Aquatic Insects as Bio-Indicators of Water Quality – A Study on Sungai Kawal, Johor National Park of Endau-Rompin, Peninsular Malaysia

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Abstract. Biological indicator species or bio-indicators are sensitive to specific environmental factors so that changes in their environment will be reflected by their incidence or abundance. In fact, aquatic insects of freshwater river and stream ecosystems have been widely used as bio-indicators to examine the species-habitat relationship with regard to the water quality of the habitat. Therefore, this study attempted to determine species richness of aquatic insects in Sungai Kawal, Johor National Park of Endau-Rompin (TNJER), Mersing, Johor, Malaysia; to identify traditional knowledge (TK) used by Jakun tribe in Kampung Peta, TNJER for maintaining rivers and streams at good level; and then to correlate the relationship between the scientific perspective and TK perspective. Aquatic insects were collected and sampled by using kick sampling technique and D-framed net. Throughout the study, a total of 618 individuals consisting of 23 families belonging to seven orders of aquatic insects were reported. The documentation of TK was done by interviewing 10 total respondents of the Jakun tribe in Kampung Peta. Physical features of Sungai Kawal were also recorded during sampling. The correlation between the scientific perspective and TK perspective regarding how the ecosystem maintenance by the Jakun tribe has contributed to an excellent habitat for the aquatic insects to breed and multiply. The number of species recorded indicated the good status of water quality of Sungai Kawal based on science and then supported by TK of the Jakun tribe of Kampung Peta. Furthermore, the findings also suggested a good correlation between the scientific perspective and TK perspective, and the significant contribution of TK of the Jakun tribe to the management of natural resources.

1. Introduction

Insects are the most diverse groups of organisms in the freshwater. There are about 45000 species of insects, known to inhabit diverse freshwater ecosystems [1]. Aquatic insects of inland wetlands comprise some well-known groups such as the mayflies (order Ephemeroptera), stoneflies (order Plecoptera) and caddies flies (order Trichoptera); which these three groups of insects are very sensitive to pollution and only inhabit an aquatic ecosystem with good water quality [2]. Their presence and absence may indicate...
the quality of the water and provide an overall view about the physical and the chemical properties of the water [3].

Johor National Park of Endau-Rompin (TNJER) was chosen in this study due to its undisturbed forests. It is the largest National Park in Johor combining with a part of the Rompin area in Pahang National Park. Sungai Kawal (N 02°31”.864’ and E 103°24”.982”) is located inside the TNJER and was chosen in this study as sampling area for aquatic insects. The aquatic insects were sampled to determine the quality of water that being preserved using traditional knowledge by the Jakun tribe of Kampung Peta. On the other hand, it has been demonstrated that water monitoring based on the values, knowledge and interests of indigenous communities has empowered them in negotiating greater involvement in water management. Traditional knowledge (TK) is the knowledge, innovation, and practices by the indigenous and local communities around the world [4] developed from the experience acquired over the centuries and adapted to the local culture and environment. Kampung Peta, Mersing, Johor located in the TNJER is perceived as rich in biodiversity and majority of the populations in the village was Jakun tribe, who belongs to the tribe of Proto-Malay.

Apart from that, a comparison was done to correlate between the science perspective and TK perspective. The assessment of the river water quality was done by examining the species-habitat relationship of the aquatic insects collected from Sungai Kawal. Beside that, the documentation of TK was done in Kampung Peta, Mersing, Johor (N 02°32.359’ and E 103°24.833’) via interview. Regarding the TK perspective, this study focused on the Jakun tribe’s beliefs and their practices since the past generations in monitoring and managing the water quality systems. Then, it was proven that the TK also produces an effective way of managing water quality, especially the freshwater. The information from this study would be a baseline data for future studies and conservation work.

2. Materials and Methods

2.1. Study Area
Kampung Peta, Mersing, Johor was chosen as the study area. It was chosen due to its location in the eco-tourism of the TNJER. The rainforest surrounding Kampung Peta covers 48,905 hectares of TNJER ecotourism area. It is a nature preserve extent in Malaysia. The place is situated at the south of Pahang and northern east of Johor. The residents of the Kampung Peta are mostly the Jakun tribe, with its geographical coordinates of 2° 33’ 0” North, 103° 25’ 0” East (Figure 1). Sungai Kawal has been chosen as the sampling site due to its location within the TNJER. It is one of the rivers that are used by the native people of Kampung Peta i.e. Jakun tribe for their daily life activities. The stream is also located close to the Nature Education and Research Centre (NERC), Endau-Rompin as well as the connecting road in the Pacau area.
2.2. Sampling of Aquatic Insects
Transect method was used to standardize the sampling method. In the sampling site, three stations were set up with the distance from one station to the next station was 100 m. Aquatic insects were searched in all possible substrates and several collection methods were incorporated including hand picking technique and kick sampling technique. The larvae of aquatic insects were also sampled using kick sampling technique with a D-shaped net placed against the water current, and an area of 1 m² in front of the net was disturbed for one minute by feet and hands. The collected samples were then placed in universal bottles with 70% ethanol for preservation. Lastly, the aquatic insects were viewed under a dissecting microscope in the laboratory and specimen identification was made up to family level by referring to the previous studies by [2,6,7].

2.3. Documentation of Traditional Knowledge
Qualitative methods were used to obtain information on the beliefs and practices of the indigenous people of Jakun tribe that contribute to the monitoring and preservation of river water quality. Respondents from the elderly were selected because they were more experienced. A total of 10 respondents from the Jakun tribe of Kampung Peta, TNJER, Mersing, Johor had been interviewed and the questions were asked based on the semi-structured interviews. The interviews involved a conversation between the respondents and the researcher.

3. Correlation of Science and Traditional Knowledge Perspectives
The total number of aquatic insect species obtained was determined after morphological identification. The assessment of the water quality was done by examining the species-habitat relationship of the aquatic insects collected from Sungai Kawal. Then, a relationship between the results from the assessment and the TK of the Jakun tribe was determined in order to find out whether their management of natural resources based on TK produces an environment with good quality. A good correlation between the two perspectives will suggest a significant contribution of TK of the Jakun tribe in their management of natural resources.

4. Results
The total number of aquatic insects collected in three days was 618 individuals that representing 23 families and seven orders. All families of aquatic insects were indicators of good water quality based on...
the statements of previous studies [6,7,8,9]. The orders of the aquatic insects are Ephemeroptera, Plecoptera, Trichoptera, Odonata, Hemiptera, Coleoptera and Diptera. Table 1 summarises the list of aquatic insects recorded along with statements whether they are good or bad indicators of water quality.

Table 1. List of aquatic insects collected from Sungai Kawal, Kampung Peta, Johor National Park of Endau-Rompin, Mersing, Johor, Malaysia.

| Order           | Family              | Statement                  |
|-----------------|---------------------|----------------------------|
| Ephemeroptera   | Heptageniidae       | Good water quality indicator|
|                 | Leptophlebiidae     | Good water quality indicator|
|                 | Isonychidae         | Good water quality indicator|
| Plecoptera      | Perlidae            | Good water quality indicator|
|                 | Chloroperlidae      | Good water quality indicator|
| Trichoptera     | Philipotamidae      | Good water quality indicator|
|                 | Hydropsychidae      | Good water quality indicator|
| Odonata         | Euphaeidae          | Good water quality indicator|
|                 | Gomphidae           | Good water quality indicator|
|                 | Amphipterygidae     | Good water quality indicator|
|                 | Plastystictidae     | Good water quality indicator|
|                 | Chlorocyphidae      | Good water quality indicator|
|                 | Coenagrionida       | Good water quality indicator|
|                 | Libellulidae        | Good water quality indicator|
| Coleoptera      | Psephenidae         | Good water quality indicator|
|                 | Eulichadidae        | Good water quality indicator|
|                 | Dytiscidae          | Good water quality indicator|
|                 | Elmidae             | Good water quality indicator|
|                 | Scirtidae           | Good water quality indicator|
|                 | Noteridae           | Good water quality indicator|
| Diptera         | Tipulidae           | Good water quality indicator|
|                 | Athericidae         | Good water quality indicator|
| Hemiptera       | Gerridae            | Good water quality indicator|

Through the interviews with the respondents of the indigenous people of Jakun tribe, it was found that the Jakun tribe respected and strictly obeyed the rules of entering the forest given by their elderly. This indirectly contributes to the conservation of nature including forest that surrounds them. With the knowledge that has been cultivated since childhood, it has made the native people growing up with a well-conserved nature. They also mentioned that people should not commit logging because forest trees are the best land cover for maximizing water yield, regulating seasonal flows and ensuring high water quality [10]. However, none of the respondents used aquatic insects as their preferences to determine whether the water of Sungai Kawal and other rivers as well as streams is potable to drink. Somehow, the adult form of the aquatic insect such as the suborder of Zygoptera (damselfly) from the order Odonata was used as the bio-indicator.

5. Discussion
The water quality assessment of Sungai Kawal using aquatic insects as the bio-indicator showed that the stream was in good quality. Physical features recorded in each point of Sungai Kawal supported good forest management by the Jakun tribe and their TK indirectly led to good conservation of the aquatic habitat as shown by the abundance of aquatic insects.

The highest number of families of aquatic insects recorded was from the order Odonata with seven families (Table 1). Six out of the seven families are damselflies, and only the family Gomphidae belongs to the dragonfly. Order Odonata comprises two suborders that are Zygoptera (damselfly) and Anisoptera (dragonfly). Based on the findings of this study, the Jakun tribe referred to the presence of adult
damselfly to indicate whether the water is safe to drink or not. This is because they believe that damselflies only inhabit a clean water bodies. Odonates were usually used in measuring water quality and for some species they cannot tolerate polluted water [11]. So, their belief about the damselfly for an indicator of good river quality was supported by scientific facts.

Order Coleoptera had the second highest number of families recorded in this study. Beetles from the order Coleoptera are used as a tool in indicating alterations in the environment [12]. They inhabit most of the terrestrial environments with a great diversity, so that they are suitable as biological indicators of environmental contaminants [13,14]. A number of six families of order Coleoptera were recorded in this study, thus indicating the water of Sungai Kawal was in good condition since the environment or the forest is well maintained.

Physical parameters in the sampling area are important in examining good habitat preferences for the insects to breed and multiply. Generally, a good quality of habitat was characterized by a heterogeneous habitat which includes a combination of fast and slow-moving water, the variety of substrate and various vegetation present and stable banks [1]. Every group or species of insects have their preferences of habitat and each has a different level of sensitivity towards changes in their environment. Thus, it makes them a good indicator of water quality. For example, some odonates are sensitive to conditions at the breeding site and surrounding terrestrial areas [14]. They usually lay their eggs near or in the freshwater [15,16], thus their abundance in a certain area is a good indication of good quality of the habitat.

Several groups of insects of the order Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) are very sensitive to pollutants and are widely known as the community of EPTs indicating the quality of clean water [17]. A number of seven families of these groups of insects were recorded in Sungai Kawal, thus indicating that the water was in good quality. The list of families based on these three orders is (i) Order Ephemeroptera - Hexageniidae, Leptophlebiidae, and Isonychiidae; (ii) Order Plecoptera - Perlidae and Chloroperlidae; and (iii) Order Trichoptera - Philopotamidae and Hydropsychidae. The families of order Diptera (i.e. Tipulidae and Athericidae) and order Hemiptera (i.e. family Gerridae) which can be categorized as 'minor' family were recorded. Both orders are also indicators of good water quality. Some families of order Diptera were not recorded in this study, and this could be due to rapid current and cool water that are unfavourable for the development of Diptera larvae [17].

Furthermore, this study also suggested that the combination of the views of science and TK produced an effective measurement tool and management of the environment. From the findings of this study, the Jakun tribe was very concern about the protection of their forest. An effective forest management by the Jakun tribe reflects positive effects, especially on the streams including Sungai Kawal. It was also supported by the high number of species richness obtained from Sungai Kawal. The abundance of insects in the stream could be reflected by enough nutrients supplied into the aquatic ecosystem and various microhabitats for the insects to breed and multiply. Generally, a good quality of habitat was characterized by a heterogeneous habitat which includes a combination of fast and slow-moving water, the variety of substrate and various vegetation present and stable banks [1]. Every group or species of insects have their preferences of habitat and each has a different level of sensitivity towards changes in their environment. Thus, it makes them a good indicator of water quality. For example, some odonates are sensitive to conditions at the breeding site and surrounding terrestrial areas [14]. They usually lay their eggs near or in the freshwater [15,16], thus their abundance in a certain area is a good indication of good quality of the habitat.

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6. Conclusion
In this study, a total of 618 individuals comprising seven orders and 23 families of aquatic insects were sampled from Sungai Kawal, Kampung Peta, TNJER, Mersing, Johor, Malaysia. There was no significant difference between strata in all three stations except in terms of the habitats of the aquatic insects which were influenced by the level of density of vegetation and canopy along the stream. Sungai Kawal was found to have good water due to the presence of high number of individuals of aquatic insects that were indicators of good water quality. Order Odonata was the most dominant order in the stream. The traditional ecological knowledge of the indigenous people i.e. Jakun tribe in managing the ecosystem also indirectly attributed to the cleanliness of Sungai Kawal. Forest management and TK by the indigenous people directly contribute to the good maintenance of ecosystems around them. It is hoped that the findings of this study will contribute to future studies on various aspects of rivers and streams in TNJER, especially in the conservation of freshwater biodiversity. Further research needs to be conducted by taking into account the physicochemical features of stream water in order to determine
the interaction between physical habitat quality characteristics, biological and ecological components in tropical freshwater ecosystem.

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