganga-02 of Myagdi district for recording their presence and further habitat assessments. Tree and habitat characteristics in a circular plot of 314m^2 around the recorded sites were measured and analyzed using MS-Excel, SPSS Packages and Kruskal Wallis Tests was performed to identify the variability of roosting height with other tree variables (dbh, height, tree canopy). We found a total of 6 nest sites and 101 roost sites. All the nests were located in tree cavities with highest in *Ficus semicordata* and *Bombax ceiba*. Mean nest height was 5.43 m (± 0.75 SE) in trees with average height of 12.05 m (± 1.45) and average DBH of 32.83 cm (± 2.03). The nest in the trunk of the trees oriented in general to the east and southeast direction. Roosts were located in several deciduous tree species (98.02 % in live tree) with moderately closed canopy (30.43%), mostly near agricultural fields; 23.23% of roosts were located in *Alnus nepalensis*. Mean roost height was 8.2 m (± 0.42) in trees with average height of 14.66 m (± 0.75) and average DBH of 29.61 cm (± 1.45). The roost sites oriented east and southeast. The roosting height was significantly different with tree height (P-value, 0.000) and tree DBH (P-value, 0.000). The roosting height also differed among the different tree species (P-value, 0.004). *Alnus nepalensis* with Important Value Index (IVI) of 58.28% (nest) and 46.54% (roost) was identified as the essential tree species in the breeding and roosting habitats. Thus, this study suggests that large trees of *Alnus nepalensis* must be protected for the habitat conservation of Asian Barred Owlet. Similarly, continuous and extensive research focusing on this species status, distribution and habitats should be implemented to promote the conservation of this species.

Impact of trophic and weather-climatic factors on dynamics of vole-eating raptors in the breeding habitat

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Keywords: *Asio otus, Asio flammeus, Falco tinnunculus*, numbers dynamic, vole-eating birds, trophic and weather-climatic factors.

The study was conducted at the Crane's Homeland Reserve (Russia, Moscow Region) from 2001 to 2016. We counted the breeding pairs of Long-eared Owl (*Asio otus*), Short-eared Owl (*A. flammeus*) and Common Kestrel (*Falco tinnunculus*) in the nesting period each year. At the same time the number of small mammals was estimated in spring and summer. We used different indicators characterizing weather-climatic parameters during the reproduction period. The aim of the study was to identify the joint influence of trophic and weather-climatic factors on the dynamics of the three species of raptors.

It is known that abundance of prey influences the dynamics of abundance of raptors. The climatic and local meteorological factors can be significant. The results of modeling showed that the number of Long-eared Owls significantly depended on only trophic factor (β=0.77±0.1). The numbers of Short-eared Owl and Common Kestrel significantly depended on both factors. The degree of influence of trophic factor on the change of the number of predators was greatest for Short-eared Owl (β = 1.64 ± 0.16) and the smallest for Common Kestrel (β = 0.38 ± 0.12). The influence of climatic and weather factors (β=0.41±0.09) slightly exceeded the influence of trophic factors for Common Kestrel. The climatic factor effect (β = 0.36 ± 0.09) was 4.5 times less than the trophic factor effect for Short-eared Owl.

Abiotic environmental factors (primarily a combination of a temperature and humidity in the spring period) can significant influence on the amplitude and frequency of fluctuations in the numbers of three species of birds of prey and lead to their reduction or growth in adverse and favorable seasons.

Owls in Myth and Culture in South Africa

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Keywords:
ethnobiology, Strigiformes, cultural beliefs, mythology, interviews, social sciences

During 2012 and 2019, we conducted interviews with 210 South African residents (ages 18 to 60+ yrs) to understand local ecological knowledge and cultural beliefs about owls. We used the standardized interview questionnaire of the Global Owl Project. Most participants were English, Afrikaans or isiZulu speakers, and the most common names for owls were “Izikhova”, “Morubitshi”, “Leribishi” and “Uile”. Of the interviewees, 88% had heard an owl call, and 94% had seen an owl; 71% stated that there were owls living in their vicinity. The vast majority correctly classified the main prey of the owls, as well as owls’ suitable nesting sites. Predominant cultural beliefs about owls included owls to be ‘wise’, ‘scary / dangerous’ and ‘bad omens that bring bad luck’. However, most participants were fully aware that owls were ‘just birds.’ Seven respondents (3%) viewed owls as ‘helpful for medicine’. 36 interviewees (18%) stated they know somebody who killed an owl. Some 52% shared stories or legends about owls with us, but only 15% believed that they were true. Despite sometimes negative connotation about owls, 77% said that owls were important for the environment, and 75% stated that owls should be protected. The predominant views were that owls were important (54%), harmless (43%), beneficial (31%), scary (23%), or bad omens (15%). Owls (*e.g.*, Barn Owls *Tyto alba*) help to control rat pests in South African townships. Owlproject.org educates school children to enable a change of societal beliefs and the attitude towards owls. There continues to be a belief-use about owls in traditional medicine or ‘muthi’.

How does Mottled Wood Owl *(Strix ocellata)* behave during rearing the chicks? A Camera Trap Investigation

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Camera trap analysis has emerged as a successful non-invasive method for collecting a wide range of biological data on diverse taxa of animals. We deployed camera traps on two nests (Nest 1, Pingori, Tal. Purandar and Nest 2, Supe, Tal. Baramati, both in Dist. Pune, Maharashtra) of Mottled Wood Owl (*Strix ocellata*). The study duration for Nest1 was 7 January to 18 February 2019, and for Nest2 was 7 February to 8 March 2019. Bushnell and Reconyx cameras were used. Nest1 was monitored from 5 days prior to hatching of first egg until the fledging (branching) of last chick (49 days) and Nest2 was monitored from hatching of first egg until one day prior to branching of last chick (29 days). Total of 65,269 images (Nest1 – 29,822, Nest2 – 35,447) were eyeballed and scrutinized. Two eggs were laid in each nest with hatching interval of 2 days. Three chicks walked out of the nest at an average of 35 days after hatching and one chick in Nest1 died on day 17 after hatching.

Time budget analysis of parents over the duration of 77,431 minutes showed that 56% (43,410 minutes) time was spent attending the nest (12% incubation, 33% warming the chicks, 9% feeding, 2% guarding). Total 170 food items were brought to the nest by both parents of which 57% were birds(Red vented bulbul, Large Grey Babbler, Prinia, House Sparrow, Baya, Indian Silverbill, Tailorbird), 7% were rodents(Mouse, Rat, Gerbil), 2% reptiles (Garden Calotes) , 1% each amphibians and insects and 32% were unidentified.

Average food delivery per night at Nest1 was 2.8 items (Range1-7; ± 1.73 SD) and at Nest2 was 3.13 items (Range 0 -15; ± 4.37 SD). Caching was seen at Nest2 and no delivery of food at nest was recorded up to 2 days after caching. Nest1 was visited by 11 visitors of four species (Five-Striped Palm Squirrel, Large Grey Babbler, Red-vented Bulbul, and South-Western Langur), but the nest was undisturbed. The food was delivered continually from 7 pm to 6 am with average of 7 (Range 5.5 to 11.5; ± 1.66) SD food items per hour. The maximum food delivery was between 11pm to 1 am (17 items). Chicks were mostly inactive from 6 am to 6 pm. Chicks started wing flapping 1 week prior to branching.

Thus, our study confirms the utility of camera trap analysis in better understanding of the secret in nest behavior of this endemic Mottled Wood Owl.

Barn owl, *Tyto alba*, a major component in the integrated rodent pest management in field and plantation crops

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Barn own (*Tyto alba*) regurgitated pellets were collected from roosting and nesting sites across Kerala and analyzed for prey composition. A total of 72 roosting sites (buildings, temples, trees, artificial nesting sites, *etc*.) were recorded during the study. Man-made structures were mostly preferred by the owls (78%). Barn owls used a variety of perch sites during foraging, with electric poles being the most favoured perch (36.2%). Inverted coconut petiole, 20 per acre of rice crop, were installed and live burrow counts (LBC) were recorded pre- and post installation. Wooden nest boxes were installed on trees, buildings, and threshing yards, near rice and vegetable fields, and coconut and cacao plantations. Both owl perch installation and artificial nesting sites resulted in a reduction of rodent activity in the field as evident from the LBC of 25 active burrows as against 41 in control plots (without owl perch and nesting sites) . In total, 359 regurgitated pellets were collected from the major rice producing locations of Kerala. Weight (mean 4.9g), length (mean 4.1cm) and breadth (mean 2.8 cm) of the pellets varied slightly in different locations of collection. Analyzed pellets showed that rodents (78%) made up the bulk of barn owl diet and rest were insectivora (21%) and birds (1%). Major field rodents, *Rattus* sp*., Mus* sp. and *Bandicota bengalensis,* constituted the barn owl diet. Our results suggest that the barn owl can be a major component in the integrated rodent pest management in agricultural fields as well as plantations.

Keywords: Barn owl, rodents, rice, coconut, owl perch

Predicting the potential roost sites of two sympatric *Otus* owls of the Andaman Islands using ecological niche models

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Keywords: MaxEnt, Otus balli, Otus sunia, roostsites, Andaman Island

Goal: To predict and compare the roost sites of two sympatric owl species (Andaman Scops Owl Otus balli, Oriental Scops Owl Otus sunia modestus) of Andaman Islands using ecological niche model.

Method: Look-see method aided by call playback of conspecifics to locate the roost sites. We recorded 42 and 69 independent roost sites of Andaman Scops Owl (ASO) and Oriental Scops Owl (OSO) respectively, but only 38 points of ASO and 65 points of OSO were retained for model building. We extracted environmental variables that explain terrain (elevation, slope, Aspect), climate (Land Surface Temperature), vegetation and water (NDVI, NWDI, LULC, Proximity to water) from satellite images. MAXENT-3.4.0and ENM tools-1.4.4 tools were used to predict and compare the ecological niches of these two species.

Results: Among the environmental variables, elevation, LULC and proximity to water contributed the most to the roost sites of ASO while it was LULC and LST for OSO. The endemic ASO preferred evergreen habitat for roosting. OSO showed no habitat preference for roosting but avoided evergreen patches. The potentialarea available to the OSO for roosting (2400 km2) was greater compared to ASO (1411 km2) based on 10% logistic threshold. Predicted area of overlap between ASO and OSO was 165 km2 (0.332 Schoener's D index).

Discussion: The predicted roost sites of ASO in Andaman Islands are restricted to narrow range of habitats (evergreen) and hence they are very specific about their roost site requirements. In contrast, OSO uses a wide array of habitats (except evergreen) in Andaman for roosting and they are tolerant to deviations from its optimum habitats. Further, these integrative modelling in complex landscapes like the Andaman Islands will help mangers to look into the critical requirement aprioristically to secure the viable populations of both species. Our findings suggest that the roost site used by the two sympatric species is clearly shaped by the characteristics of evergreen forests of Andaman, so any further changes to this habitat may cause adverse effects on ASO populations.

Survival and Conservation of Owls: Role of Gut Microbiota

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The microbiota of the gastrointestinal (GI) tract and its interactions with host physiology and immune function are emerging topics in microbiology, ecology and medicine. Gastrointestinal microbiota of any species including humans play a vital role in maintaining organismal health, through facilitating nutrient uptake, detoxification and interactions with the immune system and competitive exclusion of pathogens. Avian species represent a diverse and evolutionarily successful lineage, occupying a wide range of niches throughout the world. The gastrointestinal microbiota of owls has been poorly studied, especially in wild species under natural conditions. Species characteristics result in a vast diversity in gut microbiota and its composition and function. Owl life history characteristics pose selection pressures on the gut microbiota, and ultimately affect host health.

In our current work, we are progressing on the microbiome explorations of owls through metagenomics and classical microbial culture approaches. Culture dependent methods, that use selective culture media for growth and isolation and culture independent molecular methods, which often involve target gene sequencing of *in situ* microbial communities are used for the study of gut microbiota of owls. Our primary sampling site of SP Pune University, Maharashtra, India, shows presence of Spotted Owlet *Athene brama* and Barn owl *Tyto alba* owing to suitable habitat on the campus, providing opportunities for roosting and nesting. Also, the University campus boasts of faunal biodiversity including rodents, reptiles, and birds thereby sustaining the owl population. Apart from University, the other sites for the sampling at different places in Maharashtra and India would be used.

Sampling a large variety of owl species (for pellets and fresh fecal droppings from wild owl populations; and cloacal swabs from rescued owls) is challenging, but collaboration between Ela Foundation and Department of Zoology, S. P. Pune University is seen to offset the challenges. We have already carried out work on microbial diversity of the Arabian Sea in the oxygen minimum zones using NGS based metagenomics analysis in the deep sea water samples. Molecular microbiome surveys produce DNA sequence data which are assigned to operational taxonomic units (OTUs), defined at 97% sequence similarity of the 16S rRNA gene, with established hierarchical phylogenetic relationships among organisms. To identify commonly shared microbial OTUs among individuals of, for example, all owl species, the concept of a core microbiota shall be used. Microbiome research of GI tracts of wild owls is expected to reveal the interactions between the environment and host to determine the composition and function of the gut microbiota. It will also suggest the pattern of gut microflora in different species, effect of climate change and pollution on prey species and its impact on the gut microbiome of owl.

Plenary

Vocalizations of endemic Mottled Wood Owl *Strix ocellata* in Western Maharashtra, India

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Keywords: Mottled Wood Owl, Strix Ocellata, Vocalization, sound call types

Mottled Wood Owl Strix Ocellata (MWO) is a poorly studied endemic owl of the Indian subcontinent. There is no information published about its vocalization and calls. We have recorded calls of MWO in their natural habitat without playback. The study areas were the nesting site in the village Pingori and nest sites in the villages Supe and Waghdarwadi, Pune district, Western Maharashtra, India. The study period was October 2018 till March 2019. In addition, sound recordings from public domain from Western Maharashtra region were also used to compare the different call types of this species. From our field recordings, calls of 6 different adults and 1 nestling were analyzed.

Pingori village nest site was studied for the entire breeding season. One young fledged successfully in this season. We made 20 visits just prior to sun set for recorded rising calls. Cor relation of rising calls with sun set was studied. Retiring calls were also recorded and their relationship with the time of sunrise was studied. It was seen that average time of rising call after the sunset time was 24 minutes (11 ~ 46 minutes, SD +/- 12.36, n=12) The calls of the nestling were recorded and analyzed from Supe from one visit.

We used Zoom H1, Zoom H5 and mobile phone applications for making recordings. Sound files were analyzed using Raven Pro, Cornell Laboratory of Ornithology. We have done temporal and spectral analysis of rising calls.

We observed that this species makes 4 different types of calls – i. Single or multiple Hoots at rising and retiring; ii. Courtship calls and duet between male and female; iii. Alarm calls and; iv. calls of nestling. The hoot had an average peak frequency of 518.8 Hz. (431 ~ 680 Hz, SD +/- 61 Hz, n=254) Average hoot duration was 414 milliseconds (283 ~ 893 mS, SD +/- 80 mS, n=254). Average peak frequency different in males (520 Hz, n=212 calls of 3 individuals) and female (619 Hz, n=42 calls of 2 individuals). Average minimum frequency of hoot was 348 Hz (217 ~ 501 Hz, SD +/- 50 Hz, n=254). Average maximum frequency of hoot was 570 Hz (488 ~ 738 Hz, SD +/- 65 Hz, n=254). Average time between two successive hoots was 34 seconds (n=47). Courtship calls had average peak frequency of 550.9 Hz (422 ~ 668 Hz, SD +/- 79 Hz, n=70). Average minimum frequency of courtship call was 387 Hz (265 ~ 495 Hz, SD +/- 75 Hz, n=70). Average maximum frequency of courtship call was 682 Hz (540 ~ 836 Hz, SD +/- 93 Hz, n=70). Average courtship call duration was 930 milliseconds (700 ~ 1227 mS, SD +/- 111 mS, n=70). Alarm calls had 4 successive hoots and were of short duration as compared to rising or retiring hoots with average call duration of 128 milliseconds (85 ~ 175 mS, SD +/- 20 mS, n=180). Peak frequency of alarm calls was 529.5 Hz (345 ~ 646 Hz, SD +/- 86 Hz, n=180) Calls of nestling of 18 days had average peak frequency of 931 Hz. (785 ~ 1045 Hz, SD +/- 68 Hz, n=28).

Acoustic methods for long-term monitoring of birds: individuality and stability in territorial calls of the Little Owl *(Athene noctua)*

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Long-term monitoring of individual animals is a crucial activity for ecological, behavioural, and conservation science. There is now a growing interest in acoustic monitoring as an alternative or complementary means of monitoring individual animals because it has been known for a long time that some animal vocalizations contain robust information about individual identity. In our contribution, we will present long-term data on individual acoustic monitoring of the rapidly declining farmland owl, the Little Owl (*Athene noctua*). The Little Owl is a non-migratory, sedentary nocturnal predator with stable long-term territories and low dispersal distances (< 15 km) of offspring, which makes it a perfect model species for acoustic identification. In the first step, we assessed how discrimination of individuals changes with methods of call description, an increasing number of individuals, and a number of calls per male. In the next step, we created catalog of territorial voices of the Little Owl during last nine years to evaluate acoustic identification as a mean to monitor population of the Little Owl over time. Specific territorial call patterns persisted over years suggesting long-term survival of some individuals. We also recorded remarkable year-to-year changes of territorial call patterns probably indicating replacement of males on the locality. However, unambiguous identification of all individual males may be complicated by the high level of call variation in some of the males. This variation may be caused by various factors, for example, presence of other conspecifics - females or other males - on the locality, calls patterns may change slightly with age, males may use variable excitement calls, etc. In conclusion, we believe that acoustic monitoring of individuals may be a valuable tool, especially for endangered species, and we will try to define possible routes that might help spreading individual acoustic identification as an available monitoring tool in near future.

Comparison of vocalization between urban and rural populations of Spotted Owlet *Athene brama* in Western Maharashtra, India

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Keywords: Spotted Owlet, *Athene brama,* Vocalization, statistical difference

Spotted Owlet *Athene brama* is a common resident of open habitats including farmland and human habitation. There is little information about its vocalizations. We made passive field recordings of Spotted Owlets in their natural habitats between October 2018 and September 2019 in urban and rural populations in Purandar taluka, Pune district, Western Maharashtra, India. We recorded four urban pairs in Pune city. For rural localities we included Ela Habitat (Pingori), Shinde Nagar(Pingori), Wadkar Dara (Kavdewadi), Khomne Wasti (Kavdewadi), Kolvihire, Morgaon and Nimgaon Ketki. We used Zoom H1, Zoom H5 recorders. Sound files were analyzed using Raven Pro from Cornell Lab. We have done temporal and spectral analysis of calls.We hypothesized that there was no difference in vocalizations between urban and rural populations of Spotted Owlet.We studied the rising call (*Chirurr Chirurr*), a common and clearly distinguishable call (consisting of 2 ~ 19 phrases) which was recorded at all localities. The co-relation of rising call time with sun set was calculated. We observed that in urban areas average time of rising call after sunset was longer than in rural areas (18.22 minutes, 14 - 28 ± 4.07 minutes, n = 11; 9.5 minutes, 5 - 18 ± 5.51 minutes, n = 5). We observed that in spite of being an *Athene*, this species did not utter any hoots. Analysis also revealed that rising call in urban areas had an average peak power frequency of 2625 Hz (2063 -3656 Hz, SD ±398 Hz, n = 58) and in rural areas was 2349 Hz (1312 - 3750 Hz ± 562 Hz, n = 59). Average minimum frequency in call of urban areas was 1591 Hz (1221 ~ 1877 Hz, SD +/- 137 Hz, n = 58) and in urban areas was 3394 Hz (2549 ~ 4881 Hz, SD +/- 589 Hz, n = 58). Average minimum frequency in call of rural areas was 1146 Hz (563 ~ 2177 Hz, SD +/- 310 Hz, n = 59) and in call of rural areas was 2881 Hz (1539 ~ 4055 Hz, SD +/- 558 Hz, n = 59). Average phrase duration in urban areas was 0.38 sec (0.22 ~ 0.62 sec, SD +/- 0.065 sec, n=58) and in rural areas was 0.34 Sec (0.09 ~ 0.61 sec, SD +/- 0.115 sec, n=59). Inter-phrase duration in urban areas was 0.40 sec (0.15 ~ 0.76 sec, SD +/- 0.177 sec, n=46) and in rural areas was 0.32 sec (0.12 ~ 0.88 sec, SD +/- 0.176 sec, n=41). Average number of phrases in a call of urban areas was 10 (6~19 , SD +/- 6.35, n=5) while in rural areas it is 10.5 (2 ~ 19, SD +/- 6.73, n=5). Average call duration of urban areas was 7.71 sec (3.56 ~ 17.43 sec, SD +/- 6.20, n = 5) and in rural areas was 8.66 sec (1.25 ~ 14.12 sec, SD +/- 4.86, n = 5). We performed student's T test to test our Null hypothesis. We tested time difference between sunset and rising call, peak power frequency, Minimum Frequency, and Maximum frequency in the data set of Rural and Urban recordings. Students T test analysis showed that the P value were < 0.05, hence the Null hypothesis was rejected, indicating that a significant statistical difference was present in rising calls of Spotted Owlet in Urban and Rural areas. Such differences have been described for diurnal song birds. This is the first such study on crepuscular and nocturnal Spotted Owlet from India and further work can help us understand the vocalization behavior of this species.

Effects of change in climate and habitat on owls of Mumbai, India.

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Keywords: Climate Change, Awareness, Mumbai, growth in number.

The owls of Mumbai were monitored from 1970 to present due to conserve their populations due to their important role in controlling rodent prey which destroy stored food and spread human disease. The effects of climate change, fast human population growth and modernization on owls and their habitats in India's economic capital are important to understand. Owls were monitored in summer, autumn, winter, and during the rainy season, and in various locations including forest, grassland, mangrove, marsh and urbane habitats. Territorial owls were located when inactive at roosts during mornings and afternoons and subsequently when they were active at nights within their territories. Owl observations were grouped into four time periods (1970-1980, 1981-1990, 1991-2000 and 2001 to present) to examine the effects of changes of climate and habitats. While some owl species appeared to be stable over the course of the study other species either increased or declined. The detection of owl species new to Mumbai since 1970 was noteworthy including migratory owl visiting Mumbai in winter. Perhaps most importantly is the detection of the Forest Owlet *Athene blewitti*, which was considered extinct for 80 years, close to Mumbai suburbs. The results document that over the 50 years since 1970 most owls have adopted to changes to prey availability and habitats including roosts. Future studies should address threats to owls in Mumbai including extensive use of pesticides and poisons to kill key prey species (i.e., rodents, lizards, insects, etc.), the capture or killing of owls by poachers for witchcraft. Additional efforts are needed to educate the public why owls are important and useful to humans and how to conserve them through campaigns, media, exhibitions, films and presentations. This will help to conserve owls the dynamic and busy modern city of Mumbai.

European Raptor Biomonitoring Facility (ERBF) for pan-European contaminant monitoring in raptors

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Keywords: bioaccumulation, pollution, populations, museum collections, ecotoxicology

As top predators, raptors, including owls, are excellent sentinels of environmental health. Persistent contaminants accumulate (and are sometimes biomagnified) along trophic chains, reaching raptors at the top. This can provide us with an early warning of emerging contaminant problems affecting both wildlife and human health. The European Raptor Biomonitoring Facility (2017-2021) is a COST action designed to develop pan-European contaminant monitoring in raptors. The initiative combines experts from three working arenas: (1) Analytical Arena, which comprises ecotoxicological laboratories, (2) Collections Arena, which comprises raptor collection facilities in natural history museums and environmental specimen banks; and (3) Field Arena, which comprises field ornithologists, ecologists and raptor conservationists. Contaminants are regulated at an EU level and so the action seeks to improve raptor biomonitoring at a pan-European level by fostering close international cooperation of experts from all three arenas. To test current capacity, a proof of concept study has been launched using two widespread raptor species in Europe, the Tawny Owl *Strix aluco* and the Common Buzzard *Buteo buteo*, as model species. The Tawny Owl is a resident rodent-eating raptor and generalist in its habitat selection and thus should efficiently reflect different contaminant problems. The focal contaminants in the study will be heavy metals and rodenticides, monitored at regional scale across Europe. Besides contaminants, the facility aims to provide key contextual information about raptors, such as for example population density, diet and breeding success, important for interpreting the impact of contaminants on raptor populations and more widely on biodiversity and humans. More information about the action is available at https://erbfacility.eu/.

Status and Conservation of the Shoco in Aruba

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Keywords: Aruba; *Athene cunicularia arubensis*; taxonomic status; vocalization; potential new species;

A taxa of owl, currently listed as a subspecies of the Burrowing Owl, *Athene cunicularia arubensis*, is endemic only to the island of Aruba, in the southern Caribbean. The Papiamento language name for this owl is the Shoco. The Shoco is the National Symbol of Aruba, and it has a favorable position in local myth and culture. There has been very limited protections in place for the Shoco, and it is considered critically endangered, with a rough population estimate of 150-200 pairs. Significant threats to the Shoco are continued habitat loss to urbanization, development and expanding tourism, predation by the invasive Boa Constrictor, feral cats and dogs, secondary pesticide poisoning, off-road vehicles, and traffic collisions. We have found the vocalization of the Shoco to be different from other Burrowing Owls, suggesting it may well qualify as a full species. Efforts are now underway to assess the genetics, vocalizations, morphology, and distributions of six different Burrowing Owl subspecies in this regards. We present new information on the ecology of the Shoco, its demography, acceptance of artificial burrows, myth and culture, and related infrastructural aspects of advancing the science and conservation for this important owl.

Video Presentation

Forest birds of Pirin in a threat: changes in distribution and population sizes (2001-2019) and locations endangered by ski resorts development in Bulgaria

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Key words: forest birds, *Aegolius funereus*, ski resorts, population, threats

A study of forest birds of high conservation status is carried out in 2019 in Pirin National Park, a UNESCO World Heritage site in southwest Bulgaria. The study compares the changes between 2001 and 2019 in the distribution and populations status of *Aegolius funereus*, *Glaucidium passerinum*, *Picoides tridactylus, Dendrocopos leucotos, Tetrao urogallus, Scolopax rusticola*, etc. During this period a serious expansion of a ski resort in the borders of the protected area was carried on. The study indicates decrease in the populations of *Aegolius funereus* and *Tetrao urogallus*. *Glaucidium passerinum* was found for the first time in the national park, as the previous locations were from South Pirin, outside the park. We discuss the threats to the birds in line with a proposed new management plan of the park that could permit even greater construction of ski lifts and ski runs and logging of forests. The field trips were planned in areas proposed as new touristic zones and areas with bird locations from previous years.

Poster

Dynamics of owl populations in the Dürrenstein Wilderness Area, Austria (IUCN Category I, UNESCO World Heritage Site)

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Keywords: owl populations, beech mast, small rodent populations, primeval forest, Austria

The Dürrenstein Wilderness Area (IUCN Category I, UNESCO World Heritage Site), including Spruce-Fir-Beech Primeval Forest Rothwald, is a natural mountainous forest rich in deadwood. Due to the deadwood, topography, climate and deep snow cover until May or June, the area is hardly passable for many months and hardly anything was known about the owl populations in the area. Through targeted surveys from 2015 to 2019 population densities of Boreal Owl *Aegolius funereus*, Eurasian Pygmy Owl *Glaucidium passerinum*, Tawny Owl *Strix aluco* and Ural Owl *Strix uralensis* have been surveyed. The Eagle Owl *Bubo bubo* breeds outside of the protected area and hunts inside of the protected area. The first brood of Long-eared Owls *Asio otus* with four fledglings was confirmed in 2017 at an altitude of 1,450 m a.s.l. With the Eagle Owl and the Long-eared Owl, six owl species occur in the area. Data reveal the Boreal Owl and the Tawny Owl to be the most common species in the study area. In 2016, a beech mast increased the density of small rodents. In the following breeding season, Boreal Owls showed a significant increase in breeding densities from 12.1 to 20.0 territories/10 km^2. Breeding success was rather high with at least twelve broods with fledglings confirmed. The species breeds exclusively in natural tree cavities, usually provided by Black Woodpeckers *Dryocopus martius*. Tawny Owls showed a slight increase from 12.7 to 13.9 territories/10 km^2. Breeding success was rather low in 2017, probably due to heavy snowfalls in April. Pygmy Owls showed relatively low densities of 1.8 to 3.0 territories/10 km^2; the high density of Tawny Owls may be the main reason for the scarcity of this species. Ural Owls have been reintroduced to the area and occur in a density of 0.6 to 1.8 territories/10 km^2.

Poster

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Poster

Moscow Owls Research Group: main results of twenty-five years work

Sharikov A.V.[1], Volkov S.V.[2], Grinchenko O.S.[3], Sviridova T.V.[2], Buslakov V.V.[1], Dombrovskaya Y.V.[1], Evseeva A.M.[1], , Karvovsky D.A.[4], Kondrakova K.D.[1], Kovinka T.S.[1], Massalskaya T.S.[1], Shishkina E.M.[1], Shpigova Y.O.[1]

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Key words: Moscow Owls Research Group, Crane's Homeland Reserve

Moscow Owls Research Group was founded in 1994. Our group engages in a variety of scientific and environmental projects in the north of Moscow Region. The group participants are professional ornithologists, bird watchers and volunteers.

The main research location is the Crane's Homeland Reserve (56°45'N, 37°45'E). The Crane's Homeland Reserve territories include mixed and floodplain forests, agricultural lands, vast swamps and flooded peatlands. The complex of these territories is included in the Reserve List of The Convention on Wetlands of International Importance and is the Key Ornithological Territory of Russia. The Moscow Owls Research Group collaborates with other Russian and international research groups and environmental organizations.

Due to the landscapes diversity in the Crane's Homeland Reserve, 12 species of owls have been observed. The most common during the breeding period are *Asio otus*, *A. flammeus*, *Aegolius funereus, Glaucidium passerinum, Strix aluco* and *S. uralensis*. The main scientific areas are the monitoring of owls numbers, breeding biology, phenology, spatial distribution, feeding ecology, acoustic repertoire and vocalization, as well as the interaction of owls and other raptors. According to the results from work in these areas, more than 40 articles were published.

In addition, our research group work on attracting owls to artificial nests, ringing and environmental education. As part of environmental education, we hold the Owls Fest since 2014. The Fest is visited annually by more than 300 guests. The aim of the Owl Fest is to draw people's attention to the problem of the conservation of owls and their habitats.

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