UNIVERSITI PUTRA MALAYSIA

COMPARISON OF POINT COUNT AND ACOUSTIC SURVEYS OF BIRDS IN AYER HITAM FOREST RESERVE, SELANGOR

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By

MOHD SHAFIQ BIN HASSAN

**A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Forestry Science with Honours in the Faculty of Forestry and Environment
Universiti Putra Malaysia**

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DEDICATION

I dedicate this final year project to myself for not giving up and being able to finish the whole process.

I also dedicate this final year project to everyone who has played a big or small role in its completion, with sincere appreciation and a heart full of thanks.

May Allah return your kindness with blessings, peace, success, good health and happiness in life.

ABSTRACT

Monitoring assemblages of animals requires effective survey methods for detecting and recording the presence and distributions of species within target areas in restricted periods of time. This study compared the effectiveness of the traditional point count method and survey using automated acoustic recordings Hutan Simpan Ayer Hitam, Puchong, Selangor. On average, acoustic recordings detected more species than point counts of equivalent sampling periods, (P = <0.001). We suggest these results are driven by the visual detection of additional species during point counts. There was significant overlap in the species detected using both methods. The Kruskal-Wallis test have been done to determine the minimum required time and the result showing the minimum recording time for a point is 150 Minutes. Consequently, we recommend the use of both techniques in tandem for future biodiversity assessments, as their respective strengths and weaknesses are complementary.

ABSTRAK

Untuk memantau spesies dan taburan hidupan liar, ahli ekologi memerlukan kaedah yang berkesan untuk mengesan dan merekod taburan spesies dalam sesebuah kawasan sasaran dalam tempoh masa yang terhad. Dalam kajian ini, kami membandingkan keberkesanan kaedah tradisional (point count) dengan kaedah yang baru (perakaman suara automatik) di Hutan Simpan Ayer Hitam, Puchong, Selangor. Secara puratanya, rakaman suara mendapati lebih banyak spesies berbanding point count, (P = <0.001). Kami mengesyorkan bahawa hasil ini dipengaruhi oleh pengesanan visual spesies tambahan semasa pengiraan titik. Terdapat pertindihan yang signifikan dalam spesies yang dikesan menggunakan kedua-dua kaedah, tetapi setiap kaedah mendapati beberapa spesies yang unik. Ujian Kruskal-Wallis telah dilakukan untuk menentukan masa minimum yang diperlukan dan keputusan yang menunjukkan masa rakaman minimum untuk satu titik ialah 150 Minit. Oleh itu, kami mencadangkan penggunaan kedua-dua kaedah secara serentak untuk penilaian kepelbagaian masa depan, kerana kelebihan dan kelemahan masing-masing bersifat saling melengkapi.

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APPROVAL SHEET

I certify that this research project report entitled "Comparison of Point Count and Acoustic Surveys of Birds in Ayer Hitam Forest Reserve, Selangor" by Mohd Shafiq bin Hassan has been examined and approved as a partial fulfilment of the requirement for for the degree of Bachelor of Forestry Science and environment the Faculty of Forestry and Environment, Universiti Putra Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Birds serve as valuable indicators for assessing the ecosystem health such as the conditions and development of early-seral forest communities. These communities represent the initial stage of regeneration following disturbances like wildfires or timber harvesting before coniferous trees dominate the landscape. Early seral forests exhibit a rich variety of plant species, particularly broadleaf shrubs, which support a diverse array of insects and wildlife. Bird surveys serves numerous purposes, and there exists a vast and extensive body of literature on the subject. Although birds are well-studied components of Earth's biodiversity, comprehensive and quantifiable knowledge about most tropical species and regions remains incomplete (Bibby et al, 2000).

This knowledge gap poses a challenge to bird conservation efforts, which can be addressed by the involvement of ornithologists. Compared to other wildlife, birds are easier to count, and ornithologists can play a pivotal role in advancing our understanding of the Earth, the distribution of biodiversity, and the potential threats it encounters due to unsustainable practices. Bird surveys also play a crucial role in ecological research and conservation efforts, providing valuable insights into bird populations, biodiversity, and habitat quality. Various methods are employed to assess bird species presence, abundance, and distributions. Two commonly used methods are acoustic recording and point sampling.

Acoustic recording involves capturing and analysing bird vocalizations, while point sampling involves stationary observations of birds at predetermined locations. Both methods offer distinct advantages and limitations, raising the need for a comprehensive comparison to determine their effectiveness and suitability in different contexts.

Automated acoustic recording devices are increasingly recognized as a valuable tool for studying bird and anuran populations across broad landscapes. (Sidie-Slettedahl et al., 2015). These devices have the capacity to collect substantial amounts of vocalization data, making them highly advantageous in ecological research (Sidie-Slettedahl et al., 2015). Moreover, studies have demonstrated that acoustic recorders can effectively detect aural signals from birds during point counts, with field observers detecting up to 94% of recorded bird species (Simons et al., 2007). This finding highlights the practicality of acoustic recorders in ornithological research and monitoring efforts (Simons et al., 2007). Overall, the utilization of automated acoustic recording devices offers significant advantages in collecting extensive vocalization data for studying bird and anuran populations, thereby enhancing our understanding of these species across diverse landscapes. (Hutto and Stutzman, 2009)

The method of point counts has been extensively employed to estimate bird richness, as well as the relative abundance and density of species (Bibby et al., 2000). This approach involves selecting a specific location and documenting all visually and/or acoustically detectable and identifiable bird species within a designated sampling time, which typically ranges from 3 to 20 minutes. In the application of this survey technique, a significant portion of bird records is obtained through acoustic detections.

Previous research has shown that acoustic recorders often perform well or better than, field observers at measuring species diversity (Haislmaier and Quinn 2000, Acevedo, and Villanueva-Rivera 2006). The former often have greater detection rates than human observers when various species are vocalizing simultaneously (Celis-Murillo et al. 2009). Previous comparisons between acoustic recordings and traditional techniques have mostly found no significant difference between survey methods with regards to the number of species or individuals detected.

However, most of these studies were conducted in temperate regions. Given the challenges associated with detecting birds in rainforests (Anderson 2011), and the lack of previous studies, this study aimed to determine whether acoustic recorders deployed could be used to generate a dataset comparable to one generated using point counts.

By conducting a comparison of acoustic recording and point sampling methods in bird surveys within forested areas, this study aimed to shed light on the most effective and reliable approach for capturing bird data. The knowledge gained from this research will contribute to the advancement of bird survey methodologies and support evidence-based decision-making for the conservation and management of avian populations in diverse ecosystems as a whole.

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1.2 Problem Statement

Point counts are one of the widely used methods for assessing bird abundance. Autonomous recording units (ARUs) are increasingly being used as a replacement for point counts. Consequently, there are several problems that arise where the ecologist needs to choose the most effective method between point count and acoustic recording. However, there is a lack of consensus in the literature on which method is more effective and accurate for assessing bird populations. Thus, there is a need as to which method is most appropriate or appropriate to use and what factors should be considered when choosing between the two methods. Such comparison between acoustic recording and point sampling in bird surveys is a prominent issue to address in the tropics, as both methods have different advantages and limitations.

1.3 Objectives

The objective of this study was to investigate and compare different methods of bird sampling, namely point count and acoustic recording. The specific objectives are as follows:

1) To compare bird species richness obtained by point count and acoustic recorder.

2) To determine the number of bird species recorded according to different recording time.

3) To determine the minimum recording time required in bird bioacoustics survey.

1.4 Significance of study

This study was conducted to determine which survey method is effective in collecting bird survey data in forested areas. The comparison between acoustic recording and point sampling methods is significant for improving bird survey in forested areas and determining existing species distribution. By evaluating the effectiveness of these methods, this research helps ecologists ensure that the data collected in their research is valid and represents the actual species richness without causing bias due to sampling method. This study aimed to fill the gap in knowledge with respect to acoustic recording within tropical lowland forest areas. By assessing the significance between these methods and evaluating the species recorded using each technique, this research seeked to provide a clearer understanding of their relative merits and limitations. Such insights will be invaluable for researchers, ecologists, and conservation practitioners in making informed decisions about the most appropriate method for capturing bird data in forested habitats.

CHAPTER 2

LITERATURE REVIEW

2.1 Acoustic Recordings

One of the most well-known tools nowadays for ecologist in assessing the biodiversity of wildlife is by using the automatic sound recording tools (Shonfield & Bayne, 2017). Automatic sound recording tools are currently the most popular devices used to detect birds (Sousa-lima, nourish, Oswald & Fernandes, 2013). Traditionally, birds are observed by using the point-count technique but nowadays automatic sound recording tools are used as supplemental approach alternatives solution to the traditional technique (Ralph, Sauer & Droege, 1998). The data obtained from acoustic recording may be influenced by numerous factors such as the structure of the habitat, temperature, ambient sound levels, sound levels originating from the source, height, and directionality of vocalization (Darras et al., 2016; Padgham, 2004)

Tropical forests with high species richness have always made researchers difficult to conduct species survey for instance, estimating species richness and its density accurately has been a problem as it requires high familiarity of species including rare one (Haselmayer & Quinn, 2000). Hence, this acoustic monitoring method has the advantage as it includes an automated recorder which can work for maximum sample collection with no observer in the field (Vold et al, 2017).

2.1.1 Advantages of Acoustic Recording

Acoustic recordings are commonly used in wildlife sampling due to their cost effectiveness and efficient data storage, which provides many opportunities for data collection by ecologists, as demonstrated in marine ecology (Dugan et al., 2018). The acoustic recording tools can operate automatically to collect big amount of sample collection without any human interference needed in the field and can also reduce the human disturbance due to the presence of surveyors to the surrounding habitat (Acevedo and Villanueva-Rivera, 2006).

2.1.2 Limitations of Sound Recordings.

Acoustic recorders are subject to species-specific detectability biases, as they cannot detect nonvocalizing birds. With the absence of triangulation or visual observation, it can be challenging to quantify the number of individuals of a species vocalizing in the survey area, and thus, species occurrence is often recorded as presence-absence instead of abundance. Detection bias may vary with survey and habitat conditions, impacting the effective sampling distance of aurally detected birds. (Furnas & Callas, 2014; McNew & Handel, 2015).

In addition, the increasing use of digital recording systems has raised a possible issue regarding differences in system performance that may introduce bias in results. Factors that vary among recording systems include sensitivity to sound, signal to noise ratio (SNR), quality and design of digital recording electronics, microphone design, configuration and directionality, physical durability, frequency sensitivity and filters, programmable noise reduction filters and recording schedule programmability. These factors have the potential to affect monitoring programmes by altering the likelihood of detecting and identifying a bird's call or song on a recording when the bird is nearby (Rempel, 2013).'

2.1.3 Factors Affecting Sound Recorder Data.

The sampling area is determined by the sound detection space, which, in turn, is determined by habitat structure, temperature, ambient sound level, sound level at source, height and vocalization directionality among others (Darras et al., 2016; Padgham, 2004). These parameters are mostly determined by the organisms and the sampling site of interest. In contrast, ecologists can maintain some control of the technical specification of their recording system, which will influence species detectability, such as microphone sound quality. "Noisy" microphones will add to the ambient sound level, so that quality of microphones is usually measured by their signal to noise ratio, which is paramount in acoustics and has long been acknowledged when automatic sound event detection methods are used (Trowitsch et al., 2017).

Additionally, the recording quality of a microphone can also be affected by its height. This is because sound is reflected off the ground, and a microphone that is placed on the ground will record less sound from distant, especially low sources (Pridmore-brown & Ingard, 1955).

2.2 Point Count Method of Wildlife Sampling

Traditionally, point counts have been the most widely method to rapidly assess the avian biodiversity of an area (Celis Murillo et al. 2009; Venier et al. 2012). There are, though, several problems with point counts: in areas with high species richness, observers may be 'swamped' and fail to record some species (Haselmayer and Quinn 2000); differences in skill between observers may manifest as interobserver effects (Hobson et al. 2002; Celis-Murillo et al. 2009); there may be a lack of trained personnel to conduct surveys (Holmes et al. 2014); birds may respond to the observers presence (Digby et al. 2013); and the cost of extended fieldwork necessary to build long-term datasets is often prohibitive (Thomas and Marques 2012). In recent years, technological advances have led to the development of automated acoustic recorders that may prove an effective, low-cost way of monitoring biodiversity over large spatial and temporal scales (Thomas and Marques 2012; Wimmer et al. 2013).

2.2.1 Limitation of Point Count Method

There is no perfect sampling method. The different approaches available have pros and cons and only provide a partial view of the actual bird diversity. While point count is the most common and widely used approach for assessing bird diversity because of their reliable results (Bibby et al., 2000), using this approach requires a certain level of expertise of the observer. It may be influenced by habitat complexity, bird conspicuousness, and foraging strata (Hutto et al., 1986, Raplh et al., 1995).

Point counts are limited by the workforce required. Implementing point counts in the field is demanding and requires a certain training level to obtain reliable results. Furthermore, point counts are dependent on weather conditions and usually are conducted at specific times of the day (usually early in the morning).

For that reason, it is common to complement point counts with other methods that provide complementary results (Blake and Loiselle, 1991, Barlow et al., 2007). Mist-nets are commonly used to complement point counts, but this approach is also highly laborious and requires trained field personnel also invasive method of approach. Recently, the use of sound recordings is becoming popular, which is less demanding in the field but requires sound databases and trained personnel for data processing (Kułaga and Budka, 2019).

2.2.2 Effect of Observer in Bird Call

Campbell and Francis (2012) found no difference in the positions of old-field birds when an observer was either present or absent, and no difference in the number of individuals or species detected or in the onset of singing. Thus, the results of studies to date suggest that the presence of observers has no significant effect on either the occurrence or singing rates of birds detected during point counts.

2.2.3 Effective Time for Point Count

Researchers typically opt for counting durations of 5, 10, or 15 minutes in both tropical and temperate habitats. This choice is influenced by considerations such as the comparability of morning sampling hours and the potential for statistical dependence in longer count durations. For instance, shorter durations like 3 minutes may offer fewer comparable hours, while longer counts, such as 20 minutes, could be inefficient or lead to statistical dependence between successive counts.

According to Esquivel.et.al (2008), even with 20-minute counts, the different daily periods surveyed did not resulting an equal number of species and individuals. This outcome indicates that increasing count durations does not mitigate hourly variations in this forest, contrasting with findings in temperate habitats. Notably, the results from the research demonstrated that after 10 minutes of counting, the number of individuals observed decreased significantly. Moreover, the count of species declined notably after 15 minutes of observation. This suggests that 10-minute counts are sufficient and more efficient and potentially yield a greater number of samples and total species occurrences during morning periods.

2.3 Forest Density and Structures Affecting Bird Species

Logically, Bird communities' size is different in different habitat structure. Bird community similarity exhibited a positive correlation with the similarity in habitat structure, indicating a preference of certain bird species for specific habitat characteristics (Darius and Roberto, 2001). Also, Darius and Roberto (2001) found that there is notable correlation between changes in bird communities and variations in vegetation structure across the gradient of non-wetland open habitats. Specifically, most bird species showed greater occupancy probability in sites inserted in more forested landscapes, while some species presented higher occurrence in patches surrounded by low-quality matrices. Conversely, only three species showed greater occupancy in landscapes with higher number of patches and dominated by forest edges (Morante et. al. 2021).

2.4 Birds in Ayer Hitam Forest Reserve

According to the study of edge-interior gradient effects on the understory bird community in the AHFR by Moradi et al. (2009), the presence of some species such as the Yellow vented Bulbul, Cream-vented Bulbul, and Plaintive Cuckoo was associated with high light intensity and shrub cover, which implied that these species were the best indicators of the edge. On the other hand, the presence of Short-tailed Babbler, Moustached Babbler, and Black-caped Babbler was associated with high relative humidity and leaf litter cover and this implied that they were the best indicators of forest interior The Short-tailed Babbler from the Timalidae family was the most abundant species in Compartment 14 with 35 encounters while in Compartment 15 Yellow-vented Bulbul from Pycnonotidse family was the most abundant species with 31 encounters. In Compatient 14. Timaliidae represented the largest number of species captured, whis Compartiment 15 there were four families equally recorded the largesi number of species namely Pycnonotidae. Timaliidae Picidae and Muscicapidae (Hossein et al, 2008) As edge specialists can be widely found in the forest edge which have high adaptability to survive thus, they require less conservation against being declined or endangered. They can be well managed in the matrix surrounding the forest patches Interior-specialists, on the other hand especially terrestrial insectivores, should be given the most attention with respect to conservation of forest areas.

CHAPTER 3

METHODOLOGY

3.1 Study Area

The study area was carried out in Ayer Hitam Forest Reserve (AHFR), Puchong, Selangor. The research took place within the Ayer Hitam Forest, located in Puchong, Selangor, spanning an area of 1248 hectares. The forest is situated approximately 20 kilometres southwest of Kuala Lumpur, ranging from 3°00.00'N to 3°02.20'N latitude and 101°37.90'E to 101°40.00'E longitude. It is an isolated lowland dipterocarp forest that has undergone selective logging. The forest is divided into six compartments (Compartments 1, 2, 12, 13, 14, and 15), each subjected to logging activities in different years. The earliest logging occurred in 1936, while the most recent took place in 1954 (Zakaria& Rahim, 1999). The Ayer Hitam Forest Reserve (AHFR) is encompassed by several surrounding developments. To the north, the forest is bordered by the Kinrara township. On the western side, there is Puchong, which comprises housing and township developments. The southern boundary of the forest faces Putra Java, the new government administrative center. On the eastern side of AHFR, there are recently established townships, including Espinra Kinrara, Columbia Asia Puchong Lotus mall Puchong.

Figure 1: Ayer hitam forest reserve aerial Map

Exact point of the recorder location

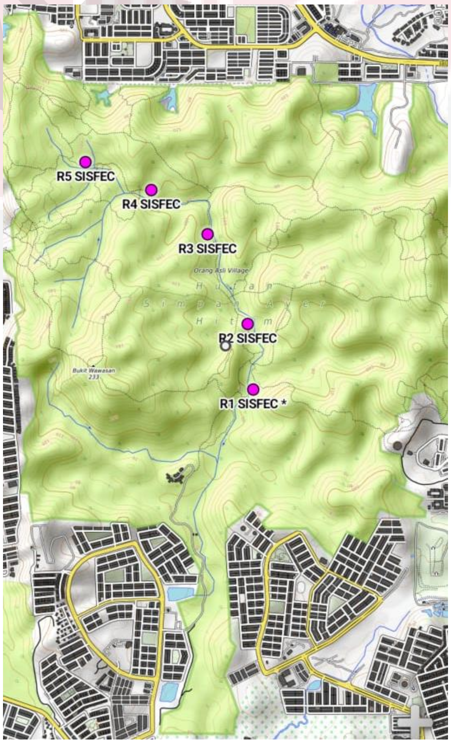

Figure 2: Point Location for recorders installation

The Ayer Hitam Forest Reserve (AHFR) has been leased to the Universiti Putra Malaysia (UPM) for a duration of 88 years, primarily designated as a research and educational forest. Harvesting activities are strictly prohibited within this forest. The Faculty of Forestry and Environment students utilize AHFR as an outdoor laboratory, conducting various research activities alongside UPM and other organizations like the Forest Research Institute of Malaysia (FRIM). Additionally, the residents of surrounding townships previously engaged in recreational and physical activities such as jogging within AHFR. However, these activities have been halted due to the implementation of fencing along the perimeter of AHFR, aiming to prevent encroachment. Consequently, this measure has led to discontent among the residents (Ahmad Ainuddin, 2007).

3.2 Study Design

Two survey methods were implemented in this study and the sampling was conducted for a total of four days from May to June 2023 started from 14 May until 10 June. To record the vocalization of the Avian species the recorders were used. Recorders were set up to record vocalization of birds at five points which were 500 m minimum apart from each other. The recordings were then analysed and used to identify the avian species collected. The second method used were point count sampling. The point count for ten minutes was conducted simultaneously within the area of recorder settled. The geographic positioning systems used to record the coordinates of the recorder locations.

3.2.1 Acoustic Recordings

The audio recorder used was Frontier Labs BAR-LT Bioacoustics Recorder. The recorder visited weekly over four weeks. The purpose was to replace the battery with the fully charged and to collect the data from the SD card. The data collected simultaneously with the point count time for the first ten minutes when the recorder started to operate. This enabled the data to be compared with the point count data in real time. The recorder was installed where the tree is not vulnerable to the people who used the nearby trails. Drying agent was put inside the recorder and the cellophanes tape were used to prevent water from entering the recorder.

Figure 3: Frontier Labs BAR-LT Bioacoustics Recorder

3.2.2 Point Count

The sampling was conducted for 10 minutes point count for each point early in the morning where the birds were at its peak to do the call. The occurrence of all bird species seen or heard at the site during the count period was recorded but counts of individual birds were not made. The distance for point sampling was within around five meters from recorder.

3.3 Data analysis

Recorded calls were assessed to identify bird species. Bird identification website used Xeno-canto (https://xeno-canto.org), Merlin (https://birdsoftheworld.org/) and Bird-net (https://birdnet.cornell.edu) to identify the bird species from the recordings. Before the data process, the recoding was sorted based on recording date (14 may,24 may, 2 June and 10 June).

After the identification was done, the data was sorted again to retrieve the recording from 7.00 until 10.00 am in the morning (Bird morning peak hour) and the bird species. Recorded in peak hour time was sorted in 10- and 30-minutes interval. The interval was following: 10 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes, 150 minutes, and 180 minutes.

SPSS (IBM) was used to perform statistical tests. To test the data normality. Normality descriptive test was conducted. Since the data collected is nonparametric, Mann-Whittney test was carried out to test the difference in bird species recorded in point count and recording in 10 minutes. Kruskal-Wallis test was performed to assess the difference in the bird species recorded in 10- and 30-minutes interval.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overall bird species by point count

In this study there were 36 unique species recorded for both in point count and acoustic recordings. A total of 36 species were detected in our study: 22 species by point counts and 32 by recordings. Of these, 17 species were detected by both methods (Sørensen's similarity index value of 0.630). On average, acoustic recordings detected a greater number of the total species present at a site than point counts across all sites.

Table 1: The list of overall bird species collected by point count in each point

Bird Species	Acoustic Recording	Point Count
Ashy Tailorbird	Present	Absent
Asian Fairy Bluebird	Present	Absent
Asian-brown Canary-Flycatcher	Present	Absent
Banded Broadbill	Present	Present
Banded Woodpecker	Present	Present
Black and Yellow Broadbill	Present	present
Blue-Eared Barbet	Present	Present
Brown Throated Sunbird	Present	Absent
Chestnut-Winged Babbler	Present	Present
Common Iora	Absent	Present
Common Tailorbird	Present	Present
Coppersmith barbet	Absent	Present
Crested Serpent Eagle	Present	Present
Crimson-Winged Woodpecker	Present	Absent

Dark-Necked Tailorbird	Present	Present
Emerald Dove	Present	Present
Fluffy-Backed Tit-Babbler	Present	Absent
Gold Whiskered Barbet	Present	Absent
Greater Racket-Tailed Drongo	Present	Present
Grey-Breasted Spiderhunter	Present	Absent
Hill Myna	Present	Absent
Little Spiderhunter	Present	Absent
Malayan Black Magpie	Present	Absent
Olive-Backed Sunbird	Present	Present
Olive-Winged Bulbul	Absent	Present
Pin-Striped Tit-Babbler	Present	Present
Plaintive Cuckoo	Present	Present
Purple-Naped Spiderhunter	Present	Absent
Red-Eyed Bulbul	Absent	Present
Rufous Woodpecker	Present	Absent
Scaly-Crowned Babbler	Present	Present
Scarlet-Backed Flowerpecker	Absent	Present
Short-Tailed Babbler	Present	Present
Spectacled Bulbul	Present	Absent
Square-Tailed Drongo Cuckoo	Present	Present
Yellow-Vented Bulbul	Present	Present

4.1.1 Bird species by point count.

In this study, originally, they were five recorders installed but one recorder was found to be not functional after one week. In general, there were 21 unique species recorded by using point count method. the data showed that the number of bird species recorded was different for each sampling point due to its distance with other points so there is difference in the resources at the surrounding. Point 2 had the most species recorded, with 11 different species listed. Second, point 3 with 9 species recorded. Third, point 4 with 7 species recorded and least point 1 with 6 species recorded.

Table 2: The list of overall bird species collected by point count in each point

Point 1	Point 2	Point 3	Point 4
Crested Serpent Eagle	Plaintive Cuckoo	Common Tailorbird	Square-Tailed Drongo Cuckoo
Common Tailorbird	Pin-Striped Tit-Babbler	Square-Tailed Drongo Cuckoo	Greater Racket-Tailed Drongo
Plaintive Cuckoo	Emerald Dove	Banded Broadbill	Black & Yellow Broadbill
Banded Woodpecker	Red-Eyed Bulbul	Greater Racket-Tailed Drongo	Blue-Eared Barbet
Pin-Striped Tit-Babbler	Scarlet-Backed Flowerpecker	Olive-Backed Sunbird	Chestnut-Winged Babbler
Greater Racket-Tailed Drongo	Square-Tailed Drongo Cuckoo	Dark-Necked Tailorbird	
	Banded Broadbill		
	Pin-Striped Tit-Babbler		

	Greater Racket-Tailed Drongo	Crested Serpent Eagle	Common Tailorbird
	Coppersmith Barbet	Scarlet-Backed Flowerpecker	Pin-Striped Tit-Babbler
	Yellow-Vented Bulbul	Scaly-Crowned Babbler	

4.1.2 Bird species by Acoustic Recorder.

Point 3 contained the highest number of species among the listed points, with a total of 26 different bird species. Following that, point 1 and Point 2 have 25 and 21 species, respectively. Point 4 had the fewest species, comprising 19 different bird species. This indicates that Point 3 has the most diverse range of species among the four points listed.

Table 3: The list of overall bird species collected by acoustic recorders in each point

Point 1	Point 2	Point 3	Point 4
Black and Yellow Broadbill	Black and Yellow Broadbill	Crested Serpent Eagle	Greater Racket-Tailed Drongo
Pin-Striped Tit-Babbler	Pin-Striped Tit-Babbler	Common Tailorbird	Pin-Striped Tit Babbler
Black-Throated Babbler	Olive-Winged Bulbul	Plaintive Cuckoo	Banded Woodpecker
Olive-Winged Bulbul	Chestnut-Winged Babbler	Banded Woodpecker	Banded Broadbill

Chestnut-Winged Babbler	Square-Tailed Drongo Cuckoo	Pin-Striped Tit-Babbler Greater Racket -Tailed Drongo	Crimson-Winged Woodpecker
Asian Fairy Bluebird	Brown Throated Sunbird	Emerald Dove	Grey-Breasted Spiderhunter
Emerald Dove	Crested Serpent-Eagle	Red-Eyed Bulbul	Malayan Black Magpie
Crimson-Winged Woodpecker	Purple-Naped Spiderhunter	Square-Tailed Drongo Cuckoo	Chestnut-Winged Babbler
Fluffy Backed Tit Babbler	Gold Whiskered Barbet	Banded Broadbill	Fluffy-Backed Tit Babbler
Dark Neck Tailorbird	Greater Racket-Tailed Drongo	Pin-Striped Tit-Babbler	Asian-Brown Canary-Flycatcher
Short-Tailed Babbler	Asian-Brown Canary-Flycatcher	Olive-Backed Sunbird	Little Spiderhunter
Asian-brown Canary-Flycatcher	Little Spiderhunter	Dark-Necked Tailorbird	Purple Naped Spiderhunter
Spectacled Bulbul	Malayan Black Magpie	Scaly-Crowned Babbler	Short-Tailed Babbler
Square-Tailed Drongo Cuckoo	Short-Tailed Babbler	Blue-Eared Barbet	Spectacled Bulbul
Ashy Tailorbird	Crimson-Winged Woodpecker	Asian-Brown Canary-Flycatcher	Crested Serpent-Eagle
Brown Throated Sunbird	Grey-Breasted Spiderhunter	Little Spiderhunter	Dark Neck Tailorbird
Greater Racket-Tailed Drongo		Malayan Black Magpie	Hill Myna
Square-Tailed Drongo Cuckoo		Gold Whiskered Barbet	

Scaly-Crowned Babbler	Spectacled Bulbul	Gold Whiskered Barbet
Purple-Naped Spiderhunter	Purple-Naped Spiderhunter	
Gold Whiskered Barbet	Short-Tailed Babbler	
Malayan Black Magpie	Brown-Throated Sunbird	
Banded Woodpecker	Square-Tailed Drongo Cuckoo	
Hill Myna	Ashy Tailorbird	
Rufous Woodpecker	Square-Tailed Drongo Cuckoo	

4.2 Comparison of bird species recorded by method.

The Mann-Whitney U test was used to compare the species richness recorded by point counts (N1 = 15) and acoustic recorders (N2 = 17) at Ayer Hitam Forest Reserve. The test was appropriate due to the non-normal distribution of the species count data. The U value was 72.500, with a corresponding Wilcoxon W value of 208.500 and a standard error of 25.600. The standardized test statistic (Z) was -2.168, indicating the observed difference in the number of species detected by each method was approximately 2.168 standard deviations below the expected mean difference under the null hypothesis. The p-value was 0.030, indicating a statistically significant difference between the two methods in terms of the number of species detected. A box plot (Figure 1) visually demonstrates the median and interquartile range of species counts for each method, suggesting that point counts may detect a higher median number of species compared to acoustic recorders. These results suggest that point counts and acoustic recorders may vary in their effectiveness for sampling species richness in this specific ecological context.

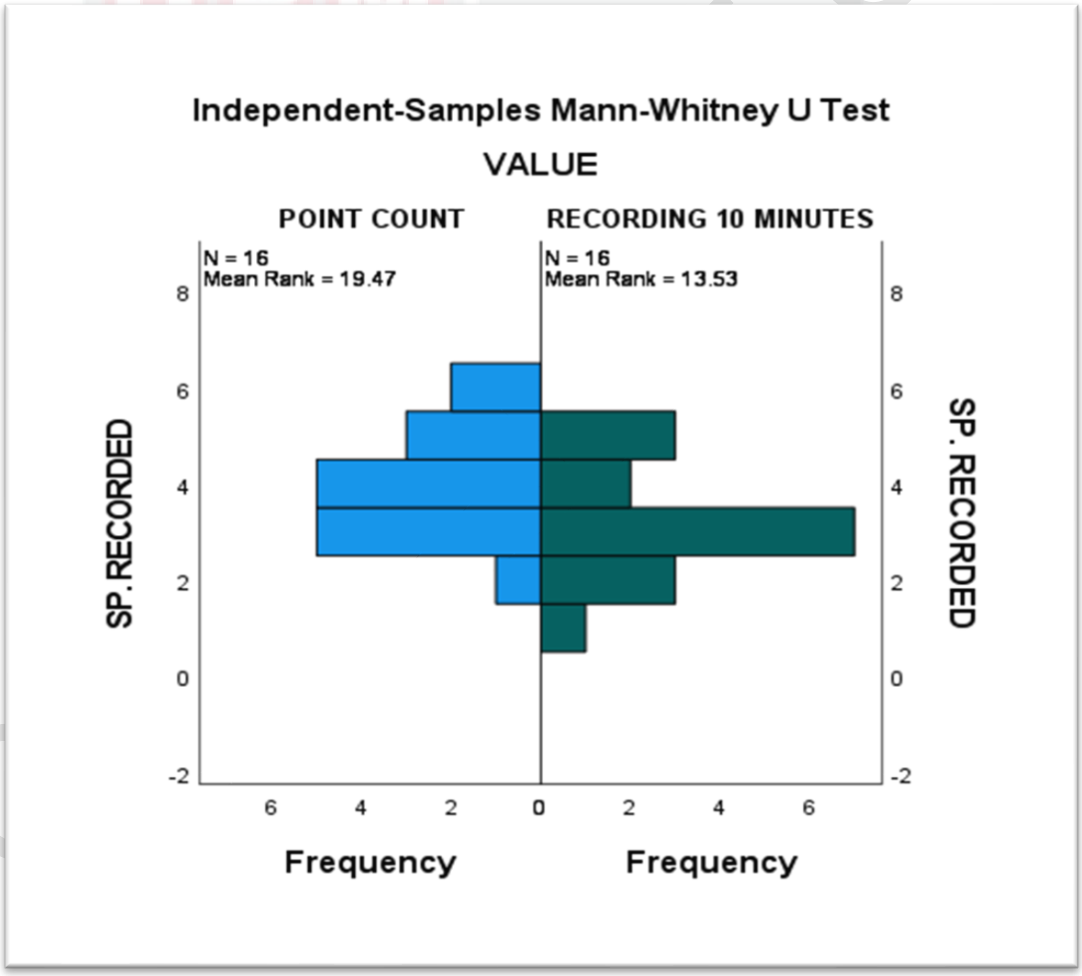

Figure 4: Comparison of number of species in box plot

The box plot above (Figure 3) suggests that the point count method may record a higher number of bird species on average compared to the 10 minutes recording method, and this difference was statistically significant based on p-value provided.

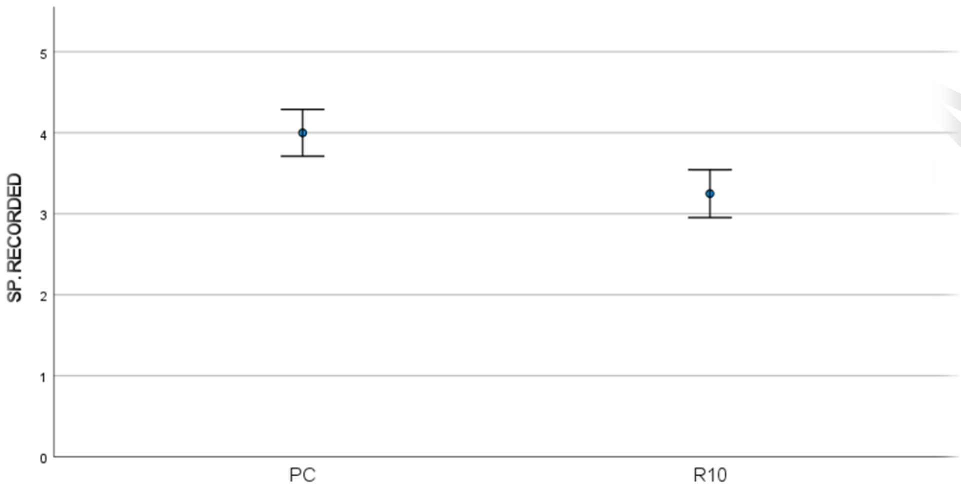

Figure 5: Comparison of number of species in error bars

As suggested by the error bars (Figure 4) which emphasising the overlap of the error bars, indicating that there was slight significant difference in the mean number of species recorded by each method.

4.3 Comparison of bird species counted by recording time

The Kruskal-Wallis test revealed a statistically significant difference in the number of species recorded across the different recording times. With a p-value of less than .001. This means that at least one of the recording times led to a different number of species being recorded when compared to the others.

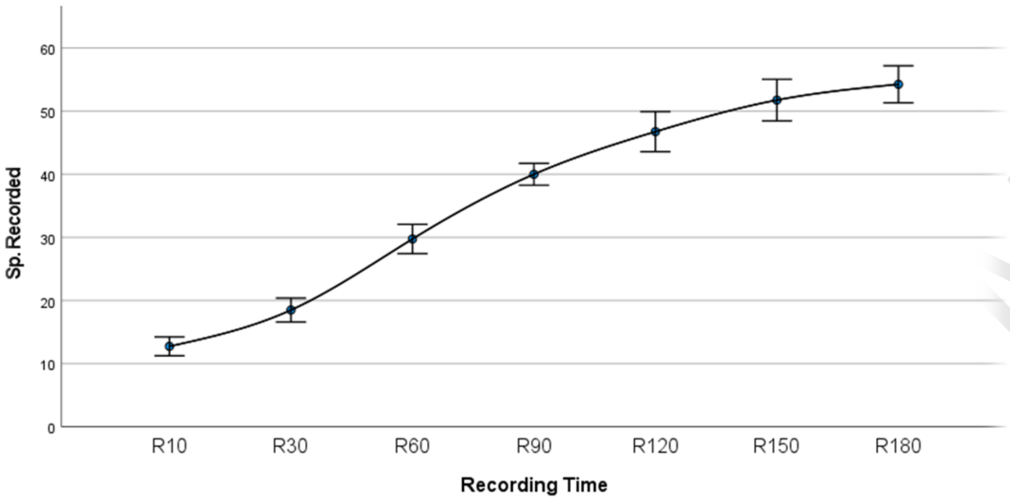

Figure 6: Comparison of number of species by acoustic recorders in error bars

Figure 5 showed a positive correlation between recording time and the number of species recorded — as the recording time gets longer, more species were detected. This suggests that longer recording sessions may be more effective for detecting a greater number of species.

However, the error bars seem to increase in size as recording time increases, which suggests greater variability in the number of species recorded at longer times.

For the comparisons made between recording time R10-R150 and R10-R180. Both comparisons had P-value values of less than 0.001, which are well below the 0.05 threshold, indicating that there were statistically significant differences between the species recorded at R10 compared to R150 and R180, respectively.

Table 4: Post Hoc result for recording in different time

Sample 1	Sample 2	Test Statistic	P - Value
R10	R30	-3.000	1.000
R10	R60	-7.500	1.000
R10	R90	-12.500	.660
R10	R120	-16.625	.089
R10	R150	-19.500	.017
R10	R180	-21.375	.005
R30	R60	-4.500	1.000
R30	R90	-9.500	1.000
R30	R120	13.625	.400
R30	R150	16.500	.095
R30	R180	18.375	.033
R60	R90	-5.000	1.000
R60	R120	9.125	1.000
R60	R150	12.000	.817
R60	R180	13.875	.356
R90	R120	4.125	1.000
R90	R150	7.000	1.000
R90	R180	8.875	1.000
R120	R150	-2.875	1.000
R120	R180	-4.750	1.000
R150	R180	-1.875	1.000

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study demonstrated that acoustic recording, if properly implemented, may yield more reliable bird sampling data. The Mann-Whitney U test results showed a statistically significant difference in the number of bird species recorded between the point count method and the 10-minute acoustic recording method. With p-values from both the asymptotic significance and exact significance tests falling below the 0.05 threshold, it can conclude that the two methods do not perform equally when it comes to detecting the number of bird species.

The Kruskal-Wallis test indicated a significant difference in the number of species recorded across different recording times, with a p-value less than .001. This suggests that the length of recording time influences the number of species detected. The trend observed in the data supports the notion that longer recording sessions may lead to the identification of a greater number of species.

Additionally, the post hoc pairwise comparisons find statistically significant differences between individual recording times, in tandem with the overall trend indicating an increase in species recorded as time extends. This could suggest that there is a clear point proving that the increasing recording time contributes to detecting more species. Ideally, the recording time of at least 120 minutes will be recommended at a sampling point to capture all species present.

5.2 Limitations

The study might be limited by the duration of acoustic recordings and the frequency of point counts. The short survey may not capture the full variability of bird vocalizations, which can fluctuate due to seasonal changes, breeding cycles, and weather conditions.

Second, each method of recording species richness either through point counts or acoustic recorders has inherent biases. For instance, point counts may miss cryptic or less vocal species, while acoustic recorders might not distinguish well between overlapping calls or accurately identify species with similar vocalizations.

This study might have been conducted during specific times of the day, potentially overlooking nocturnal or crepuscular bird species. The diurnal focus may limit the understanding of the overall acoustic landscape and niche partitioning. So, the data provided is not enough to look for overall species community interactions.

In addition, the quality of the recordings can be influenced by equipment sensitivity, the positioning of recorders, and environmental noise, which can affect the ability to detect and accurately identify species. The presence of other sounds such as wind, rain, or human activity can interfere with bird call recordings, potentially leading to underrepresentation of some species.

Lastly, the study is limited to one site, i.e. the Ayer Hitam Forest Reserve, and the findings may not be generalizable to other regions or habitats with different acoustic environments or bird communities.

5.3 Recommendations

There are several recommendations that can be considered when pursuing other research that have link with wildlife sampling in general specifically point count or acoustic recorders. First thing is to consider or apply the methodological Integration approach. Given the significant differences in species richness recorded by point counts and acoustic recorders, it is recommended to use a combined approach in future studies to take into account on the strengths of both methods. Integrating visual surveys with acoustic monitoring could provide a more comprehensive picture of avian biodiversity.

Second consideration is to extended monitoring period range. To address the objective of testing the consistency of species recorded by acoustic recorders, extending monitoring over various seasons and times of the day is recommended. This could help account for variations due to behavioural changes in birds across seasons and daily cycles.

Third consideration is that the study proposes the use of more sophisticated acoustic recording technology that can filter out background noise and distinguish overlapping calls more effectively, improving the quality and reliability of the data.

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