INFLUENCE OF PHYSICOCHEMICAL PARAMETERS ON ABUNDANCE OF AQUATIC INSECTS IN RIVERS OF PERAK, MALAYSIA

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Abstract - The effect of physicochemical factors on the abundance of aquatic insects has been studied in Kuala Woh, LataKinjang, BatuBerangkai and Dipang Rivers, Perak, Malaysia. The focuses are to identify the aquatic insect families, to compare the abundance of aquatic insects in four sampling areas and to investigate the effect of physical factors (water temperature, depth of water, canopy, and water velocity) and chemical factors (pH and dissolved oxygen) of rivers on the abundance of aquatic insects. The samples were collected by using aquatic net. Physical and chemical parameters have been measured in situ and recorded. A total of 631 individuals classified into 6 orders and 18 families of aquatic insects were identified from four sampling sites. The largest percentage of samples collected is from order Plecoptera 35.8%, followed by Ephemeroptera 32.6%, Trichoptera 17.0%, Hemiptera 8.1%, Coleoptera 4.8%, and Odonata 1.7%. The aquatic insects collected from Dipang River have the highest abundance of 273 individuals from 6 orders and 13 families compared to Lata Kinjang which only have 64 individuals from 5 orders and 6 families. Dipang River has a moderate stream flow (0.11 m/s) of warm water (27^{o}C), pH 7.5 and DO 8.21 mg/L with 0.95 m depth and not covered by canopy. Lata Kinjang has faster stream flow (0.84 m/s) with the temperature of 24^{o}C, pH 7.2 and DO 5.86 mg/L, 0.36 m depth and covered by canopy. The results reveal that the abundance of aquatic insects is high when water temperature increases, low water velocity, high dissolved oxygen (DO) level, deeper water and the area that is not covered by canopy.

Keywords - Aquatic insects, Physicochemical factors, River.

I. INTRODUCTION

Aquatic insects spent most of their life cycle in water, living under the water or on water surface. Physical and chemical parameters such as water depth, water temperature, canopy cover, water velocity, pH and dissolved oxygen are often used in studying the diversity of aquatic insects. This study shows the physical environments and chemical factors do give impacts to the abundance and diversity of aquatic insects. The objectives of this research are to study the composition of aquatic insects' families in Kuala Woh, LataKinjang, BatuBerangkai and Dipang Rivers, to compare the abundance of aquatic insects in four sampling areas and to investigate the influence of physicochemical factors (water temperature, canopy, water velocity, depth of water, pH and dissolved oxygen) on the abundance of aquatic insects. Any changes in water quality due to chemical and physical environment can affect the aquatic insect's assemblages or richness. The methods include sampling of the aquatic insects, identification of aquatic insect collected, record physical and chemical parameters of rivers, statistical analysis, and report. A total of 631 individuals classified into 6 orders and 18 families of aquatic insects were identified from sampling sites. The order with the highest abundance is Plecoptera which is 226 individuals, followed by Ephemeroptera (206), Trichoptera (107), Hemiptera (51), Coleoptera (30), and Odonata (11).

In Malaysia, few studies had highlighted application of benthic macro-invertebrates including aquatic insects as bio-indicators to assess the condition and water quality of the river and waterfall (Al-Shami et al. 2011; Azrina et al. 2005). There is always growing interest among the aquatic ecologists to understand the relationship between river water quality and the diversity of aquatic insects as bio-indicators for stream water quality and ecosystem condition (Bonada et al. 2007). Suhaila et al. (2014) found that the Ephemeroptera, Plecoptera and Tricoptera (EPT) abundance were high in wet season while it was higher during dry season (27^{o}C) in Tupah River, Kedah. In dry season, the suitable temperature that causing the high abundance were recorded as the factor that increase the abundance of the aquatic insects in that area. The abundance of insects per unit area was correspondingly high in dry season.

The accomplishment of various species and the pattern of abundance, diversity and distribution are completely correlated and influenced by the canopy cover (Grether et al. 2001). Stephenson et al. (2007) wrote that cover being important as prey protection while closure directly influences understory light and temperature at a given point. The ecological relevance of each measurement is needed to interpret

their biological importance. The environment with densely packed canopy will prevent the penetration of sunlight to the water thus making the water temperature decrease. A cool environment does not promote growth for the aquatic insects as they can die from over-cooling. Canopy cover of trees is among the main factor in aquatic insects' distribution and process of ecosystem in aquatic habitats (Batzer, Palik and Buech, 2004).

Depth and velocity are some of important factors in the model for taxonomic richness, and abundances of invertebrates. Velocity of a river refer to the rate of water movement which are mainly measured in meter per second. The water velocities however are not the same indifferent depth of river. The highest velocity usually occurs bellow water surface, while the middle depth have lower velocity, and lowest velocity occurs along the benthos section due to friction with air and substrate of the river (Michelland Stapp,2000).

As aerobic organisms, all insects must obtain sufficient oxygen in order to carry out their metabolic machinery (Thorp and Covich, 2009). This shows a particular challenge for aquatic insects because water, even when saturated, contains much less oxygen than terrestrial environments. Dissolved oxygen play an importance role affecting aquatic invertebrates' abundance and diversity. Therefore, many forms of lentic larvae can supplement atmospheric oxygen with dissolved oxygen. Concentration of oxygen levels below 2 mg/L may reduce the fitness and chances of survival for many aquatic insects. For instances, Caddisfly larvae are especially vulnerable to decreased oxygen levels because their locomotion is restricted (Thorp and Covich, 1991).

The other factor is pH which is measure of the intensity of acidity or alkalinity and the concentration of hydrogen ions in water. Ngodhe et al. (2014) indicated that pH of water affects the normal physiological functions of aquatic organisms, including the exchange of ions with the water and respiration. Such important physiological processes operate normally in most aquatic under a relatively wide pH range for example 6-9 pH units.

II. METHODOLOGY

Any changes in water quality due to physical and chemical environment can affect the aquatic insect's assemblages or richness. The water quality of a waterfall or river can be determined by carrying out study on aquatic insect's assemblages and richness to examine the species-habitat relationship. Aquatic insects has been widely used as indicators for monitoring river quality (Yoshimura, 2012) due to continuous response to a variety of perturbations, present in a wide array of aquatic habitats, relatively easy to sample and process and standardized methods of collection and analysis have been greatly progressed (Al-Shahmi et al. 2011). The degree of environmental impact can be determined using the data provided by these indicator organisms. Indicator organisms refer to those taxa known to have their own sensitivity towards environmental changes. Changes of abundance of an organism can reflect the environmental condition. The differences in chemical and physical environments were the reason for the chosen of those study areas. Description of methodology as follows:

2.1. Sampling of the aquatic insect

The study was conducted at Lata Kinjang (N04° 18.14', E101° 15.38'), Kuala Woh (N04° 14.657', E101° 19.317'), Batu Berangkai (N04° 18.47', E101° 10.12'), and Dipang River (N04° 23.05', E101° 10.04') which are in Perak state between January and September 2016. These rivers have different canopy cover, water temperature, water velocity, depth of water, pH value and amount of dissolved oxygen. The aquatic insects were sampled at riffle habitats using kick sampling technique, aquatic D-net.

2.2. Identification of aquatic insects collected

In the laboratory, the aquatic insects were sorted on a tray and identified to the family level using taxonomic keys. Small aquatic insects were sorted by using light microscope while the larger one were identified using naked eyes. The sorted specimens are kept in properly labeled universal bottles containing 70% ethanol.

2.3. Physicochemical parameter of rivers

Physical parameters such as water velocity, water temperature, water depth and canopy cover together with chemical parameters which are pH value and dissolved oxygen level have been measured in situ and recorded.

2.4. Statistical analysis

Values of ecological indices, Shannon (H') Diversity Index, Evenness Index (E'), Richness Index (R) for aquatic insects' composition in different sampling areas were tested. Pearson Correlation analysis also being used to measure the association between physicochemical parameters and the abundance of aquatic insect communities.

III. RESULTS AND DISCUSSION

Table 1 shows the result for the total number of aquatic insects collected in four sampling sites; Kuala Woh, Lata Kinjang, Batu Berangkai and Dipang rivers.

The total number of individuals in all sampling areas is 631 with 273 individuals from Dipang River, 80 individuals from Batu Berangkai River, 214

individuals from Kuala Woh River and 64 individuals from Lata Kinjang River (see **Table 1**).

Order	Family	Abundanceof aquatic insects				Total
		Dipang	Batu Berangkai	Kuala Woh	Lata Kinjang	
Ephemeroptera	Heptageriidae	117	34	13	9	173
	Ephemerellidae	0	1	0	0	1
	Tricorythidae	17	2	0	0	19
	Baetidae	3	4	0	0	7
	Leptophlebiidae	6	0	0	0	6
Plecoptera	Pteronarycyidae	7	13	101	25	146
	Chloroperlidae	14	12	33	15	74
	Nemouridae	2	2	0	0	4
	Perlidae	0	2	0	0	2
Trichoptera	Philopotamidae	51	0	11	6	68
	Polycentropodidae	10	0	27	0	37
	Rhyacopholidae	0	2	0	0	2
Coleoptera	Gyrinidae	16	3	3	0	22
	Elmidae	0	1	0	0	1
	Dytiscidae	6	0	0	0	6
	Haliplidae	0	0	1	0	1
Odonata	Libellulidae	7	0	1	3	11
Hemiptera	Gerridae	17	4	24	6	51
Total No. Of Individual		**273**	**80**	**214**	**64**	**631**
Total No. Of Order		**6**	**5**	**6**	**5**	**6**
Total No. Of Family		**13**	**12**	**9**	**6**	**18**

Table 1: Numbers of aquatic insects collected in four rivers of Perak

From Dipang River and Kuala Woh, the total number of orders is 6 which are Ephemeroptera, Plecoptera, Odonata, Trichoptera, Coleoptera and Hemiptera. While Batu Berangkai and Lata Kinjang only have 5 total number of orders which are Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Hemiptera, and order Ephemeroptera, Plecoptera, Odonata, Trichoptera, Hemiptera respectively.

The largest percentage of samples collected is from order Plecoptera35.8% (226), followed by Ephemeroptera 32.6% (206), Trichoptera17.0% (107), Hemiptera8.1% (51), Coleoptera4.8% (30) and Odonata 1.7% (11). Figures of some aquatic insects' orders have shown in **Fig. 1** until **Fig. 4**.

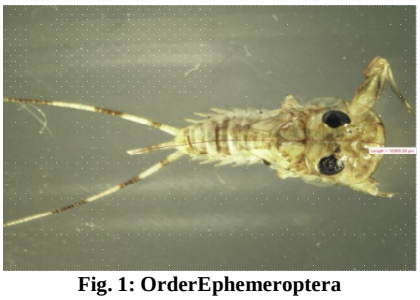


Fig. 1: OrderEphemeroptera

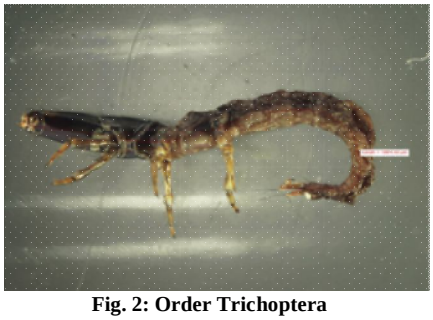


Fig. 2: Order Trichoptera



Fig. 3: OrderPlecoptera

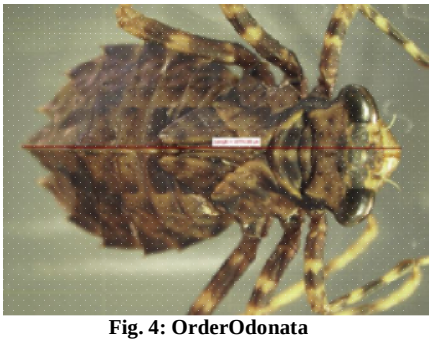


Fig. 4: OrderOdonata

Highest diversity index (H'=1.903) was recorded fromDipang River and the lowest diversity index recorded from LataKinjang(H'=1.570) as stated in **Table 2**. LataKinjang has the highest evenness index (E'=0.876) while the lowest evenness index belongs to Kuala Woh River (E'=0.720). The highest richness index was recorded at BatuBerangkai (R=2.510) while the lowest was at LataKinjang(R=1.202).

Location	H'	E'	R
Dipang	1.903	0.742	2.139
Batu Berangkai	1.845	0.742	2.510
Kuala Woh	1.582	0.720	1.491
Lata Kinjang	1.570	0.876	1.202

Table 2: Values of ecological indices,Shannon (H') diversity index, evenness index (E'), richness index (R) for aquatic insects' compositions in all selected rivers

Four physical factors that were recorded are water temperature, water velocity, depth of water and canopy cover (see **Table 3**).

Parameters	**Temperature (°C)**	**Velocity (m/s)**	**Depth (m)**	**Canopy cover (%)**	**H**	**Dissolved oxygen (mg/L)**
Dipang	27.2 ± 0.12	0.11 ± 0.70	0.95 ± 0.04	0 (Open)	7.5 ± 0.45	8.21 ± 0.45
Batu Berangkai	25.2 ± 0.09	0.78 ± 0.65	0.56 ± 0.09	50 (Close)	7.2 ± 0.26	7.18 ± 0.30
Kuala Woh	27.2 ± 0.04	0.17 ± 0.56	0.85 ± 0.02	0 (Open)	6.5 ± 0.15	7.33 ± 0.11
Lata Kinjang	24.4 ± 0.08	0.84 ± 0.78	0.36 ± 0.03	50 (Close)	7.2 ± 0.21	5.86 ± 0.18

Correlation value, r	0.937	-0.969	0.947	-0.951	0.030	0.838

Table 3: Mean (± SE) of physical parameters in four rivers and Pearson correlation value

The environmental effect which is water temperature influences the abundance of aquatic insects. From the result, there was a strong, positive correlation between water temperature and diversity of aquatic insects, r=0.937. Warmer temperature in Dipang and Kuala Woh rivers with average temperature of 27^{o}C increases the metabolism of aquatic insects. The emergence of many aquatic insect is influenced by water temperature (Burgmer, 2009) and thus warmer temperature leads to earlier emergence of insects for example, egg may hatch when temperature reaches a certain level.

Water velocity is one of the factors that effect on the abundance of aquatic insects. The result shows that there was a strong, negative correlation between water velocity and aquatic insects diversity, r=-0.969. Rock, rubble, and sand offer different types of niches for aquatic insects in fast flowing stream of BatuBerangkai and LataKinjang. Leaf litters, algae, and aquatic plant are a suitable habitat for macroinvertebrates in slow moving stream. Macroinvertebrates have developed adaptations to live in these environments. As stated by Bispo et al. (2004), sudden increase in water flow causes streambed translocation with the consequence removal of insect and reduction in their local abundance. Moreover, aquatic invertebrates rely on the current of the stream to bring nutrient down from the upstream.

According to Luoto (2011), aquatic mite and insect distributions in Lake Moaralmsee, Austria were strongly related to water depth, which mostly determines in-lake variability in temperature, substrate, and water chemistry. More species accumulate in soft sediment and warmer temperature which is in deep water sites. This statement supports the result where water depth has strong, positive correlation with diversity of aquatic insects (r=0.947).

Canopy cover has strong, negative correlation with aquatic insects diversity, r=-0.951. Aquatic insect prefer a place that is less densely packed with canopy as shown in Dipang and Kuala Woh. In other words, aquatic insects prefer environment that has a direct penetration of sunlight to the water. Canopy cover also influences the water temperature. If the canopy cover is partly open, the temperature of water might be increase due to the penetration of light. High richness and abundance of aquatic insects happen in more open canopy ponds (Palik et al. 2001; Tuno et al. 2005).

The result shows that there was strong, positivecorrelation between dissolved oxygen level and aquatic insects diversity, r=0.838. The insects prefer to live in higher dissolved oxygen concentration since that cold-water mayflies and stoneflies cannot tolerate dissolved oxygenconcentrations much below 5 mg/L (Gaufin, 1971). A study about diversity and abundance of aquatic macroinvertebratesin Brazil reports that the sampling station with the highest dissolved oxygen level had the highest Shannon-Weiner diversity index (Silva et al. 2009).Stoyanova et al. (2014) found that usually gill-breathing aquatic insects (e.g. mayflies, caddisflies and stoneflies) are affected by conditions that reduce the dissolved oxygen of the water, like pollution; therefore the presence of mayflies, caddisflies and stoneflies indicates high stream quality.

Next, aquatic insects' abundance showed no statistically significant correlated withpH value, r=0.030.Scheibler et al. (2014) stated that a pH range of 6.5 to 8.0 provides adequate protection for the life of freshwater fish and bottom-dwelling macroinvertebrates. Thus,all of the four sites are still inthe acceptable range of pH to aquatic life which all freshwater aquatic life is unharmed and no bad impacts occur.

The results reveal that the abundance of aquatic insects depends on the physical factors of the rivers which is high when water temperature increases, low water velocity, deeper water, high dissolved oxygen level and the area that is not covered by canopy.

CONCLUSIONS

Based on this study, it can be concluded that the physical parameters of Dipang, BatuBerangkai, Kuala Woh and LataKinjangrivers which are water temperature, water velocity, water depth, dissolved oxygen level, and canopy cover strongly influence the abundance of aquatic insects. Thus, we can develop the alternative bioindicator for water condition by using aquatic insects. Almost all ecosystems especially freshwater ecosystems have an abundance of insects which can be used as the measurement in environmental change. By studying their diversity, population, behavior and taxonomy of species, estimation of the current degradation rate and future consequences can be assumed.

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LIST OF SYMBOLS

E’	Evenness index
H’	Shannon diversity index
R	Richness index
r	Pearson correlation
DO	Dissolved oxygen

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