

**FORAGING ECOLOGY OF GREAT-SLATY WOODPECKER IN AND  
AROUND PAWALGARH CONSERVATION RESERVE IN WESTERN  
HIMALAYA**

A THESIS

Submitted by

**SARABJEET KAUR**

for the award of the degree of

**DOCTOR OF PHILOSOPHY**

**IN**

**WILDLIFE SCIENCE**

Under the guidance of

**Dr. Gopi G.V.**

**Dr. V.P. Uniyal**



**WILDLIFE INSTITUTE OF INDIA  
DEHRADUN, UTTARAKHAND (INDIA)  
SAURASHTRA UNIVERSITY  
RAJKOT- 360005 (GUJARAT)**

**March, 2024**



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to

**Saurashtra University**

**Rajkot- 360005 (Gujarat)**

Under the supervision of

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**भारतीय वन्यजीव संस्थान  
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## DECLARATION

I, hereby, declare that the work conducted under this thesis titled “Foraging ecology of Great-Slaty Woodpecker in and around Pawalgarh Conservation Reserve in Western Himalaya” is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Doctor of Philosophy in Wildlife Science** to the **Saurashtra University, Rajkot (Gujarat)**. This research work has been carried out under the guidance and supervision of Dr Gopi G. V. and Dr V. P. Uniyal of Wildlife Institute of India, Dehradun. The work has not formed the basis for the award of any other degree, diploma or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

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**Miss Sarabjeet Kaur** has researched on this thesis for more than six terms under our supervision and guidance. The work presented in this thesis has not been submitted for any other degree. It meets all of the specifications stated forth in the ordinances of Saurashtra University in Rajkot, Gujarat, and the Wildlife Institute of India.



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I certify that the research work was appreciated by all who were present, and the comments made by the faculty and researchers have been appropriately included in the thesis.

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Dedicated to

*My family*

&

*The **Slaties** of Pawalgarh, Sitabani, and Kalyanpur*

*who fill my life with love*

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**SARABJEET KAUR NARULA**

## **List of Publications**

**Kaur, S.,** Gopi, G. V., & Uniyal, V. P., 2024. Grouping and home-range of the vulnerable Great Slaty Woodpecker *Mulleripicus pulverulentus* in the western Himalaya. *Indian BIRDS* 19 (6): (180-184).

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2. Participation during the **8<sup>th</sup> International Woodpecker Conference: Conservation & Ecology of Woodpeckers** at Białowieża, Poland - **March 16 - 20, 2019**
3. Full presentation in the **15<sup>th</sup> Internal Annual Research Seminar** at the Wildlife Institute of India, Dehradun – **August 2019**
4. Full presentation during **Workshop cum Symposium on Traditional & Modern Taxonomy and IPR Issues for Biodiversity Protection and**

**Conservation** in collaboration with Zoological Survey of India (ZSI) and Indian Council of Agricultural Research – Indian Institute of Soil and Water Conservation (ICAR-IISWC) at Dolphin Institute of Biomedical & Natural Sciences (DIBNS), Dehradun – **November 25 -29, 2019** (First prize for oral presentation)

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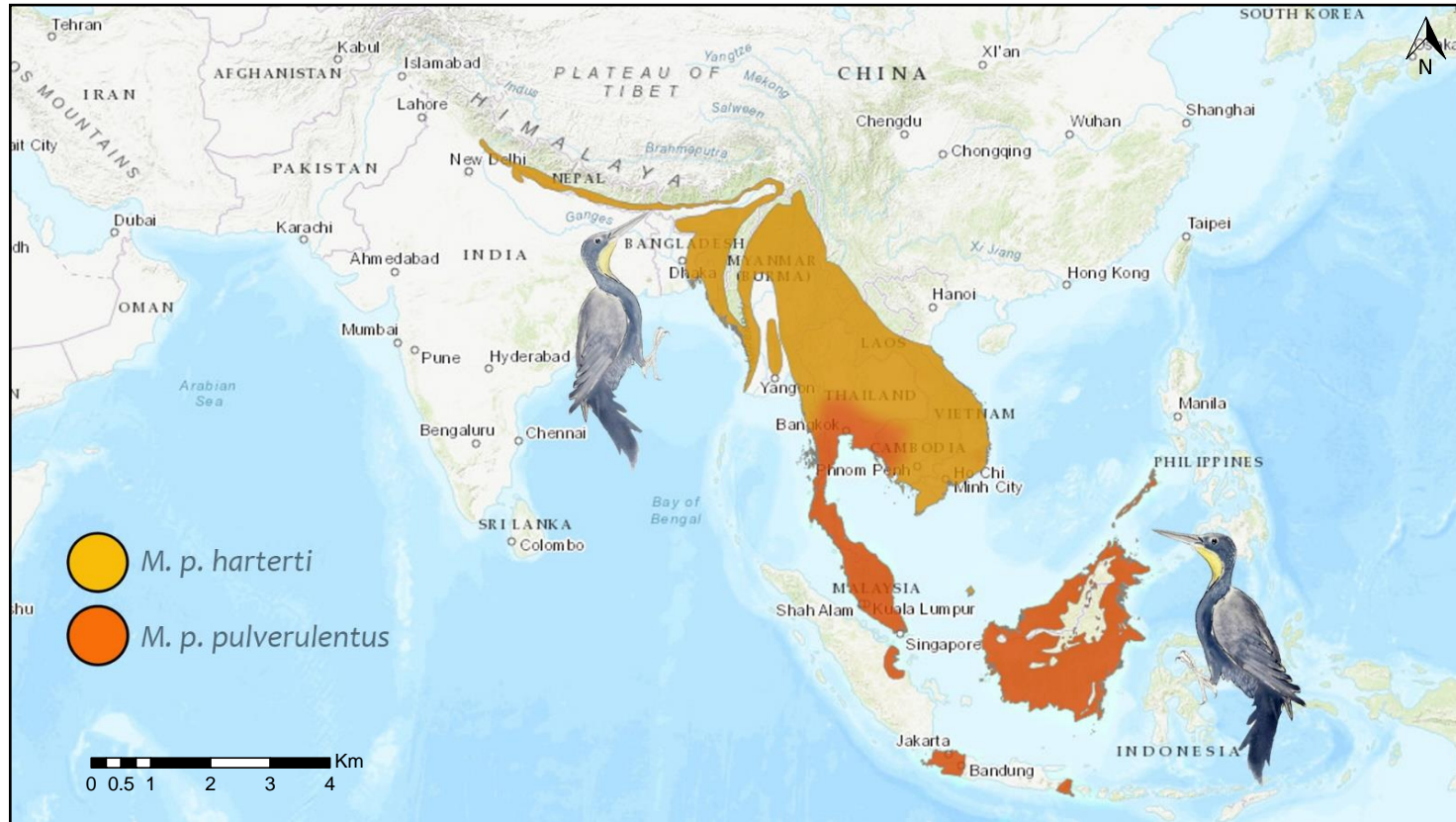
## EXECUTIVE SUMMARY

The Great Slaty Woodpecker (*Mulleripicus pulverulentus*, Temminck 1826) is an old-world woodpecker that prefers mature and old-growth dipterocarp forests (including *Shorea robusta*, Sal) across its known distribution range. The study reveals population demography, the social system and foraging behavior from logged forest and infer the distribution and home range of the Great Slaty Woodpecker, a cooperative breeding bird species, in and around the Pawalgarh Conservation Reserve in the western Himalaya of Uttarakhand state. I found 14 family groups, each composed of three to seven individuals, equally distributed within the conservation reserve (approximately 58.24 sq. km) and its peripheral area (~ 29.47 sq. km). Overall, the area supports a population of 63 individuals.

This study presents the first census conducted for the Great Slaty Woodpecker, providing an ecological baseline for the species population estimation from its known distribution range. I inferred the home range size of each group based on 161 independent sightings of 11 family groups. These sightings represent behaviors such as foraging, nesting, roosting, vocalizations, and territory defense. Using a maximum convex polygon, I found that the maximum and minimum areas used and defended by the family groups were 408 ha (4.08 sq. km) and 77 ha (0.7 sq. km), respectively. I found that the areas defended by each group were not affected by the number of sightings or group size. Each family group maintained and defended territories on consecutive days throughout the two-year study period, including two breeding and post-breeding seasons, with minimal overlap. I observed this behavior four times before the breeding season and termed it Inflight dance. This observed behavior

involves a temporary association between two overlapping family groups, where members of two groups came together at a point within the shared boundary and performed flight movements, including circling and vocalizing, for approximately 21 minutes ( $\pm 17$  minutes). The behavior of the Great Slaty Woodpecker in obtaining food varied significantly between the breeding and post-breeding seasons, with a preference for different tree species. However, there was no difference in foraging substrate, foraging maneuver, or foraging height. I observed no sexual differentiation in foraging behavior, and the species exclusively foraged on live Sal trees to acquire food items such as arboreal termites (*Nasutitermes* sp.), weaver ants (*Oecophylla smaragdina*), stingless bees (genus *Tetragonula* sp.), the seeds of *Mallotus philippensis*, and beetle larvae (one sighting). I recorded the predominant preference for trees with diameter 1 to 3 m during the breeding and post-breeding seasons. The study also reports the presence of two individuals with color aberration (one male and one female individual) in one family group of four individuals, who had otherwise normal pale chin and throat diffused completely with black coloration (the abnormal deposit of melanin pigments) and the use of seeds of *Mallotus philippensis* for the first time. Although, I did not quantify the disturbances, however, I found that natural disturbances like competition with secondary cavity nesters is prominent during the breeding period for nest cavity, periodic fires and removal of snags also contribute to dispersal of the family groups to areas outside their familiar breeding territories particularly during the nesting season. I also recorded the continuous assignation of selective logging throughout the study period in various areas within the protected area in variable capacity that piloted a shift in the use of the areas frequented formerly for meeting their foraging requirements and used for nesting within their marked territories during the second year of the study.

The lack of awareness among the local community and the forest department concerning the woodpeckers was another challenge recorded throughout the survey period. Therefore, long-term monitoring is necessary to develop an understanding of conservation methods for biodiversity and how the species responds to various threats, and similar studies should be carried out throughout the species range to formulate a management plan, leading to effective conservation of the suitable habitat for this Vulnerable species.



**Plate 1. Distribution map adapted for the Great Slaty Woodpecker, *Mulleripicus pulverulentus* based on the classification by Winkler *et al.*, 1995 that recognizes two subspecies *M. p. harterti* and *M. p. pulverulentus***

**(Base Map ©IUCN and Species Artwork ©Vivek Sarkar)**

## Chapter 1. Introduction

### *An overview of woodpeckers*

Woodpeckers (Family: Picidae) are primarily insectivorous birds having widespread distribution except in Antarctica and Australia. They possess large bills, have loud calls, and show different arrays of plumage variation. The woodpeckers are resident species reported from tropical and temperate forests except Australia and Antarctica. The woodpecker community represented by a total of 239 species belongs to 37 genus namely; *Jynx* (2 species), *Picumnus* (26 species), *Verreauxia* (1 species), *Sasia* (2 species), *Nesocittes* (1 species), *Hemicircus* (2 species), *Melanerpes* (24 species), *Sphyrapicus* (4 species), *Xiphidiopicus* (1 species), *Pardipicus* (2 species), *Geocolaptes* (1 species), *Campethera* (11 species), *Yungipicus* (7 species), *Picoides* (3 species), *Dendrocoptes* (3 species), *Leiopicus* (1 species), *Chloropicus* (3 species), *Dendropicus* (12 species), *Dryobates* (5 species), *Veniliornis* (14 species), *Leuconotopicus* (6 species), *Dendrocopos* (12 species), *Piculus* (7 species), *Colaptes* (14 species), *Celeus* (13 species), *Dryocopus* (6 species), *Campephilus* (11 species), *Chrysophlegma* (3 species), *Picus* (14 species), *Dinopium* (5 species), *Chrysocolaptes* (9 species), *Gecinulus* (3 species), *Blythipicus* (2 species), *Reinwardtipicus* (1 species), *Micropternus* (1 species), *Meiglyptes* (3 species), and *Mulleripicus* (4 species).

**Table 1. List of woodpecker species occurring in India with their IUCN Red List**

**Status and movement**

<b>S. No.</b>	<b>Scientific Name</b>	<b>Common Name</b>	<b>Size (cm)</b>	<b>Movement</b>	<b>Conservation Status</b>
<b>Genus: <i>Mulleripicus</i></b>					
<b>1</b>	<i>M. pulverulentus</i>	Great Slaty Woodpecker	45-50	R	<b>VU</b>
<b>Genus: <i>Jynx</i></b>					
<b>2</b>	<i>J. torquilla</i>	Eurasian Wryneck	16-18	M	<b>LC</b>
<b>Genus: <i>Picumnus</i></b>					
<b>3</b>	<i>P. innominatus</i>	Speckled Piculet	9- 10.5	R	<b>LC</b>
<b>Genus: <i>Sasia</i></b>					
<b>4</b>	<i>S. ochracea</i>	White-browed Piculet	9-10	R	<b>LC</b>
<b>Genus: <i>Hemicircus</i></b>					
<b>5</b>	<i>H. canente</i>	Heart-spotted Woodpecker	15-17	R	<b>LC</b>
<b>Genus: <i>Yungipicus</i></b>					
<b>6</b>	<i>Y. nanus</i>	Brown-capped Pygmy Woodpecker	13	R	<b>LC</b>

7	<i>Y. canicapillus</i>	Grey-capped Pygmy Woodpecker	14-16	R	LC
<b>Genus: <i>Dendrocoptes</i></b>					
8	<i>D. auriceps</i>	Brown-fronted Woodpecker	19-20	R	LC
<b>Genus: <i>Leiopicus</i></b>					
9	<i>L. mahrattensis</i>	Yellow-crowned Woodpecker	17-18	R	LC
<b>Genus: <i>Dendrocopos</i></b>					
10	<i>D. hyperythrus</i>	Rufous-bellied Woodpecker	20-25	R	LC
11	<i>D. macei</i>	Fulvous- breasted Woodpecker	18-20	R	LC
12	<i>D. atratus</i>	Stripe-breasted Woodpecker	21-22	R	LC
13	<i>D. darjellensis</i>	Darjeeling Woodpecker	23-25	R	LC
14	<i>D. himalayensis</i>	Himalayan Woodpecker	23-25	R	LC
15	<i>D. assimilis</i>	Sind Woodpecker	20-22	R	LC
16	<i>D. major</i>	Great Spotted Woodpecker	24	R	LC

<b>Genus: Dryobates</b>					
17	<i>D. cathpharius</i>	Crimson-breasted Woodpecker	18	R	LC
<b>Genus: Dryocopos</b>					
18	<i>D. javensis</i>	White-bellied Woodpecker	40-48	R	LC
19	<i>D. hodgei</i>	Andaman Woodpecker	38	R	VU
<b>Genus: Chrysophlegma</b>					
20	<i>C. flavinucha</i>	Greater Yellownape	32-35	R	LC
<b>Genus: Picus</b>					
21	<i>P. chlorolophus</i>	Lesser Yellownape	25-28	R	LC
22	<i>P. viridanus</i>	Streak-breasted Woodpecker	30-33	R	LC
23	<i>P. vittatus</i>	Laced Woodpecker	30-33	R	LC
24	<i>P. xanthopygaeus</i>	Streak-throated Woodpecker	30	R	LC
25	<i>P. squamatus</i>	Scaly-bellied Woodpecker	35	R	LC
26	<i>P. canus</i>	Grey-headed Woodpecker	28-33	R	LC

<b>Genus: <i>Dinopium</i></b>					
<b>27</b>	<i>D. shorii</i>	Himalayan Flameback	30-32	R	LC
<b>28</b>	<i>D. javanense</i>	Common Flameback	28-30	R	LC
<b>29</b>	<i>D. benghalense</i>	Black-rumped Flameback	26-29	R	LC
<b>Genus: <i>Chrysocolaptes</i></b>					
<b>30</b>	<i>C. guttacristatus</i>	Greater Flameback	30-34	R	LC
<b>31</b>	<i>C. festivus</i>	White-naped Woodpecker	29	R	LC
<b>Genus: <i>Gecinulus</i></b>					
<b>32</b>	<i>G. grantia</i>	Pale-headed Woodpecker	25-27	R	LC
<b>Genus: <i>Blythipicus</i></b>					
<b>33</b>	<i>B. pyrrhotis</i>	Bay Woodpecker	26.5- 30	R	LC
<b>Genus: <i>Micropternus</i></b>					
<b>34</b>	<i>M. branchyurus</i>	Rufous Woodpecker	25	R	LC

\*R – Resident, M – Migratory; LC – Least Concern, VU- Vulnerable

In India, 34 species of woodpeckers are found and represented by 18 genera, of which only one is migratory, and two woodpecker species belong to the Vulnerable category of IUCN Red List Category and criteria (Kazmierczak and Perlo, 2000; Table 1). There are no existing management plans in case of any woodpecker species in India. The sub-Himalayan dipterocarp *Shorea robusta* (Sal) forests in the western part of Uttarakhand, India, supports a diverse assemblage of woodpeckers, ranging from the smallest Speckled Piculet (*Picumnus innominatus*) to the largest Great Slaty Woodpecker (*Mulleripicus pulverulentus*). Due to their predominantly insectivorous diet, they maintain a frequent check on harmful timber-destroying invertebrates, thus ensuring the growth of trees. The indicator potential of the woodpeckers has been widely discussed for forest biodiversity and habitat management (Mikusinski *et al.*, 2001) and as a reliable indicator for high avian diversity (Mikusinski and Angelstam, 1998; Menon and Shahabuddin, 2021), forest health and harvest (Drever *et al.*, 2008).

### **Avian Biodiversity loss**

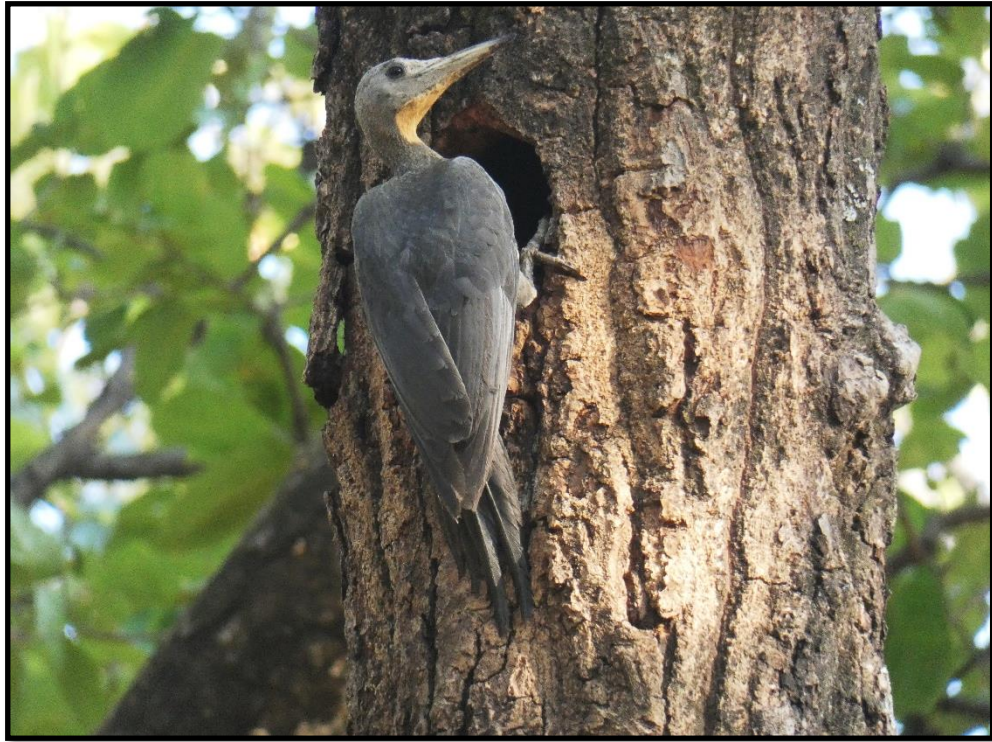
The distribution of avian species is dependent on a combination of temperature, topographical variability, historical environmental processes, and the legacy of evolutionary history. Approximately 80% of bird species are continentally distributed, with the remainder restricted to islands (Newton, 2003). More than half of all bird species are restricted to the tropics, and 91% of all birds have geographic ranges that intersect at least seasonally with the tropics via migration (Barlow *et al.*, 2018). Avian species richness is unevenly distributed across biogeographic realms, with the Neotropical realm hosting the highest percentage of landbird species, followed by the Afrotropical, Indomalayan, Australasian, Palearctic, Nearctic, and Oceanic realms

(Lees *et al.*, 2022). Forest or woodland birds are considered *a priori* for several pioneering studies on community and population ecology (MacArthur, 1958). Several threats contribute to avian biodiversity loss, like Land cover and Land use change (Pimm and Askins, 1995; Gatson *et al.*, 2003; Donald *et al.*, 2010; BirdLife International, 2020), habitat fragmentation and degradation (Lees *et al.*, 2009; Barlow *et al.*, 2016; Cornelius *et al.*, 2017; Betts *et al.*, 2019; Sheard *et al.*, 2020), hunting and trapping (Schemske *et al.*, 2009; Beastall *et al.*, 2016; Jiguet *et al.*, 2019; BirdLife International, 2020; Siriwat and Nijman, 2020), the impact of invasive alien species and disease (Clavero *et al.*, 2009; Loss *et al.*, 2015; Dyer *et al.*, 2017), infrastructure, energy demands and pollution (Bernardino *et al.*, 2018; Kuhn and Franekar, 2020; Chilvers *et al.*, 2021; Uddin *et al.*, 2021), agrochemical and pharmaceutical usage (Hallmann *et al.*, 2014; Møller and Laursen 2015; BirdLife International, 2020; Morelli *et al.*, 2021), and climate change (Strong *et al.*, 2015; Mayor *et al.*, 2017; Shipley *et al.*, 2020; Weeks *et al.*, 2020). A few ecological studies conducted on woodpeckers focus on a single species in India and discuss its biology (Santharam, 2003; Shahabuddin, 2018). The ecology of only two species, the White-bellied Woodpecker (*Dryocopus javensis*) from South India and the Rufous-bellied Woodpecker (*Dendrocopos hyperythrus*) in the Himalayan region of Uttarakhand, is covered. However, if the aim of conservation biology is to prevent species from declining or becoming extinct (Soule 1985, Sodhi and Ehrlich 2010), we ideally need to be proactive and take steps toward early recognition and detection of threats, downward trajectories in abundance, and contracting distribution.

## **The Great Slaty Woodpecker**

### *Morphology, social structure and foraging behavior*

The Great Slaty Woodpecker is an old-world woodpecker measuring 45 to 50 cm long (Ali and Ripley, 1989) with a body mass of *c.* 430 g (Lammertink, 2004). The morphological features include an entirely slate-grey plumage with a pale chin, pale throat, and zygodactyl toes (four in number). The diagnostic characteristic is the presence of a red malar or a moustachial stripe distinguishing the male from a female individual. The hind neck and ear coverts sometimes show the presence of whitish-tipped gray feathers. The scientific name *pulverulentus* (Temminck, 1826) means dusty, covered with a fine powder (Jobling, 1991) which is apparent in the young and adult individuals as white speckles on the head and neck feathers (Plate 2). The Great Slaty Woodpecker is a cooperative breeder, and each family party or an independent unit comprises three to six boisterous birds (Ali and Ripley, 1970; Short, 1973; Lammertink, 2004), and at times groups comprising 12 individuals have also been reported (Winkler *et al.*, 1995). The reported dominant food items procured by the individuals are ants, followed by stingless bees, termites, and larvae of wood-boring beetles, and the occasional consumption of fruits. The use of dead wood and snags in leafy upperstorey was reported to be used by the Great Slaty Woodpecker in logged and unlogged forests in west Malayasia (Styring and Hussin, 2004).



**Plate 2. A female individual showing neck feathers with powder-covered cropped plumage, Jobling 1991 (©Sarabjeet Kaur)**

*Distribution and habitat*

The species is found in South and Southeast Asia (Plate 1), from northern **India** through the foothills of the Himalayas to southern **China, Nepal, Myanmar, Laos, Vietnam, Cambodia, and Thailand**, and peninsular **Malaysia** and **Singapore** to the western islands of **Indonesia** and the **Philippines** (Winkler *et al.*, 2002; Inskipp *et al.*, 2011). It is deemed the largest woodpecker in the world and in its genus *Mulleripicus* after the reports of the likely extinction of the Imperial Woodpecker (*Campephilus imperialis*) and Ivory-billed Woodpecker (*Campephilus principalis*) by U.S. Fish & Wildlife Service in 2022. The up listing of the Great Slaty Woodpecker to Vulnerable A2bc category came in 2016

(IUCN 2016) and the Vulnerable C2a(i) category for Andaman Woodpecker in 2017 (IUCN 2017). The threats to both species include logging of the forest, extensive habitat destruction, and additional conversion of forests to agricultural land in the latter. In India, the distribution of the species aligns chiefly with the distribution of primary semi-open moist deciduous and tropical evergreen old-growth forests utilizing the mature *Shorea robusta* (Sal) trees primarily for foraging, nesting, and roosting. Elevation limits vary geographically, and the range of the species extends from areas with elevation below 600 m to 1100 m in the Himalayas and occasionally up to 2000 m (Ali & Ripley, 1989). Locally, the species is rare and uncommon in much of the western part of the state of Uttarakhand, with most records from the protected areas (Jim Corbett National Park, Pawalgarh Conservation Reserve, Rajaji National Park, Kalagarh Tiger Reserve, Lansdowne Forest Division, and Thano Reserve Forest) and few from the surrounding areas (eBird India).

#### *Life history*

**Genus** *Mulleripicus* is represented only by the Great Slaty Woodpecker in India. Four species belong to the genus *Mulleripicus*, and the size varies from 29 cm to 50 cm (Winkler et al., 2020). A few studies on the Great Slaty Woodpecker (*M. pulverulentus*), a species of management concern (Lammertink et al., 2009) occur. However, no scientific data is available for the remaining three species in the genus, the Southern Sooty Woodpecker (*M. fuliginosus*), the Northern Sooty Woodpecker (*M. funebris*), and the Ashy Woodpecker (*M. fulvus*). Three subspecies recognized for the Great Slaty Woodpecker are *M. p. mohun* (India, Nepal and North-east India), *M. p. harterti* (North-east India to South-west China, Indochina and North Malay

Peninsula), and *M. p. pulverulentus* (South Malay Peninsula, Sumatra, North Natuna Island (North-west of Borneo), Borneo Java and Palawan group (South-west Philippines)) (Gill *et al.*, 2023). However, other sources recognize only the latter two subspecies, the only subtle morphological difference being the dark coloration of *pulverulentus* (Winkler *et al.*, 1995).

### **Previous studies on the Great Slaty Woodpecker**

The ecology and conservation status of the Great Slaty Woodpecker and other woodpecker species have not been studied in detail in the western Himalaya of Uttarakhand, except for a few comparative woodpecker studies (Kumar and Singh, 2010; Kumar *et al.*, 2011; Kumar *et al.*, 2014; Kumar *et al.*, 2020; Menon and Shahabuddin, 2021). An understanding of the preferred foraging, nesting and roosting requirements of each woodpecker species is necessary to outline conservation strategy. The comparative ecological study of sympatric woodpeckers is essential and have been studied elsewhere concerning foraging (Styring and Hussin, 2004; Kumar *et al.*, 2020), effects of logging on woodpecker community (Styring and Hussin, 2004; Lammertink, 2007), nesting (Hågvar *et al.*, 1990; Kosinski *et al.*, 2007; Lammertink *et al.*, 2020).

### **Organization of the thesis**

Several aspects of the ecology of the Great Slaty Woodpecker in the Sal forests of Uttarakhand were studied, including their distribution (estimate of local abundance), diet, and nesting requirements. This thesis aims to develop an understanding of the requirements of the focal species in a sympatric woodpecker community that have important conservation implications. Documenting information on their habitat needs

will provide insight into the ecology of the Great Slaty Woodpecker and will help promote effective habitat management for that region.

Chapter 2 includes the study area in the state of Uttarakhand with a detailed description of the location, flora and fauna, and land cover. The next chapter deals with the distribution of the focal species and provides ecological baselines regarding the number of individuals and groups of the cooperative breeding Great Slaty Woodpecker. Although this information is based only on the data combined for two seasons (breeding and post-breeding), it still indicates the actual number of birds present in the area. The second component of the study forms the fourth chapter and describes the foraging substrates, techniques, and food items chosen by the species during two seasons (breeding and post-breeding). The microhabitat preferences reflected help in the evaluation of the year-round foraging needs of the bird. In Chapter 5, I tried to understand how the juveniles obtain food post-fledging and, therefore, explore the relationship between foraging skills, energy intake, and habitat use. In Chapter 6, I tried to assess the potential disturbances and sensitivity of the woodpecker species to the observed risks within the study area.

### **Objectives of the study**

I have outlined the principal objectives of the study below, with detailed questions answered within the individual chapters:

1. To assess the distribution and abundance of Great Slaty Woodpeckers in and around Pawalgarh Conservation Reserve
2. To understand the seasonal changes in Great Slaty Woodpecker foraging strategies and substrates

3. To determine the mechanics of juvenile foraging proficiency
4. To examine the potential threats and disturbances to the Great Slaty Woodpecker

### **Hypothesis**

As there is no baseline data available on ecology of the Great Slaty Woodpecker from the Himalaya, hypothesis is therefore not constructed.

### **Justification of the study**

I chose the Great Slaty Woodpecker because of their specialized habitat preference. To understand the ecology of the poorly studied Great Slaty Woodpecker by the objectives and hypothesis, I carried out this study to highlight the conservation and management of this Vulnerable species with the following vital arguments that will prove beneficial for framing conservation strategies:

1. *Movement studies*

The information on the home-range size of the focal species across their geographical range is unavailable. And, therefore this study will provide the first ecological baseline estimates of the home range of the various family groups within the study area. The study will help to enhance the understanding of the spatial distribution of the species in the sub-Himalayan Uttarakhand. Additionally, the census can be used in the global population assessment of the species and provide the current scenario of the population of the Great Slaty Woodpecker from a small area in the western Himalaya.

## 2. *Foraging behavior*

The woodpecker guild forms the principal insectivore community and a reliable indicator of forest health, keeping a check on the harmful pests by feeding on the grubs and larvae of several wood-boring beetles. With this line of thought and given their uniform diet, and with the help of visual observations of their foraging behavior, I recorded the food items procured during breeding and post-breeding season. Any seasonal differences in their foraging choices will help refine our understanding of the equilibrium between a species and its environment.

## 3. *Juvenile foraging proficiency*

Few studies focus on the foraging behavior of juvenile birds in the woodpecker guild, and a lack of literature on the foraging proficiency of the focal species exists. Therefore, it is imperative to assess the skill development of the juvenile birds for the survival of the breeding population in the area. It may prove insightful in understanding whether the species display site fidelity or exhibit dispersal into resource-rich habitats following the fledging period. The purpose of the relative objective is to examine the development of foraging skills in the Great Slaty Woodpecker and to explore the relationship between the foraging components that help shape the foraging behavior of a young.

## 4. *Threats*

An attempt to understand the potential disturbances in the light of inadequate existing knowledge from Indian Subcontinent in South Asia and this baseline will help shape the future implications of these threats. Therefore, identifying the threats will assist us in employing systematic and focused long-term monitoring studies, help fill the knowledge gap from the entire distribution range, and enhance our understanding of the effects of future climate change impacts.



**Plate 3. Sal dominated forest patch at the eastern boundary of the Pawalgarh Conservation Reserve**

(©Sarabjeet Kaur)

## **Chapter 2. Study area**

### **Pawalgarh conservation reserve**

#### *Location*

#### **Core area and peripheral area**

The surveyed area for the study on the Great Slaty Woodpecker is the woodland area of Pawalgarh Conservation Reserve (hereafter PCR) with an area of 4946.19 ha and 878.57 ha (c. 5824.76 ha) governed by Ramnagar and Terai West Forest Division, respectively. The area lies at 29°42' N and 79°21' E on the northern side of the Ramnagar-Haldwani Highway (NH-121), and the river Dabka (Plate 4) intersects the landscape into eastern and western parts with an altitude range of 300-700 msl (Figure 1). The region was notified of a conservation reserve on December 14, 2012, under the provisions of Clause (3) of Article 348 of the Constitution of India with notification No. 2233/X-2-2012-19(7)/2012. Before the declaration of the area as a conservation reserve, the area was notified as Shiwalik Elephant Reserve by the Government of Uttarakhand Van and Paryavaran Anu – 2 letter no. 1777/1(2)/2002-19(2)/2002, dated October 28, 2002, due to ecological, floral, geomorphological, natural, and zoological significance and to protect, propagate, and develop wildlife and its environment. The area mainly consists of Shiwalik and is flanked by River Kosi in the west and River Baur in the east. Therefore, it garners recognition as the Kosi-Baur corridor and a critical link for the wildlife movement across the Terai Arc Landscape (TAL).

The conservation reserve is governed collectively by three ranges viz., Dechauri and Kota ranges of Ramnagar and Bail Parao range of Terai West Forest divisions. The woodpecker survey was also carried out in an additional 2947 ha and comprises the

immediate forest and the peripheral area outside the protected area (hereafter, PA) (Figure 1) that falls in the Dechauri range, Ramnagar Forest division.



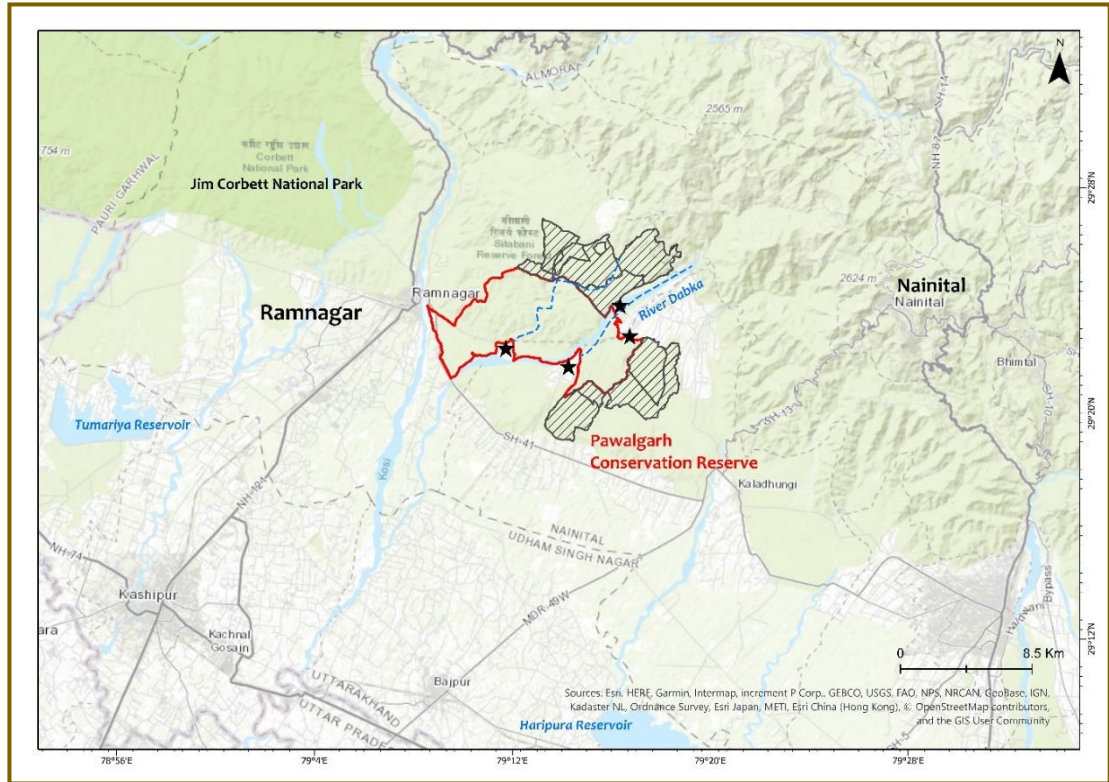
**Plate 4. River Dabka (perennial river) intersects the Pawalgarh Conservation Reserve (©Sarabjeet Kaur)**

**Table 2.** Description of beat-wise area encompassing the northern, eastern, southern and western boundaries of the of the Pawalgarh Conservation Reserve

<b>S. No</b>	<b>Beat</b>	<b>Block/compartments</b>	<b>Area (in hectares)</b>
<b>I.</b>	<b>Teda</b>	Teda 5	628.5
		Kailakhur 2	273.2
		Kailakhur 3	223.4
<b>ii.</b>	<b>Kailakhur</b>	Kailakhur 1	311.6
		Kailakhur 4 (a)	72.8
		Kailakhur 4 (b)	63.9
		Kailakhur 4 (c)	85
		Kailakhur 5	284.9
		Kailakhur 6 (a)	32
		Kailakhur 6 (b)	178.1
		Kailakhur 7 (a)	27.9
		Kailakhur 7 (b)	89.99
		<b>iii.</b>	<b>Belgarh</b>
Belgarh 3 (b)	42.5		
Belgarh 4 (a)	595.7		
Belgarh 4 (b)	24.7		
<b>iv.</b>	<b>Pawalgarh</b>	Pawalgarh 1 (a)	67.6
		Pawalgarh 1 (b)	56.7
		Pawalgarh 1 (c)	67.2
		Pawalgarh 1 (d)	62.3

		Pawalgarh 1 (e)	125
		Pawalgarh 2	324.1
		Pawalgarh 3	266.7
		Pawalgarh 4 (a)	93.1
		Pawalgarh 4 (b)	172.4
<b>V.</b>	<b>Barua</b>	Barua 3	60.7
		Barua 4	90.6
		Barua 1	581.94
		Barua 2	134.76
		Barua 3 (partly)	161.87
	<b>Total area</b>		<b>5824.76</b>

The **northern** boundary of the conservation reserve comprises various blocks or compartments of the beats Kisani, Teda, Kailakhur, and parts of Barua and Belgarh beat, enveloping both the Ramnagar and Terai West Forest divisions. The jurisdiction of the **eastern** and **southern** boundaries lies with the Ramnagar Forest Division and includes the compartments of the beat Lachchampur and Pawalgarh. The **western** boundary is governed chiefly by the Terai West Forest division and comprises exclusively blocks of the beat Barua (Table 2).



**Figure 1.** Map showing the Pawalgarh Conservation Reserve (outlined red) with the surveyed area outside the protected area (PA) outlined black in the state of Uttarakhand, India. The stars depict the four nearby villages in close proximity to the conservation reserve.

The area lies in the Bhabar belt and is relatively dry, and the composition of the forest is affected by the physical, hydrological, and ecological features. These include geology, rock and soil, climate, rainfall, water sources, and part of the conservation reserve occupied by the tertiary foothill rocks of the Shiwalik group and alluvium of the plains. Pawalgarh is located at the junction of the Bhabar and Terai formations extending up to the Dabka. The tectonic contact between the Shiwalik group and the pre-tertiary rocks is known as the boundary fault. There is a narrow strip of Bhabar between the sub-montane road and foothills. The recent deposits of coarse gravel and

torrent boulders are generally mixed with ferruginous sand/or clay along the margins of the streams and cover large portions of duns and *chaurs*. Types of soils are Forest and Hill soil and Gangetic Alluvial (calcareous), with soil depth ranging from 165-168 cm and pH between 5.2-8.0. The soil is usually deep alluvial, clayey loam, porous, and well-drained, providing favorable conditions, and is well-suited for the growth of *Shorea robusta* (Sal). The typical climate of the lower ranges of the Himalayas and an average rainfall of about 140 cm prevail in the area. Several small rivulets emerge from the woodland and discharge into small *nalahs* that drain into the Kosi and Dabka.

### **Flora and fauna**

Pawalgarh Conservation Reserve consists of North Indian moist deciduous forest with sub-groups- a) Moist Siwalik Sal 3C/c.2a and b) Moist bhabar Sal 3c/c 2b (1) (Champion and Seth, 1968). The tree canopy dominated by *Shorea robusta* (Sal; 80-90%) has principal associates such as *Terminalia tomentosa*, *Terminalia bellerica*, *Lannea coromandelica*, *Adina cordifolia*, *Syzygium cumini*, *Garuga pinnata*, *Lagerstroemia parviflora* with *Anogeissus latifolia* found in slopes. The middle and lower stories consist mainly of *Ougeinia oojeinensis*, *Mallotus philippensis*, *Cassia fistula*, *Ehretia laevis*, and *Phyllanthus emblica*. The underwood is dense at some locations due to *Clerodendrum infortunatum* and *Bergera koenigii* (syn. *Murraya koenigii*) and includes some areas under plantations of *Tectona grandis* (Teak). The vegetation comprises more than 125 tree species, 58 species of shrubs, 68 species of climbers and grasses, 76 species of medicinal herbs, and 18 types of ferns and their allies have been identified and reported from the conservation reserve.

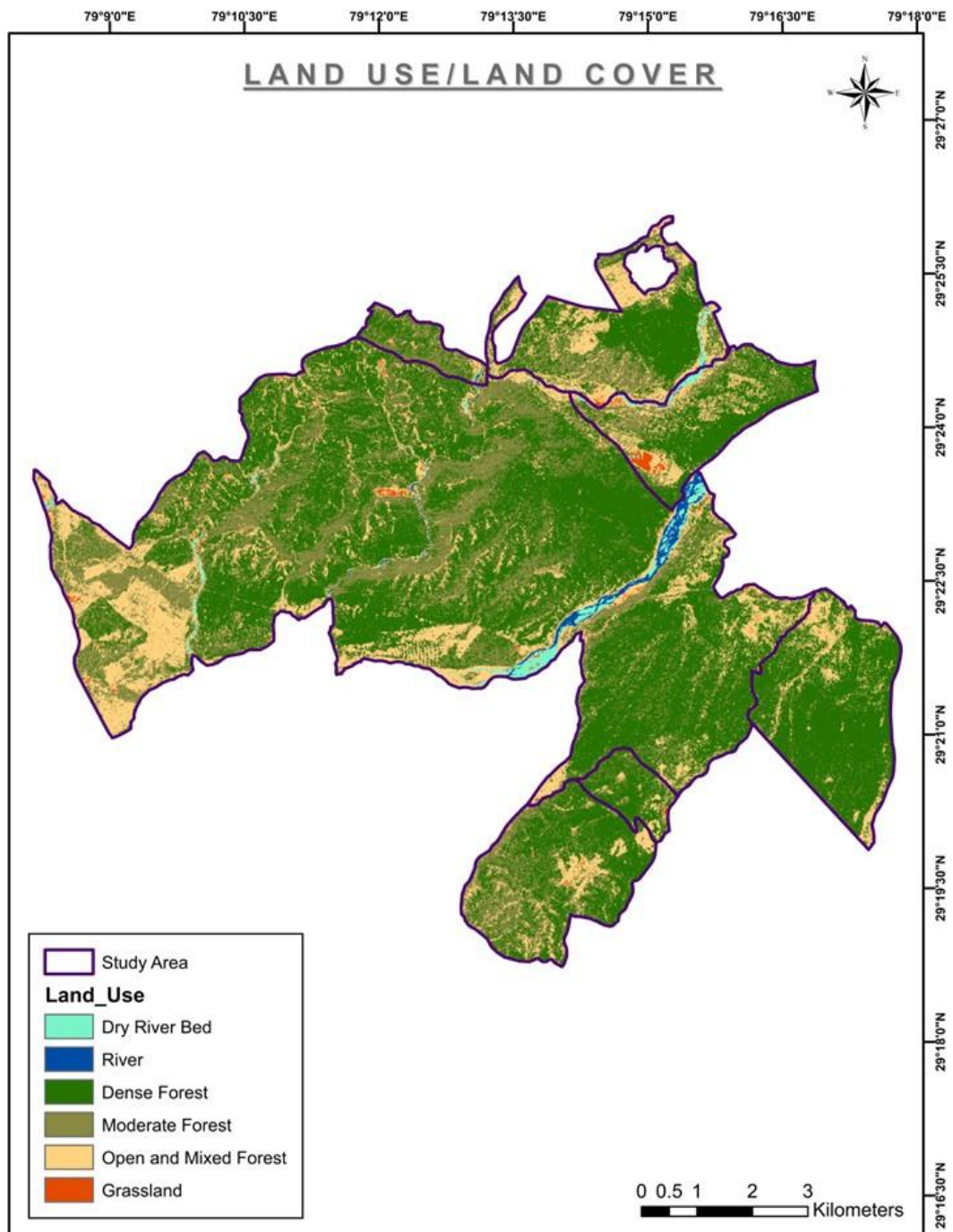
The area is rich in biodiversity and characterized by the presence of 30 species of mammals, 12 species of reptiles, eight species of fishes, and more than 300 species of birds (the number collectively represents the generous efforts of bird enthusiasts from the Uttarakhand Bird Festival held at Pawalgarh and the Asian Waterfowl Census held for Kosi Barrage over the years).

### **Avifaunal Research in Pawalgarh Conservation Research**

Before this, no focused research on birds conducted in the conservation reserve is present. Therefore, I present a checklist of 262 species of birds represented by 45 families (Appendix I) sighted during the fieldwork from 2018-2021.

### ***Land Use/Land Cover***

I prepared a LU/LC map for the study area (Figure 2) using ESRI Sentinel-2 10-metre resolution Land Use/Land Cover Time Series (<https://www.arcgis.com/home>) to understand the preferred habitat for the GSW. I characterized six LU/LC classes (Table 2) using the ESRI Sentinel-2 2021: river, dry river bed, dense forest, moderate forest, open and mixed forest, and grassland (shrubs, grasses, and bare ground). I established the classification of classes both on satellite imagery and ground truthing. Dense forest occupied the highest proportion of area (50%), followed by moderate forest (30%) while river and grassland covered a miniscule of 0.7% and 0.8% respectively.



**Figure 2. An overview of LU/LC within the Pawalgarh Conservation Reserve and in the areas covered outside the PA**

**Table 3.** Land Use/Land Cover extents in the c. 8720 ha Pawalgarh Conservation Reserve (inclusive of area outside PA)

<b>S. No.</b>	<b>LU/LC Category</b>	<b>Area (in ha)</b>	<b>Area (%)</b>
<b>1</b>	Dry River Bed	104.09	1.2
<b>2</b>	River	64.79	0.7
<b>3</b>	Dense Forest	4522.27	50.3
<b>4</b>	Moderate Forest	2717.57	30.2
<b>5</b>	Open and mixed forest	1511.38	16.8
<b>6</b>	Grassland	68.36	0.8
	<b>TOTAL</b>	<b>8988*</b>	<b>100</b>

**\*Note that the slight difference in the total areas reflect gaps in information from various GIS data sources**



**Plate 7. Three members (one male and two female individuals) of the Great Slaty Woodpecker family group 10 perch outside the nest cavity (©Sarabjeet Kaur)**

## **Chapter 3. Distribution and abundance of the Great Slaty Woodpecker**

### **Introduction**

Habitat suitability is analogous to the term ecological niche, implying an association of organisms concerning a place it inhabits. This concept involves a hierarchy of decisions yoked with underlying behavioral processes to initiate an active habitat selection (e.g., *Hylocichla mustelina*, Kaiser 2004; *Sturnus vulgaris*, Tinbergen 1981). One can attribute the specialized knowledge to the criteria of selecting a particular habitat by a single species to create ecological baselines that will prove beneficial in drawing better conservation strategies. For any organism, the most important thing is to delineate areas with clear-cut spaces for foraging, breeding, or both, and these spaces are termed territories. These zones used intensively by an occupant are defined in combination by the degree of overlap (Schoener 1968), site fidelity, and vigorous behavioral defense of their home range involving displays and vocalizations. Both migratory and resident bird species defend territories year-long or seasonally. The availability of resources that direct the daily or seasonal activities of the individuals in an area influences the occurrence of a species in a habitat. Many species adapt spatial strategies, like migratory non-flocking passerine species, and defend resource-based territories for the majority of the winter season (Holmes *et al.* 1989, Winker *et al.* 1990). Therefore, a variation exists between species in their territory size depending on the degree and nature of the threat. These resource-based territories define the fine-scale movement and yield the home range of an individual species. Data on

movements, foraging range, and behavior - key in any management program are lacking in combination for many species and may be effective in drawing conservation strategies (Brown *et al.*, 2000; Bamford *et al.*, 2007; Doucette, 2010) both for residents and migrant birds. The home range size and social interaction of the Black Woodpecker (*Dryocopus martius*) revealed a significant variation among individuals, and core areas covered about a third of the total home range, and also suggests that home ranges during the breeding period were more restricted than during post-breeding period. The overlap of home ranges was prominent and broad to the core area overlap with a high site fidelity across all-year ranges (Bocca *et al.*, 2007). Radio telemetry study in the Australian owl-nightjars (*Aegotheles cristatus*) in a Eucalypt woodland coupled with GPS recordings reveals home range size requirements and site fidelity of this highly territorial bird did not differ seasonally and shows no correlation with arthropod abundance (Doucette, 2010). A study on wintering social behavior and spatial movement in Hermit Thrush (*Catharus guttatus*) revealed that they occupy and defend small territories in pine plantations and hardwood forests in Louisiana with minimal overlapping territories (Brown *et al.*, 2000). The study on movement patterns of adult and juvenile 'Akohekohe, an endangered Hawaiian honeycreeper (*Palmeria dolei*), revealed a significant difference in the home ranges of adult and juvenile individuals which is attributed to the increased risk of malarial infection (Wang *et al.*, 2020). Studies on area requirements and the responses of several forest birds to the management practices are crucial. In Southern Africa, the Cape Vulture (*Gyps coprotheres*), an endemic and critically endangered species, has suffered a massive decline in its range and population size. A study on their movement, foraging range, and behavior revealed a variation in the ranging behavior of the adults

throughout the year, with an observed relatedness to their nesting behavior. The foraging range in other studies was sizeable and revealed the use of freehold farms exclusively. The nesting birds spend more time foraging near their nest sites (Bamford *et al.*, 2007).

The responses of Picids (woodpeckers) to implement suitable management practices framed by several studies on habitat use concerning the home range (Franzreb, 2006), the reproductive success of Black-backed Woodpecker (*Picoides arcticus*) in response to forest fires (Nappi & Drapeau, 2009), and space use in terms of foraging habitat (Walters *et al.*, 2002) are available for Red-cockaded Woodpecker (*Dryobates borealis*) and Black-backed Woodpecker (*Picoides arcticus*).

In the woodpecker group, four species represent the genus *Mulleripicus*, and size varies from 29 cm to 50 cm (Winkler *et al.*, 2020). However, no scientific study is available for three species: Southern Sooty Woodpecker (*M. fuliginosus*), Northern Sooty Woodpecker (*M. funebris*), and Ashy Woodpecker (*M. fulvus*), and a few studies conducted on Great Slaty Woodpecker (*M. pulverulentus*), a species of management concern (Lammertink *et al.*, 2009) are available. It is the largest woodpecker in the world and Vulnerable (VU) in the IUCN Red List. The distribution range of the species varies geographically, and the range of species extends from areas with elevations below 600 m to 1,100 m in the Himalayas within the various protected areas (Winkler *et al.*, 2020) and occasionally up to elevations of ~2000 m (Ali & Ripley, 1989) in India. The species is strongly associated with mature and old-growth dipterocarp forests (particularly *Shorea robusta*, Sal) (Birdlife International, 2023), where they forage primarily on beetle larvae (Ali & Ripley, 1987). The Great Slaty Woodpecker is a logging-sensitive species, and the decline in the population

during recent years can be associated with the loss of a favorable habitat probably due to selective logging for commercial use and habitat fragmentation (Lammertink, 2004). As a result, the deterioration of the habitat strongly affects the nesting and foraging opportunities adopted by the species. To safeguard the habitat, an integral aspect of conservation, local information on home ranges, habitat use, and food availability is required. In the known breeding range, the home range of the Great Slaty Woodpecker (GSW) is not evaluated elsewhere in the species distribution extent, and I attempt to infer the variation in home range size among various family groups of GSW in and around a small protected area in the western Himalaya of Uttarakhand. I include the patterns of spatial use and social behavior by the Great Slaty Woodpecker to investigate the ranging behavior. I followed various family groups of the Great Slaty Woodpeckers and assessed their ranging behavior based on foraging, nesting, and roosting observations during two breeding and post-breeding seasons each. Our objectives were to determine the spatial distribution of the species concerning their movement patterns and to assess the variation in the home range size and overlap among the groups both outside and inside the protected area (PA).

## ***Methods***

### **a) Distribution of transects**

I surveyed the study region along 52 transects of several kilometers as several birds have large home ranges (Bibby *et al.*, 2000), and each sampling site carefully represented various habitat patches like Sal and miscellaneous forest stands, perennial and seasonal river beds, Teak (*Tectona grandis*) plantations, grasslands, roads, and

village boundaries. Although each transect varied in length from the smallest two km to the longest nine km, I ensured these transects had an open canopy of up to 100 m on both sides to incur visibility of the family groups and individuals. The detectability of the Great Slaty Woodpecker is challenging in the absence of aural cues, and I walked each transect at a fixed speed of 500 m/hr to ensure detection. I covered the seven, eight, and nine km transects on two consecutive days owing to their distance and identified the transects throughout the study area. All locations reported here resulted from direct sightings of GSWs. However, I could not sample the western side of the study area as I did not receive due permission from the Terai West Forest Department.

#### **b) Sampling**

I primarily based the data collection on locating each group and recording the number of individuals with their identity (male and female) from 2018 to 2020. I surveyed the transects and based the sightings of each family group of GSW on random encounters throughout the two years. During the morning, I carried out the transect walk from 0530 to 0930 h during the summer (April to June) and 0700 to 1100 h during the winter (October to March) months. Similarly, I followed each family group from 1600 to 1830 h during the summer (April to June) and 1500 to 1730 h during the winter (October to March) evening. I recorded the GPS location of the first encounter and then followed the family groups intensively to assess the variations in group sizes (if any) during both seasons. While following the group, I recorded the second GPS coordinates corresponding to losing the group (the group flew very far or a barrier to proceed like a steep ridge, river, presence of tiger and elephants). Data collection was

equally comprehensive for the peripheral areas around the conservation reserve. Each transect was surveyed 14 times during each season for morning and evening hours equally. I actively followed each group and denoted these family groups with a unique identification code based on their multiple sightings from the same area. I was able to differentiate each group and individual based on the morphology characters of all or any individual in that group based on multiple sightings from the area in use. These characters include the presence of individuals with a black throat patch rather than the usual pale coloration of the chin and throat, a male or female individual with a silver-grey colored forecrown, a female and a male individual with a small dark black dot on the throat (Plate 5 and 6) in two separate groups utilizing the same area, and also noted the missing primary, secondary, or tail feathers during the nesting season which helped us confirm that the same individuals were attending the nest each day. I summarized the field identification of each group in Table 4.

I identified territory boundaries based on behavioral observations like foraging, roosting, boundary disputes, and calling perches, thus delineating areas for each group. The display also includes loud calls, and each performed territorial display was marked and considered an independent fix to evaluate the home-range size for each family group. Similarly, to locate the nesting and roosting cavities, I conducted systematic nest searches across all sites with an average effort of 28 observer hours per week during the morning and 12-15 observer hours per week during the evening survey. I also carried out intensive surveys in the marked territory of each group to locate the nest cavities along transects. The nesting cavities were located by listening to the continuous excavating sounds of the individuals of the species. I made all observations with binoculars (8X and 12X) or a spotting scope (45X) from a distance with no

disturbances caused to the family groups. I did not use the call playback method for any group to define their respective territories. I used a handheld GPS



**Plate 5. A female individual shows a dark black mark near the chin (an identity mark) used to confirm the identity of a family group 10 (©Sarabjeet Kaur)**

(Global Positioning System) to obtain location data, which I then used to map out the territories of birds. To delineate the territories, I used standard territory-mapping techniques (Bibby et al., 2000) based on the behavioral attributes of the bird registrations and digitization in ArcGIS 10.6.1 (ESRI 2016) for geospatial analysis. I defined the territories as non-overlapping maximum defended areas.



**Plate 6. A female individual shows a dark black dot on the inner chin (an identity mark) used to confirm the identity of a family group 7 (©Sarabjeet Kaur)**

**Table 4.** Differences in the morphological characters of an individual in a group that were noted to confirm the identity of each family group in the two breeding and post-breeding seasons from 2018-2020

<b>S. No</b>	<b>Group ID</b>	<b>Notes</b>
<b>1</b>	Group 1	A female with a darker right wing in comparison to the typical colouration of the left.
<b>2</b>	Group 2	A female individual showing presence of two white spots at the base of the beak and on the throat margin
<b>3</b>	Group 3	Presence of two individuals (a male and a female) bearing diffused black colouration on the typical pale-yellow chin and throat (Kaur <i>et al.</i> , 2023).
<b>4</b>	Group 4	A male individual with almost white/silver forecrown and lore region (Kaur <i>et al.</i> , 2024)
<b>5</b>	Group 5	No distinct character noted. However, Group 1 separates this group from Group 6.
<b>6</b>	Group 6	No overlap with Group 5 noted and no distinct character present in any individual.
<b>7</b>	Group 7	A female individual with a tiny black spot on the right upper portion of the chin (Plate 6).
<b>8</b>	Group 8	Group located outside PA and no noticeable character.
<b>9</b>	Group 9	A female individual with almost white/silver forecrown and lore region.
<b>10</b>	Group 10	A group situated outside the PA and a female individual with a black mark on the chin (Plate 5)
<b>11</b>	Group 11	Outside PA; only group with one female individual.
<b>12</b>	Group 12	Not included in the analysis
<b>13</b>	Group 13	Not included in the analysis
<b>14</b>	Group 14	Not included in the analysis

## **Statistical Analysis**

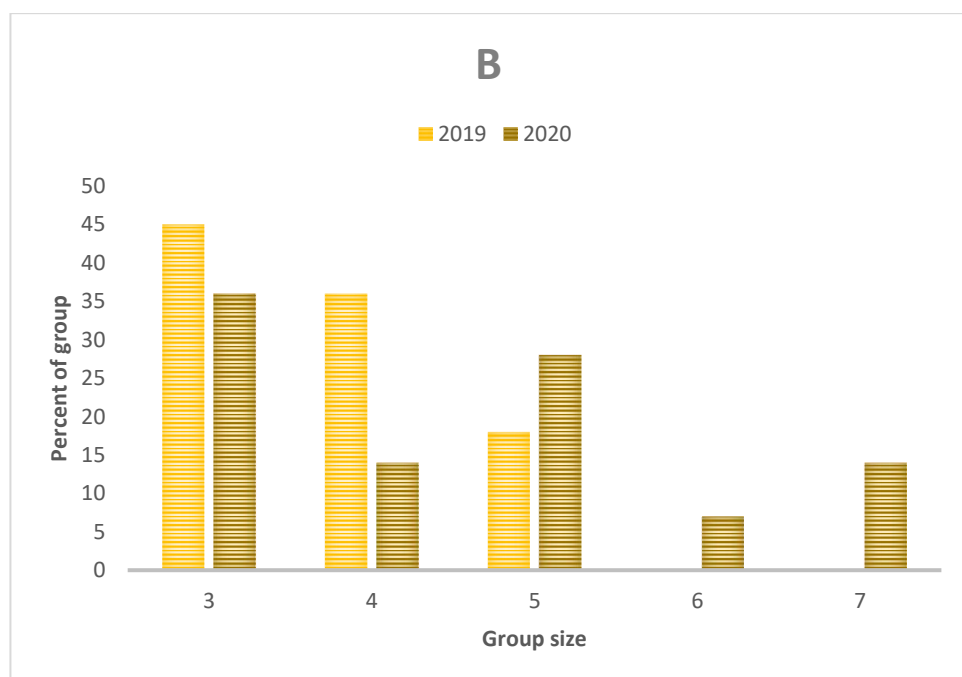
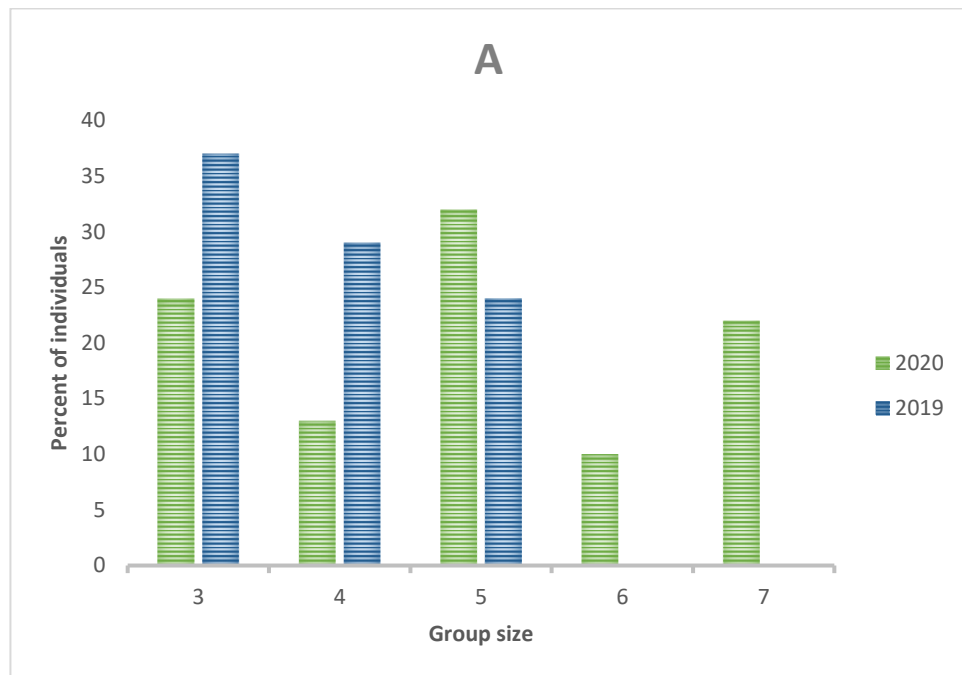
I used an array of 161 GPS locations for 11 groups to map the spatial extent of each group. The locations for each group represent their activity patterns during the winter (post-breeding) and summer (breeding) seasons. I recorded the points (GPS locations) or independent locations or fixes for each group of GSW wherein each independent location is a categorical representation of one family group and defines a particular activity as being in flight or perched in a tree (foraging, vocalizing, nesting, roosting, and even territorial displays). In the case of both nesting and roosting, the locations used by the groups were included as one data point in the analysis, irrespective of the number of times I recorded the birds using that particular active roost or nest. I based the home ranges on movements and various associated behavioral activities (foraging, vocalizing, display, and nesting). I formulated the home range for only 11 groups of the 14 family groups due to insufficient fixes available for the remaining three groups. Hence, I excluded one group within the PA and two family groups outside the PA from the analysis. I estimated territory size with the minimum convex polygon (MCP) method, where when calculating the area rather than considering the density of recorded points, a polygon around the outermost locations is framed. I used 100% estimates for MCP analysis and based the inference on the area bounded by the outermost fixes. I also ran a simple linear regression using the home range as the dependent variable and number of fixes (n) and group size as independent variables. This test was performed to determine whether the home range size is dependent on the number of fixes or the group size of various family groups.

## ***Results***

### **Grouping**

In 2019, I recorded 41 individuals represented by 17 males and 24 females belonging to 11 independent family groups, each comprising 3 to 5 individuals (Table 5). I located seven groups inside the conservation reserve and mapped four family groups outside the protected area. 45% of the groups consisted of three individuals, 36% had four individuals, and the remaining 18% consisted of groups represented by five individuals.

In 2020, I recorded 63 individuals (28 male and 35 female) belonging to 14 independent family groups, each comprising 3-7 individuals (Table 5, Figure 3). In addition to the groups identified in the previous year, three additional groups were recorded for the area outside the PA boundary with an increase in the number of individuals (can be attributed to the identification of new groups or nest success of the previous nesting period). I concluded the identity of each individual (the total number of males and females) for all group assemblages.

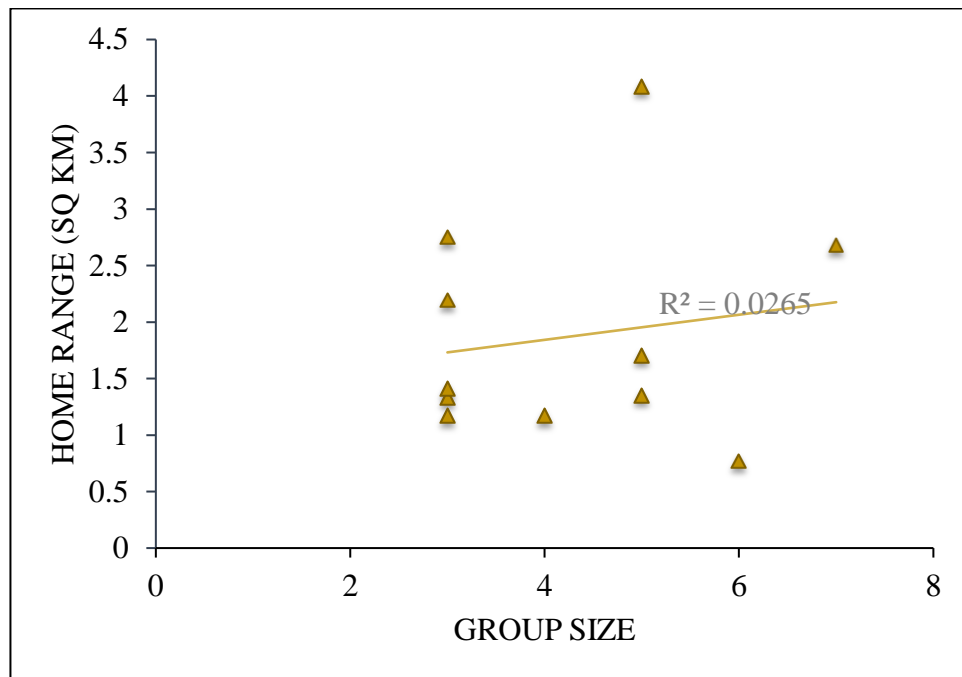


**Figure 3.** (A) Frequency of individuals occurring as member of group sizes, and (B) Frequency of Great Slaty Woodpecker group sizes

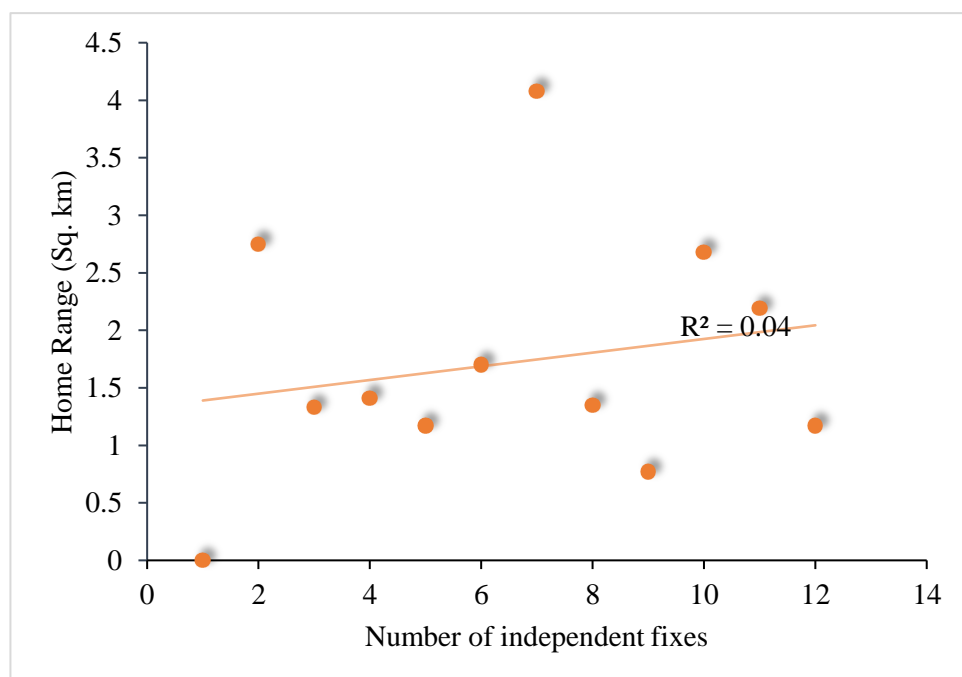
## **Home-range size and social interactions**

### *Overlap area and size of home ranges*

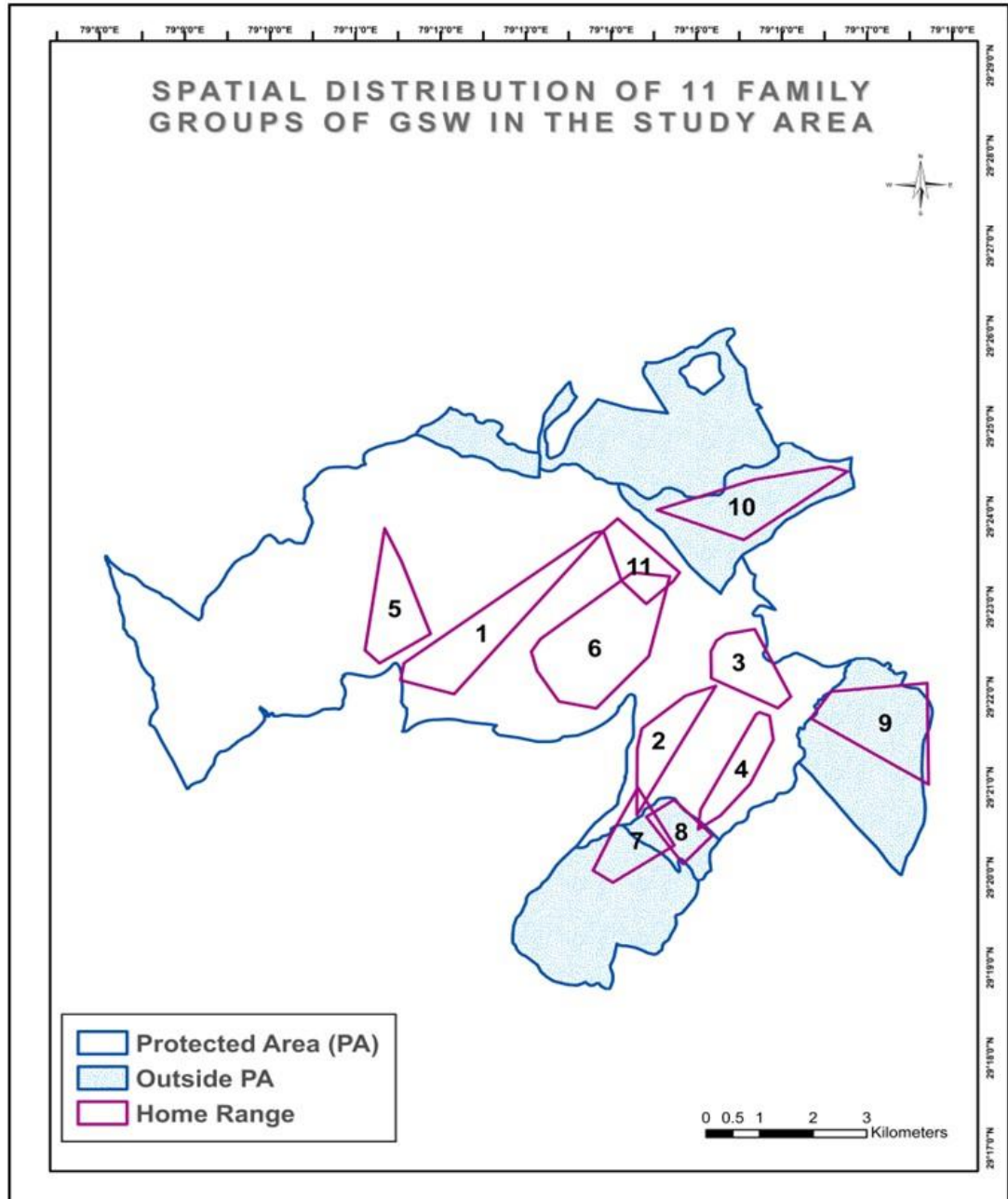
Eleven groups of GSW showed short-ranging movement (Figure 6), ranging over 2060 ha of the 8720 ha surveyed woodland habitat. Group 6 and Group 8 represent the maximum and minimum home ranges covering an area of 408 ha (n=18) and 77 ha (n=22), respectively. I found that groups occupy *c.* 23.62% of the study area (PA and OPA) (Table 6). The neighboring family groups displayed intraspecific territoriality with a slight overlap in habitat use. I detected the only evident territorial interaction during the breeding season. I found that six groups (Groups 2, 4, 5, 7, 8, and 11) of GSW show minimal overlapping in their use of the area. Additionally, I observed that the individuals of two family groups sharing the same boundary would come together to perform an inflight dance, circling above the trees, vocalizing, and chasing one another mid-flight. This display activity lasted 21.5 minutes ( $\pm 17$  minutes), and both groups disintegrated into their territories with their respective individuals in the family groups. I recorded an overlapping area of 34.11 ha (Groups 5 and 11), *c.* 52 ha (Groups 4 and 8), 9.9 ha (Groups 7 and 8), and 5.07 ha (Groups 2 and 7). Group 8 was the only group recorded showing overlap with two neighboring groups (Group 4 and Group 7) in the landscape. Group 8 shares a total area of 10.42 ha with two other groups (0.52 ha with Group 4 and 9.9 ha with Group 7). Regression analyses showed that the home range size was not correlated to neither the group size nor the number of independent fixes (Figure 4 and 5).



**Figure 4.** Relationship between the home range of 11 groups with respect to group size ( $r = 0.16$ ,  $P = 0.198$ )



**Figure 5.** Response of the home range of 11 groups with respect to the total number of independent fixes ( $r = 0.02$ ,  $P = 0.154$ )



**Figure 6.** Distribution of family groups (n=11) known from territory mapping (MCP 100%) throughout the study period irrespective of seasons

**Table 5.** Summarization of group size and number of individuals in each group of Great Slaty Woodpecker within the PCR and the area surveyed outside the protected area (in 2019 and 2020)

S. No.	Group ID	2019			2020		
		Group size	Male individual(s)	Female individual(s)	Group Size	Male individual(s)	Female individual(s)
1	Group 1	3	1	2	3	1	2
2	Group 2	3	1	2	3	1	2
3	Group 3	3	1	2	3	1	2
4	Group 4	4	2	2	4	2	2
5	Group 5	5	2	3	5	2	3
6	Group 6	-	-	-	5	3	2
7	Group 7	4	2	2	5	3	2
8	Group 8	4	2	2	6	3	3
9	Group 9	5	2	3	7	3	4
10	Group 10	3	1	2	3	1	2
11	Group 11	3	2	1	3	2	1
12	Group 12	4	2	2	4	1	3
13	Group 13	-	-	-	5	2	3
14	Group 14	-	-	-	7	3	4
	<b>TOTAL</b>	<b>41</b>	<b>18</b>	<b>23</b>	<b>63</b>	<b>28</b>	<b>35</b>

**Table 6.** Summation of the home range for the different groups of Great Slaty Woodpecker

<b>Group Id</b>	<b>Group Size</b>	<b>Total number of independent locations (n)</b>	<b>Home-range (sq. km)</b>	<b>Total area used (% of the surveyed area)</b>
Group 1	3	11	<b>2.75</b>	3.15
Group 2	3	17	1.33	1.52
Group 3	3	19	1.41	1.61
Group 4	4	22	1.17	1.34
Group 5	5	9	1.70	1.94
Group 6	5	18	<b>4.08</b>	4.67
Group 7 <sup>†</sup>	5	15	1.35	1.54
Group 8 <sup>†</sup>	6	11	0.77	0.88
Group 9 <sup>†</sup>	7	11	<b>2.68</b>	3.07
Group 10 <sup>†</sup>	3	17	2.19	2.51
Group 11	3	11	1.17	1.34
Group 12	4	-	Not analysed	Not analysed
Group 13 <sup>†</sup>	5	-	Not analysed	Not analysed
Group 14 <sup>†</sup>	7	-	Not analysed	Not analysed

## ***Discussions and conclusions***

The home range for following species of Picids is available *Campephilus magellanicus* (Ojeda & Chazarreta, 2014), *Dryocopus pileatus* (Mellen *et al.*, 1992; Tomasevic & Marzluff, 2018), *Dryocopus martius* (Bocca *et al.*, 2007), *Picoides arcticus* (Dudley & Saab, 2007; Rota *et al.*, 2014; Tingley *et al.*, 2014), *Dryobates borealis* (Porter & Labisky, 1986; Franzreb, 2006), *Dryobates albolarvatus* (Lorenz *et al.*, 2015), *Dryobates minor* (Wiktander *et al.*, 2001) over the However, no knowledge on the movement and ranging pattern for the genus *Mulleripicus* is available despite the Vulnerable status of the species. In recent years, a high degree of habitat fragmentation, modification, and degradation has accelerated. Habitat loss is the most urgent threat faced by any species, and it becomes imperative to evaluate the role and effectiveness of the existing habitat concerning a particular species to develop a better understanding. The Great Slaty Woodpecker is a cooperative breeder i.e. family groups comprising a pair and helpers (Lammertink, 2004). This attempt, as the first estimate of home range and group size for a small population of the Great Slaty Woodpecker, represents the western distribution, may add to the present knowledge of the species and may prove beneficial in preparing a much-needed management plan for the species. The woodpecker species mentioned have differences in body size, habitat type, diet, and life history traits, and the comparison of variation in home-range size in these interspecific species must be interpreted precisely.

In 1976, a study of the spacing system of a cooperative breeder, Green Woodhoopoes (*Phoeniculus purpureus*), revealed that the species is territorial and occupies year-round territories (Ligon & Ligon, 1982). The study highlights the significant and

dynamic relationship between the group size and the territory size with an inference that a group with 15 birds occupied an area of 133 ha, and the group of four woodhoopoes had an area of 26 ha. Therefore, I hypothesized that the variation in the home range size of each family group irrespective of the year or season, can be attributed to the differences in the total number of independent fixes and the group size. However, after the analysis, I noted that Group 4, although represented by the highest number of independent fixes ( $n=22$ ), utilized an area less than Group 5, which has the lowest number of independent fixes ( $n=9$ ) with an area of 170 ha. Similarly, five of the total 11 groups analyzed constitute three individuals each. Of these, I digitized a total of 19 fixes for one group (Group 3), 17 for the other two (Groups 2 and 10), and 11 for the remaining two groups (Groups 1 and 11). Similarly, the group size of two family units (9 and 8) is represented by 7 and 6 individuals, the highest recorded from the landscape for any group. I observed both these groups utilize an area of 2.68 sq. km (the second largest) and 0.77 sq. km (the lowest area), respectively. Group 6 has a size of five individuals and represents the highest area in use (408 ha;  $n=18$ ). Group 5 and Group 7 have the same number of individuals and show variation in the home range area with 170 ha ( $n=9$ ) and 135 ha ( $n=15$ ), respectively. Group 4 is the only group analyzed and represented by four individuals with a home range of 117 ha ( $n=22$ ). Therefore, I infer that the differences in the home range size for each group depend neither on the number of fixes nor the group size (Table 5). The overlap in territory was minimal and stipulated the saturation level and potential for interaction between the neighboring family groups.

Further, I observed that each family groups maintain stable territories year-round concerning the number of individuals and their identity, and this reasonable threshold

value of habitat use forms the preliminary evaluation of the minimum area required by one group of the GSW. The only change I noticed in the group structure (increase in the number of individuals) was likely a characteristic of successful nesting attempt or dispersal, evident and recorded for three groups during the next post-breeding and breeding seasons (Table 5). Home range overlap was minimal for the family groups. Since I did not acquire significant sightings (independent locations) for any family group, I did not use more robust methods like Kernel estimation. Kernel Utilization Distribution (KUD) evaluates the density of recorded locations, thereby assigning a probability of area use based on the number and spatial arrangement of locations, and helps to describe the relative amount of time an animal spends in each area (e.g., a 95% kernel is an area where the animal occurs 95% of the time) (Worton, 1989). Since with KUD, one can typically overestimate the home range size of an animal with small sample sizes. So, I evaluated MCPs for each group as the method estimates biologically meaningful home ranges even with fewer location samples (Wang *et al.*, 2020). Additionally, this study shows that the degree of overlap is minimal in terms of the MCPs, and intraspecific territoriality can be explained by Inflight Dance involving the temporary association of two neighboring family groups during the breeding season. During the breeding season, I observed an increase in vocalizations, especially soft calls in response to communication between members of one family group. I also used these conspicuous displays as a measure of territory size that transpired at territorial boundaries and included vocal confrontations with the immediate neighboring group(s). I observed this dynamic interaction among six family groups, and the limited overlap of home ranges in the forest suggests that the great Slaty Woodpecker family groups maintain stable ranges year-round. Interestingly, I

observed that the groups were not absent in the managed forests of the area and showed flexibility in habitat use. Since information on the estimation of abundance at the local scale in a primary forest for *Mulleripicus* spp. is scarce, this study highlights that the presence of a viable population helps in inferring the quality of the habitat with favorable forest features must be safeguarded for these family groups to occupy and use. Understanding and maintaining the population dynamics is crucial for conserving this threatened species, as the decline of suitable habitat directly impacts the species. However, this study only points out variability in home-range sizes among different family groups. However, on a large scale, the distribution of territories may be dependent on the spatial distribution of the preferred habitat that the birds occupy during breeding and post-breeding seasons. To understand the degree of territoriality, I must consider more robust methods for territory mapping, compare the results obtained year-round, and note down the variation in different seasons. Therefore, I propose long-term monitoring studies with multiple site comparisons for the species involving radio telemetry and ringing to outline an effective conservation strategy.



**Plate 8. Three members of the family group outside the PA raiding the nest of stingless bees,**

*Tetragnola* sp. inside a cavity (©Sarabjeet Kaur)

## **Chapter 4. Foraging behavior of the Great Slaty woodpecker**

### ***Introduction***

The abilities and behavior of an organism reflect the fitness of an individual. The degree of specialization of a species concerning their behavior is best explained by discerning differences in generalist, specialist, opportunist, coarse-grained, etc. (Rosenzweig, 1981). Birds use a particular habitat that meets their breeding and foraging requirements, and this selection is dependent on several factors varying from one species to another. For example, forest birds strategize different search patterns and utilize different foraging maneuvers for capturing different prey species depending on the area used for foraging (Robinson and Holmes, 1982). The foraging behavior is a gradual phenomenon involving search, attack, foraging site, food, and food handling. This aspect is a typical representation of a time activity budget, and data on foraging can help us understand the community organization in a habitat. The quantification of resources is a critical criterion for understanding the population dynamics and species interactions based on the distribution and abundance of a particular resource in a community. Measuring the availability of food has several limitations (Hutto, 1990) and involves accuracy, lack of bird's perception, scale-of-measurement, assumptions, sample size, proposed sampling method, spatial and temporal evaluation, food handling time as highlighted in shorebirds (Baker and Baker, 1973) and forest birds (Wolda, 1990). In the Black Woodpecker (*Dryocopus martius*), the habitat analysis revealed avoidance of the dominant local Mountain Pine (*Pinus mugo uncinata*) forest

type and selection of Scots Pine (*Pinus sylvestris*) stands based on the foraging observations due to the presence of ants in abundance in the latter (Bocca *et al.*, 2007). The Great Slaty Woodpecker (*Mulleripicus pulverulentus*) is a flagship species and is considered vulnerable due to loss of the preferred habitat, and recognizing the seasonal patterns during their foraging performance on a spatial scale can be used as a measure to deem the species as generalist and specialist. The mature Sal forests are the predominant habitat for nesting, roosting, and foraging for the species. Habitat loss (fragmentation and decline) is paramount for classifying the species as Vulnerable (IUCN Red List). The information on the foraging behavior is critical for understanding the habitat requirements. Ensuring the prospects for survival and gaining insight into a particular food source may help examine the exploitation pattern relative to the availability of that food (Hutto, 1990). The species uses large areas to meet its foraging requirements and prefers to forage on Sal and other trees. The extensive areas used for foraging and the fact that forest management continually alters foraging habitats, I studied the foraging behavior of the focal species in a mature Sal-dominated forest stand to:

- (a) discern possible variations in foraging behavior for two sampling periods (post-breeding and breeding)
- (b) characterize the similarities and differences in food items of the Great Slaty woodpecker during the same periods,

## ***Methods***

I conducted the fieldwork from October to February (during the post-breeding season) and March to July (during the breeding season) from 2018-2019 and 2019-2020. To obtain data on the foraging by the ten woodpecker species, I identified 52 transects of variable lengths of 2 km to 9 km. Each transect outlines different habitats corresponding to Sal and miscellaneous forest stands, perennial and seasonal river beds, Teak (*Tectona grandis*) plantations, grasslands, roads, and village boundaries. To ensure even coverage of all segments of the transects, I walked at a fixed speed of 500 m/hr during the morning survey. I recorded the woodpecker activity between 0530 hrs to 0900 hrs. during the breeding season coinciding with the summer and 0700 hrs to 1100 hrs during the post-breeding season coinciding with the winter season. I alternated walking and stationary searches approximately every 15 minutes.

### **A sampling of foraging behavior**

On sighting the group, I recorded the individuality of each member and several aspects of its behavior and location. I followed the group for several hours and noted the observations. Upon detecting a bird, I observed its activity for 15 seconds before recording it as a foraging observation. I recorded the foraging site (tree species, ground or other), the Girth at breast height (GBH), the foraging substrate (the part of the tree towards which a foraging maneuver was directed (twig, tertiary branch, secondary branch, primary branch or main trunk, leaves, seeds)), and foraging maneuver. From March 2018 to May 2020, I identified and followed 14 family groups of Great Slaty Woodpeckers, and observations served as a check on the validity of our sampling of rare foraging behavior corresponding to intake of fruits, seeds, and water. On many

occasions, when several individuals were present at the same time in a group of trees, I noted the identity of each visitor and the duration of stay for each bird. I ceased the observation when we could no longer see the foraging behavior of the bird. The foraging behavior was determined by following two approaches during two post-breeding and breeding seasons each. Each tactic involves associated prey-attacking maneuvers involving a) frequent hops (near-perch maneuvers; probe) and b) short flights between long durations at the substrate (Peck).

### **Foraging manoeuvres**

I categorized the prey-attacking tactics attempted by an individual during an active foraging session. First, I cataloged the different foraging behaviors and then classified each behavior into several attack methods (Table 7). I modify the methods recorded frequently used by the Great Slaty Woodpecker following the classification and terminology for terrestrial foraging birds (Remsen and Robinson, 1990).

**Gleaning:** The bird acquires stationary prey from the following substrates: fissures in the tree bark, ground, or other(s) and involves scaling that particular substrate for further prey search.

**Reaching:** A combination of hanging and gleaning. The individual birds fly to a perch like a twig or cluster of leaves at the canopy of trees and hang from it. It involves extending the legs and neck upwards, outwards, or downwards to reach the desired prey. Moreover, hanging is a way that includes suspending the body below to acquire a food item else out of reach. Depending on the surface of the substrate (vertical, horizontal, and diagonal), I further distinguished reaching into hanging upside down, hang-up, hang-down, and hang-sideways.

**Pecking:** This involves striking the bill against a substrate to excavate a hole or a small cavity in bark or wood to probe prey. In this method, the beak is aimed perpendicularly into the substrate. It is a subsurface maneuver involving manipulation. This method does not include hammering and is allocated only to sound production during the breeding season in several sympatric woodpeckers. However, I did not observe hammering in the Great Slaty Woodpecker.

**Probing:** This involves inserting the beak into a hole, cavity, and cracks in either the firm or the soft substrates such as mud channels or tubes of termites on the surface of the tree trunks for extracting the food item. This method is also a subsurface maneuver like pecking and involves no substrate manipulation to pry the food.

**Table 7.** Classification of attack methods of the foraging behaviour of Great Slaty Woodpecker

S. No.	I. Near-perch manoeuvres	II. Subsurface Manoeuvres	
		No substrate manipulation	Substrate manipulation
1	Glean	Probe	Peck
2	Reach	-	-

## **Analyses**

I analyze the seasonal shift by the woodpecker species separately for each attribute (i.e., foraging substrate (horizontal part of the tree: trunk, base, middle or ends of branches and vertical zones of the tree: above or below the crown) and foraging maneuver (e.g., glean, peck, probe)). In addition, I determined the feeding habits of the birds by direct visual observations of food consumption by foraging individuals. From the data collected, I calculated the percent use of different foraging variables (tree condition: live or dead, size (Girth at Breast Height, GBH), and tree species) used by this insectivorous bird species for both seasons separately. The minimum sample size recommended by Moreno (1984) is 30 for analyzing avian foraging behavior. However, I recorded and analyzed 12 and 26 foraging observations for the two post-breeding and breeding seasons. Unfortunately, our sample size was too small for comprehensive analysis in multi-way contingency tables. Therefore, I performed the analysis to search for seasonal changes in foraging patterns with the help of Generalized Additive Models (GAMs). I performed the analyses in R Software using the packages “dplyr”, “mgcv”, and “tidyr” to check whether seasonal foraging performance by the family groups of the Great Slaty Woodpecker depends on any of the following variables: foraging site, substrate, or the maneuver. Additionally, we present a summary of seasonal variations of independent foraging behavior with 25 and 51 foraging observations recorded and analyzed for the two post-breeding and breeding seasons at individual levels.

## ***Results***

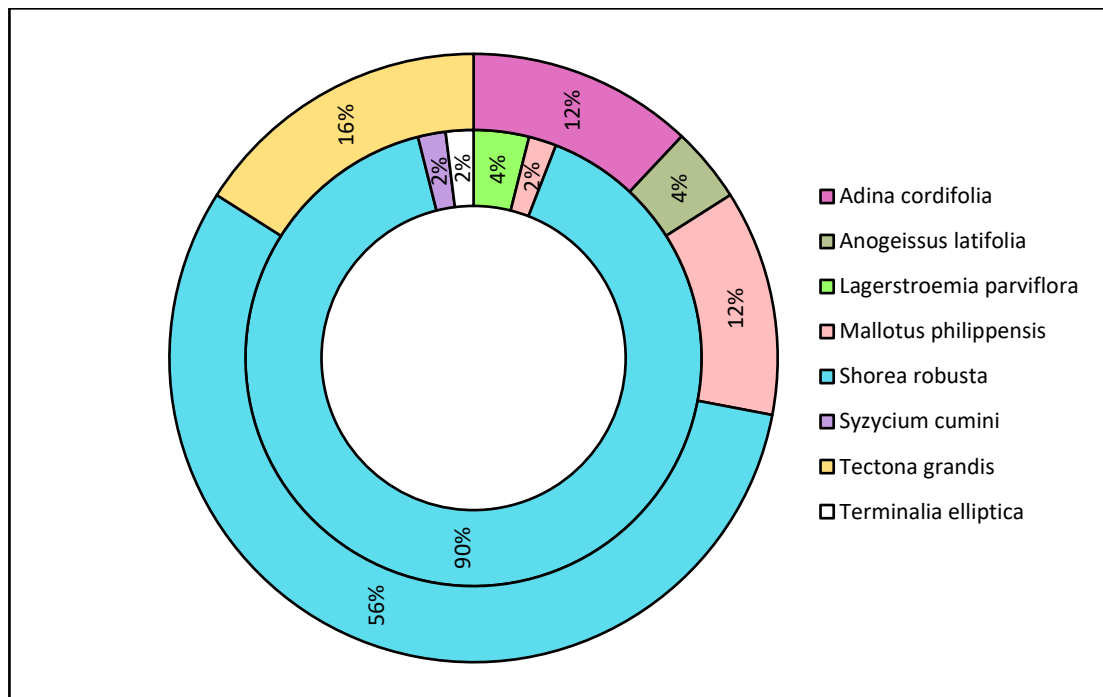
### **Independent observations and foraging events at the group level**

I compared the foraging behavior of the Great Slaty Woodpecker for two different seasons, breeding and post-breeding season, and the formulation of the generalized additive model reveals a significant difference in the use of the foraging site (the tree species during each season). However, there is no significant difference in the foraging substrate or maneuver. I found family groups of Great Slaty Woodpeckers show a preference for *Shorea robusta* across the two seasons. The selection of *Shorea robusta* constitutes 50% and 88% during the post-breeding and breeding season, respectively. However, tree species like *Mallotus philippensis* were preferred in both seasons with varying intensity (1.96% during breeding and 12% during post-breeding season), and observed selection of other tree species during one season and not during the other.

### **Independent observations and foraging events at the individual level**

***Trees selected for foraging:*** I found that the individuals of the Great Slaty Woodpecker preferred live trees of *Shorea robusta* as foraging substrate during both seasons (Table 1, Figure 9). In addition, I also recorded the species foraging on *Tectona grandis*, *Adina cordifolia*, *Mallotus philippinensis*, *Syzygium cumini*, *Terminalia elliptica*, *Anogeissus latifolia*, and *Lagerstroemia parviflora*. During both seasons, I noted the use of only five of the total eight tree species by the foraging groups of the Great Slaty Woodpeckers (Figure 9). Nearly 90% of all feeding records were on Sal trees (n=46), followed by *Lagerstroemia parviflora* (3.9%), and 1.96% each of *Mallotus philippensis*, *Syzygium cumini*, and *Terminalia elliptica* during the

breeding season (n=51). However, during the post-breeding season (n=25), 56% of the observations were from Sal trees (n=14), followed by *Tectona grandis* (16%), *Adina cordifolia* (12%), *Mallotus philippensis* (12%) and *Anogeissus latifolia* (4%).

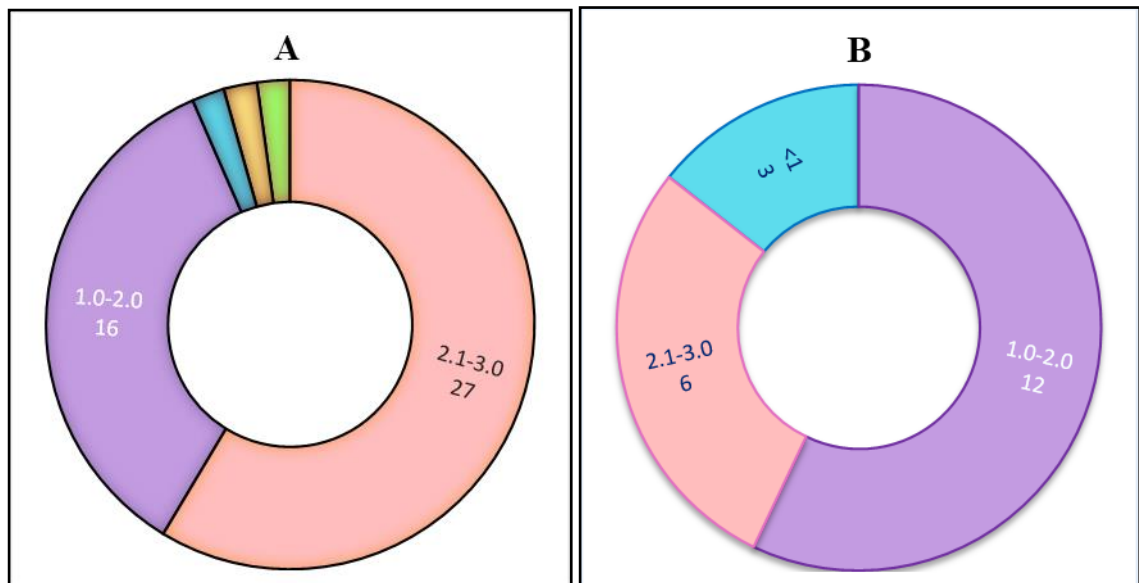


**Figure 7.** Percent use of foraging sites (tree species) during the two seasons

There was no sexual difference in the use of a foraging tree. Both males and females of each group frequently foraged on the same trees seldom choosing another tree for meeting their foraging requirements. During the breeding season, I inferred that the individuals foraged on trees with mean diameters of 2.2 m (n=51), while during the post-breeding season, a mean diameter of 1.6 m for all the foraging trees. I observed both sexes showing a strong preference for foraging trees greater than 1 m and avoidance for trees less than 0.4 m in diameter (Figure 10).

During the breeding season, I recorded the Great Slaty Woodpecker exhibiting a strong preference for Sal trees and diameters ranging from 1 m to 4.14 m (mean 2.3 m; n=46),

including other trees and diameters ranging from 0.6 m to 2.85 m. Similarly, during the post-breeding season, Sal trees were chosen as primary feeding trees with diameters ranging from 0.9 m to 2.2 m (mean 1.5 m; n=14), including other tree species ranging from 0.4 m to 2.85 m in diameter.

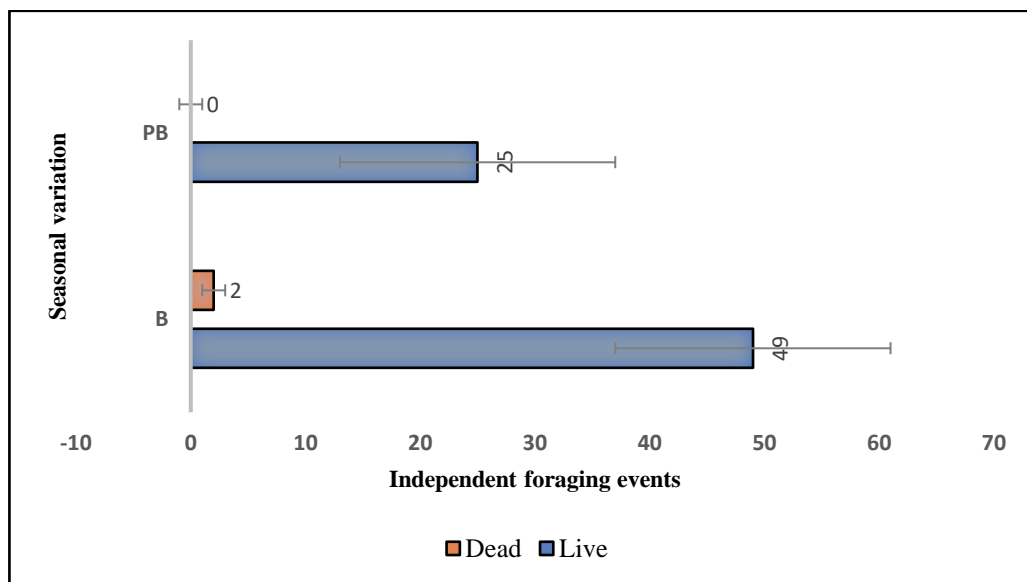


**Figure 8.** Diagrammatic representation of foraging preference of the Great Slaty Woodpecker for diameter class during **a)** breeding season and **b)** post-breeding season

**Foraging substrate:** I found that foraging individuals did not use all eight tree species but instead selected a specific substrate for procuring food on each site. I observed the following microhabitats in use as foraging substrates: main trunk, primary branch, secondary branch, leaves, and cavities present on different sites on the tree.

*Shorea robusta* was used explicitly for foraging throughout both seasons, and I recorded the use of all the foraging substrates. During the breeding season, the main trunk was foraged singly (n=15) and sometimes with a primary branch (n=3)

depending upon the foraging maneuver used for obtaining the food. I found that the main trunk is the most used foraging substrate, followed by primary branch (n=9), leaves (n=8), cavities on primary branch and secondary branch (n=5 and n=1 respectively), and secondary branch (n=2). Similarly, during the post-breeding season, the most preferred foraging substrate was the main trunk (n=7) followed by a combination of the main trunk and primary branch (n=5), primary branch, and leaves with one observation each.

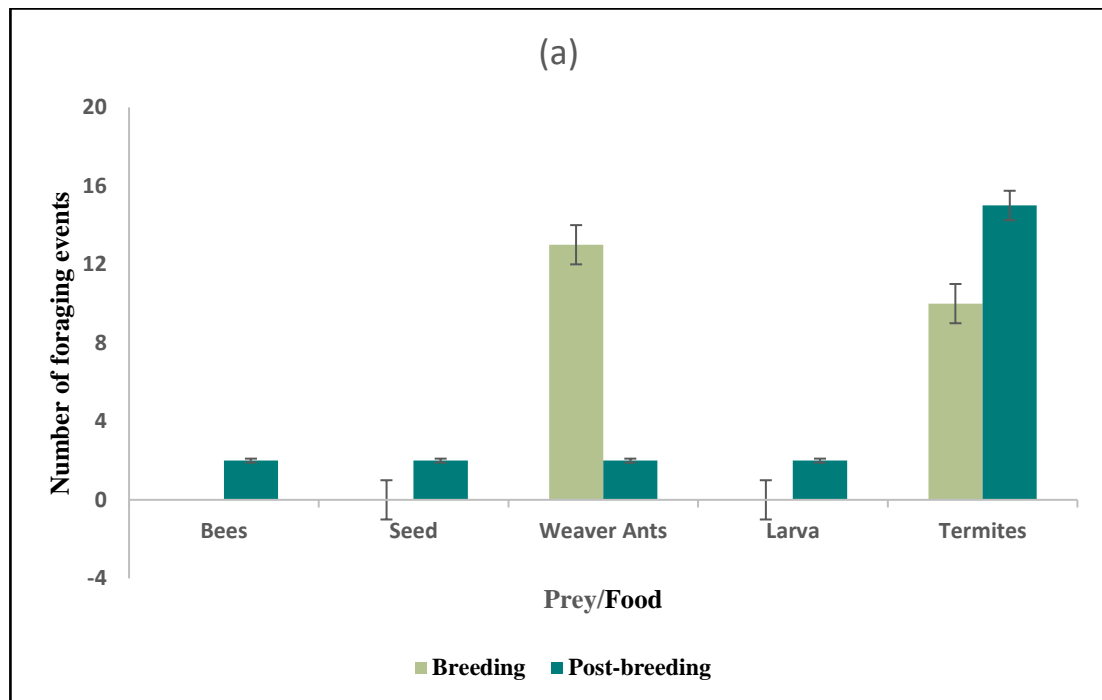


**Figure 9.** Seasonal variation in the use of eight tree species with respect to their quality (live and dead) from the independent foraging observations

Likewise, the findings of the study reveal the use of the main trunk of *Mallotus philippensis* for obtaining food only once during both seasons and the use of the main trunk of *Tectona grandis* and *Anogeissus latifolia* for foraging during the post-breeding season with no observations recorded from the breeding season. I observed foraging on the main trunk, and a natural cavity on *Adina cordifolia* during the post-

breeding season. The findings reveal the use of the main trunk of *Syzygium cumini*, secondary branches of *Lagerstroemia parviflora*, and a cavity present on a primary branch of *Terminalia elliptica* as substrates during the breeding season and no recorded observations during the post-breeding season for the same.

**Food items:** I sighted the Great Slaty Woodpeckers procuring the following prey and food items (Plate 9 and 10) during the quantitative study from two post-breeding and two breeding seasons each: termites, stingless bees, weaver ants, seeds of *Mallotus philippensis*, and larvae of wood boring beetles.



**Figure 10.** Food items procured by the Great Slaty Woodpecker during breeding and post-breeding season from 2018-2020

**Foraging methods:** I observed the male and female individuals of all family units secure a food item from live Sal trees. I recorded the application of four foraging maneuvers to acquire the food item: probing, pecking, gleaning, and reaching.



**Plate 9. The seeds of *Mallotus philippensis* were consumed as food during the breeding season and the nest of *Oecophylla smaragdina* were raided during both the seasons by different family group of the Great Slaty Woodpeckers**

(©Sarabjeet Kaur)

*Use of other substrates:* I sighted individuals of one group of Great Slaty Woodpeckers consume the seeds of *Mallotus philippensis* in April 2019 (Kaur *et al.*, 2023). The utilization of *Mallotus* has not been reported earlier anywhere in the range of the species and therefore marks the first observation as a food item.

*Use of water:* I observed two cases of Great Slaty Woodpecker drinking water. On both occasions, the individuals drank water from old nesting/roosting cavities on Sal trees. I made both observations during the breeding season (April to June). Groups likely had year-round access to water, and birds may have gone undetected multiple times.



**Plate 10. A male Great Slaty Woodpecker outside a cavity on *Shorea robusta* harbouring the nest of stingless bees (©Sarabjeet Kaur)**

### ***Discussion and conclusion***

Crucially, as a primary cavity-nester, the findings constitute an integral contribution to the existing ecological knowledge with the help of a predictive tool. The generalized additive model (GAM) was employed to predict the seasonal patterns in resource selection. I recorded no seasonal variation in the prey species selected or the foraging maneuvers. I recorded each family group robustly engaged in raiding the nests of stingless bees in hollow trunks, tree branches, and cavities belonging to genus *Tetragonula sp.*, complex nests of the weaver ants in the tree canopy represented

by *Oecophylla smaragdina*, and channels of arboreal termites belonging to genus *Nasutitermes* spp. on the tree species like *Shorea robusta*, *Mallotus philippensis*, and *Syzycium cumini*. Each foraging bout lasted a minimum of 45 minutes and extended to several hours or a whole day with intervals characterized by preening, short flights to other trees, vocalizations, or just perching silently with no movement. During each foraging event, I noted one member from the family group acting as a sentinel, inactive in the foraging, and uttering regular calls approximately 20 to 50 m away. The study highlights the exploitation of food items seasonally by the family groups of Great Slaty Woodpeckers. This exploitation behavior within a given habitat toward a food item or a particular prey species is a biological interaction and reflects fitness. Several insectivorous birds and foliage-foraging ants are established biological controls or natural enemies of insect pests and play an intrinsic role in restoring several damages inflicted by insect pests (Crawford and Jennings, 1983; Torgersen *et al.*, 1990). Termites are insect pests that can cause significant damage to forests. As a forest professional, it is essential to minimize this damage to improve the overall health of the forest. Anecdotal evidence from a study on species in West Borneo and Lingga Islands in Southeast Asia supports our findings on the stingless bees, foraging on live trunks and branches of trees with large girth at breast height (Lammertink, 2004), and differs in the use of dead wood including dead limbs and dead trees. A comprehensive study involving a large sample concerning the foraging behavior is still desirable to assess the frequency of use of live trees by the Great Slaty Woodpecker and further investigation of the habitat availability *versus* use needs to be prioritized.



**Plate 11. A juvenile male individual peering outside the nest cavity with a hint of red hue on the forecrown and a developing red moustachial stripe (Group 10) (©Sarabjeet Kaur)**

## **Chapter 5. Juvenile foraging proficiency**

### ***Introduction***

Proficiency is the ability of an organism to acquire a resource from a habitat and the cognitive role of learning in developing a skill. In the context of feeding, juveniles must attain expertise in key challenges like predator avoidance (Pyke *et al.*, 1977, Arnold and Wade, 1984), social interactions with competitors and conspecifics, time and energy allocation (Krebs, 1974, Smith and Sweatman, 1974; Zach and Falls, 1979; Heinsohn, 1991) to efficiently meet the demands for survival. Therefore, the extent of parental care is critical for these behaviors to develop and provide a means to overcome constraints like mortality during the juvenile period. In many species, juvenile mortality is a limiting factor during the first year of life, either immediately following the first few days of independence (Drury and Smith, 1968; Sullivan, 1988) or the first winter when there is a constraint in food resources (North and Morgan, 1979; Grant and Grant, 1989; Butler, 1994). In Great Blue Heron (*Ardea Herodias*), a 69-73% mortality rate was recorded during the first year in comparison to a 22-27% mortality rate following the second year (Butler, 1995). Additionally, high mortality rates in juveniles may be attributed to other factors such as predation, starvation, and in urban settlements due to collision with power and telephone lines, and hunting pressure. The foraging proficiency or performance of a juvenile of any species can be used as a surrogate measure of fitness cost (Schoener, 1971; Wolf *et al.*, 1975; Sullivan, 1990). However, internal and external factors must be weighed while understanding the development of foraging behavior. The interactions with the environment may influence the skill development of a young individual. For example, weather and

climate conditions, distribution and abundance of prey, observational learning, and dominance may affect the efficiency of juvenile foraging and hinder skill enhancement during the early development stage. In the case of social bird species, the juveniles most likely possess an increased survival probability due to the facilitation of shared vigilance by the flock, benefitting the development of foraging skills as it allows them more time to forage (Sullivan, 1988). The radio tracking of Palila (*Loxioides bailleui*), an endangered Hawaiian Honeycreeper, was carried out to investigate the development of the juvenile foraging skill, movement pattern, and social dynamics with the aid of opportunistic sightings and intensive nest monitoring (Miller, 1998). In Herring Gull (*Larus argentatus*), delay in reproduction or the first breeding is linked to the slow development of foraging skills (Greig *et al.*, 1983).

In addition to foraging, a young bird has to develop and learn various traits involved in skill development like balancing and grasping a substrate, ability to fly, coordination, finding a suitable perch, recognition of a food item(s), and time spent in foraging and food handling. Young birds likely require more food for their growth and survival during both the nestling and post-fledging stages. In several cases, food is delivered by both or either parent but in some cases, food provisioning is fulfilled by both parents and helpers in conjunction. The rate of survival is only half in case of the absence of support for young parents during the fledging to independence period (Wolf *et al.*, 1988). The foraging skills of juvenile birds are not well-developed in comparison to the adults and therefore, to assess the mechanics of juvenile foraging proficiency of the Great Slaty Woodpecker I outlined the following aspects to understand the foraging behavior namely, foraging site, substrate, search pattern, and foraging maneuver, selection of food item, and food handling. These variables are fundamental to the

optimal foraging theory and important determinants of foraging proficiency (Groves, 1978). And, the rate at which these components are utilized by both adults and juveniles varies from species to species (Jansen, 1980; MacLean, 1986) and may depend on the prey type (Wunderle, 1991). The choice of foraging location may be dependent on the foraging skill of an individual and therefore, the age-related differences in habitat use occur in many species (e.g., Great Blue Heron, *Ardea herodias*, Butler, 1991; Butler *et al.*, 1995). Generally, a hierarchy of behavioral decisions and skills is important in developing an efficient foraging technique, and locating a suitable foraging habitat is of utmost importance when searching for a food item (Gutsell, 1995; Krebs, 1974). Intraspecific interactions also influence the difference in foraging behavior as the adults are dominant to younger birds which may result in their elimination from a preferred foraging area (Sutherland and Parker, 1985; Gustafsson, 1988) and in case of absence of exclusion, aggressive interactions may hinder the foraging of individuals in a flock relative to adults (Smith and Metcalfe, 1994). To compensate, juveniles may spend more time foraging (Cook, 1978; Porter and Sealy, 1982; Burger and Gochfeld, 1984; Weathers and Sullivan, 1989), engage in flock foraging (Buckley and Buckley, 1974), and choose a food item that does not require employing a skilled maneuver (Morrison *et al.*, 1978; Desrochers, 1992).

In summary, the following components of foraging behavior: habitat selection and prey detection, prey selection, prey capture, and prey handling underline a foraging sequence and reveal the cost of energy intake. In juveniles, it was observed that lower intake rates due to a lack of foraging skills lead to insufficient daily energy requirements (e.g., Bald Eagle, *Haliaeetus leucocephalus*, Stalmaster and Gessaman

1984; Great Blue Heron, *Ardea herodias*, Butler 1991) and delayed molting (e.g., Yellow-eyed Juncos, *Junco phaeonotus*; Weather and Sullivan, 1989). In many studies, a clear distinction has been observed in acquiring a food item or prey detection by an adult and a juvenile. Adults were more thorough and successful than juveniles in their detection ability (e.g., Common Crane, *Grus grus*, Alonso and Alonso, 1993; Verbeek, 1977a; Greig *et al.*, 1983; Burger and Gochfeld, 1984). However, lower efficiency in juveniles can be attributed to learning and food recognition (Common Reed Warbler, *Acrocephalus scirpaceus*, Davies and Green, 1976; Grey Heron, *Ardea cinerea*, Cook, 1978; Bananaquit, *Coereba flaveola*, Wunderle and Lodge, 1988) and in case of multiple food items, specialization of a foraging maneuver during the early stages of learning may prove a hindrance in developing different foraging technique for a different food later (Davies, 1976; Richardson and Verbeek, 1987), as well as, recognition (Espin *et al.*, 1986; MacLean, 1986). In *Sitta europaea*, efficient foraging is reported in adults than in juveniles during the summer season concerning the dominance of adults over juveniles of the same sex. However, during the autumn season, a change in foraging behavior (more efficient collection of sunflower seeds, *Helianthus annuus* from the feeders to store for winter) was observed in juveniles which can be attributed to growth in beak and recognition of the food resource (Enoksson, 1988). Since the juvenile habitat use and complexity of foraging skills differ from that of adults, therefore, I outlined the objective to assess the development of foraging behavior after a juvenile has fledged from the nest with the hypothesis that there is a continuous increase in foraging skill until the individuals attempt nesting in the next season.

### ***Limitation***

I was unable to complete the objective concerning the juvenile foraging proficiency of the Great Slaty Woodpecker with enough findings due to the following reasons:

#### **Detectability**

The Great Slaty Woodpecker c.50 cm is a territorial bird with large territories that live in family flocks of 3-7 individuals (Table 4 and Table 5). I observed that the individuals cover even large distances during the post-breeding season, and in the absence of an aural cue, it becomes difficult to locate these woodpeckers.

#### **Permission from the Uttarakhand State Forest Department and the concerned Range Office for the study area**

Due to the lack of sanctions for the surveys during the monsoon season from the concerned authority and the lack of literature on the fledging period of the Great Slaty Woodpecker, I was unable to frame a proper methodology for this particular objective and hence support the partial fulfillment of our aim with the three opportunistic observations.

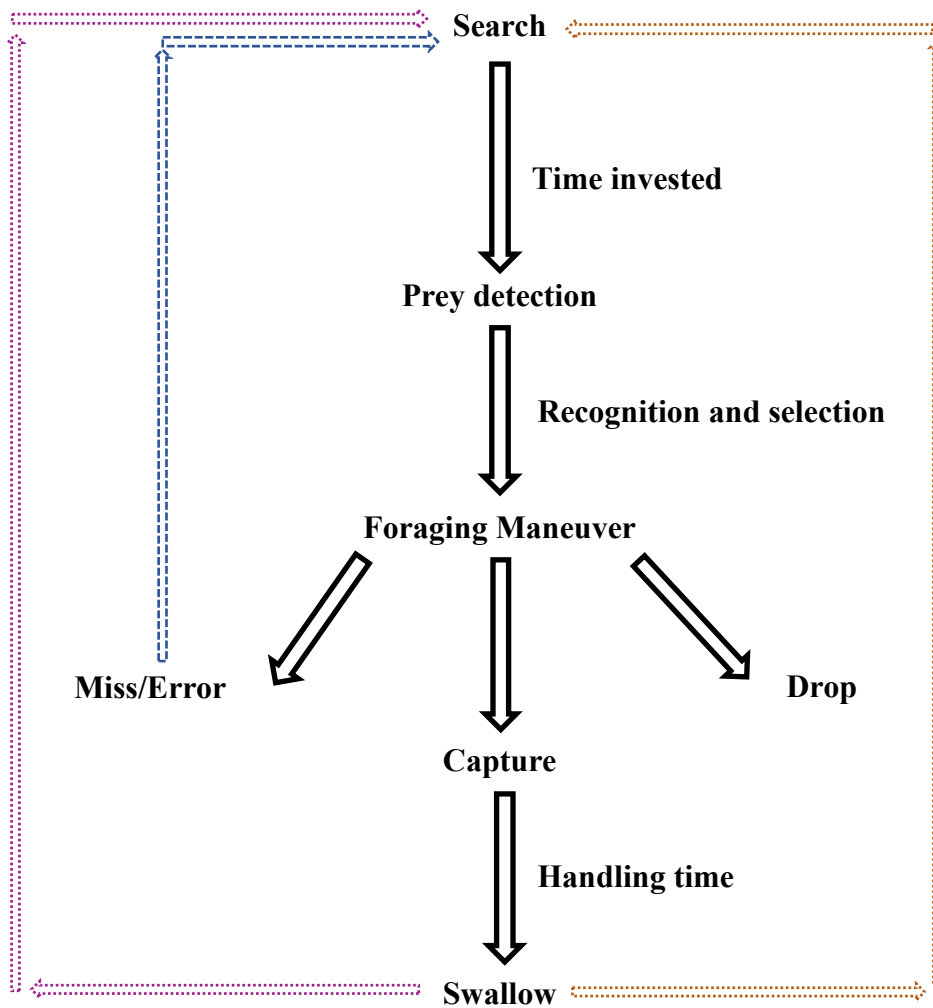
### ***Methodology***

I carried out active nest searches from April to June 2019 and 2020 in the study area, concentrating efforts on areas where I found single trees bearing multiple nest cavities from previous seasons. During both years, systematic and intensive nest searches were carried out along the transects. In 2020, the nest sites from previous seasons were monitored consistently to record the movement of the respective family group identified from that area in addition to the new nest sites (if located successfully). I

observed the interaction between adults and juveniles and recorded the foraging behavior immediately after the fledging. Additionally, I recorded the sequence of foraging observations by the juveniles (Figure 11) and observed the juveniles after the fledglings left the nest. I observed the individuals with the help of a spotting scope (45x, Burris) mounted on a tripod. I started the observation when a chosen individual oriented toward a prey or a food item and ended the observation soon after the juvenile stopped foraging or flew to a distance immediately after ceasing the foraging exercise.

### ***Results and discussion***

I collected opportunistic data on the activity of juvenile foraging performance after the early initiation and completion of the breeding season during the first year. Crucially, I was able to account for only three opportunistic observations of the juvenile-adult interaction from the three nests of three different family groups of the Great Slaty Woodpecker. I recorded that juvenile birds in each feeding flock of these family groups covered only a small distance from the nest after fledging and were completely dependent on the adults to acquire a food resource. Furthermore, I observed that in all these cases, one adult (either a helper or a parent) was feeding termites (food items) to the fledgling on the main trunk of a *Shorea robusta* tree. This indicates that the juveniles are inept during the initial stage of fledging and are assisted by their respective family group comprising parents and helpers to meet their foraging requirements. This indicates that parents and helpers remain under the constraint of attending to the young and are required to make an increased effort for both their body condition and juvenile provisioning. However, these observations are neither sufficient to suggest the development of learning in the juvenile Great Slaty Woodpecker nor



**Figure 11. Schematic illustration to record the foraging performance of a juvenile Great Slaty Woodpecker**

development of foraging behavior. Although the importance of proficiency in foraging is a proven aspect in the development of the individual (Morse 1980), our observations of the same were constrained due to the incidence of fledging of juveniles coinciding with the monsoon season (July-September). Due to the limitations, I was unable to assess the juvenile foraging proficiency from the study area and therefore, only outline the qualitative aspect of the known observations from the three nests immediately after

the fledglings were seen leaving the nest. Based on these three observations, I prognosticate that: a) learning is essential for the survival of the juveniles, b) foraging skills are learned from adults (both parents and helpers), and c) the risk of mortality is high between the fledging and post-fledging stage (e.g., European Shags, *Phalacrocorax aristotelis*, Daunt et al. 2007). In conclusion, due to the small population of the Great Slaty Woodpecker, their elusive behavior in the absence of aural cues, territoriality, and range of movement in addition to the limitations outlined above, I present only a brief account of the foraging behavior of the juveniles.

### ***Conclusion***

At present, the extent of foraging performance and post-fledging parental care remains unclear in the Great Slaty Woodpecker. The question remains unanswered as the quantification of foraging proficiency was not evaluated through our study. However, I propose that it would be valuable to conduct an experiment involving age-related differences for this particular species along with a sample of marked juveniles that would determine what proportion of time spent in foraging enables efficiency and would also be helpful in understanding whether mortality of young individuals is in response to poor foraging and thus expedite an understanding between the foraging component and survival relationship.



**Plate 12. A Great Slaty Woodpecker flying away to start the day (©Sarabjeet Kaur)**

## **Chapter 6. Threats and disturbances**

### ***Introduction***

The Great Slaty Woodpecker (*Mulleripicus pulverulentus*) is the largest, resident extant woodpecker species after the declaration confirming the extinction of Ivory-billed Woodpecker (U.S. Fish & Wildlife Service, 2022), primarily insectivorous and a primary cavity nester. These cavities are significant habitat opportunities for other species for nesting and roosting. The population decline in recent years is attributed majorly to the loss of favorable habitat and habitat fragmentation (Birdlife International, 2016).

### **Needs of Great Slaty Woodpecker**

Great Slaty Woodpeckers are old-growth specialists (Lammertink *et al.*, 2009) closely associated with mature Sal (*Shorea robusta*) stands. The distribution of the species is limited, thus restricting its range (Winkler *et al.*, 2020, and in India, the habitat preference of the focal species currently includes the following (Kumar *et al.*, 2011 and Kumar *et al.*, 2014):

1. Natural Sal stands with no silviculture operations
2. Mature to old managed Sal stands under the final stage of silvicultural management

### **Habitat Requirements**

The Great Slaty Woodpeckers are closely associated with mature dipterocarp forests, especially *Shorea robusta* (Sal). This habitat, once abundant, has been altered considerably due to deforestation, commercial logging, and fire. In combination, all these factors have contributed to habitat fragmentation, thus restricting their

distribution throughout their range in Himachal Pradesh, Uttarakhand, Bihar, and Arunachal Pradesh in India (Winkler *et al.*, 2020). This habitat fulfills the nesting, ranging, and foraging needs of the woodpecker, where they choose old, living trees for constructing their nests and foraging on dead and live Sal trees to procure food items. The food most commonly includes termites, stingless bees, red ants, larvae of wood-boring beetles, and seeds of *Mallotus philippensis* (Kaur *et al.*, 2023).

### **Management Status and existing management plans**

Great Slaty Woodpecker is listed as Vulnerable (VU) under criteria A2bc in the IUCN Red List of Threatened Species as of 2016 (IUCN 2016). Globally, the range of GSW extends into the tropical forests of South and Southeast Asia, including a southern portion of China. Without a monitoring program or recovery plan for any woodpecker species across their entire range, the biodiversity of an area is constantly at risk from natural disturbances and human activities such as degradation, fragmentation, and conversion. These factors can cause stress on the ecosystem and threaten its stability. To identify the potential disturbances in the study area and given lacking management implication, the studied aspects of ranging and foraging by the focal species proved helpful in outlining the following threats that may provide information for framing strategies and taking the necessary steps for the effective conservation of the species.

## ***Results***

### **Risk factors/ threats**

Practices like timber harvesting, prescribed fires, fire suppression (in some cases), and replacement of natural and mature stands with young stands are induced risks that limit

the habitat and food resources, thus proving detrimental to the populations of any concerned woodpecker species. We have addressed the responses of the Great Slaty Woodpeckers to these risks at a smaller spatial scale where the relevant disturbances occur in two broad categories: a) Forest management activities prioritizing commercial silvicultural operations with the lack of a proper conservation plan on the species and b) Natural disturbance. Table 8 summarises the threats in order of increasing level of concern (high to low) observed, and each is discussed briefly below based on the observations recorded during the survey period.

### *Selective logging*

The Great Slaty Woodpeckers face threats from the loss or degradation of mature Sal forests, and conserving these forests is crucial to ensure the survival of this magnificent bird species. As a specialized species, it is likely sensitive to logged forests, although the extent of this sensitivity remains unclear. During the field survey, we came across six small-scale timber harvesting sites in the areas that were part of the total territory for a few family groups of the focal species. The timber removal for commercial purposes included live and dead trees of different tree species, including *Shorea robusta*, *Anogeissus latifolia*, *Lagerstroemia parviflora*, *Tectona grandis*, etc. However, we could not assess the exact count of trees removed from each site due to a lack of permission from the concerned department. I only observed two groups of Great Slaty Woodpeckers showing signs of disturbance and a shift in the use of the areas frequented formerly for meeting their foraging requirements and used for nesting within their marked territories during the second year of the study.

**Table 8.** List of potential threats and responses in general recorded during the survey  
in Pawalgarh Conservation Reserve

S. No	Threat	Level of concern	Extent	Occurrence	Frequency	Severity
<b>Anthropogenic Impacts on habitat</b>						
1	Selective logging	High	Widespread	Current	Continuous	High
2	Removal of snags	Medium	Widespread	Current	Continuous	Unknown
3	Removal of nest/roost trees during breeding season	Low	Localized	Anticipated	Seasonal	Low
4	Firewood cutting	Low	Localized	Current	Continuous	Low
5	Traffic Volume (Tourism)	Low	Localized	Current	Recurrent	Low
<b>Changes in ecological or natural dynamics</b>						
6	Competition for nest sites with secondary cavity nesters	Medium	Widespread	Current	Seasonal	Medium (Pawalgarh) Unknown (Rest of range)
7	Fire	High	Widespread	Current	Seasonal	Low
8	Storms	Low	Widespread	Current	Recurrent	Low
9	Climate change	Low	Widespread	Anticipated	Unknown	Unknown
<b>Sensitisation</b>						
10	Lack of awareness	High	Localized	Current	Continuous	High

### *Lack of awareness*

The communities of Village Pawalgarh, Kyari, Mankanthpur, and Devirampur are predominantly small landholders who practice agriculture (Wheat, Rice, and Mustard) and manage orchards of *Phyllanthus emblica*, *Mangifera indica*, and *Litchi chinensis*. Despite having significant knowledge of common bird species in their agricultural areas and orchards, they possess negligible knowledge of identifying several forest bird species.

I conducted a simple survey inquiring about the different types of woodpecker species and asked 250 individuals to share their observations. During the survey, the participants shared their knowledge about these birds nesting and foraging habits. The people living in the villages informed us that they have witnessed the woodpeckers nesting in and around their homes for as long as they have lived in those areas. In addition, we approached a few locals (n=50) who frequently visit the forest area for various activities like grazing the cattle, fodder collection, or people who serve with the forest department as fire watchers every season and forest staff to comprehend their understanding of woodpeckers in general with a primary focus on the identification of Great Slaty Woodpecker. I learned that out of all the people, only one individual could successfully identify the focal species and informed us that he had sighted the species rarely in the area he frequents with his cattle. Additionally, we found that the rest of the villagers confused the Woodpeckers in general with the Eurasian Hoopoe and that the locals misidentified the Indian Gray Hornbill for the Great Slaty Woodpecker. I realized that the lack of awareness may negatively impact the long-term monitoring of the Great Slaty Woodpecker population in the area.

To address this issue and sensitize the locals about the occurrence and importance of different woodpecker species, we prepared a pictorial guide on the 12 most common woodpecker species found during our field survey at the study site (Kaur *et al.*, 2020) and distributed them to the forest department, local children in villages and conducted bird walks to highlight the importance of birds and woodpeckers (Plate 13).



**Plate 13. Distribution of pictorial guide on the 12 most common woodpecker species at Pawalgarh Conservation Reserve as awareness material to the locals**

### *Periodic fires*

Fires play a crucial role in altering the breeding habitat of the Great Slaty Woodpecker, leading to limited reproductive success. If intense fire events continue to occur at a high rate, it will inevitably cause a decline in the suitable habitat of the bird. It is

essential to note that the breeding season, which starts in May, coincides with the fire season months from March to June (Plate 14). Therefore, appropriate measures to prevent further habitat degradation are critical.



**Plate 14. A fire event recorded in May 2019 at Pawalgarh Conservation Reserve**

During the field survey, I came across two fire events in the second year (2020) that point to a concern regarding the utilization of that particular area. I found that a family group of Great Slaty Woodpeckers had initiated the process of nest construction before the fire, and they abandoned the area post-fire event that lasted five hours. I have noticed that several woodpecker species, namely Greater Yellownappe, Himalayan Flameback, Grey-headed Woodpecker, and Black-rumped Flameback, have abandoned their nests just as their young ones were about to fledge. I recorded no

activity by any of these species at or near their nest sites after this incident. The cause of this behavior may be due to a 13-hour fire that damaged the trees containing the nest cavities (Plate 15). The placement of the nest cavity in the damaged trees varied from 152 cm for the Grey-headed Woodpecker to approximately 2100 cm for the Greater Yellownape and Great Slaty Woodpecker. The intensity of the fire event differed in both these sites within the study area, but the outcome was the same - forcing the woodpeckers to leave the area.

The occurrence of seasonal fires, especially during the summer, in any landscape can be devastating. The intensity of the fire event can prove detrimental, whether it is a single fire event or a series of fire events over time from the same areas, and this may lead to population declines as it affects the vegetation structure and composition, thus impacting the dependency of an animal that could have otherwise survived in these areas.

### *Snag removal*

Standing dead trees, also known as snags, are vital for many species of birds. They provide principal sites for foraging, nesting, vocalizing, and perching. Unfortunately, these trees removed during forest management operations in protected areas, conservation reserves, parks, highways, and private lands can lead to habitat degradation and modification over time, thus impacting the ecosystem. I observed Gray-headed Woodpecker, Fulvous-breasted Woodpecker, and Gray-capped Pygmy Woodpecker using these snags commonly for foraging. However, I recorded that the Great Slaty Woodpeckers used these snags as calling perches or for preening. I did not make any foraging or nesting observations by the focal species on the dead trees. The

research findings about foraging and nesting suggest that the Great Slaty Woodpeckers only foraged and nested on live Sal trees. However, it is paramount to consider the value and preservation of snags in forest management. Forest birds utilize snags differently during different seasons and for various purposes such as foraging, nesting, vocalizing perches, and sometimes just perches.



**Plate 15. The forest floor shows the residues of an intense fire event**

***Competition for nest sites with secondary cavity nesters***

I observed the Brown Hawk-Owl (*Ninox scutulata*), Brown-headed Barbet (*Psilopogon zeylanicus*), Rose-ringed Parakeet (*Psittacula krameri*), Common Myna (*Acridotheres tristis*), Jungle Myna (*A. fuscus*), Dollarbird (*Eurystomus orientalis*), and Oriental Magpie Robin (*Copsychus saularis*) using the cavities left by the focal

species either after the completion of their nesting season or before the beginning of the next nesting season. However, competition for nest sites with secondary cavity nesters (e.g., Common Myna (*Acridotheres tristis*), Rose-ringed Parakeet (*Psittacula krameri*), Dollarbird (*Eurystomus orientalis*)) is a natural threat to the focal species and recorded during both the breeding seasons from the study area (Plate 16).



**Plate 16. The Rose-ringed Parakeet, *Psittacula krameri* peering outside the nesting cavity a few metres above the nest cavity of the Great Slaty Woodpecker, *Mulleripicus pulverulentus* with the female individual perched outside (©Sarabjeet Kaur)**

## ***Discussion***

Since the response to a particular disturbance by a bird depends on habitat and species, the intensity of the threat may vary from one area to the other, and the response to an individual threat may also vary among different species of birds utilizing these habitats. Woodpeckers are considered reliable indicators of bird richness (Mikusinski *et al.*, 2001; Kumar *et al.*, 2011; Menon and Shahabuddin, 2014) and the health of a forest (Drever *et al.*, 2008). The response of any woodpecker species to an existing forest management practice(s) can help modify the existing management implications and thus shape a better plan for future conservation steps. Many woodpecker species rely on the dead and dying trees for foraging and nesting. The permanent conversion of suitable habitat over time to another type of habitat, thus disrupting the natural processes, may be termed habitat loss. Loss of habitat is considered a primary threat that can directly influence the occurrence of any species in an area. The intensity with which a viable habitat required by a particular species is changed or converted plays an essential role in framing a suitable conservation strategy.

Forest degradation is attributed to a loss in response to a disturbance and has been defined in many ways and includes different perceptions, objectives, and values (Ghazoul *et al.*, 2015). The most common cause of tropical forest degradation is high timber harvest and poor silvicultural practices, and this practice is termed logging. A meta-analysis of more than 100 publications uncovers considerable variability on the subject and reveals that 85-100% of species of mammals, birds, invertebrates, and plants remain after logging (Putz *et al.*, 2012). It is crucial to implement selective logging carefully to avoid irreversible degradation over time. A meta-analysis of 26 studies on the responses of 992 bird species to selective logging found 2022 negative

and 2052 positive responses (Burivalova et al., 2015). Selective logging is considered one of the most common aspects of forest use that may include the removal of trees with multiple nests extensively used for nesting and roosting by several bird and mammal species. The logged tropical rainforests exhibit a decline in species richness among mixed flocks of insectivores and solitary large insectivores, which unequivocally represent mature understory species (Thiollay, 1997). The logging practices in Terai Sal forests are detrimental to the habitat as they result in the removal of crucial mature trees. Timber is harvested for commercial and subsistence purposes, which exacerbates the problem. This practice may have an immediate impact on the nest trees and cavity-nesting species alike. Therefore, it is essential to understand the effect of timber harvesting on landscape level. In the case of the Black-backed Woodpecker (*Picoides arcticus*), the lowest amount of timber harvesting in ponderosa pine stands had a maximum density of the woodpecker. Black-backed Woodpeckers selected mature timber areas for nesting, foraging, and roosting. Therefore, the removal of suitable trees during this forest management operation may have a negative impact and continue to cause habitat degradation.

Forest fires in India are a significant cause of forest degradation, and it is crucial to determine their underlying causes. Non-wood forest products (NWFPs) collection and controlled fires for optimized growth of grass cover for cattle grazing are among the main factors causing these fires. Forest fires can have varying degrees of intensity, and their impact can be significant. They may affect biodiversity, water regulation, air pollution, and carbon sequestration, leading to changes in ecological processes. Biodiversity is particularly vulnerable to fires, and frequent fires in sensitive areas may result in the complete loss of the ecosystem. However, fires can also create habitats

and niches for many species, and some ecosystems depend on them. The occurrence of fire is known to significantly impact the breeding success of the Red-tailed Black Cockatoo, *Calyptorhynchus banksii*. This species is a specialist feeder and relies solely on the seeds of three types of trees: Brown Stringybark, Desert Stringybark, and Buloke. During the breeding period, the availability of these seeds in the landscape is already limited, and a post-fire event further exacerbates this situation, resulting in reduced breeding success (Olsen and Weston, 2005).

However, many studies link fire suppression negatively to a woodpecker species. For example, in the case of Lewis's Woodpecker (*Melanerpes lewis*), suppression of fire alters the habitat required by the species and results in the initiation of hardwood understory development. Similarly, fire suppression is a risk for Black-backed Woodpeckers (Saab and Dudley, 1998). For both these species, nesting in dead trees is common, and prescribed fires prove beneficial as they create new snags for nesting and the foraging habitat is renewed. Stand-replacing fires in mature and old-growth forests alter the habitat characteristics required for nesting. However, the ideal size of prescribed burns is not known.

Snags or standing dead trees are characteristics of the management of birds. High species richness, bird abundance, and species diversity were reported from the plots with snags during a four-year survey during the breeding season (Dickinson *et al.*, 1984). Glossy Black Cockatoo, *Calyptorhynchus lathami* is a Vulnerable species of coastal forest and open woodland in E and SE Australia which largely depends on available cavities for nesting either on a live or a dead tree (Rowley and Boseman, 2020). However, continuous salvage logging practice for an extended period after fire events may result in the decline of the trees from the landscape, which presents a

challenge for the nesting bird. In many cases, the observations during the first year of a fire age show a limit on the available resources like food and cover. However, as the fire age advances, these limitations start disappearing, and the abundance of species concerning the habitat, floristics, and patch size begins to change. Some habitats (for example, old-growth forests) have a slow regeneration, and the hollow tree nesters and canopy foragers, the characteristics representatives may still not appear actively following an intense fire (Woinarski and Recher, 1997).

Similarly, logging also plays a critical role in maximizing the conservation values for forests of protected and outside protected areas. A meta-analysis of over 200 publications (Burivalova et al., 2015) on the impact of selective logging on avifauna in tropical forests revealed that the interaction between logging variables and species traits is necessary for explaining the influence of logging. Based on the effects of Reduced Impact Logging (RIL) and high-intensity Conventional Logging (CL), the findings depict that RIL is relatively less harmful in species abundance. The analysis also reveals variation among species concerning the feeding groups viz nectarivores, granivores, carnivores, frugivores, and insectivores, and therefore, the feeding group becomes an essential predictor of logging and its intensity. Positive and negative responses of a particular feeding group will also depend on the time since logging.

Bird communities in a forest ecosystem are known to be determined by the presence of decaying woods used by several bird species like Red-headed Woodpeckers, Great-crested Flycatchers, Downy Woodpecker, Hairy Woodpeckers, Caroline Chickadee (Dickinson *et al.*, 1983). The study found a significant difference in bird communities between the plots with the presence and absence of snags. As a result, high species richness, bird abundance, and bird species diversity from the plots with snags are

known. Snags are essential for primary cavity nesters, which help secondary cavity nesters by providing opportunities for nesting and roosting. During the field survey, we failed to establish the use of snags either foraging or nesting by the Great Slaty Woodpeckers.

Insectivorous birds like Striped Wren-Babbler, *Kenopia striata*, and Sooty-capped Babbler, *Malacopteron affine* depend on the forest understory. In the former, logging practices make the species susceptible to decline owing to its specialized diet (Collar and Robson, 2020). The latter can survive forest edges, and river banks benefit from the initial clearings of the forest. However, these gaps start filling up as the forest regenerates, a disadvantage to the species (Collar and Robson, 2020). The Great Slaty Woodpecker is an insectivorous bird, and it is unclear to detect the change in their abundance concerning time since logging through a single qualitative case study such as this and more long-term studies are required to understand the impact of the logging operations in the areas of their extant range.

## ***Conclusion***

I carried out this study with limited resources and logistic support and suggest that long-term monitoring of the areas with an emphasis on species that are currently globally threatened may help us understand the habitat conditions, the abundance, and diversity of birds from those areas with an advantage of strategizing long-term improvement of viable habitat. Since the occurrence of a viable habitat in fragments may not necessarily prove suitable for both adult and young birds of a species, and therefore left unoccupied. In addition, the overall suitability of an intact habitat gets

disrupted over time due to alterations caused by fire regimes, logging operations, introduction of invasive species (in some cases), diseases, air, water, and noise pollution. I conducted this study for two years, and the complete knowledge to suggest the severity of the above-outlined disturbances is crucial. Long-term monitoring is necessary to develop an understanding of conservation methods for biodiversity and how each species responds to various threats. Until an assertive management plan and guidelines are in place for the area and the species, it is advisable to exercise cautionary measures.



**Plate 17. The grassland patch at the eastern part of the Pawalgarh Conservation**

**Reserve and continuous Sal Forest (©Sarabjeet Kaur)**

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## APPENDIX

**APPENDIX 1.** Checklist of birds recorded during the woodpecker survey from March 2018 to January 2021 in the Pawalgarh Conservation Reserve

<b>S. No</b>	<b>Common name</b>	<b>Scientific name</b>	<b>IUCN Red List Status</b>
1	Gray Francolin	<i>Ortygorniss pondicerianus</i>	LC
2	Common Quail	<i>Coturnix coturnix</i>	LC
3	Red Junglefowl	<i>Gallus gallus</i>	LC
4	Kalij Pheasant	<i>Lophura leucomelanos</i>	LC
5	Indian Peafowl	<i>Pavo cristatus</i>	LC
6	Little Grebe	<i>Tachybaptus ruficollis</i>	LC
7	Painted Stork	<i>Mycteria leucocephala</i>	NT
8	Asian Openbill	<i>Anastomus oscitans</i>	LC
9	Black Stork	<i>Ciconia nigra</i>	LC
10	Woolly-necked Stork	<i>Ciconia episopus</i>	LC
11	Red-naped Ibis	<i>Psuedibis papillosa</i>	LC
12	Indian Pond Heron	<i>Ardeola grayii</i>	LC
13	Cattle Egret	<i>Bubulcus ibis</i>	LC
14	Great Egret	<i>Ardea alba</i>	LC
15	Intermediate Egret	<i>Ardea intermedia</i>	LC
16	Little Egret	<i>Egretta garzetta</i>	LC
17	Little Cormorant	<i>Microcarbo niger</i>	LC

18	Great Cormorant	<i>Phalacrocorax carbo</i>	LC
19	Collared Falconet	<i>Microhierax caerulescens</i>	LC
20	Eurasian Kestrel	<i>Falco tinnuncius</i>	LC
21	Black-winged Kite	<i>Elanus caeruleus</i>	LC
22	Black Kite	<i>Milvus migrans</i>	LC
23	Oriental Honey Buzzard	<i>Pernis ptilorhynchus</i>	LC
24	Egyptian Vulture	<i>Neophron percnopterus</i>	EN
25	Himalayan Griffon	<i>Gyps himalayensis</i>	NT
26	Cinereous Vulture	<i>Aegypius monachus</i>	NT
27	Crested Serpent Eagle	<i>Spilornis cheela</i>	LC
28	Eurasian Marsh Harrier	<i>Circus aeruginosus</i>	LC
29	Shikra	<i>Accipiter badius</i>	LC
30	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	LC
31	White-eyed Buzzard	<i>Batastur teesa</i>	LC
32	Indian Spotted Eagle	<i>Clanga hastata</i>	VU
33	Tawny Eagle	<i>Aquila rapax</i>	VU
34	Steppe Eagle	<i>Aquila nipalensis</i>	EN
35	Bonelli's Eagle	<i>Aquila fasciata</i>	LC
36	Booted Eagle	<i>Hieraetus pennatus</i>	LC
37	Changeable Hawk-Eagle	<i>Nisaetus cirrhatus</i>	LC
38	Mountain Hawk-Eagle	<i>Nisaetus nipalensis</i>	LC
39	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	LC
40	River Lapwing	<i>Vanellus duvaucelli</i>	NT

41	Red-wattled Lapwing	<i>Vanellus indicus</i>	LC
42	Common Greenshank	<i>Tringa nebularia</i>	LC
43	Common Sandpiper	<i>Actitis hypoleucos</i>	
44	Green Sandpiper	<i>Tringa ochropus</i>	LC
45	Rock Pigeon	<i>Columba livia</i>	LC
46	Oriental Turtle-Dove	<i>Streptopelia orientalis</i>	LC
47	Eurasian Collared-Dove	<i>Streptopelia decacota</i>	LC
48	Red Collared-Dove	<i>Streptopelia tranquebarica</i>	LC
49	Spotted Dove	<i>Streptopelia chinensis</i>	LC
50	Laughing Dove	<i>Streptopelia senegalensis</i>	LC
51	Yellow-footed Green- Pigeon	<i>Treron phoenicopterus</i>	LC
52	Wedge-tailed Green- Pigeon	<i>Treron sphenurus</i>	LC
53	Asian Emerald Dove	<i>Chalcophaps indica</i>	LC
54	Alexandrine Parakeet	<i>Psittacula eupatria</i>	NT
55	Rose-ringed Parakeet	<i>Psittacula krameria</i>	LC
56	Slaty-headed Parakeet	<i>Psittacula himalayana</i>	LC
57	Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	LC
58	Red-breasted Parakeet	<i>Psittacula alexandri</i>	NT
59	Pied Cuckoo	<i>Clamator jacobinus</i>	LC
60	Common Hawk-Cuckoo	<i>Heirococcyx varius</i>	LC
61	Indian Cuckoo	<i>Cuculus Micropterus</i>	LC

62	Common Cuckoo	<i>Cuculus canorus</i>	LC
63	Gray-bellied Cuckoo	<i>Cacomantis passerines</i>	LC
64	Square-tailed Drongo-Cuckoo	<i>Surniculus lugubris</i>	LC
65	Asian Koel	<i>Eudynamys scolopaceus</i>	LC
66	Green-billed Malkoha	<i>Phaenicophaeus tristis</i>	LC
67	Sirkeer Malkoha	<i>Taccocua leschenaultia</i>	LC
68	Greater Coucal	<i>Centropus sinensis</i>	LC
69	Barn Owl	<i>Tyto alba</i>	LC
70	Indian Scops-Owl	<i>Otus bekkamoena</i>	LC
71	Collared Scops-Owl	<i>Otus lettia</i>	LC
72	Asian Barred Owlet	<i>Glaucidium cuculoides</i>	LC
73	Jungle Owlet	<i>Glaucidium radiatum</i>	LC
74	Spotted Owlet	<i>Athene brama</i>	LC
75	Spot-bellied Eagle-Owl	<i>Bubo nipalensis</i>	LC
76	Brown Fish-Owl	<i>Ketupa zeylonensis</i>	LC
77	Tawny Fish-Owl	<i>Ketupa flavipes</i>	LC
78	Brown Wood-Owl	<i>Strix leptogrammica</i>	LC
79	Brown Boobook	<i>Ninox scutulata</i>	LC
80	Large-tailed Nightjar	<i>Caprimulgus macrurus</i>	LC
81	Indian Nightjar	<i>Caprimulgus asiaticus</i>	LC
82	Himalayan Swiftlet	<i>Aerodramus brevirostris</i>	LC
83	Crested Treeswift	<i>Hemiprocne coronata</i>	LC

<b>84</b>	Little Swift	<i>Apus affinis</i>	LC
<b>85</b>	Eurasian Hoopoe	<i>Upupa epops</i>	LC
<b>86</b>	Indian Roller	<i>Coracias benghalensis</i>	LC
<b>87</b>	Dollarbird	<i>Eurystomus orientalis</i>	LC
<b>88</b>	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	LC
<b>89</b>	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	LC
<b>90</b>	Common Kingfisher	<i>Alcedo atthis</i>	LC
<b>91</b>	Crested Kingfisher	<i>Megaceryle lugubris</i>	LC
<b>92</b>	Pied Kingfisher	<i>Ceryle rudis</i>	LC
<b>93</b>	Blue-bearded Bee-eater	<i>Nyctyornis athertoni</i>	LC
<b>94</b>	Asian Green Bee-eater	<i>Merops orientalis</i>	LC
<b>95</b>	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	LC
<b>96</b>	Indian Gray Hornbill	<i>Ocyceros birostris</i>	LC
<b>97</b>	Oriental Pied Hornbill	<i>Anthracoceros albirostris</i>	LC
<b>98</b>	Great Hornbill	<i>Buceros bicornis</i>	VU
<b>99</b>	Great Barbet	<i>Psilopogon virens</i>	LC
<b>100</b>	Brown-headed Barbe	<i>Psilopogon zeylanicus</i>	LC
<b>101</b>	Lineated Barbet	<i>Psilopogon lineatus</i>	LC
<b>102</b>	Blue-throated Barbet	<i>Psilopogon asiaticus</i>	LC
<b>103</b>	Coppersmith Barbet	<i>Psilopogon haemacephalus</i>	LC
<b>104</b>	Rufous Woodpecker	<i>Micropternus brachyurus</i>	LC
<b>105</b>	Great Slaty Woodpecker	<i>Mulleripicus pulverulentus</i>	VU

106	Gray-capped Pygmy Woodpecker	<i>Yungipicus canicapillus</i>	LC
107	Brown-capped Pygmy Woodpecker	<i>Yungipicus nanus</i>	LC
108	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	LC
109	Brown-fronted Woodpecker	<i>Dendrocoptes auriceps</i>	LC
110	Lesser Yellownape	<i>Picus chlorophus</i>	LC
111	Greater Yellownape	<i>Chrysophlegma flavinucha</i>	LC
112	Streak-throated Woodpecker	<i>Picus xanthopygaeus</i>	LC
113	Scaly-bellied Woodpecker	<i>Picus squamatus</i>	LC
114	Gray-headed Woodpecker	<i>Picus canus</i>	LC
115	Himalayan Flameback	<i>Dinopium shorii</i>	LC
116	Black-rumped Flameback	<i>Dinopium benghalense</i>	LC
117	Greater Flameback	<i>Chrysocolaptes guttacristatus</i>	LC
118	White-naped Woodpecker	<i>Chrysocolaptes festivus</i>	LC
119	Indian Pitta	<i>Pitta brachyura</i>	LC
120	Hooded Pitta	<i>Pitta sordida</i>	LC
121	Large Woodshrike	<i>Tephrodornis virgatus</i>	LC

122	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	LC
123	Bar-winged Flycatcher-Shrike	<i>Hemipus picatus</i>	LC
124	Large Cuckooshrike	<i>Coracina macei</i>	LC
125	Black-winged Cuckooshrike	<i>Lalage melaschistos</i>	LC
126	Small Minivet	<i>Pericrocotus cinnamomeus</i>	LC
127	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	LC
128	Scarlet Minivet	<i>Pericrocotus speciosus</i>	LC
129	Common Iora	<i>Aegithinia tiphia</i>	LC
130	Brown Shrike	<i>Lanius cristatus</i>	LC
131	Long-tailed Shrike	<i>Lanius schach</i>	LC
132	Gray-backed Shrike	<i>Lanius tephronotus</i>	LC
133	Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i>	LC
134	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	LC
135	Hair-crested Drongo	<i>Dicrurus hottentotus</i>	LC
136	Black Drongo	<i>Dicrurus macrocercus</i>	LC
137	Ashy Drongo	<i>Dicrurus leucophaeus</i>	LC
138	White-bellied Drongo	<i>Dicrurus caerulescens</i>	LC
139	Bronzed Drongo	<i>Dicrurus aeneus</i>	LC

140	Indian Golden Oriole	<i>Oriolus kundoo</i>	LC
141	Black-hooded Oriole	<i>Oriolus xanthornus</i>	LC
142	Maroon Oriole	<i>Oriolus trailii</i>	LC
143	Yellow-bellied Fairy Fantail	<i>Chelidorhynch hypoxanthus</i>	LC
144	Gray-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	LC
145	White-throated Fantail	<i>Rhipidura albicollis</i>	LC
146	White-browed Fantail	<i>Rhipidura aureola</i>	LC
147	Indian Paradise-Flycatcher	<i>Terpsiphone paradisi</i>	LC
148	Black-naped Monarch	<i>Hypothymis azurea</i>	LC
149	Red-billed Blue Magpie	<i>Urocissa erythrorhyncha</i>	LC
150	Common Green Magpie	<i>Cissa chinensis</i>	LC
151	Rufous Treepie	<i>Dendrocitta vagabunda</i>	LC
152	Gray Treepie	<i>Dendrocitta formosae</i>	LC
153	Large-billed Crow	<i>Corvus macrorhynchus</i>	LC
154	House Crow	<i>Corvus splendens</i>	LC
155	Cinereous Tit	<i>Parus cinereus</i>	LC
156	Pale Sand Martin	<i>Riparia diluta</i>	LC
157	Gray-throated Martin	<i>Riparia chinensis</i>	LC
158	Dusky Crag-Martin	<i>Ptyonoprogne concolor</i>	LC
159	Wire-tailed Swallow	<i>Hirundo smithii</i>	LC
160	Barn Swallow	<i>Hirundo rustica</i>	LC

161	Red-rumped Swallow	<i>Cecropis daurica</i>	LC
162	Himalayan Bulbul	<i>Pycnonotus leucogenys</i>	LC
163	Black-crested Bulbul	<i>Rubigula flaviventris</i>	LC
164	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	LC
165	Red-vented Bulbul	<i>Pycnonotus cafer</i>	LC
166	Ashy Bulbul	<i>Hemixos flavala</i>	LC
167	Black Bulbul	<i>Hypsipetes leucocephalus</i>	LC
168	Gray-breasted Prinia	<i>Prinia hodgsonii</i>	LC
169	Ashy Prinia	<i>Prinia socialis</i>	LC
170	Plain Prinia	<i>Prinia ornate</i>	LC
171	Zitting Cisticola	<i>Cisticola juncidis</i>	LC
172	Common Tailorbird	<i>Orthotomus sutorius</i>	LC
173	Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>	LC
174	Common Chiffchaff	<i>Phylloscopus collybita</i>	LC
175	Dusky Warbler	<i>Phylloscopus fuscatus</i>	LC
176	Smoky Warbler	<i>Phylloscopus fuligiventer</i>	LC
177	Tickell's Leaf Warbler	<i>Phylloscopus affinis</i>	LC
178	Lemon-rumped Warbler	<i>Phylloscopus chloronotus</i>	LC
179	Hume's Warbler	<i>Phylloscopus humei</i>	LC
180	Greenish Warbler	<i>Phylloscopus trochiloides</i>	LC
181	Blyth's Leaf Warbler	<i>Phylloscopus reguloides</i>	LC
182	Whistler's Warbler	<i>Phylloscopus whistleri</i>	LC

<b>183</b>	Gray-hooded Warbler	<i>Phylloscopus xanthoschistos</i>	LC
<b>184</b>	Western-crowned Warbler	<i>Phylloscopus occipitalis</i>	LC
<b>185</b>	White-browed Shrike- Babbler	<i>Pteruthius aeralatus</i>	LC
<b>186</b>	Lesser Whitethroat	<i>Curruca Curruca</i>	LC
<b>187</b>	Puff-throated Babbler	<i>Pellorneum ruficeps</i>	LC
<b>188</b>	Black-chinned Babbler	<i>Cyanoderma pyrrhops</i>	LC
<b>189</b>	Rusty-cheeked Scimitar Babbler	<i>Erythrogenys erythrogenys</i>	LC
<b>190</b>	Large Gray Babbler	<i>Argya malcolmi</i>	LC
<b>191</b>	Jungle Babbler	<i>Argya striata</i>	LC
<b>192</b>	White-crested Laughingthrush	<i>Garrulax leucolophus</i>	LC
<b>193</b>	White-throated Laughingthrush	<i>Pterohinus albogularis</i>	LC
<b>194</b>	Indian White-Eye	<i>Zosterops palpebrosus</i>	LC
<b>195</b>	Indian Nuthatch	<i>Sitta castanea</i>	LC
<b>196</b>	Chestnut-bellied Nuthatch	<i>Sitta cinnamoventris</i>	LC
<b>197</b>	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	LC
<b>198</b>	Wallcreeper	<i>Trichodroma muraria</i>	LC
<b>199</b>	Jungle Myna	<i>Acridotheres fuscus</i>	LC
<b>200</b>	Common Myna	<i>Acridotheres tristis</i>	LC

201	Indian Pied Starling	<i>Gracupica contra</i>	LC
202	Chestnut-tailed Starling	<i>Sturnia malabarica</i>	LC
203	Brahminy Starling	<i>Sturnia pagodarum</i>	LC
204	Rosy Starling	<i>Pastor roseus</i>	LC
205	Bar-tailed Treecreeper	<i>Certhia himalayana</i>	LC
206	Blue-whistling Thrush	<i>Myophonus caeruleus</i>	LC
207	Oriental Magpie Robin	<i>Copsychus saularis</i>	LC
208	White-rumped Shama	<i>Copsychus malabaricus</i>	LC
209	Indian Robin	<i>Copsychus fulicatus</i>	LC
210	Indian Blue Robin	<i>Larvivora brunnea</i>	LC
211	Plumbeous Redstart	<i>Phoenicurus fuliginosus</i>	LC
212	Whit-capped Redstart	<i>Phoenicurus leucocephalus</i>	LC
213	Blue-capped Redstart	<i>Phoenicurus coeruleocephala</i>	LC
214	Black Redstart	<i>Phoenicurus ochruros</i>	LC
215	Siberian Stonechat	<i>Saxicola maurus</i>	LC
216	Pied Bushchat	<i>Saxicola caprata</i>	LC
217	Gray Bushchat	<i>Saxicola ferreus</i>	LC
218	Variable Wheatear	<i>Oenanthe picata</i>	LC
219	Brown Rock Chat	<i>Oenanthe fusca</i>	LC
220	Dark-sided Flycatcher	<i>Muscicapa sibirica</i>	LC
221	Asian Brown Flycatcher	<i>Muscicapa daurica</i>	LC

222	Rusty-tailed Flycatcher	<i>Muscicapa ruficauda</i>	LC
223	Rufous-gorgeted Flycatcher	<i>Ficedula strophciata</i>	LC
224	Red-breasted Flycatcher	<i>Ficedula parva</i>	LC
225	Taiga Flycatcher	<i>Ficedula albicilla</i>	LC
226	Snowy-browed Flycatcher	<i>Ficedula hyperythra</i>	LC
227	Little Pied Flycatcher	<i>Ficedula westermanni</i>	LC
228	Ultramarine Flycatcher	<i>Ficedula superciliaris</i>	LC
229	Slaty-blue Flycatcher	<i>Ficedula tricolor</i>	LC
230	Verditer Flycatcher	<i>Eumyias thalassinus</i>	LC
231	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>	LC
232	Blue-throated Flycatcher	<i>Cyornis rubeculoides</i>	LC
233	Rufous-bellied Niltava	<i>Niltava sundara</i>	LC
234	Small Niltava	<i>Niltava macgrigoriae</i>	LC
235	Orange-headed Thrush	<i>Geokichla citrina</i>	LC
236	Scaly Thrush	<i>Zoothera dauma</i>	LC
237	Gray-winged Blackbird	<i>Turdus boulboul</i>	LC
238	Tickell's Thrush	<i>Turdus unicolor</i>	LC
239	Black-throated Thrush	<i>Turdus atrogularis</i>	LC
240	Golden-fronted Leafbird	<i>Chloropsis aurifrons</i>	LC
241	Orange-bellied Leafbird	<i>Chloropsis hardwickii</i>	LC
242	Thick-billed Flowerpecker	<i>Dicaeum agile</i>	LC
243	Pale-billed Flowerpecker	<i>Dicaeum erythrorhynchos</i>	LC

244	Purple Sunbird	<i>Cinnyris asiaticus</i>	LC
245	Green-tailed Sunbird	<i>Aethopyga nipalensis</i>	LC
246	Crimson Sunbird	<i>Aethopyga siparaja</i>	LC
247	House Sparrow	<i>Passer domesticus</i>	LC
248	Yellow-throated Sparrow	<i>Gymnoris xanthocollis</i>	LC
249	Baya Weaver	<i>Ploceus philippinus</i>	LC
250	Indian Silverbill	<i>Euodice malabarica</i>	LC
251	Scaly-breasted Munia	<i>Lonchura punctulata</i>	LC
252	Western Yellow Wagtail	<i>Motacilla flava</i>	LC
253	Citrine Wagtail	<i>Motacilla citreola</i>	LC
254	Gray Wagtail	<i>Motacilla cinerea</i>	LC
255	White Wagtail	<i>Motacilla alba</i>	LC
256	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	LC
257	Paddyfield Pipit	<i>Anthus rufulus</i>	LC
258	Long-billed Pipit	<i>Anthus similis</i>	LC
259	Olive-backed Pipit	<i>Anthus hodgsoni</i>	LC
260	Common Rosefinch	<i>Carpodacus erythrinus</i>	LC
261	Rock Bunting	<i>Emberiza cia</i>	LC
262	White-capped Bunting	<i>Emberiza stewarti</i>	LC

**APPENDIX 2.** Checklist of mammals recorded during the woodpecker survey from  
March 2018 to January 2021 in the Pawalgarh Conservation Reserve

<b>S. No</b>	<b>Common Name</b>	<b>Scientific Name</b>
1	Golden Jackal or Asiatic Jackal	<i>Canis aureus</i>
2	Rhesus Macaque	<i>Macaca mulatta</i>
3	Himalayan Grey Langur	<i>Semnopithecus schistaceus</i>
4	Small Inian Mongoose	<i>Herpestes auropunctatus</i>
5	Indian Crested Porcupine	<i>Hystrix indica</i>
6	Three-striped Palm Squirrel	<i>Sciurus carolinensis</i>
7	Sloth Bear	<i>Melursus ursinus</i>
8	Spotted Deer	<i>Axis axis</i>
9	Barking Deer / Muntjac	<i>Muntiacus vaginalis</i>
10	Nilgai / Blue Bull	<i>Boselaphus tragocamelus</i>
11	Sambhar	<i>Rusa unicolor</i>
12	Himalayan Goral	<i>Naemorhedus goral</i>
13	Wild Boar	<i>Sus scrofa</i>
14	Leopard Cat	<i>Prionailurus bengalensis</i>
15	Tiger	<i>Panthera tigris</i>
16	Leopard	<i>Panthera pardus</i>
17	Elephant	<i>Elephus maximus</i>
18	Indian flying Fox	<i>Pteropus medius</i>

**APPENDIX 3.** Checklist of reptiles and amphibians recorded during the woodpecker survey from March 2018 to January 2021 in the Pawalgarh Conservation Reserve

<b>S. No</b>	<b>Common Name</b>	<b>Scientific Name</b>
<b>1</b>	Marbled Toad	<i>Duttaphrynus stomaticus</i>
<b>2</b>	Skittering Frog	<i>Euphlyctis cyanophlyctis</i>
<b>3</b>	Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>
<b>4</b>	Indian Burrowing Frog	<i>Sphaerotheca breviceps</i>
<b>5</b>	Northern House Gecko	<i>Hemidactylus flaviviridis</i>
<b>6</b>	Garden Lizard or Bloodsucker	<i>Calotes versicolor</i>
<b>7</b>	Indian Monitor Lizard	<i>Varanus bengalensis</i>
<b>8</b>	Himalayan Ground Skink	<i>Asymblepharus himalayanus</i>
<b>9</b>	Little or Bronzed Grass Skink	<i>Eutropis macularia</i>
<b>10</b>	Dotted Garden Skink	<i>Lygosoma punctata</i>
<b>11</b>	Indian Rat Snake	<i>Ptyas mucosa</i>
<b>12</b>	Checkered Keelback	<i>Xenochrophis piscator</i>
<b>13</b>	Spectacled Cobra	<i>Naja naja</i>
<b>14</b>	King Cobra	<i>Ophiophagus hannah</i>
<b>15</b>	Black Pond Turtle	<i>Melanochelys trijuga</i>
<b>16</b>	Tricarinate Hill Turtle	<i>Melanochelys tricarinata</i>
<b>17</b>	Indian Flapshell Turtle	<i>Lissemys punctata</i>
<b>18</b>	Yellow-headed Tortoise	<i>Indotestudo elongata</i>

# CERTIFICATE of PARTICIPATION

This is to certify that Ms. Sarabjeet Kaur participated in "THE RUFFORD INDIA CONFERENCE: FOSTERING GRASS-ROOTS CONSERVATION IN INDIA - A RUFFORD INITIATIVE" organised by Foundation for Ecological Research Advocacy and Learning (FERAL), and The Rufford Foundation, UK at Corbett National Park, Ramnagar, Uttarakhand from 8th to 11th February 2019.



\_\_\_\_\_  
Rajat Nayak  
Conference Coordinator





**Certificate of attendance**

**Sarabjeet Kaur Narula**

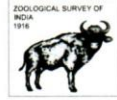
has participated in

**THE 8<sup>th</sup> INTERNATIONAL  
WOODPECKER CONFERENCE  
March 16-20, 2019 - Białowieża, Poland**

Chair of the conference committee

Dorota Czeszczewik





*Workshop cum Symposium*  
on  
**Traditional & Modern Animal Taxonomy and IPR Issues for  
Biodiversity Protection & Conservation**


*In collaboration with*  
**Zoological Survey of India (ZSI) & Indian Council of Agricultural Research-  
Indian Institute of Soil and Water Conservation (ICAR-IISWC)**  
**(25<sup>th</sup> to 29<sup>th</sup> November, 2019)**


**Organized by: Department of Zoology**

*Certificate*

This is to certify that SARABJEET KAUR (Research Scholar)  
of Wildlife Institute of India, Dehradun  
has been conferred Best Presentation Award for Oral/Poster presentation in the A  
Workshop cum Symposium on **Traditional & Modern Animal Taxonomy and IPR  
Issues for Biodiversity Protection & Conservation** on 25<sup>th</sup> to 29<sup>th</sup> November, 2019  
held at Dolphin (PG) Institute of Biomedical & Natural Sciences, Dehradun.

  
(Dr. Beena Joshi Bhatt)  
Organising Secretary  
DIBNS, Dehra Dun

  
(Dr. M. Muruganadam)  
Principal Scientist  
ICAR-IISWC, Dehra Dun

  
(Dr. Shailja Pant)  
Principal  
DIBNS, Dehra Dun

  
(Shri Arvind Gupta)  
Chairman  
DIBNS, Dehra Dun

## CERTIFICATE of PARTICIPATION

This is to certify that Ms Sarabjeet Kaur Narula participated and gave a talk entitled '*Status of Mulleripicus pulverulentus – the largest woodpecker in Pawalgarh Conservation Reserve*' in **"THE RUFFORD INDIA CONFERENCE: FOSTERING GRASS-ROOTS CONSERVATION IN INDIA - A RUFFORD INITIATIVE"** organised by Foundation for Ecological Research Advocacy and Learning (FERAL), and The Rufford Foundation, UK at Sun-n-Sand, Juhu Beach, Mumbai, Maharashtra from 6th to 9th December 2021.



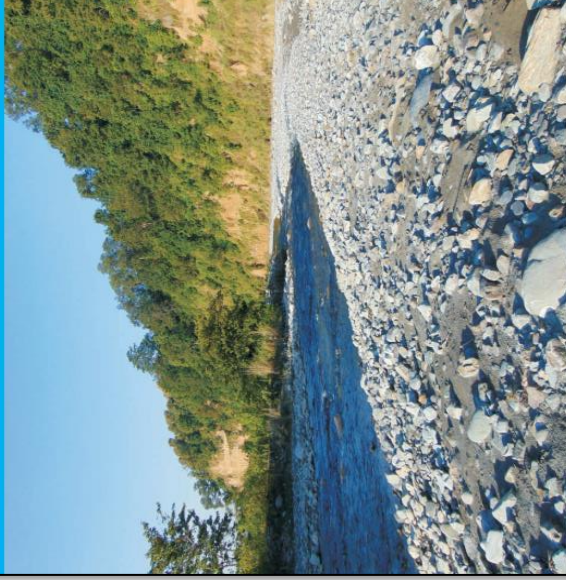
\_\_\_\_\_  
Rajat Nayak  
Conference Coordinator



# WOODPECKERS OF PAWALGARH CONSERVATION RESERVE



Front Cover Photograph Lesser Yellowmame (*Picus chlorocarpus*)  
Back Cover Photograph River Dabka  
Map Uttarakhand Forest Department  
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few small or pruned trees that were around in the agriculture fields were not suitable for nesting and the pair found the power transformer more suitable to provide protection to the nest.

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#### An accidental death of a Critically Endangered White-rumped Vulture *Gyps bengalensis*

On 21 November 2022, during a field visit to Jaisalmer, Rajasthan, India, we witnessed an unusual death of a White-rumped Vulture *Gyps bengalensis*. Based on information from a local shepherd, we visited an area near Veer Singh Ki Dhani of Myajlar village, where a vulture was found dead under a camel carcass (26.27°N, 70.37°E). The camel carcass was originally lying on its right side. We failed to extract the vulture carcass from under the camel. When we lifted the camel carcass, we discovered that the head of the vulture was wedged between the ribs of the camel [183]. The vulture was identified as a juvenile White-rumped Vulture [184], which is listed as Critically Endangered by the IUCN (BirdLife International 2023).



183. A White-rumped Vulture with its neck stuck between the ribs of the camel carcass. Note that the vulture is lying on its back in this image.



184. The vulture carcass after it was extracted from the camel carcass.

Observing the posture of the camel carcass in relation to the vulture, we inferred that the vulture was trying to feed in between ribs and somehow its head was fatally stuck between the camel's ribs resulting in its death. Vultures have a long and supple neck, and while such unusual mortalities of vultures do happen, they are not common. It may also be possible that the vulture got accidentally stuck during the feeding frenzy when a large number of vultures were feeding on the camel carcass. The camel carcass may have then toppled over by the activity of other scavengers. This type of mortality in vultures has been reported previously by others (Allen 1920; Greenwood 1938; Samson & Ramakrishnan 2017).

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#### Colour aberration in the Great Slaty Woodpecker *Mulleripicus pulverulentus* from Pawalgarh Conservation Reserve, Uttarakhand

We report multiple sightings of colour aberrant individuals in a Great Slaty Woodpecker *Mulleripicus pulverulentus* (GSW) flock at Pawalgarh Conservation Reserve (PCR, 29.33°–29.40°N, 79.13°–79.27°E) in Ramnagar, Uttarakhand, India.

GSW is a cooperative breeder (Lammertink 2004) and occurs in small flocks, with a pair and helpers. The species is sexually dimorphic, with males bearing a red moustachial stripe. Both sexes have a yellow chin, throat, and fore neck [185, 186]. The juveniles are similar to the female with yellowish throat, dull slate plumage, and more profusely spotted underparts (Ali & Ripley 1987). We identified 14 family groups represented by 63 individuals during the entire study period. However, we noticed this particular colour aberration only in two individuals belonging to a particular family group. On 31 March 2019, we came across this family group of four GSW of which two individuals showed a throat-colour that was different than usual. The flock had a male that had an entirely black throat and another male which had a regular, pale, yellowish throat [187, 188, 189]. Interestingly, the same flock had two females, one with a normal throat colour while another had a diffused black throat [190]. All four individuals were recorded foraging for c.45 min, probing and gleaning the termites from the fissures in the bark of *Shorea robusta* (Sal) as well as feeding on the seeds of *Mallotus philippensis* [189]; a hitherto undocumented feed of GSW (Ali & Ripley 1987). After foraging, the pair that had darker throats separated themselves from the other individuals and was involved in a display on the trunk of a *Lannea coromandelica* tree. The male called while tilting the head back, opening the wings wide open, and pecking hard on the tree bark, chipping wood off the surface. They were observed pecking each other on the wings and legs. This lasted for c.20 min, followed by copulation. We saw this same family flock on the next day as well as on 06 May. On 15 June, we recorded the same group constructing a nest cavity on the main trunk of Sal with a 145 cm girth. Each individual participated in the construction of the nest cavity but the nest cavity was abandoned on 02 July due to unknown reasons.

During the next season, we saw presumably the same family flock (identified by the aberrant individuals) on 01 April 2020 foraging together at the same site. On 17 May, we saw them again and on the next day they were seen exploring the previous year's nest cavity. On subsequent days, we had multiple sightings of this group foraging or preening on a Sal, and once, on 25 May, the normal coloured individuals were seen copulating.

The multiple sightings of the same individuals during the two consecutive post-breeding and breeding seasons (2019 and 2020) confirm that the individuals were neither moulting nor young. To verify if there is any prior documentation of such a colour patch on its throat, we requested for photographs of type specimens of both subspecies (*M. p. harterti* and *M. p. pulverulentus*) at the Bombay Natural History Society (BNHS), Smithsonian Institution Washington D.C., and Natural History Museum (NHM), London. We also transmitted our photographs to the said museums to compare against the existing set of skins. However, none of museum skins had such a throat patch. Additionally, we reviewed all the available photographic records submitted to eBird ([www.ebird.org](http://www.ebird.org)) across the species range and found no similar plumaged individuals.

There are no known incidences of colour aberration in the genera *Mulleripicus* (Family: Picidae) represented by four species occurring in South and Southeast Asia. van Grouw (2013) identifies albinism, leucism, brown, dilution, ino, and melanism as the different type of colour aberrations. Ours would qualify as a case of abnormal deposit of melanin pigment on the yellow throat but not melanism entirely (Hein van Grouw in email dated 07 August 2023).



185, 186. Male (Top) and Female (Bottom) Great Slaty Woodpeckers showing normal pale coloration of the throat from a different family group in the study area.



187, 188. Two male Great Slaty Woodpeckers of the same family group at the same foraging substrate showing typical coloration to the throat (Top) and diffused black coloration to the otherwise pale throat (Bottom) during the breeding season of 2020 in May.

Ali, Sanjiv Kaur



Both: Sarabjeet Kaur

189, 190. A male Great Slaty Woodpecker feeding on the seeds of *Mallotus philippensis* (Top) and a female showing a throat with diffused black coloration (Bottom) from the same family group observed prior to the 2019 breeding season in March.

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#### A Whiskered Tern *Chlidonias hybrida* from Buhchangphai, Mizoram

On 15 June 2022, we visited Buhchangphai (24.33°, 92.67°E; 42 m asl) which is 22 km north from Kolasib town, in northern Mizoram, India. The area is rich in bird life, since there are paddy

fields and fishponds, as well as some forested areas. After observing and photographing birds such as Baya Weaver *Ploceus philippinus*, Bronze-winged Jacana *Metopidius indicus*, Bengal Bushlark *Mirafra assamica*, and Cinnamon Bittern *Ixobrychus cinnamomeus*, we also see three Oriental Pratincoles *Glareola maldivarum* flying high and crossing our path. Soon after, we were surprised to see a lone, unfamiliar light-grey bird with red bill and legs and black crown, that approached us and alighted on power cables besides a few Blue-tailed Bee-eaters *Merops philippinus*, before flying off again in a few minutes. We searched the nearby area to get another look at it, but only saw Watercock *Gallixrex cinerea*, some kingfishers *Alcedinidae* sp., and Scaly-breasted Munia *Lonchura punctulata*. Meanwhile, we consulted the Merlin app on our mobile phones, and arrived at a preliminary identification of the bird as a Whiskered Tern *Chlidonias hybrida*.

The bird was photographed from a distance of c.150 m. It was light grey with black crown and white cheeks and sides of the neck, which give its "whiskered" appearance. The wings extend beyond the tail during rest [191]. The long wings, grey rump, and weakly forked tail are clearly visible in flight [192]. Moreover, the red bill and legs, typically seen in their breeding plumage, were also observed. Identification was confirmed after consulting descriptions and illustrations in Ali & Ripley (1983) and Grimmett *et al.* (2013) as no other tern species of this size has a combination of black cap, grey rump, shallow tail, and red bill.

The Whiskered Tern has a wide range, spreading over Africa, Asia, Europe, and Australia, and is a winter visitor or passage migrant in most of parts of the Indian Subcontinent (Ali & Ripley 1983; Grimmett *et al.* 2013; Gochfeld *et al.* 2020). It is reported to breed in North Cachar in Assam, Kashmir, Delhi,



Tharindra Pathan

191. Whiskered Tern showing conspicuous white cheeks, red bill, red legs, and neck contrast with the black crown and light grey body.