**Journal of Threatened Taxa**

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)


## Communication

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26 October 2020 | Vol. 12 | No. 14 | Pages: 16954–16961
DOI: 10.11609/jott.5213.12.14.16954-16961



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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 October 2020 | 12(14): 16954–16961
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
DOI: https://doi.org/10.11609/jott.5213.12.14.16954-16961
#5213 | Received 04 July 2019 | Final received 30 September 2020 | Finally accepted 03 October 2020
PLATINUM OPEN ACCESS

COMMUNICATION

# Species diversity and feeding guilds of birds in Malaysian agarwood plantations

**Nor Nasibah Mohd Jamil [1], Husni Ibrahim [2], Haniza Hanim Mohd Zain [3] & Nur Hidayat Che Musa [4]**

[1-4] Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia.
[1] nasibahmjamil@gmail.com, [2] husni@fsmt.upsi.edu.my (corresponding author), [3] haniza@fsmt.upsi.edu.my, [4] nurhidayatchemusa89@gmail.com

**Abstract:** In Malaysia, the current status of birds inhabiting agarwood *Aquilaria malaccensis* plantations has not been specifically studied, and little research has been conducted to investigate birds in other agricultural areas (e.g., rubber, acacia, and oil palm plantations) and disturbed areas. This study was conducted to assess bird species richness and relative abundance, as well as feeding guilds, in two agarwood plantation sites: Universiti Pendidikan Sultan Idris in Tanjong Malim (UPSI), and Slim River (SR). The presence of birds was recorded using a combination of techniques (mist-nets and point count), while various sources were used to compile feeding information. This study recorded 364 birds from 36 species in 24 families. Shannon diversity index (H') values for the UPSI and SR sites were 2.896 and 2.492 respectively, indicating high bird diversity. The Bray-Curtis index was 0.29, indicating these sites share few species. Insectivorous and omnivorous birds were dominant in UPSI (31%), and omnivores at SR (32%). The commonest insect order at both sites was Orthoptera (UPSI 48%, SR 25%). While agarwood plantations are relatively homogeneous, they provide a variety of food sources and shelter for a wide range of birds.

**Keywords**: Avian fauna, mist-net, point count, status.

**Editor:** Anonymity requested.

**Date of publication:** 26 October 2020 (online & print)

**Citation:** Jamil, N.N.M., H. Ibrahim, H.H.M. Zain & N.H.C. Musa (2020). Species diversity and feeding guilds of birds in Malaysian agarwood plantations. *Journal of Threatened Taxa* 12(14): 16954–16961. https://doi.org/10.11609/jott.5213.12.14.16954-16961



**Funding:** Al-Hilmi Group of Companies (Project code: 2016-0058-102-29 & 2015-0170-102-29), Universiti Pendidikan Sultan Idris.

**Competing interests:** The author declares no competing interests. The views expressed are those of the author.

**Author details:** Nor Nasibah Mohd Jamil is a biology PhD student at Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris. Interested in ecology and conservation biology. Husni Ibrahim is a lecturer (Associate Professor) at Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris. Specialization in Ecology, Conservation Biology and Environmental Education. Haniza Hanim Mohd Zain is a lecturer (Associate Professor) at Department of Biology and also a Dean in Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris. Specialization in Animal Science, Animal Biotechnology and Histology. Nur Hidayat Che Musa is a research assistant at Universiti Pendidikan Sultan Idris. Interested in Animal Science, Animal Biotechnology and Histology.

**Author contribution:** NNMJ—conducts, collect and analyze data from the research field. Contribute in giving ideas and writing the manuscript. HI—principal investigator of the research grant and responsible for the whole research, including designing and planning the data collection and main contributor for the manuscript. Revised the article before submission. HHMZ—co-researcher of the research grant and assist in designing and planning the research. Review and suggest some comments on the article. NHCM—assists in conducting and collecting data from the research field. Propose some ideas and comments on the article.

**Acknowledgements:** The authors would like to thank the Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris for allowing conducting this research at Universiti Pendidikan Sultan Idris karas plantation and Al-Hilmi Group of Companies to provide research grant and facilities for this study to be carried out at Al-Hilmi Agrofarm Sdn Bhd, Kg Tambak karas plantation. This study was supported by the Research Grant Scheme 2015-0170-102-29 & 2016-0058-102-29.

## INTRODUCTION

Peninsular Malaysia is home to 718 species of birds from 96 families (BirdLife International 2017). There has been considerable loss of natural habitat due to deforestation for commercial plantations such as oil palm, rubber, agarwood, and paddy field (Achondo et al. 2011). While plantations often decrease bird diversity, they can sometimes provide new food resources and areas of shelter (Benayas & Bullock 2012), showing similar species and the numbers of birds to nearby native forest fragments, particularly in the old plantation, while the bird species richness decreased when the young plantation was located far from the native forest (Styring et al. 2018).

The exploitation of natural resources in the forest not only causes their excessive consumption but also leads to a severe threat to the ecosystem (Hashim & Ramli 2013). The agarwood *Aquilaria malaccensis* industry is growing in Malaysia because of its high price in the worldwide market. Malaysia is one of the most suitable countries for planting agarwood trees as it has suitable climate (e.g., 50–80% exposure to sunlight and annual rainfall of 1000–2000 mm) and soil conditions (e.g., soil pH range from 4.0 to 6.0) which are the essential requirement for agarwood tree growth and development (Yahya 2011; Azahari et al. 2015). As the demand for agarwood supply increased globally, agarwood plantations have been established as an alternative to avoid the uncontrolled exploitation of agarwood resources resulting in their inadequacies in natural forests and large-scale production of agarwood (Azahari et al. 2015). The overexploitation of agarwood tree for its resin not only caused the extinction of agarwood species but also bird species in their natural forest habitat. The establishment of agarwood plantations, however, might play a crucial role in an agroforestry system by providing habitats favourable for native birds from natural forest.

A few kinds of research have been conducted to investigate the interaction of birds and their dynamic community at agriculture area such as acacia plantation (Styring et al. 2018), rubber plantation (Peh et al. 2006; Li et al. 2013; Sreekar et al. 2016), and oil palm plantation (Jambari et al. 2012; Amir et al. 2015) as well as logged forest (Ramly & Ramli 2009; Cosset & Edwards 2017). To date, however, no study about bird species diversity has been done in agarwood plantations. A complex habitat structure and plant diversity of forested habitats were important determinants of the bird species diversity and abundance (Azman et al. 2011). As majority of tree plantations are monocultures (homogeneous vegetation), they do not provide a great foraging opportunity to many bird species (Yahya et al. 2017). The conversion of forest to any plantation to some extent had annihilated nourishment sources that are available to birds (Subasinghe et al. 2014), while young and immature tree plantations are known to lack of food sources and may be an unfavourable habitat for birds (Sánchez-Oliver et al. 2014). As a result, the immigration of birds to another habitat will occur after their habitat decimated, caused the reduction of bird abundance and geographical distribution distance (Haddad et al. 2015), which may also lead to local extinction particularly for birds that cannot migrate and adapt (Mansor et al. 2018a).

Although the baseline data on the diversity of birds and their distribution had been collected all over the years, to date, there is still no study was done to examine the status of bird species inhabiting the agarwood plantation area in Malaysia. Hence, this study was done to document the bird species inhabiting in the two agarwood plantations to explore the present status of bird community, their composition and feeding guilds in ensuring a sustainable agroforestry and plantation management in the future. The purpose of this study, however, was not intended to compare bird data obtained in both areas, but rather only to collect data on the bird species richness, their abundance and to classify their feeding guilds by referring on comprehensive literatures, during a young stage and when the agarwood trees start to mature. The two study areas were chosen to cover both developmental stages of agarwood tree.

## MATERIALS AND METHODS

### Study Site

The study was carried out in two agarwood plantation areas:(1) Universiti Pendidikan Sultan Idris, Tanjong Malim (UPSI) (3.723N & 101.541E) from March 2016 until August 2017 (Image 1); and (2) Kg Tambak, Slim River (SR) (3.850N & 101.458E) from July 2017 until October 2017 (Figure 1). The plantations on both sites are monocultures surrounded by forest and near the lake or stream. The agarwood plantations in UPSI and SR are planted with young two and four years old agarwood trees respectively. The UPSI agarwood plantation consists of trees with a height of about 150–200 cm, the circumference between 9–15 cm, the numbers of main branches range between 11–18, the number of leaves within 100–200 and they lack canopy. Grasses and shrubs such as *Melastoma* sp., *Imperata cylindrical*

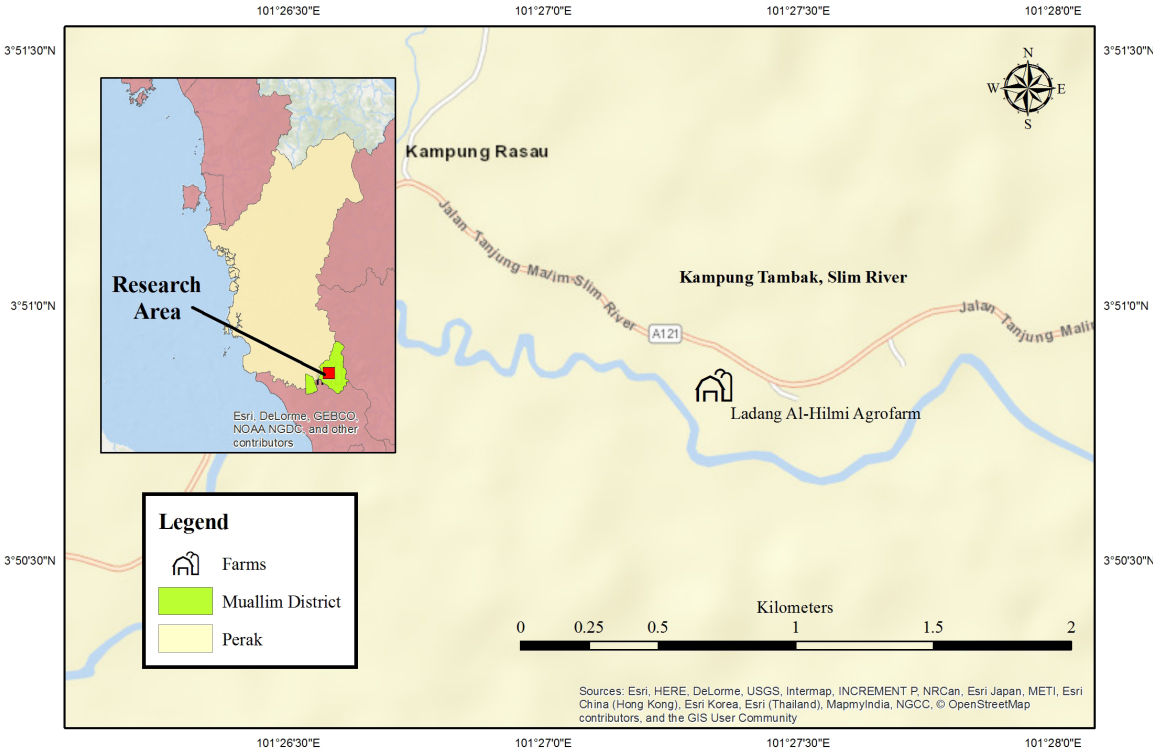


Figure 1. Agarwood plantation at Kg Tambak, Slim River (SR)

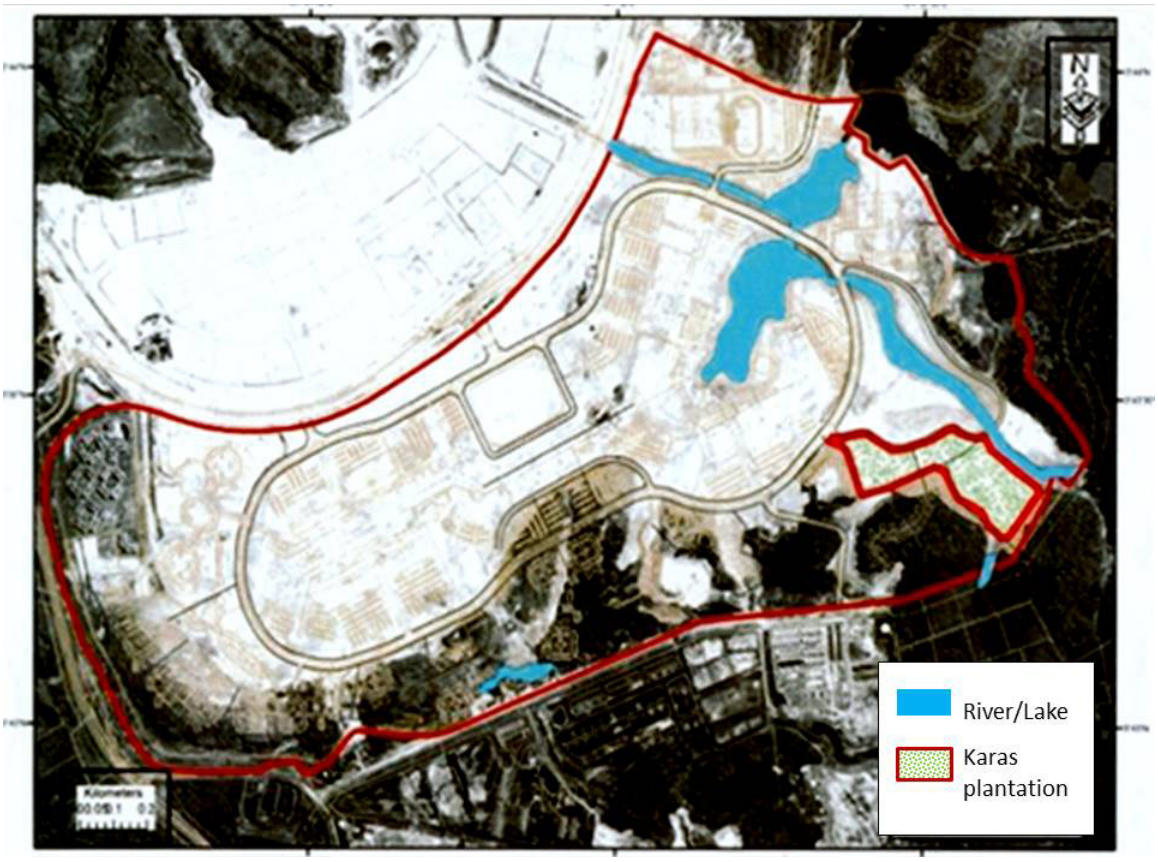


Image 1. Agarwood plantation at Universiti Pendidikan Sultan Idris (UPSI)

and *Cyperus esculentus* grow around this study area. Meanwhile, the SR agarwood plantation consists of trees that have a height of about 300–400 cm, circumference between 30–40 cm, the main numbers of branches are about 23–26 and number of leaves are within the range of 300–500 with slight canopy.

**Bird Survey**

A combination of two techniques (i.e., mist-net and point count) were used to survey the bird population (Zakaria & Rajpar 2010). The mist-netting method is apt to capture birds that are commonly unobtrusive and hardly give unique calls (Hashim & Ramli 2013). Mist-nets were opened daily at 0700h and closed at 18.00h. Nets were placed for three consecutive days every month and monitored every hour to extract captured birds. Three days of netting was enough to capture most of the birds at the site because birds may become aware of the mist net after three days (Zakaria & Rajpar 2010). The birds were marked on their tarsus using numbered aluminium ring upon capture, and standard biometric measurements were recorded and released close to the point of capture to lessen the disturbance. Recaptured birds were excluded from analyses.

Point count technique was used as a supplement to survey birds that were not captured in the mist nets. Five stations were surveyed in a 500m transect and each station was placed 100m apart while the starting and the end of the station were placed 50m from the edge of the plantation. The survey was done for 10 minutes at each station to record a sufficient number of individuals detected by sight within the 25m radius. The bird observed by point count method and captured by mist net method were then identified (Wells 2007; Robson 2008), photographed and recorded.

**Feeding Guilds**

This study did not apply a method to collect data on bird feeding guilds in the field. The identification and classification of bird feeding guilds, however, were done by referring to several comprehensive literatures (Zakaria & Rajpar 2010; Li et al. 2013; Tanalgo et al. 2015).

**Insect Survey**

There were two methods used to sample insect populations in agarwood plantations including pitfall traps and sweep net. For pitfall traps, four parallel transects measuring about 40m in length with a 10m inter-transect distance were set up in the plot, and five pitfall traps were placed 10m apart on each transect for three days and nights. Each pitfall trap consisted of a disposable cup, measuring about 10cm in height and 6cm in diameter. The cups were buried at ground level and contained detergent solution to prevent the insects from getting out of the trap. For the sweep net method, three straight–line transects of about 100m were marked out with a count station every 20m. This method was conducted by walking in a straight line, making two sweeps for every step, resulting in 40 sweeps per 20m. All of the sampled specimens in the pitfall traps were collected every 24h over three consecutive days. The number of insects collected by both methods was calculated and identified by their order based on Borror & White (1970), Weng & Yew (1983), and Walters (2013).

**Data Analysis**

The bird species richness and their relative abundance in the agarwood plantation were determined and presented in the number of percentages (%). Data analysis for diversity of birds was measured using Shannon's diversity index. Bray-Curtis index was used to calculate and quantify whether bird species composition is similar in both agarwood plantations. The Shannon's diversity index was calculated by:

$$H' = \sum Pi \ln Pi$$

Where P*i* is the proportion of each species in the sample and *ln* P*i* is the natural logarithm of this proportion. For similarity of the species occurring in the agarwood plantations, Bray-Curtis index was determined by:

$$\beta' = \sum \frac{(Xi - Yi)}{(Xi + Yi)}$$

Where X and Y are the compared areas, while X*i* and Y*i* is the number of individuals per species of compared areas.

**RESULTS**

A total of 36 species of birds represented by 364 birds belongs to 24 families were recorded in both of the agarwood plantations. *Geopelia striata* (Zebra Dove) made up the highest percentage of species captured in both study areas (UPSI = 12.3%, SR = 15.5%), and *Halcyon smyrnensis* (White-throated Kingfishers) was highest in SR site (15.5%) (Table 1; Image 1). Columbidae had the highest diversity in the both agarwood plantations, with four species (16.67%), followed by Estrildidae and Sturnidae with three species (12.5%), and Pycnonotidae, Nectariniidae, Cuculidae, and Apodidae with two species (8.33%) (Table 1). The remaining families were the least dominant families with only one species each. *Lonchura*

**Table 1. Birds species in agarwood plantations.**

| Family | Species | Common name | Percentage (%) | |
|---|---|---|---|---|
| | | | UPSI | SR |
| Columbidae | *Geopelia striata* | Zebra Dove | 12.3 | 15.5 |
| | *Streptopelia chinensis* | Spotted-necked Dove | 1.3 | 1.6 |
| | *Chalcophaps indica* | Asian Emerald Dove | 0.4 | 8.5 |
| | *Treron olax* | Little Green Pigeon | 0.9 | - |
| Estrildidae | *Lonchura maja* | White-headed Munia | 9.4 | - |
| | *Lonchura atricapilla* | Chestnut Munia | 11.5 | - |
| | *Lonchura punctulata* | Scaly-breasted Munia | 3.0 | - |
| Pycnonotidae | *Pycnonotus goiavier* | Yellow Vented Bulbul | 9.4 | 2.3 |
| | *Pycnonotus finlaysoni* | Stripe-throated Bulbul | 0.9 | 0.8 |
| Hirundinidae | *Hirundo rustica* | Barn Swallow | 8.9 | 6.2 |
| Ploceidae | *Ploceus philippinus* | Baya Weaver | 6.8 | - |
| Sturnidae | *Aplonis panayensis* | Asian Glossy Starling | 5.1 | - |
| | *Acridotheres tristis* | Common Myna | 4.7 | 12.4 |
| | *Gracula religiosa* | Common Hill Myna | - | 3.9 |
| *Motacillidae* | *Anthus rufulus* | Paddy Field Pipit | 4.3 | - |
| Apodidae | *Collocalia esculenta* | Glossy Swiflet | 3.4 | - |
| | *Aerodramus brevirostris* | Himalayan Swiftlet | 2.1 | - |
| Alcedinidae | *Halcyon smyrnensis* | White-throated Kingfishers | 3.0 | 15.5 |
| Aegithinidae | *Aegithina tiphia* | Common Iora | 3.0 | 3.1 |
| Eurylaimidae | *Cymbirhynchus macrorhynchos* | Black-and-red Broadbill | 2.1 | 1.6 |
| Muscicapidae | *Copsychus saularis* | Oriental Magpie-robin | 1.3 | 14.7 |
| Laniidae | *Lanius cristatus* | Brown Shrike | 1.3 | - |
| Meropidae | *Merops philippinus* | Blue-tailed Bee-eater | 1.3 | - |
| Phasianidae | *Synoicus chinensis* | Blue-breasted Quail | 0.9 | - |
| Oriolidae | *Oriolus chinensis* | Black-naped Oriole | 0.9 | - |
| Turnicidae | *Turnix suscitator* | Barred Buttonquail | 0.4 | - |
| Picidae | *Chrysophlegma miniaceum* | Banded Woodpecker | 0.4 | - |
| Nectariniidae | *Arachnothera longirostra* | Little Spiderhunter | 0.4 | - |
| | *Anthreptes malacensis* | Brown-throated Sunbird | - | 1.6 |
| Cuculidae | *Phaenicophaeus curvirostris* | Chestnut-breasted Malkoha | 0.4 | - |
| | *Clamator coromandus* | Chestnut-winged Cuckoo | - | 0.8 |
| Corvidae | *Platysmurus leucopterus* | Black Magpie | 0.4 | 0.8 |
| Motacillidae | *Dendronanthus indicus* | Forest Wagtail | - | 0.8 |
| Psittaculidae | *Psittacula longicauda* | Long-tailed Parakeet | - | 6.2 |
| Bucerotidae | *Anthracoceros albirostris* | Oriental Pied-Hornbill | - | 1.6 |
| Falconidae | *Microhierax fringillarius* | Black–-highed Falconet | - | 2.3 |

*atricapilla* and *L. maja* from Estrildidae family which had the highest abundance at UPSI site, however, were not recorded at SR site.

Present study recorded one Vulnerable species which is *Psittacula longicauda* (Long–tailed Parakeet) while the other species are classified as the Least Concern in the latest International Union for Conservation of Nature (IUCN) Red List classification (BirdLife International 2018). The major feeding guild was omnivorous and insectivorous. Agarwood plantation at UPSI site recorded the highest percentage of insectivorous and omnivorous birds from nine species each (31.03%) while at SR site, the most preferred feeding guilds were omnivorous from six species (31.58%) as shown in Table 2.

For insect survey, the highest abundance of insect in both study areas were Orthoptera (UPSI 47.9%, SR 24.6%), followed by Order Hymenoptera (UPSI 32.4%, SR 16.6%), while the lowest was Mantodea (UPSI 0.2%, SR 0.1%). The results of the Shannon's diversity index of bird species in both UPSI and SR agarwood plantations were 2.896 and 2.492, respectively. These result showed that UPSI agarwood plantation had higher species diversity of birds than SR agarwood plantation. Bray-Curtis index result showed the value is 0.29, indicating that there was some similarity in bird species present in both agarwood plantations.

**Table 2. Classification of bird feeding guilds in agarwood plantations.**

| Feeding guild | Percentage (%) | |
|---|---|---|
| | UPSI | SR |
| Insectivore | 31.03 | 26.31 |
| Granivore | 20.70 | 10.53 |
| Frugivore | 10.34 | 15.80 |
| Omnivore | 31.03 | 31.58 |
| Carnivore | 3.45 | 10.53 |
| Nectarivore | 3.45 | 5.26 |

**Table 3. Relative abundance of insect orders in two agarwood plantation areas.**

| Order | Percentage (%) | |
|---|---|---|
| | UPSI | SR |
| Orthoptera | 47.9 | 24.6 |
| Lepidoptera | 2.3 | 1.2 |
| Coleoptera | 4.7 | 2.4 |
| Hymenoptera | 32.4 | 16.6 |
| Diptera | 2.6 | 1.3 |
| Hemiptera | 0.8 | 0.4 |
| Blattodea | 0.7 | 0.3 |
| Odonata | 4.3 | 2.2 |
| Mantodea | 0.2 | 0.1 |
| Isoptera | 3.8 | 2.0 |
| Tricoptera | 0.3 | 0.2 |

## DISCUSSION

The bird species and population, as well as their community structure, are influenced by habitat types and diet preferences (Khairuddin 2013; Hashim & Ramli 2013). In this study, the combination of two techniques (i.e., mist-net and point count) was an effective methodological approach to observe and monitor bird species in the agarwood plantation. The results showed that the species obtained in this study were typical species that can be found in other plantations and forests, namely, Oriental Magpie-Robin *Copsychus saularis*, White-throated Kingfisher *Halcyon smyrnensis*, Yellow-vented Bulbul *Pycnonotus goiavier*, Spotted Dove *Streptopelia chinensis*, and Zebra Dove *Geopelia striata*. Moreover, agarwood plantations in UPSI and SR also shared 12 similar species of birds including Black-and-red Broadbill *Cymbirhynchus macrorhynchos*, Asian Emerald Dove *Chalcophaps indica*, and Common Myna *Acridotheres tristis*.

Basically, most plantations may have nearby forest patches or fragments that act as wildlife corridors which can influence the presence of certain bird species (Wilson et al. 2006; Mansor et al. 2018a). This association makes these birds good indicators to study and examine the impact of agarwood plantations because they are easy to sample and highly responsive to the environmental changes (Gregory & Strien 2010). Although the UPSI agarwood plantation consists of only young trees, with no dense canopy, it still contributes to high bird species richness due to their proximity to the other forest (Styring et al. 2018). Obtaining this information can possibly be used to enhance bird populations in managed landscape plantations (Peh et al. 2006). Thus, bird populations occupying plantations near the native forest will increase in comparison to those found further away from the native forest (Styring et al. 2018).

A slight high number of bird species in agarwood plantation highlights such habitat can provide food resources for the birds . The presence of many insect groups in the agarwood plantation may attract insectivorous birds to utilize the agarwood plantation area (Table 3). The orders Orthoptera (e.g., crickets and grasshoppers) and Hymenoptera (e.g., bees and ants) are frequently consumed by insectivorous birds and some of the omnivorous birds for their diet (Wells 2007). This finding was similar as in Mansor et al. (2018b) where a high number of Hymenoptera was reported to be consumed by insectivorous birds in a Malaysian rainforest. The high number of insectivorous species feeding on harmful insects and pests in the agricultural area may convey that birds constitute a vital part in agriculture ecosystems which is worthwhile to farmers and owners of the agarwood plantations. Insectivorous bird species such as Glossy Swiflet *Collocalia esculenta*, Paddyfield Pipit *Anthus rufulus*, Oriental Magpie Robin *Copsychus saularis*, and Brown Shrike *Lanius cristatus* are assumed to be a biological control because of their role in retaining insect populations in the plantation (Achondo et al. 2011). Besides that, the presence of grasses such as *Imperata cylindrica* and *Cyperus esculentus* as well as shrubs such as *Melastoma* sp. at UPSI site influenced the presence of granivorous birds such as *Lonchura maja* and *Lonchura atricapilla* in the study area that consume seed of grasses and sedges (Payne 2019a,b).

## CONCLUSION

This study is helpful in documenting the presence of bird species, as many of the studies focused more on other plantations, the present study revealed the capability of karas plantation to accommodate many

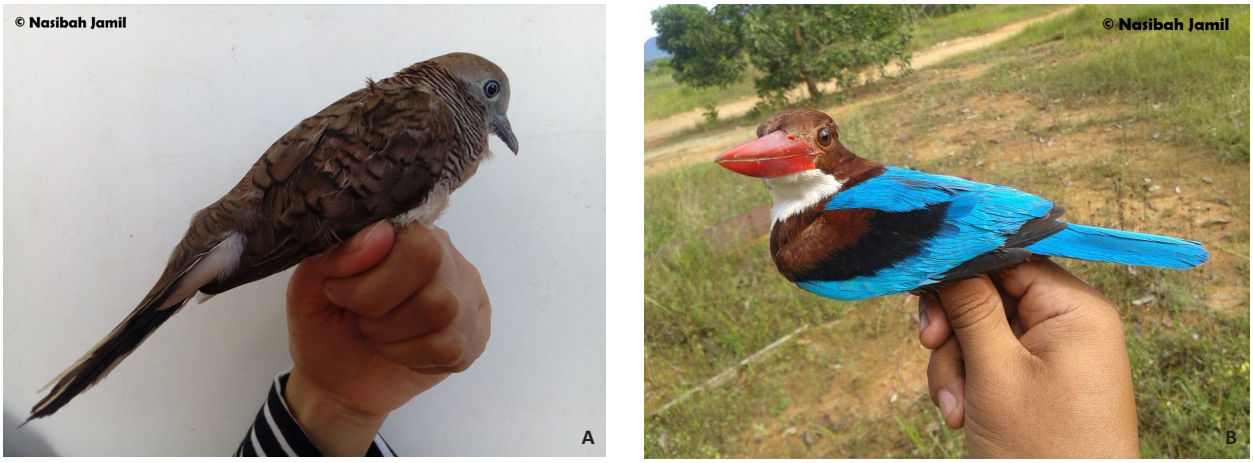


**Image 2. Dominant bird species in agarwood plantations: A—*Geopelia striata* (UPSI & SR) | B—*Halcyon smyrnensis* (SR).**

bird species, particularly insectivores and its associated insect groups. There is, however, more data that needs to be assessed to understand bird diversity in agarwood plantations which may be affected by tree maturity, proximity to other native habitats and climatic condition. This information can be used to develop sustainable management and conservation strategies of complex ecological networks in managed landscapes. Continuous efforts and more studies need to be conducted in this area to obtain detailed information on bird status and their community composition to conserve species from local extinction in modified landscape.

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Journal of Threatened Taxa

www.threatenedtaxa.org

PLATINUM OPEN ACCESS



**ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)**

**October 2020 | Vol. 12 | No. 14 | Pages: 16927–17062**
**Date of Publication: 26 October 2020 (Online & Print)**
**DOI: 10.11609/jott.2020.12.14.16927-17062**



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