# Diversity of Birds in Bidong Island

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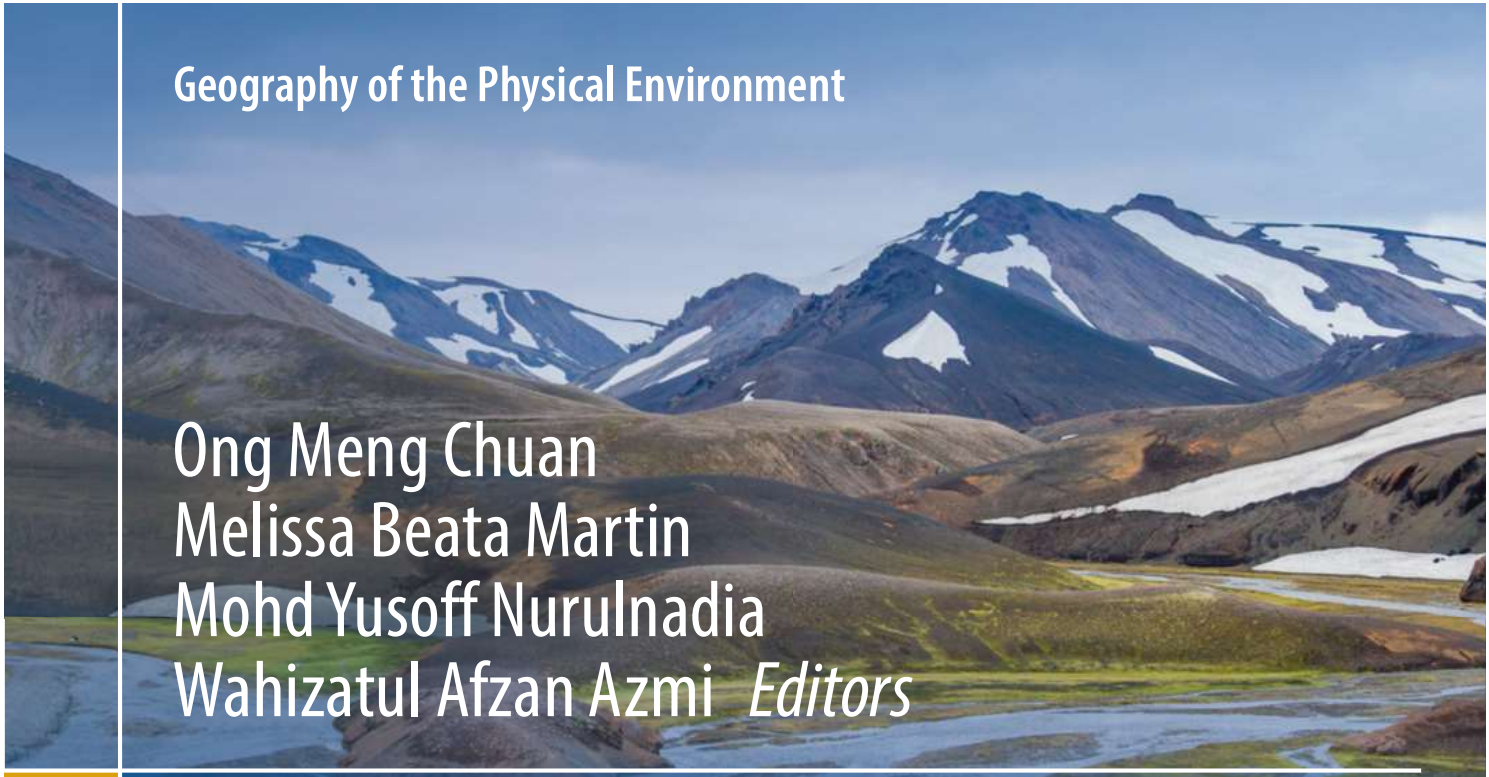

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# Bidong Island

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# Diversity of Birds in Bidong Island

8

Abdulmaula Hamza, Anuar Mcafee, and Amirrudin Ahmad

**Abstract**

Bidong Island is one of the least known islands in terms of birds; very few surveys have been conducted on this island. The island is part of a small archipelago called Bidong Laut, located to the northwest of Kuala Terengganu, on the east coast of Peninsular Malaysia. A total count of 30 bird species, from 19 families and 25 genera were found on this island between 2006 and 2020. Collected data (nine days) were analysed for biodiversity indices. Alpha diversity indices showed variations among sampling years, Simpson 1-D range 0.76–0.89; Shannon (H) range 1.74–2.48; species richness 8–16 species; dominance (D) range 0.11–0.24. Species richness estimators indicate that more species can be added with additional sampling and better coverage of the island area. The relatively low avian species richness compared to other east coast islands is discussed. Further surveys during migration season can reveal the importance of this island as a stop over site for several migratory species.

**Keywords**

Bidong Island · Bird diversity · Island · Malaysia · South China sea

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## 8.1 Introduction

Islands have been the focus of biological research for many years. Island bird fauna was the primary model of several ecological theories, such as the Origin of Species, and the Island Biogeography theory (Valente et al. 2017). Due to cover area and habitat limitations, islands host much smaller diversity compared to the mainland, which can be explained by several factors, such as the limited habitat diversity and consequently lower niche capacity of islands. Resources for feeding and breeding are less



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compared to the mainland (Lack 1970) as the area available for each species' establishment on islands is limited, making the conservation of large-area islands much worth it in terms of long-term planning (Koh et al. 2002). However, this should not reduce the importance of small islands, as they can serve as fuelling stations for migratory bird species, and be centres of endemism for other species, as previously found on similar forested islands in Southeast Asia (Turner et al. 2002).

Along the Malaysian coast, several small, heavily forested islands can be found. These islands have a significant ecological role (Cronk 1997). The state of Terengganu has some 17 islands of different sizes and morphology (Teh 2000). Some of them are inhabited such as Redang Island and Perhentian Island, while others are mainly used for tourism (e.g. Lang Tengah Island and Kapas Island). In contrast, other islands of the Bidong Island archipelago are uninhabited.

Information on the biological diversity of birds on Malaysian islands varies greatly. Extensive floral and faunal research was conducted for some islands, such as Langkawi Island (Abdullah 2006) and Tioman Island (Ng et al. 1999; Sodhi et al. 1999), and Perhentian Island (Tamblyn et al. 2005; David et al. 2016). Other islands lack such coverage, except for a few old reports of short expeditions by foreign researchers (Bonhote 1901; Gibson-Hill 1952).

Islands located off the east coast of Peninsular Malaysia have received very little research effort on avifauna. However there have been some surveys conducted on other organisms and plants on Bidong Island, for example, algae (Armugam 1981; Khor 2002), butterflies (Rosmidi et al. 2017), dipterocarp trees (Pesiu et al. 2016), bats (Roslan et al. 2016), crustaceans (Nakajima et al. 2013), fish (Jeropakal 1998; Lorenzo et al. 2016) and reptiles (Grismer et al. 2014).

European explorers used to shoot and collect bird specimens and skins for private or museum collections during the nineteenth century. First surveys of birds at Bidong Island date back to the Skeat Expedition during December 1899 (Gibson-Hill 1952). They collected six bird specimens of five species. Later the Kloss Expedition spent two days on the island in August 1910, collecting four additional bird species. Nearly four decades later, Gibson-Hill visited Bidong Island on August 9th, 1949 and added three other bird species to the previous lists (Gibson-Hill 1952). Since then, there have been no updates on the birds of Bidong Island.

Furthermore, birds on Bidong Island have not been mentioned anywhere in the previously published literature on the birds of Peninsular Malaysia (e.g. Wells et al. 1999; Wells 2007; Jeyarajasingam and Pearson 2012), clearly due to scarcity of data. Recent seabird surveys were conducted on several east coast islands (Hamza et al. 2016a, b; Hamza and Ho 2020), but these surveys did not include Bidong Island. This paper presents an annotation of bird species present on Bidong Island between 2006 and 2020.

Biodiversity conservation strategies require a full understanding of the diversity patterns. Alpha diversity describes diversity at a local scale, while beta diversity tackles a more regional scale; this is to compare species diversity variation among communities. Understanding these two diversity measures can help in providing a comprehensive reference for protecting biodiversity on a regional level (Jamoneau et al. 2018).

## 8.2 Bidong Island

Bidong Island is the largest island within a small archipelago called Bidong Laut, historically known as Little Redang (Fig. 8.1), with a surface area of a one-kilometre square, and an elevation of 321 m above sea level. It is located 18 nautical miles (later nmi) to the northeast of Kuala Terengganu, and 8 nmi southeast of Redang Island, Terengganu. Less than 1 nmi to the south, there is a smaller islet called Kapak Island and over 1.8 nmi to the north another islet called Gelok Island, while at over 8 nmi to the east of Bidong Island lie two other islets of Yu Besar Island and Yu Kecil Island. All of these islands are much smaller in size that Bidong Island.

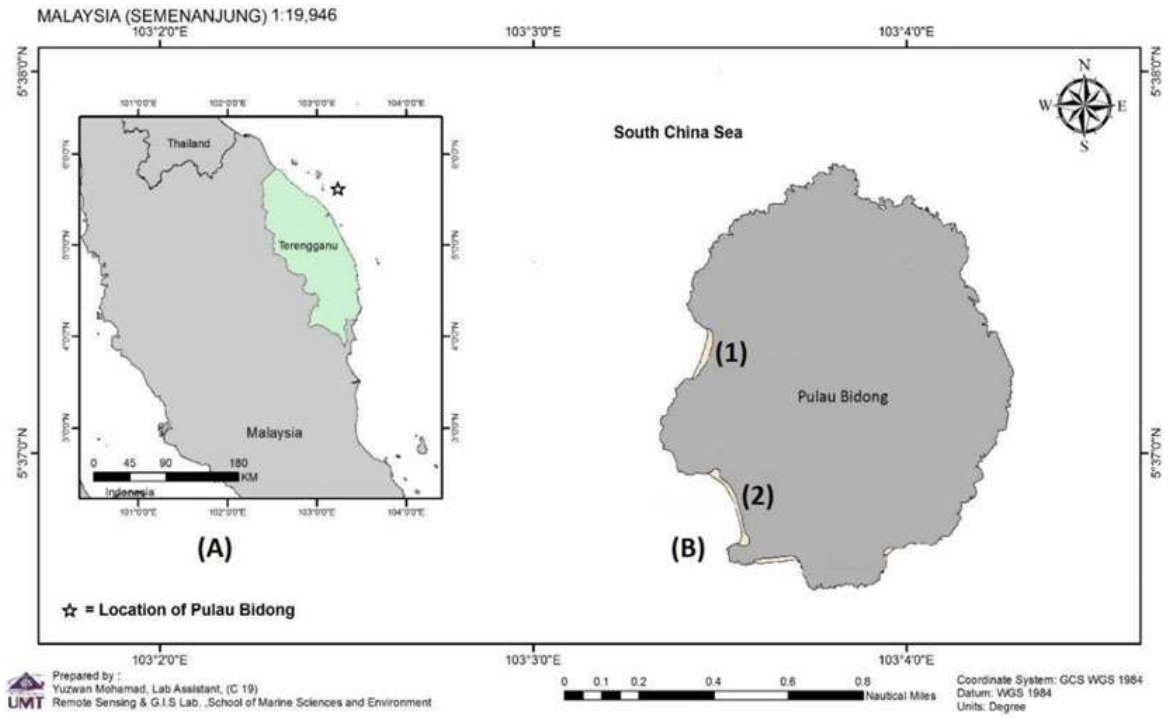


**Fig. 8.1** Location of Bidong Island, Terengganu, Malaysia (**A**), Bidong Island (**B**), Pantai Pasir Cina (1) and Pantai Pasir Pengkalan (2)

## 8.3 Field Surveys

Surveys were conducted using 8 × 40 binoculars to identify bird species (and vocalisations when birds could not be seen) during May 2006, August 2014, May and August 2015, August 2016 and July 2020 (Table 8.1). These surveys took place at the two beach areas and adjacent forest (point count, three points each), with 100 m between each two stations. Data were also collected in 2006 along the Bidong hiking trail (line transect). Vocalisations of some species were used as a record for that species. The Bidong hiking trail was selected as it connects the two beach areas of the island, extending through dense forest. Surveys were conducted during early morning (0700–1000 h) and late afternoon (1700–1900 h), when bird activity is optimal. Two mist-nets on 3 m poles were erected for four full days in May 2006 and May 2015 at the Pantai Pasir Cina and near the Pantai Pasir Pengkalan beach in July 2020, covering the understory level of the canopy. Mist-nets were checked every two hours and closed before dusk. Birds were identified using Jeyarajasingam and Pearson (2012), then released immediately. The sampling effort is shown in Table 8.1.

## 8.4 Data Analyses

Diversity indices (Dominance, Simpson's index, Shannon index) were calculated using PAST v.4.03 (Hammer et al. 2001). Species richness indices and species accumulation rates were assessed by species richness estimators and rarefaction curve analysis, respectively, using row data in estimate S software v9.0.1. The then obtained indices were plotted using MS Excel 2019. The Menhinick's and Margalef indices were selected as measures for species richness measurement. Additionally, five nonparametric species richness estimators (based on abundance data) were computed using EstimateS Version 9.1 (Colwell 2013) to detect changes in species richness estimates and select which estimators are best depending on the collected dataset.

**Table 8.1** Sampling effort, number of bird species and diversity indices in Bidong Island

| | May 2006 | August 2014 | May 2015 | August 2015 | August 2016 | July 2020 |
|---|---|---|---|---|---|---|
| No. sampling days | 2 | 3 | 3 | 3 | 3 | 1 |
| No. observers | 2 | 1 | 2 | 1 | 1 | 3 |
| No. sampling hours | 8 | 12 | 12 | 12 | 12 | 4 |
| No. species | 16 | 9 | 8 | 8 | 16 | 14 |
| No. bird Individuals | 61 | 51 | 40 | 61 | 79 | 81 |
| No. bird individuals/hour | 7.6 | 4.25 | 3.34 | 5.08 | 6.58 | 20.25 |
| Dominance (D) | 0.11 | 0.22 | 0.24 | 0.20 | 0.16 | 0.23 |
| Simpson index (1-D) | 0.89 | 0.78 | 0.76 | 0.80 | 0.84 | 0.77 |
| Shannon index (H) | 2.48 | 1.74 | 1.74 | 1.80 | 2.22 | 1.96 |
| Menhinick index | 2.05 | 1.26 | 1.27 | 1.02 | 1.80 | 1.56 |
| Margalef index | 3.65 | 2.04 | 1.90 | 1.70 | 3.43 | 2.96 |

These estimators are Chao1, Jack1 (i.e. first-order Jackknife), ACE (abundance-based coverage estimator), Bootstrap richness estimator (mean among runs), and Michaelis–Menten Means estimator (MMMeans). Bias, precision and accuracy were calculated for each estimator and ranked from small to large. Then the ranks were summed up for each estimator for Bias, Precision and Accuracy ranking. The lowest total of ranks was considered as the best estimator of species richness.

Species were divided into three categories based on their encountering among sampling years. The categories are "unique species" (species only found at a single time), "duplicates" (species present at two samplings), and "common" (species present at three or more surveys). Furthermore, the species were also classified into three statuses, M = Migrant, R = Resident and RM = mixed populations of resident birds and migrant birds of the same species.

## 8.5 Species Composition and Relative Abundance

A total of 373 bird occurrences, belonging to 30 species have been recorded during the six sampling times (Annex 1). The most observed species was the Black-naped Tern (n = 96, 25.7%). Eighteen families represented the birds of Bidong, the most abundant in terms of species richness was Nectariniidae (n = 5 species, 27.8%), followed by Sternidae and Apodidae (n = 3 species, 16.7%), and Ardeidae, Columbidae, Hirundinidae, (n = 2 species, 11.1%), and the remaining families with one species each: Sturnidae, Accipitridae, Scolopacidae, Charadriidae, Cuculidae, Alcedinidae, Coraciidae, Motacillidae, Sylviidae, Dicaeidae, Oriolidae, Dicruridae (n = 1 species, 5.55%). Species accounts were published earlier in Hamza et al. (2018). During the July 2020 sampling, an additional three species were added to the checklist, namely the Common Tern (*Sterna hirundo*), the Emerald Dove (*Chalcophaps indica*) and an unidentified species of Drongo (*Dicrurus* sp.) The Common Tern is a resident/migrant mixed species, while both Emerald Dove and Drongo are resident species.

## 8.6 Diversity Indices

Table 8.1 shows diversity indices used to define the assemblages of the birds of Bidong Island. In relation to the sample size, dominance was relatively low in May 2006 (0.11) and in August

2016 (0.16) due to high sample size (# observed = 61, # species = 16 for May 2006 and # observed = 79, # species = 16). In May 2015 and July 2020 it was as high as = 0.24 and 0.23 respectively, due to lower species richness (# observed = 40, # species = 8 in Aug 2015 and # observed n = 81, # species 14 in July 2020). This shows the interrelation between sample size, species richness and dominance. Simpson's 1-D diversity index increases wherever dominance is low. Most diverse samples were in May 2006 and August 2016 with 0.89 and 0.85, respectively. A similar trend was observed in Shannon_ H′ values, as May 2006 showed the highest H′ value (2.48) and May 2015 showed the lowest H′ value (1.66).

## 8.7 Species Richness

Species richness varied between eight species (in both May and August 2015) and 16 species (in May 2006 and August 2016), with an overall average of 11.83 ± 3.92 species/year. The Menhinick index showed that the highest species richness (D = 2.05), was reported in May 2006, while the lowest D = 1.02 was in August 2015. A similar trend was obtained for the Margalef index (Table 8.1).

The surveys resulted in a total of 17 (56.7%) "unique species" (species only found at a single time), two species (6.7%) were "duplicate" (species present at two samplings), while the remaining 11 species (36.7%) were "common" (species present at three or more surveys). Based on the species status in Malaysia (Resident, Migrant, Resident or Migrant), results showed that 17 species (63.3%) of birds in Bidong Island were resident, while five species (16.67%) were migratory and six species (20%) belong to the Resident or Migrant mixed population group (Fig. 8.2).

Based on species division into unique, duplicate and common, 8 out of 19 resident species (42.1%) were unique, two species were duplicates (10.53%), and nine species were common (47.37%). In the migratory species group, there were five unique species, while both duplicates and common were not represented. In the mixed populations of both migratory and resident species, four species were unique (66.67%) whilst two species were common (33.33%), with no duplicates detected.

Duplicate species gradually decreased towards the last sampling whilst unique species still showed increments, although in smaller numbers (Fig. 8.3).

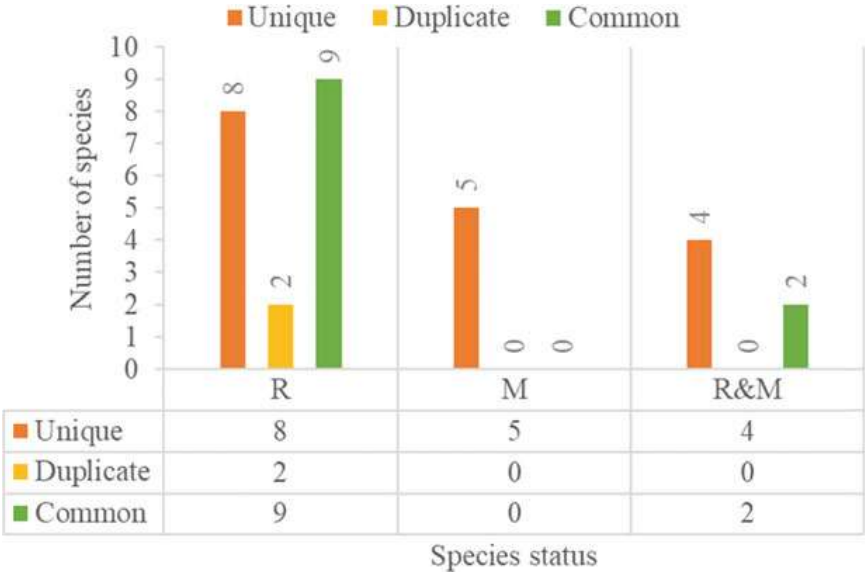


**Fig. 8.2** The number of unique, duplicate and common species according to residential status; resident (R), migrant (M), resident and migrant (R/M)

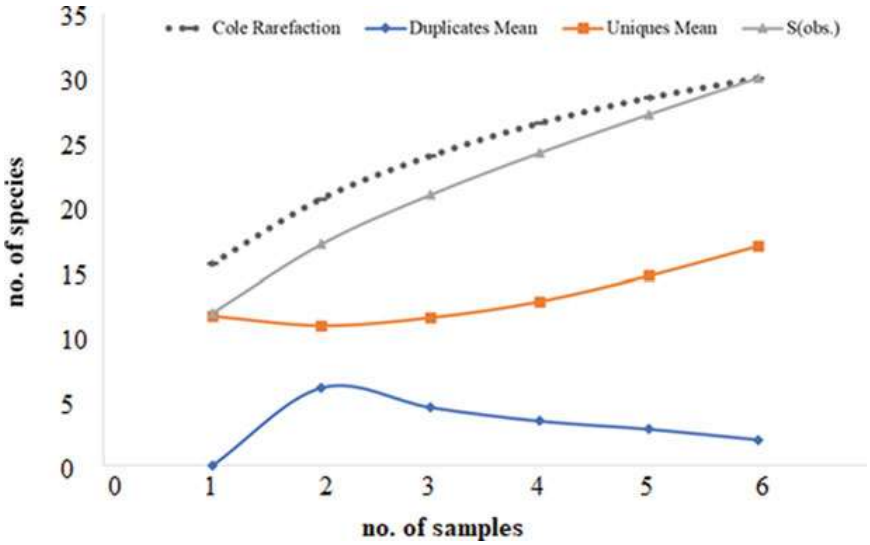


**Fig. 8.3** Species accumulation and Cole rarefaction curve for bird species richness and their unique and duplicate occurrence during six samplings (years) at Bidong Island

## 8.8 Performance Evaluation of Estimators

The Chao-1 estimator was the least biased and most accurate or precise estimate for species richness in Bidong Island birds, followed by the abundance-based coverage estimator (ACE) and Bootstrap (Fig. 8.4). Meanwhile, both MMMeans and Jack-1 showed higher bias and lower accuracy and precision; therefore, they were less suitable to estimate the real species richness of birds at Bidong Island. Chao-1 estimated the total species richness of birds in Bidong to reach 35.32 species, i.e. five more species than the observed species in this study. Bootstrap was 35.92 and ACE estimated 36 species, in close similarity to the bootstrap estimator. On the other hand, the Jack-1 estimate was 44.17 and MMMeans was 40.99, leaving these two estimates the least accurate and most biased among the five estimators used.

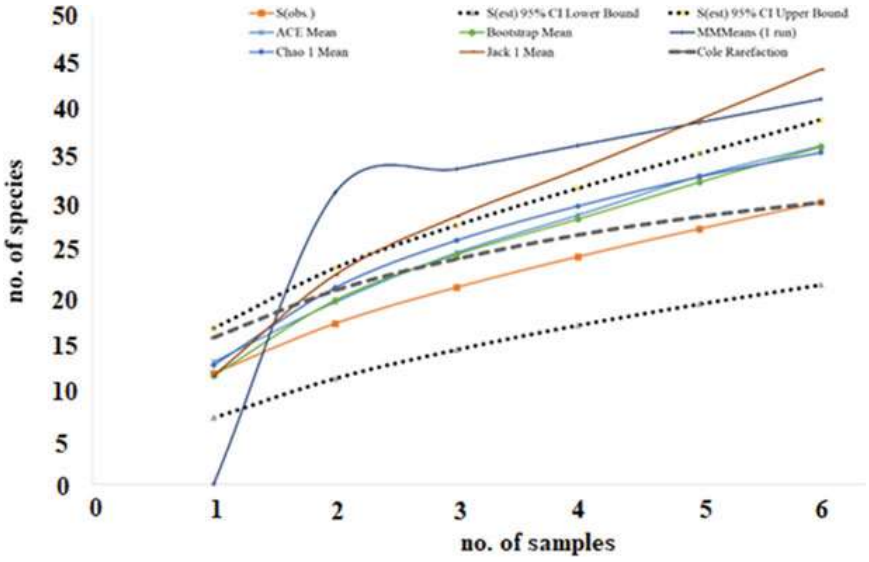


**Fig. 8.4** Observed sampling accumulation curve (with lower and upper bounds) and nonparametric estimator performance of birds in Bidong Island, from the three least bias, most accurate and precise estimators (Chao-1, ACE and Bootstrap)

## 8.9 Species Composition and Relative Abundance

The species composition of bird fauna at Bidong Island is 30 species. Other islands have a much higher species count. For example, 148 species at Tioman Island, and 46 species at Redang Island (Tamblyn et al. 2005). Bidong Island belongs to lower diverse islands, similar to Perhentian Island that has 31 bird species (Tamblyn et al. 2005). The diversity of birds in Terengganu state is 463 species (McAfee 2017). The species accumulation curve in the present study did not reach an asymptote; therefore the sampling was considered incomplete because the number of unique species was still increasing, adding new species to the total diversity (Azman et al. 2019). A further long-term survey is needed to obtain complete bird species richness at Bidong Island.

A notable anthropogenic effect on Bidong ecosystems happened between 1978 and 1991, pas the island became a refugee camp, with a population of as many as 40,000 Vietnamese refugees at one time. With the need for timber to build houses and other structures, a change of vegetative cover can drive some species to abandon the island (birds and bats) or cause local extinctions to others. A set of recent surveys reported, for example, five species of wild bees (Adanan et al. 2016), ten species of butterflies (Rosmidi et al. 2017), 13 species of reptiles (Zakaria et al. 2017), and ten species of bats (Roslan et al. 2016). Bird species counts at Bidong Island are much lower than those from Redang and Perhentian Island. When it comes to tree species, both Bidong and Redang support 56 species each (Pesiu et al. 2016), however, there are only ten plant species shared between the two islands. This differences in tree composition can produce differences in bird species composition (Hořák et al. 2019). Furthermore, the small surface area of Bidong Island (one square kilometre), should also be taken into account, when comparing this island with larger islands in the area, a small area can support a limited number of species (The Theory of Island Biogeography).

With no long-term data in the past 100 years, it would be challenging to choose which hypothesis is more accurate. Is this lower bird diversity on Bidong a result of smaller surface area/ habitats diversity and resources, or it was drastically affected during the Vietnamese refugee crisis. Bidong is located not too far apart from other islands, thus relocation and colonisation are still possible, which explains why the species accumulation curve does not reach asymptotic in this study.

Species composition, therefore, reflects the present diversity of habitats and feeding guilds available on the island. Most of the surveyed area was a growing secondary forest with understory plant cover. This habitat can increase bird species richness and abundance of some bird species (Nájera and Simonetti 2010), particularly the understory bird communities (insectivorous, frugivorous, granivorous, and nectarivorous birds). These make up the majority of the birds in Bidong Island. Eleven species were insectivores (36.67%), and five species were nectarivores (16.67%), while other species were frugivores (two Pigeon species). Habitat changes can influence the community structure of understorey birds (Ramli et al. 2010). Therefore, the present composition of the understory bird community can be different from other undisturbed islands in Malaysia. The total recovery of forest specialist birds in regenerated forest increases with time when the regenerated forests are left untouched for about 20–40 years (Dent and Write 2009).

The sample size of birds in the present study caused lower dominance in both 2006 and 2016, whilst when species richness is lower, dominance was higher in May 2015 and July 2020. A similar

trend was observed for species diversity, where 2006 had the highest species diversity while in 2015, the lowest diversity was recorded. This finding can also be attributed to individual differences in observation and sampling effort. Species richness of many organisms' changes over time (Hillebrand et al. 2018; McGlynn 2010) as the artefact of habitat or environmental changes. This is also true for bird species on Bidong Island. Species richness is changing continuously but remains in equilibrium with other food sources (Duffy 2002; Wiens 2011). In 2006, four days of two daily surveys yielded a higher diverse species list than two days sampling in 2014–2016 and one day in 2020. Thus, higher species richness was noted in 2006 compared to the other years, from both Menhinick and Margalef indices (Table 8.1).

Unique species represented the highest proportion of reported species (56.7%), due to the continuous recording of new species at each sampling, which gradually contributed to the incremental increase of the species accumulation curve. Only 6.7% of the species were seen twice (duplicates), and 36.7% of species were encountered at three or more samplings (common). This situation also reflects the island's topography, as several areas were inaccessible due to dense canopy and altitude, with no suitable trails to cover the whole island. Therefore when we used the limited area near the coast, newer species were added each time, as those species do forage at the lower, more open area of the island. The remaining species that were more common and seen at each survey, such as the Pied Imperial Pigeon, Black-naped Tern, White-bellied Sea Eagle and White-nest Swiftlet, were all open area species that can be easily spotted.

Bidong Island was found to harbour a total of 30 bird species, which represent 62.13% more species than previously collected by Bonhote (1901), Kloss (1911) and Gibson-Hill (1952). An additional nine species were observed by either the historical studies mentioned above or from recent observations by Bruce (2018) and Rahman (2019), both retrieved from the eBird database. Details of species reported by all studies including the present study is detailed in Table 8.2.

Nearly two-thirds of Bidong Island birds (19 species) were resident species. Migrant and resident/migrant species were five and six species

**Table 8.2** Taxonomic composition of Bidong Island bird species, based on published data, and the results of the present study

| No | Common name | Latin name | Bonhote (1901) | Kloss (1911) | Gibson-Hill (1952) | Bruce (2018) | Rahman (2019) | This study |
|---|---|---|---|---|---|---|---|---|
| 1 | Cattle egret | *Bubulcus ibis* | | | | | | X |
| 2 | Pacific reef egret | *Egretta sacra* | | X | X | X | X | X |
| 3 | White-bellied sea eagle | *Haliaeetus leucogaster* | | | | X | X | X |
| 4 | Common sandpiper | *Actitis hypoleucos* | X | X | | | | X |
| 5 | Greater sand plover | *Charadrius leschenaultii* | | | | | | X |
| 6 | Kentish plover | *Charadrius alexandrines* | X | | | | | |
| 7 | White-breasted waterhen | *Amaurornis phoenicurus* | | | | | X | |

(continued)

**Table 8.2** (continued)

| No | Common name | Latin name | Bonhote (1901) | Kloss (1911) | Gibson-Hill (1952) | Bruce (2018) | Rahman (2019) | This study |
|---|---|---|---|---|---|---|---|---|
| 8 | Black-naped tern | *Sterna sumatrana* | | | X | X | | X |
| 9 | Bridled tern | *Onychoprion anaethetus* | | | | X | | X |
| 10 | Common tern | *Sterna hirundo* | | | | | | X |
| 11 | Great crested tern | *Sterna bergii* | | | | X | | |
| 12 | Lesser frigatebird | *Fregata ariel* | | | | X | | |
| 13 | Emerald dove | *Chalcophaps indica* | | | | | | X |
| 14 | Pied imperial pigeon | *Ducula bicolour* | | X | X | | X | X |
| 15 | Asian Koel | *Eudynamis scolopacea* | | X | | | | X |
| 16 | House swift | *Apus affinis* | | | | | | X |
| 17 | Silver-rumped Needletail | *Rhapidura leucopygialis* | | | | | | X |
| 18 | Black-nest swiftlet | *Aerodramus maximus* | | | | | | X |
| 19 | White-nest swiftlet | *Aerodramus fuciphagus* | | | | X | | X |
| 20 | Collared Kingfisher | *Todiramphus chloris* | | | | X | X | X |
| 21 | Dollarbird | *Eurystomus orientalis* | | | | | | X |
| 22 | Barn swallow | *Hirundo rustica* | | | | | X | X |
| 23 | Pacific swallow | *Hirundo tahitica* | | | | | | X |
| 24 | Grey wagtail | *Motacilla cinerea* | | | | | | X |
| 25 | Eastern yellow wagtail | *Motacilla tschutschensis* | | | | X | | |
| 26 | Arctic warbler | *Phylloscopus borealis* | | | | | | X |
| 27 | Purple-throated sunbird | *Nectarinia sperata* | | | X | | | X |

(continued)

**Table 8.2** (continued)

| No | Common name | Latin name | Bonhote (1901) | Kloss (1911) | Gibson-Hill (1952) | Bruce (2018) | Rahman (2019) | This study |
|---|---|---|---|---|---|---|---|---|
| 28 | Brown-throated sunbird | *Anthreptes malacensis* | X | | | | X | X |
| 29 | Olive-backed sunbird | *Nectarinia jugularis* | | | | | | X |
| 30 | Little spiderhunter | *Arachnothera longirostra* | | | | | | X |
| 31 | Ruby-cheeked sunbird | *Anthreptes singalensis* | | | | | | X |
| 32 | Orange-bellied flowerpecker | *Dicaeum trigonostigma* | | | | | | X |
| 33 | Black-naped oriole | *Oriolus chinensis* | | | | | | X |
| 34 | Asian glossy starling | *Aplonis panayensis* | | X | X | | | X |
| 35 | Drongo sp. | *Dicrurus sp.* | | | | | | X |
| 36 | The crow-billed drongo | *Dicrurus annectens* | X | | | | | |
| 37 | Sunda crow | *Corvus compilator* | X | | | | | |
| 38 | Tiger shrike | *Lanius tigrinus* | | | | X | | |

respectively, indicating the island's importance for migratory species. Similar results were obtained from Peninsular Malaysia rice fields, where resident species also are dominant (Azman et al. 2019). The migrant species at Bidong were spotted at the start of the migration season in mid-August. All migrant species encountered in the present study (5 species) were unique species (i.e., observed once for each). At the same time, four of the mixed resident/migrant species were also unique species, and two were duplicate. Additional species are expected to be added if other surveys cover the peak migration season in October and November. It is also predicted that duplicate species would continue to decrease, while unique species would meet at a point with duplicate species and decrease gradually with completion of species richness.

## 8.10 Performance Evaluation of Estimators

Given the present data from 2006, 2014–2016, and 2020 surveys, three nonparametric species richness estimators (Chao-1, ACE and bootstrap) were the least biased, most accurate and precise estimators of avian species richness in Bidong Island. All three estimators suggesting an additional 5–6 species to be added to the birds of Bidong if more sampling were conducted. However, we cannot assume that the total species richness of birds at Bidong Island is 36 species, as this estimate isn't built on saturated sampling (i.e., the species accumulation curve did not reach asymptote). After this estimate, we have added data collected by two professional birders, Neil Bruce and Abdul Jalil Rahman, during 2018 and 2019, respectively. These additions make the total number of species observed 39, close to the statistical estimators used here. These estimates are extrapolating the final species richness estimate based on available data. Nonetheless, species richness estimators give us a good estimation of local diversity with limited data. This information will be helpful in biodiversity assessment and help conservation managers to assign management tools to safeguard avifauna on the islands.

## 8.11 Conclusion

Diverse habitats on this island allowed resource partitioning among avian species. Each species is restricted to a specific feeding guild, such as nectarivores and frugivores, with a limited number of insectivores and piscivores. The presence of Vietnamese refugees between 1978 and 1991 can be one of the factors which may have influenced the lower species richness of birds and other vertebrates on the island compared to the nearby islands in the region, due to the overcrowded population and major changes to plant cover and landscape at both coastal sites of this study. An assessment of native and introduced flora and fauna should be conducted in both Bidong Island and the nearby islands to quantify that impact. More systematic surveys during the migration season, and extended point counts and mist-netting to other sides of Bidong Island and the nearby smaller islands would undoubtedly add more bird species that were not reported in the present study. The use of modern acoustic stations and camera traps for long term data collection can expose the full potential of Bidong Island Faunal diversity.

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## Annex 1

A collage of selected species of birds from Bidong Island, numbers corresponding to species name at Table 8.3. Photo credits Anuar McAfee and A Hamza

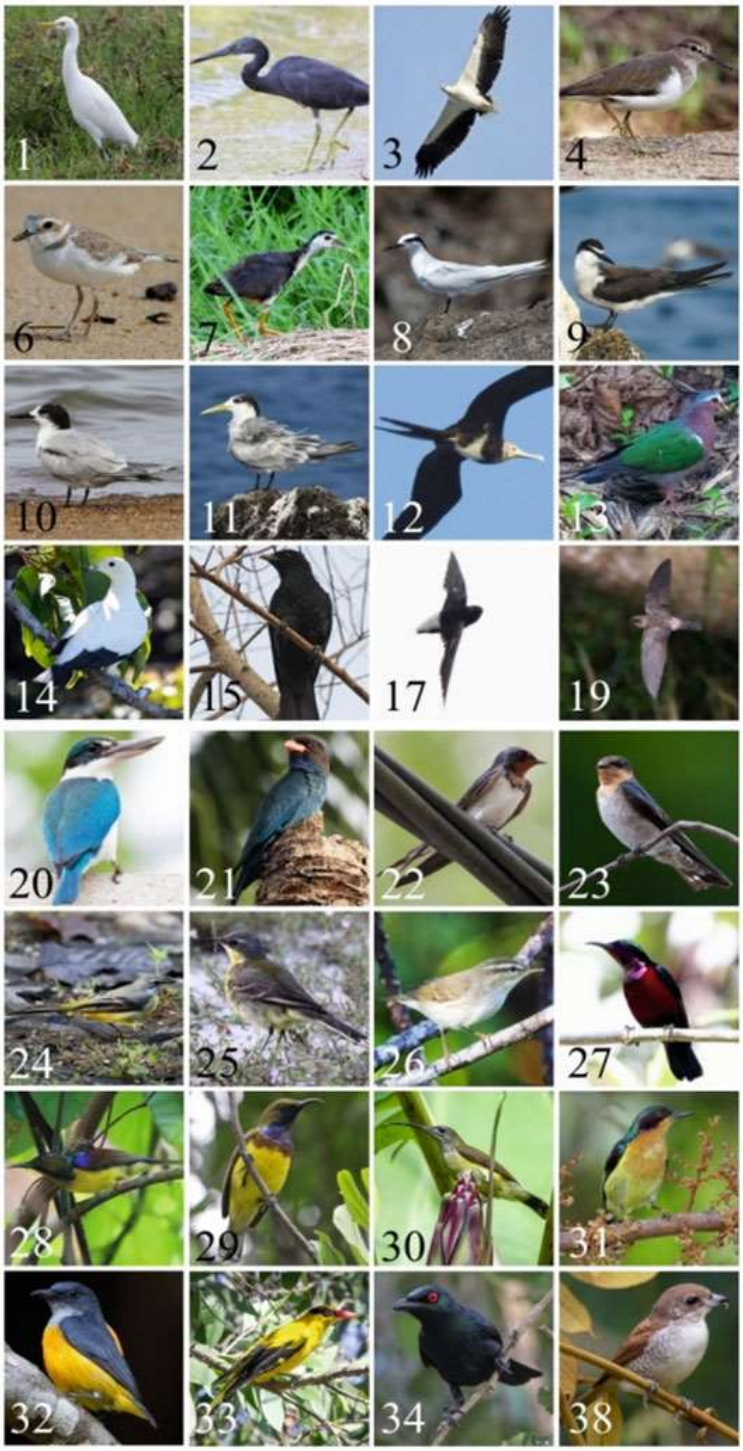
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**Table 8.3** List of bird species from Bidong Island and its status, according to IUCN Red List and Wildlife Conservation Act (WCA2010). LC = Least Concern; TP = Totally Protected species; HS = Hunted species, NL = Not listed in WCA 2010

| No | Family | Common name | Latin name | IUCN red list status | WCA 2010 | May-2006 | Aug-2014 | May-2015 | Aug-2015 | Aug-2016 | Jul-2020 | Total | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ardidae | Cattle egret | *Bubulcus ibis* | LC | TP | 0 | 0 | 0 | 0 | 1 | 0 | 1 | R, M |
| 2 | Ardidae | Pacific reef egret | *Egretta sacra* | LC | TP | 6 | 3 | 4 | 4 | 5 | 3 | 25 | R |
| 3 | Accipitridae | White-bellied sea eagle | *Haliaeetus leucogaster* | LC | TP | 3 | 2 | 3 | 3 | 2 | 3 | 16 | R |
| 4 | Scolopacidae | Common sandpiper | *Actitis hypoleucos* | LC | TP | 0 | 0 | 0 | 0 | 1 | 0 | 1 | M |
| 5 | Charadriidae | Greater sand plover | *Charadrius leschenaultii* | LC | TP | 0 | 1 | 0 | 0 | 0 | 0 | 1 | M |
| 6 | Laridae | Black-naped tern | *Sterna sumatrana* | LC | TP | 5 | 15 | 0 | 19 | 22 | 35 | 96 | R |
| 7 | Laridae | Bridled tern | *Onychoprion anaethetus* | LC | TP | 1 | 2 | 0 | 0 | 2 | 2 | 7 | R |
| 8 | Laridae | Common tern | *Sterna hirundo* | LC | TP | 0 | 0 | 0 | 0 | 0 | 2 | 2 | R, M |
| 9 | Columbidae | Emerald dove | *Chalcophaps indica* | LC | HS | 0 | 0 | 0 | 0 | 0 | 1 | 1 | R |
| 10 | Columbidae | Pied imperial pigeon | *Ducula bicolour* | LC (pop decreasing) | TP | 15 | 15 | 17 | 10 | 8 | 5 | 70 | R |
| 11 | Cuculidae | Asian Koel | *Eudynamis scolopacea* | LC | NL | 1 | 0 | 0 | 0 | 0 | 0 | 1 | R, M |
| 12 | Apodidae | House swift | *Apus affinis* | LC | TP | 2 | 2 | 0 | 4 | 0 | 0 | 8 | R |
| 13 | Apodidae | Silver-rumped Needletail | *Rhapidura leucopygialis* | LC | TP | 2 | 0 | 0 | 0 | 0 | 0 | 2 | R |
| 14 | Apodidae | Black-nest swiftlet | *Aerodramus maximus* | LC | NL | 0 | 0 | 0 | 0 | 0 | 10 | 10 | R |
| 15 | Apodidae | White-nest swiftlet | *Aerodramus fuciphagus* | LC | NL | 6 | 10 | 0 | 15 | 18 | 10 | 59 | R |
| 16 | Alcedinidae | Collared Kingfisher | *Todiramphus chloris* | LC | TP | 3 | 1 | 0 | 2 | 2 | 1 | 9 | R, M |
| 17 | Coraciidae | Dollarbird | *Eurystomus orientalis* | LC | TP | 0 | 0 | 0 | 0 | 1 | 0 | 1 | R, M |

(continued)

**Table 8.3** (continued)

| No | Family | Common name | Latin name | IUCN red list status | WCA 2010 | May-2006 | Aug-2014 | May-2015 | Aug-2015 | Aug-2016 | Jul-2020 | Total | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Hirundinidae | Barn swallow | *Hirundo rustica* | LC | TP | 0 | 0 | 0 | 0 | 3 | 0 | 3 | M |
| 19 | Hirundinidae | Pacific swallow | *Hirundo tahitica* | LC | TP | 0 | 0 | 2 | 4 | 2 | 5 | 13 | R |
| 20 | Motacillidae | Grey wagtail | *Motacilla cinerea* | LC | TP | 0 | 0 | 0 | 0 | 1 | 0 | 1 | M |
| 21 | Sylviidae | Arctic warbler | *Phylloscopus borealis* | LC | TP | 2 | 0 | 0 | 0 | 0 | 0 | 2 | M |
| 22 | Nectariniidae | Purple-throated sunbird | *Nectarinia sperata* | LC | TP | 6 | 0 | 7 | 0 | 5 | 0 | 18 | R |
| 23 | Nectariniidae | Brown-throated sunbird | *Anthreptes malacensis* | LC | TP | 0 | 0 | 3 | 0 | 0 | 0 | 3 | R |
| 24 | Nectariniidae | Olive-backed sunbird | *Nectarinia jugularis* | LC | TP | 2 | 0 | 0 | 0 | 0 | 1 | 3 | R |
| 25 | Nectariniidae | Little spiderhunter | *Arachnothera longirostra* | LC | TP | 1 | 0 | 0 | 0 | 1 | 0 | 2 | R |
| 26 | Nectariniidae | Ruby-cheeked sunbird | *Anthreptes singalensis* | LC | TP | 0 | 0 | 2 | 0 | 0 | 0 | 2 | R |
| 27 | Dicaeidae | Orange-bellied flowerpecker | *Dicaeum trigonostigma* | LC | TP | 0 | 0 | 2 | 0 | 0 | 0 | 2 | R |
| 28 | Oriolidae | Black-naped oriole | *Oriolus chinensis* | LC | TP | 3 | 0 | 0 | 0 | 5 | 2 | 10 | R, M |
| 29 | Sturnidae | Asian glossy starling | *Aplonis panayensis* | LC | NL | 3 | 0 | 0 | 0 | 0 | 0 | 3 | R |
| 30 | Dicruridae | Drongo sp. | *Dicrurus sp.* | – | TP | 0 | 0 | 0 | 0 | 0 | 1 | 1 | R |

## References


Abdullah F (2006) Diversity of beetles in the North East Langkawi Islands, Malaysia. Malay Nat J 57:419–431

Adanan NA, Basari NO, Rosmidi FH, Pesiu EL, Abdullah MT (2016) Preliminary studies on bees at Pulau Bidong and Pulau Perhentian, Terengganu. J Sustain Sci Manag (1):36–40

Armugam P (1981) Algal distribution in a Malaysian coral reef at Pulau Bidong Laut. Pertanika 4(1):99–102

Azman NM, Sah SAM, Ahmad A, Rosely NF (2019) Contribution of rice fields to bird diversity in Peninsular Malaysia. Sains Malaysiana 48(9):1811–1821

Bonhote JLJ (1901) On the birds collected during the "Skeat Expedition" to the Malay Peninsula, 1899–1900. Zoological Society of London

Bruce N (2018) eBird checklist: https://ebird.org/australia/checklist/S48900603. eBird: an online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. http://www.ebird.org. Accessed 9th May 2021

Colwell RK (2013) EstimateS: statistical estimation of species richness and shared species from samples. Version 9.1.0. User's guide and application. http://purl.oclc.org/estimates. Accessed 10th Aug 2021

Cronk QCB (1997) Islands: stability, diversity, conservation. Biodivers Conserv 6:477–493

David G, Roslan A, Mamat M, Abdullah MT, Hamza A (2016) A brief survey on birds from Pulau Perhentian Besar, Terengganu. J Sustain Sci Manag Int Sem Straits Malacca South China Sea 11–18

Dent DH, Wright SJ (2009) The future of tropical species in secondary forests: a quantitative review. Biol Conserv 142(12):2833–2843

Duffy JE (2002) Biodiversity and ecosystem function: the consumer connection. Oikos 99:201–219

Gibson-Hill CA (1952) Ornithological Notes from the Raffles Museum 15, Notes on the Avifauna of Great Redang Island (Terengganu). Bullet Raffles Museum 24:220–240

Grismer LL, Wood PL Jr, Ahmad AB, Sumarli AS-I, Vazquez JJ, Ismail LH, Nance R, Mohd-Amin MAB, Othman MN, Rizaijessika SA (2014) A new species of insular Rock Gecko (genus *Cnemaspis* Strauch 1887) from the Bidong Archipelago, Terengganu, Peninsular Malaysia. Zootaxa 3755:447–456

Hammer Ø, Harper DAT, Ryan PD (2001) PAST: Paleontological statistics software package for education and data analysis. Palaeontol Electron 4(1):1–9

Hamza A, Ho WC (2020) Updates on seabirds of the northern Seribuat Islands, Pahang, Malaysia. Mar Ornithol 48:1–7

Hamza A, David G, Mcafee A, Tajuddin M (2018) Annotated checklist of avifauna in Pulau Bidong, Malaysia. J Sustain Sci Manag 13(1):105–118

Hamza A, Wong CH, Ahmad A (2016) Pulau Ling: an important seabird hotspot on the east coast of Peninsular Malaysia. J Asia-Pacific Biodiv 9:437–442

Hamza AA, Wong CH, Ahmad A (2016) Rediscovery of least known breeding sites for seabirds in East Coast Peninsular Malaysia. Malay Nat J 68:121–129

Hillebrand H, Blasius B, Borer ET, Chase JM, Downing JA, Eriksson BK, Filstrup CT, Harpole WS, Hodapp D, Larsen S, Lewandowska AM (2018) Biodiversity change is uncoupled from species richness trends: consequences for conservation and monitoring. J Appl Ecol 55(1):169–184

Hořák D, Ferenc M, Sedláček O, Motombi FN, Svoboda M, Altman J, Albrecht T, Djomo Nana E, Janeček Š, Dančák M, Majeský Ľ (2019) Forest structure determines spatial changes in avian communities along an elevational gradient in tropical Africa. J Biogeogr 46(11):2466–2478

Jamoneau A, Passy SI, Soininen J, Leboucher T, Tison-Rosebery J (2018) Beta diversity of diatom species and ecological guilds: response to environmental and spatial mechanisms along the stream watercourse. Freshw Biol 63(1):62–73

Jeropakal AJ (1998) A study on clownfish (*Amphiprion* sp.) diversity and associate with sea anemone in some selected sites in Pulau Bidong and Pulau Redang. B. Sc. Thesis. Fakulti Perikanan dan Akua-Industri. Kolej Universiti Sains dan Teknologi Malaysia (KUSTEM)

Jeyarajasingam A, Pearson A (2012) A field guide to the birds of Peninsular Malaysia and Singapore. Oxford University Press, London, UK

Khor HM (2002) Composition and distribution of corals and macroalgae in Pulau Bidong and the island's proposed management plan. Master thesis. Fakulti Sains dan Teknologi, Kolej Universiti Sains dan Teknologi Malaysia (KUSTEM)

Kloss C (1911) On a collection of mammals and other vertebrates from the Terengganu Archipelago. J Fed Malay States Museums 4:175–212

Koh LP, Sodhi NS, Tan HTW, Peh KSH (2002) Factors affecting the distribution of vascular plants, springtails, butterflies and birds on small tropical islands. J Biogeogr 29(1):93–108

Lack D (1970) Island birds. Biotropica 2(1):29–31

Lorenzo B, Kochzius M, Cardenosa D, Borsa P, Ambak MA, Joseph J (2016) Connectivity and population structure of Blacktip reef sharks, *Carcharhinus melanopterus*, in two islands in Terengganu, Malaysia. Book of Abstracts: Vliz Marine Scientist Day Vives, Brugge. http://pure.ilvo.vlaanderen.be/portal/files/4227992/VLIZ_2016_Book_of_asbtracts.pdf#page=32. Accessed 11th Aug 2017

McAfee A (2017) Birds of Terengganu: Burung-burung Di Negeri Terengganu. Penerbit Universiti Sultan Zainal Abidin. pp157

McGlynn T (2010) Effects of biogeography on community diversity. Nat Educ Knowl 1(8):32

Nájera A, Simonetti JA (2010) Enhancing avifauna in commercial plantations. Conserv Biol 24(1):319–324

Nakajima R, Yoshida T, Azman BAR, Yamazaki H, Toda T, Othman BHR, Effendy AWM (2013) A preliminary study of small scavenging crustaceans

collected by baited traps in a coral reef of Bidong Island Malaysia. Malaysian J Sci 33(2):59–66
Ng PK, Yong HS, Sodhi NS (1999) Biodiversity research on Pulau Tioman, Peninsular Malaysia: a historical perspective. Raffles Bull of Zool 6:5–10
Pesiu E, Abdullah MT, Salim J, Salam MR (2016) Tree species composition in Pulau Bidong and Pulau Redang. J Sustain Sci Manag (1):48–50
Rahman A (2019) eBird checklist: https://ebird.org/malaysia/checklist/S54472874. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. http://www.ebird.org. Accessed 9th May 2021
Ramli R, Ya'cob Z, Aimi F, Ezyan NH (2010) A survey of avifauna in Bachok District, Kelantan, Peninsular Malaysia. Malaysian J Sci 29:121–130
Roslan A, David G, Ahmad NI (2016) Notes of Bats in Pulau Bidong and Pulau Perhentian Besar, Terengganu, Malaysia. J Sustain Sci Manag Int Sem Straits Malacca South China Sea 2016:2026–2035
Rosmidi FH, Zahidin MA, Adanan A, Azizah A, Pesiu E, Abdullah MT (2017) Checklist of butterflies in Pulau Perhentian and Pulau Bidong, Terengganu. J Sustain Sci Manag 12(1):40–48
Sodhi NS, Briffett C, Lee BPY, Subaraj R (1999) An annotated checklist of the birds of Pulau Tioman, Peninsular Malaysia. Raffles Bull Zool 6:125–130
Tamblyn A, Turner C, O'Malley R, Hughes T, Hardingham S, Roberts H (2005) Malaysian tropical forest conservation project. Report of the Perhentian Phase, London, United Kingdom
Teh T (2000) Sustainable development and environmental management of Malaysian islands. In: Islands in Malaysia: issues and challenges. Kuala Lumpur: University of Malaya, , pp 319–340
Turner C, King T, O'Malley R, Cummings M, Raines P (2002) Danjugan Island Biodiversity survey: terrestrial. final report. Coral Cay Conservation Ltd., London, unpublished report. https://silo.tips/download/2-nd-danjugan-island-biodiversity-survey-terrestrial. Accessed 10th Aug 2021
Valente L, Illera JC, Havenstein K, Pallien T, Etienne RS, Tiedemann R (2017) Equilibrium bird species diversity in Atlantic islands. Curr Biol 27(11):1660–1666
Wells D, Round PD, Treesucon U (1999) The birds of the Thai-Malay Peninsula: covering Burma and Thailand south of the eleventh parallel. Academic Press, San Diego, Peninsular Malaysia and Singapore
Wells DR (2007) The birds of the Thai-Malay Peninsula Passerines of Passerines, vol 2. Christopher Helm, London, UK
Wiens JJ (2011) The causes of species richness patterns across space, time, and clades and the role of "ecological limits." Q R Biol 86(2):75–96
Zakaria AA, Noor Aisyah AR, Abdullah MT (2017) Reptile diversity as an ecotourism attraction in Pulau Bidong. In: Mariapan M, Evelyn LAL, Isa SS, Karim MS, Hakeem KR (eds) Ecotourism potentials in Malaysia. Universiti Putra Malaysia

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