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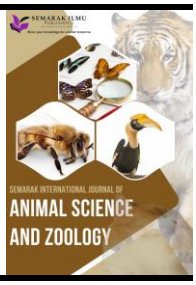

Diversity and Richness of Birds in Tasik Chin Chin, Melaka, Peninsular Malaysia

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ABSTRACT

Tasik Chin Chin serves as a vital wetland habitat, home to a rich diversity of wildlife, particularly avian species. However, there are plans to construct a dam to meet the increasing water demands in the state, raising concerns about the potential impact on local ecosystems. To address the lack of prior research concerning bird species richness in this area, a comprehensive study was conducted to establish a detailed inventory. Over the course of two days in March 2023, bird observations and photographic documentation were carried out during the early morning and evening—times when bird activity is highest. This effort led to the identification of 401 individual birds representing 45 species across 26 families. Notably, the family Cuculidae displayed the greatest species richness, comprising five distinct species. The most prevalent bird observed was the *Acridotheres javanicus*, commonly known as the Javan Myna, which accounted for 53 sightings. The findings also indicated the presence of two bird species of conservation concern, both listed on the IUCN Red List. *Acridotheres javanicus* is classified as Vulnerable, while *Phaenicophaeus diardi*, or the Black-bellied Malkoha, is considered Near Threatened. The analysis of species diversity yielded a Shannon Index value of H' = 3.12, indicating high diversity, which is further supported by a Simpson Index value of 1/D = 0.94. Additionally, the Chao-1 estimator suggested that a total of approximately 85 bird species could be found in the region with more extensive sampling efforts. The results of this study will serve as a crucial resource for developers, providing a basis for monitoring changes during and after the implementation of development activities. Moreover, these findings can be utilized as a benchmark for future restoration and conservation initiatives aimed at preserving avian biodiversity in Tasik Chin Chin.

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1. Introduction

Birds are capable of inhabiting and thriving in a wide range of terrestrial environments across all seven continents. They can be found in diverse habitats including coastal regions, freshwater bodies, seas, agricultural lands, urban areas and islands. Currently, there are 44 orders of birds and a total of 11,032 bird species documented globally over the past century [1]. Unfortunately, over the last five centuries, it is estimated that more than 150 bird species have gone extinct, and over 1,400 species are now threatened with extinction [2]. Malaysia stands out for its remarkable biodiversity, largely due to its strategic location in the tropics, characterized by abundant rainfall and a variety of ecosystems. This diversity of habitats significantly contributes to the richness of avifauna found in the region. Birds fulfill various critical ecological roles in their environments, including seed dispersal, pollination, pest control and nutrient cycling. They also serve as indicator species, reflecting the overall health and integrity of the ecosystems they inhabit.

Preserving bird diversity is essential for maintaining a balanced and healthy environment [3]. The presence, abundance, and diversity of specific bird species can provide vital insights into ecosystem health. However, human activities that transform or extract from natural habitats, such as deforestation and other land-use changes, pose significant threats to bird communities. Habitat destruction and degradation are among the most pressing challenges facing avifauna. The loss of natural habitats, including unregulated deforestation and drastic alterations of landscapes, disrupts the annual breeding cycles of birds [4], leading to declines in bird biodiversity in affected regions.

The state of Melaka, situated along the Straits of Malacca, is renowned for its rich biodiversity, which includes a diverse array of flora and fauna thriving in its lush forests, wetlands and coastal regions. As a strategic maritime trade gateway, Melaka has experienced a blending of various cultural influences, contributing to a unique ecological landscape.

Melaka's dynamic geography enhances its biodiversity, making it a hub for a wide range of plant and animal species. The tourism industry plays a pivotal role in the state's efforts to conserve its biological heritage; however, water scarcity presents a significant challenge to urban tourism development [5]. Rapid population growth coupled with increased tourist activity has intensified public health concerns, economic pressures and environmental degradation, particularly regarding water shortages.

In response to these pressing issues, the TAPS (Takungan Air Pinggiran Sungai) project has been initiated to augment the raw water supply in Melaka. This development initiative involves constructing critical infrastructure, including retention ponds, barrages, holding ponds, inlet structures and draw-off towers, particularly at strategic sites such as Tasik Biru Chin Chin in Jasin. With federal government funding secured, the TAPS project aims to reduce Melaka's dependency on raw water supplies from neighbouring states and to provide additional water resources, supporting the state's needs through to 2040 [6].

Plans for a dam construction at Tasik Chin Chin are underway, raising concerns about the potential negative impact on the local bird population due to physical disturbances and changes in land use. To ensure that this development aligns with conservation efforts for both flora and fauna, it is essential to strike a balance between national development and the preservation of natural ecosystems. Currently, there is a lack of detailed research on the diversity and richness of bird species in the Tasik Chin Chin area. In response, a study is being conducted to assess the avifauna diversity within the surrounding habitat. This research aims to identify the extent and composition of bird species present, providing critical insights into their ecological status.

The findings from this monitoring study will play a vital role in tracking spatial and temporal changes in bird habitats. Furthermore, the results will serve as a benchmark for implementing

effective conservation measures, ensuring the protection of the bird species that inhabit this important ecosystem.

2. Methodology

2.1 Study Location

Melaka includes 17 permanent reserve forests with a total area of about 5199.49 ha, and seven of them are located in Jasin district. Sungai Kesang is one of the main rivers in Jasin, while Tasik Chin Chin is a lake that is the focus of visitors because of its blue water. Chin Chin Lake is a location in Melaka that is the center of the development of the Melaka TAPS (Takungan Air Pinggiran Sungai) project. Sungai Kesang is a river that flows from Negeri Sembilan and Johor before emptying into the Malacca Strait. Melaka's TAPS (Takungan Air Pinggiran Sungai) project will take water from the Kesang River to be stored in the dam that will be built. This study will be conducted in Chin Chin Lake and the surrounding area in Malacca. The proposed study area is around a 5-10 km radius from the Chin Chin Lake area, Malacca as shown in Figure 1.

Fig. 1. Photo from Enviro Knowledge Management Center (EKMC), Department of Environment

2.2 Sampling and Identification of Bird Species

A team of three people will be involved in bird observation and photography with the aim of recording the birds found. The survey was carried out early in the morning at 0700h until about 1100h when the birds are most active and in the evening at 1400h until 1800h, using binoculars with a magnification of 8 x 42. The observation period was carried out for three days on 20 and 21 March

2023.Daily surveys will be conducted in every direction along roads, forest trails, especially within a 500-m radius, when the weather is clear.

All existing trails, forested areas, and lakeside regions underwent thorough surveys. The survey process involved slow movement, with a driving or walking speed of less than 1 km/h, allowing for frequent stops to observe and document the avifauna. Every bird seen or heard within a 25-meter radius of the path was recorded and photographed.

Bird identification was facilitated using a DSLR camera, focusing on morphological characteristics such as feather color, wing and tail shapes, beak structure and leg features. This detailed approach ensures comprehensive data collection on the bird species present in these habitats.

Identification of bird species was accomplished by referring to several field guides, including [7]. The database of the MyBIS website (http://www.mybis.gov.my/) was also referred to obtain information the latest nomenclature. Only species presence and the number of individuals were utilised for each record. All diurnal species (Falconiformes), migratory birds and resident species were documented. The equipment used to take pictures of birds was as follows:

[1] Nikon D500 + AF-S Nikkor 300 mm F/4E PF ED VR + AF-S TC-14EIII Teleconverter, which effectively provides a 630 mm zoom lens capability. 18
[2] Nikon D500 + AF-S Nikkor 200-500 mm F/5.6E ED VR, which effectively provides the capability of a 750 mm zoom lens.
[3] Nikon D850 + AF VR Zoom-Nikkor 80-400 mm F/4.5-5.6D ED with approximately 520 mm zoom lens capability.

2.3 Data Analysis

Recorded bird species were classified according to family taxonomy, the abundance of each bird species and IUCN Red List status. Three components were used to measure species diversity based on the objectives of the study, namely the rank abundance curve, rarefaction curve and diversity indices, including dominance values, Shannon index, evenness index, Brillouin index, Margalef index and NMDS (Non-metric Multidimensional Scaling) analysis. All data analyses for biodiversity were prepared using PAST version 4.03 software [8].

3. Results

3.1 Species Composition and Abundance

The study conducted at Tasik Chin Chin recorded a total of 401 birds representing 45 identified species across 26 different bird families (Figure 2). The family with the highest species richness was Cuculidae, which included five species. This was followed by Columbidae and Accipitridae, each comprising four species. Families Hirundinidae, Ardeidae and Sturnidae contained three species each, while Laniidae, Apodidae and Cisticolidae each had two species. Additionally, 17 families were represented by a single species.

In terms of individual bird abundance, the Sturnidae family had the highest number, with 103 individuals, followed by Columbidae with 46 individuals and Pycnonotidae with 39 individuals. The species comprising the largest portion of the total bird population was *Acridotheres javanicus* (Javan Myna), with 53 individuals, accounting for 13.2 % of all birds observed. It was closely followed by *Aplonis panayensis* (Asian Glossy Starling) with 50 individuals (12.5 %) and *Pycnonotus goiavier* (Yellow-vented Bulbul) with 39 individuals (9.7 %).

Notably, two bird species recorded in the area are listed on the IUCN Red List: *Acridotheres javanicus* is categorized as vulnerable, while *Phaenicophaeus diardi* (Black-bellied Malkoha) is classified as near-threatened.

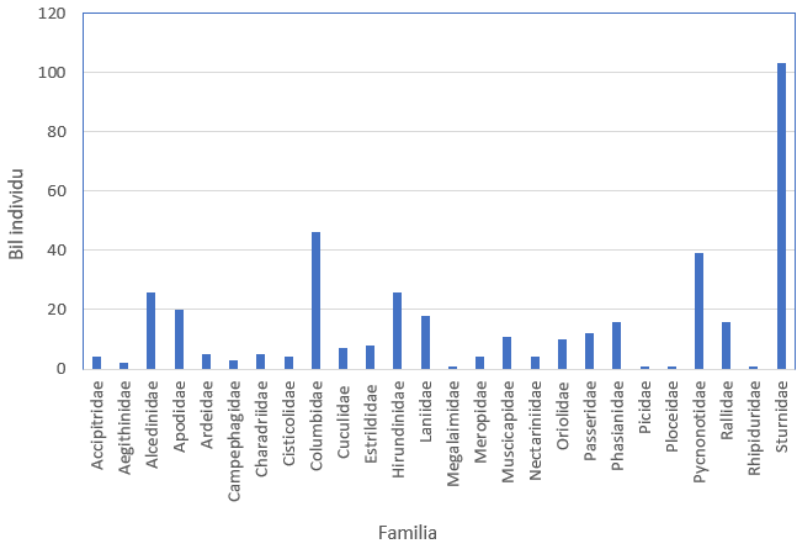

Fig. 2. Graph of families *vs* the number of individuals

3.2 Rank Abundance Curve

The broken stick model (Figure 3) was identified as the most suitable curve due to its highest chi-square value and lowest *p*-value. Bird species were ranked from most to least abundant, producing a 'broken-stick' distribution in descending order of abundance [9]. This model has been widely employed to assess species abundance in various habitats [10] and effectively illustrates the relationship between species abundance in animal communities, including birds and fish [11].

In the plot, the left side represents species with high abundance (low rank), demonstrating a steep decline that indicates a small number of species occupy a significant share of the ecosystem's resources. Conversely, the right side displays species with low abundance (high rank), reflecting the presence of many species with very low numbers, each capturing a small portion of the total resources in the ecosystem.

The gradient of the plot, beginning with *Acridotheres javanicus* (Javan Myna, Fam. Sturnidae), is steep, highlighting that the high-ranking species possess significantly greater abundance than their low-ranking counterparts. The recorded species abundance reveals a wide range, with some species numbering in the hundreds while others are present in minimal counts. This model clearly illustrates that most species are rare, while a few dominate the ecosystem.

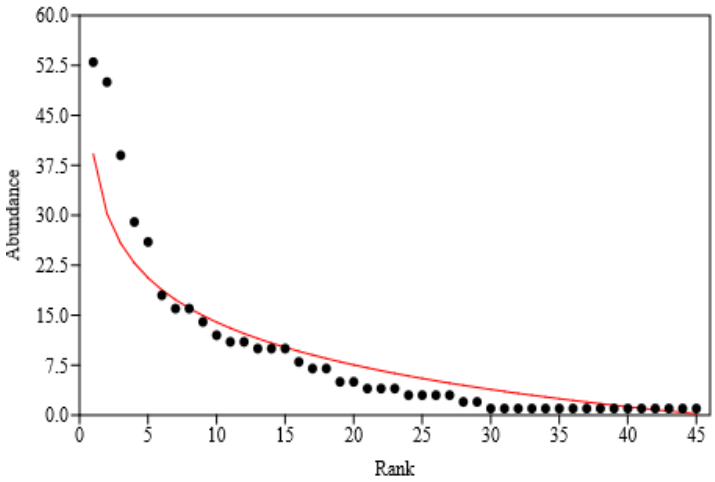

Fig. 3. Broken Stick model rank abundance curve of bird species abundance in Chin Chin Lake

3.3 Rarefaction Curve

Figure 4 presents the individual distribution curve for the total number of birds across the entire sampling location. The rarefaction curve for the species richness index exhibits a sharp increase with a steep gradient at the outset. Notably, the curve in Figure 4 does not reach a definitive asymptote, as it encompasses 401 individuals from 45 species.

In contrast, the Shannon Index rarefaction curve depicted in Figure 5 has reached an asymptote, indicating that the sampling effort has been sufficient and that it is unlikely additional species will be discovered in the study area. Similarly, the Simpson Index rarefaction curve in Figure 6 appears to be approaching its asymptote, suggesting that sampling is nearly adequate, and the recorded relative abundance of species and individuals is sufficient for this habitat.

These findings indicate that the current sampling efforts adequately capture the majority of bird species present in the area; however, they are insufficient to fully document the complete bird species richness of Chin Chin Lake. To obtain a more comprehensive understanding of bird species diversity in this habitat, additional sampling and survey efforts are necessary to identify the remaining less abundant species and attain the asymptote in the rarefaction curve.

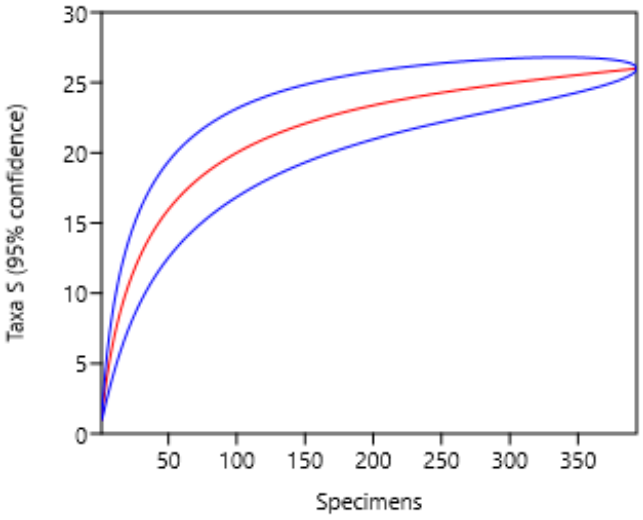

Fig. 4. Rarefaction curve for the bird species (individual) richness index for the entire study location

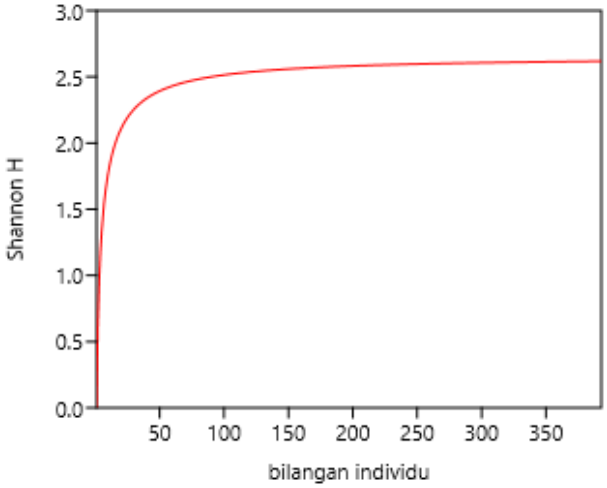

Fig. 5. Rarefaction curve of the Shannon index (individual) of birds for the entire study location

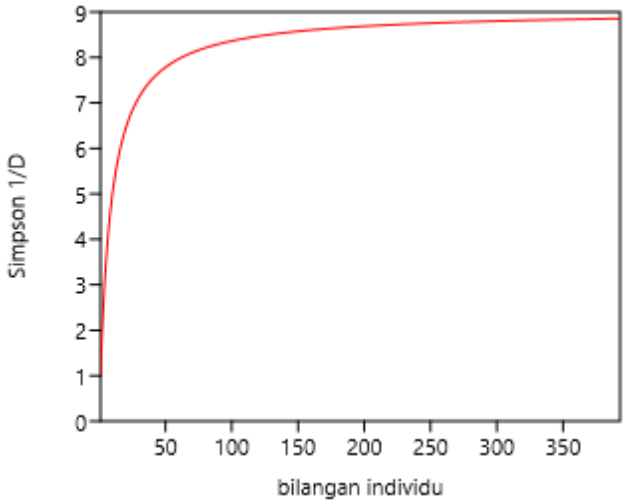

Fig. 6. Rarefaction curve of Simpson index 1/D (individual) of birds for the entire study area

The dominance index quantifies the probability that two randomly selected individuals from a community belong to the same species [12]. Lower values on this index signify reduced dominance and greater biodiversity. The Simpson Diversity Index (1–D) assesses community diversity, with values approaching 1 indicating higher diversity. In contrast, the Shannon Index (H') measures entropy within a community; higher values denote increased diversity, with values exceeding three generally suggesting a highly diverse community. The Shannon Index accounts for both richness and evenness, increasing with the presence of unique or rare species as well as greater species evenness.

A high value in the Shannon Index is often corroborated by a high Simpson Index, which reflects species dominance and evenness within the community. Notably, the Shannon Index (H') is particularly sensitive to the presence of rare species, while the Simpson Index tends to emphasize dominant species and is less affected by rare species. Moreover, evenness measures the distribution of individuals among species, with values ranging from 0 to 1. Higher evenness values indicate a more equitable distribution of individuals among the various species present in the community.

The Chao-1 Index is a valuable tool for estimating the total number of species in a community, including those that have not been observed. In this study, the Chao-1 value suggests the presence of approximately 85 species in total, indicating that the 45 species recorded represent only a fraction

of the actual bird species in the study area. Notably, 17 families are represented by only one species, which are seldom observed in this region.

Recognized as one of the most effective estimators for calculating species richness in ecology, the Chao-1 Index is particularly valuable in studies where rare or infrequently observed species are present in the sample [13]. The estimator utilizes data regarding species that were observed only once (singletons) and twice (doubletons) to infer the number of unobserved species within the sample. The Chao-1 Index's effectiveness in estimating species richness while accommodating the biases associated with rare species likely contributes to its superior performance compared to other estimators, such as ACE [14]. Additionally, Chao-1 demonstrates improved efficiency in reaching an accurate asymptote sooner [15], making it the ideal choice for estimating species richness in the study area.

Several other indices, such as the Dominance Index and Evenness Index, further complement the diversity profiles provided by the Shannon and Simpson indices. The low Dominance Index value indicates a high degree of species abundance, while the moderate Evenness Index reflects that the abundance of different species is nearly uniform. Collectively, these diversity and richness indices reinforce the conclusion of high biodiversity in Tasik Chin Chin.

The elevated bird species diversity in Tasik Chin Chin can be attributed to its variety of habitats, which encompass ecosystems that offer diverse resources, including food, water availability, stopover sites during migration, and protective environments. In comparison, eBird (2024) [16] lists 126 bird species across the Melaka state, of which this study documented approximately 36 % (45 species). Despite being a relatively small lake, Tasik Chin Chin boasts a significant bird species count, highlighting its ecological importance as a habitat for avian diversity.

Table 1
Species diversity profile for the entire sampling location

Indeks	Value
Taxa_S	45
Individuals	401
Dominance_D	0.06458
Simpson_1-D	0.9354
Shannon_H	3.118
Evenness_e^H/S	0.5024
Brillouin	2.943
Menhinick	2.247
Margalef	7.341
Equitability_J	0.8191
Fisher_alpha	13
Berger-Parker	0.1322
Chao-1	85

4. Conclusions

This study has provided important insights into the bird community inhabiting the freshwater lake habitat of Tasik Chin Chin in Malacca. Conducted as a proactive initiative prior to the construction of a water catchment dam, the research aimed to assess the ecological conditions and habitats that support the area's avifauna. The findings serve as a foundational checklist and database, which are crucial for the conservation and preservation of the unique habitats and biological diversity of birds in Chin Chin Lake.

The diversity of bird species around Chin Chin Lake is particularly high, especially in light of rapid development and impending water catchment activities that pose risks of water pollution and threaten aquatic life. Consequently, measuring bird diversity is essential for evaluating the conservation status of various species and implementing targeted conservation strategies. Understanding avifaunal diversity is pivotal for conservation and restoration efforts in habitats surrounding the lake, particularly as these areas serve as vital stopover sites for migratory birds. However, to achieve a more accurate understanding of bird population dynamics, it is imperative to conduct extended ecological studies that monitor changes in diversity and community composition over time. The bird diversity in Melaka reflects the region's varied landscapes and habitats. Continuous monitoring and research are crucial for informing effective conservation strategies that protect the rich bird communities within these dynamic coastal and urban environments.

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