Received: 03 July 2025 | Revised: 28 August 2025 | Accepted: 05 September 2025

https://doi.org/10.56946/jzs.v3i2.754

Journal of Zoology and Systematics

Research Article

Population Estimation and Behavioral Study of the Spotted Owl (*Athene brama*) in Southern Punjab, Pakistan

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Abstract

Spotted Owl (*Athene brama*) is a widely distributed Indian subcontinental owl species that serves as a natural pest regulator. Little information has been documented on its ecology and the attitudes of people toward *A. brama* in Pakistan. Thus, this study investigated population density, nesting and roosting habits, diet composition, and attitudes toward *A. brama* in southern Punjab. Between March 2020 and January 2021, a block of 600 km² was surveyed through line transects, point counts, pellet analysis, and interviewing. A total of 111 owlets and 51 nests were recorded, corresponding to a density of 18.5 owlets and 8.5 nests per 100 km². Owlets were raised mainly in *Dalbergia sissoo* and *Acacia nilotica* tree hollows, with a mean height was 4.2 ± 1.2 m and a DBH of 54.8 ± 7.8 cm. Clutch size was a mean of four eggs, with >90% nest success and 80% hatching success. Pellet analysis (n = 67) showed that rodents and shrews accounted for almost 90% of prey biomass, followed by birds (5.1%) and amphibians (5.1%). Roosting usually occurred close to fields and power poles, and breeding was most concentrated from February to April. Interviewing 238 residents showed that 60% regarded owlets as being superstitious, and 25% only valued their ecological significance. These findings show the importance of *A. brama* as a main biological control agent and emphasize the value of conservation measures such as cavity tree protection, artificial nest boxes, and culturally compatible awareness campaigns to ensure coexistence in agroecosystems.

Keywords: Spotted Owl, population density estimation, habitat preference, conservation, Southern Punjab

1. Introduction

The intensification of agriculture characterized by mechanization, pesticides, and fertilizers has drastically changed the population of birds throughout Asia and Europe [1]. Although intended to enhance agricultural output, the change has led to habitat degradation, reduced insect populations, and interference with natural balance. Consequently, several farmland birds, especially those that are insectivorous and predatory in nature, have declined sharply during the last few decades [2]. Some of these include owls, which are ecologically significant but are usually underappreciated because of myths and unfavorable cultural connotations [3].

The Spotted Owlet (*Athene brama*), a small nocturnal bird of prey [4], feeds on a wide range of prey, including small mammals (28%), birds (12%), reptiles (2%), plants (11%) and insects (47%) [5,6]. It occupies various habitats ranging from open grasslands to semi-urban areas and, is frequently encountered in agricultural landscapes. Although it can serve as a pest controller, very few studies have been conducted on its population status, nesting ecology, and feeding habits in Pakistan [7]. In areas such as Southern Punjab, agriculture is a

primary occupation, and rodent and pest infestations tend to result in economic losses for farmers [8, 9].Spotted Owlet can also function as a biological control agent in agroecosystems. Nonetheless, it is believed to be an omen bird because of myths and misconceptions, which discourages local communities from preserving it [10]. This research investigates the behavioral ecology of the species and gauges public attitudes toward its occurrence in human-dominated environments.

Three interconnected grounds underpin this research: anthropogenic habitat modification, ecological value of owls, and public opinion about them. The growing application of chemical fertilizers and pesticides has adversely affected the ecological balance and diminished the number of prey species necessary for owls. Although owls, such as *A. brama*, can accommodate in human-modified landscapes, habitat loss is a significant issue. Public perception further worsens the issue; most individuals associate owls with black magic and superstition, restricting their conservation [11]. Diet analysis is critical for understanding the ecological function of the species. In this study, pellet analysis showed that rodents were the most dominant prey category (38.4%), followed by insects (78.8%) [12]. This demonstrates the potential use of Spotted Owlet as a natural pest control agent. Roosting preference was observed primarily in *Dalbergia sissoo* and mango trees in cultivated lands and residential gardens, indicating adaptation to altered environments [10]. Although the species exhibits behavioral flexibility and habitat plasticity, it remains susceptible to swift changes in the environment, particularly in highly cultivated regions. In addition, even though the species is found in agricultural fields, it is barely protected, and studies on its behavioral ecology are insufficient in Pakistan [13]. Among other countries, India has instituted nest box programs and behavioral monitoring, which have demonstrated enhanced breeding success and public engagement [14]. Artificial nest boxes have, become an effective conservation tool for agroecosystems. Likewise, research in Madurai and Maharashtra has established patterns of daily activity and roosting preferences that facilitate practical conservation design. However, no such effort has been made in Pakistan to emulate such success [15]. Such international models are used in this research and are localized to Southern Punjab. Notwithstanding the existence of such models, critical knowledge gaps remain. The population status of the Spotted Owlet in Southern Punjab is unknown, and systematic data on its breeding and roosting habits are unavailable [7].

Against the backdrop of such challenges, this study seeks to generate baseline information to guide conservation efforts. This study examines the public's response to the spotted owlet (*Athene brama*), food preferences based on pellet analysis, nesting site selection and roosting behavior, and population density estimation in southern Punjab. Such goals seek to fill the gap between ecological knowledge and socio-cultural acceptance of the species, fostering sustainable agriculture and long-term avian conservation in the area.

This study aims to examine the behavioral ecology of the Spotted Owlet (*Athene brama*) in Southern Punjab, Pakistan, specifically its nesting and roosting behavior, diet preference, population density, and sociocultural perceptions related to the species within human-dominated environments. By combining ecological observations with knowledge of community attitudes, the research hopes to gain insights.

2. Materials and methods

2.1. Study area and climate

The study was conducted over an area of 600 km^2 from March 2020 to January 2021. The area includes the agricultural land, arid and surroundings of the Sutluj River, Bahawalpur, Lodhran, in southern Punjab, Pakistan. These areas lie in 71°E to 73°E longitude and 28°N to 30°N, and the temperature range in summer exceeds 41°C, and it is 10°C in winters. The average rainfall in this area is 100-200 mm.

2.2. Target species

The study was conducted on spotted owl (*Athene brama*) to determine the public's response toward spotted owl, feeding behavior, nesting strategies, and population density estimation. A total of 111 Owlets and 51 nests were observed for one year. Field equipment used in the survey of spotted Owls listed in

Table 1.

2.3. Data collection techniques

A questionnaire was also filled out to record the public's point of view against the Spotted Owlet.

2.4. Population estimation

2.4.1. Transect method

A total of 20 transects were placed at different locations to observe the Spotted owl. Each transect was 400 m long and subdivided into sections of 100 m [16]. The transects were placed in agricultural lands around Patisar Lake and, arid zones to observe the species in varied habitats. Observations were carried out twice daily at approximately 6:30 to 10:00 AM and 4:00 to 6:30 PM. Observations, including flight observation, vocalization, number, age, and sex of the Specie, were recorded in each season. The details are presented in Table 2.

2.4.2. Direct method

Weekly ground surveys were performed during breeding to visually observe the nest, egg laying, chicken growth, and fledgling behavior. Droppings and feathers were used as sign to locate roosts. The detail of field visits for Spotted owls, parameters recorded and tools used to monitor breeding strategies mentioned in Table 3 and Table 4.

Table 1. Field equipment used in the survey of spotted Owls (*Athene brama*) in southern Punjab, Pakistan

Tools/Equipment's	Purpose
Binocular (10x50mm)	Identification and behavioral observation of birds
Zoom scope (15-60x60)	Distant and nest observations
Digital Camera	Photographic documentation of the nest and birds
GPS (Garmin e Tracx)	Recording coordinates of birds or nesting sites
Notepad and Field Guide	Species identification and behavioral data recording

Table 2. Line-transect layout used for estimating Spotted owl populations.

Method	No. of Transect	Transect Length	Sub-transect length	Distance between the sites
Line Transect	20	400 meters	100 meters	195 meters

Table 3. Seasonal field visit schedule for Spotted owls (*Athene brama*).

Session	Time	Season	Months Observed	Observation Frequency
Morning	06;30 AM-10.00 AM	Hot dry/Rainy	March-September 2020	Twice Weekly
Evening	04.00 PM- 10.00 PM	Hot dry/Rainy	March-September 2020	Twice Weekly
Morning	06;30 AM-10.00 AM	Cool-Dry	October 2020- January 2021	Weekly
Evening	04.00 PM- 10.00 PM	Cool-Dry	October 2020- January 2021	Weekly
Point Count	15-minute slots at each point (200m^2)	Across all seasons	Every 2 weeks	March 2020-January 2022
Indirect pin count	Bird calls identified by an expert field guide	Across all seasons	Every 2 weeks	March 2020-January 2022

Table 4. Parameters measured during the breeding monitoring of Spotted owls, corresponding tools, and measurement frequency.

Parameters	Tool used	Frequency
Egg Dimensions	Vernier Caliper	Per nest visit
Nest Coordinates	GPS	Per Nest Found
Chicken Growth	Inch Tape	Daily Observation
Fledgling Age	Field Notes	Per Nest
Roost signs (feathers)	Visuals, Camera	As Observed

2.5. Indirect method

The survey was conducted every two weeks to collect data using the "Counting Point Method" as described by used field guides to identify the bird species using binoculars (10x 50 mm) and Zoom-scope (15- 60 x 60 mm). A digital camera was used to take field photographs of the observed birds. The geographic coordinates of the locations were obtained using Garmin eTrex Vista software. In addition, nests of numerous bird species were discovered in the research area, suggesting their presence and breeding. The vantage points were selected using a fixed radius of 200 m^2 and a 15-minute period for each. The calls of different bird species were listened to and identified at each of the four sampling sites. Informal meetings with the local community and other related individuals were frequently used as an indirect method of data collection [17].

2.6. Breeding observations

The number of eggs, chick development, and fledging success was recorded for all active nests. The nests were checked every day with minimum disturbance. Chick length and brood size data during the incubation period were noted with a caliper, and the measurement details are listed in table 4.

2.7. Statistical analysis and outcome measurements

The data were tabulated and monitored using Microsoft Excel. Average, mean, percentages, range, and standard deviation were calculated from the data. The measured outcomes include population size per transect, relative abundance, vocal activity, age, sex ratio, nest success rate, brood size, and chicken development stages. In addition to descriptive statistics (mean, SD, percentages), inferential statistical techniques were used to test for differences between sites and seasons. Chi-square tests were used to compare nest-site preference between habitats, one-way ANOVA was used to investigate variation in nest height and tree DBH among nesting trees, and t-tests were used to compare pellet biomass by season. These analyses illustrated statistically significant patterns of habitat use and seasonality in diet, presenting more compelling evidence than descriptive summaries alone. The application of these inferential methods ensures that our results are robust and that natural variation between study sites and seasons is controlled.

3. Results and discussion

3.1. Population density

A total of 111 Spotted Owlets and 51 nests were counted throughout the 600 km² study area, resulting in crude densities of 18.5 owlets and 8.5 nests per 100 km². In terms of habitat, owlets were most commonly seen in cultivated lands (70 owlets, 32 nests; 28.0 owlets and 12.8 nests per 100 km²), riparian areas along the Sutluj River (28 owlets, 12 nests; 14.0 owlets and 6.0 nests per 100 km²), and arid scrub habitats (13 owlets, 7 nests; 8.7 owlets and 4.7 nests per 100 km²). Habitat specific differences indicate that owlet populations are denser in agricultural landscapes with high cavity-bearing tree retention and water availability, whereas owls' population are only scattered in arid zones. Although, the current estimates are not detectability corrected, they do offer useful baseline data and relative abundance indices to inform future monitoring and conservation planning.

3.2. Nesting ecology and roosting habits

A total of 51 homes/perches of the Spotted Owlet were observed during the one year of this examination. Settling endeavors were recorded at 27 homes during the main year and

24 during the second year of the investigation. 20 were in tree hollows, and the remaining two were in breaks of structures dividers. Nine homes were situated in *Dalbergia sissoo*, four in *Acacia nilotica*, three in *Butea monosperma*, two each in *Ficus benghalensis*, and *Mangifera indica*, and one in *Eucalyptus citriodora*. The mean DBH and the mean height of homes over the ground were 54.8 ± 7.8 (SD) cm (range = 55–75 cm; N = 51) and 4.2 ± 1.2 m (range = 2.7–6.7; N = 51), respectively listed in Table 6. Fourteen of the homes were in the primary trunk of the tree, five were in the tree appendages, two were in revealed despondencies at the highest point of snapped tree trunks (obstacles), and others were man-made locations like tube wells, bridges, and earth cuttings. Thirteen home pits opened, four had two and two each had three and four openings, respectively. This study shows that species live on old trees and natural cavities, as previously supported by 2007 study [7]. The reuse of nests shows strong site fidelity and limited nesting sites. Efforts should be made to conserve nesting trees and agricultural lands. In this study, all nests were situated in the periphery or inside cultivated fields. Owlets frequently reoccupied the same nesting cavities to roost during the non-breeding season. Most cavities had a single entrance, but those with multiple entrances could offer predators improved escape routes. Spotted owls are crepuscular and generally occupy available cavities in trees or buildings for nesting. Example of adult Spotted owl and its nesting cavities are shown in Figure 1. The cavities provide protection and the convenience of access at night-time predation, which was previously supported by a study in 2008 [18].

A total of 51 focal nest sites were studied, collectively hosting 111 individual owlets in and around the nesting zones. Of these, 13 nests were found on *Acacia nilotica*, 4 were located near tube wells, and 2 were found in other tree (earth cuttings) species. Most nests were located at distance of 250–500 m from nearby human settlements. Adult Spotted owl spotted at day roost in agricultural fields shown in Figure 2. Notably, all nest sites had a nearby water source, indicating its potential importance for selection of nest (Table 5).

From the trees given above, the following trees are selected for nesting by the owlet. Owls prefer to live on a variety of trees, but in our study, owls selected these trees (shown in Table 7) for nesting because most bird species, including owls, prefer to nest on trees that provide ample food resources, as previously reported by a study on the avian community [19].

3.3. Breeding phenology and reproductive output (RO)

Egg laying was observed from February to April, with 34 documented nesting attempts between the study periods. During 2001, the initial clutch of the year (consisting of four eggs) was deposited on March 4, 2020, whereas no fresh eggs were seen after April 19, 2020. During the next year, the initial clutch (including one egg) was documented on February 13, and the last egg laying event occurred on April 26. Nonetheless, most egg laying occurred between late March and late April. Newly hatched chicks were observed mainly between late March and mid-May. Juvenile owlets were observed foraging with their parents as early as late May. Between May and July, three to five owlets were perched and foraged in company. These juvenile owlets stayed within their parental ranges and continued to forage until August. A single brood was produced annually by each breeding pair; neither second clutches nor replacement broods were found during the study [20]. The breeding chronology of Spotted owl from 2020 to 2021 summarized in Table 8.

Thirty-four clutches and 31 broods of Spotted Owlet were observed during the study period. The median clutch and brood size for both years were four eggs and four fledglings, respectively. More than 90% of the nests were successful, and nearly 80% of the eggs hatched (Table 5). Nevertheless, the hatching rate could be slightly underestimated because of the low frequency of observation every nest once a month). It most probably resulted in underestimation of egg losses or partial clutches lost early during the laying period and subsequently replaced.

In the study area, egg-laying had an average longevity of 46 ± 5 days. Hatching occurred from the last week of March to mid-May. Fledging occurred toward the end of May and was usually completed in late June or early July.

Table 5. Nest-site categories used by Spotted owl (n = 51), with percentage of nest and mean nest height per habitat category.

Sr. no.	Nesting sites	No. of nest per site	No. of nest % (n=51)	Nesting height in meters
1	Tree Hollow	20	39.21	2.5-8.0
2	Occupied residential premises	8	15.68	4.5-8.5
3	Abandoned Places	9	17.64	3.0-8.0
4	Tube well wall	4	7.8	3.0-6.0
5	Earth cuttings	2	3.9	3.0-6.0
6	Under the bridge constructed walls	8	15.68	1.0-2.0

Table 6. Spotted owl nesting tree characteristics (n = 51), with mean ± SD and range for DBH (tree diameter at breast height) and nest height above ground.

Parameter	Mean ± (SD)	Range
Nest tree diameter	54.8 ± 7.8 cm	55-75 cm
Nest height above ground	4.2 ± 1.2 m	2.7-6.7 m

Throughout this time, juveniles tagged along with adults during foraging excursions and were mostly seen feeding on plentiful insects during the season. Spotted owls are annual breeders, that breed from, late winter to early summer. Both pairs lay 3-4 eggs a year, with the female providing the most parental. The young are nurtured for 1-2 months after hatching. Mating occurs at or near dusk [21]. Egg laying occurred from February to April, with most active period from mid-March to late April. The average clutch size was four eggs, and fledging occurred by July. The seasonal timing coincided with peaks in prey abundance, as mentioned by [22,23], supporting the connection between food abundance and reproductive success. Contrary to the Indian population results, no second brood or replacements were observed, indicating a more restrictive breeding period in the southern part of Punjab.

3.4. Feeding behavior

Spotted owls eat meat and consume small mammals, such as mice and rodents, as their major food source. They do not present as herbivores. Owlets hunt individually and do not hunt in packs. Because of their poor eyesight in full sunlight, dawn and dusk are their favorite times for hunting. This crepuscular behavior corresponds to the physiological constraint generated by the reduced density of rod cells in their eyes. Owing to their low occurrence within the study site, their contribution to small mammal populations is negligible. A similar behavior in owls was previously observed in a study conducted in southern Punjab [24].

Pellet content analysis (n = 67) provided a total of 28 identifiable prey items with a collective biomass of 105 g. Small mammals dominated the prey group, with common field shrews (n = 19; 77.6% biomass, 76 g) and red-skin field mice (n = 3; 12.2%, 12 g) collectively contributing almost 90% of the ingested biomass. Other prey included anurans (n = 2; 5.1%, 5 g) and small birds such as black Sparrows (n = 4; 5.1%, 12 g). These results validate that Spotted Owlets depend extensively depend on rodents and shrews as staple prey and opportunistically prey on amphibians and small birds.

Although, insects were occasionally found in the pellets, they did not significantly contribute to the overall biomass indicating that they primarily function as subsidiary food items. The presence of small mammals in the diet supports previous research that described owlets as efficient rodent controllers, thus establishing their ecological role within agricultural ecosystems. The predation success rate of 60-70% also supports their efficacy as lone predators and points to their possible role in pest control in Southern Punjab fields. Our results are consistent with those of previous studies, as shown in table 9 [5, 6], upholding the ecological function. Evidence from the research reaffirms that Spotted Owlets are

acclimatized to human presence.

Table 7. Tree species used by the Spotted owl for roosting and nesting.

Common name	Scientific name
Kikkar	*Acacia nilotica*
Suhaanjna	*Moringa oleifera*
Berr	*Ziziphus martynia*
Uconn/Mora	*Tamarix aphylla*
Jaal	*Salvadora oldies*
Peepal	*Ficus religiosa*
Taalhi	*Dalbergia sissoo*
Popular	*Populus alba*
Sunbal	*Bombax ceiba*
Sufaida	*Eucalyptus globulus*
Kachnaar	*Bauhinia variegata*
Neem	*Azadirachta indica*
Sahreen	*Albizia lebbeck*
Bargad	*Ficus benghalensis*
Baken	*Melia azedarach*
Jaamun	*Syzygium cumini*
Mango Tree	*Mangifera indica*
Palm Tree	*Phoenix dactylifera*
Conu Carpus	*Conocorpus erectus*

They are silent near settlements and cultivated land and even help farmers by hunting small mammals such as *Funambulus pennanti* (five-striped palm squirrels). Their pest control work can benefit local farmers by reducing crop destruction.

Spotted owls are solitary predators. They depend on powerful hearing senses and a flexible neck (capable of rotation by up to 270°) to locate prey, similar findings were observed in a study on the Baren Owl [25]. Their predatory adaptations are as follows: pointed beak, strong claws, light weight, strong audio aid, body-balancing tail, easily rotating neck, light weight, and strong skeleton [26]. In spite of their adaptations, Spotted Owlets have some weaknesses such as: weak eye sight during the day, small legs compared to best predation, and small size. Field observations revealed that spotted owls had a predation success rate of approximately 60-70%, indicating effective and goal-directed hunting behavior [18, 27, 28].

3.5. Behavioral adaptation, avian co-existence, and human impact

Spotted owls coexist peacefully with other birds and do not hunt their young because they prefer nesting in tree cavities. However, food scarcity may lead to competition; similar findings have been observed [29,30]. The following species were often seen in the company of owls. Bird species co-existing with spotted owl mentioned in Table 10.

Spotted owls display thermoregulation behaviors similar to those of other bird species. Spotted owls sit in the shade of trees in summer to escape heat, whereas, they bask in sunlight in winter to keep their bodies warm [31, 32]. No definitive sexual dimorphism has been observed in Spotted owlets, so identify males and females through physical features is challenging [18].

Table 8. Chronology of Spotted owl breeding from 2020 to 2021.

Breeding Activity	Year	Start date	End date	Observation
Egg laying period	2020	4 March	19 April	First clutch (4 eggs); no new eggs after April 19
Egg laying period	2021	13 February	26 April	First clutch (1 egg), an early start
Peak egg laying period	Both	1 March	30 April	The majority of egg laying occurs during this period
Chicken hatchling period	Both	Late Marc	Mid-May	Most of the chicks observed during this period
Juvenile foraging period	Both	Late May	July	3-5 juvenile seen foraging and roosting
Juvenile hatchling period	Both	May	August	Juvenile remains in the parental area until August
Broods per year	Both	One Brood	Whole year	No second and replacement clutches were recorded

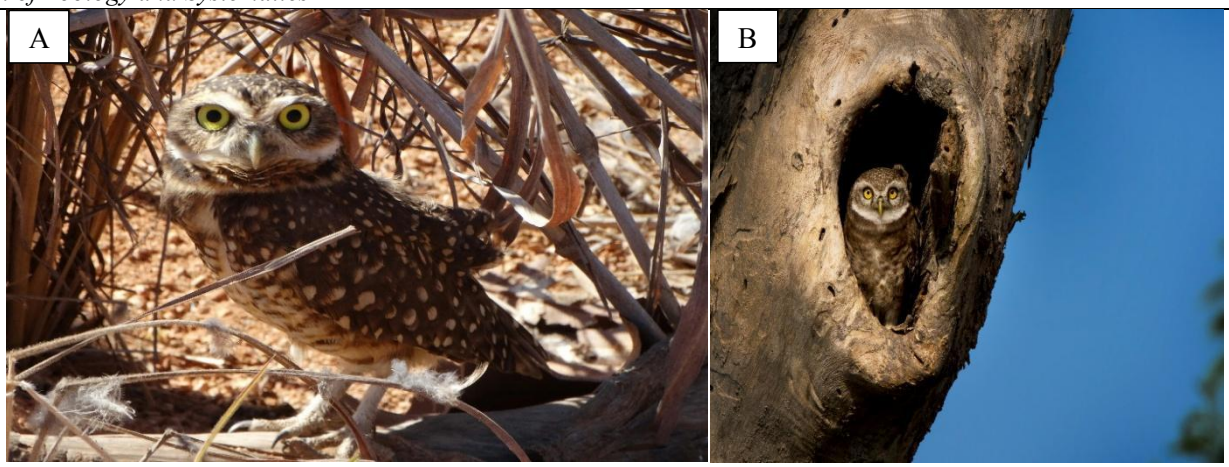

Figure 1. (a) Adult Spotted owl at day roost (b) Nesting cavity of the Spotted owl (*Athene brama*).

Figure 2. Adult Spotted owlet (*Athene brama*) photographed at day roost in an agricultural landscape.

Spotted Owls demonstrated great adaptability by breeding in natural and man-made structures, such as tree cavities, bridges, wells, and crevices on buildings. However, this adaptability increases their contact with humans, leading to several hazards. Tree pruning and felling decrease availability of natural cavities, and persecution based on superstitious grounds directly threatens survival. The use of agrochemicals in agricultural fields can lower prey densities and raise the risk of secondary poisoning. Man-made structures such as electric poles, also enhance the risk of electrocution. Together these pressures demonstrate how human activity influences owlet distribution and breeding ecology. They highlight the need for conservation interventions specific to human-dominated landscapes and immediate conservation action.

3.6. Public awareness and threats

Interviews with 238 locals revealed that 60% of respondents related owls to unfavorable omens, and 25% identified them as positive shown in Figure 3 These attitudes may slow down conservation initiatives and even lead to direct harm. These cultural beliefs [3] reinforce, the need for public education and awareness campaigns to promote co-existence.

Most rural dwellers regard Spotted Owlets as harbingers of bad fortune, leading to antagonism and even violence against them. This is a prevalent belief in villages and is one of the major threats to their conservation. Spotted owls are harmless and are vital ecological pest control agents.

With negative cultural perceptions documented in interviews, conservation must include community participation. Local schools and colleges can conduct awareness campaigns to inform young generations of the ecological importance of owlets as natural rodent regulators. Farmer field schools and training activities should highlight the advantages of owlets for pest control and promote the use of nest boxes on farms. Religious leaders and community elders can be mobilized as ambassadors to disperse superstitions and minimize persecution. Furthermore, local FM radio outreach, social media groups, and printed flyers can facilitate the rapid and widespread distribution of conservation messages. Such tangible measures not only promote awareness but also promote the coexistence of Spotted Owls and their communities.

Table 9. Composition of Spotted owl prey from pellet analysis (n = 67), with prey numbers, mean prey weight, and percentage contribution to biomass.

Type of prey	No. of individuals	Average weight in gram	s % Biomass	Total biomass (g)
Common field shrews	19	4	77.6%	76.0
Red-skin field mouse	3	4	12.2%	12.0
Anurans	2	2.5	5.1%	5.0
Black Sparrow	4	3	5.1%	12.0
Total	28	___	100%	105.0 g

Table 10. Bird species found to coexist with Spotted Owlets at common roost or foraging locations in the study area.

Common Name	Scientific Name
Parrot	*Psittacula krameri*
Laali	*Acridotheres tristis*
Hud hud	*Upupa epops*
Collar dove	*Streptopelia decaocto*
Blue rock pigeon	*Columba livia*
House sparrow	*Passer domesticus*
Black drongo	*Dicrurus macrocercus*

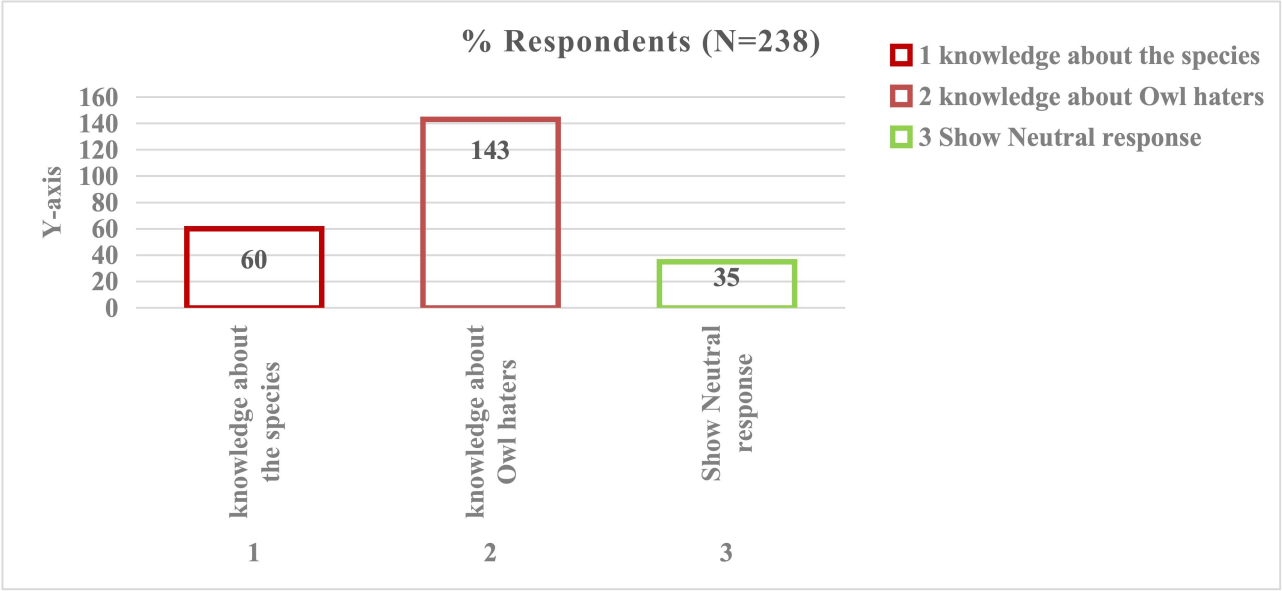

Figure 3. Perception of Spotted owls in local participants (n=238). The bar shows the percentage of respondent's attitude towards owl.

Future studies must utilize sophisticated monitoring devices, such as camera traps, GPS tracking, and banding, to collect accurate data on movement patterns, nesting performance, and use of the Spotted owl habitat, whereas long-term ecological surveys must follow population trends, reproductive variables, and prey dynamics. Genetic diversity measurements will reveal

population structure and robustness and inform targeted conservation interventions. Although the current study has limitations such as the lack of continuous nest monitoring, individual identification, and possible bias in the informally conducted interviews, the results emphasize the ecological function of the species as a natural pest suppressor and its plasticity in human-altered landscapes. Comprehensive strategies involving an integration of ecological studies, habitat protection, nest-box development, cavity-bearing tree restoration, and culturally appropriate community involvement programs are imperative to advocate for sustainable cohabitation of owlets and humans in agroecosystems.

4. Conclusion

This study proves that the Spotted owl (*Athene brama*) is a flexible predator that successfully inhabiting human-altered landscapes of Southern Punjab, where it acts as an essential natural pest suppressor. Population pressures from habitat destruction, agricultural intensification, and unfavorable cultural perceptions continue to pose serious threats. Its long-term survival is ensured by wider conservation measures involving the integration of ecological research with effective interventions such as the preservation of cavity-bearing trees, the use of artificial nest boxes, the reclaiming of degraded habitats, and pesticide reduction through environmentally friendly pest management. Community-based education programs aimed at counting deleterious superstitions and promoting stewardship are equally important. By integrating habitat management and socio-cultural involvement, it is possible to achieve sustainable coexistence between agroecosystems and owlets, which benefits both biodiversity conservation and agricultural resilience.

Author Contribution Statements

Aftab Aslam: Data collection, formal analysis, and preparation of the original draft (equal contribution).

Muhammad Khalid Afzal: Data collection, formal analysis, and preparation of the original draft (equal contribution).

Tanveer Hussain Turabi: Conceptualization and overall supervision of the study, with critical guidance and manuscript revision. Aftab Aslam and Muhammad Khalid Afzal contributed equally to this work.

Ethical approval

The study used only non-invasive techniques, and formal ethical consent was obtained from the Institute of Forest Sciences, Baghdad-ul-Jadeed Campus, The Islamia University of Bahawalpur, Pakistan. Nests were never watched for more than five minutes on any visit to cause minimal disturbance, and no owlets were handled, tagged, or captured. Informal interviews of local communities were carried out after obtaining verbal consent, and voluntary participation was solicited. All procedures conformed to the guidelines of Ornithological Council for the ethical treatment of wild birds in research.

Conflicts of Interest

The authors report no conflicts of interest.

Acknowledgment

The authors gratefully acknowledge the Institute of Forest Sciences, The Islamia University of Bahawalpur, for providing essential facilities and support throughout this study. We also thank the local communities of Bahawalpur and Lodhran for their cooperation during field surveys and interviews.

Data availability statement

The data presented in this study are available on request from the corresponding author.

Funding

Not Applicable (N/A)

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How to cite this article: Aslam A, Turabi TH, Afzal MK, (2025). Population Estimation and Behavioral Study of the Spotted Owl (Athene brama) in Southern Punjab, Pakistan. Journal of Zoology and Systematics, 3 (2), 45-56.