# DIVERSITY OF KINGFISHER (ALCEDINIDAE) AS A BIOINDICATOR OF THE HEALTHY ECOSYSTEM IN LATA HOKKAIDO GLAMPING PARK JELI, KELANTAN

by

**MUHAMAD FAHMI AMIN BIN ROSLAN**



A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Natural Resource Science) with Honours



**FACULTY OF EARTH SCIENCE**
**UNIVERSITI MALAYSIA KELANTAN**



2024

# DECLARATION

I declare that this thesis entitled “Diversity of Kingfisher (Alcedinidae) as a Bioindicator of the Healthy Ecosystem in Lata Hokkaido Glamping Park Jeli, Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

**Signature** : 

**Name** : MUHAMAD FAHMI AMIN BIN ROSLAN

**Date** : 5 AUGUST 2024

# ACKNOWLEDGEMENT

First and foremost, I would like to express my sincere appreciation and acknowledgement the contribution of the individuals who always supported me throughout my Final Year Project (FYP). I would like to acknowledgement and thank my supervisor Dr. Aainaa Syazwani binti Mohamad Amir Hamzah, for her invaluable guidance and mentorship throughout the research process. My perspective on the avian community changed because of her unwavering enthusiasm and passion upon birds. Nothing is indeed as important as passion. No matter what you want to do with your life, be passionate. Then, I am grateful to have a willing and helpful coursemate for helping me out to complete this research. Special thanks to Aslan, Nizam, Fais, Syahir and Syazwan for their companion during the site survey and sampling sessions. I appreciate everyone who helped me throughout this journey. Last, without any doubt, my parents always support me in completing this final year project.

# DIVERSITY OF KINGFISHER (ALCEDINIDAE) AS A BIOINDICATOR OF THE HEALTHY ECOSYSTEM IN LATA HOKKAIDO GLAMPING PARK JELI, KELANTAN


## ABSTRACT

The kingfisher birds possess distinct characteristics and specific habitat requirements, making them reliable bioindicators of the overall ecosystem's health. This study investigates the diversity of kingfisher birds (Alcedinidae) at Lata Hokkaido Glamping Park to determine their role as bioindicators of the overall environmental health. The objectives of this study are to identify and record the species and number of kingfisher birds in the park using visual and auditory surveys, and to examine the relationship between the diversity and abundance of kingfisher birds and water quality using statistical methods and models. The methodology used in this study includes direct observation and point count. Statistical models used to study the relationship between diversity kingfisher and water quality are Descriptive statistics, Correlation analysis, Shannon-Wiener Diversity Index and Margalef Diversity Index. The results of this study show that only 5 species of kingfisher birds were found in Lata Hokkaido Glamping Park, Jeli, Kelantan. The White-throated kingfisher species was the most prevalent at 49%. Using the Shannon-Wiener Index, the highest index was found in the river area with H' = 1.096 compared to the pond area with H' = 1.063. This shows that the ecosystem in the river area is healthier than in the pond area because the river area has a high diversity. The findings of this study can offer important insights into the ecological well-being of Lata Hokkaido Glamping Park and guide conservation initiatives aimed at protecting the environment.


**Keyword:** Kingfisher, bioindicator, water quality, point counts, Correlation analysis

**KEPELBAGAIAN BURUNG RAJA UDANG (ALCEDINIDAE) SEBAGAI BIOINDIKATOR EKOSISTEM SIHAT DI LATA HOKKAIDO GLAMPING PARK JELI, KELANTAN**


## ABSTRAK

Burung raja udang mempunyai ciri-ciri tersendiri dan keperluan khusus untuk habitatnya dijadikan sebagai penunjuk bioindikator yang boleh dipercayai bagi keadaan keseluruhan ekosistem. Kajian ini meninjau kepelbagaian burung raja udang (Alcedinidae) di Lata Hokkaido Glamping Park, untuk menentukan peranan mereka sebagai bioindikator kesihatan persekitaran secara keseluruhan. Objektif kajian ini adalah untuk mengenal pasti dan merekodkan spesies dan bilangan burung raja udang di taman menggunakan tinjauan visual dan pendengaran serta untuk mengkaji hubungan antara kepelbagaian dan kelimpahan burung raja udang dan kualiti air menggunakan kaedah dan model statistik. Metadologi yang digunakan dalam kajian ini adalah dengan menggunakan pemerhatian langsung dan kiraan titik. Model statistik yang digunakan untuk mengkaji hubungan antara kepelbagaian burung raja udang dengan kualiti air ialah Statistik Deskriptif, Analisis Korelasi, Indeks Kepelbagaian Shannon-Wiener dan Indeks Kepelbagaian Margalef. Keputusan dalam kajian ini menunjukkan hanya 5 spesies burung raja udang sahaja yang didapati di Lata Hokkaido Glamping Park, Jeli Kelantan. Spesies burung raja udang White-throated adalah yang paling tinggi dengan 49%. Menggunakan Indeks Shannon Weiner dalam kajian ini yang paling tinggi Indeks Shannon Weiner adalah di kawasan sungai iaitu H’ = 1.096 berbanding di kawasan kolam H’ = 1.063. Ini menunjukkan ekosistem di kawasan sungai lebih sihat berbanding di kawasan kolam kerana di kawasan sungai mempunyai kepelbagaian yang tinggi. Penemuan kajian ini boleh menawarkan pemahaman penting tentang kesejahteraan ekologi Lata Hokkaido Glamping Park dan membimbing inisiatif pemuliharaan yang bertujuan untuk melindungi persekitaran.


**Kata kunci**: Burung raja udang, bioindikator, kualiti air, kiraan titik, analisis Korelasi

**TABLE OF CONTENT**

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABREVIATIONS

| | |
|---|---|
| DO | Dissolved Oxygen |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| IUCN | International Union for Conservation of Nature |
| LC | Least Concern |
| MNS | Malaysia Nature Society |
| NT | Near Threatened |
| SAC | Species Accumulation Curve |
| WQI | Water Quality Index |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Dickinson and Fry, (2003) and Krueper, (2001) have the opinion that the term kingfisher (Alcedinidae) refers to a cheerful groups or families of birds that usually prefer to live near water and you can find them in almost every part of the world. They are always recognized for their strong beak in fishing and catching other prey with the long and sharp ones.

Conversely, in addition to playing a role in maintaining ecological equilibrium and pleasing look, kingfishers are themselves threatened by different ironies that may lead to their extinction or dwindling of numbers. Trapping, shooting and poaching have also been cited as threats to other species in the country Sarker et al. (2009). Next comes the predator. Local residents have been informed that the small Indian fox (Herpestes auropunctatus) preys on kingfisher eggs and hatchlings. Turčoková et al. (2016), the loss of kingfisher nests in the Danube River system from Bratislava to Gabčíkovo in the south-west of the Slovak Republic is mainly due to predation.

Hence it would be necessary to watch the kingfishers' diversity and numbers in different regions and habitats as well as find out what is in charge of population changes and conservation status of the kingfishers. Lata Hokkaido Glamping Park Jeli, Kelantan has its own uniqueness which is having a unique and diverse ecosystem, including rivers and ponds that are natural habitats for kingfishers. This uniqueness makes it an ideal location to study the diversity of kingfisher species and the health of aquatic ecosystems. This study used the observation approach with point count to confirm that the kingfisher has more diversity, is always safe, and has the least concern "LC" IUCN Red List rating. Furthermore, this study focuses on the kingfisher as a bioindicator in Lata Hokkaido Glamping Park, Jeli Kelantan. The study focuses on the number of kingfisher species and water quality as a bioindicator at Lata Hokkaido Glamping Park in Jeli, Kelantan.

Apart from the Lata Hokkaido Glamping Park Jeli, Kelantan which are the recreational and tourism sites where the kingfishers can be found, this is where many visitors visit to enjoy its natural and scenic environment. Area along the Lata Hokkaido river are clean and unpolluted, making them ideal for kingfishers and other aquatic species to reside in. On the contrary, these two activities have some negative effects on the local kingfisher population and the surrounding ecosystem. However, the impact may vary and not all humans involved might be harmful to the kingfisher range. Furthermore, there are recreational activities that have a positive impact on the environment. It may raise tourists' awareness of the necessity of environmental protection. The kingfisher species in the Lata Hokkaido Glamping Park area of Jeli Kelantan can be better maintained by implementing programmes and activities targeted at educating tourists about environmental responsibility.

Thus, it is crucial to determine how many kingfishers are dispersed and numerous throughout the park, and to determine what role humans and the ecosystem play in these differences.

According to the study done by (BirdLife-International, 2016), kingfishers residing in Europe and the European Union (EU), the club of 27 member countries, are likely to face a severe hit, a drop between 30% to 49%, in the next 13 years. The common kingfisher is widespread in Europe, Asia, and North Africa, especially south of 60°N. It is a widespread breeding species in most of the vast Eurasian region. In temperate areas, this kingfisher likes clean, slow-flowing streams and rivers, as well as lakes with well-grown sides. According to the IUCN Red List, it can be said that all kingfisher species in Malaysia have a Least Concern (LC) status. However, only two species are near threatened (NT) in Malaysia, namely the Rufous-collared kingfisher and the brown-winged kingfisher. European geography poses quite a few challenges to the kingfisher and the kingfisher industry in general. This report suggests that, among others, climate change would become one of the most essential threats to the Kingfisher, which is a species of birds. This underlines the fact too that the breeding place and clean water are problems of Kingfishers. On top of these, overfishing and ocean warming are two fundamental things that have devastating effects on ocean fish. Hence the numbed population of the kingfisher will decrease because the situation would unfold out of the habitat of busses specifically with the water bodies like mangrove swamps, rivers, ponds etc.

However, future research studies in this field of study should also include investigations into effects of conservation measures on the continuity of ecosystems. In this manner, wildlife areas conservation and clean water promotion, would give the opportunity for kingfishers to reproduce and feel safer. This consequently makes the kingfisher population to continuously prosper in the ecosystem.

Many species have seen drastic declines in population numbers since the advent of active logging in Indonesia, Malaysia, and the Philippines. The blue-banded kingfisher *(Aeriosceps euryzona)*, the Sulawesi kingfisher (*Ceyx fallax*), the brown-winged kingfisher (*Pelargopsis amauropterus*), and several New Guinea paradise kingfishers (*Tanysiptera*) fall within this category.

## 1.2 Problem Statement

How does the diversity and abundance of kingfishers in the Lata Hokkaido Glamping Park Jeli, Kelantan, reflect the health and quality of the ecosystem in the park, and how are they affected by environmental factors? The primary research goal for studying the diversity and abundance of kingfishers at Lata Hokkaido Glamping Park in Jeli, Kelantan, is to identify and record the species and number of kingfishers in the park using visual and auditory surveys, as well as to investigate the relationship between kingfisher diversity and abundance and water quality using statistical methods. The association between kingfisher species diversity and water quality is intimately related to using kingfishers as bioindicators at Lata Hokkaido Glamping Park in Jeli, Kelantan.

## 1.3 Objective

The objective of this study is to conduct a bioindicator study of kingfishers in the Lata Hokkaido Glamping Park Jeli, Kelantan, to assess the health and quality of the ecosystem in the park. The specific objectives are:

- To identify and record the species and number of kingfishers in the park using visual and auditory surveys.

- To examine the relationship between the kingfisher diversity and abundance and the water quality using statistical methods and models.

## 1.4 Scope of Study

The population and sample. The population consists of all the kingfishers that inhabit the park, which is 51 individuals. The sample size will be determined by using a formula that considers the population size, the confidence level, and the margin of error. The sample selection will be done by using a stratified random sampling technique, which will ensure that the sample is representative of the population and that the different species of kingfishers are proportionally included. The study region will be separated into strata based on relevant habitat characteristics, such as habitat type for example, rivers and ponds. Each layer should indicate different environmental conditions and the existence of kingfisher species. Data collected from each stratum. Data on the presence and abundance of kingfishers in each stratum will be gathered by direct observation methods such as audio recordings and smartphone images. Researchers will guarantee that the region of each layer is extensively explored to discover and record all kingfisher species there.

## 1.5 Significant of Study

The significance of study for this study is to demonstrate the importance and value of diversity of kingfisher as a bioindicator of the healthy ecosystem in Lata Hokkaido Glamping Park, Jeli, Kelantan.

This research can improve the current literature and understanding of kingfisher ecology and conservation in Malaysia and Southeast Asia, addressing the lack of comprehensive and up-to-date information available on these birds. The findings from Lata Hokkaido Glamping Park Jeli, Kelantan, will be compared to other places in Malaysia and Southeast Asia using numerous systematic methodologies.

First, local information on kingfisher species diversity and water quality will be gathered and analysed. This includes determining the species of kingfisher, the number of individuals, and the physicochemical conditions of the water. Examine prior research and published data on the variety of kingfisher species in various parts of Malaysia and Southeast Asia. A diversity indicator, such as the Shannon-Wiener indicator, will be used to compare species diversity in Lata Hokkaido Glamping Park, Jeli Kelantan, and other areas.

Statistical analysis used to detect significant variations in species diversity and ecosystem health. Using this method, the findings from Lata Hokkaido Glamping Park will provide a clear picture of how the diversity of kingfisher species and ecological health in the area compare to other places in Malaysia and Southeast Asia. It will offer fresh insights and data on the diversity, distribution, abundance.

CHAPTER 2

# LITERATURE REVIEW



## 2.1 The Ecology and Conservation of Kingfishers in Malaysia and Southeast Asia.

According to (Wikipedia, 2023), there are about 114 species of kingfishers in the world, of which 28 are found in Southeast Asia. Malaysia, which is located in the heart of Southeast Asia, has a rich and diverse avifauna, including 18 species of kingfishers. Some of the common and widespread kingfisher species in Malaysia are the Collared Kingfisher (*Todiramphus chloris*), the Blue-banded Kingfisher (*Alcedo peninsulae*), the White-throated Kingfisher (*Halcyon smyrnensis*), and the Common Kingfisher (*Alcedo atthis*). Some of the rare and endemic kingfisher species in Malaysia are the Bornean Banded Kingfisher (*Lacedo pulchella*), the Blue-banded Pitta (*Hydrornis baudii*), and the Rufous-collared Kingfisher (*Actenoides concretus*).

The diversity and distribution of kingfishers in Malaysia and Southeast Asia are influenced by various factors, such as the availability and quality of water, the abundance and diversity of prey, the presence and suitability of nesting sites, and the degree and type of human disturbance. In Malaysia, the kingfisher suffers serious threats like as habitat loss from logging, development, and water pollution. This dangerous exists in different parts of Southeast Asia, albeit its degree and form may vary. For example, in Indonesia, illicit logging and the conversion of forests into oil palm plantations put a strain on kingfisher habitat. Coastal development and agricultural deforestation pose significant risks in Thailand and the Philippines. However, in Malaysia, conservation initiatives frequently entail the participation of local communities and education programmes.

Furthermore, public education and the participation of local communities and indigenous people in conservation initiatives, such as reforestation and wildlife monitoring, are vital to raising awareness and support for the conservation of kingfishers and their habitats. These actions are intended to maintain and restore the kingfisher population and habitat, ensuring the survival of endangered species in Malaysia and Southeast Asia.

There are various barriers to implementing kingfisher conservation efforts in this region. Habitat loss due to unregulated development, logging, and deforestation is a big concern, as repairing destroyed habitats takes a significant amount of time and resources. Furthermore, water contamination from uncontrolled agricultural and industrial activity is a major issue, and regulating these sources of pollution necessitates close oversight and the collaboration of many parties. Lack of public understanding of the need of preserving the kingfisher and its habitat is another impediment, as raising awareness and changing community attitudes necessitates constant education and awareness campaigns.

## 2.2 The Role and Value of Kingfishers as Indicators of The Health and Quality of Aquatic Ecosystems.

Kingfishers are a group of aquatic birds that play an important role in maintaining the balance and diversity of wetland ecosystems. They are also considered as indicators of the health and quality of the water and the habitat they inhabit. This is because kingfishers are sensitive and responsive to changes in water conditions, prey availability, and habitat loss, and their presence and abundance can reflect the state and status of the aquatic ecosystems. Studies using kingfishers as bio-indicators have been undertaken all over the world, and the results demonstrate this species' ability to provide significant information regarding ecosystem health.

Several studies, including those conducted in the Thames River in the United Kingdom, Lake Victoria in East Africa, and the Mekong River in Southeast Asia, have revealed similar patterns in the use of kingfishers to assess water quality and habitat conditions. These data suggest that the presence and quantity of kingfishers is associated with improved water quality and riparian habitat sustainability. However, in the context of the study in Lata Hokkaido Glamping Park, Jeli Kelantan, and other areas, significant difficulties in employing kingfishers as bioindicators have been observed.

The findings of this study can be used to conservation efforts or larger policy formulation. Evaluation of water quality and habitat. Water quality and habitat data can be used to make suggestions for improving or maintaining water quality. This includes initiatives to reduce pollution from agriculture, animal husbandry, industry, and so on. Stricter policies for reducing water pollution and protecting riparian habitats can be advocated. This policy may involve restrictions governing the disposal and usage of pesticides in agricultural areas near aquatic habitats.

According to (Scitable Nature Education, 2010), kingfishers can be used as indicators of the health and quality of aquatic ecosystems in various ways, such as, the exact method and instruments used to determine species richness, population size, distribution, and behaviour of kingfishers in Lata Hokkaido Glamping Park, Jeli Kelantan are field surveys of the area.

## 2.3 The Kingfishers as a Bioindicator of The Healthy Ecosystem

Bioindicators are species utilized to assess environmental health conditions and are capable of evaluating the environments integrity through their various biological functions. The suggested conservation efforts at Lata Hokkaido Glamping Park, Jeli Kelantan, include habitat monitoring and protection. By ensuring that environmental rules are respected. Examples include outlawing actions such as deforestation, poaching, and unlawful dumping. The existence of environmental protection legislation in Lata Hokkaido Glamping Park, Jeli Kelantan, can help to limit human activities like deforestation and unlawful hunting. Furthermore, restricted zones must be established to guarantee that human activities do not disrupt the natural habitat of kingfishers and other wildlife. The next step is to replace trees. Tree replanting programmes in regions damaged by deforestation or development activities, such as forest areas in Lata, Hokkaido, can be carried out as a result of rubber tree felling. Educational and awareness campaigns. Create a "love your river" environmental education and awareness programme for visitors and local people about the necessity of ecosystem conservation.

The kingfisher was chosen as a bioindicator for this study based on its sensitivity to changes in water quality. Kingfishers rely significantly on bodies of water to forage, particularly for fish and aquatic invertebrates. Their sensitivity to changes in water quality, such as pollution and dissolved oxygen concentration, makes them useful markers of aquatic ecosystem health. In the context of the study at Lata Hokkaido Glamping Park in Jeli, Kelantan, 'environmental integrity' refers to the overall status of the ecosystem, ensuring that ecological functions and processes run smoothly and without major interference from human activities or other causes.

The fast response of kingfishers to environmental changes, such as changes in water quality or the presence of contaminants, makes them sensitive indicators of ecological disruption. With constant non-invasive monitoring, kingfishers can be a more cost-effective and efficient alternative to chemical and physical testing that require specialised laboratory equipment and analysis. However, integrating kingfisher observations with traditional approaches is required to produce a comprehensive and accurate picture of ecological conditions, as well as to aid in suitable conservation activities.

Conservation biologists have employed bioindicators to gain a better understanding of ecosystems in a straightforward manner (Asefa et al., 2018). Studies using kingfishers as bio-indicators have been undertaken all over the world, and the results demonstrate this species' ability to provide significant information regarding ecosystem health. Several studies, including those conducted in the Thames River in the United Kingdom, Lake Victoria in East Africa, and the Mekong River in Southeast Asia, have revealed similar patterns in the use of kingfishers to assess water quality and habitat conditions. These data suggest that the presence and quantity of kingfishers is associated with improved water quality and riparian habitat sustainability.

By indirect means, the existence of kingfisher species will be attracted as a bioindicator of the river. Severe water pollution leads to a decline in the population of the bird due to water contamination Roche et al., (2010).

# CHAPTER 3

# MATERIAL AND METHOD

## 3.1 Study Area

This research was carried out in Lata Hokkaido Glamping Park in Jeli, Kelantan, next to Krai Aquaculture (catfish aquaculture). The coordinates for this location were (5°39'00''N 101°45'41''E). The distance between Lata Janggut and this research site was around 2.5 km. Lata Hokkaido had a beautiful natural background with creeks and was surrounded by green plants where a variety of life, both terrestrial and aquatic, could be found. Lata Hokkaido Glamping Park in Jeli, Kelantan, was surrounded by the natural beauty of the area as well as a diverse collection of flora and animal species. The environment of Lata Hokkaido Glamping Park was robust and well-balanced, which was one of the reasons why kingfisher species felt at home there. This was because the study area had a healthy and stable ecosystem. For example, the ecosystem in the study area had a wealth of species such as fish, birds, insects, and so on.

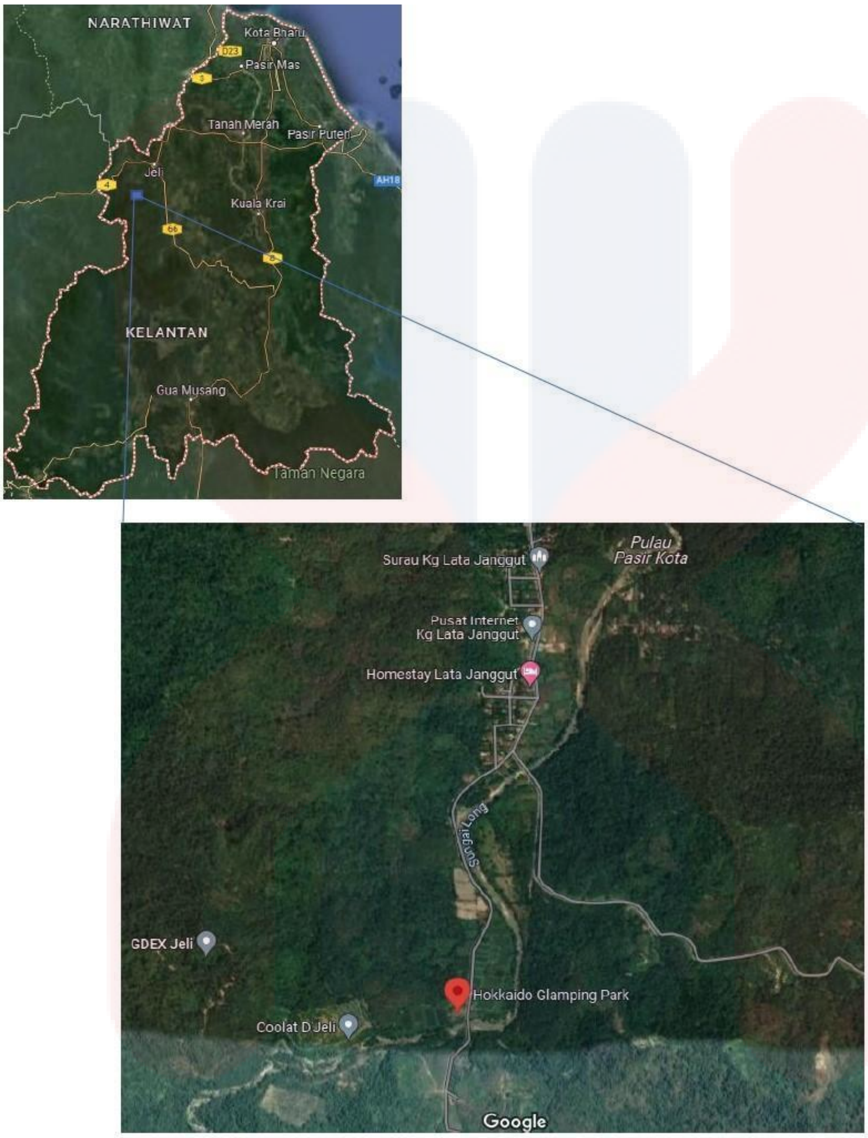


**Figure 3.1** The maps of Lata Hokkaido Glamping Park Jeli, Kelantan (Source: Google Maps)

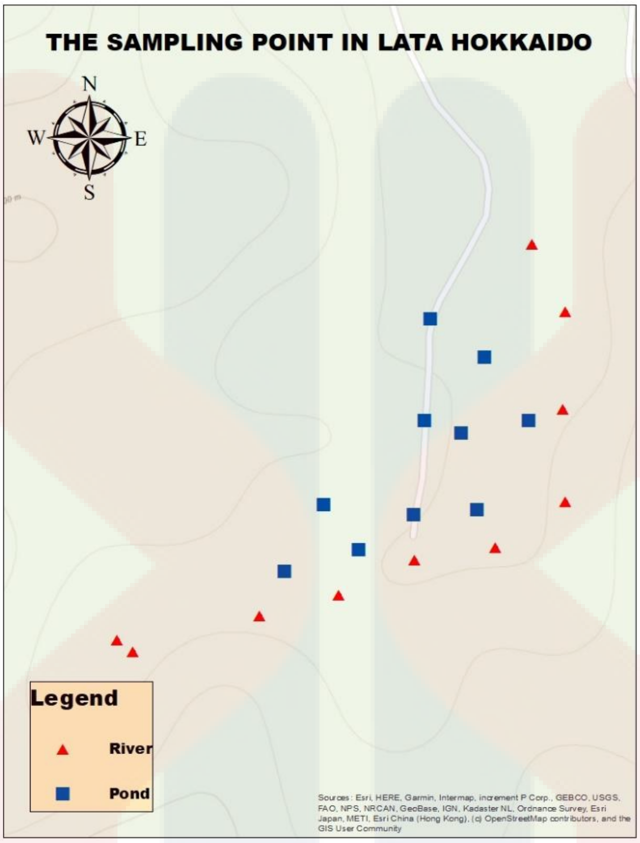


**Figure 3.2** The sampling point in Lata Hokkaido Glamping Park Jeli, Kelantan

**Figure 3.3** The study area Lata Hokkaido Glamping Park Jeli, Kelantan

The variety of kingfisher species in the study area was assessed via direct observation. Direct observations are made in river and pond settings with the capacity to determine the richness of kingfisher species. Lata Hokkaido Glamping Park in Jeli Kelantan, observers can analyse the richness of kingfisher species using binoculars, smartphone cameras, GPS and books (a field guide to the birds of Malaysia and Singapore). In figure 3.2, point counts are taken at predetermined points, such as ponds and rivers. The study sampling region included up to 20-point counts, including 10 in the river and 10 in the pond.

The exact criteria utilised to choose observation stations in the study area were observers conducting direct observations using recognised techniques. Observers walk along the point count, which includes the river and pond, with 100m intervals between each point count. When the observer reaches the next point count, take a 2- to 3-minute break to look about and acclimatise to your surroundings. Direct observation is used to assess and identify kingfisher species in river and pond habitats, using binoculars, smartphone cameras, GPS, and books (a field guide to the birds of Malaysia and Singapore). A 10-minute direct observation of kingfisher species was done to determine their existence. When an observer discovers or sees a kingfisher species, it must be recorded and recognised.

The Species Richness Index assesses ecosystem health and stability. Measuring the number of species present in an ecosystem. The Shannon-Wiener index was also employed to assess species diversity, accounting for the species richness and relative abundance of each kingfisher species. In addition, chemical parameters for measuring pH, dissolved oxygen (DO), and so on. Physical characteristics are used to measure water temperature and turbidity. Temperature and rainfall also have a crucial impact in the health and stability of the ecosystem, as measured by changes in temperature and rainfall affecting the kingfisher ecology at Lata Hokkaido Glamping Park in Jeli, Kelantan. The existence of kingfisher species is detected through visual perception and direct observation. To some extent, taking video or images with a smartphone allows observer to witness the diversity of kingfisher species in the river and pond at Lata Hokkaido Glamping Park, Jeli Kelantan.

Figure 3.1 depicts the distribution of kingfisher species within a certain area or habitat, as well as their diet, which includes invertebrates and small insects. For example, woodland regions have the smallest influence on the spread of kingfisher species because they are far from water sources and eat little fish. River and pond habitats influence the distribution of kingfisher species due to the availability of water sources and their diet, which includes catfish seeds in ponds. This study spans 21 days, from February 20, 2024 to March 11, 2024. Weather and climate changes are also taken into account during data collecting because this study considers the difference between the rainy and dry seasons, both of which might affect kingfisher abundance and activity, as well as water quality and habitat. Seasonal temperature differences can also influence kingfisher behaviour, including as feeding and breeding.

## 3.2 Material

In this study, tools such as binoculars (shown in figure 3.4 (A)) were used to view or observe the diversity of kingfisher species and identify them. Binoculars are used specifically to observe and identify various kingfisher species. When a kingfisher is discovered, observers use binoculars to examine specific features about the kingfisher species, such as plumage colour, pattern, size, and other characteristics that identify the kingfisher species. Furthermore, the Global Positioning System (GPS) (shown in figure 3.4 (B)) was employed to estimate latitude and longitude coordinates in the point count to monitor or listen to the kingfisher species. The global positioning system (GPS) is used to collect latitude and longitude coordinates via a series of technical stages.

First, turn on the GPS device and wait a few seconds for it to lock onto signals from at least four Earth-orbiting satellites. Each of these satellites transmits a time signal as well as orbital data, which the GPS device receives. The gadget then calculates the distance from each satellite using the time it takes for the signal to travel from the satellite to the device, as well as the orbital data, a technique known as trilateration. The GPS device may calculate the exact location in latitude and longitude coordinates by calculating the distance between multiple of these satellites. Once the location is calculated, the GPS device's screen displays the coordinates in degree format (°, ', and ").

This procedure permits the acquisition of precise position data for a variety of applications, including monitoring and field research. This coordinate data is used to map the locations of sightings, allowing researchers to better understand the geographical distribution of kingfisher species. Researchers can return to the same location for repeated measurements if they know the particular coordinates, which helps them track population changes and behaviour over time. This information can be entered into a geographic information system (GIS) for additional analysis, such as establishing the range or habitat of kingfisher species. These coordinates are also required to maintain a systematic and detailed record of the observation site.

The smartphone camera (shown in figure 3.4 (C)) was then utilized to record or capture the visual of several kingfisher species. One specific advantage of this strategy is that the smartphone camera is relatively portable, making it an ideal instrument for field observations. This allows observers to easily acquire photos or video of kingfishers without using bulky and heavy equipment. Next, easy for observation and identification of species, such as digital field guides and bird identification software. In addition, (shown in figure 3.4 (D)) was a guide book on a field guide to the birds of Malaysia and Singapore. Very handy for quick identification in the field, such as kingfishers. Detailed identification of kingfisher physical traits like as plumage colour, and shape as well as species identification and comparisons kingfisher species.

Next, (shown in figure 3.4 (E)) was a YSI multiparameter digital water quality. The YSI multiparameter digital water quality tool evaluates multiple water quality parameters at the same time, delivering comprehensive and efficient results. To ensure measurement accuracy, calibrate the YSI equipment before using it. To use it, dip the probe into water and wait 2 to 3 minutes for a stable reading, which is displayed on the screen in real time. Temperature, pH, dissolved oxygen (DO), turbidity, and salinity are the parameters measured. Dissolved oxygen and pH are frequently prioritised because they are essential for the survival of aquatic species and influence ecological conditions. YSI multiparameter digital water quality worked as an indicator of water quality. It also helped identify different variables such as pH value, total dissolved solids (TDS), oxygen, nitrogen, conductivity, temperature, and so on.

Last not but least, (shown in figure 3.4 (F)) Portable turbidimeter used to identify turbidity for water quality. Portable turbidimeters are specifically designed to detect water turbidity more accurately, providing measurements in NTU (Nephelometric Turbidity Units). It is used by calibrating it with a standard solution, collecting a sample in a tube, and measuring it with the instrument. Turbidity is essential because it can disrupt aquatic insect in water and can make contamination from sediment.

(A)


(B)


(C)


(D)


(E)

(F)


**Figure 3.4** materials (A) Binocular, (B) Global Positioning System (GPS), (C) Smartphone camera, (D) A field guide to the birds of Malaysia and Singapore, (E) YSI multiparameter digital water quality, and (F) Portable turbidimeter

## 3.3 Data Collection

### 3.3.1 Visual and Auditory Surveys

The visual and auditory surveys were based on the point count method, which was a widely used technique for monitoring bird populations and diversity. The point count method involved selecting a number of fixed points within the study area, and recording all the birds seen or heard within a certain radius and time interval from each point. The point count method provided reliable and comparable data on the species richness, abundance, and distribution of birds in different habitats and regions.

For this study, 20 points were selected within the park area, covering different types of habitats such as the river and the pond. There are certain criteria used in this study, such as 20-point counts picked in the study's sampling area, with 10 points in the river and 10 points in the pond. Each point counts at a distance of 100 metres, with a 10 minute between each point. Each point count distance must be measured using GPS coordinates in order to be included in the recorded data. The coordinates of each point were recorded using a Global Positioning System (GPS) device. The surveys were conducted for 21 days, from February 20, 2024, to March 11, 2024. Weather and climate conditions, study time constraints, and other factors all have an impact on the duration of this study.

The surveys were done in the morning (from 7:00 am to 11:00 am) to capture the diurnal variations and changes in the kingfisher population and the ecosystem. The observers used binoculars, cameras, and audio recorders to observe and record the kingfishers at each point. The observers recorded the following information for each kingfisher detected:

- The species name and the number of individuals
- The distance and the direction from the point

The data collected from the visual and auditory surveys were entered and stored in a spreadsheet, and were checked and verified for accuracy and completeness. To achieve uniformity among observers in kingfisher identification and data collection during morning and evening surveys, a number of standardisation and training methods should be used. Preliminary training. Provide an introduction course for all observers on the kingfisher species to be monitored, covering physical traits, behaviour, and habitat. Training in the use of binoculars, cameras, and audio recorders, ensuring that all observers understand how to use the equipment correctly. There's also field training. Conduct field training sessions in which observers can practise detecting and recognising kingfishers with the available equipment. Train observers in data collection strategies, such as taking consistent field notes.

The data were then analysed using descriptive statistics, such as frequency, percentage, mean, and standard deviation, to summarize and present the diversity and abundance of kingfishers in the park, as well as their behaviour and activity patterns. Descriptive statistics utilised include frequency. Was used to compute the number of observations for each kingfisher species and recorded behaviour. It summarises the frequency with which a certain species is observed, as well as the specific behaviour observed.

Furthermore, the proportion. The frequency of observations is expressed as a percentage of the total number of observations. It aids in understanding species variety and behaviour in the context of the entire population under study. Next, the minimum. Used to compute the average number of kingfishers seen during a certain observation session or location. It offers a centralised value for the number of kingfishers, which aids in the identification of population patterns. Last but not least, consider the standard deviation. Used to assess the degree to which the number of kingfisher values depart from the mean. It gives information about the variability in the kingfisher population, which aids in assessing its stability or instability.

The reason for using descriptive statistics is to improve readability and interpretation. As a researcher, can easily comprehend descriptive statistics like frequency and percentage. The mean and standard deviation provide a clear description of the data's centre and spread, allowing for easier comparisons between groups or circumstances. One of the issues of applying it to data sets is that errors in data collection or differences in observation methods might affect data quality. Provide complete observer training utilising established protocols, and conduct periodic data audits to ensure accuracy and consistency.

Potential biases or assumptions that may influence the interpretation of survey results are examples of measurement errors. Measurement equipment, such as the YSI multiparameter digital water quality, may have limitations in accuracy and precision, resulting in less reliable data. To resolve or reduce these limitations, utilise properly calibrated devices and perform periodic calibrations. Measure often to verify data consistency and dependability. There are also individual observations. Inconsistencies in data collecting might occur due to observer skills and experience. One way to mitigate or decrease this issue is to provide full training to all observers before the study begins. Using explicit standard protocols for all observers, as well as making several observations at the same site by different observers and comparing the results to identify inconsistencies.

Using established protocols in visual and aural surveys. Observers followed recognised standard techniques for collecting visual and aural data. The protocol offers thorough instructions on how to detect and record the presence of kingfishers using sight and sound. Observers were trained to identify kingfisher species both visually and verbally, ensuring consistency in data gathering. Observers utilise binoculars, cameras, and audio recorders to identify and record kingfisher species at Lata Hokkaido Glamping Park in Jeli, Kelantan.

### 3.3.2 Physicochemical Parameters

The physicochemical parameters are important indicators of the health and quality of the aquatic ecosystems, as they affect the availability and diversity of food and nesting resources for kingfishers and other aquatic wildlife, and their distribution and behaviour. The physicochemical parameters can be influenced by various factors, such as the climate, the hydrology, the geology, and the human activities and disturbances in the park. Therefore, it is necessary to measure and analyse the physicochemical parameters of the water and the habitat in the park, and to examine their relationship with the kingfisher diversity and abundance.

For this study, 2 sampling sites were selected within the park area, corresponding to the 20 points used for the visual and auditory surveys. The sampling sites covered different types of water bodies, such as the river and the pond. The sampling was conducted for 21 days, from February 20, 2024, to March 11, 2024. The sampling was done in the morning (from 9:00 am to 11:00 am) to capture the diurnal variations and changes in the water quality. The researcher used standard methods and instruments to measure and collect the following physicochemical parameters at each sampling site:

First of all, temperature. The temperature of the water was measured by using a thermometer, which was submerged in the water at a depth of 0.5 m. The temperature was recorded in degrees Celsius (°C).

Next, pH. The pH of the water was measured by using a pH meter, which was calibrated before and after each sampling session. The pH meter was submerged in the water at a depth of 0.5 m. The pH was recorded in standard units (SU).

Moreover, dissolved oxygen. The dissolved oxygen of the water was measured by using a dissolved oxygen meter, which was calibrated before and after each sampling session. The dissolved oxygen meter was submerged in the water at a depth of 0.5 m. The dissolved oxygen was recorded in milligrams per liter (mg/L).

Besides, turbidity. The turbidity of the water was measured by using a turbidity meter, which was calibrated before and after each sampling session.

The turbidity meter was submerged in the water at a depth of 0.5 m. The turbidity was recorded in nephelometric turbidity units (NTU).

In addition, salinity. The salinity of the water was measured by using a salinity meter, which was calibrated before and after each sampling session. The salinity meter was submerged in the water at a depth of 0.5 m. The salinity was recorded in parts per thousand (ppt).

The data collected from the physicochemical parameters were entered and stored in a spreadsheet, and were checked and verified for accuracy and completeness. The data were then analysed using descriptive statistics, such as frequency, percentage, mean, and standard deviation, to summarize and present the water and habitat quality in the park. The data were also analysed using correlation analysis to examine the relationship between the physicochemical parameters and the kingfisher diversity and abundance on the water quality.

### 3.3.3 Observational Methods

Direct observation was used to observe and record the behaviour and activity of kingfishers and other aquatic wildlife in the park. The direct observation was done by using binoculars, cameras, and audio recorders, and by following a standardized protocol and procedure. Preliminary training is a specialised procedure used to assure the correctness and consistency of recorded data. This initial training was conducted to boost knowledge of the kingfisher's behaviour and traits, allowing for easier identification. smartphone camera and audio recorders can be used to lessen potential bias and the level of training required to undertake good direct observation.

Observers can employ technology such as cameras and audio recorders to capture objective data that can be validated later, and they can also use programmes or data collection software to require the completion of specific fields and reduce human error.

The direct observation was done at different times of the day and locations of the park, depending on the objectives and scope of the study. The observation location is alternated on a constant basis, such as the first day in the river, the second day in the pond, and so on for up to 21 days. Because kingfishers are more active in the morning than in the evening, the best time to observe them directly is between 7 and 11 a.m. Observation sites in rivers and ponds can help us understand kingfisher behaviour and environmental conditions.

Taking into account the weather circumstances during direct observation is critical to guarantee that the data acquired is reliable and not impacted by external factors that can alter kingfisher behaviour and presence in specific habitats. Keep a record of the weather and environment. Record physicochemical parameters throughout each observation session in rivers and ponds. In addition, monitor water quality metrics in rivers and ponds to determine pH, temperature, dissolved oxygen, salinity, and turbidity. These more thorough recordings contribute to a better knowledge of kingfisher ecology. The observers recorded the following information for each observation session:

- The date and time of the observation
- The location and coordinates of the observation
- The weather and environmental conditions of the observation
- The species and number of kingfishers observed

## 3.4 Data Analysis

The statistical methods and models are essential tools for analysing and interpreting the data collected from the visual and auditory surveys and the physicochemical parameters, and for testing the research question and hypothesis of the study. The statistical methods and models can provide reliable and valid results and conclusions on the relationship between the kingfisher diversity and abundance and the water quality. The statistical methods and models can also provide useful information and recommendations for the conservation and management of kingfishers and the ecosystem in the park. For this study, the following statistical methods and models will be used:

Descriptive statistics. These will be used to summarize and present the data collected from the visual and auditory surveys and the physicochemical parameters, such as the frequency, percentage, mean, and standard deviation of the kingfisher diversity and abundance and the water and habitat quality in the park. The descriptive statistics will also be used to compare and contrast the data across different times of the day, locations of the park, and to identify the trends and patterns in the data.

Correlation analysis. This will be used to measure and test the strength and direction of the linear relationship between the kingfisher diversity and abundance and the water and habitat quality in the park, such as the temperature, pH, dissolved oxygen, turbidity, and salinity. The correlation analysis will also be used to measure and test the strength and direction of the linear relationship between the diversity kingfisher and water quality.

The correlation analysis was done by using the Pearson correlation coefficient r, which ranges from -1 to 1, where -1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. The correlation analysis will also be done by using the p-value, which indicates the probability of obtaining the observed correlation coefficient by chance, assuming that there is no correlation in the population. The p-value was compared with a significance level of 0.05, which indicates the maximum acceptable probability of making a type I error, or rejecting the null hypothesis when it is true. If the p-value was less than 0.05, the correlation coefficient was considered to be statistically significant, meaning that there was strong evidence of a linear relationship between the variables in the population. If the p-value was greater than 0.05, the correlation coefficient was considered to be not statistically significant, meaning that there was weak evidence of a linear relationship between the variables in the population.

In this study I will use the Shannon-Wiener Diversity Index and Margalef Diversity Index. The Shannon-Wiener Diversity Index attempts to quantify kingfisher species diversity. A higher Shannon Index value indicates that the species community is more diverse. $H' = - [p(i) * \ln(p(i)]$ is the formula for determining the Shannon Index (H').

$$H' = -\Sigma [p(i) * \ln(p(i)]$$

where:

H = number of individuals the species

S = total number individuals of samples

Furthermore, the Margalef Diversity Index (Margalef, 1958) will be utilized as a simple measure of kingfisher species richness. Many measurements of species richness have the drawback of relying largely on sampling effort. The greater the sampling effort, the higher the index value could be. The Margalef Diversity Index is calculated as (S - 1) / In N.

$$(S - 1) / \ln N$$

where:

S = total number of species kingfisher

N = total number of individuals in the sample

In = natural logarithm

The data collected from the statistical methods and models were entered and stored in a spreadsheet, and were checked and verified for accuracy and completeness. The data were then analyzed using statistical software, such as Excel to perform the descriptive statistics and the correlation analysis. In addition, the Shannon-Wiener Diversity Index and Margalef Diversity Index are also data analysis that will be used in this study to measure the diversity and abundance species richness of kingfisher species in the study area. The data were then presented and interpreted using tables, graphs, and charts, to show the relationship between the kingfisher diversity and abundance and the water quality. The data will also be discussed and explained using the relevant theories and concepts, to answer the research question and hypothesis of the study.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Water Quality the Physicochemical Parameters

These parameters are measured using the equipment or methods that are appropriate for the physicochemical parameter being measured. For example, the YSI Multiparameter digital water quality tool can be used to determine water pH, temperature, dissolved oxygen, and salinity. Other factors, such as water turbidity, can be measured using a portable turbidimeter, as well as particles present in rivers and ponds.

If these metrics agree with the narrative about the cleanliness and acceptability of water, particularly the pH level, the measurement findings should be consistent with the hygiene standards or thresholds established for the pH level in water. These hygiene criteria may differ based on the needs of certain aquatic species and environmental conditions. For example, most aquatic species require a pH concentration within a specific range to survive and flourish. As a result, if the measured pH level is within the range required by aquatic life, it shows that the water is suitable for the species that live there.

World Water Development Report, (2021) published by UNESCO reveals that the worldwide use of freshwater has multiplied by six during the last century and has been steadily increasing at a rate of around 1% a year since the 1980s. The rise in water demand is posing significant difficulties to water quality. This, in turn, has consequences for human health and the long-term viability of society Xu et al., (2022a). The assessment of river water quality can be conducted using either a limited number of significant water quality measures or by examining individual parameters Ibrahim et al., (2015).

The Water Quality Index (WQI) has been regarded as a potential criterion for classifying river water based on the use of conventional parameters for water classification. The Water Quality Index (WQI) is a numerical measure that condenses extensive water classification data into a single value, indicating the degree of water quality (Bordalo et al. 2006; Sánchez et al. 2006).

As to the National Water Quality Standard for Malaysia in 2022, the acceptable pH range for class 1 clean water is 6.5 to 8.5. The water quality of the cascading river at Hokkaido Glamping Park in Jeli Kelantan is excellent, with a pH level ranging from 7.5 to 7.7, indicating pure and pristine water. The Hokkaido Glamping Park Jeli in Kelantan can serve as an alternative water source during disruptions or water shortages because of its provision of pure water that is good for drinking and bathing. In addition, the cleanliness of river water can also impact the population of kingfisher species, which serves as a bioindicator for the quality of the river water.

The Malaysian Urban-Rural National Indicator Network for Sustainable Development (MURNInets, 2022) categorizes water for human activities into six classes: class I, class IIA, class IIB, class III, class IV and class V. River water at Lata Hokkaido Glamping Park, Jeli, Kelantan is clean because of dissolved oxygen with an estimate of 7 and above which is 9.47 to 10.10 mg/l. While for the pH of the water in the Lata Hokkaido Glamping Park, Jeli Kelantan shows clean and clear water which is 7.0 and above with an estimate of 7.5 to 7.7. This shows that Lata Hokkaido Glamping Park, Jeli Kelantan is not yet contaminated and is still safe to use.

Furthermore, class IIB is designated for leisure activities such as swimming, kayaking, and other similar pursuits. Class III necessitates the use of an incentive-based approach in order to render river water suitable for consumption. Class IV is only designated for irrigation purposes, whereas class V does not fall into any of the aforementioned categories. The Hokkaido cascade river is deemed safe and clean as indicated by its low turbidity level, ranging from 1.96 to 2.69.

**Table 4.1:** The physicochemical parameters

| Area | Point | pH | Temperature | Dissolved oxygen | Turbidity | Salinity |
|---|---|---|---|---|---|---|
| **River** | A | 7.5 | 24.9 | 9.92 | 1.96 | 0.02 |
| | B | 7.7 | 25.5 | 9.47 | 2.69 | 0.02 |
| | C | 7.5 | 25.4 | 10.10 | 2.03 | 0.02 |
| **Pond** | A | 8.2 | 28.7 | 8.29 | 8.17 | 0.02 |
| | B | 8.5 | 30.5 | 8.83 | 10.31 | 0.02 |
| | C | 8.5 | 30.3 | 9.46 | 8.59 | 0.02 |

Physicochemical factors and water quality categorization are strongly related to the presence and density of kingfisher populations in the area, as kingfishers rely heavily on good water environmental conditions to survive. Physicochemical properties, such as water pH. Kingfishers require water with a balanced pH (typically between 6.5 and 8.5). Water that is overly acidic or alkaline might limit the availability of food for fish and aquatic invertebrates. Areas with constant pH typically have healthier and denser kingfisher populations. For example, the water pH in the Lata river region of Hokkaido Glamping Park, Jeli Kelantan, is assessed to be 7.5 to 7.7, shows clean.

Furthermore, kingfisher prey species require appropriate water temperature to survive. Water that is too hot or too cold might reduce fish populations, affecting the presence of kingfishers. Kingfisher numbers tend to be higher in areas with year-round acceptable water temperatures. The water temperature in the Lata river area of Hokkaido Glamping Park, Jeli Kelantan, is optimally estimated between 24.9 to 25.5 degrees Celsius.

Low turbidity suggests cleaner and healthier water, which is critical for kingfisher species diversity. turbidity water can obscure their vision, making hunting difficult. Clear water is correlated with a larger kingfisher population and density. Water turbidity in the Lata River vicinity of Hokkaido Glamping Park, Jeli Kelantan ranges from 1.96 to 2.69 NTU. The water turbidity in the Lata River area of Hokkaido Glamping Park, Jeli Kelantan shows clean and clear, that is clean and safe conditions with an estimate of less than 5 NTU.

Finally, high dissolved oxygen levels imply good water and promote healthy fish populations, which are the primary food source for kingfishers. Kingfisher populations tend to be denser in areas with high dissolved oxygen levels. In the Lata River section of Hokkaido Glamping Park, Jeli Kelantan, dissolved oxygen levels range from 9.47 to 10.10 mg/l, indicating a clean that is level of 7 or higher. The Lata river area of Hokkaido Glamping Park, Jeli, Kelantan has high dissolved oxygen levels due to the existence of robust aquatic life such as, fish which require it.

Water quality is rated based on its purity and appropriateness for aquatic life. Areas with a high-water quality grade (good or very good) imply healthy aquatic ecosystems and a high biodiversity, including kingfisher populations. In contrast, locations with a low.

These factors can serve as early indicators of changes in water quality, including acidification, according to a review by Ormerod and Tyler (1993). The link between kingfishers and water quality is highly correlated, as kingfishers serve as bioindicators. The presence of a greater number of kingfisher species in a specific location indicates a cleaner environment, such as a river. The study conducted by Barik et al. (2022) demonstrates the utility of kingfishers as indicators for comprehending environmental changes.

## 4.2 Number of Observation and Status Kingfisher Species

The table above shows 5 species of kingfishers observed at Lata Hokkaido Glamping Park in Jeli, Kelantan. These species include *Actenoides concretus* (Rufous-collared Kingfisher), *Halcyon coromanda* (Ruddy Kingfisher), *Halcyon smyrnensis* (White-throated Kingfisher), *Halcyon pileata* (Black-capped Kingfisher), and *Alcedo meninting* (Blue-eared Kingfisher). Among these, the White-throated Kingfisher is the most frequently observed species, with 25 sightings in both rivers and ponds. In contrast, the Blue-eared Kingfisher is the least observed, with only 2 sightings.

Most of the kingfisher species recorded at the park are classified as "Least Concern" (LC) according to the IUCN Red List, indicating they are not currently at significant risk of extinction. However, one species, the Rufous-collared Kingfisher, is listed as "Near Threatened" (NT) on the IUCN Red List. This species was observed 6 times during the study. The presence of both LC and NT species highlights the park's role in supporting a variety of kingfisher species, some of which may require monitoring and conservation efforts due to their vulnerable status.

**Table 4.2:** Number of observation kingfisher species

| No. | Scientific name | Common name | Number of Observation | Status IUCN Red List |
|---|---|---|---|---|
| 1. | *Actenoides concretus* | Rufous-collared Kingfisher | 6 | Near Threatened |
| 2. | *Halcyon coromanda* | Ruddy Kingfisher | 5 | Least Concern |
| 3. | *Halcyon smyrnensis* | White-throated Kingfisher | 25 | Least Concern |
| 4. | *Halcyon pileata* | Black-capped Kingfisher | 13 | Least Concern |
| 5. | *Alcedo meninting* | Blue-eared Kingfisher | 2 | Least Concern |

Methodology for observing kingfisher species. This observation is carried out with direct vision. Observers undertake direct visual study using binoculars, smartphone cameras, GPS, and the book A Field Guide to the Birds of Malaysia and Singapore. This will make it simpler for observers to see the variety of kingfisher species in Lata Hokkaido Glamping Park, Jeli Kelantan.

White-throated Kingfisher is more commonly seen in ponds than other species because of the existence of a nutritional food, such as catfish seeds preserved by local residents. A nutritional food, such as catfish seed, allows the White-throated Kingfisher to live more comfortably because it does not have to worry about its nutritional needs.

Species classified as "Least Concern" typically have stable populations and do not face significant risks in the short term. As a result, this species may have a lesser conservation priority than more threatened species. For example, Least Concern species include the ruddy kingfisher, white-throated kingfisher, black-capped kingfisher, and blue-eared kingfisher. Species classified as "Near Threatened" have challenges that could lead to population decrease in the near future if suitable conservation measures are not taken. These species require more attention to prevent them from becoming endangered or threatened. For example, the rufous-collared kingfisher is a near-threatened species.

First and foremost, periodic monitoring. Conduct periodic surveys to assess Rufous-collared Kingfisher populations and habitat changes. This includes measuring habitat use, breeding rates, and foraging success using technologies such as smartphone cameras and GPS to acquire precise information about their movements and behaviour. The next step is to restore and protect the habitat. Replant native trees and plants in damaged areas to provide suitable nesting places and food sources. Create protection zones in important locations where Rufous-collared Kingfishers are commonly seen. Disruptive human activity, like logging and development, should be avoided in advance.

### 4.3 Relative Abundance of Kingfishers Species

The table shows the greatest relative abundance in the river area with the presence of all species in the river area. While the least species in terms of relative abundance is in the pond area. The river area shows the most species which are 5 species which are Rufous-collared kingfisher, Ruddy kingfisher, White-throated kingfisher, Black-capped kingfisher and Blue-eared kingfisher. While the pond only has 4 species, namely Rufous-collared kingfisher, Ruddy kingfisher, White-throated kingfisher, and Black-capped kingfisher. But the highest percentage of relative abundance is in the area of the pond which is White-throated as much as 53.33% while the least is in the area of the pond which is Rufous-collared kingfisher and Ruddy kingfisher get the same percentage which is 6.67%.

The relative abundance of a species is influenced by the habitat and nutritional status of an area. For example, in the pond area the relative abundance is 4 species because of their habitat and diet, such as the pond has catfish fry and the forest has small insects to eat. Lower relative abundance in pond areas than in river areas. this may be due to the presence of nets used by catfish farmers will make it difficult for kingfishers to find food. In addition, the poor water quality in the pond area will also make it difficult for the kingfisher to find its food. The primary diet of the Common Kingfisher is fish. However, they occasionally consume other types of prey such as crustaceans, amphibians, or reptiles (Cvech & Cvech, 2015).

The relative abundance in the pond area is reduced to 4 kingfisher species, namely the Rufous-collared kingfisher, Ruddy kingfisher, White-throated kingfisher, and Black-capped kingfisher. This may be due to the pond being covered by nets making it difficult for the kingfisher to find food. In addition, competition between prey and predators also plays an important role in relative abundance.

The primary factors that determine habitat selection are the abundance of food and the characteristics of the feeding place Okore OOw and Amadi C., (2016). Research conducted by Strong and Sherry (2000) and Fayt (2003) supports the idea that food availability and distribution play a crucial role in determining habitat choices. The presence of rivers and ponds affects the relative abundance of kingfishers. The presence of catfish seeds in the pool area facilitates the hunting of prey by kingfishers. The river ecosystem also supports a diverse food, including tiny fish. Farine and Lang, (2013) discovered that the rate of food consumption is greater in the morning compared to other times of the day.

In their study, Bonter et al. (2013) observed that the majority of bird species start their foraging activities prior to sunrise, persist throughout the day, and conclude before dusk. The feeding behaviour of birds is also influenced by intricate ecosystems. Kingfisher species have higher levels of activity during the early hours in order to forage for food, as opposed to the evening. The kingfisher is most active in searching for food between 7 am and 11 am. Kingfishers are less busy in the afternoon and evening while they are searching for food.

The relative abundance of kingfisher species in the pond and river areas reveals that the river area has more kingfisher species, including rufous-collared kingfisher, reddish kingfisher, white-throated kingfisher, black-capped kingfisher, and blue-eared kingfisher. This is because the river area near the woodland area contains a lot of food, such as small insects and fish. As a result, the river area has a higher relative number of species than the pond area, which focuses on a single food, catfish seeds. The relative abundance of kingfisher species at Lata Hokkaido Glamping Park in Jeli, Kelantan, is also influenced by habitat factors, prey availability, and potential human impact. Habitats with abundant prey will affect the relative abundance of kingfisher species. Potential human influences, such as logging, will have an effect on the relative abundance of kingfisher species. Human activities can disrupt the richness of kingfisher species and ecosystems.

**Table 4.3:** Relative abundance of kingfishers in pond and river

| Scientific name | Common name | Pond | River |
|---|---|---|---|
| *Actenoides concretus* | Rufous-collared Kingfisher | 6.67 | 19.05 |
| *Halcyon coromanda* | Ruddy Kingfisher | 6.67 | 14.29 |
| *Halcyon smyrnensis* | White-throated Kingfisher | 53.33 | 42.86 |
| *Halcyon pileata* | Black-capped Kingfisher | 33.33 | 14.29 |
| *Alcedo meninting* | Blue-eared Kingfisher | - | 9.52 |

The net result of prey-predator conflict in ponds is a reduction in food availability. Kingfishers' primary food source is fish, which are frequently caught using nets. Excessive use of nets can severely diminish the fish population, resulting in a scarcity of food for Kingfishers.

In addition, there is competition with other species. Kingfishers may compete with other birds that eat fish and small water creatures. This competition can restrict prey availability and thus Kingfisher abundance. Predators such as huge birds of prey, animals, and reptiles can deplete Kingfisher populations by consuming young or adult individuals. The presence of predators might cause Kingfishers to change their behaviour, such as avoiding specific locations or spending more time in shelter, affecting their abundance and sightings. The relationship of prey and predator is critical to preserving ecological balance. An imbalance, such as a rapid rise of predators or a quick decrease in prey, might have an impact on the Kingfisher population.

## 4.4 Diversity Index

Diversity is a commonly employed concept in various scientific fields, including biology (OE et al. 2000) and ecology (Nagler J, 2014), as well as investment and portfolio theory (Blume ME, Crockett J et al., 1974; Haldane AG and May RM, 2011), linguistics (Greenberg JH, 1956, Yule CU 2014), and sociology (Penner A and Penner E, 2017). Diversity, in the context of these fields, refers to the extent and distribution of specific characteristics within a particular population. It is seen as a crucial characteristic that may change dynamically, impacted by interactions within a population, and altered by external influences.

Since the river value of r is 0.04, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, pH at river (y) of species kingfisher and water quality physicochemical parameters. The correlation between kingfisher and water quality is very important because to see that these two variables have a relationship that can be used as a bioindicator in this study. Lack of physicochemical parameters, a short period of time can also affect these two variables. While the pond value of r is 0.06, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, pH (y) of species kingfisher and water quality physicochemical parameters. Since the river value of r is -0.17, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, temperature (y) of species kingfisher and water quality physicochemical parameters. While the pond value of r is 0.09, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, temperature (y) of species kingfisher and water quality physicochemical parameters.

Since the river value of r is 0.17, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, dissolved oxygen (y) of species kingfisher and water quality physicochemical parameters. While the pond value of r is -0.19, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, dissolved oxygen (y) of species kingfisher and water quality physicochemical parameters.

Since the river value of r is -0.01, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, turbidity at river (y) of species kingfisher and water quality physicochemical parameters. While the pond value of r is 0.05, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, turbidity (y) of species kingfisher and water quality physicochemical parameters.

Since the river value of r is there is 0 no correlation between number of species kingfisher (x) and the physicochemical parameters, salinity at river (y) of species kingfisher and water quality physicochemical parameters. While the pond value of r is 5.13201E-17, there is no correlation between number of species kingfisher (x) and the physicochemical parameters, salinity (y) of species kingfisher and water quality physicochemical parameters.

**Table 4.4:** Pearson correlation coefficient

| Physicochemical parameters | River | Pond |
|---|---|---|
| **pH** | 0.04 | 0.06 |
| **Temperature** | -0.17 | 0.09 |
| **Dissolved oxygen** | 0.17 | -0.19 |
| **Turbidity** | -0.01 | 0.05 |
| **Salinity** | 0 | 5.13201E-17 |

The variables of number of kingfisher species and physicochemical parameters of water quality cannot be used because kingfishers cannot be determined by numbers. Using the kingfisher as a bioindicator in determining the quality of river water in the Hokkaido cascade cannot be demonstrated through statistical calculations such as Pearson Correlation Coefficient. variables between the number of kingfisher species and the physicochemical parameters of water quality in both areas, namely rivers and ponds, showed no correlation. This may be due to factors such as the time period of sampling limits, human activities, weather and climate factors and so on that can affect those variables.

The brief duration or period of time used to perform this study could be one of the reasons for the lack of correlation. The time period of this study is at least 6 months to 1 year. This is because it can make all water quality parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen, Total Dissolved Solid, Total Suspended Solid and so on. This study ran for 21 days. This means that the data collected in the study is insufficient to create variables that correlate the variety of kingfisher species with the physicochemical characteristics of water quality in both rivers and ponds. Furthermore, weather and climate conditions could explain no correlation. This is because weather and climate conditions, such as strong rains, can have an impact on the quantity of kingfisher species as well as the physicochemical characteristics of water quality. Water quality physicochemical characteristics such as pH, turbidity, and so on can vary as a result of heavy rain, which affects the reading of these parameters. This results in a lack of correlation between kingfisher species diversity and physicochemical factors of water quality.

This finding has implications for the practicality of utilising kingfishers as a bioindicator to measure the quality of river water in Lata Hokkaido Glamping Park, Jeli Kelantan, as well as the accuracy of water quality evaluation. Human activities can disrupt Kingfisher populations, resulting in population fluctuations that do not always reflect water quality but rather ecological disturbances. Complex ecological factors like prey and predator competition, as well as seasonal change, influence kingfisher abundance. This makes them a less specific indicator of water quality because population shifts can be driven by a multitude of sources other than water pollution.

**River**

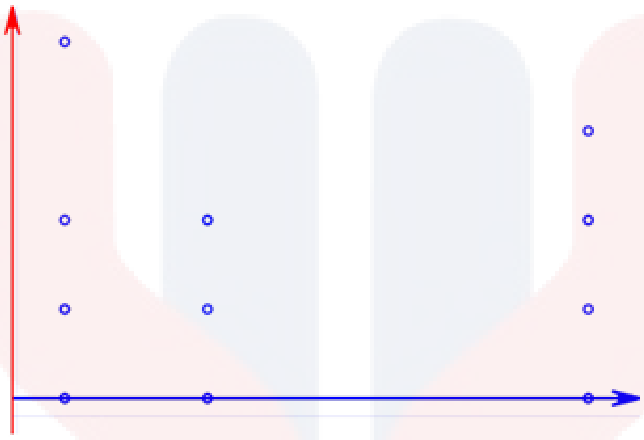

**Figure 4.1:** shows no correlation between species kingfisher and pH

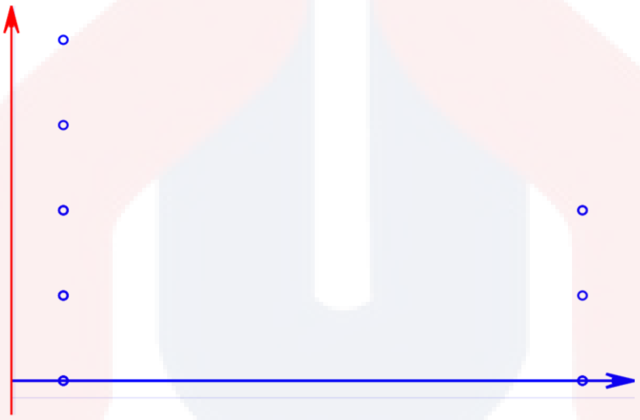

**Figure 4.2:** shows no correlation between species kingfisher and temperature

**Figure 4.3:** shows no correlation between species kingfisher and turbidity

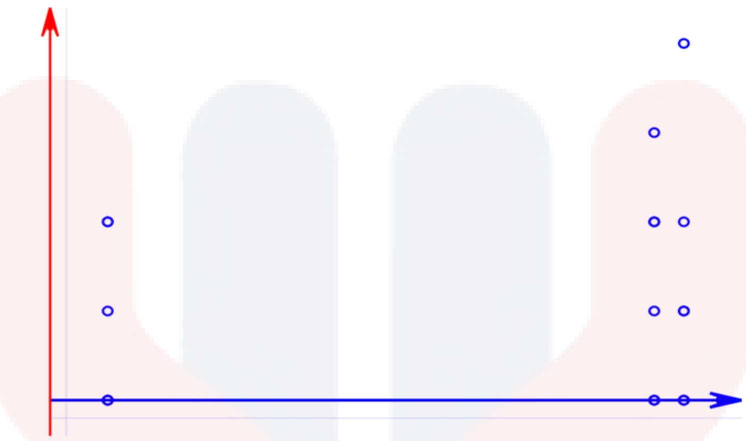

**Figure 4.4:** shows no correlation between species kingfisher and dissolved oxygen

**Figure 4.5:** shows no correlation between species kingfisher and salinity

## Pond

**Figure 4.6:** shows no correlation between species kingfisher and pH

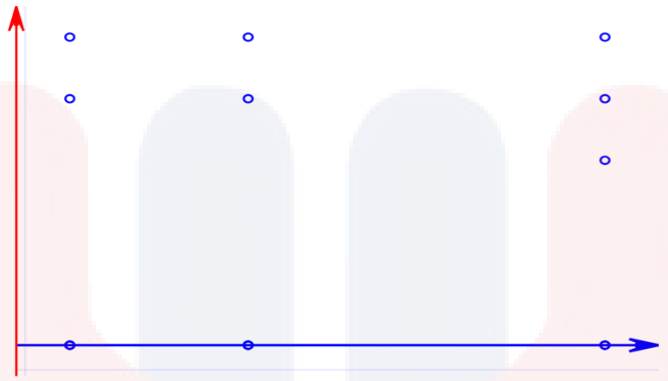

**Figure 4.7:** shows no correlation between species kingfisher and temperature

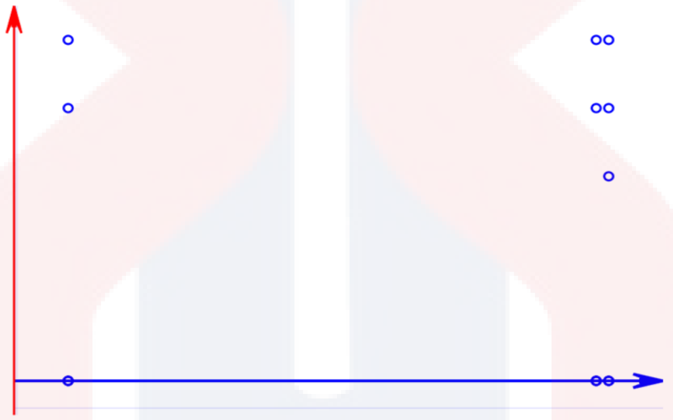

**Figure 4.8:** shows no correlation between species kingfisher and turbidity

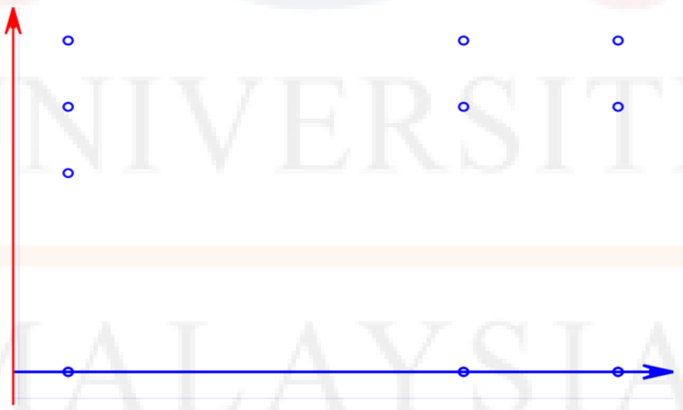

**Figure 4.9:** shows no correlation between species kingfisher and dissolved oxygen

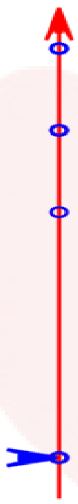

**Figure 5.0:** shows no correlation between species kingfisher and salinity

Descriptive statistics were used to compare and contrast kingfisher population data with physicochemical parameters of water quality, such as pH, temperature, dissolved oxygen, turbidity and salinity. This comparison aims to identify any potential correlations or patterns between kingfisher presence and abundance and measured water quality indicators. By using these statistical tools, it can effectively highlight differences and similarities in the data, facilitating a better understanding of the interactions between bird species and their environments. This approach allows for a more comprehensive analysis of the ecosystem and the factors that influence the presence of different species in Lata Hokkaido Glamping Park, Jeli Kelantan.

**Table 4.5:** descriptive statistics for physicochemical parameter

| | River | | | | Pond | | | |
|---|---|---|---|---|---|---|---|---|
| **Physicochemical parameters** | **Min.** | **Max.** | **Mean** | **Std. Dev** | **Min.** | **Max.** | **Mean** | **Std. Dev** |
| pH | 7.46 | 7.68 | 7.55 | 0.095 | 7.90 | 8.74 | 8.41 | 0.37 |
| Temperature | 29.6 | 31.95 | 30.65 | 0.99 | 29.6 | 31.95 | 30.65 | 0.99 |
| Dissolved oxygen | 7.6 | 9.41 | 8.65 | 0.76 | 7.63 | 9.41 | 8.65 | 0.76 |
| Turbidity | 6.67 | 10.57 | 9.24 | 1.86 | 6.67 | 10.57 | 9.24 | 1.86 |
| Salinity | 0.02 | 0.02 | 0.02 | 3.56E-18 | 0.02 | 0.02 | 0.02 | 3.56E-18 |

The least frequency of observation is *Alcedo meninting* or Blue-eared kingfisher which is only 2 with a percentage of 4%. While the most Frequency of observation is *Halcyon smyrnensis* or White-throated kingfisher which is 25 with the highest frequency which is 49%. Food availability factors may contribute to the frequency of kingfishers in a given habitat. For example, in ponds that have catfish seeds that make it easier for kingfishers to find food. The second highest frequency of observation is *Halcyon pileata* or Black-capped kingfisher which is 13 with a percentage of 25%.

**Table 4.6:** descriptive statistics for kingfisher species

| Scientific name | Common name | Frequency of observation | Percentage % |
|---|---|---|---|
| *Actenoides concretus* | Rufous-collared Kingfisher | 6 | 12 |
| *Halcyon coromanda* | Ruddy Kingfisher | 5 | 10 |
| *Halcyon smyrnensis* | White-throated Kingfisher | 25 | 49 |
| *Halcyon pileata* | Black-capped Kingfisher | 13 | 25 |
| *Alcedo meninting* | Blue-eared Kingfisher | 2 | 4 |



In this study, Shannon-Wiener Diversity Index and Margalef Diversity Index were used to calculate the diversity of kingfisher species. The Shannon-Wiener

Diversity Index attempts to measure the diversity of kingfisher species. A higher Shannon Index value indicates that the species community is more diverse. H' = - [p(i) * ln(p(i)] is the formula to determine the Shannon Index (H'). The area with the highest diversity is in the river area with H' = 1.096 while in the pond area is lowest diversity H' = 1.063. This may be due to the presence of many diets such as small fish in the river area. This indicates that the river area supports a more diverse kingfisher community compared to the pond area. One possible explanation for this higher diversity in the river area is the abundance of various food sources, such as small fish, which can support a larger and more varied kingfisher population. The presence of a rich diet can lead to a more stable and diverse ecosystem, allowing multiple species to thrive and maintain a balanced distribution of individuals.

Furthermore, the Margalef Diversity Index (Margalef, 1958) was used as a simple measure of kingfisher species richness. Many measures of species richness have the disadvantage of being dependent on sampling effort. The greater the sampling effort, the higher the index value. The Margalef Diversity Index is calculated as R1 = (S - 1) / In N. in the river area has the highest R1 = 4.67. River areas show higher species richness. While in the lowest pond area which is R1 = 3.7. In the pond area it shows a lower species richness than in the river area. This difference may be due to the difference in the number of species found or the number of individuals collected in the two areas. For example, river areas may offer more diverse or larger habitats, which support more kingfisher species, while pond areas may be more limited in these aspects.

Other elements that affect the existence and behaviour of Kingfishers. One of the most significant elements is food availability, since a suitable abundance of tiny fish and aquatic invertebrates is critical for the kingfisher. If this food source is insufficient, the kingfisher may not be present in the area, even if the water quality is high. Furthermore, habitat structure as is the availability of adequate roosting and nesting locations. Human activities such as logging, and camping might disrupt kingfishers for reproduction.

Next, for kingfisher species, analysing the frequency of observations and variations in the number of individuals will aid in determining the most impacted or dominant species in the research area. Species with the most data from one observation to the next may demand additional attention, as this could suggest sensitivity to environmental changes.

Moreover, trend or trend analysis can be performed by reviewing observational data from the study period. For example, if the number of one species of kingfisher consistently increases or decreases over time, it may indicate the presence of particular variables influencing their populations.

The river area has higher Shannon-Wiener Diversity and Margalef Richness Indexes than the pond area. In the river area, H' = 1.096 and R1 = 4.67. This is owing to the abundance of prey, such as aquatic insects and small fish. While in the pool area, H'=1.063 and R1=3.71. In the pool region, there is only one diet: catfish seeds. The Shannon-Wiener Diversity Index and the Margalef Richness Index can be used to identify and quantify the diversity of kingfisher species at Lata Hokkaido Glamping Park in Jeli, Kelantan.

**Table 4.7:** Shannon-Wiener Index (H'), Margalef's Richness Index (R1)

| Areas | H' | $R_1$ |
|---|---|---|
| River | 1.096 | 4.67 |
| Pond | 1.063 | 3.71 |

## 4.5 Bird Diversity

### 4.5.1 Kingfisher Species

From this study, 5 kingfisher species of the same family Alcedinidae were recorded which had 51 individuals in Lata Hokkaido Glamping Park, Jeli Kelantan in 2024. The main method of sampling kingfisher bird species was recorded through direct observation, and points count Based on Figure 4.1 the highest percentage of recorded species is *Halcyon smyrnensis* or its common name is white-throated kingfisher which is 49%. Halcyon smyrnensis (white-throated kingfisher) had the highest percentage at 49% compared to other kingfisher species. This may be due to habitat factors and sufficient food factors and the lack of human disturbance there.

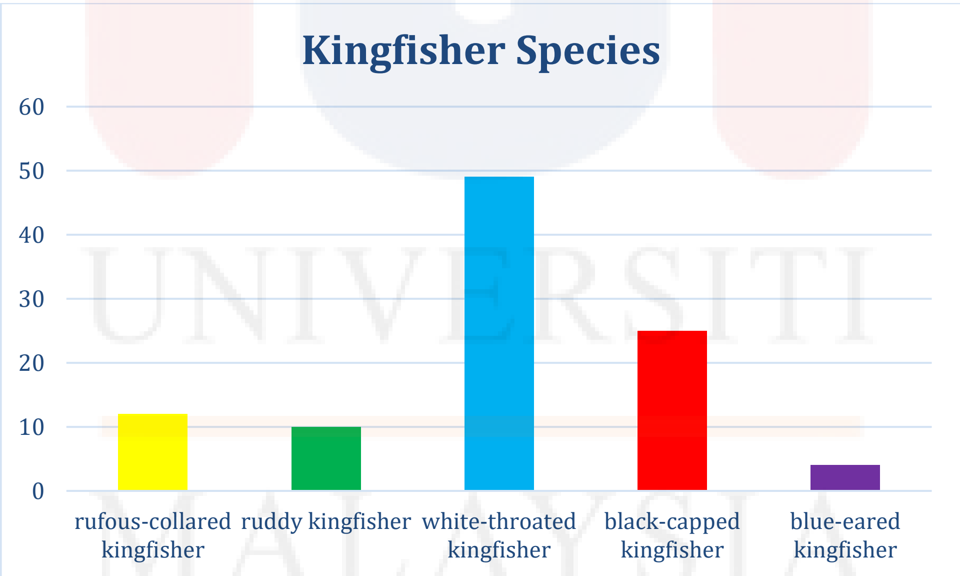


**Figure 5.1:** percentage kingfisher species

The highest percentage of the recorded kingfisher species is *Halcyon smyrnensis* or its common name is white-throated kingfisher. While the lowest percentage is *Alcedo Meninting* or its common name is blue-eared kingfisher with only 4%. All species presented in this research have been identified as

"Least Concern" or LC and "Near Threatened" or NT species according to the IUCN Red List of Threatened Species. Table 4.1 lists the bird species observed in this study according to their respective order.

**Figure 5.2:** *Halcyon smyrnensis* (White-throated kingfisher)

The approach utilized in this study to sample the diversity of kingfisher species included used binoculars, GPS, smartphone cameras, and the book A Field Guide to the Birds of Malaysia and Singapore. The approach employed in this study can be applied to collect and measure the diversity of kingfisher species in the river and pond region at Lata Hokkaido Glamping Park, Jeli Kelantan.

Techniques for direct observation and eye count based on standardised protocol guidelines. Kingfishers are observed directly in ponds and rivers. Binoculars, GPS, smartphone cameras, and the book A Field Guide to the Birds of Malaysia and Singapore can all help with direct observation. Direct observation and point counting are used throughout the investigation in accordance with protocol standardlized. The study area has a point count of 20 points, with 10 points in the river and another 10 in the pond. Observers follow the standard protocol technique of strolling to the river and pond area at a 100m interval from each count site. When the observer reaches a point count, he will stop and explore his surroundings for 2 to 3 minutes before returning to his observations of the kingfisher species for another 10 minutes. The distance between the observer and the kingfisher species is 25 metres. This allows the observers to observe the kingfisher species peacefully and without disruption.

The value of kingfisher species variety as a bioindicator of a healthy ecosystem stems from the fact that it demonstrates ecological balance. The presence of different species suggests that the ecosystem has enough habitat diversity and food resources to support the survival of different species. This is typical in stable and healthy ecosystems with low levels of pollution, habitat loss, and human pressure. Kingfisher as a bioindicator also helps with environmental management decisions. Data on the diversity and health of kingfisher populations can be used to develop conservation plans, maintain habitats, and reduce pollution. This not only helps to preserve the kingfisher population, but it also enhances the overall health of the aquatic ecosystem, which is critical for the survival of many ecosystems.

## 4.6 Relationship Kingfisher and Water Quality

The study conducted by India Water Portal revealed a notable rise in air temperature, water temperature, and turbidity, along with a decline in humidity in the mangrove areas. The rise in air temperature led to a gradual rise in water temperature, which in turn affected water quality by causing changes in pH levels and the amount of dissolved oxygen in the water. Additionally, human activities such as agricultural run-off, domestic and industrial waste disposal, as well as the presence of microplastics and heavy metals, also played a role in influencing water quality.

The presence of these fish in the waterways has a negative impact on both the fish themselves and the survival of water birds in the vicinity of the water bodies. The rise in turbidity of wetland waterways was seen to adversely affect the population of kingfishers, since it impairs their capacity to visually detect and capture fish in the water. Kingfishers have a higher ability to locate prey that is in motion in waterways that are clear or have less turbidity.

Elevated levels of suspended solid particles impede the transmission of light, hence reducing the optical distance within which prey may be observed. This has the potential to reduce their ability to search for food effectively. Aquatic creatures that live at the bottom and rely on light for survival are greatly impacted by the reduction of light and are vulnerable to the rise in temperature caused by the absorption of heat by suspended solid particles.

The study conducted at Lata Hokkaido Glamping Park in Jeli Kelantan examined the correlation between kingfishers and water quality as a bioindicator. The results indicate that kingfishers are not suitable as bioindicators, since there is no significant association between them and water quality. Figure 4.1 to 5.0 demonstrate that there is no association between kingfisher and physico-chemical indices of water quality, such as pH, temperature, dissolved oxygen, turbidity, and salinity.

The findings of this study may be constrained due to several circumstances, such as restricted sample duration, climatic and meteorological conditions, human activities, and other related aspects. Prior research has demonstrated that king prawns can serve as a bioindicator in a river environment. Birds serve as reliable indicators of pollution in both terrestrial and aquatic habitats. Avian species such as the Kingfisher, Cormorant, and Heron are commonly found in proximity to rivers or ponds, where they typically capture tiny fish, insects, and insect larvae. Severe water pollution leads to a decline in the avian population due to water contamination Roche et al., (2010).

The presence of kingfishers may be more closely tied to the availability of food resources or other habitat factors than water quality. For example, the presence of fish as the kingfisher's primary food source may influence their presence in a given location, even if these characteristics are unrelated to water quality. Second, the sensitivity of kingfisher species to pollution varies depending on the type of pollution and its intensity. If the major pollutant is a specific chemical that has no direct impact on the kingfisher's food source, their presence may not accurately indicate the level of water pollution. Third, habitat stress, climate change, and human disturbance can all have an impact on kingfisher populations. This suggests that, while water quality is crucial in the ecosystem, other aspects should be addressed when utilising kingfishers as indicators.

## 4.7 Species Accumulation Curve (SAC)

Various curve-fitting models frequently yield divergent predictions of species richness for a certain level of effort, and the inaccuracy increases as the extrapolation to a total species count becomes bigger Thompson et al., (2003). Various techniques for assessing species abundance and distribution are more precise depending on the taxonomic group, environmental conditions, and the quantity or methodology of surveys. Estimates of the overall number of species in a certain region can be derived from data presented in reports by consultants or used to validate the estimates of species richness provided by consultants Thompson and Withers (2003).

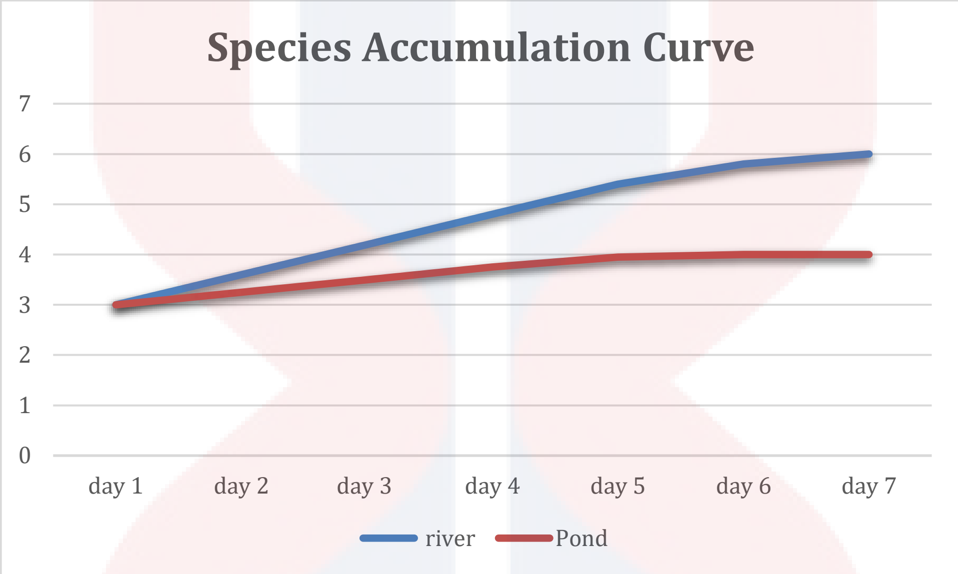


**Figure 5.3:** species accumulation curve (SAC)

Regarding the SAC in Figure 5.3, the graph reaches an asymptote at the final sampling point, indicating that all kingfisher species recorded in this study are accounted for. From day 5 to day 7, the graph shows a curved trend for river and pond areas. This shows that there are not many kingfisher species in the area, there are only 5 species namely *Actenoides concretus*, *Halcyon coromanda*, *Halcyon smyrnensis*, *Halcyon pileate* and *Alcedo meninting.*

Future studies should evaluate the necessity for ongoing monitoring to address potential variations in the abundance and distribution of kingfisher species over time. This could be due to natural ecological changes or manmade pressures, both of which could have an impact on ecosystem health. With regular monitoring and data analysis, researchers will be able to detect long-term trends in the quantity and distribution of kingfisher species, as well as identify reasons contributing to such changes.

Finally, this knowledge provides useful context for interpreting SAC findings and their implications in a broader ecological framework. Understanding trends and patterns in kingfisher species abundance allows SAC to develop more effective conservation and management plans to protect the health of habitats kingfisher. This is critical for ensuring the long-term viability of kingfisher resources as well as the overall environment.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

In conclusion, this study concludes that the kingfisher is not a suitable bioindicator for assessing the environmental conditions at Lata Hokkaido Glamping Park, Jeli, Kelantan. The lack of a substantial association between the number of kingfisher species and water quality factors such as pH, temperature, dissolved oxygen, turbidity, and salinity is the reason for this. Possible factors that might contribute to this inaccuracy include a lack of appropriate sample time or duration, which may not capture the whole range of diversity in kingfisher communities. To address inaccuracies in this study in the future, the duration should be extended using the established standard protocol. Extreme weather fluctuations or unstable climate conditions might alter the habitat and behaviour of ospreys, hence influencing the outcomes of the research.

In order to enhance the efficacy of kingfishers as a bioindicator, more research involving extended and thorough sampling, along with minimising human interference, is necessary to get more precise and compelling data.

## 5.2 Recommendation

Recommendation based on the results can be concluded as follows in Lata Hokkaido Glamping Park, Jeli Kelantan can improve existing methods for improvement such as taking river water velocity, river water depth, nutrient content, etc. to improve the relationship between kingfisher species and water quality so that there is a strong correlation to prove kingfisher as a bioindicator in Lata Hokkaido Glamping Park, Jeli Kelantan.

Extreme weather variations and human activity are two distinct elements that contribute to the inaccuracy of employing kingfishers as bioindicators. Extreme weather fluctuations: Weather patterns, such as significant floods or droughts, can have a direct impact on kingfisher habitats. Extreme flooding can harm kingfisher nests and breeding grounds, while extended droughts can limit the availability of water and prey. This can affect the abundance and distribution of kingfishers, as well as their foraging and breeding habits. In addition, there is human activity. Development in regions near rivers or wetlands may damage kingfisher habitat. Human development pressures, such as riverbank development or water resource exploitation, can alter the physical and chemical features of river ecosystems, influencing kingfisher populations and behaviour. Furthermore, human activities such as deforestation, intensive agriculture, and river pollution can diminish the species diversity of kingfisher prey, affecting their capacity to find food.

The proposed actions, such as prolonged and extensive sampling and reducing human disturbance, are sufficient to improve the kingfisher performance as a bioindicator. Extended sampling. Continuous sampling at designated research sites is required to monitor kingfisher numbers and distribution. This will enable researchers to monitor long-term trends in kingfisher populations and identify potential habitat or environmental changes. Last but not least, reduce human disturbance. Reducing or managing human disturbance in the research area is critical to ensuring that the data collected is accurate and reflects the ecosystem's natural state. This could include limiting human access to the research area, such as creating restricted zones or eliminating human activities that harm kingfisher habitat.

# REFERENCES


Amano, T., Székely, T., Wauchope, H.S. et al. Responses of global waterbird populations to climate change vary with latitude. Nat. Clim. Chang. 10, 959–964 (2020).

Arthur, A. D., Reid, J. R. W., Kingsford, R. T., McGinness, H. M., Ward, K. A., & Harper, M. J. (2012). Breeding Flow Thresholds of Colonial Breeding Waterbirds in the Murray-Darling Basin, Australia. Wetlands, 32(2), 257–265. https://doi.org/10.1007/s13157-011-0235-y

Asefa, A., Mengesha, G., Sori, T., & Mamo, Y. (2018). Local- and landscape-level effects of land use change on bird diversity in Abiata-Shalla Lakes National Park, Ethiopia. 57(1), 51–58. https://doi.org/10.1111/aje.12558

Barik, S., Saha, G. K., & Mazumdar, S. (2022). Conservation prioritization through combined approach of umbrella species selection, occupancy estimation, habitat suitability and connectivity analysis of kingfisher: A study from an internationally important wetland complex (Ramsar site) in India. Ecological Informatics, 72, 101833. https://doi.org/10.1016/j.ecoinf.2022.101833

Bird As Bio-Indicator Which Help To Measure Environmental Health | PDF | Biodiversity | Natural Environment. (n.d.). Scribd. Retrieved May 25, 2024, from https://www.scribd.com/document/575646170/Bird-as-Bio-Indicator-Which-Help-to-Measure-Environmental-Health

Bobika et al. Does Substrate Quality Influence Diversity and Habitat Use of Waterbirds?: A Case Study from Wetlands in Southern India Ekológia (Bratislava), vol. 40, no. 1, 1 Mar. 2021, pp. 70–79, https://doi.org/10.2478/eko-2021-0009.

Bonnington, C., Weaver, D., & Fanning, E. (2008). The habitat preference of four kingfisher species along a branch of the Kilombero River, southern Tanzania. African Journal of Ecology, 46(3), 424–427. https://doi.org/10.1111/j.1365-2028.2007.00812.x

Bonter DN, Zuckerberg B,Sedgwick CW, Hochachka WM.Daily foraging patterns in free-living birds: exploring thepredation–starvation trade-off. ProcR Soc, B. 2013; 280(1760):20123087 https://www.researchgate.net/publication/344403486_Foraging_Behavior_of_Birds_at_Morning_and_Evening_Times_A_Preliminary_Study

Bordalo, A.A., Teixeira, R. & Wiebe, W.J. 2006. A water qualityindex applied to an international shared river basin: The caseof the Douro River. Environmental Management 38: 910-920.doi: 10.1007/s00267-004-0037-6.

C.T. Shifa, Salindra K. Dayananda, Xu Yanjie, K.A. Rubeena, Sabir Bin Muzaffar, Aymen Nefla, T. Jobiraj, P. Thejass, Omer R. Reshi, K.M. Aarif. (2023, November 10). Waterbirds, indicators of wetland health. India Water Portal Hindi. https://www.indiawaterportal.org/articles/waterbirds-indicators-wetland-health

Čech, M., & Čech, P. (2015). Non-fish prey in the diet of an exclusive fish-eater: The Common KingfisherAlcedo atthis. Bird Study, 62(4), 457–465. https://doi.org/10.1080/00063657.2015.1073679

Chiu, M.-C., Kuo, M.-H., Hong, S.-Y., & Sun, Y.-H. (2013). Impact of extreme flooding on the annual survival of a riparian predator, the Brown DipperCinclus pallasii. Ibis, 155(2), 377–383. https://doi.org/10.1111/ibi.12035

CHIU, M.-C., KUO, M.-H., SUN, Y.-H., HONG, S.-Y., & KUO, H.-C. (2008). Effects of flooding on avian top-predators and their invertebrate prey in a monsoonal Taiwan stream. Freshwater Biology, 53(7), 1335–1344. https://doi.org/10.1111/j.1365-2427.2008.01968.x

CUMMING, G. S., PAXTON, M., KING, J., & BEUSTER, H. (2012). Foraging guild membership explains variation in waterbird responses to the hydrological regime of an arid-region flood-pulse river in Namibia. Freshwater Biology, 57(6), 1202–1213. https://doi.org/10.1111/j.1365-2427.2012.02789.x

Deomurari, Arpit, et al. Projected Shifts in Bird Distribution in India under Climate Change. Diversity, vol. 15, no. 3, 10 Mar. 2023, p. 404, https://doi.org/10.3390/d15030404.

Department of Environment. (2022). National Water Quality Standards and Water Quality Index – Department of Environment. Doe.gov.my. https://www.doe.gov.my/en/national-river-water-quality-standards-and-river-water-quality-index/

Domina, T., Penner, A., & Penner, E. (2017). Categorical Inequality: Schools As Sorting Machines. Annual Review of Sociology, 43(1), 311–330. https://doi.org/10.1146/annurev-soc-060116-053354

Farine DR, Lang SD. The early birdgets the worm: foraging strategies ofwild songbirds lead to the earlydiscovery of food sources. Biol Lett.2013; 9(6): 20130578.

Filardi, C. E. (2023, February 23). Why I collected a moustached kingfisher. Audubon. https://www.audubon.org/news/why-i-collected-moustached-kingfisher

Forest and Rangeland Ecosystem Science Center. Birds as Indicators of Ecosystem Health | U.S. Geological Survey. Www.usgs.gov, 18 May 2022, www.usgs.gov/centers/forest-and-rangeland-ecosystem-science-center/science/birds-indicators-ecosystem-health.

Francis, E. A. (2017). Paramount Roles of Wild Birds as Bioindicators of Contamination. International International Journal of Avian & Wildlife Biology, 2(6). https://doi.org/10.15406/ijawb.2017.02.00041

Green, Andy J., and Johan Elmberg. Ecosystem Services Provided by Waterbirds. Biological Reviews, vol. 89, no. 1, 21 June 2013, pp. 105–122, https://doi.org/10.1111/brv.12045.

Guerrero-Aguilar, Armando, et al. Bioindicators and Biomonitoring: Review of Methodologies Applied in Water Bodies and Use during the Covid-19 Pandemic. Acta Universitaria, vol. 32, 2022, www.redalyc.org/journal/416/41674605026/html/

Haldane, A. G., & May, R. M. (2011). Systemic risk in banking ecosystems. Nature, 469(7330), 351–355. https://doi.org/10.1038/nature09659

Holt, Emily. Bioindicators: Using Organisms to Measure Environmental Impacts | Learn Science at Scitable. Nature.com, 2010, www.nature.com/scitable/knowledge/library/bioindicators-using-organisms-to-measure-environmental-impacts-16821310/. https://doi.org/10.1038/s41558-020-08723

Husseman, Jason S., et al. Assessing Differential Prey Selection Patterns between Two Sympatric Large Carnivores. Oikos, vol. 101, no. 3, 6 May 2003, pp. 591–601, https://doi.org/10.1034/j.1600-0706.2003.12230.x.

Ibrahim, M., Faridah, O., Adriana, I.N.I., Alaa-Eldin, M.E. &Rossita, M.Y. 2015. Assessment of water quality parametersusing multivariate analysis for Klang River basin, Malaysia.Environmental Monitoring and Assessment 187(1): 1-12. https://www.researchgate.net/publication/324151101_Assessment_of_Pollution_and_Improvement_Measure_of_Water_Quality_Parameters_using_Scenarios_Modeling_for_Sungai_Selangor_Basin

International), BirdLife International (BirdLife. IUCN Red List of Threatened Species: Alcedo Atthis. IUCN Red List of Threatened Species, 1 Oct. 2016, www.iucnredlist.org/species/22683027/89575948.

Jonsson, M., Deleu, P., & Malmqvist, B. (2012). PERSISTING EFFECTS OF RIVER REGULATION ON EMERGENT AQUATIC INSECTS AND TERRESTRIAL INVERTEBRATES IN UPLAND FORESTS. River Research and Applications, 29(5), 537–547. https://doi.org/10.1002/rra.2559

Jonsson, M., Strasevicius, D., & Malmqvist, B. (2012). Influences of river regulation and environmental variables on upland bird assemblages in northern Sweden. Ecological Research, 27(5), 945–954. https://doi.org/10.1007/s11284-012-0974-0

Keten, Akif, et al. Temporal Patterns of Wetland-Associated Bird Assemblages in Altered Wetlands in Turkey. Polish Journal of Ecology, vol. 67, no. 4, 6 Mar. 2020, p. 316, https://doi.org/10.3161/15052249pje2019.67.4.004.

Kirschbaum, K. 2004. Alcedinidae, Animal Diversity Web https://animaldiversity.org/accounts/Alcedinidae/

Kronfeld N-S, Dayan T.Partitioning of time as an ecologicalresource. Annu Rev Ecol Evol Syst.2003; 34(1): 153-181 https://www.researchgate.net/publication/344403486_Foraging_Behavior_of_Birds_at_Morning_and_Evening_Times_A_Preliminary_Study

Liang, Jie, et al. Impacts of Changing Climate on the Distribution of Migratory Birds in China: Habitat Change and Population Centroid Shift. Ecological Indicators, vol. 127, Aug. 2021, p. 107729, https://doi.org/10.1016/j.ecolind.2021.107729.

Mo, Ling, et al. Using the Kingfisher (Alcedo Atthis) as a Bioindicator of PCBs and PBDEs in the Dinghushan Biosphere Reserve, China. Environmental Toxicology and Chemistry, May 2013, p. n/a-n/a, https://doi.org/10.1002/etc.2227.

Morin, A., Chamaillé-Jammes, S., & Valeix, M. (2021). Climate effects on prey vulnerability modify expectations of predator responses to short- and Long-Term climate fluctuations. Frontiers in Ecology and Evolution, 8. https://doi.org/10.3389/fevo.2020.601202

Morin, Aïssa, et al. Climate Effects on Prey Vulnerability Modify Expectations of Predator Responses to Short- and Long-Term Climate Fluctuations. Frontiers in Ecology and Evolution, vol. 8, 22 Jan. 2021, https://doi.org/10.3389/fevo.2020.601202.

MURNInets. (2022). Planmalaysia.gov.my. https://murninetsv2.planmalaysia.gov.my/cms/penunjuks/28/52

Nations, United. "Checklist of CITES Species 2003." Unep.org, 2022, wedocs.unep.org/20.500.11822/8995, https://doi.org/1-%20899628-%2023-%201.

Okore OOw, Amadi C. Bird speciesof Mouau with special emphasis onforaging behavior of the northerngrey-headed sparrow (Passergriseus). Anim Res Int. 2016; 13(1):2338-2344 https://www.researchgate.net/publication/344403486_Foraging_Behavior_of_Birds_at_Morning_and_Evening_Times_A_Preliminary_Study

Ornithology, B. T. F. (2023, March 24). Kingfisher. BTO - British Trust for Ornithology. https://www.bto.org/understanding-birds/birdfacts/kingfisher

Perrins, Christopher M. The New Encyclopedia of Birds. Oxford University Press EBooks, Christopher Perrins, 1 Jan. 2003.

R. Renila, et al. Hunting Behavior and Feeding Success of Three Sympatric Kingfishers' Species in Two Adjacent Wetlands in Southwestern India. Proceedings of the Zoological Society, vol. 73, no. 4, 8 Aug. 2020, pp. 392–399, https://doi.org/10.1007/s12595-020-00344-4 .

Sala, O. E. (2000). Global Biodiversity Scenarios for the Year 2100 . Science, 287(5459), 1770–1774. https://doi.org/10.1126/science.287.5459.1770

Sánchez, E., Colmenarejo, M.F., Vicente, J., Rubio, A., Maria,G.G., Travieso, L. & Rafael, B. 2006. Use of the water qualityindex and dissolved oxygen deficit as simple indicators ofwatersheds pollution. Ecological Indicators 7(2): 315-328.doi: 10.1016/j.ecolind.2006.02.005

Shawn Laidlaw. Kingfisher - Facts and Beyond. Biology Dictionary, 8 Sept. 2020, biologydictionary.net/kingfisher/

Shifa, C., Dayananda, S. K., Xu, Y., Rubeena, K. A., Muzaffar, S. B., Nefla, A., Jobiraj, T., Thejass, P., Reshi, O., & Aarif, K. (2023b). Long-term anthropogenic stressors cause declines in kingfisher assemblages in wetlands in southwestern India. Ecological Indicators, 155, 111062. https://doi.org/10.1016/j.ecolind.2023.111062

Sibley, D., Elphick, C., & Dunning, J. B. (2001). The Sibley guide to bird life & behavior. New York, Alfred A. Knopf

Steinmetz, J., Kohler, S.L. and Soluk, D.A. (2003), BIRDS ARE OVERLOOKED TOP PREDATORS IN AQUATIC FOOD WEBS. Ecology, 84: 1324-1328. https://doi.org/10.1890/00129658(2003)084[1324:BAOTPI]2.0.CO;2

Stollmeier, F., Geisel, T., & Nagler, J. (2014). Possible Origin of Stagnation and Variability of Earth's Biodiversity. Physical Review Letters, 112(22). https://doi.org/10.1103/physrevlett.112.228101

Strasevicius, D., Jonsson, M., Nyholm, N. E. I., & Malmqvist, B. (2013). Reduced breeding success of Pied FlycatchersFicedula hypoleucaalong regulated rivers. Ibis, 155(2), 348–356. https://doi.org/10.1111/ibi.12024

Strong AM, Sherry TW. Habitat-specific effects of food abundanceon the condition of ovenbirdswintering in Jamaica. J Anim Ecol.2000; 69(5): 883-895.

Sumudumali, R.G.I., Jayawardana, J.M.C.K. A Review of Biological Monitoring of Aquatic Ecosystems Approaches: with Special Reference to Macroinvertebrates and Pesticide Pollution. Environmental Management **67**, 263–276 (2021). https://doi.org/10.1007/s00267-020-01423-0

The Migratory Bird Treaty Act (MBTA) | Animal Legal & Historical Center." Www.animallaw.info, www.animallaw.info/intro/migratory-bird-treaty-act-mbta.

The vibrant coloured Rufous-collared Kingfisher - Forest Research Institute Malaysia. (2023, October 11). Forest Research Institute Malaysia. https://www.frim.gov.my/quicklinks/the-vibrant-coloured-rufous-collared-kingfisher/

Thompson, G. G., Withers, P. C., Pianka, E. R., & Thompson, S. A. (2003). Assessing biodiversity with species accumulation curves; inventories of small reptiles by pit-trapping in Western Australia. Austral Ecology, 28(4), 361–383. https://doi.org/10.1046/j.1442-9993.2003.01295.x

VAUGHAN, I. P., NOBLE, D. G., & ORMEROD, S. J. (2007). Combining surveys of river habitats and river birds to appraise riverine hydromorphology. Freshwater Biology, 52(11), 2270–2284. https://doi.org/10.1111/j.1365-2427.2007.01837.x

Waterbirds, indicators of wetland health. (2023, November 10). India Water Portal Hindi. https://www.indiawaterportal.org/articles/waterbirds-indicators-wetland-health

Wikipedia contributors. (2023, November 9). Kingfisher. In Wikipedia, The Free Encyclopedia. Retrieved 18:27, November 21, 2023, from https://en.wikipedia.org/w/index.php?title=Kingfisher&oldid=1184327306

Woodall, C.W., et al. "Classifying Mature Federal Forests in the United States: The Forest Inventory Growth Stage System." Forest Ecology and Management, vol. 546, Oct. 2023, p. 121361, www.fs.usda.gov/research/publications/jrnl/wo_2023_woodall_001.pdf, https://doi.org/10.1016/j.foreco.2023.121361.

Xu, X., Yang, H., & Li, C. (2022). Theoretical Model and Actual Characteristics of Air Pollution Affecting Health Cost: A Review. International Journal of Environmental Research and Public Health, 19(6), 3532. https://doi.org/10.3390/ijerph19063532

Yule, C. U. (2014). The statistical study of literary vocabulary. Cambridge University Press.

## APPENDICES

Appendix A.1: the *Halcyon smyrnensis* and *Halcyon pileate*


Appendix A.2: take the water quality