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Research Article

Comparison of Visual Count Survey and Passive Acoustic Monitoring for Avifauna Diversity in Purwosari Village, Girimulyo, Kulonprogo

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ABSTRACT
Accurate diversity research in areas with high biodiversity is challenging. Challenges include a lack of human resources, time constraints, and difficulty in accessing remote environments for data collection. Passive-Acoustic Monitoring (PAM) has emerged as a viable ecological data collection method. This study aims to compare the PAM method with the visual count sampling method for bird diversity monitoring. This study was conducted from September 1 to November 29, 2023, on the slopes of Nggirgadung, Purwosari village, Girimulyo, Kulonprogo. The results obtained from this study revealed 42 bird species. The VES method identified 36 bird species, whereas the PAM method identified 30 bird species. However, 12 types of sounds recorded using the PAM method could not be identified. The findings suggest that while VES detected more species, PAM can complement VES by capturing visually difficult species. This study highlights the advantages of combining both methods for comprehensive biodiversity monitoring.

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INTRODUCTION

Indonesia is one of the countries with abundant biodiversity, especially in birds. As of 2007, Indonesia ranked second globally in bird species diversity, with 1,599 recorded species. (Widjaja et al. 2014), and by 2024, this number had increased to 1877 (Lepage 2025). However, Indonesia also faces significant conservation challenges, with 12 % of endangered birds in the world. (Burung Indonesia n.d.). From these issues, we understand that a good conservation strategy is needed. A good conservation strategy requires an optimal data collection method. (Primack. 2004).

The Visual Encounter Survey method is often used in biodiversity data collection, but it has various weaknesses, such as the lack of human resources, time constraints, and the inability of ecologists to collect data in difficult environments. (Setiawan et al. 2016). In response to these challenges, Passive-Acoustic Monitoring (PAM) has emerged as a reliable and cost-effective alternative or complement to the traditional method. (Obrist et al. 2010). PAM is particularly effective for monitoring species that communicate through sound, as it allows for continuous data collection over extended periods without the need for constant human presence (Haver et al. 2020).

The Passive Acoustic Monitoring method has many advantages, like running recordings over multiple periods in a single deployment and detecting cryptic species. However, combining sound recording with direct observation gives the best results. (Darras et al. 2019). Research on the comparison of passive acoustic monitoring methods for monitoring avifauna biodiversity in tropical rainforests is rarely conducted in tropical rainforest regions, more specifically in Indonesia. Some studies that have been carried out include those in Australia (Leach et al. 2016), Ecuador (Blake 2021), and Brazil (Metcalf et al. 2021)

Therefore, it is necessary to compare methods from research in other areas as a reference. These two approaches are important to compare in order to determine the most effective method that can be used for bird research in Purwosari. The purpose of this research is: 1) to identify the types of avifauna detected by Passive Acoustic Monitoring and Visual Count Sampling methods, and 2) to compare the number of species found in the Visual Encounter Survey Method with Passive Acoustic Monitoring based on the recorded time. By identifying the species encountered and determining the time required to detect all species, we can assess and determine the most effective survey method for application on the slopes of Nggirgadung, Purwosari Village, Girimulyo, Special Region of Yogyakarta.

MATERIALS AND METHODS

Data collection

This research was conducted from September 1 to November 30 2023 at five sampling points (TS), namely TS 1 (S 07.72928°, E 110.15348°), TS 2 (S 07.73052°, E 110.15288°), TS 3 (S 07.73054°, E 110.15195°), TS 4 (S 07.72982°, E 110.15074°) and TS 5 (S 07.73068°, E 110.14936°). This data collection was located on the slopes of Nggirgadung, located in Purwosari Village, Girimulyo District, Kulonprogo Regency, Yogyakarta Special Region. This data collection is located. To minimise the risk of double-counting, the sampling points were spaced at least 200 meters apart.

The methods used in this study were the Visual Encounter Survey and the Passive Acoustic Monitoring. The Visual Encounter Survey (VES) method is a survey conducted by observing an area or habitat during a certain period of time to systematically search for animals. (Cholifatullah et al. 2020). Meanwhile, Passive Acoustic Monitoring is conducted using sound (acoustic sensors). The acoustic tool is left in the field for several days to get the expected sound data results. (Browning et al. 2017). The research location map can be seen in Figure 1.

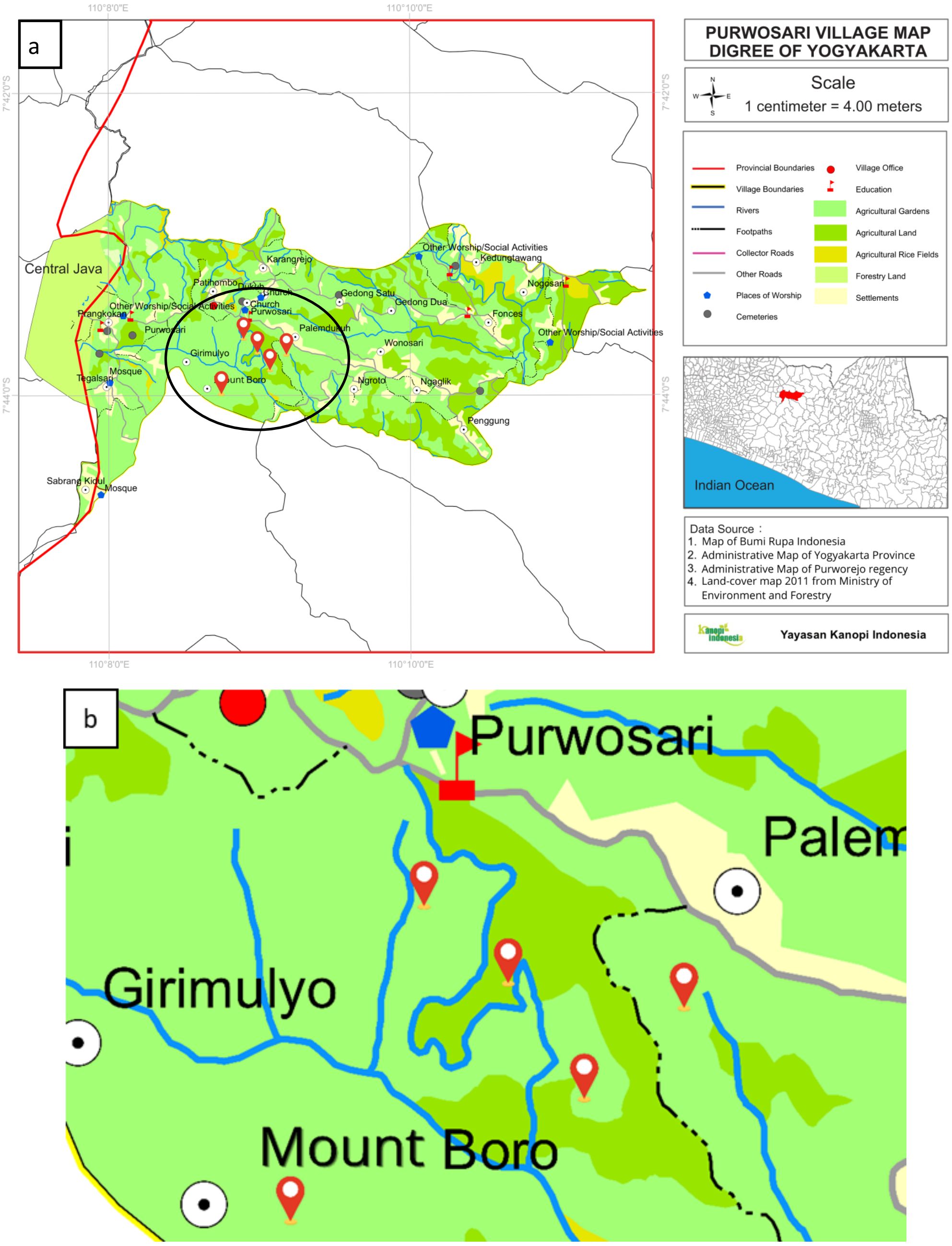

Figure 1. Location map of the research sampling points. (a) location of Nggirgadung slope in Purwosari village, (b) Research point in Nggirgadung slope.

The Visual Encounter Survey was carried out twice daily, namely in the morning with a time range between 06.00-10.00 WIB and in the afternoon between 13.00-17.00 WIB. This data was collected at 5 observation points with 3 repetitions at each point. The Visual Encounter Survey is done using a field tally sheet and a digital camera as the main tools of observation. The time allocation for each observation point is 80 minutes, which includes 5 minutes for adjustment to the surrounding conditions and preparation, and 75 minutes for observation. During data collection using the VES method, exploration was conducted once all birds at the observation point had been recorded. The exploration was carried out within a 50-meter radius. All occurrences of bird species seen at the site during the calculation period were then recorded in the tally sheet in the form of the number of species and the time of finding. All birds recorded through the Visual Encounter Survey (VES) method were individuals visually detected by the researcher.

Acoustic data collection was carried out in the same place as the Visual Encounter Survey data collection. At the sampling locations. Passive Acoustic Monitoring data collection is done using a SwiftOne and two handphones

(Xiaomi Redmi Note 7 and Sony Xperia), the recording device and microphone are tied to a chest-high tree or about 1.5 m above ground level. This sound recording device is to record for 1 minute every 9 minutes pause in recording time. The time range is between 05.00-17.00 WIB, so that the recording file will be taken in the next 3 days, with 150 minutes per data collection per point, and carried out a total of 4 repetitions of time. The first three repetitions are the main data, while 1 additional repetition is supplementary data if the hours in the PAM method have not matched the VES.

Data analysis

The environmental acoustic data obtained were then analysed manually with the help of Raven Pro 1.6 software from the K.Lisa Yang Centre for Conservation Bioacoustics, Cornell University. The acoustic parameters measured were low frequency (Hz), high frequency (Hz), and peak frequency (Hz). The sound recording data was identified to determine the species of birds found by comparing with the bird sound database that has been identified through the website: Xeno-Canto with url: www.xeno-canto.org, ebird.com by macaulaylibrary.org, and Avisoft. birds from all over the world. The identification of sound species is also assisted by an expert in the field of fauna, especially by a bird expert, and experts from the local community to confirm the type of bird sound.

RESULTS AND DISCUSSION

Results

Pasive Acoustics Monitoring was carried out for 32 active days. Active days refer to the periods during which the recording device is operational and continuously capturing acoustic data. with a total recording time of 37.5 hours. The Visual Encounter Survey was conducted for 20 days with a total active observation time of 37.5 hours. A comparison of species encounters can be seen in Table 1.

If we look at the data above, the VES method has the largest number of species found, with 36 species, while the PAM method could only find 30 bird species. The total species found in both methods is 42. If we look more carefully, there are some species found in both methods, it was 24 species. The species only found in VES is 12 species (not found in PAM), and the species only found in the PAM methods is 6 species (not found in VES). Some documentation of bird species and the results of recording specific species in each method can be seen in Figure 2.

Pictured above are some of the birds that were not included in the PAM method and were documented with the camera. Some birds that were not documented in the camera include *Phaenicophaeus curvirostris*, *Chalcophaps indica*, *Apus nipalensis*, *Hemiprocne longipennis*, *Macropygia emiliana, and Collocalia linchi*. While the sounds recorded and not found in the VES method can be seen in Figure 3.

Discussion

The PAM and VES methods are two different methods in their application. Passive Acoustic Monitoring did not involve researchers directly in the field, so that the time of field observations could be done longer depends on battery capacity and memory. It also detected bird sounds that are sensitive to the presence of researchers, and the results were in the form of sound storage files so that they could be analysed at any time without fear of losing data. On the other hand, Visual Encounter Sampling has the advantage of being able to explore the area around the point; it also detects silent birds and gets visual information to facilitate identification. Visual Encounter Surveys and Passive Acoustic Monitoring have various differences in results in the form of the

Table 1. Bird species encounters in the Visual Encounter Survey and Passive Acoustic Monitoring Methods.

No	Species Name	Family	Visual Count Survey	Passive Acoustic Monitoring
1	*Aegithina tiphia*	Aegithinidae	V	V
2	*Aethopyga mystacalis*	Nectariniidae	V	V
3	*Alophoixus bres*	Pycnonotidae	V	V
4	*Anthreptes malacensis*	Nectariniidae	V	V
5	*Arachnothera affinis*	Nectariniidae	V	V
6	*Arachnothera longirostra*	Nectariniidae	V	V
7	*Cacomantis sonneratii*	Cuculidae	V	V
8	*Cinnyris ornatus*	Nectariniidae	V	V
9	*Dicaeum trigonostigma*	Dicaedae	V	V
10	*Dinopium javanense*	Picidae	V	V
11	*Enicurus leschenaultia*	Muscicapidae	V	V
12	*Gallus varius*	Phasianidae	V	V
13	*Halcyon cyanoventris*	Alcedinidae	V	V
14	*Malacocincla sepiaria*	Pellorneidae	V	V
15	*Mixornis flavicollis*	Timaliidae	V	V
16	*Orthotomus sutorius*	Cisticolidae	V	V
17	*Pachycephala cinerea*	Pachycephalidae	V	V
18	*Pellorneum capistratum*	Pellorneidae	V	V
19	*Pericrocotus cinnamomeus*	Campephagidae	V	V
20	*Pernis ptilorhynchus*	Accipitridae	V	V
21	*Psilopogon javensis*	Megalaimidae	V	V
22	*Rubigula dispar*	Pycnonotidae	V	V
23	*Spilornis cheela*	Accipitridae	V	V
24	*Surniculus lugubris*	Cuculidae	V	V
25	*Cacomantis variolosus*	Cuculidae		V
26	*Cyanoderma melanothorax*	Timaliidae		V
27	*Cyornis banyumas*	Muscicapidae		V
28	*Enicurus velatus*	Muscicapidae		V
29	*Orthotomus sepium*	Cisticolidae		V
30	*Todiramphus chloris*	Alcedinidae		V
31	*Accipiter trivirgatus*	Accipitridae	V	
32	*Apus nipalensis*	Apodidae	V	
33	*Apus pacificus*	Apodidae	V	
34	*Chalcophaps indica*	Columbidae	V	
35	*Collocalia linchi*	Apodidae	V	
36	*Dicaeum minullum*	Dicaedae	V	
37	*Hemiprocne longipennis*	Hemiprocnidae	V	
38	*Lonchura leucogastroides*	Estrildidae	V	
39	*Macropygia Emiliana*	Columbidae	V	
40	*Phaenicophaeus curvirostris*	Cuculidae	V	
41	*Phylloscopus borealis*	Phylloscopidae	V	
42	*Yungipicus moluccensis*	Picidae	V	
	Total		36	30
	Total types of both methods		42	

number of species identified, or not identified (Leach et al. 2016).

These distinct sensory approaches naturally lead to variations in species identification between the two methods. Passive Acoustic Monitoring observes on auditory, making it more effective for capturing and vocalising bird species, while the Visual Encounter Survey depends on visual observation, allowing for the detection of silent or visually conspicuous birds. The variables we measured had varying effects on them to different extents. The detection probability varied relatively little among human observers, with minor

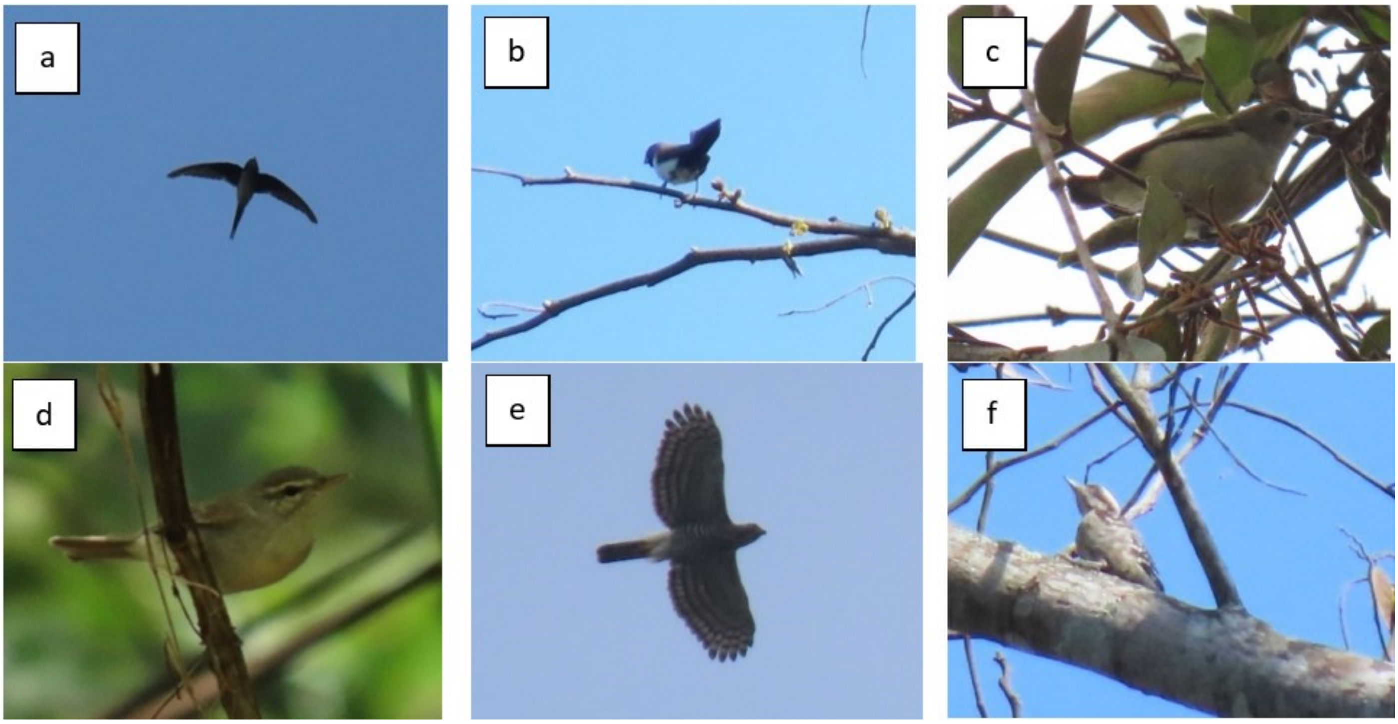

Figure 2. Bird species that were not detected in the PAM method. (a) *Apus pacificus*, (b) *Lonchura leucogastroides*, (c) *Dicaeum minullum*, (d) *Phylloscopus borealis*, (e) *Accipiter trivirgatus*, (f) *Yungipicus moluccensis*.

individual differences. In contrast, Passive Acoustic Monitoring showed greater variations in detection probability. The variability of the ARUs may be due to their susceptibility to surrounding objects, such as varying forest densities and obstacles in the environment. The ARUs' variability may be caused by their susceptibility to nearby objects, including differing forest densities and environmental obstacles. ARUs have been found to have a smaller hearing radius than humans do (Yip et al. 2017),

From the data above, it can be seen that there are three categories of birds, namely found in both methods as many as 24 species, only found in VES as many as 12 species, and only found in PAM as many as 6 species. These three categories of birds have their own background reasons for their presence in a method. First, we discuss the birds present in both methods.

1. Birds present in both methods

The first characteristic is birds that have a higher abundance in the research location (Nggirgadung slope, Purwosari village). Higher abundance refers to the large number of individuals of a species found at the study site. In general, species with higher abundance are more commonly encountered in the field and are easier to detect during observations (Brown 1984). This type of bird is the easiest to find. This type of bird is not too disturbed by the presence of humans (MacKinnon 2010). Some birds of this type are *Dicaeum trigonostigma*, *Anthreptes malacensis*, and *Orthotomus sutorius*.

The second characteristic is the bird with a loud voice. This type of bird is easier to find than the silent birds. Voice greatly influences sightings in both VES and PAM methods. The PAM method focuses on recording and analyzing bird vocalisation as primary data, while the VES method primarily relies on visual sightings of birds, although vocalising birds are not directly recorded, their sounds can guide researchers and facilitate locating birds in the field. This type of bird includes the *Spilornis cheela*. The slow movement of the *Spilornis cheela* and its ability to soar in the open sky make it easy to detect in the VES method (Akbar et al. 2020). The third characteristic is that birds with habitat preferences are relevant to the sampling points. The birds with habitat preferences are easily recorded in acoustic and visual observations.

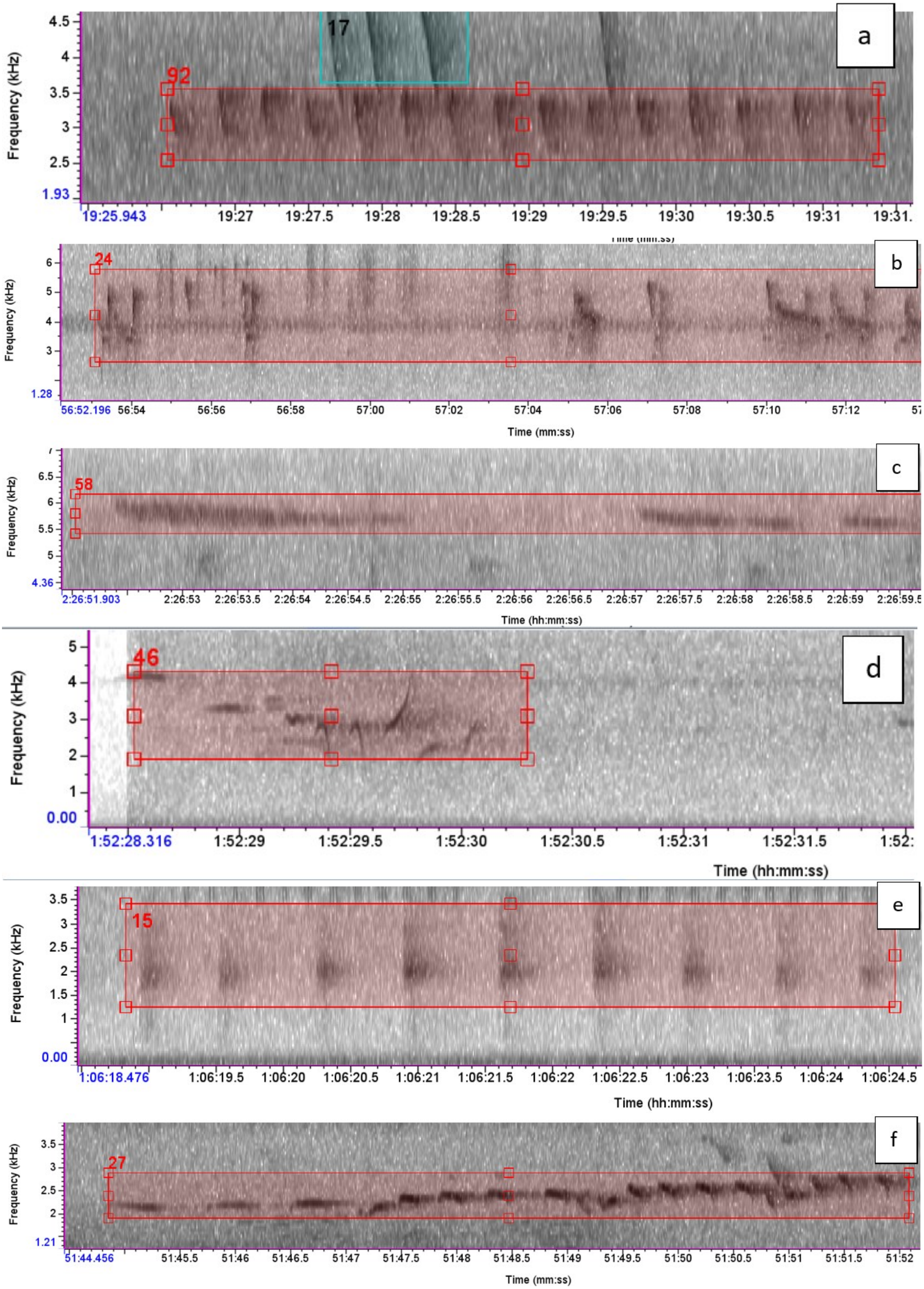

Figure 3. Detected and unseen bird sound types in the VES method. *(a) Todiramphus chloris, (b) Orthotomus sepium, (c) Enicurus velatus, (d) Cyornis banyumas, (e) Cyanoderma melanothorax, (f) Cacomantis variolosus.*

Bird habitats provide a variety of bird needs such as food, homes, and water sources. Some sampling points were found to be in good habitat. Some birds that are often recorded in specific locations are *Psilopogon javensis*, often observed at point 5, because it is a clove plantation that provides a favourable habitat with dense vegetation and abundant food sources, including insects and fruit-bearing trees that complement the bird's frugivorous diet (Taufiqurrahman et al. 2022), *Enicurus leschenaulti*, often recorded at point 4, which is a small stream where the bird is looking for food. *Malacocincla sepiaria* and *Pellorneum capistratum* are often recorded at points 4 and 5 because there are many spice plants that are favored by both species (MacKinnon 2010).

The fourth factor is that some birds have characteristics that make them easier to observe. This can be divided into two aspects: morphological and behavioral. Morphologically, birds were large in size and have contrasts colour with their habitat are generally easier to spot. Behaviourally, birds that are less sensitive to human presence, those that often move in flocks, and species that tend to perch in open areas are also more easily observed. The last factor is bonus bird occurrence. In this study, 'bonus' birds are usually hard to find in both methods, but unexpectedly showed up in both during the data collection. This factor sometimes happens in observation. Some examples of such birds are the *Cacomantis sonneratii*, *Surniculus lugubris*, and *Gallus varius*. These birds have loud voices and can always be heard during observation; they have their own difficulties to be observed visually (Taufiqurrahman et al. 2022). In this research, these bird only detected once in Visual Encounter Surveys. To increase chances, researchers use strategies like listening for calls, wearing camouflage, moving quietly, and understanding bird habitats. Adding the optimal number of observers also increases the chances of finding birds.

2. Birds present in the VES method.

Our next discussion is on the factors that cause the presence of birds that are only found in the VES method. The lack of these birds in Passive Acoustic Monitoring could be due to certain behavioral factors, including flying at high elevations, which is beyond the range of the recording equipment. In addition to altitude, the birds' flying speed is significant. Bird species exhibiting these traits include *Apus pacificus*, *Accipiter trivirgatus*, *Apus nipalensis*, *Hemiprocne longipennis*, and *Collocalia linchi* (Taufiqurrahman et al. 2022).

The second reason is the mismatch of the bird habitat with the observation location. Birds that have unsuitable habitats tend to spend less time at the observation site. During observation, these birds were only observed flying through the researcher and not making any sound at all. Some birds were also observed at the top of trees far from the observation location, so that they could not be recorded by the acoustic recorder. Birds with this trait include *Lonchura leucogastroides*, *Dicaeum minullum*, *Yungipicus moluccensis, and Chalcophaps indica* (Taufiqurrahman et al. 2022).

The third reason is the silent bird characteristic. Bird with this characteristic is quite easy to find during VES observations, but has no records during acoustic observations. Some of these birds include *Phylloscopus borealis and Phaenicophaeus curvirostris* (MacKinnon 2010).

3. The last one is the weaknesses of the methodology, *Macropygia emiliana.*

This bird has a habitat that matches the Nggirgadung slopes and has a loud voice (Mackinnon et al. 2010). This bird was only seen once in the VES method and was not seen in the acoustic recording. There is little information regarding the breeding season of this bird, but according to GBIF. In a normal situation, *Macropygia emiliana* is easy to find if the habitats are matched.

Macropygia emiliana is normally sighted from June to November, with peak sightings in August, according to Taufiqurrahman et al. (2022). The peak of the breeding season of this bird is in April-May and August-November. The reason why this bird was very rarely seen on the Nggirgadung slopes because the number of individuals in its population was unknown. The encounter with the Uncal buau only occurred once, on November 15, 2023. Birds present in the PAM method.

The last Discussion is the factors that cause the presence of birds that are only found in the PAM method. These birds have the following characteristics. The first is a bird with a loud voice without presence. This bird has a loud voice so that even from a considerable distance it can still be heard. Unlike the *Spilornis cheela*, this bird is not equipped with behaviors that make it easy to detect some species are *Todiramphus chloris* and *Cacomantis variolosus*.

The second characteristic is that the bird is very sensitive to human presence, so it tends not to appear in front of researchers due to its high threat sensitivity. This bird is also not abundant on the slopes of Nggirgadung, adding to the difficulty of observation, as it was only observed 1-2 times in the entire data collection. Some examples of these birds are *Enicurus velatus, Cyornis banyumas, and Cyanoderma melanothorax.*

There is also *Orthotomus sepium*, a bird for unknown reasons. In various literature, this bird has a habitat that matches the data collection location. This bird is also easy to see and has a distinctive voice. However, during the observation, this bird was only recorded once and was not observed visually at all. Based on the various discussions above, the Visual Encounter Survey has advantages in the number of species encountered. If we examine the overall data, there are interesting things when viewed from the total number of species obtained; both VES and PAM have special species that are only obtained in their methods. An interesting conclusion can be drawn from the above cases. In this case, PAM is not considered inferior to VES but complementary to VES. Better data will be obtained if the two methods are carried out side by side (complementary). It is hoped that in the future, this PAM method research will continue to be developed, and the bird sound database will be completed to facilitate data collection for further bird research.

Several weaknesses in the study are also worth discussing. There is a temporal mismatch in this research because, in PAM, data collection starts from 05:00 to 17:00 with a 9-minute interval, while in VES, it is conducted between 06:00-10:00 and 13:00-17:00 without any intervals. This difference in data collection timing may affect the results obtained.

The second weakness is that the data recorded only includes birds detected visually and acoustically, without considering birds that were only heard but not seen. Such data could be included in a third category. The data obtained from this study is also qualitative. The addition of quantitative data can be included as a suggestion for future research. Recording the number of individuals became an issue in the PAM method of this study due to the lack of literature on population counting using the PAM method.

CONCLUSIONS

The Visual Encounter Survey can detect more species on the slopes of Nggirgadung. VES captured 36 species, while PAM captured 30 identified species. However, the total number of species obtained was 42 bird species. Of these, both VES and PAM had specific species that were only obtained in their methods. Birds detected only in the VES method are characterised by high-flying behaviour without making loud sounds, a mismatch of bird habitat with the observation site, and rare vocalisations. Birds detected only in the PAM method are characterised by loud vocalisations without human presence and are very sensitive to human presence. However, we did have an anomaly of *Orthotomus sepium*, a bird of unknown cause. This bird should have been found, but was not during field observations.

PAM is complementary to VES. Better data will be obtained if both methods are conducted side by side (complementary). It is hoped that in the future, research on the PAM method will continue to be developed, and the bird sound database will be more complete so as to facilitate data collection for further bird research.

AUTHOR CONTRIBUTION

A.S.F. designed the study and supervised all the processes. A.S.F. also conducted the analysis and wrote the paper with assistance from all authors. S., T.H., and A.A.P. assisted in methodology expertise and data analysis. M.I.A assisted in writing the paper and translation. S. was also a co-author of this manuscript

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CONFLICT OF INTEREST

We certify that there is no conflict of interest in the research or funding of this manuscript.

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