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Comparative Analysis of Bioacoustic and Point Count Methods for Calculating Bird Species Richness in Bukit Watu Ondo, Mount Ungaran, Central Java

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Abstract
The study aims to compare the effectiveness of bioacoustic and point count methods in assessing bird species richness in Bukit Watu Ondo, Mount Ungaran, Central Java. A quantitative approach was employed through simultaneous data collection using both methods at six observation points. Bird observations were conducted visually and acoustically for 15-minute sessions at each point, repeated three times. The data were analyzed using a paired t-test to determine statistical differences between the two methods. Results showed that the point count method identified 29 species from 22 families, while the bioacoustic method recorded 25 species from 17 families. Statistical analysis revealed no significant difference ($p = 0.927$) between the two methods in the number of detected species, indicating comparable effectiveness. However, bioacoustics proved more efficient in detecting vocally active or cryptic species that were difficult to observe visually, whereas point count performed better for visually conspicuous species. The combination of both methods provided a more comprehensive representation of avifaunal diversity. These findings demonstrate that bioacoustic techniques are a viable and complementary alternative to traditional visual methods in biodiversity monitoring and conservation management.

Keywords: Bird diversity, point count, bioacoustics, Mount Ungaran

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Introduction

Birds are members of the Animalia Kingdom, belonging to the group of vertebrates classified in the class Aves (1). Birds are a component of ecosystems that have reciprocal and interdependent relationships with their environment (2). Birds can be used as indicators of forest quality because the diversity of bird species can reflect the high diversity of other living things (3). Diversity is a characteristic of a community and is related to the number of species and the number of individuals of each species that comprise the community (4).

Mount Ungaran boasts a high level of biodiversity, encompassing a diverse array of flora and fauna, as well as various protected wildlife species (5). Mount Ungaran has been designated as an Alliance for Zero Extinction (AZE) and Important Bird Area (IBA) (6). Mount Ungaran features a topography characterized by steep and rugged hills and valleys. The mountains on Mount Ungaran consist of Suralaya Hill, Wayang Hill, Gajah Mungkur Hill, Watu Ondo Hill, Celeng Hill, and Gentong Hill. Watu Ondo Hill is located in Gunungsari Hamlet, Ngesrepbalong Village, Limbangan Subdistrict, Kendal Regency. Watu Ondo Hill features a habitat type characterized by a diverse array of shrubs, flowering plants, bushes, and trees with broad canopies. One of the species found in the Watu Ondo area is the *Rhyticeros undulatus* (7).

To conserve the rich bird species in Bukit Watu Ondo, monitoring needs to be carried out in the area. The point count method is a standard technique commonly used in bird surveys (8). The point count method involves standing at a specific point in the habitat being

studied and recording bird sightings to a particular time and location, either directly (visually) or indirectly (by sound) (9). When applying this survey technique, many bird species are recorded through sound detection, especially when dense vegetation makes it difficult to observe them (10). The large number of individuals that may be vocalizing simultaneously also poses a challenge, as it is difficult to separate sounds and identify individuals in a short period of time.

Bioacoustic technology is a potential method (11). Bioacoustics enables the observation of bird species through sound recordings and acoustic analysis, making it possible to detect species that are difficult to observe visually (12). This method is particularly beneficial in habitats that are difficult to access and can enhance the accuracy of biodiversity data (13). Several previous studies have been conducted to determine the effectiveness of bird observation methods, including a comparison between ARU and Point Count Birds in Open Forest Savannas (14). However, no studies compared direct observation (point count) and bioacoustic methods in Mount Ungaran. This research needs to be conducted to determine the number of birds identified and the effectiveness of the two processes.

Material and Methods

The research was conducted at Bukit Watu Ondo, located in Gunungsari Hamlet, Ngesrepbalong Village, Limbangan District, Kendal Regency, Central Java. The study took place from March to August 2025, during the dry season, when bird vocal activity was relatively high. Observations were conducted in the morning from 06:00 to 11:00 Western Indonesian Time (WIB).

This study employed a quantitative comparative design to evaluate differences in bird species detection between the *Point Count* and *Bioacoustic* methods. Six observation points were established, each spaced approximately 100 meters apart. At each point, simultaneous observations were conducted using both methods. The bioacoustic recordings were repeated three times, each lasting 15 minutes, with 10-minute intervals between recordings. During the same session, visual observations were conducted using binoculars to identify species that were seen and/or heard.

Table 1. Research Tools and Materials

No	Tools and Materials	Function
1.	Binoculars	Observing birds from a distance that cannot be seen directly with the naked eye
2.	Tascam recorder	Actively recording bird sounds
3.	Stationery	Marking or writing down observation results
4.	Handphone	Installing the RecForge II application
5.	DSLR camera	Photographing or taking pictures of observations
6.	Clipboard	Protection and support when writing on the tally sheet
7.	GPS	Determining observation points, navigation, and time
8.	Plastic Map	A place to carry and keep tally sheets
9.	Field guide by MacKinnon	As a guide to bird species during observation
10	Tally Sheet	Recording bird observation results

Notes: This table lists the tools and materials used during bird watching, along with their respective functions, to support the field observation process.

The research utilized several instruments, including (Table 1):

- Binoculars for visual bird observation at long distances.
- Tascam recorder for capturing bird vocalizations.
- GPS to determine coordinates and observation points.
- Camera (DSLR) for photo documentation.
- Field guidebook (*Burung-Burung di Sumatera, Jawa, Bali, dan Kalimantan* by MacKinnon et al., 2010) for species identification.
- Tally sheets and writing tools for data recording.
- Mobile phone with the RecForge II application for supporting audio data collection.

Each observation session involved recording both visual and acoustic detections. The observer noted the presence of species as *"seen," "heard,"* or *"seen and heard."* All recorded sounds were later analyzed using RecForge II and cross-validated with the Xeno-Canto (*https://xeno-canto.org/*) online database to ensure species accuracy. Data were analyzed using a paired t-test in IBM SPSS 25 to compare

the number of species detected by each method at the six observation points. The null hypothesis (H_0) stated that there was no significant difference between the methods. Additionally, species richness was interpreted using Shannon–Wiener and Evenness indices to describe diversity levels.

Results and Discussion

Observations using the point count method successfully recorded 29 bird species belonging to 22 families, totaling 545 individuals (Table 2). The families with the highest number of species included Cuculidae, Megalaimidae, and Pycnonotidae (3 species each) (Figure 1). The bird species with the highest number of individuals was *Collocalia linchi* (swiftlet), with 167 individuals, followed by Loriculus pusillus (Javanese serindit), with 128 individuals, and Pycnonotus aurigaster (cucak kutilang), with 57 individuals. The high number of swiftlets is due to their active flying in open areas and their visibility in the sky above Bukit Watu Ondo. Meanwhile, the white-rumped shama, a generalist species, was found at almost all observation points due to its ability to adapt to various types of open vegetation (15) (16).

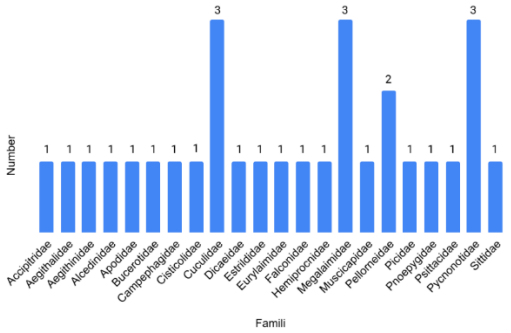

Figure 1. Species Composition Based on Family *Point Count* Method

Table 2. Bird Species in Bukit Watu Ondo Using the *Point Count* Observation Method

Family	Species Name	Local Name	English Name	Conservation status			Amount
				P.106	IUCN	CITES	
Accipitridae	*Spilornis cheela*	Elang-ular bido	*Crested Serpent Eagle*	TL	LC	II	3
Aegithalidae	*Psaltria exilis*	Cerecet jawa	*Pygmy Tit*	L	LC	0	27
Aegithinidae	*Aegithina tiphia*	Cipoh kacat	*Common Iora*	TL	LC	0	5
Alcedinidae	*Todiramphus chloris*	Cekakak sungai	*Collared Kingfisher*	TL	LC	0	1
Apodidae	*Collocalia linchi*	Walet linci	*Cave Swiftlet*	TL	LC	0	167
Bucerotidae	*Rhyticeros undulatus*	Julang emas	*Wreathed Hornbill*	L	VU	II	2
Campephagidae	*Pericrocotus flammeus*	Sepah hutan	*Scarlet Minivet*	TL	LC	0	5
Cisticolidae	*Orthotomus sutorius*	Cinenen pisang	*Common Tailorbird*	TL	LC	0	12
Cuculidae	*Cacomantis variolosus sepulcralis*	Wiwik uncuing	*Rusty-breasted Cuckoo*	TL	LC	0	2
Cuculidae	*Cacomantis sonneratii*	Wiwik lurik	*Banded Bay Cuckoo*	TL	LC	0	3
Cuculidae	*Surniculus lugubris*	Kedasi hitam	*Square-tailed Drongo-Cuckoo*	TL	LC	0	6
Dicaeidae	*Dicaeum trigonostigma*	Cabai bunga api	*Orange-bellied Flowerpecker*	TL	LC	0	10
Estrildidae	*Lonchura leucogastroides*	Bondol jawa	*Javan Munia*	TL	LC	0	5
Eurylaimidae	*Eurylaimus javanicus*	Sempur hujan rimba	*Banded Broadbill*	TL	LC	0	2
Falconidae	*Falco severus*	Elang alap macan	*Oriental Hobby*	TL	LC	II	1
Hemiprocnidae	*Hemiprocne longipennis*	Tepekong jambul	*Grey-rumped Treeswift*	TL	LC	0	28
Megalaimidae	*Psilopogon armillaris*	Takur Tohtor	*Rufous-browed Babbler*	L	LC	0	7
Megalaimidae	*Psilopogon javensis*	Takur tulung tumpuk	*Black-banded Barbet*	L	LC	0	10
Megalaimidae	*Psilopogon australis*	Takur tenggeret	*Blue-eared Barbet*	TL	LC	0	30
Muscicapidae	*Enicurus velatus*	Meninting kecil	*Blue-eared Kingfisher*	TL	LC	0	1
Pellorneidae	*Malacocincla sepiaria*	Pelanduk semak	*Rufous-browed Babbler*	TL	LC	0	1

Pellorneidae	*Pellorneum capistratum*	Pelanduk topi-jawa	*Rufous-browed Babbler*	TL	LC	0	6
Picidae	*Dendrocopos analis*	Caladi ulam	*Freckle-breasted Woodpecker*	TL	LC	0	1
Pnoepygidae	*Pnoepyga pusilla*	Berencet kerdil	*Pygmy Cupwing*	TL	LC	0	2
Psittacidae	*Loriculus pusillus*	Serindit jawa	*Blue-crowned Hanging Parrot*	L	NT	II	128
Pycnonotidae	*Pycnonotus goiavier*	Merbah cerukcuk	*Yellow-vented Bulbul*	TL	LC	0	2
Pycnonotidae	*Pycnonotus simplex*	Merbah corok-corok	*Cream-vented Bulbul*	TL	LC	0	6
Pycnonotidae	*Pycnonotus aurigaster*	Cucak kutilang	*Sooty-headed Bulbul*	TL	LC	0	57
Sittidae	*Sitta frontalis*	Munguk beledu	*Velvet-fronted Nuthatch*	TL	LC	0	15

Notes: P.106: Minister of Environment and Forestry Regulation on protected animals (TL = not protected). IUCN: International conservation status (LC = low risk; VU = vulnerable). CITES: Animal trade regulations (0 = not listed; II = monitored/Appendix II).

Based on the results of the Shannon-Wiener diversity index analysis, a value of H' = 4.443 was obtained, which falls into the high category (H' > 4.0). This value indicates that the Bukit Watu Ondo area has a relatively stable ecosystem that supports the life of various bird species. This diversity is thought to be influenced by habitat heterogeneity, food availability, and minimal anthropogenic disturbance.

Using bioacoustic methods, 25 bird species from 17 families were successfully identified (Table 3). The family with the most species was Cuculidae (3 species), followed by Pycnonotidae, Megalaimidae, and Aegithinidae (each with 2 species) (Figure 2). Bioacoustic methods enable the detection of species that are difficult to see visually, such as birds that are active under dense canopy or are shy (skulking species). Several species, such as *Cacomantis sonneratii* (wiwik lurik), *Psilopogon australis* (takur tenggeret), and *Hydrornis guajanus* (paok pancawarna), were more frequently detected through sound recordings than through direct observation. This indicates that bioacoustic methods are effective for detecting species with high vocalization activity at certain times (12) (13).

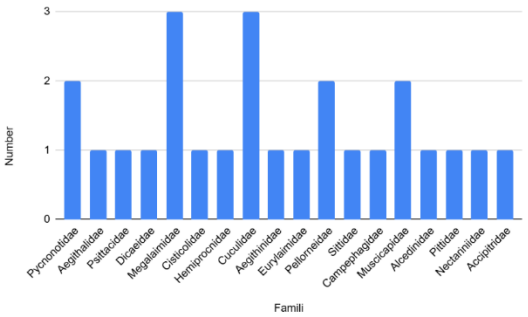

Figure 2. Composition of Species Numbers Based on Family Using *Bioacoustic* Methods

Table 3. Bird Species in Bukit Watu Ondo with *Bioacoustic* Observations

No	Family	Species Name	Local Name	English Name	Conservation status		
					P.106	IUCN	CITES
1	Pycnonotidae	*Pycnonotus aurigaster*	Cucak kutilang	*Sooty-headed Bulbul*	TL	LC	0
2	Aegithalidae	*Psaltria exilis*	Cerecet jawa	*Pygmy Tit*	L	LC	0
3	Psittacidae	*Loriculus pusillus*	Serindit jawa	*Blue-crowned Hanging Parrot*	L	NT	II
4	Dicaeidae	*Dicaeum trigonostigma*	Cabai bunga api	*Orange-bellied Flowerpecker*	TL	LC	0
5	Megalaimidae	*Psilopogon australis*	Takur tenggeret	*Blue-eared Barbet*	TL	LC	0
6	Cisticolidae	*Orthotomus sutorius*	Cinenen pisang	*Common Tailorbird*	TL	LC	0
7	Hemiprocnidae	*Hemiprocne longipennis*	Tepekong jambul	*Grey-rumped Treeswift*	TL	LC	0
8	Cuculidae	*Surniculus lugubris*	Kedasi hitam	*Square-tailed Drongo-Cuckoo*	TL	LC	0
9	Cuculidae	*Cacomantis sonneratii*	Wiwik lurik	*Banded Bay Cuckoo*	TL	LC	0
10	Aegithinidae	*Aegithina tiphia*	Cipoh kacat	*Common Iora*	TL	LC	0
11	Cuculidae	*Cacomantis variolosus sepulcralis*	Wiwik uncuing	*Rusty-breasted Cuckoo*	TL	LC	0

12	Megalaimidae	*Psilopogon javensis*	Takur tulung tumpuk	*Black-banded Barbet*	L	LC	0
13	Eurylaimidae	*Eurylaimus javanicus*	Sempur hujan rimba	*Banded Broadbill*	TL	LC	0
14	Pellorneidae	*Malacocincla sepiaria*	Pelanduk semak	*Rufous-browed Babbler*	TL	LC	0
15	Pycnonotidae	*Pycnonotus simplex*	Merbah corok-corok	*Cream-vented Bulbul*	TL	LC	0
16	Sittidae	*Sitta frontalis*	Munguk beledu	*Velvet-fronted Nuthatch*	TL	LC	0
17	Campephagidae	*Pericrocotus flammeus*	Sepah hutan	*Scarlet Minivet*	TL	LC	0
18	Muscicapidae	*Enicurus velatus*	Meninting kecil	*Blue-eared Kingfisher*	TL	LC	0
19	Muscicapidae	*Enicurus leschenaulti*	Meninting Besar	*White-crowned Forktail*	TL	LC	0
20	Pellorneidae	*Pellorneum capistratum*	Pelanduk topi-jawa	*Rufous-browed Babbler*	TL	LC	0
21	Alcedinidae	*Todiramphus chloris*	Cekakak sungai	*Collared Kingfisher*	TL	LC	0
22	Megalaimidae	*Psilopogon armillaris*	Takur Tohtor	*Rufous-browed Babbler*	L	LC	0
23	Pittidae	*Hydrornis guajanus*	Paok Pancawarna	*Javan Banded Pitta*	L	LC	0
24	Nectariniidae	*Arachnothera affinis*	Pijantung Gunung	*Streaked Spiderhunter*	TL	LC	0
25	Accipitridae	*Spilornis cheela*	Elang-ular bido	*Crested Serpent Eagle*	TL	LC	II

Notes: P.106: Minister of Environment and Forestry Regulation on protected animals (TL = not protected). IUCN: International conservation status (LC = low risk; VU = vulnerable). CITES: Animal trade regulations (0 = not listed; II = monitored/Appendix II).

From the family composition analysis, the results show that the secondary forest vegetation of Bukit Watu Ondo supports the existence of medium and lower canopy birds. This is in line with the characteristics of the Mount Ungaran ecosystem, which has moderate vegetation cover with variations in canopy structure and shrub density. The results of statistical analysis using the Paired Samples Test showed a significance value of p = 0.927 (p > 0.05) (Table 5). This value indicates that there is no significant difference between the point count and bioacoustic methods in detecting the number of bird species. Thus, both methods have comparable effectiveness in avifauna survey activities (Figure 3).

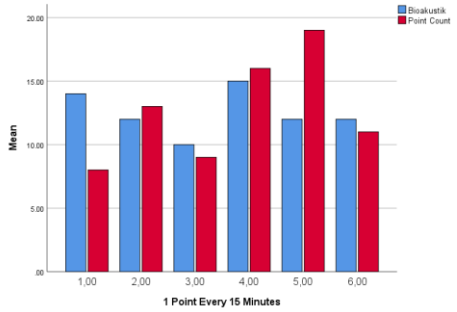

Figure 3. Comparison Chart of the Number of Species Detected Using *Bioacoustic* and *Point Count* Methods

However, each method has its own advantages, albeit qualitatively. The bioacoustic method excels at detecting species that are difficult to observe or vocally active, such as shy birds and those dwelling in dense canopies. Meanwhile, the point count method is more effective at detecting species that are active flyers, large in size, or easily visible, such as *Falco severus* (tiger falcon) and *Todiramphus chloris* (river kingfisher) (Table 4). These results align with the research of Kühl et al. (2011) and Fajri et al. (2022), which suggest that bioacoustics can complement visual methods in expanding the scope of species detection and reducing observation bias due to visual limitations in the field. Thus, the application of a combination of both techniques can provide more comprehensive and accurate results in studies of bird diversity in natural habitats.

Table 4. Bird Species Detected at Six Points Using *Point Count* and *Bioacoustic* Methods

No	Family	Local Name	Sample points											
			1		2		3		4		5		6	
			PC	B	PC	B	PC	B	PC	B	PC	B	PC	B
1	Pycnonotidae	Cucak Kutilang	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
2	Aegithalidae	Cerecet Jawa	✓	✓			✓	✓	✓			✓	✓	
3	Psittasidae	Serindit Jawa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	Dicaidae	Cabai Bunga Api	✓	✓	✓	✓	✓	✓		✓		✓	✓	
5	Megalaimidae	Takur Tenggeret	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

6	Cisticolidae	Cinenen Pisang	✓	✓		✓			✓	✓	✓	✓			
7	Hemiprocnidae	Tepekong Jambul	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
8	Cuculidae	Kedasi Hitam	✓	✓	✓	✓						✓	✓	✓	
9	Cuculidae	Wiwik Lurik				✓	✓		✓						
10	*Aegithinidae*	Cipoh Kacat				✓			✓	✓	✓	✓		✓	
11	Cuculidae	Wiwik Uncuing											✓	✓	
12	Megalaimidae	Takur Tulung Tumpuk							✓	✓	✓	✓	✓		
13	Eurylaimidae	Sempur Hujan Rimba											✓	✓	
14	Pellorneidae	Pelanduk Semak				✓			✓	✓		✓			
15	Pycnonotidae	Merbah Corok-corok	✓				✓	✓	✓			✓		✓	
16	Sittidae	Munguk Beledu							✓	✓	✓	✓		✓	
17	Campephagidae	Sepah Hutan			✓				✓		✓				
18	Muscicapidae	Meninting Kecil					✓	✓							
19	Muscicapidae	Meninting Besar				✓									
20	Pellorneidae	Pelanduk Topi Jawa	✓			✓				✓	✓	✓	✓	✓	
21	Alcedinidae	Cekakak sungai	✓							✓					
22	Megalaimidae	Takur Tohtor								✓	✓	✓	✓		
23	Pittidae	Paok Pancawarna										✓			
24	Nectariniidae	Pijantung Gunung				✓						✓			
25	*Acciptridae*	Elang ular Bido			✓										
26	Apodidae	Walet linci	✓		✓		✓		✓		✓				
27	Bucerotidae	Julang emas	✓												
28	Estrildidae	Bondol jawa	✓		✓										
29	Falconidae	Elang alap macan	✓												
30	Pnoepygidae	Berencet kerdil			✓										
31	Picidae	Caladi ulam							✓						
32	Pycnonotidae	Merbah cerukcuk									✓		✓		

Notes: PC = Point Count; B = Bioacoustic; the ✓ symbol indicates that the species was detected at that point.

Table 5. Results of paired t-test analysis using SPSS

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Point Count - Bioakustik	.16667	4.21505	1.72079	-4.25676	4.59009	.097	5	.927

Notes: Mean = mean difference; Std. Deviation = standard deviation; Std. Error Mean = standard error; CI = Confidence Interval; t = t-statistic value; df = degrees of freedom; Sig. (2-tailed) = two-tailed significance value.

The high diversity of birds in Bukit Watu Ondo reflects a healthy and well-functioning ecosystem. Several species found, such as *Rhyticeros undulatus* (golden hornbill) and *Loriculus pusillus* (Javanese serindit), are classified as protected animals according to Minister of Environment and Forestry Regulation Number P.106/MENLHK/SETJEN/KUM.1/12/2018, and are listed in CITES Appendix II. The results of this study highlight the importance of forest habitat management in the Mount Ungaran area in maintaining the sustainability of bird populations and ecosystem functions. In addition, bioacoustic methods can be integrated into long-term ecological monitoring programs, as they enable efficient, objective, and re-analyzable passive data recording in the future.

Conclusion

This study demonstrated that the bird species richness in Bukit Watu Ondo, Mount Ungaran, is relatively high, with a total of 32 species recorded through the combined application of point count and bioacoustic methods. The point count method identified 29 species from 22 families, while the bioacoustic method detected 25 species from 17 families. The paired samples t-test showed no significant difference between the two methods ($p = 0.927$), indicating that both methods have comparable effectiveness in detecting bird diversity. The new contribution of this study lies in the empirical validation that bioacoustics can serve as an equally effective and complementary technique to point count, especially for detecting vocally

active or visually cryptic species within structurally complex habitats. Thus, integrating both methods provides a more comprehensive and ecologically representative assessment of avifaunal richness in tropical forest environments.

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Conflict of Interest

All authors declare no conflicts of interest in conducting, analyzing, and reporting this research.

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