Use of Field Recorded Sounds in the Assessment of Forest Birds in Palawan, Philippines

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Abstract -*The uses of bioacoustics in biological applications are getting popular in research communities. Among such application is the use of sound recordings in avifaunal researches. This research explored the possibility of using the sound recording in the assessment of forest birds in Palawan by comparing it in widely used Point Count Method (PCM). To compare the two methods, a simultaneous point count and sound recording surveys from February to November 2017 in the forested slopes of Victoria-Anipahan Mountain in Aborlan, Palawan were conducted. The Sound Recording Method (SRM) listed slightly lower species richness than the PCM, but the difference in the mean number of species was not significant ($F1,49=1.05$, $p > 0.05$). The SRM was found to be biased towards noisy and loud calling bird species but it failed to detect the silent and rarely calling species. SRM was also equally sensitive as compared to PCM in detecting endemic and high conservation priority species. Because of these, it was recognized that SRM could be used as one of the alternative methods in forest bird assessment particularly if the concern is avifaunal species richness. Its potential application in monitoring specific groups such as endemic, high conservation priority and indicator species was also realized.*

Keywords -*bioacoustics, avifaunal assessment, bird calls and songs*

INTRODUCTION

Animals produce sounds for various purposes such as attraction of mate [1]-[3], warning signals [4]-[6], defense of territories [7], attracting prey [8], and orientation [9], [10]. Most of the sound produced by animals are species specific, highly distinct and can be heard at long distances in highly obstructed habitats. Because of these, sound emissions of animals are commonly used in many biodiversity assessment and monitoring studies.

Birds are one of the animals that have rich collection of sounds used for communication. In most cases, birds are easily heard than seen particularly in highly obstructed habitats such as forest and tall grasslands. For this reason, most of the common bird survey methods use the combination of visual and auditory cues in detecting and identifying the bird species in the field [11]. However, using sound in avifaunal study must be used with caution and careful attention; because bird sounds vary from species to species and often a single species can produce variety of calls and songs. Furthermore, there are some species that mimics the calls and song of other species [12]. These make avifaunal studies using bioacoustics difficult and complicated.

The usual avifaunal assessment methods such as fixed listing, timed species count, point count and transect walk require trained experts and experienced birdwatchers to accurately identify the birds in the field. However, when experts are not available, the SRM may be used as an alternative [13], [14]. This method is a game changer because without sending an expert in the field, the collection of data is carried out by ordinary workers using a standardized protocol. The identification and classification of birds which are based on permanent field recordings are usually done later in the laboratory or remotely by experts using sound processing computer software. Moreover, applying modern technology even allowed automatic field recording using automated systems [13],[15] ,[16]. This method involves installation of Automatic Recording Units (ARU) which record ambient sound at pre-set time intervals [15]-[18].

The use of field recordings to supplement the data taken from actual ocular field surveys is gaining popularity because it is less expensive as experts are not required in the field [19]. In addition to it, automatic sound recording units may be deployed in risky and difficult to access areas [15]. However, like the other methods of avifaunal survey this method has its own set of limitations. As it is purely based on recorded sounds, it fails to detect the silent species and it may overlook the rarely calling species [20]. Moreover, it also fails to quantify the number of individuals that are present at a given time in the area.

Despite the weaknesses of this method, its potential is realized in places where vast tracts of protected areas are present while the availability of experts and funding for research and monitoring are limited. Furthermore, the increasing rate at which these areas are degraded due to anthropogenic activities greatly emphasizes the usefulness of this method particularly as a supplemental method during long monitoring period. To come up with reliable results, it is recommended that the method be refined and standardized [20]. They further asserted that if properly done this method of avifaunal survey is effective and time efficient.

The use of field recording method in Palawan's forest ecosystem could be a potential supplement to augment the limitation of the scarcity of experts and funding. The need for avifaunal assessment and monitoring among its protected areas are seriously needed as human related disturbances intensify. However, the recording of bird sound for avifaunal assessment purposes was not yet tested in Palawan's forest ecosystem. Hence, the study was realized.

The findings of this study could provide useful information in the field of avian bioacoustics particularly the effectiveness of using sound recordings in the assessment of bird diversity in Palawan setting. The recorded bird sounds and the corresponding spectrograms will also be part of the archive which will be of significant use to ornithologists interested in doing avian studies in Palawan.

OBJECTIVES OF THE STUDY

The objective of this study is to investigate if Sound Recording Method (SRM) can be used as an alternative or a supplementary method for the assessment of birds in Palawan's forest ecosystem. For the purpose of understanding the effectiveness of this method, this study compared it with the Point Count Method (PCM) which is considered as one of the most commonly used avifaunal assessment methods. Specifically, the study compared the avifaunal assessment methods in terms of species richness.

METHODS

Materials Used in the Study

The study used a Sony CSM-CS3 microphone to capture the ambient sound in the forest and converts it into electrical signal which is then feed into a sound recorder. This electret condenser microphone is sensitive enough to detect the bird sounds within the frequency range of 15-15000 Hertz and is also capable of detecting sounds coming from all directions. The omnidirectional (non-directional) microphone was preferred in this study to have a 360^{O} detection capability which is needed to avoid the bias in comparing the SRM with PCM which also used a 360^{O} observation field in every point count station.

The microphone is connected to a 3.5-millimeter microphone jack of the Sony ICD-UX543F portable sound recorder which functions as the input port of electrical signals coming from the microphone and an output port of "plug in power" (PiP) needed by the electret condenser microphone which according to specification of the recorder has a minimum level of 1 millivolt.

The microphone and recorder were both mounted in a tripod to avoid the noise resulting from the movement of the person operating the recorder. Furthermore, the head unit of the microphone is covered with windshield foam to reduce the wind noise.

All the bird sounds detected while listening to ambient sound recordings were analyzed using the Audacity version 2.1 software installed in a laptop computer.

Time and Place of the Study

The study was conducted in the forested slopes of the Victoria-Anipahan mountain range in Aborlan, Palawan from February to November 2017. The chosen study site was a relatively intact primary forest with large trees and dense understory vegetation. Sightings of diverse wildlife species which are sensitive to anthropogenic disturbances such as Palawan Bearcat (*Arctictis binturong* Raffles), Palawan Peacock-Pheasant (*Polyplectron napoleonis* Lesson, R.), Palawan Hornbill (*Anthracoceros marchei* Oustalet), Bearded Pig (*Sus barbatus ahoenobarbus* Huet) and Common Hill Myna (*Gracula religiosa palawanensis* Sharpe) during the site selection visits indicate that the anthropogenic disturbance in the area is relatively low despite evidences of small scale extraction of non-timber forest products.

Data Collection

The study used five-point count stations that were evenly distributed at 200 meters interval in a transect line laid at the center of the chosen study plot [11]. To avoid the biases due to spatial distribution of birds, all the point count stations were also used as the recording stations. Moreover, to avoid the differences due to temporal distribution of birds, the counting and recording were done at the same time in every station.

All observations were made between 6:00 to 10:00 in the morning as birds were most active during this time of the day [21]. The counting of birds and recording of sound were done simultaneously within the 20-minute period allotted for each station. The data collection in all stations was repeated monthly for 10 months to give enough allowance to the result of the species discovery curve. The standard protocol for PCM such as settling time, avoiding double counting of the same individual, use of auditory and visual cues and re-scheduling of data collection in times of unfavorable weather events were strictly followed.

A Sony portable digital recording device mounted with non-directional condenser microphone was used in this study. The head unit of the microphone is covered with windshield foam to reduce the wind noise. Both the microphone and the recording device were attached to a tripod at approximately the same level with the head of the observer doing the point count. All sound recording files were saved in Motion Picture Experts Group Audio Layer 3 (MP3) format and the corresponding waveforms and spectrograms were analyzed using Audacity Version 2.1 software.

The sound files recorded from the point count stations were saved in a laptop computer with corresponding file names that matches the codes in PCM data. By listening to the playback of ambient sounds in Audacity software, the researcher carefully identified all the bird species using vocalization patterns such as pitch, tone, rhythm, length, repetitions and spacing.

Even though the bird calls and songs are unmistakable or distinct in most species, some birds like drongos, shama and myna have unusual capabilities of mimicking the sound of other birds. In these cases, spectrogram analysis becomes important. To ensure the correctness of the bird identification, all bird sound spectrograms including the peculiar ones were verified. Confirmation of the detected bird species was done by comparing the spectrogram patterns with the bird sound database previously prepared by the researcher using the Audacity software. Since the verification of bird species using spectrogram is done manually, the process used simple criteria instead of a complicated algorithm. The sound analysis includes comparing the waveform features such as frequency, amplitude and peak patterns.

Data Analysis

The data obtained using the PCM and SRM were compared using species richness. The total number of species of birds detected using visual and auditory cues during the point count observations and the total number of birds heard in the recordings were reported as species richness. A test of variance between species richness obtained using the PCM and SRM was also made using F Ratio test at 95% level of significance.

RESULTS AND DISCUSSION

Table 1. shows a total of 61 species of birds belonging to 30 families were detected using the two avifaunal survey methods. All the 61 species of birds recorded in the study area were detected by the PCM while only 55 species of the 28 families were detected by SRM.

The PCM detected more species of birds (61) than the SRM (55). This could be attributed to the advantage of the PCM over the SRM in detecting birds because it uses both visual and auditory cues. This way, the PCM was able to detect the bird species that are silent or those that produce very faint sounds which are undetected by the SRM. In addition to it, the ambient noise produced by the wind and other animals in the forest also interfere in the sound analysis and might reduce the effectiveness of the SRM. However, despite these limitations, the SRM performed well in detecting bird species in the forest. The result of the 50 simultaneous point count and sound recording samples revealed that the mean number of species detected using the PCM (9.92) was slightly higher than the mean number of species detected using the SRM (9.40) but the difference was not significant ($F_{1,49}=1.05$, $p > 0.05$).

Table 1. Species, conservation status and endemism of birds detected using Point Count Method and Sound Recording Method.

	Common Name	Scientific Name	Conservation Status (IUCN)	Level of Endemism	Detected in PCM	Detected in SRM
Dicaeidae	Palawan Flowerpecker	*Prionochilus plateni plateni* Blasius, W, 1888	LC	PES	+	+
Dicaeidae	Pygmy Flowerpecker	*Dicaeum pygmaeum palawanorum* Hachisuka, 1926	LC	RPER	+	+
Nectariniidae	Pale Spiderhunter	*Arachnothera dilutior* Sharpe, 1876	LC	PES	+	+
Nectariniidae	Olive-Backed Sunbird	*Cinnyris jugularis aurora* Tweeddale,1878	LC	RPER	+	+
Nectariniidae	Brown-Throated Sunbird	*Anthreptes malacensis paraguae* Riley, 1920	LC	RPER	+	+
Nectariniidae	Lovely Sunbird	*Aethopyga shelleyi* Sharpe, 1876	LC	PHES	+	+
Sturnidae	Common Hill Myna	*Gracula religiosa palawanensis* Sharpe, 1890	LC	RPER	+	+
Monarchidae	Blue Paradise Flycatcher	*Terpsiphone cyanescens* Sharpe, 1877	NT	PES	+	+
Monarchidae	Black-Naped Monarch	*Hypothymis azurea azurea* Boddaert, 1783	LC	R	+	+
Rhipiduridae	Philippine Pied Fantail	*Rhipidura nigritorquis* Vigors, 1831	LC	PHES	+	+
Muscicapidae	Palawan Flycatcher	*Ficedula platenae* Blasius, W, 1888	NT	PES	+	+
Muscicapidae	Palawan Blue Flycatcher	*Cyornis lemprieri* Sharpe, 1884	NT	PES	+	+
Muscicapidae	White-Vented Shama	*Copsychus niger* Sharpe, 1877	LC	PES	+	+
Cisticolidae	Rufous-Tailed Tailorbird	*Orthotomus sericeus sericeus* Temminck,1836	LC	R	+	+
Phasianidae	Red Junglefowl	*Gallus gallus* Linnaeus, 1758	LC	R	+	+
Phasianidae	Palawan Peacock-Pheasant	*Polyplectron napoleonis* Lesson, R, 1831	V	PES	+	+
Columbidae	Thick-Billed Green-Pigeon	*Treron curvirostra erimacrus* Oberholser, 1924	LC	R	+	+
Columbidae	Pink-Necked Green-Pigeon	*Treron vernans* Linnaeus, 1771	LC	R	+	+
Columbidae	Black-Chinned Fruit Dove	*Ptilinopus leclancheri* GironieriVerreaux, J & Des Murs, 1862	LC	RPER	+	+

Table 1 Continuation						
Columbidae	Green Imperial Pigeon	*Ducula aenea palawanensis* Blasius, W, 1888	LC	R	+	+
Columbidae	Philippine Cuckoo-Dove	*Macropygia tenuirostris* Bonaparte, 1854	LC	R	+	+
Columbidae	Common Emerald Dove	*Chalcophaps indica indica* Linnaeus, 1758	LC	R	+	+
Psittaculidae	Blue-Naped Parrot	*Tanygnathus lucionensis salvadorii* Ogilvie-Grant, 1896	NT	R	+	+
Psittaculidae	Blue-Headed Racket-Tail	*Prioniturus platenae* Blasius, W,1888	V	PES	+	+
Cuculidae	Asian Koel	*Eudynamys scolopaceus mindanensis* Linnaeus, 1766	LC	R	+	+
Cuculidae	Chestnut-Breasted Malkoha	*Phaenicophaeus curvirostris harringtoni* Sharpe, 1877	LC	RPER	+	
Cuculidae	Chestnut - Winged Cuckoo	*Clamator coromandus* Linnaeus, 1766	LC	M	+	
Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus merulinus* Scopoli, 1786	LC	R	+	+
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis orientalis* Linnaeus,1766	LC	R	+	+
Alcidinidae	Blue-Eared Kingfisher	*Alcedo meninting meninting* Horsfield, 1821	LC	R	+	+
Alcidinidae	Oriental Dwarf Kingfisher	*Ceryx erithaca motleyi* Chasen& Kloss, 1929	LC	R	+	+
Bucerotidae	Palawan Hornbill	*Anthracoceros marchei* Oustalet, 1885	V	PES	+	+
Picidae	Great Slaty Woodpecker	*Mullerripicus pulverulentus pulverulentus* Temminck, 1826	V	R	+	+
Picidae	Red-Headed Flameback	*Chrysocolaptes erythrocephalus* Sharpe, 1877	E	PES	+	+
Picidae	Spot-Throated Flameback	*Dinopium everetti* Tweeddale,1878	NT	PES	+	+
Pittidae	Philippine Pitta	*Erythropitta erythrogaster propinqua* Sharpe, 1877	LC	PHES	+	+
Pittidae	Hooded Pitta	*Pitta sordida palawanensis* Parkes, 1960	LC	RPER	+	+
Campephagidae	Bar-Bellied Cuckooshrike	*Coracina striata difficilis* Hartert, 1895	LC	RPER	+	+
Campephagidae	Pied Triller	*Lalage nigra nigra* Forster, JR,1781	LC	R	+	+
Campephagidae	Fiery Minivet	*Pericrocotus igneus igneus* Blyth, 1846	NT	R	+	
Chloropseidae	Yellow-Throated Leafbird	*Chloropsis palawanensis* Sharpe, 1876	LC	PES	+	+
Aegithinidae	Common Iora	*Aegithina tiphia aequanimis* Bangs, 1922	LC	R	+	+
Pycnonotidae	Black-Headed Bulbul	*Pycnonotus atriceps atriceps* Temminck,1822	LC	R	+	+

Table 1
Continuation

Pycnonotidae	Ashy-Fronted Bulbul	*Pycnonotus cinereifrons* Tweeddale, 1878	LC	PES	+	+
Pycnonotidae	Sulphur-Bellied Bulbul	*Hypsipetes palawanensis* Tweeddale, 1878	LC	PES	+	+
Pycnonotidae	Palawan Bulbul	*Alophoixus frater* Sharpe, 1877	LC	PES	+	+
Dicaeidae	Ashy Drongo	*Dicrurus leucophaeus leucophaeus* Vieillot, 1817	LC	R	+	+
Dicaeidae	Hair-Crested Drongo	*Dicrurus hottentottus palawanensis* Tweeddale,1878	LC	RPER	+	+
Laniidae	Brown Shrike	*Lanius cristatus lucionensis* Linnaeus, 1766	LC	M	+	+
Oriolidae	Dark-Throated Oriole	*Oriolus xanthonotus persuasus* Bangs, 1922	NT	RPER	+	+
Oriolidae	Black-Naped Oriole	*Oriolus chinensis chinensis* Linnaeus, 1766	LC	R	+	+
Irenidae	Asian Fairy-Bluebird	*Irena puella tweeddalii* Sharpe, 1877	LC	RPER	+	+
Corvidae	Slender-Billed Crow	*Corvus enca pusillus* Tweeddale, 1878	LC	R	+	+
Paridae	Palawan Tit	*Pardaliparus amabilis* Sharpe, 1877	NT	PES	+	+
Sittidae	Velvet-Fronted Nuthatch	*Sitta frontalis palawana* Hartert, 1905	LC	RPER	+	
Pellorneidae	Ashy-Headed Babbler	*Malacocincla cinereiceps* Tweeddale,1878	LC	PES	+	+
Timaliidae	Pin-Striped Tit-Babbler	*Macronous gularis woodi* Sharpe, 1877	LC	RPER	+	+
Timaliidae	Falcated Wren-Babbler	*Ptilocichla falcata* Sharpe, 1877	LC	PES	+	+
Accipitridae	Crested Goshawk	*Accipiter trivirgatus palawanus* Mayr, 1949	LC	RPER	+	
Accipitridae	Changeable Hawk-Eagle	*Nisaetus cirrhatus limnaeetus* Horsfield, 1821	LC	R	+	
Accipitridae	Crested Serpent Eagle	*Spilornis cheela palawanensis* Sclater, WL, 1919	LC	RPER	+	+

Legend: LC – Least concern
NT – Near-threatened
V – Vulnerable
E – Endangered
RPER - Resident with Palawan endemic race
R - Resident
M - Migrant
PHES - Philippine endemic species
PES - Palawan endemic species

The results show in Table 2. indicate that despite the slight difference in the mean number of species detected by the two methods, the F Ratio statistically proved that SRM performed similarly with PCM. It is then possible to use the SRM in rapid survey and monitoring of birds with some degree of confidence. However, it will be effective only if the objective of bird assessment is determining the species richness of the area. Haselmayer and Quin [20] declared that PCM is still necessary because SRM will not detect silent and rarely calling species.

The SRM is not capable of detecting the number of individual birds present in a particular area. But, using in depth analysis of the data, this method can provide an index of abundance using the frequency of appearance of each bird species in the samples.

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Table 2. Result of F-Test for variance of mean number of bird species detected by PCM and SRM

	PCM	SRM
Mean	9.92	9.4
Variance	5.462857143	5.183673469
Observations	50	50
df	49	49
F	1.053858268	
P(F<=f) one-tail	0.427533114	
F Critical one-tail	1.607289464	

Not significant at 0.05 level

The SRM also appears to be biased towards noisy and loud calling birds. The 14 species of birds with higher detection rate in this method were all noisy and loud calling birds. On the other hand, it failed to detect six species of birds that were silent and/or rarely producing sound (Table 1).

The top five species of birds detected by the two methods were the same except that the frequencies of occurrence in sound recordings were relatively higher than in point counts. Palawan Flowerpecker (*Prionochilus plateni plateni* Blasius, W.), a frugivore Palawan endemic species had the highest detection frequency in both methods. It was followed by the Pygmy Flowerpecker (*Dicaeum pygmaeum palawanorum* Hachisuka), Pin-Striped Tit-Babbler (*Macronous gularis woodi* Sharpe), Rufous-Tailed Tailorbird (*Orthotomus sericeus sericeus* Temminck) and Common Iora (*Aegithina tiphia aequanimis* Bangs).

The SRM also detected seven out of the eight Near-threatened species, and all the Vulnerable and Endangered species (IUCN) recorded by the PCM. Likewise, it also detected all the 18 Palawan endemic species and three Philippine endemic species detected by the PCM. Moreover, it also detected 12 out of 15 resident species with Palawan endemic races detected by PCM. These findings implied that SRM was also equally sensitive in detecting endemic and high conservation priority species as compared to PCM.

CONCLUSION

The result of the study revealed that the SRM was effective in determining the avian species richness in forest habitat and the result was comparable to the commonly used PCM. The findings proved the worth of SRM as a supplementary method in surveying and monitoring bird species richness in forest protected areas particularly if periodic point count survey is not possible. However, the result must be reported with caution since the method might fail to detect the silent and rarely calling species.

The SRM was also comparably effective as PCM in detecting endemic and high conservation priority bird species in Palawan forest setting. Monitoring of specific target groups of birds such as rare, endemic, endangered and keystone species could be considered as potential future application of this method particularly in places like Palawan where availability of experts is a common problem.

RECOMMENDATION

It is recommended that SRM be used in rapid assessments and long-term monitoring of bird species richness in protected forest areas in Palawan as it provides comparable results to the commonly used PCM. In addition, the SRM is also time efficient, cost effective and provides a record of data that can be archived and verified by experts in the future if needed.

Additional researches must also be conducted particularly in fine tuning the method such as finding an indicator species, determining the optimum recording time and development of autonomous recording set-up.

One of the limitations of this study is that the assessment was made only in one particular forest habitat and was never tested in other places. Thus, it is recommended that the SRM must be tested in other forest habitats in Palawan to verify the effectiveness of this method in determining the species richness of birds. Extensive testing of SRM in various habitat types like grasslands, agro-ecosystem, riparian vegetation, fragmented landscape and urban habitats is also recommended.

Another limitation of this study is the poor quality of the recorded soundscape from the sampling stations. The noise produced by wind and other ambient sound interferes with the spectrogram analysis. Testing the SRM using appropriate noise reducing methods such as better wind screen and microphone set-up is recommended.

Finally, the omnidirectional microphone used in the study is less sensitive to soft and faint sound of birds. Studies using sound focusing and amplifying devices like parabolic dish and high sensitive condenser microphone must be conducted to improve the detection capabilities of SRM.

REFERENCES

[1] Lundberg, K. and Gerell, R. (1986). Territorial advertisement and mate attraction in the bat Pipistrelluspipistrellus. Ethology, 71, 115–124.

[2] Harrison, S.J., Thomson, I.R., Grant, C.M., Bertram, S.M. (2013). Calling, courtship, and condition in the Fall Field Cricket, Grylluspennsylvanicus. PLoS ONE, 8(3), e60356. https://doi.org/10.1371/journal.pone.0060356. Accessed on 8 February 2018.

[3] Shonfield, J., and Bayne, E.M. (2017). The effect of industrial noise on owl occupancy in the boreal forest at multiple spatial scales. Avian Conservation and Ecology, 12(2), 13.

[4] Macedonia, J.M. and Evans, C.S. (1993). Variation among mammalian alarm call systems and the problem of meaning in animal signals. Ethology, 93, 177-197.

[5] MacKay, B.K. (2001). Birds. How and Why Birds Sing, Call, Chatter and Screech. Stackpole Books. Mechanicsburg, Pennsylvania, USA. 151p.

[6] Cäsar, C., Byrne, R.W., Hoppit, W., Young, R.J. and Zuberbühler, K. (2012). Evidence for semantic communication in Titi Monkey alarm calls. Animal Behaviour, 84(2), 405-411.

[7] Amorim, M.C.P. and Neves, A.S.M. (2008). Male painted gobies (Pomatoschistuspictus) vocalise to defend territories. Behaviour, 145(8). 1065-1083.

[8] Calleia, F.O., Rohe, F. and Gordo, M. (2009). Hunting strategy of the Margay (Leoparduswiedii) to attract the Wild Pied Tamarin (Saguinus bicolor). Neotropical Primates, 16(1), 32-34.

[9] Jeffs, A., Tolimieri, N.T. and Montgomery, J.C. (2003). Crabs on cue for the coast: the use of underwater sound for orientation by pelagic crab stages. Marine and Freshwater Research, 54(7), 841-845.

[10] Montgomery, J.C., Jeffs, A., Simpson, S.D., Meekans, M. and Tindle, C. (2006). Sound as orientation cue for pelagic larvae of reef fishes and decapods crustaceans. Advances in Marine Biology, 51, 143-196.

[11] Gibbons, D.W. and Gregory, R.D. (2006). Birds. In: Sutherland, W. (ed). Ecological Census Techniques: A Handbook. 2nd edition. Cambridge University Press, United Kingdom. P308-344.

[12] Goodale, E. and Kotagama, S.W. (2006). Vocal mimicry by a passerine bird attracts other species involved in mixed-species flocks. Animal Behaviour, 72(2), 471-477.

[13] Brandes, S.T. (2008). Automated sound recording and analysis techniques for bird surveys and conservation. Bird Conservation International, 18, 163-173.

[14] Celis-Murillo, A., Deppe, J.L. and Allen, M.F. (2009). Using soundscape recordings to estimate bird species abundance, richness, and composition. Journal of Field Ornithology, 80(1), 64-78

[15] Hutto, R.L. and Stutzman, R.J. (2009). Humans versus autonomous recording units: a comparison of point-count results. Journal of Field Ornithology, 80(4), 387–398.

[16] Digby, A., Towsey, M., Bell, B.D. and Teal, P.D. (2013). A practical comparison of manual and autonomous methods for acoustic monitoring. Methods in Ecology and Evolution, 4(7), 675-683.

[17] Bardeli, R., Wolff, D., Kurth, F., Koch, M., Tauchert, K.H. and Frommolt, K.H. (2010). Detecting bird sounds in a complex acoustic environment and application to bioacoustic monitoring. Pattern Recognition Letters, 31(12), 1524-1534.

[18] Potamitis, I., Ntalampiras, S., Jahn, O. and Riede, K. (2014). Automatic bird sound detection in long real-field recordings: applications and tools. Applied Acoustics, 80, 1-9.

[19] Charif, R. (2008). Automated detection of Cerulean Warbler songs using XBAT data template detector software. Technical report 08-02. The Cornell Laboratory of Ornithology, Ithaca, New York, USA. 16p.

[20] Haselmayer, J. and Quinn, J.S. (2000). A comparison of point counts and sound recording as bird survey methods in Amazonian Southeast Peru. Condor, 102(4), 887-893.

[21] Bibby, C., Jones, M. and Marsden, S. (1998). Expedition Field Techniques: Bird Surveys. Expedition Advisory Centre. Royal Geographic Society. London. 137p.

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