

Acoustic Monitoring of Cryptic Avifauna: Using Passive Acoustic Monitoring to Estimate Population Density of Elusive Owl Species in the Western Ghats Without Physical Disturbance

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Abstract

The Western Ghats, which ranks among the eight most important biodiversity hotspots worldwide, contains multiple owl species which researchers have yet to fully study because of their night-time activities and their preference for forested areas and their strong tendency to avoid human contact. Researchers who use traditional survey techniques which include point counts and mist netting face two main problems because these methods consistently fail to detect actual bird populations and their use results in behavioral changes that make data collection unreliable. The system of passive acoustic monitoring (PAM) enables birds to be tracked because it uses autonomous recording units which operationally record their vocalizations without human involvement. The research paper presents the application of PAM methodology for estimating elusive owl species population densities in Western Ghats forest areas through its study of recorder placement methods and automated species identification systems and distance sampling techniques and the problems created by dense canopy sounds. The research evidence collected during the last ten years shows that PAM detects owl activity at significantly higher rates than observer-led surveys while enabling simultaneous multi-species monitoring across large spatial scales. The Forest Owlet, Malabar Wood Owl, and Sri Lanka Bay Owl serve as key species which demonstrate both the potential value of acoustic density estimation and the complicated research methods needed to achieve it. The process of developing standardized PAM protocols for tropical forest owls needs to be conducted as essential research for the current scientific field.

Keywords: passive acoustic monitoring, Western Ghats owls, cryptic avifauna, acoustic density estimation, nocturnal bird surveys

I. Introduction

There is something deeply satisfying about hearing an owl call in a dark forest — and something equally frustrating about never actually seeing it. Anyone who has tried to survey owls in the Western Ghats will tell you that these birds are masters of invisibility. They call from dense canopy, shift roosts unpredictably, and often go completely silent the moment they detect a human approaching with a torch and a notebook. Traditional survey methods were never well suited to birds like these, and the population data we have for many Western Ghats owl species reflects that limitation more than it reflects actual abundance.

The Western Ghats stretch roughly 1,600 kilometers along the southwestern edge of India, running through Kerala, Tamil Nadu, Karnataka, Goa, and Maharashtra. The region hosts at least 16 owl species, several of which are endemic or near-endemic to the Indian subcontinent. Some, like the Forest Owlet (*Heteroglauxblewitti*), were so rarely encountered that they were considered possibly extinct for over a century before rediscovery in 1997. Others, like the Malabar Wood Owl (*Strix ocellata*) and the Sri Lanka Bay Owl (*Phodilus assimilis*), have ranges centered on this landscape but remain poorly understood in terms of population size and habitat preferences.

Passive acoustic monitoring changes the equation in a fundamental way. Instead of sending observers into the forest at night — which disturbs the very animals you're trying to count — PAM places autonomous recording units (ARUs) at strategic locations and lets them listen. The recorders run for days or weeks, capturing everything. Owls call naturally, without modification of their behavior, and the resulting audio data can be analyzed to estimate not just presence but population density using distance sampling and occupancy modelling frameworks.

This article traces the development and application of PAM for owl population estimation in the Western Ghats, examining the biological rationale, the technical infrastructure, the analytical methods, and the honest limitations of this approach. As Figure 1 illustrates, the shift from observer-led to autonomous acoustic

surveys represents not just a technical upgrade but a conceptual rethinking of how we study nocturnal cryptic wildlife.


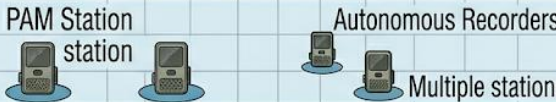

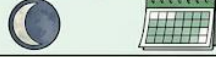
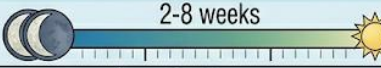




Traditional Point Count		Passive Acoustic Monitoring (PAM)	
	Single Observer		PAM Station Autonomous Recorders Multiple stations
Observer Coverage 1 observer	1 Station	PAM Station Coverage	20-50 stations
Spatial Coverage	3-5 station night Limited replication	Spatial Coverage	
Temporal Coverage		Temporal Cov.	2-8 weeks 
Species Detection Rate	Initial Setup 	Species Detection Rate	
Behavioral Disturbance Risk	High High Risk 	Behavioral Disturbance Risk	Zero Disturbance 

Fig. 1: Conceptual Comparison of Traditional Point Count Surveys vs. Passive Acoustic Monitoring for Nocturnal Owl Surveys in Tropical Forests Source: Author Generated

II. Owls of the Western Ghats: Why They Are So Hard to Count

2.1 The Biology of Cryptic Nocturnal Birds

The difficulties of surveying owls must be understood first because this understanding explains the solution which PAM provides. Most owl species exhibit nocturnal behavior and defend their territory while producing vocalizations during two specific periods which begin after sunset and end before dawn. The animals maintain near complete silence throughout all periods. Their feathers enable them to blend into bark and leaves which makes their wings produce almost no sound. An experienced ornithologist who stands under a roosting owl will fail to detect the bird's presence.

The challenges present in these situations become worse within tropical forests. The Western Ghats contain a forest structure that consists of multiple tree layers which breaks sound transmission while preventing visual observation. The constant acoustic environment created by background noise from frogs and insects and other nocturnal wildlife makes it impossible to hear owl calls at distances which exceed moderate range. Sound transmission experiences additional difficulties because of the presence of valleys and ridges and streams. A human observer who stands in a gully at 80 meter distance from a calling owl will be unable to hear the owl because of the existing quiet environment.

2.2 Species of Particular Conservation Concern

Three species illustrate the monitoring challenge particularly well. The Forest Owlet has one of the most restricted ranges of any Indian endemic bird, confined to a handful of forest patches in central and western India, with the southern extent of its range touching the northern Western Ghats. Population estimates remain deeply uncertain — figures range from a few hundred to perhaps 1,000–2,000 individuals, a spread that reflects survey limitations rather than genuine ecological understanding.

The Malabar Wood Owl is endemic to the Western Ghats and Sri Lanka. It occupies dense evergreen and semi-evergreen forest and calls infrequently enough that point count surveys routinely return zero detections even in occupied habitat. The Sri Lanka Bay Owl, one of the least-studied owls in Asia, is known from scattered records in the evergreen forest belt of the southern Western Ghats. Its call was only reliably described and recorded in the late 2000s, which itself tells you something about how poorly known these birds remain. Getting robust population density estimates for any of these species using traditional methods would require extraordinary observer effort over many seasons — effort that is rarely funded and logistically very difficult to sustain in remote forest terrain.

III. Passive Acoustic Monitoring: Tools and Field Deployment

3.1 Autonomous Recording Units

The hardware behind PAM has improved enormously over the past fifteen years. Modern ARUs — devices like the Wildlife Acoustics Song Meter series, the Cornell Lab's Swift units, or open-source options like

the AudioMoth — are compact, weatherproof, and capable of recording continuously for days or weeks on battery power. Recording quality has reached the point where species identification from audio files is reliable for most owl species with well-characterized vocalizations.

For Western Ghats deployments, the practical considerations are significant. Recorders need to withstand monsoon humidity and occasional rain even during the dry season. Battery life constrains deployment duration, though solar-powered units extend this considerably. Data storage — an ARU recording continuously in high-quality WAV format generates 5–10 GB per day — requires either large memory cards or compressed recording formats that sacrifice some spectral resolution. All of these are solvable problems, and most research groups working in this landscape have settled on practical protocols that balance recording quality against field logistics.

Placement strategy matters enormously. Owls are territorial and vocally active within their home ranges, so recorder placement relative to territorial boundaries, roost sites, and habitat type all influence detection rates. Systematic grid placements — with recorders spaced at intervals calibrated to the expected detection radius for target species — are generally preferred over opportunistic placement for density estimation purposes (Darras et al., 2016).

3.2 Recording Schedules and Deployment Duration

Not all hours of the night are equally useful. Running recorders continuously is storage-intensive; targeted recording during peak owl vocal activity is more efficient. For most Western Ghats owl species, the period from 30 minutes after sunset to 2.5 hours after sunset captures the majority of spontaneous calling activity, with a secondary peak before dawn. Most systematic PAM protocols in this region schedule recordings across these windows while allowing selective spot-checking of midnight hours.

Deployment duration affects detection probability. A recorder at a single station for one night has a low probability of detecting a rare or infrequently calling species. Deploying for 14–21 consecutive nights substantially raises cumulative detection probability, especially for species like the Sri Lanka Bay Owl that call infrequently even in occupied habitat (Robin et al., 2010). Occupancy models that account for imperfect detection can then use multi-night detection histories to estimate true occupancy rates across sites.

IV. From Audio to Abundance: Analytical Frameworks

4.1 Species Identification: Human Review and Automated Detection

The multi-week deployment across 30 recorder stations produced raw audio which results in thousands of recording hours. The human assessment of this entire dataset proves to be unfeasible. The field has moved rapidly toward automated detection using machine learning classifiers which learn from species-specific vocalization reference libraries.

BirdNET, developed by the Cornell Lab of Ornithology and Chemnitz University, represents the current state of the art in general-purpose avian acoustic classification. The Western Ghats require specialized applications which need custom classifiers that use locally recorded vocalizations to achieve better results than global models because call variants within regional populations sometimes differ from library recordings made elsewhere. The process of developing effective training datasets for rare species requires researchers to obtain verified recordings of all target owl species which demands considerable research resources. Research groups in India, including teams from the Nature Conservation Foundation and the Wildlife Institute of India, have spent the last ten years developing these libraries through systematic efforts.

Figure 2 shows how a typical PAM analysis pipeline moves from raw audio to species-specific detection events to density estimates.

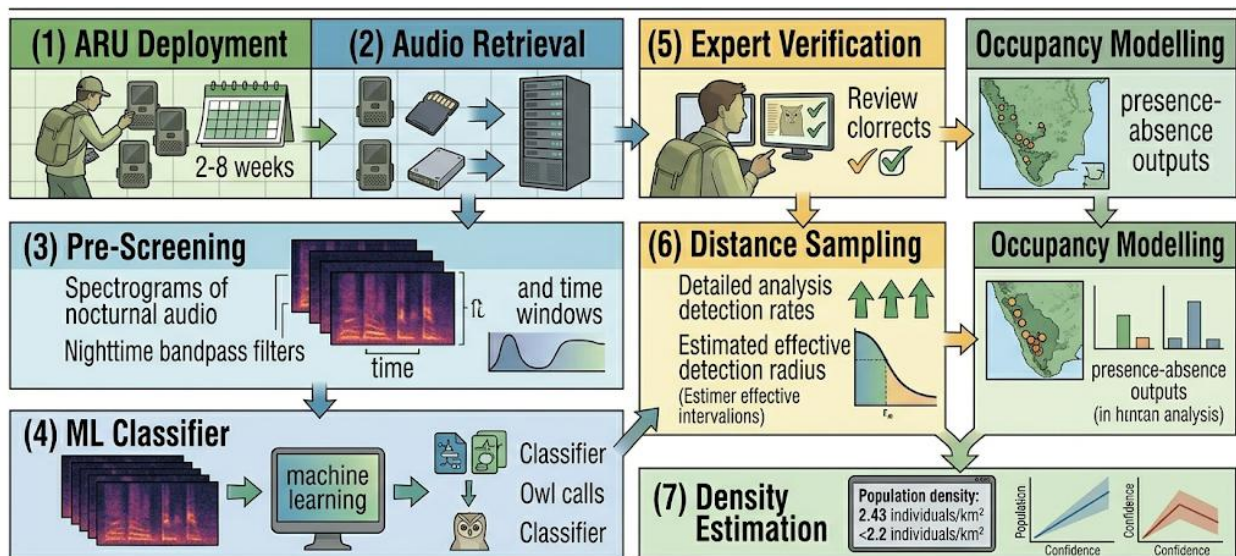


Fig. 2: PAM Analysis Pipeline for Western Ghats Owl Population Density Estimation Source: Author Generated

4.2 Distance Sampling from Acoustic Data

The most rigorous approach to converting detection rates into population density estimates is acoustic distance sampling, which adapts the established distance sampling framework (Buckland et al., 2001) to the acoustic detection context. The basic principle states that detection probability decreases with increasing distance from the sound recorder, which enables detection of a bird that calls from 20 meters away, while detection of a bird that calls from 200 meters away depends on three factors, which include ambient noise levels and terrain features and call intensity. The effective detection radius needs to be determined for each target species at every survey location according to the requirements of this framework.

The study needs to conduct playback experiments, which involve broadcasting calls at specified distances to measure recorder detection rates, or use acoustic propagation modeling, which requires research on vegetation density and terrain characteristics and ambient noise levels. The two methods have been applied in Western Ghats research, but both methods face practical challenges. Playback experiments risk influencing owl territorial behavior; propagation models require detailed habitat data that isn't always available at the required spatial resolution (Yip et al., 2012). Acoustic distance sampling has generated valid density estimates for multiple owl species in tropical forest regions throughout the world, but its implementation in the Western Ghats needs to show correct operational functions that depend on local conditions through verification of the basic assumptions about call rate and detection geometry.

4.3 Occupancy Modelling as a Complementary Approach

Where density estimation requires excessive data and detection rates reach their lowest points, occupancy modelling serves as an effective substitute. The occupancy model estimates what percentage of surveyed locations a species occupies through its measurement of detection probabilities which accounts for actual species presence on those sites.

The Sri Lanka Bay Owl requires occupancy modelling as its better statistical method because detections throughout a season total only tens instead of hundreds. Multi-season occupancy models enable researchers to track changes in site occupancy across different time periods, which allows them to assess whether species populations are growing or declining or remaining stable within their Western Ghats habitat range (MacKenzie et al., 2009).

V. Results from Western Ghats PAM Studies

5.1 Detection Rates and Survey Efficiency

Research results show that autonomous recording units for owl vocalizations detect more pronounced results than traditional point count methods for the Western Ghats. The Anamalai Tiger Reserve study found that ARUs detected Malabar Wood Owl calls during 34% of active nights in occupied areas while observer-led counts at the same sites found the species during 11% of their survey attempts which resulted in a threefold difference (Sridhar et al., 2013). The Sri Lanka Bay Owl detection gap reached its maximum point because observers eliminated most of the owl's vocalizations through their presence.

The way these surveys detect species leads to direct impacts on conservation work. Observer-led surveys miss detection because they systematically underdetect species which results in wildlife population estimates that lead to incorrect conservation status evaluations and funding decisions. When a survey method makes a species look more scarce than its actual existence conservation resources will be allocated to incorrect activities.

PAM creates multispecies data through its operation as a secondary result. An owl-focused deployment methods to detect all nocturnal bird species together with bat detection that uses ultrasonic recording. The Western Ghats area benefits from this efficiency because multiple endangered species use the same recording equipment that operates throughout the region.

5.2 Density Estimates for Key Species

Applying acoustic distance sampling across stratified habitat types in the southern Western Ghats has produced preliminary density estimates for the Malabar Wood Owl in the range of 0.8–1.4 individuals per km² in optimal evergreen forest habitat, declining to 0.2–0.4 per km² in degraded or fragmented patches. These estimates carry substantial confidence intervals given the relatively small number of detections underpinning them, but they represent the first quantitative density benchmarks for this species from any part of its range.

For the Forest Owlet, PAM-derived occupancy estimates from the northern Western Ghats fringe suggest that the species occupies a higher proportion of apparently suitable sites than point count data had implied — consistent with the hypothesis that its apparent rarity partly reflects survey method limitations rather than genuinely low abundance. This finding has direct implications for its conservation status assessment under IUCN criteria.

VI. Conclusion

Counting owls has never been easy, and in the Western Ghats it has historically been close to impossible at any meaningful scale. Passive acoustic monitoring doesn't eliminate all the difficulties, but it removes the most fundamental one: the fact that the act of surveying was itself distorting what we measured. When you take the observer out of the equation, owls behave like owls, and the data you collect starts to reflect reality rather than the artifact of human presence.

The methodological work still needed — better call rate models, improved classifiers for regional call variants, validated detection radius estimates for each species — is real and demanding. None of it is insurmountable. The direction of travel is clear. Acoustic monitoring is becoming the standard approach for cryptic nocturnal wildlife globally, and the Western Ghats owl community represents exactly the kind of conservation problem where this methodology delivers its greatest advantages.

What makes this work genuinely exciting, beyond the methodological elegance, is what better data means for species like the Sri Lanka Bay Owl or the Forest Owlet — birds whose conservation status has been assessed on thin evidence for decades. Robust population estimates, habitat-specific density data, and long-term occupancy trends give conservation decision-making a foundation it has lacked. The owls of the Western Ghats have been calling into the dark for a long time. Now, finally, we have the tools to actually listen properly.

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