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IDENTIFICATION OF BIRD SOUND AS THE TOOLS FOR ENVIRONMENTAL QUALITY MONITORING IN GREEN OPEN SPACE

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ABSTRACT

The presence of a bird community can be used as a bioindicator of environmental quality in suburban areas. Bird identification from sound recording has developed in the last decade. This research aims to identify the bird species from sound recording as a potential tool to analyze the quality of green open space in the suburban area of Sleman Regency. Data collection was carried out from November 2020 to March 2021 on river borders and city parks. Bird sound data was carried out using a mobile phone, facilitated by the Arbimon Touch application, in the morning, afternoon, and evening for three hours each at intervals of five minutes on and ten minutes off for five days. Abiotic data were also measured in the morning, afternoon, and evening for five days. The sound recordings and spectrograms were identified and validated through the database on the xeno-canto website. The identified birds are then used to calculate the Bird Community Index (BCI). The analysis of sound recordings found 29 bird species from 18 families in the sampling location. In addition, four birds were recorded as vulnerable or protected. The Progo River Border is the green open space with the highest species number of birds, but, based on BCI, the 2Kayen River border and the Taman Keanekaragaman Hayati dan Arboretum Bambu have the best environmental quality to the presence of the higher specialist bird. Based on the bird community index, the environmental quality of the Green Open Space in the suburban area of Sleman Regency has a moderate to very low level of environmental quality due to the low presence of specialist birds.

Key words: *guild, specialist, river border, city park, sleman, spectrogram*

INTRODUCTION

Suburban areas are the location affected by urban sprawl with high land conversion (Phelps & Wood, 2011; Hlavácek et al., 2019). Generally, commuters live in suburban areas, so the rapid development of facilities and infrastructure occurs to meet the community's needs (Reis et al., 2016; Tryjanowskia et al., 2017). The impact of environmental damage due to anthropogenic in suburban areas is reducing green open space (GOS) and declining environmental quality (Sadewo et al., 2018; Leveau et al., 2019). In contrast, the presence of green open space is a means of improving human health and preserving diversity in urban or suburban areas (Stott et al., 2015; Ward et al., 2016). The decrease in the quality of green open space is usually followed by a decrease in the presence of animals, such as birds which are bioindicators of environmental quality (Dewita et al., 2016; Groot et al., 2021). The ecological characteristic, or guild, of a bird community in an ecosystem, can be used to measure environmental quality based on the bird community index (BCI) (de Iongh, 2006; Sastranegara et al., 2020). The high presence of birds with specific guilds indicates that the environmental quality in the habitat is still good (O'Connell, 2009). For example, the Universitas Indonesia city park has better environmental quality (BCI value 70.8 with 44 bird species) compared to the Monas city park (BCI value 61.6 with 54 bird species) because the Universitas Indonesia city forest is inhabited by groups of birds with specialist guilds and have a great variety of guild (Rumblat, 2016). The development of BCI is now used for environmental quality monitoring, especially in suburban areas (Irfanullah et al., 2017).

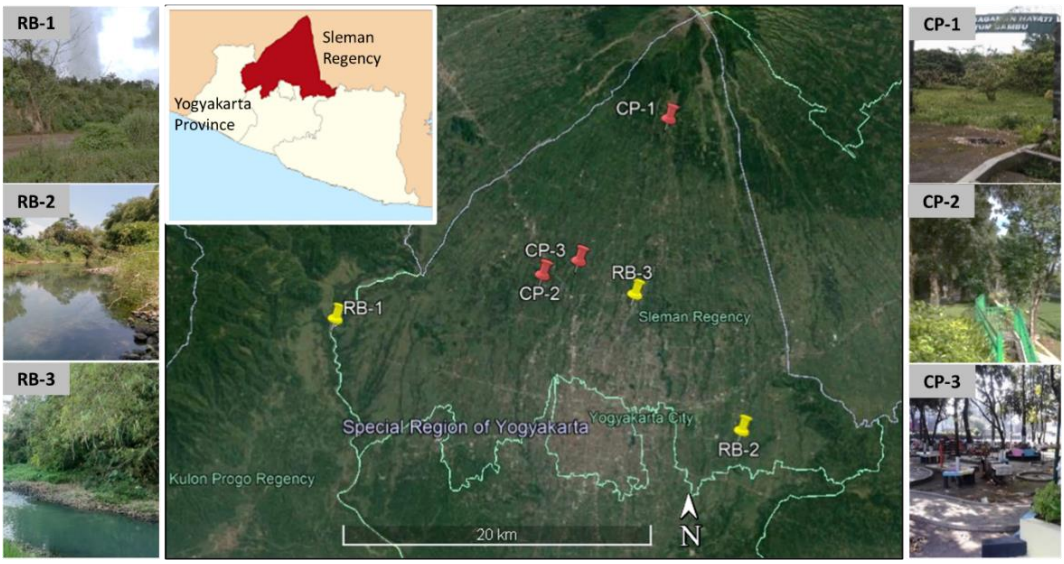
Monitoring the presence of birds is now starting to develop in identifying sounds (Marini et al., 2015). Recording bird sounds can minimize humans' effort, time, and presence (Stowell et al., 2019). The accuracy rate of bird sound identification has now exceeded 98%, even for large samples (> 130 color-banded individuals) (Xia et al., 2012), and the worldwide bird sound database continues to increase to more than 10,000 data (Xeno-canto Website, 2021). Identification of sound recordings can also use a spectrogram by observing the distance between syllabus, dominant and maximum frequencies, and the number of peak frequencies (Irwandi et al., 2005). In addition, the type of ecosystem, the structure of the vegetation, and the seasons will affect the identified bird species (Sandstroem et al., 2006; Celis-Murillo et al., 2012; Ehnes et al., 2018). Acoustic identification technology analyzes species with specific behavior and environmental landscape conditions, such as disturbance and environmental quality monitoring (Izaguirre et al., 2018). Identification of bird sounds has become a way out for a more efficient and precise form of monitoring, especially on a broad scale, up to

500 meters depending on the recording device used, both spatially and temporally (Hill et al., 2017). The use of sound recording technology periodically to identify bird sounds can be an alternative for monitoring animal diversity inurban forest areas and suburban areas as a buffer around them (Irvine et al., 2009).

Sleman Regency is the main suburban area for Yogyakarta City as the capital of Yogyakarta Province, Indonesia (Selang et al., 2018). Located between 7°34′51″-7°47′30″S and 110°33′00″-110°13′00″E (Pemkab Sleman, 2021), Sleman Regency is located just north of the Yogyakarta City. The total area of Sleman Regency is 57,482 ha, with a population density of 1,959 people/km^2 or the second most populous in Yogyakarta Province after Yogyakarta City (Dataku DIY, 2021). Public green open space in this Regency in 2017 was recorded at 883 ha or only 1.5% of the total area of Sleman Regency (DLH Kabupaten Sleman, 2019). The Sleman government's efforts to increase the green open space area to 1,060 ha (1.8%) in 2020 (DLH Kabupaten Sleman, 2020) still have not been able to increase the public green open space, which should cover 20% of the city area (BPN, 2011). This public green open space area is part of the area with forest cover in Sleman Regency (other types such as private forest and conservation forest), which only cover 13.39% of the total area (DLH Kabupaten Sleman, 2020). Monitoring the presence of birds by visual identification in this regency was still published. At the UII Kaliurang campus in 2016, 17 bird species were identified with the dominance of the granivorous and omnivorous guild types, while in the UGM campus, 24 bird species were identified with the dominance of the granivorous, omnivorous, insectivorous, and frugivorous guild types (Suripto et al., 2019). In the future, the combination of identification with bird acoustics and analysis with guilds is expected to become a more advanced monitoring technology for monitoring birds in suburban vegetated areas . This study aimed to identify the bird species from sound recording as a potential tool to analyze the quality of green open space in Sleman Regency. The methods and results of this study are expected to be an alternative for bird monitoring with the advanced technology for green open space management in suburban areas.

RESEARCH METHOD

Data collection was carried out from November 2020 to March 2021 on two public green open space, namely river borders and city parks. Those green open space's were managed by the Dinas Lingkungan Hidup Sleman Regency. Sampling locations were carried out at three river borders, namely the Progo river border (RB1), the Opak river border (RB2), the Kayen river border (RB3), and also three city parks in Sleman Regency, namely Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1), Taman Bukit Bulan city park (CP2), and Taman Denggung city park (CP3) (Figure 1). Determination of the location was done purposively based on the highest tree density on each type of public green open space from google maps. Then, the sound recording of each sampling location was taken with a recorder placed on the tree in the center of green open space (Figure 2). Sound recording was done using a mobile phone and clip-on facilitated by the Arbimon Touch application in the morning (05.30-08.30 WIB), in the afternoon (10.30-13.30 WIB), and in the evening (15.30-18.30 WIB) to see temporal fluctuations (Fuller et al., 2015). Voice recording with this smartphone (merk Vivo Y95) can cover a radius of 200 meters from sound recorder placement and up to 90% of the city park sampling area (Table 1). Therefore, the selection of a mobile phone for voice recording must be checked first to cover the broadest possible sampling area. The recording was carried out in intervals of five minutes on and ten minutes off in the morning, afternoon, and evening for five days for each location (Setyantho et al., 2017). In addition, abiotic parameters that affect the abundance of birds in habitats include light intensity, air humidity, air temperature, and wind speed (Carvajal-Castro et al., 2019; Sinnott et al., 2021), which were measured by lux meter, sling psychrometer, anemometer in the each morning, afternoon and evening during five days on data collection.



Notes:

RB 1 (7°44'23.61"S 110°12'59.67"E)	CP 1 (7°37'3.90"S 110°25'21.56"E)
RB 2 (7°48'26.35"S 110°27'33.28"E)	CP 2 (7°43'8.96"S 110°21'2.78"E)
RB 3 (7°44'9.42"S 110°23'7.77"E)	CP 3 (7°43'17.78"S 110°21'38.64"E)

Figure 1. Location of data collection

Figure 2. Placement of sound recorder in CP1 (representative)

Table 1. The total area of each sampling location

Sampling location	Total area (Ha)	Extreme width (m)
CP1	2,00	245
CP2	2,30	220
CP3	1,04	180

Sound recordings and spectrograms were identified and validated using audacity software by comparing through databases on the xeno-canto website and the Macaulay Library (Betancourt & McLinn, 2012; Vellinga & Planque, 2015). The spectrogram of a bird species can generally still be seen in the audacity software, so that bird species identification can still be made when the bird's song is faint due to anthrophony to geophony disturbances. The identified bird data is then used to calculate the Bird Community Index (BCI) by determining the guild and score of each bird (O'connell et al., 2000). The

number of guilds created by O'cConnell et al. (2000), as many as 16 categories for birds in the forests of the United States, modified and adjusted by Rumblat (2016) into 25 categories (categorized as six types of the guild) based on the characteristics of birds in the vegetated area in Indonesia. Each bird species is assigned a number 1 for each guild corresponding to its character, which can be found in identification books. After all the birds have 87etermineed the guild selection, they are numbered, and the proportion is calculated in one type of guild. Each existing proportion is converted to a score (Rumblat, 2016) and totaled per type of guild. Total scores for all types of guilds are multiplied by 0.8 to obtain the BCI value for each sampling location. The number of bird species and BCI values for each location was analyzed quantitative descriptively to compare the total score at the river border and the city park of Sleman Regency. Both data of number species were also analyzed inferentially to test the hypothesis of the two groups of green open space. The bird species found will also be analyzed for their conservation status based on the International Union for Conservation of Nature (IUCN) Red List and protection status based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia number P.106/MENLHK/SETJEN/KUM.1/12/2018 concerning protected plant and animal species. The BCI value obtained by each sampling location was used to determine the environmental quality with categories of very low (20≤ BCI ≤39.9), low (40≤ BCI≤ 54.9), medium (55≤ BCI ≤69.9), good (70≤ BCI ≤84.9), and very good (85≤ BCI ≤100) (Desantoro et al., 2020). According to Rumblat (2016), the categories have been adjusted so that the distance for each category is 15 points, except for the distance from very low to low category of 20 points, so that all categories are represented with almost the same range of points. In addition, the number of bird species and BCI values were also tested for correlation to see the abiotic parameters correlated with the data.

RESULT AND DISCUSSION

1. Types of Birds

The six green open space of the Sleman Regency show that 29 bird species from 18 families were identified by sound recordings (Table 2). The Progo River border (RB1) showed the highest bird findings with 20 species compared to other green open space. Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1) dominated the number of birds identified with 18 species compared to other city parks. The river border types have more bird species than city parks (Table 2). Only two birds are not found on the river border, namely Pycnonotus goiavier and Anthreptes malacensis. Rubigula dispar and Centropus nigrorufus are classified as vulnerable according to the IUCN Red List, both of which are only found on the Progo river border (RB1). In addition, there are three protected birds, namely Centropus nigrorufus, Rhipidura javanica, and Spilornis cheela where all three are found in the Progo river border (RB1) and Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1). Most of the bird species were identified by sound, and a few were identified by spectrogram if the sound of birds was low. Birds were identified by spectrogram, including Dicaeum trochileum, Pycnonotus aurigaster, Halcyon cyanoventris, Cinnyris jugularis, and Alcedo meninting (Figure 3). The identification with the spectrogram is also strongly influenced by environmental conditions such as rain which makes the spectrogram unclear. However, the pattern is still more visible than identification with an obscure bird sound.

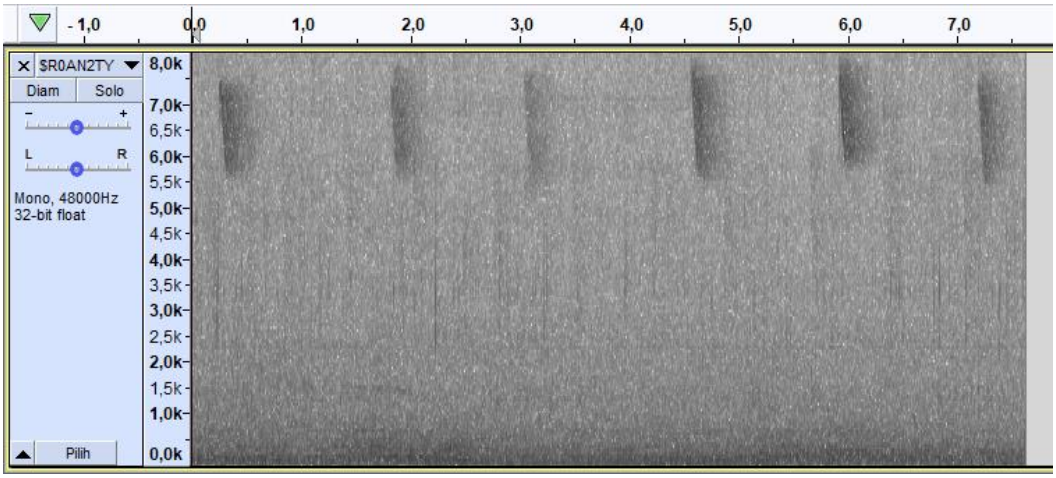
Table 2. Bird species identified based on sound recordings in Audacity software.

Family	Latin Name	Local Name	Location						Conservation Status*)
			RB1	RB 2	RB 3	CP 1	CP 2	CP 3	
Pycnonotidae	*Pycnonotus aurigaster*	Cucak kutilang	✓	✓	✓	✓	✓	✓	LC, NP
	Pycnonotus goiavier	Merbah cerukcuk						✓	LC, NP
	Rubigula dispar	**Cucak kuning**	✓						**VU**, NP
Nectariniidae	*Cinnyris jugularis*	Burung-madu sriganti	✓		✓	✓	✓	✓	LC, NP
	Anthreptes malacensis	Burung-madu kelapa				✓	✓		LC, NP
Cisticolidae	*Orthotomus sutorius*	Cinenen pisang	✓	✓		✓	✓		LC, NP
	Prinia inornata	Perenjak padi	✓						LC, NP
	Cisticola juncidis	Cici padi	✓	✓					LC, NP
Alcedinidae	*Todiramphus chloris*	Cekakak sungai	✓			✓			LC, NP
	Halcyon cyanoventris	Cekakak jawa	✓	✓	✓	✓			LC, NP
	Alcedo meninting	Raja-udang meninting	✓		✓				LC, NP

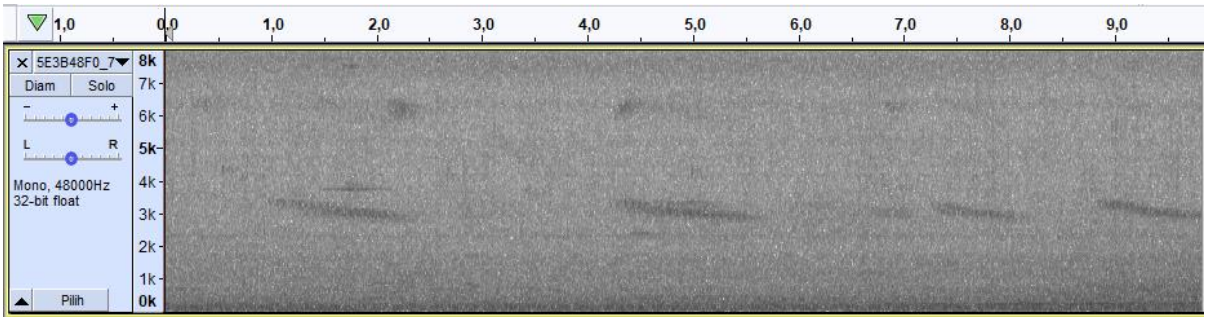
Family	Latin Name	Local Name	Location						Conservation Status*)
			RB1	RB 2	RB 3	CP 1	CP 2	CP 3	
Cuculidae	*Cacomantis merulinus*	Wiwik kelabu	✓	✓		✓			LC, NP
	Centropus nigrorufus	**Bubut jawa**	✓						**VU, P**
	Centropus bengalensis	Bubut alang-alang			✓	✓			LC, NP
	Phaenicophaeus curvirostris	Kadalan birah	✓						LC, NP
Estrildidae	*Lonchura punctulata*	Bondol peking	✓	✓	✓				LC, NP
	Lonchura leucogastroides	Bondol jawa	✓	✓	✓	✓	✓	✓	LC, NP
Dicaeidae	*Dicaeum trochileum*	Cabai jawa	✓	✓	✓	✓	✓	✓	LC, NP
Picidae	*Picoides moluccensis*	Caladi tilik	✓		✓				LC, NP
Aegithinidae	*Aegithina tiphia*	Cipoh kacat	✓			✓			LC, NP
Turnicidae	*Turnix suscitator*	Gemak loreng	✓			✓			LC, NP
Columbidae	*Spilopelia chinensis*	Tekukur biasa	✓	✓	✓	✓	✓	✓	LC, NP
Rallidae	*Amaurornis phoenicurus*	Kareo padi	✓	✓	✓				LC, NP
Passeridae	*Passer montanus*	Burung-gereja erasia		✓	✓	✓	✓	✓	LC, NP
Caprimulgidae	*Caprimulgus affinis*	Cabak kota			✓				LC, NP
Campephagidae	*Pericrocotus cinnamomeus*	Sepah kecil				✓			LC, NP
Rhipiduridae	***Rhipidura javanica***	**Kipasan belang**				✓			LC, **P**
Zosteropidae	*Zosterops palpebrosus*	Kacamata biasa				✓			LC, NP
Accipitridae	***Spilornis cheela***	**Elang-ular bido**				✓			LC, **P**
	Total species in each location		20	11	13	18	8	7	

*)LC: less concern; VU: vurnerable; P: protected; NP: non-protected

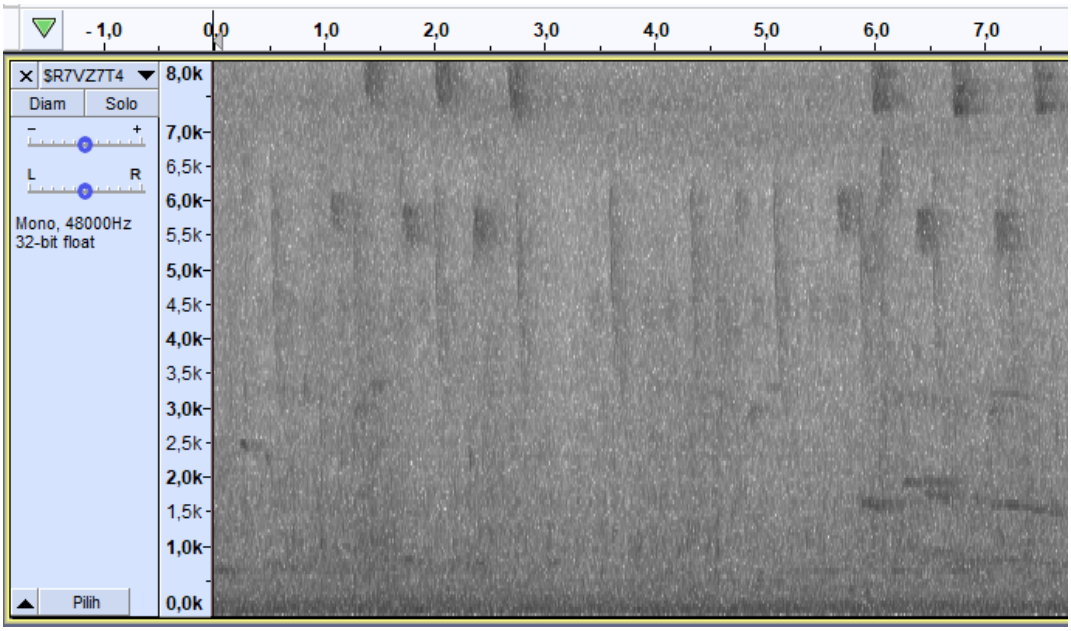
Dicaeum trochileum (Cabai Jawa)



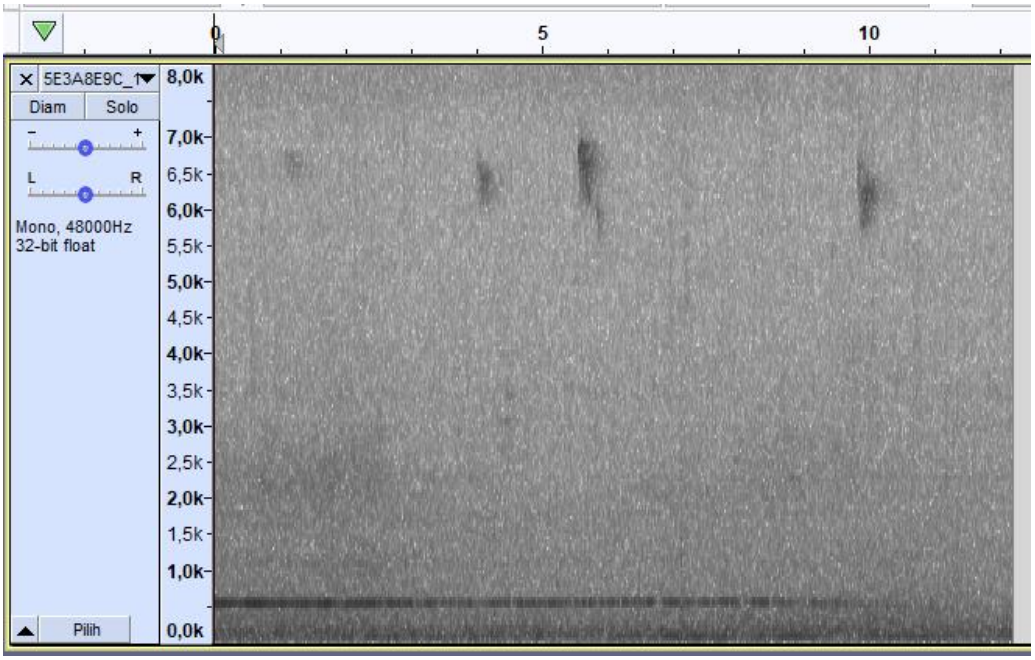
Pycnonotus aurigaster (Cucak Kutilang)



Halcyon cyanoventris (Cekakak Jawa)



Cinnyris jugularis (Madu Sriganti)



Alcedo meninting (Raja Udang Meninting)

Figure 3**.** Spectrogram of birds analyzed by the Audacity application

2. The Quality of Green Open Space in Sleman Regency

Based on the calculation of the BCI, it was found that the location of the Kayen river border (RB3) and the Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1) had a medium level of environmental quality with the highest BCI value among other sampling locations, namely 60%, and 56%. On the other hand, the Progo river border (RB1) and the Opak river border (RB2) have low quality, while the Bukit Bulan city park (CP2) and Denggung city park (CP3) have very low quality (Figure 4). When compared with the number of species found in each location in Table 1, it is estimated that there is no correlation between the number of species and environmental quality. According to regression analysis, the number of species does not affect the BCI value because the analysis showed a significance value of around 0.19 ($\alpha > 0.05$). According to O'Connell (2009), the BCI value is not directly influenced by the number of species but is influenced by the presence of species from specialist guild groups which are more than species with generalist guilds. Birds with specialist and generalist guilds have different scoring systems (ascending and descending) (Rumblat, 2016), so the score for specialist birds will be higher as the proportion of specialist birds increases.

The presence of species with specialist guild interpretations will increase the value of the guild category and environmental quality (O'Connell, 2009). Based on Figure 5, the Kayen River border (RB3) and the Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1) are superior in feeding, nest replacement, and activity time guilds due to the presence of species belonging to the guild with specialist category according to Rumblat (2016). For example, at the Kayen river border (CP3), there are *Cinnyris jugularis* as nectar eaters, *Alcedo meninting* as fish eaters, *Halcyon cyanoventris* as predators that nest in cliff holes or the ground, *Picoides moluccensis* as insectivores by hollowing trees and nesting in trees, *Amaurornis phoenixucrus* as insectivorous on the forest floor or in the litter, *Caprimulgus affinis* which nests on the ground and is active at night, *Passer montanus* which nests in buildings, all of which are specialist species. Bird species belonging to specialist groups have characteristics such as occupying a narrow niche in the selection of feed, having a unique way and specific resources in obtaining food, being sensitive to the presence of humans, and having specific roles such as pollination agents (Rumblat, 2016; O'Connell et al., 2000). For example, insectivores will be grouped into specialist guilds. In contrast, omnivores will be grouped into generalist guilds because the availability of insects will be more limited than omnivore food available in varied habitats (Rumblat, 2016).

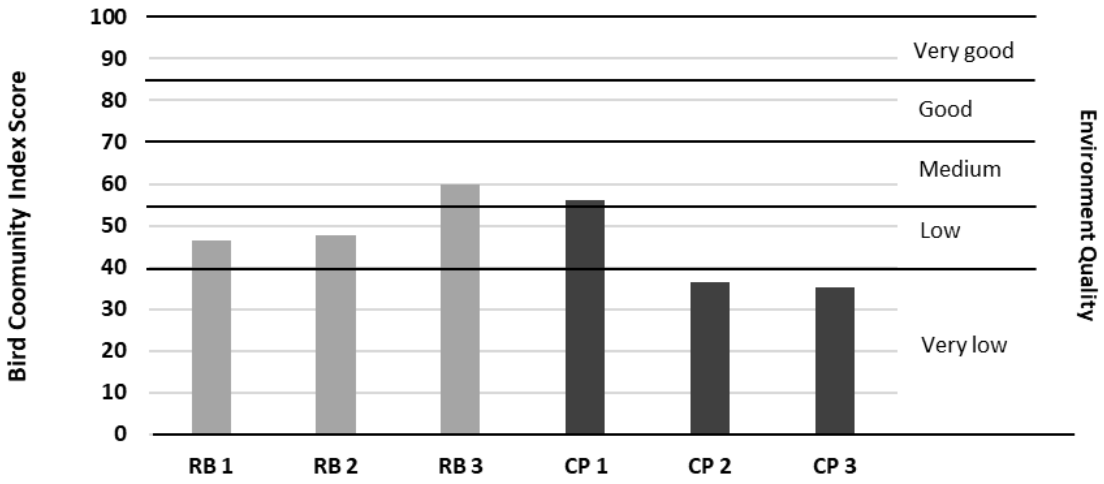


Figure 4. BCI results of the six sampling locations and their relationship to environmental quality

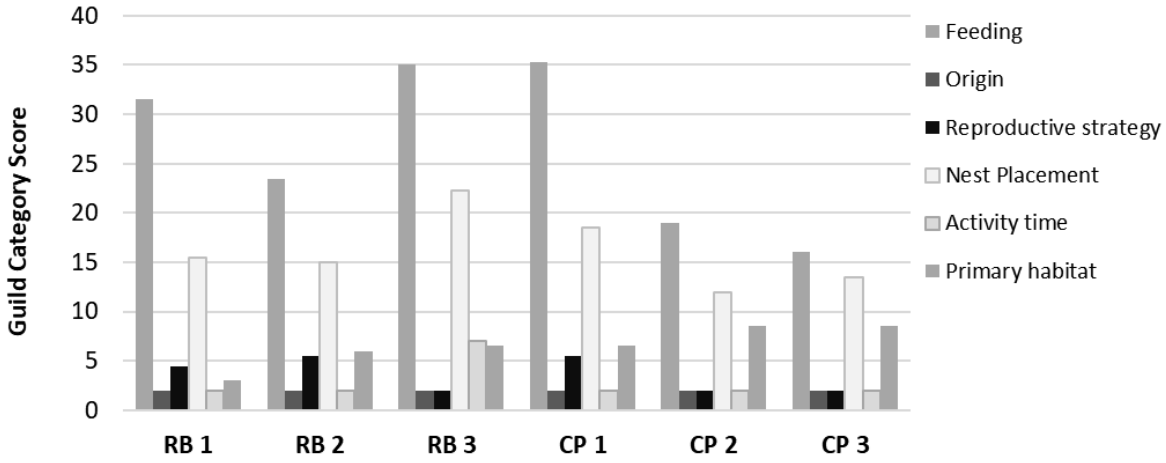


Figure 5. The category value of each guild has six sampling locations

The recording of bird sounds serves to map the home range of a bird species in a suburban environment (Betts et al., 2005). Based on Table 2, it can be seen that the six sampling locations have a reasonably even species distribution throughout the suburban area of Sleman Regency. Therefore, the presence of species in certain green open space can map the distribution of living areas or their habitats. Four bird species were present in all sampling locations, namely *Pycnonotus aurigaster*, *Lonchura leucogastroides*, *Dicaeum trochileum*, and *Spilopelia chinensis.* The distribution of these four species is extensive in almost all lowlands and highlands in the Sleman Regency area and is even found to the south of Yogyakarta Province in Bantul Regency (Wicaksana et al., 2020, Wicaksana & Utami, 2021). Still, if analyzed again, the four species are classified as generalist guild species. The classification of specialist and generalist groups is based on the relationship of each guild to specific elements of ecosystem structure, function, and composition (O'connell et al., 2000). Species with narrow niches, such as those from the Alcedinidae family, will occupy areas with a narrow distribution because they are included in specialist groups with fish food sources that are only found in water bodies such as rivers (Al-Zahaby & Elsheikh, 2014). In general, the condition of the suburbs of Sleman has begun to be disturbed by developments in various places (Sutrisno, 2014). As a result, specific ecosystems with unique characters are reduced in number. The low quality of the environment in some green open space's proves that the condition of green open space in Sleman Regency has also begun to be disturbed not only because of development but also anthropogenic such as traffic (Nugroho, 2015).

Bird presence and environmental quality based on bird guild parameters are influenced by the abundance of feed sources, matrix conditions or dominant landscape types covering the land, and microclimate conditions (O'Connell, 2009). Sampling locations on the three river borders have landscapes in the form of a more complex combination of ecosystems such as rivers, shrubs, and high and lowland forests compared to the urban park,

which contains urban forests with vegetation of trees, shrubs near roads, buildings, and settlements like urban ecosystems (Figure 1). Thecondition of the Taman Keanekaragaman Hayati dan Arboretum Bambu city park (CP1), which represents the city park, is dominated by large trees, and there is a river with a distance of 300 meters, thus supporting the presence of specialist birds that occasionally perch in the CP1 area. Feed sources in the river border are more varied, with feed from terrestrial and aquatic environments. According to the Pearson test, air humidity, wind speed, and light intensity strongly correlate with BCI values (Table 2). The microclimate at the sampling location also affects the presence of birds and the quality of the green open space environment. Based on the correlation coefficient value, the higher the air humidity and wind speed, the higher the BCI value at a location. On the other hand, the BCI value will be lower if the light intensity at a location is higher.

The limited area of green open areas is still a problem for local governments in urban and suburban areas (Phelps & Wood, 2011). Monitoring biodiversity and environmental quality is a step that must be carried out periodically as a form of suburban area management. Monitoring environmental quality using a bird community index is common, but it is still combined with manual observations in the field that take time and energy (Sastranegara et al., 2020; Rumblat, 2016). The novelty and contribution of this research are that the bird identification process is carried out from the sound recordings with a validation process on the bird's sound database by xeno-canto and the Macaulay Library. Environmental sound recording technology will also affect the quality of the recording and the continuous development of the level of accuracy of a technology (Mortimer & Greene, 2017). In this study, voice recording using a mobile phone with an external microphone and the arbimon touch application is considered a simple technology that is easy to find. Therefore, the sound recordings obtained can be identified easily. However, these tools have limitations on safety (theft and rain damage) and are difficult to place on trees. The development of animal voice recording devices such as audiomoth is now growing and needs to be tried for further research. This tool has a casing and components that make it easy to put on a tree branch with a safety lock, making it safer from theft and damage to the tool due to rain. Before recording, this tool can also be set in advance the recording time and the frequency captured. According to Hill et al. (2017), the audiomoth recording range can reach one kilometer and is suitable for sound recording in conservation forest areas with a wide range.

Tabel 2. Correlation between bird community index value and abiotic parameters

		Air temperature	Air humidity	Wind speed	Light intensity
Bird Community Index value	Correlation coefficient	.019	.364*	.521**	-.481**
	Sig. (2-tailed)	.921	.048	.003	.007

*Correlation is significant at 0.05 level
** Correlation is significant at 0.01 level

CONCLUSION

Based on the analysis of sound recordings in six green open space in the Sleman Regency, 29 species of birds from 18 families were identified. The Progo River border is the green open space with the highest number of birds identified through sound recordings. In addition, green open space with river border types has a higher number of birds than city parks in the Sleman Regency. The Kayen river border and the Taman Keanekaragaman Hayati dan Arboretum Bambu city park have the highest BCI values among the other sampling locations, even though both have medium environmental quality. The presence of bird species with specialist guild interpretation will increase the value of the guild category, especially the feed guild, nest replacement, and activity time.

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