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Preliminary Distribution of Ephemeroptera, Plecoptera and Trichoptera (EPT) in Kerian River Basin, Perak, Malaysia

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ABSTRAK

Kajian permulaan terhadap tiga order serangga akuatik, Ephemeroptera (lalat Mei), Plecoptera (lalat batu) dan Trichoptera (lalat kandul) (EPT) telah dijalankan di Lembangan Sungai Kerian (LSK) di sempadan negeri Kedah-Perak di Semenanjung Malaysia. Ephemeroptera yang terdiri daripada enam famili, 10 genus dan 460 individu adalah order yang paling dominan di situ. Sungguhpun Plecoptera dan Trichoptera diwakili oleh bilangan famili yang sama, lalat batu didapati lebih limpah di lembangan sungai tersebut. Mengikut turutan kelimpahan lalat batu Tetropina, *lalat Mei* Caenis, *dan* Centroptilum, *dan lalat kandul* Macrostemum *adalah paling dominan. Kepelbagaian fauna EPT berjulat 1.41 - 2.65 (H') dengan taburan yang berbeza (ANOVA, $F_{15,340} = 1.68$) pada P= 0.05 dan kesamaan taburan yang tak sekata (Indeks Kesamaan berjulat 0.15-0.95). Indeks kekayaan EPT adalah rendah di semua sungai dan nilai indeks FBI mengkategorikan kualiti air sungai sebagai sederhana tercemar sehingga kualiti yang sangat baik.*

ABSTRACT

A preliminary study on three aquatic insect orders, Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) (EPT) was carried out in Kerian River Basin (KRB), at the border of Kedah-Perak states, in Peninsular Malaysia. Ephemeroptera comprising six families of 10 genera and 460 individuals was the most dominant order. Although both Plecoptera and Trichoptera was represented by similar number of families, stoneflies were found to be more abundant in the river basin. In order of abundance, stonefly Tetropina, mayflies Caenis, *and* centroptilum, *and caddisfly* Macrostemum *were the most common geneva. The diversity of the EPT fauna ranged 1.41 - 2.65 with significantly different distribution (ANOVA, $F_{15,340} = 1.68$) at P= 0.05 and fairly unevenly distributed (Evennes Index Ranged 0.15-0.95). The EPT Richness indices were in low ranges in all river and the FBI scores categorised the water quality of river in this river basin as moderately polluted to excellent.*

INTRODUCTION

Among the macroinvertebrates, insects are the most successful inhabitants of fresh water environment. This is demonstrated by their compositions and abundance, broad distribution and their ability to exploit most types of aquatic habitats (Wallace Anderson 1996). The Ephemeroptera, Plecoptera and Trichoptera (EPT) are insect orders that recently have been proposed for biological monitoring of water quality especially in pristine areas (Lenat 1988). The mayflies are categorised as a primitive winged insect while stoneflies are primarily associated with clean and cool running water. Caddisflies is one of the largest group of aquatic insects (Morse *et al.* 1994) inhabiting aquatic ecosystem from moderately poor to good water quality.

Composition and distribution of EPT is determined by their physical-chemical tolerance to an array of environmental factors (Dudgeon 1984; Hyness 1976). Their distribution varies due to availability and types of microhabitats. As aquatic insects tend to remain in their original habitats, they are affected by local changes in water quality. By assessing the diversity and composition of indicator species such as EPT, it is possible to determine the status of water quality of an aquatic system.

Aquatic insects are not widely studied especially in the northern region of Peninsular Malaysia. This research provided a preliminary record of the EPT of the KRB. Their composition and distribution in several river basins would indicate their specificity towards available habitats or microhabitats in the area thus reflecting their affinity towards certain parameters of the environment. The implication of the distribution was compared to water quality categorization using other biological indices.

MATERIALS AND METHODS

Study Area

The Kerian River basin (5° 09'N - 5° 21'N and 100° 36.5'E - 100° 46.8'E) consists of two main rivers; Kerian and Selama (Fig. 1). The Selama River meets Kerian River approximately at the middle of the basin and continues westward to the Straits of Malacca. Kerian River, the main rivers that border the states of Kedah and Perak, starts from the hilly headwaters in Mahang, Kedah while the Selama River originates from hilly areas in Selama, Perak. Several tributaries contribute to the flow of these two rivers. Sixteen of them, Chelong, Incong, Air Puteh, Salleh, Air Itam, Damak, Siputeh, Nor, Selama, Relau, Mengkuang, Charok Merah, Taka, Kangar, Mahang and Serdang rivers were selected as sampling sites. Except for Serdang which is categorized as second order, all other rivers are first order rivers. They flow through forested areas, rubber and oil palm plantations, orchards, several newly constructed settlement areas and villages down to the Kerian Valley in Parit Buntar, Perak before entering the sea. Some of the rivers receive inflows of rice field drainage canals. Dominant riparian vegetation in the basins are oil palm, *Athocarpus* sp., *Ipomea* sp., tapioca, banana, wild rambutan (*Nephelium lappacaeum*) and rubber. *Hydrilla* is a dominant aquatic growth in several sampling stations.

Sampling of Insects

The mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) were collected along a 100 m stretch of each station by kick sampling techniques from September 1998 until May, 1999. Two stations were selected in each river and 10 samples were collected in each station. The sample size represented approximately 75% of the total insect taxa from each habitat which was below 40% standard error acceptable for benthic sampling (Elliot 1973; Furse *et al.* 1984). The kick net (500 mm mesh) was placed against water current and about a meter square area immediately in front of the net was disturbed for approximately 3 minutes (Davis and Simon 1995). The insects collected in the net were sorted in the laboratary and transferred into universal bottles containing 80% ETOH. They were identified to genera using keys of Merrit and Cummins (1996); Morse *et al.* (1994); McCafferty (1981); Edmondson (1683); and Usinger (1956). Differences in distribution of the EPT among rivers were analysed using a one way ANOVA. Selected biological indices were calculated to examine the structure of EPT community (Ludwig and Reynolds 1988) and scores of Family Biotic Index (FBI) (Hilsenhoff 1988) and EPT taxa richness (Morse *et al.* 1994) were used to categorize the quality of water of the rivers.

Measurement of Water Parameters

Several water parameters were measured to investigate the properties of aquatic habitat that possibly influenced the distribution of EPT in this river basin. They were also used to justify the reliabilities of scores of biological indices on data collected. Dissolved oxygen and water temperatures were measured using an oxygen meter (YSI-55). Water conductivity was recorded by a TDS meter (YSI-44600). A Toledo pH meter was used to measure the pH of the water and penetration of light on water surface was measured using a lux meter. A measuring tape was used to record the width and depth of the river and water flow was recorded using a hydoprop flow meter (MK-11-90 cm).

RESULTS

Ephemeroptera was the most abundant among the three orders in this river basin comprising more than half of the total number of all individuals collected (Table 1). Six genera representing six families of mayflies were recorded (Appendix 1). Plecoptera was relatively abundant, making up approximately 30% of total collection. Trichoptera contributed 18% of total EPT in the area. Dominant mayfly genera were identified (Table 2) and the most dominant among the three, *Caenis* had more than twice the number of the other two genera combined. However, although Plecoptera was fewer in number than the Ephemeroptera, *Tetropina* out-

numbered all other dominant genera of EPT. Caddisfly *Macrostemum* was relatively numerous in the Kerian River Basin. Appendix 1 shows detail distribution of EPT in all sixteen rivers sampled. *Caenis* was widely distributed in all but Mahang River. *Tetropina* was not collected from six rivers but was found in abundance in Mengkuang River. *Macrostemum* preferred Nor River and was hardly found in other rivers. A one way ANOVA indicated that the distribution of EPT was significantly different among rivers ($F_{15,340} = 1.68$) at P=0.05.

The EPT in this river basin were moderately diverse (H' range 1.41-2.65, D' range 0.45-0.16) with a relatively uneven distribution. The EPT richness Index was slightly low indicating the areas were slightly to seriously impacted (EPT Richness Index of 5-10, Davis and Simon 1995). Based on FBI scores, the water quality in these tributaries however was still in a relatively good condition with six rivers having excellent water quality (Category I), two rivers with slightly contaminated with organic matter (Category II) and the rest of the rivers moderately polluted with organic matter (Category III) (Table 3).

In general dissolved oxygen in the water was in good range in all rivers. The temperature difference was within 6°C which possibly related to the time of temperature recording. Water conductivities were in low ranges reflecting little contamination. The water however was slightly acidic in Mengkuang, Kangar, and Charok Merah rivers to acidic such as in Chelong and Salleh rivers. Current velocities were relatively slow in many rivers that might implicate sampling stations were in depositional zones. Most of the

TABLE 1
Composition and abundance of Ephemeroptera, Plecoptera and Trichoptera in Kerian River Basin

ORDER/Family	Abundance (Numbers)		
	Family	Genus	Individual
EPHEMEROPTERA	**6**	**6**	**460 (52.04%)**
Lepthophlebiidae	1	-	65
Pothamanthidae	1	-	12
Heptageniidae	1	1	21
Baetidae	1	4	180
Caenidae	1	1	181
Siphlonuridae	1	-	1
PLECOPTERA	3	1	263 (29.57%)
Perlidae	1	1	247
Perlodidae	1	-	9
Peltoperlidae	1	-	1
Unidentified	-	-	9
TRICHOPTERA	4	4	161 (18.21%)
Polycentropodidae	1	1	32
Hydropsychidae	1	3	113
Limnephilidae	1	-	16
TOTAL	**13**	**11**	**884 (100%)**

TABLE 2
Dominant genera of the EPT in Kerian River Basin

ORDER	Family	Genus	Individual	Total
EPHEMEROPTERA	Baetidae	*Baetis*	62	
		Centropilum	93	
	Caenidae	*Caenis*	**181**	336
PLECOPTERA	Perlidae	*Tetropina*	**247**	247
TRICHOPTERA	Polycentropodidae	*Polycentropus*	32	
	Hydropsyhidae	*Hydropsyche*	21	
		Macrostemum	**91**	144

TABLE 3
Scores of biological indices on EPT of Kerian River Basin

River	Shannon's Index (H')	Simpson's Index (D')	Evenness Index (E)	EPT Richness Index	Family Biotic Index (category)
Chelong	2.56	0.23	0.79	7	3.70 (I)
Inchong	2.14	0.18	0.52	5	5.72 (III)
Serdang	2.46	0.26	0.61	7	5.37 (III)
Air Puteh	2.48	0.16	0.25	5	5.00(III)
Salleh	2.65	0.30	0.40	6	4.26 (III)
Air Itam	2.52	0.24	0.61	6	5.11(III)
Damak	2.10	0.42	0.90	10	1.93 (I)
Siputeh	2.38	0.36	0.52	9	3.37 (I)
Nor 1.91	0.25	0.91	7	4.47 (III)	
Selama	1.41	0.42	0.38	8	4.24 (II)
Kangar	2.57	0.18	0.35	7	3.39 (I)
Mahang	2.16	0.20	0.17	7	3.13 (I)
Relau	2.46	0.23	0.15	5	4.46 (III)
Mengkuang	2.37	0.38	0.95	6	1.78 (I)
Charok Merah	2.59	0.45	0.48	10	3.93 (I)
Taka	2.65	0.22	0.48	5	5.48 (III)

TABLE 4
Water parameters and morphologies of the rivers in Kerian River Basin

River	Dissolved oxygen (mg/1)	Temperature (°C)	pH	Light Penetration (lux)	Conductivity (µs)	Width (m)	Depth (m)	Velocity (m/s)
Chelong	6.20-7.50	27.0-28.0	4.40-4.45	6.13-619	23-28	2.35	2.75	0.004
Inchong	6.70-7.45	29.0-30.0	5.40-5.50	1156-1558	50	8.00	1.40	0.02
Air Puteh	6.50-7.50	27.0-29.0	4.43-4.52	310-424	27-28	12.00	2.50	0.02
Serdang	6.10-7.60	26.0-30.0	5.24-5.38	259-760	35-37	11.50	4.60	0.029
Salleh	4.40-4.70	26.0-27.0	4.10-4.13	177-263	50	11.50	1.40	0.013
Air Itam	6.50-6.80	28.0-29.0	5.05-5.07	458-508	40	6.50	1.00	0.026
Relau	6.84-6.86	38.1-28.5	5.47-5.49	848-856	40-50	7.50	0.60	***
Mengkuang	7.78-7.85	26.2-26.6	6.63-6.67	653-852	12-20	11.00	5.00	0.004
Nor	6.50-6.80	26.0	5.40-5.54	1112-1240	10-12	3.70	0.80	0.171
Siputeh	7.50-7.70	27.0-28.0	5.18-5.37	235-270	18-20	18.50	4.00	0.019
Damak	7.10-7.30	27.0	5.36-5.54	115-193	20-40	6.40	4.00	0.017
Selama	8.10-8.15	26.0-27.0	5.58-5.65	394-407	20-30	25.00	2.50	0.155
C. Merah	7.41-7.47	26.8-27.0	5.89-5.86	418-428	60	6.30	0.60	0.005
Taka	6.17-6.23	28.7-29.4	5.65-5.71	540	35-40	4.80	0.85	0.036
Kangar	8.36-8.44	24.0	6.10-6.25	290-292	18-20	16.00	1.20	0.064
Mahang	8.56-8.57	24.3-24.5	4.82-4.88	250-252	18-20	10.50	2.00	0.045

*** no measurement made

sampling stations were partially shaded. Analysis of Pearson Correlation indicated that there was no correlation of water parameters with the distribution of EPT between rivers at P=0.05. Except for low water pHs, many of the rivers would make suitable habitats for the EPT.

DISCUSSION

A relatively abundant EPT fauna in KRB was quite diverse. Epheroptera was the most dominant orders of EPT in the area. Although they were differently distributed among rivers, a number of mayfly genera such as *Caenis*, *Centroptilum* and *Baetis* were collected in most of the river studied. In general mayfly are nearly cosmopolitan. The larvae of various species in-

habit an extensive range of standing and running fresh waters. Some of them burrow in substrates while others sprawl amongst fine sediment and detritus. Most mayfly larvae are collectors or scrapers and feed on a variety of detritus, some macrophyte and animal material (Dudgeon 1984; Merrit and Cummins 1996; Hong 1994). A few species are true carnivores. *Baetis* for example, occurs in permanent, flowing water and its species are most common in the clear water of cold streams. Some *Baetis* species together with *Centroptilum* and *Caenis* however live in erosional and depositional regions of rivers. They feed mostly by scraping algae and collecting diatoms and fine particulate detritus from solid surfaces. Many rivers in the KRB are slow flowing which would represent the depositional habitats that were suitable for these geneva.

Ephemeropterans are preys for carnivorous aquatic insects such as stoneflies (Stewart and Stark 1993). Selective pressures due to predation have resulted in behavioral responses by prey species. Some mayflies react to predators by drifting or by displaying scorpion - like threat postures (Peckarsky 1980; Peckarsky and Dodson 1980). Mayflies can apparently detect predators by non-contact chemical cues. They may be able to distinguish between predaceous and detritivorous stoneflies that have a similar body form. Suitable habitats in the KRB, behavioral adaption and sensitivity towards chemical cues may have contributed to the abundance of ephemeropterans in this river basin.

The distribution of stoneflies is rather restricted due to their preference for clean, lower temperature flowing water. Several species however, have adapted to living in warm and organically enriched environment (Harper 1994). They tend to prefer specific substract type and stream size or stream reach. Microhabitats preference include boulder surfaces, cobble and gravel interstices, debris accumulations and leaf packs as well as the hyporheal. Perlidae was the most abundant Plecopterans found in selected few rivers in the river basin such as Mengkuang, Damak, Kangar and Siputeh. Obviously they have adapted to living in fine sand and muddy substrates that represent habitats in those rivers. Most members of this family are engulfers that are herbivores-detritivors or carnivores throughout nymphal development. Stonefly carnivores subsist primarily on chironomid and mayfly larvae (Stewart and Stark 1993) that thrive in habitats found in many rivers in the KRB. As a group, stoneflies have diversified their food habits such that the different species fill about every conceivable major food niche in streams. Many species shift from herbivory-detritivory in later periods. However, some species such as *Pteronarcella badia* was herbivory-detritivory through their development and other species such as *Claassenia sbulosa* and *Hesperoperla pacifica* were carnivores throughout development (Fuller and Stewart 1977; 1979).

A member of the third order, the Trichoptera (caddisfly) occurs in most types of freshwater habitats such as streams and seepage areas, river, lakes, marshes and temporary pools. Many of them have exploited freshwater habitats that are larger, warmer and more lentic. Some larvae are mainly predaceous. Generally larval Trichoptera show little selectivity of food they are highly and diversely specialized for food acquisition (Morse *et al.* 1994). In the KRB, *Macrostemum* was abundant in Nor River that had a lot of decaying leaves and tree branches, submerged tree stumps and macrophytes along river margins. A net spinner that usually lives in fixed retreats is a collector-filterer of fine particulate organic matter that usually clings to its substrate. It is widely distributed in lotic water erosional zone such as that found in Nor River. *Hydropsyhe* was the next common genus of this caddisfly in this area. This genus is probably quite tolerant and widespread in distribution. In Langat River in the state of Selangor, *H. annulata* and *H. doctersi* were very commonly found (Rahim 1992).

Categorization of a river's water quality using the EPT richness index in this study was not conclusive mainly due to inability to identify specimens to species. For example, 247 individuals of *Tetropina* and *Caenis* could represent more than species. The number of taxa (species) is important since a richer community would reflect a healthier environment of unimpacted water. The FBI however, classified the water in sixteen rivers into three categories I, II and III implicating the water was without, slightly and moderately polluted with organic matter respectively. The classification of water using the FBI too needs to be interpreted with caution because the tolerance values used to calculate the index was based on those assigned for Wisconsin's insect (Hilsenhoff 1988). It has been proven that ecoregions influenced the scores of such

indices (Lenat 1988; 1993; 1994). Nevertheless these values could be used as guidelines until more appropriate values are available for Malaysian insects.

Within range of water parameters in this study, no significant correlation between distribution of EPT taxa and water parameters was detected, and no trend of any water parameter that might influence categorization of water quality was observed. Except for slightly lower river basin is relatively in good condition.

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