Macroinvertebrates Checklist in River Intakes of Pergau Lake, Jeli, Kelantan

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Abstract. This study was conducted in several selected river intakes of the Pergau Lake as well as Sungai Pergau to determine the macroinvertebrate community, and also to update checklist of those macroinvertebrates known to the area. Previous study was done by Suhaila et al in 2017 with seven sampling points; Sungai Terang, Sungai Suda, Sungai Renyok 2, Sungai Renyok 3, Sungai Kalai, Sungai Long 1 and Sungai Long 2. Meanwhile, this study maintain the similar sampling points except Sungai Kalai, besides introduction of new sampling points at Sungai Renyok 1 and Sungai Pergau. Result shows the study rivers have great number of macroinvertebrates taxa. Sungai Renyok 2 recorded the most diverse aquatic insect collected with 29 genera while the least diversity of aquatic insects was recorded in Sungai Suda (16 genera). A total of 53 genera and 34 families from nine different orders of benthic macroinvertebrates namely Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera, Decapoda, and Lepidoptera were recorded. The existence of some orders such as Ephemeroptera, Plecoptera and Trichoptera (EPT) showed rivers in Pergau has good water quality and habitats for macroinvertebrates especially aquatic insects.

1. Introduction

Macroinvertebrates or known as benthos is animal without backbone with has size larger than \( \frac{1}{2} \) milimeter that lives in benthic zone of water body. Benthic zone can be defined as the lowest layer of a sea, lake, stream or river [1]. Acts as important link in the food chains in aquatics environments, the presence of aquatic insects ensures the continuity of the fish population in the lake [2]. Invertebrates have becuoap of advantages as good biological indicator in monitoring the water quality for stream environment. Adults aquatic insects play an important role in food web within forest ecosystem [3,4]. Application of invertebrates in water quality monitoring is suitable as they are relatively sensible to habitat changes and yet cannot escape pollution and severe natural events [5]. Thus, various biological indices were established and extensively used to estimate and evaluate the aquatic ecosystem quality by using this macroinvertebrate.

Relocation of river intakes is the effect of reservoir’s development and consequently affect the environment and its living organisms as well [6]. The small environment’s changes will have considerable response on the benthic community and its valid to measure the level of pollution [7,8,9]. Therefore, this study aim to determine the diversity of aquatic insects in selected rivers intakes of...
Pergau Lake and to update of macroinvertebrates checklist. Suhaila et al. [6] has done a study in the area and collected some specimens of macroinvertebrates.

2. Methodology
The sampling was undertaken on 28th October until 3rd November 2019. Macroinvertebrates were collected from eight selected river intakes: Sungai Terang, Sungai Suda, Sungai Renyok 1, Sungai Renyok 2, Sungai Renyok 3, Sungai Pergau, Sungai Long 1 and Sungai Long 2 (Figure 1).

Six replicates were collected from each sites (three replicates at upstream and three replicates at downstream). Aquatic D-frame net was used to collect benthic macroinvertebrates which is considered to be more suitable for shallow water. The sample was collected by placing the net facing against the water current while the substrate immediately disturbed using hand and foot. The surface of pebbles and gravel were rubbed so that the macroinvertebrates on the stones or leaf pack fall off and be carried by the current into the net. The content was poured into a sieve for screening of benthic macroinvertebrates and remove foreign substances that are not needed. Collected samples (debris and other materials) were washed and rinsed through 200µm pore size sieve and retain materials were then transferred into plastic bag. The samples then were preserved with 5% ethanol for temporary preservation.

In the laboratory, samples were then washed with tap water to remove preservative and invertebrates were sorted in white bottom tray. Collected organisms then identified to the family level in the laboratory according to Pennak [10] and Thorp and Covich [11]. Habitat assessment was conducted during the sampling through eye vision. All necessary characteristics such as water colour, substrate types and canopy cover were recorded in the habitat assessment form.
3. Result and Discussion

A total of 53 genera and 34 families from nine different order of benthic macroinvertebrates namely Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Trichoptera, Diptera, Decapoda, and Lepidoptera were recorded from all eight sampling points (Table 2). Rivers in Pergau could be considered to have excellent water quality as Ephemeroptera, Plecoptera and Trichoptera (EPT) can only be found in non-polluted water bodies [12]. Some of the rivers such as Sungai Renyok 2, and Sungai Long 2 have suitable surrounding environment for aquatic insect’s population, thus many insects’ taxa were found here. Sungai Renyok 2 recorded the most number of genera identified with 29 genera of Coleoptera, Diptera, Ephemeroptera, Hemiptera, Odonata, Plecoptera, and Trichoptera. The difference in number of genera in Sungai Renyok 2 compared to the other rivers may be due to the difference in availability of food, habitat preferences and adaptations at that area [13]. Furthermore, the environmental characteristics play an important role in shaping the structure of benthic macroinvertebrates communities in the rivers [14]. The least number of genera identified recorded on Sungai Suda with 16 genera. This was believed due to surrounding environment which were less canopy covered and sandy substrate river composition. River with open canopies had lower production of certain insects group compared with rivers in forested areas [15,16,17].

In Sungai Renyok, there were 7 genera of Coleoptera and 5 genera of Diptera recorded. Both Sungai Renyok 2 and Sungai Long 2 reported 5 genera of Ephemeroptera. Order Hemiptera was reported the greatest in Sungai Long 1 with 4 genera followed by Sungai Terang and Sungai Suda with 2 genera, respectively. No Hemiptera found at Sungai Renyok, Sungai Renyok 3 and Sungai Pergau. Four sampling points; Sungai Terang, Sungai Renyok 2, Sungai Long 1 and Sungai Long 2 showed same number of genera (2 genera) of Odonata while in the other side, no genera of Odonata was found at Sungai Renyok 3. Sungai Pergau was reported with 4 genera of Plecoptera followed by 3 genera at Sungai Renyok 2. Trichoptera was mostly found at Sungai Long 2 with 8 genera followed by Sungai Renyok 1 and Sungai Renyok 2 with 6 genera, respectively. Order Decapoda only been found at Sungai Renyok 3 and order Lepidoptera only been found at Sungai Suda and Sungai Long 1. These two orders had the least genera (only 1 genera). Table 1 showed river necessary characteristics based on field observation. There is no exactly percent for canopy cover since no details study done on forest gap. Changes in water quality, including hydrological, physical and chemical aspects of the rivers results different rivers recorded slightly different diversity of aquatic insects [18,19,20].

The most diverse order was Trichoptera with 15 genera recorded while Decapoda and Lepidoptera had the least genera detected with 1 genus, respectively. Order Trichoptera was most diverse taxa with 15 genera, followed by Coleoptera with 9 genera and 8 genera from Ephemeroptera. In all selected rivers, Narpus (order Coleoptera), Chironomi and Simulium (order Diptera) and Hydropsyche (order Trichoptera) most abundance followed by Baetis, Platybeatis and Thalerospyhrus; all from same order Ephemeroptera. Those four genus dominated all the rivers due to food availability and variety of substrates in rivers [6].

Table 1: River characteristics at the seven sampling points

| River     | Water Index Range | Substrate class | Canopy cover (estimation in %) |
|-----------|-------------------|-----------------|--------------------------------|
| Sg. Terang| Clean             | Sand            | <30                            |
| Sg. Suda  | Clean             | Rocky boulder   | 41-59                          |
| Sg. Renyok 1 | Clean       | Rocky fine      | 41-59                          |
| Sg. Renyok 2 | Clean       | Bedrock         | >60                            |
| Sg. Renyok 3 | Clean       | Rocky fine      | 41-59                          |
| Sg. Pergau | Clean             | Bedrock         | 41-59                          |
| Sg. Long 1  | Clean            | Rocky fine      | 41-59                          |
| Sg. Long 2  | Clean            | Bedrock         | >61                            |
Ephemeroptera, Plecoptera and Trichoptera (EPT) is known for their abundant in upland rivers and the adults spend their whole life in the riparian zone [21,22,23,24]. According to Suhaila et al. [6], due to high density of arthropods, adults of aquatic insects become the prey for riparian birds [25,26] and bats [27].

3.1 Comparison with previous study
The previous study of Pergau Valley done by Suhaila et al. [6] at seven sampling points reported seven orders, 46 families and 72 genera. This current study had added two more sampling points at Sungai Renyok 1 and Sungai Pergau; and excluded Sungai Kalai as had been sampled in previous study. Even though last study recorded more families and genera, but the current study has recorded the order and genera as compared with the previous study. Two more orders discovered during current study were Decapoda and Lepidoptera. Decapoda was recorded at Sungai Renyok 3 and Lepidoptera was found at Sungai Suda and Sungai Long 1. Sungai Renyok 3 had clean fresh water bodies from lowland to mountain was the habitat for relatively common found Potamidae (Decapoda). In the other hand, running water of Sungai Suda and Sungai Long 1 were habitat for rarely found Pyralidae (Lepidoptera) [2]. For order Coleoptera and Diptera, both order reported four new genera; Stenocilus, Helophorus, Elodes and Narpus from order Coleoptera and Tanypodinae, Orthocladiinae, Chironomini and Tanytarsini from order Diptera respectively. Order Trichoptera had most new discovered genera compared to previous study found such as Cheumatopsyche, Ceratopsyche, Diplectrona, Dolophilodes and Hydroptila. Three new discovered genera compared to previous study recorded for Ephemeroptera and Odonata respectively. Ephemeroptera had added Nigrobaetis, Gratia and Teloganodes into their list and Acroghomphus, Erpetoghompus and Euphaea added into order Odonata. No new genus found for Hemiptera and Plecoptera.
Table 2. Composition of aquatic insects in River Intakes of Pergau Lake, Jeli, Kelantan

| Order     | Family         | Genus             | Sg. Terang | Sg. Suda | Sg. Renyok 1 | Sg. Renyok 2 | Sg. Renyok 3 | Sg. Pergau 1 | Sg. Long 1 | Sg. Long 2 |
|-----------|----------------|-------------------|------------|----------|--------------|--------------|--------------|--------------|------------|------------|
| Coleoptera| Eulichadidae   | *Eulichas*        | +          | +        |              |              |              |              |            |            |
|           |                | *Stenocilus*      |            |          |              |              |              |              |            |            |
| Hydrophilidae| *Laccobius*     |                    |            |          |              |              |              |              |            |            |
|           | *Berosus*      |                    |            |          |              |              |              |              |            |            |
|           | *Helophorus*   |                    |            |          |              |              |              |              |            |            |
| Psephenidae| *Eubrianax*    |                    | +          |          |              |              |              |              | +          |            |
| Scirtidae | *Cyphon*       |                    | +          | +        |              |              |              |              |            |            |
|           | *Elodes*       |                    | +          | +        | +            |              |              |              |            |            |
| Elmidae   | *Narpus*       |                    |            | +        |              |              |              |              |            |            |
| Diptera   | Chironomidea   | *Tanypodinae*     | +          |          |              |              |              |              |            |            |
|           |                | *Orthocladiinae*  |            |          |              |              |              |              |            |            |
|           | *Chironomini*  |                    | +          |          | +            |              |              |              |            |            |
|           | *Tanytarsini* |                    |            | +        |              |              |              |              |            |            |
| Simuliidae| *Simulium*     |                    | +          |          |              |              |              |              | +          | +          |
| Tipulidae | *Hexatoma*     |                    |            | +        |              |              |              |              |            |            |
| Ephemeroptera| Baetidae      | *Baetis*          | +          |          |              |              |              |              | +          | +          |
|           |                | *Platybaetis*     | +          |          |              |              |              |              | +          | +          |
|           |                | *Nigrobaetis*     |            |          |              |              |              |              | +          | +          |
|           |                | *Gratia*          |            |          |              |              |              |              |            |            |
| Ephemereellidae| *Crinitella*  |                    | +          |          |              |              |              |              |            |            |
| Heptageniidae| *Thalerosphyrus*|                 |            |          |              |              |              |              |            |            |
| Teloganodidae| *Teloganodes* |                    |            |          |              |              |              |              |            |            |
| Caenidae  | *Caenis*       |                    |            |          |              |              |              |              |            |            |
| Hemiptera| Aphelocheiridae| *Aphelocheirus*   | +          |          |              |              |              |              |            |            |
|           | *Ptilomera*    |                    |            |          |              |              |              |              |            |            |
|           | *Rhagadotarsus*|                    |            |          |              |              |              |              |            |            |
|           | *Rhagovelia*  |                    |            |          |              |              |              |              |            |            |
| Odonata  | Chlorogompidae| *Chlorogomphus*   | +          |          |              |              |              |              | +          | +          |
| Gompidae | *Megalogomphus*|                    |            |          |              |              |              |              |            |            |
| Order | Family | Genus | Sg. Terang | Sg. Suda | Sg. Renyok 1 | Sg. Renyok 2 | Sg. Renyok 3 | Sg. Pergau | Sg. Long 1 | Sg. Long 2 |
|-------|--------|-------|------------|----------|--------------|--------------|--------------|------------|------------|------------|
|       | Euphaeidae | Acrogonopus | +         | +         |              |              |              |            |            |            |
|       | Acrogonopus | Erpetogomphus | +         | +         |              |              |              |            |            |            |
|       | Euphaeidae | Euphaea | +         | +         |              |              |              |            |            |            |
|       | Plecoptera | Perlidae | Ectroconema | +         | +         | +         | +         | +         | +         | +         |
|       | Plecoptera | Perlidae | Kaminuria | +         | +         | +         | +         | +         | +         | +         |
|       | Plecoptera | Perlidae | Neolerpa | +         | +         | +         | +         | +         | +         | +         |
|       | Plecoptera | Peltoperlidae | Cryptoperla | +         | +         | +         | +         | +         | +         | +         |
|       | Trichoptera | Hydropsychidae | Hydropsyche | +         | +         | +         | +         | +         | +         | +         |
|       | Trichoptera | Hydropsychidae | Cheumatopsyche | +         | +         | +         | +         | +         | +         | +         |
|       | Trichoptera | Hydropsychidae | Ceratopsyche | +         | +         | +         | +         | +         | +         | +         |
|       | Trichoptera | Hydropsychidae | Diplectrone | +         | +         | +         | +         | +         | +         | +         |
|       | Hydropsychidae | Macrostromum | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Hydropsychidae | Chimarra | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Hydropsychidae | Dolophilodes | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Hydropsychidae | Gumaga | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Stenopsyche | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Lepidostoma | +         | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Polycentropodidae | Polycentropus | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Leptoceridae | Ceraclea | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Hydropsychidae | Hydroptila | +         | +         | +         | +         | +         | +         | +         |
|       | Sericostomatidae | Rhyacophilidae | Rhyacophilia | +         | +         | +         | +         | +         | +         | +         |
|       | Decapoda | Potamidae | Johora | +         | +         | +         | +         | +         | +         | +         |
|       | Lepidoptera | Pyralidae | Parapoynx | +         | +         | +         | +         | +         | +         | +         |
4. Conclusion
The composition of aquatic insects were different at all selected rivers. Sungai Renyok 2 reported the greatest diversity of aquatic insect taxa with 29 genera. Order Trichoptera record the highest number of diversity with 15 genera followed with 9 genera from order Coleoptera and Ephemeroptera with 8 genera in all selected rivers. In general, all selected rivers was suitable for aquatic insects community with averagely considered as good quality and non-impacted river. This was strengthen by the existence of order namely Ephemeroptera, Plecoptera and Trichoptera (EPT).

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References
[1] Montagna P A, Baguley, J G, Cooksey C, Hartwell I, Hyde L J, Hyland J L, Kalke, R D, Kracker L M, Reuscher M and Rhodes A C E 2013 Deep-sea benthic footprint of the deepseawater horizon blowout. Public Library of Science 8(8).
[2] Che Salmah M R, Suhaila A H and Nurul Huda A 2014 Aquatic macroinvertebrates of Belum Temengor Rainforest Streams (Petaling Jaya, Selangor: Pulau Banding Foundation)
[3] Bonada N, Prat N, Resh V H and Statzner B 2006 Development in aquatic insect biomonitoring: a comparative analysis of recent approaches. Anna Rev Entomol 51(1) 495-523
[4] Suhaila A H, Che Salmah M R and Al-Shami S A 2012 Temporal distribution of Ephemeroptera, Plecoptera and Trichoptera (EPT) adults at a tropical stream: response to seasonal variations The Environmentalist 32 28-34.
[5] Morse J C, Bae Y J, Munkhjargal G, Sangpradub N, Tanida K., Tatyana S V, Wang B, Yang L and Yule C M 2007 Freshwater Biomonitoring with Macroinvertebrates in East Asia Frontiers in Ecology and the Environment 5(1) 33-42.
[6] Suhaila A H, ‘Amila Faqhira Z, Norshamiera N, Siti Hamidah I, Mohd Hafizul Hasmadi M N and Amir Shah Ruddin M S 2017 Diversity and distribution of aquatic insects in rivers of Pergau Valley, Jeli, Kelantan (Kota Bharu,: Jabatan Perhutanan Negeri Kelantan) 32-38.
[7] Coull B C 1973 Estuarine meiofauna a review, tropic relationship and microbial ecology. L. H. Stevenson and Colwell (Eds.) (Columbia : University of South Carolina Press) pp. 449-511.
[8] Fernando O J 1981 Ecological studies in the international region of the Vellar estuary (Porto novo, S. India) (Ph.D. Thesis, Annamalai University, India).
[9] Aweng E R, Suahaimi O and Nur Izzati S 2012 Benthic Macroinvertebrate Community Structure And Distribution In Sungai Pichong,Gunung Chamah, Kelantan, Malaysia American International Journal of Contemporary Research 2(1) 163-167
[10] Pennak R W 1953 Freshwater Invertebrates of The United States (New York: John Wiley & Sons)
[11] Thorp J H and Covich A P 1991 Ecology and Classification of North American Freshwater Invertebrates (San Diego: Academic Press)
[12] Sharroum-Harrison F, Sulaiman M H, Ellias N H and Adam Embong M S 2015 Aquatic biodiversity in the Belum-Temenggor Forest Complex. International Conference on Sustainability Initiatives (ICSI) 2015 in conjunction with 8th ASEAN Environmental Engineering Conference (AEEC).
[13] Lastra M, De la Huz R, Sanchez-Mata A G, Rodil I F, and Aerts K 2006 Ecology of exposed sandy beaches in northern Spain: environmental factors controlling macrofauna communities Journal of Sea Resources 55 128-140.
[14] Beauger A, Lair N, Reyes-Marchant P, and Peiry J L 2006 *The distribution of macroinvertebrates assemblages in a reach of the River Allier (France), in relation to riverbed characteristics* Hydrobiologia **571**(1) 63–67.

[15] Meehan W R 1996 *Influence of riparian canopy on macroinvertebrate composition and food habits of juvenile salmonids in several Oregon streams* (Portland : USDA Forest Service, Pacific Northwest Research Station)

[16] Hawkins C P, Murphy M L and Anderson N H 1982 Effects of canopy, substrate composition, and gradient on the structure of macroinvertebrate communities in cascade range streams of Oregon *Ecology* **63**(6) 1840–1856.

[17] Newbold JD, Sweeney BW, Vannote RL 1994 *A model for seasonal synchrony in stream mayflies* *J N Am Benthol Soc* **13**(1) 3–18.

[18] Al-Shami S A, Md Rawi C S, Ahmad A H, Abdul Hamid S, Mohd Nor S A 2011 Influence of agricultural, industrial, and anthropogenic stresses on the distribution and diversity of macroinvertebrates in Juru River Basin, Penang, Malaysia *Ecotox Environ Safe* **74** 1195–1202.

[19] Che Salmah M R, Salman A A, Madzatiutul R M and Abu Hassan A 2013 Biological and ecological diversity of aquatic macroinvertebrates in response to hydrological and physiochemical parameters in tropical forest streams of Gunung Tebu, Malaysia: Impcicataions for ecohydrological assessment *Ecohydrology* **7**(2) 496-507.

[20] Al-Shami S A, Jani H, Che Salmah M R, Abu Hassan A, Suhaila A H and Madzatiutul R M 2013 *Drivers of beta diversity of macroinvertebrate communities in tropical forest streams* *Freshwater Biology* **58** 1126-1137.

[21] Jackson J and Resh V H 1989 Activities and ecological role of adult aquatic insects in the riparian zone of streams. *USDA Forest Service General Technical Report* PSW-110 342–345.

[22] Briers R A, Cariss H M and Gee J H R 2002 Dispersal of adult stoneflies (Plecoptera) from upland streams draining catchments with contrasting land-use *Arch Hydrobiol* **155**(4) 627–644.

[23] Clarke A, Mac Nally R, Bond N and Lake P S 2008 Macroinvertebrate diversity in headwater streams: a review *Freshw Biol* **53**(9) 1707–1721.

[24] Kasangaki A, Chapman L J and Balirwa J 2008 Land use and the ecology of benthic macroinvertebrate assemblages of highaltitude rainforest streams in Uganda *Freshw Biol* **53**(4) 681–697.

[25] Blancher P J, Furlonger C L and McNicol D K 1987 *Diet of nestling tree swallows (Tachycineta bicolor) near Sudbury, Ontario, Canada* (Ontario: Canadian Wildlife Service)

[26] Murakami M and Nakano S 2002 Indirect effect of aquatic insect emergence on a terrestrial insect population through predation by birds *Ecol Lett* **5**(3) 333–337.

[27] Herd R. M. and Fenton M. B. 1983 *An electrophoretic, morphological, and ecological investigation of a putative hybrid zone between Myotis-Lucifugus and Myotis-Yumanensis (Chiroptera, Vespertilionidae)* *Can J Zool* **61**(9) 2029–2050.
Appendix A: Some of the sample recorded during expedition.

Baetidae

Caenidae

Hydropsychidae

Heptageniidae