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COMPOSITION AND DISTRIBUTION OF ODONATA LARVAE AND ITS RELATIONSHIP WITH PHYSICOCHEMICAL WATER QUALITY IN NORTHERN PENINSULAR MALAYSIA

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Abstract A study on composition and distribution for Odonata larvae and their relationship with physicochemical parameters was carried out in selected rivers of Gunung Jerai Forest Reserve, Kedah. Different river physichochemical parameters might influence or affect different type of Odonata composition. Therefore, Odonata larvae were sampled monthly at three selected rivers in Gunung Jerai Forest Reserve which were Teroi, Tupah, Batu Hampar rivers from August 2007 until January 2008 by using a D-frame aquatic net. A total of 253 individuals of 12 genera belonging to nine families of Odonata have been identified. Greatest number of odonates individuals was recorded in Teroi River (112 individuals) with mean density recorded highest in January 2008 (6.6 ind/m2). The major families were Libellulidae, Euphaeidae and Gomphidae. Aeshnidae, Macromiidae, Calopterygidae, Coenagrionidae, Amphipterygidae and Chlorocyphidae represented the minority groups. Libellulidae reported the greatest number of individuals in all study areas, followed by Euphaeidae. Ranking from the highest to the lowest number of genus collected were *Zygonyx, Euphaea, Macromia, Anax, Ophiogomphus, Libellago, Vestalis and Devadatta, Neurobasis, Cercion, Pseudagrion, Gamphidictinus,* and *Paragamphus.* The distribution of these genera were significant in different months studied (Kruskal Wallis, $p<0.05$) in all three rivers. The abundance of individuals collected was strongly influenced by velocity of water. Libellulid *Zygonyx* was the most affected by velocity and biochemical oxygen demand in all studied river. A *Euphaea* larva was influenced by temperature, depth, pH and biochemical oxygen demand. The ecological index (Richness, diversity and evenness index) exhibited poor Odonata communities in all studied rivers. In conclusion, water velocity, biochemical oxygen demand do have influenced on Libellulidae family while temperature, depth, pH and biochemical oxygen demand have influenced on Euphaeidae family.
Keywords: diversity, odonata, northern peninsular Malaysia, physicochemical.

Abstrak Satu kajian keatas komposisi dan taburan larva Odonata dan hubungkait dengan parameter fiziko-kimia telah dijalankan di beberapa sungai di Hutan Simpan Gunung Jerai, Kedah. . Parameter fiziko-kimia sungai yang berlainan mungkin mempengaruhi atau memberi kesan keatas komposisi Odonata. Justeru, larva Odonata telah disampel setiap bulan di tiga buah sungai dari Hutan Simpan Gunung Jerai iaitu iaitu Sungai Teroi, Sungai Tapah dan Sungai Batu Hampar bermula dari bulan Ogos 2007 hingga Januari 2008 dengan menggunakan jarring akuatik berbingkai D. Jumlah Odonata yang telah berjaya dikenalpasti hingga ke tahap genus ialah sebanyak 253 individu yang terdiri daripada 12 genus daripada sembilan famili. Jumlah individu Odonata tertinggi dicatatkan di Sungai Teroi (112 individu) denan purata kepadatan direkodkan tertingi pada bulan Januari 2008 (6.6 ind/m^2). Antara family utama ialah Libellulidae, Euphaiedae dan Gomphidae manakala Aeshnidae, Macromidae, Calopterygidae, Coenagrionidae, Amphipterygidae dan Chlorocyphidae merupakan famili yang kecil. Libellulidae mencatatkan bilangan individu terbanyak di semua kawasan kajian diikuti dengan Euphaeidae. Turutan genus terdiri daripada dominan kepada yang kurang dominan adalah *Zygonyx, Euphaea, Macromia, Anax, Ophiogomphus, Libellago, Vestalis* and *Devadatta, Neurobasis, Cercion, Pseudagrion, Gomphidictinus,* dan *Paragomphus* Taburan larva Odonata adalah berbeza pada setiap bulan persampelan di semua sungai (Kruskal-Wallis, $p<0.05$). Kelimpahan larva Odonata sangat dipengaruhi oleh faktor halaju air. Larva *Zygonyx* (Libellulidae) merupakan genus yang paling dipengaruhi oleh faktor tersebut. Larva *Euphaea* (Euphaeidae) lebih dipengaruhi oleh faktor suhu air, kedalaman sungai, pH dan juga keperluan oksigen biologi. Indeks Ekologi (Indeks Kekayaan, Indeks Kepelbagaian, Indeks Keseragaman) menunjukkan bahawa komuniti Odonata adalah kurang di semua sungai. Sebagai kesimpulan, halaju air, permintaan oksigen biokimia mempunyai pengaruh keatas family Libellulidae manakala suhu air, kedalaman, pH dan permintaan oksigen biokimia mempengaruhi famili Euphaeidae.
Kata kunci: kepelbagaian, odonata, utara Semenanjung Malaysia, fiziko-kimia.

INTRODUCTION

Odonata mostly had fast, whirring flight and often vivid coloration – red, yellow or metallic blue or green. They are harmless to human and they hunt by sight. They visually oriented predators with their large eyes, strong mandibles and spiny legs. The immature stages are strictly aquatic, very voracious and armed with an enormously enlarged, hinged labium which is used as an extendable grasping organ for capturing prey.

In Malaysia, there are 342 named species of odonata fauna. These include 161 species of Zygoptera in 10 families and 181 species of Anisoptera in 5 families. Overall 239 species are known from Sabah, Sarawak and Brunei and 226 from Peninsular Malaysia including Singapore [1]. Although the diversity of Odonata is relatively low compared to most other orders of insects, the odonates show preferences to specific requirements and habitats. The good value of Odonata is based on their good correlation with certain structural components of the habitats especially aquatic and amphibious vegetation and the present of certain species. They are ecologically important because they are major predators and recognized as good indicators of the condition of aquatic and terrestrial ecosystem.

River provides numerous microhabitats for Odonata larvae. As noted by [2], stability of the river ecosystem may be viewed as a tendency for reduced fluctuations in energy flow, while community structure and function are maintained, in face of environmental variations. The river with high degree of physical variation may have high species diversity or at least high complexity in species function which acts to maintain stability. In addition, [3] stated that water quality influences were isolated by excluding taxa with low tolerance to degraded water quality conditions. The difference in the presence of indicator genera from studied rivers was used to evaluate the water health [1].

Odonata have considerable potential as indicators of environmental disturbances as noted by [1]. They are flying over ponds, streams, and fields however the larvae of this insect were not very well known among people. Larvae of the Odonata could be found abundantly in lentic water but many species also occur in lotic water [4].

This study focused on the distribution of Odonata larvae and their relation to the status of habitats they lived in. The goals of this study was to identify a rapid, yet realistic and reliable method for an early detection of the health of river environment using the odonates' community structure in both aquatic and terrestrial ecosystem as guidelines or indicators. This study was undertaken to determine the composition and distribution for Odonata larvae and to study the influence and relationship of the physicochemical parameters that affect the composition, abundance and diversity of Odonata in selected rivers of Gunung Jerai Forest Reserve, Kedah.

MATERIAL AND METHODS
STUDY SITES

This study was carried out in Teroi, Tupah and Batu Hampar rivers located in Gunung Jerai Forest Reserve, Kedah. Most of the rivers are rocky and cobble substratum with some vegetation. These three rivers are popular as recreational places in Kedah. Teroi River is located at the peak of Gunung Jerai which consists of hill dipterocarp forest. This river was chosen because it is located at higher altitudes and distribution of odonate larvae can be compared with the low altitude population. The sampling point was determined at N5^{o}48.328' E100^{o}25.913' at Teroi River. Tupah River composes of lowland dipterocarp forest. For this river, sampling activities were done at N5^{o}45.008' E100^{o}26.526'. Batu Hampar River flows through a populated village and fruit orchards in a low land dipterocarp forest and the sampling was done at at N5^{o}46.668' E100^{o}23.835'.

ODONATA LARVAES

Samplings were carried out monthly at the study site beginning August 2007 until January 2008. Sampling of Odonata larvae was carried out using a D-framed aquatic net of 0.38 diameters. The D-pond net was held vertically against the flow of water current with its opening facing upstream. About one m² distance from the opening of the net was disturbed by hand or by foot, thus the dislodged insect was carried into the net by the current. The loose stones and aquatic plant were lifted inside the net and the attached or creeping specimens were removed by hand and added to the sample. The sample was transferred into labeled plastic bags with some river water inside and was brought to the laboratory in an ice chest. Twenty bags of samples were collected from each river. The specimens were stored and kept in a labeled universal bottle filled with 75% ethyl alcohol. The specimens were identified using taxonomical key of [5], [1], [6] and [7] to the generic level.

PHYSICO-CHEMICAL WATER QUALITY

The measurement of water quality parameters were done concurrently with Odonata sampling. The physical parameters included dissolved oxygen (mg/L), water temperature (°C), pH, water velocity (m/s), depth (cm) and width (cm) of the river. Dissolved oxygen and water temperature were measured with Dissolved Oxygen meter Model YSI 550A, pH was measured using pH meter Model YSI PH100, velocity was measured with Auto flow watch JDC Instruments and the river depth and width were measured using ruler and measuring tape. Three bottles of water sample (500ml) were collected from each site for chemical analysis. The biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonium-nitrogen, and total suspended solids (TSS) were all determined using a standard kit of DR/890 HACH Calorimeter in the laboratory.

STATISTICAL ANALYSIS

Based on normality tests, all data of Odonata larvae in the three rivers were not normally distributed. Therefore, nonparametric test, Kruskal-Wallis test was used to analyze the data. Spearman's Rho correlation was used to investigate the correlation between the water parameters and the distribution of odonate larvae in the rivers. The one-way ANOVA (at ρ <0.05) was used to test any significant difference in the physical and chemical parameters over various sampling period and between sampling sites (SPSS, version 18).

RESULTS

DIVERSITY AND COMPOSITION OF ODONATA IN RIVERS OF GUNUNG JERAI FOREST RESERVE

Overall 253 individuals of 12 genera belonging to nine families of Odonata have been identified from three rivers of the Gunung Jerai from August 2007 until January 2008 (Table 1). Teroi River had the highest number of Odonata while Tupah River had the lowest. *Zygonyx* was the most dominant genera, making 73.33% of total individuals collected. They were relatively numerous in all rivers. It was followed by *Euphaea* with 13.4% while *Macromia* contributed the third highest with 3.56% of total abundance. Other less common genera were *Anax*, *Ohiogomphus*, *Libellago*, *Vestalis* and *Devadatta*. Meanwhile, *Neurobasis*, *Cercion*, *Pseudagrion*, *Gomphidictinus*, and *Paragomphus*, were rarely found.

Table 1: Composition and abundance of Odonata larvae in rivers of Gunung Jerai Forest Reserve, Kedah.

Taxa		Rivers			Total individuals	% individuals
		Teroi	Tupah	Batu Hampar		
Suborder: Anisoptera						
Aeshnidae	*Anax guttatus*	5	0	0	5	2.0
Gomphidae	*Gomphidictinus perakensis*	1	0	0	1	0.4
	Ophiogomphus sp.	1	1	2	4	1.58
	Paragomphus caprinicornis	0	1	0	1	0.4
Macromiidae	*Macromia* sp.	9	0	0	9	3.56
Libellulidae	*Zygonyx iris*	93	38	52	183	72.33
Suborder: Zygoptera						
Amphiterygidae	*Devadatta argyoides*	1	1	1	3	1.19
Calopterygidae	*Neurobasis chinensis*	0	1	0	1	0.4
	Vestalis sp.	1	3	1	5	2.0
Chlorocyphidae	*Libellago*	0	3	1	4	1.58
Coenagrionidae	*Cercion* sp.	1	0	0	1	0.4
	Pseudagrion sp.	0	1	0	1	0.4
Euphaeidae	*Euphaea ochracea*	0	19	15	34	13.44

Eight genera were recorded at Teroi River during sampling period which consisted of *Anax, Gomphidictinus, Ophiogomphus, Zygonyx, Macromia, Devadatta, Vestallis* and *Cercion*. Study in Tupah River showed that *Zygonyx* was the most dominant genus collected. Eight other genera were *Euphaea, Pseudagrion, Libellago, Vestalis, Neurobasis, Devadatta, Paragomphus* and *Ophiogomphus.* Batu Hampar River also showed the highest number of *Zygonyx*. Six genera were recorded at Batu Hampar River which consist *Ophiogomphus, Zygonyx, Devadatta, Vestalis, Libellago* and *Euphaea*. The Odonata diversity did not varied significantly between rivers at $P < 0.05$ (Kruskal-Wallis test).

The highest total individuals of Odonata larvae were recorded in January 2008 with density 6.6 individuals per m^2 (Figure 1). The least individuals were collected in October 2007 with only 0.7 individuals per m^2. In this study, Teroi River was found to have the highest abundance of odonate larvae collected for almost every month during the sampling period. Meanwhile, the population in Batu Hampar River increased in December 2007 (3.4 individuals/ m^2) to January 2008 (3.4 individuals/ m^2). However, no larva was collected in October 2007. In Tupah River, the highest number of larvae was collected in December 2007 (3 individuals/ m^2) while in other months the collection odonate larvae were negligible in this river. The results reveal that the abundance of Odonata larvae varied significantly during the period of study (Kruskal-Wallis test, $\rho < 0.05$). The Odonata larvae was most diverse in Teroi River with H' values of 0.95 (Table 2). The Batu Hampar River had the lowest diversity score (H'= 0.87). The Tupah River was the least evenly distributed (E = 0.16). More even distribution of Odonata taxa was observed in Teroi River (E = 0.22).

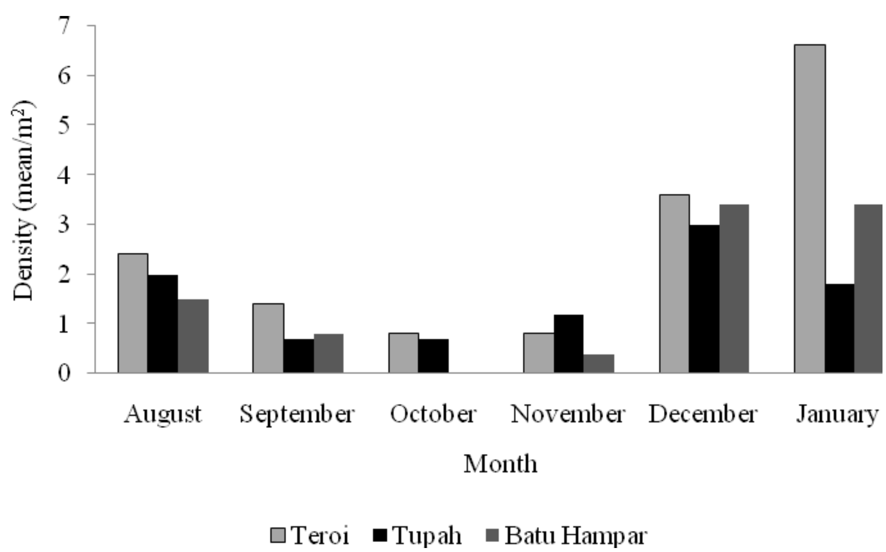

Figure 1: Density of individuals (mean individuals/m^2) in Teroi, Tupah and Batu Hampar rivers.

Table 2: Richness, diversity and eveness indices (mean ± SE) of Odonata collected monthly from August 2007 to January 2008 in rivers of Gunung Jerai Forest Reserve, Kedah.

Index	Teroi	Tupah	Batu Hampar
Margalef (R_1)	1.57 ± 0.19	1.7 ± 0.01	1.92 ± 0.01
Menhinick (R_2)	0.82 ± 0.06	0.78 ± 0.01	0.91 ± 0.02
Shannon-Wiener (H’)	0.95 ± 0.10	0.91 ± 0.02	0.87 ± 0.09
Simpson (1-D)	0.41 ± 0.04	0.36 ± 0.03	0.35 ± 0.04
Eveness (J)	0.22 ± 0.02	0.16± 0.04	0.17 ± 0.01

INFLUENCE OF PHYSICO-CHEMICAL PARAMETERS ON ABUNDANCE OF ODONATE LARVAE

Table 3 shows the water in Teroi River was acidic with pH ranging from 4.1-6.2. The deepest water depth was recorded in Tupah River (0.507 ± 0.045). Many species of Odonata in GJFR preferred to live in depth water (Tupah River). Table 1 show that Tupah River had the highest number of Odonata taxa. However, an Odonata larva was most abundant in Teroi River. Parameters such as temperature, DO, TSS, pH and Ammonia were significantly different among rivers (One-way ANOVA, $P < 0.05$). Nevertheless, all measured parameters did not show any significant difference among sampling periods (One-way ANOVA, $P > 0.05$). According to Table 4, only *Zygonyx* and *Euphaea* showed significant correlation with water temperature, velocity, depth, pH and BOD. No significant correlation was noted between physico-chemical parameters and total abundance of Odonata larvae except for velocity ($r_{velocity} = -0.501$, $P = 0.034$). The abundance of *Zygonyx* was correlated with velocity (r = -0.501) and BOD (r = 0.568). Meanwhile, *Euphaea* was significantly correlated with water temperature (r = 0.505), depth (r = 0.543), biochemical oxygen demand (r = 0.469) and pH (r = 0.59).

Table 3: Physico-chemicals parameters measured mean ± SE (range) for Teroi (TRI), Tupah (TPH) and Batu Hampar (BHP) rivers.

Parameter	TRI	TPH	BHP	P - value
Depth (m)	0.4 ± 0.11	0.507 ± 0.045	0.45 ± 0.12	0.834
	(0.17-0.9)	(0.35-0.61)	(0.26-1.0)	
Width (m)	6.56-7.7	3.45-4.54	4.02-4.38	0.423
	(5.63 ± 1.23)	(3.96 ± 0.42)	(4.67 ± 0.76)	
Water temperature (°C)[b]	20.3-22.7	23.4-24.3	23.5-25.3	0.005
	(21.6 ± 0.78)	(23.7 ± 0.20)	(24.2 ± 0.31)	
Velocity (m/s)	0.4-1.3	0.5-2.2	0.3-1.8	0.449
	(1.0 ± 0.16)	(1.06 ± 0.21)	(0.71 ± 0.25)	
pH [b]	4.1-6.2	6.2-6.6	6.04-6.6	0.002
	(5.22 ± 0.31)	(6.36 ± 0.13)	(6.36 ± 0.15)	
DO (mg/L) [b]	6.7-7.5	7.3-7.9	7.5-7.9	0.002
	(7.33 ± 0.13)	(7.5 ± 0.09)	(7.66 ± 0.09)	
BOD (mg/L)	0.9-1.4	0.8-1.6	0.3-1.6	0.342
	(0.97 ± 0.12)	(2.82 ± 1.74)	(0.90 ± 0.12)	
COD (mg/L) [b]	2-16	2-16	2-16	0.056
	(13.85 ± 2.43)	(7.38 ± 2.04)	(7.04 ± 1.57)	
TSS (mg/L) [b]	1-7	1-4	1-5	0.000
	(5.23 ± 0.31)	(3.0 ± 0.52)	(1.5 ± 0.22)	
Ammonium-N (mg/L) [b]	0.01-2.51	0.01-0.12	0.01-1.1	0.004
	(0.05 ± 0.02)	(0.02 ± 0.002)	(0.02 ± 0.007)	

DO = dissolved oxygen, BOD = biochemical oxygen demand, COD = chemical oxygen demand and TSS = total suspended solid.

[a] Significant at $\rho < 0.05$ (ANOVA, factor = month, df = 5)
[b] Significant at $\rho < 0.05$ (ANOVA, factor = river, df = 2)

Table 4: Influence of physicochemical parameters on abundance and species of Odonata larvae (*r* values of Spearman Rho correlation analysis).

	Temp	Velocity	Depth	pH	BOD
Abundance	-0.194	**-0.501***	0.238	-0.81	0.467
Zygonyx	-0.0236	**-0.795****	-0.319	-0.17	**0.568***
Euphaea	**0.505***	-0.259	**0.543***	**0.59***	**0.469***

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

DISSCUSSION

Libellulidae made up the biggest number of individuals in all study areas, followed by Euphaeidae. Aeshnidae, Macromiidae, Calopterygidae, Gomphidae, Coenagrionidae, Amphipterygidae and Chlorocyphidae were represented as minority groups. Libellulidae was widely distributed in the Gunung Jerai Rivers due to it wide range of environmental tolerance. Interestingly, only *Zygonyx* was collected from all of the selected rivers at Gunung Jerai. Libellulidae usually inhabit the surface of floating leaves of vascular hydrophytes or fine sediments. They commonly live with modifications for staying on top of the substrate and maintaining the respiratory surfaces free of silt [5]. Moreover, according to [6], these dragonflies are common and widespread..

In addition, *Zygonyx* is usually found on swift flowing streams in primary forest up to 1500 m. Their mating often takes place on the wing and female oviposits into swiftly flowing water. The long-legged, robustly built larvae cling to boulders in the stream [1]. The water in Teroi, Batu Hampar and Tupah rivers are shallow and fast running waters thus provide suitable habitat for the *Zygonyx* (Libellulidae). Aeshnidae and Macromiidae were only found at Teroi River. They were represented by *Anax* and *Macromia* respectively. Macromiidae larvae generally live beneath sand and silt. Aeshnid larvae usually categorized as climbers. They were adapted for living on vascular hydrophytes or detrital debris such as overhanging branches, roots and vegetation along streams [5]. They can be found in some streams under logs and stones or in snags [7]. Teroi River provides the appropriate microhabitat for these families where there were some fringing vegetations along the river bank and some water column made up a small pool within sand inside it.

In contrast, Gomphid larvae were diverse in the three rivers with representations of *Gomphidictinus, Ophiogomphus,* and *Paragomphus*. Similar to Libellulidae, Gomphidae was found in all rivers in the study area. The presence of this family showed that the Teroi, Tupah and Batu Hampar rivers were less polluted and still in good condition. According to [1], Gomphidae are considered to be one of the families which are most sensitive to environmental disturbance.

Another genus, *Euphaea* (Euphaeidae) was collected in high numbers at Tupah and Batu Hampar rivers. They have auxiliary filamentous gills along the sides of the abdomen but they inhabit unpolluted riffles in clear streams which show that the gills are not an adaptation to low oxygen [1]. At Tupah and Batu Hampar rivers, these larvae were found under the debris and litter of leaves. They sometimes live under the stones in fast moving water. The present of families Amphipterygidae, Calopterygidae, Chlorocyphidae and Coenagrionidae showed that the river were not polluted because these families prefer to inhabit clear forest streams from lowlands to highlands [1].

The Odonata community richness in each river was relatively low.

According to [8], invertebrate taxa richness in small steam may be limited by low flow, lower habitat diversity, and greater thermal constancy. These three rivers are small with shallow water hence lower odonate diversity. The scores calculated for chemical parameter were low indicating that the rivers were not polluted. This problem arises when applying Margalef index in the absence of a limit value. Some ecologists consider the values of less than four as typical of polluted water but others prefer the values below 2.05 [9]. Likewise, the diversity index of Shannon-Wiener also scored the lower values for all those rivers studied. [10] suggests that polluted stream often exhibit a reduced number of species with great abundances and unpolluted streams exhibit the reverse. In contrast, this index lack of objectivity when establishing as a precise manner from what value it should start detecting the effect of pollution [9]. However, low index values are considered to be indication of pollution. In addition, this study only considered one insect order. As a comparison, Batu Hampar River can be considered less clean than Tupah River and Teroi River because the diversity index for this river was the lowest.

The present study suggested that biotic and abiotic factors related to the physical structure of a habitat may play important roles in the influencing odonate abundance at any habitat. Analysis of correlation test between water parameter and the abundance of Odanata in each studied river suggested that the velocity significantly influenced the abundance of Odonata larvae. Fewer larvas were found in higher water velocity areas because the larvae could not attach themselves well to the substrate. Clingers including most zypoterans, aeshnids and some libellulid species e.g *Zygonyx* which cling to fast flowing riffles areas of steams were very much affected by variations of water velocity [1]. They could also be washed away when the water move very fast.

The biological oxygen demand is the amount of oxygen utilized in the biodegradation of organic material over a given time period. The abundance of Odonata in these three rivers were influenced to some extent by these rivers were always contaminated by discarded waste materials and human discharges. Hence, more oxygen was required to degrade there resulting in low biological oxygen demand values in the rivers. Regular disturbances of the habitats by visitors caused sedimentation and damaged numerous insect habitats. [11] stated that sedimentation of fine material may cover up gravel and stones over months or even years and this affect habitat and food availability for grazers.

The abundance of two most dominant odonate genera in these rivers; *Zygonyx* and *Euphaea* were found to be influenced by the velocity of water and the amount of organic decomposition in the rivers (BOD). In addition the abundance of *Euphaea* was induced by temperature, depth and pH. [12] stated that temperatures are important in adult dragonfly thermoregulatory and foraging behavior whereby they are more active in higher temperatures. It is further supported by [4] who found that aquatic insect survives in optimum temperature of 32°C. In general, the three rivers in this study were partially to almost completely shade by canopies. With the presence of floating macrophytes which covered the Teroi River, Tupah River and Batu Hampar River, the sunlight penetrations into the water were very much reduced the water temperature and maintained a low range of 20.5°C to 24.3°C. However in the presence of suitable substrates and water quality these temperatures were obviously very suitable to these odonate genera.

The pH also showed strong correlation to the abundance of *Euphaea*. The pH values were ranged between 6 to 6.69 at Tupah River and Batu Hampar River and 4 to 6 at Teroi River. Teroi River contained macrophytes and tree root inside the water that contributed to the lower pH [1]. The trees around its river banks were highly suspected to add coloration to the water which was slightly brownish. Among the species at Teroi River banks were *Agathis alba*, *Baeckis flustenses*, *Tristania* sp., *Podocarpus nerifolius*, *Leptospermum flavescens* and *Dacrydium elatum*. Some of this species such as *Agathis alba* has high content of tannin especially in the tree bark.

The depth of the river also plays a major factor that stimulated the abundance of *Euphaea* larvae. According to [1], many *Euphaea* females insert their eggs firmly into the wood and some species seem to depend absolutely on the presence of large, partly submerged logs. It is very likely that a deeper river affords many submerged logs and stones, hence provides numerous habitats for this genus. [14] reported that as an order Odonata are used to larger areas which in tandem with the biogeographic principle whereby larger areas support more species. The behavior of the odonate larvae could also influence the density of the Odonata larvae in their respective habitas. As noted by [3] the odonates were very much adapted to coarse bed substrates and riffles which were fundamental habitats for many clinger taxa such as Libellulidae. Those adonates are morphologically adapted to attaching themselves to surfaces in riffles. It has been found that these habitats provide the greatest diversity and density of benthic macroinvertebrate. Meanwhile, according to [13] vegetation along stream banks provides necessary habitat for many of the climber insects, those that have evolutionary adaptations for vegetative habitats along stream banks, including overhanging branches and roots. Leaf pack also provides an essential habitat for many benthic organisms, in addition to serving as the foundation layer of the food resources for entire aquatic ecosystem [2]. [15] noted that dragonfly larvae prey on each other in simple laboratory habitats, although is not known whether this potential for predation is realized in natural habitats. This is because the odonate population dynamics depend on high rates of resources renewal. Natural conditions of prey recruitment are requisite for measuring ecologically relevant intensities of competition and predation. However, [16] reported that the species of prey eaten by Libellulidae larvae at a given time and place depend on the size of instar of the larva and on its behavioural characteristics. Cannibalism among odonate larvae was also mentioned by [17] as dragonflies do cannibals both in the larval and imaginal stages. The odonates species in Gunung

Jerai rivers were probably used to this behavior and prey on each other resulting in low numbers of collected specimens in the area. Consequently, the abundance as well as diversity of Odonata population in those rivers was low with only few dominant genera.

The other study of aquatic insect at stream ecosystem by [18] reported a very rich assemblage of Odonata larvae which consist of 25 genera of 13 families at Temengor Lake, Perak. Simirlarly, the study at Pantai Acheh Forest Reserve, Penang by [19] also showed that moderately polluted rivers consists Euphahaeidae, Gomphidae, Megapodagrionidae, Coenagrionidae and Libellulidae as their inhabitants. The former study at stream ecosystem showed some similarities with Gunung Jerai rivers in the presence of odonata genera such as *Neurobasis, Vestalis, Euphaea*, *Pseudagrion*, *Zygonyx* and *Macromia* as noted by [20] in Gunung Stong Forest Reserve, Kelantan. These genera seem to prefer the stream ecosystem as well.

Our result from this study reveals relationships of odonate compositions with physicochemical parameters in rivers. Libellulidae and Euphaeidae were the two dominant genus found from this study. Fast water velocity and low biochemical oxygen demand were the two main factors that favors the composition and distribution of Odonata larvae. In general, the clean, fast water in the study area was a suitable habitat for reported Odonata larvae.

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