Faculty of Resource Science and Technology

AQUATIC INSECT DRIFT AT ROCKY SUBSTRATE OF A SMALL RIVER IN RANCHAN RECREATIONAL PARK, SERIAN

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DECLARATION

This is original work as there is no section has referred in this dissertation has been submitted in support of an applications for another degree qualification of this or any other university or institution of higher learning.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

DO	Dissolved Oxygen
TSS	Total Suspended Solid
GPS	Global Positioning System
pH	Power of Hydrogen
EPT	Ephemeroptera, Plecoptera, Trichoptera
H'	Shannon-Weiner Diversity Index
D	Margalef Richness Index

LIST OF TABLES

LIST OF FIGURES

AQUATIC INSECT DRIFT AT ROCKY SUBSTRATE IN A SMALL RIVER NEAR RANCHAN RECREATIONAL PARK, SERIAN

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Aquatic Resource Science and Management Programme

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ABSTRACT

Population composition of aquatic insects in a small river in Ranchan Recreational Park was studied. Samplings were carried out for 6 times to study the pattern of aquatic insects in the river. The samplings were carried out for 24 hours. Surber sampler was used to collect the samples of aquatic insects in the small river. Water quality variables such as pH, dissolved oxygen, water velocity, water discharge, water depth and total suspended solid were significantly associated with the abundance of aquatic insects. A total of 553 individuals comprising 7 orders of aquatic insects were recorded throughout the sampling period. The drift was dominated by Ephemeroptera followed by Trichoptera, Plecoptera, Diptera, Coleoptera, Odonata and the least was Hemiptera. Sampling 4 has the highest taxa diversity with 7 orders of aquatic insects and highest number of aquatic insects. Sampling 1 has the highest taxa richness of aquatic insects as the abundance of individuals in every order is highest. Ephemeroptera, Plecoptera and Trichoptera (EPT) are used as the biological indicator. High number of this organism in the river shows a good quality of water in the small river of Ranchan Recreational Park. Low number of less-sensitive order Diptera could be an indication of no pollution occurred in the small river.

Key Words: aquatic insects, water quality, abundance, bio indicator

ABSTRAK

Kepelbagaian komposisi serangga akuatik di anak sungai di Taman Rekreasi Ranchan telah dikaji. Pensampelan dijalankan sebanyak 6 kali untuk mengkaji pola serangga akuatik di anak sungai. Setiap pensampelan telah dijalankan selama 24 jam. Surber sampler telah digunakan untuk mengumpul sampel serangga akuatik di anak sungai. Pembolehubah kualiti air seperti pH, jumlah oksigen terlarut, kelajuan arus air, pengaliran air, kedalaman air dan jumlah pepejal terampai adalah berkait rapat dengan kelimpahan serangga akuatik di anak sungai. Sebanyak 553 individu yang terdiri daripada 7 order serangga akuatik telah direkodkan sepanjang tempoh pensampelan. Serangga akuatik hanyut di anak sungai telah didominasi oleh order Ephemeroptera diikuti oleh Trichoptera, Plecoptera, Diptera, Coleoptera, Odonata dan paling kurang adalah order Hemiptera. Persampelan 4 mempunyai kepelbagaian order tertinggi iaitu sebanyak 7 order serangga akuatik dan mencatat bilangan tertinggi serangga akuatik. Persampelan 1 mempunyai kekayaan order serangga akuatik tertinggi disebabkan kebanyakkan individu di dalam setiap order adalah paling tinggi berbanding persampelan lain. Ephemeroptera, Plecoptera dan Trichoptera (EPT) digunakan sebagai penunjuk biologikal. Jumlah tertinggi organisma ini menunjukkan kualiti air yang baik di anak sungai Taman Rekreasi Ranchan. EPT lebih dipengaruhi oleh halaju air, pengaliran air dan suhu air di anak sungai.

Kata Kunci: serangga akuatik, kualiti air, kelimpahan, penunjuk biologikal

1.0 INTRODUCTION

Aquatic insects can be commonly found in all types of aquatic habitat throughout the world. There are many different types of aquatic insects and nearly every type of freshwater environment will have some type of aquatic insects. In some period in their life, aquatic insects live on rocks, logs, sediment, debris and aquatic plants (Aweng *et al.*, 2012).

Aquatic insects are invertebrates that belong to the category of animals without backbones or arthropods. They are a critical part of the food web in streams and are easy to sample and identify (Kamsia *et al.*, 2007). Aquatic macroinvertebrate are aquatic insects that spend most of their life-cycle in the water. They are also called benthic macroinvertebrates which are larger than 0.5 millimeters. Macroinvertebrates are found in aquatic habitat such as rivers, ponds and streams around vegetation and also along with sediment in the bed of water bodies. Some larval forms of insects are macroinvertebrates (Kannoje *et al.*, 2012).

Freshwater aquatic insects live in rivers and stream beds, lakes and reservoirs and are connected with various types of substrates such as mineral sediments, detritus, macrophytes and filamentous algae. The distribution of aquatic organisms is the result of interactions among their ecological role and the physical conditions that characterize the habitat and food availability in the aquatic habitat (Payakka & Prommi, 2014). The dominance of aquatic insects is considered as important information that can influence the species diversity of a river. The collection of macroinvertebrate in most streams is highly diverse and many of the individual species may be absent in the sense that ecosystem functions can continue if they are absent (Derleth, 2003).

Benthic macroinvertebrates which are dislodged from the bottom of streams become part of the drift (Statzner *et al.*, 1985). Drift has been found to be caused and

influenced by a number of factors that are both abiotic and biotic. Drift which is the downstream transport of aquatic organisms in the current was first observed in the early part of the twentieth century. Large bodies of water with low water current velocities can act as catching basins for drifting organism (Giannico & Heider, 2001). Some main categories of drift include catastrophic drift, behavioural drift and constant drift. Catastrophic drift is more common in small flowing streams than in large flowing rivers. Behavioural drift involves animal behaviour in the river. Constant drift is defined as drift in low numbers due to accidental dislodgement flow of the substrate notwithstanding of any diurnal periodicity (Matzinger & Bass, 1995). Invertebrates suspended in water flows are part of the stream drift. Organisms such as mayfly families are common members of the drift while many other organisms that are smaller and larger seldom drift.

Rivers are dynamic systems that exist on earth (Foottit & Adler, 2009). Rivers have essential characters that can contribute to determine their biota and biological characteristics. This is the running waters from the upstream and downstream. The flowing water carries inorganic debris, organic matter and nutrients. There are a large variety of organisms in the running water of rivers such as microbes, fungi, insects and also fishes (Tanida, 2003). Streams are typically more turbulent than lakes.

Many freshwater invertebrate taxa are controlled to headwater streams and rivers by their unique environmental characteristics while fish and invertebrate diversity are greater in lotic than lentic habitat. Substrate type and size are of major importance for the survival of the most benthic invertebrate populations. Substrate provides sites for resting, food acquirement, reproduction and development and also prevention from attack by predators. The distribution and abundance of invertebrates are strongly influenced by physical and chemical habitat.

According to Chang (2002), the flow of a river is directly related to the amount of water moving off the watershed into the river channel. Flow is a function of water volume and velocity. It is important because of the impact on water quality and the living insects and habitats in the river. The biotic communities in upstream reduce food resources but produce nutrients and particulate organic matter which are a basic resource and food for downstream biota (Chapman, 1996). The diversity of insects found in upstream, middle stream and downstream is different (Tanida, 2003). Small streams vary widely in physical, chemical and biotic features and in providing habitat for a range of aquatic species (Suhaila & Che Salmah, 2011).

Water quality parameters are determined by macroinvertebrates in terms of pollution, because they function as a biological indicator. The concept of macroinvertebrate families are that they are very diverse and sensitive to pollution of a water body and may be suitable for assessment of uncleanness of water pollution (Kannoje *et al.,* 2012). Benthic macroinvertebrates are good indicators of watershed health because they live in the water for all or most of their life and are easy to collect, and differ in their tolerance to amount and types of pollution and habitat alteration (Aweng *et al.,* 2012).

The presence of a wide variety of environments, particularly in tropical rainforests, provides an enormous number of ecological niches. Habitat destruction however is causing the extinction of many aquatic insects (Mohd Rasdi *et al.,* 2012). Responses by macroinvertebrates to watershed impacts have been studied broadly and are commonly used as a measure of the intensity of watershed pollution, disturbances and also to evaluate the ecological reliability of stream systems (Svendsen *et al.,* 2004). Aquatic insects and other components of the aquatic biota have been used widely to evaluate the degree of anthropogenic disturbance to both lotic and lentic ecosystems (Wallace & Webster, 1996).

Some species of aquatic insects such as, Ephemeroptera, Plecoptera and Trichoptera (EPT) are very sensitive to pollution and live in high quality environment with good water quality. The absences of species that are sensitive to pollution provide a good sign of pollution. The existence of certain organisms in the water indicate the quality of water and provide an overall view about physical and chemical properties of the water (Mohd Rasdi *et al.*, 2012).

There are several factors that may affect streams negatively. The factor that probably causes the most intense effect is acidification. Acidification in a stream may cause the stream to lose up to 60% of its original number of species with possibly large consequences for the function of the stream (Jonsson, 2003). As a community, benthic macroinvertebrates demonstrate high diversity and abundance, and are highly sensitive response to environmental changes and have a restricted movement that reflects their habitat.

The occurrence of invertebrate drift in streams has received a considerable amount of scientific attention in the past three decades. But very few studies on invertebrate drift have been done on rivers in Sarawak where research on fishes and macroinvertebrates in Padawan Limestone by Grinang (2013) and study on macrofauna of Rajang River by Shabdin (2010). Only few studies have been conducted on the diversity and biological characteristics of aquatic insects in the rivers in Sarawak (Shabdin, 2010). Further, since there are no studies on invertebrate drift in small river in the Ranchan Recreational Park, the present study has been undertaken to identify the abundance of aquatic insects at a small river in the park.

The concept of biological indicators using aquatic insects is based on their diversity, abundance and distribution in relation to the physical condition of the habitat. The composition of EPT can determine the quality of the rivers. The field of aquatic insect

biology studies requires intensive work and investigation for getting the insects for estimation of the diversity of the insects, together with further biological studies in laboratory.

The main objectives of this study are.

1) To identify the population structure of aquatic insects from the rocky substrate of a small river in the Ranchan Recreational Park
2) To determine the relationship of aquatic insects with water quality parameters of the rocky substrate of a small river in Ranchan Recreational Park
3) To identify the drift pattern of the aquatic insects occurring in the drift of the rocky substrate of the small river in Ranchan Recreational Park

2.0 LITERATURE REVIEW

2.1 Ecology of Aquatic Insects

Aquatic insects are aquatic organisms without backbones that are larger than 0.5 millimetres. Aquatic insects usually live on rocks, sediment, debris and aquatic plants during some part of their life cycle (Aweng *et al.*, 2012). Aquatic insects can be found in almost all aquatic habitat including lakes, streams, pools, coastal waters, estuaries, hot spring and also peat swamp (Mohd Rasdi *et al.*, 2012). As these organisms live in the water, aquatic insects are highly dependent on the water quality for their survival (Water and Rivers Commission, 2001). Most studies on freshwater river and stream ecosystems usually examine the species in the river or stream with their habitat relationship than on the water quality of the river or stream (Wahizatul *et al.*, 2011). The warm and wet climate of Malaysia and Sarawak in particular provides an ideal environment for the life cycle of aquatic insects as they are commonly dependent on a moist habitat (Mohd Rasdi *et al.*, 2012).

Aquatic insects form an important part in the food chain of aquatic life. They can be categorised based on as their roles as functional feeding groups (Wallace & Webster, 1996). The four different functional feeding groups which aquatic insects can be classified into are shredders, collectors or filter feeders, scrapers and predators. Shredders feed on the organic material including leaves and woody material which they convert into finer particles. These include amphipods, isopods, freshwater crayfish and some Trichoptera (caddisfly) larvae (Water and Rivers Commission, 2001).

Collectors or filter feeders feed on the organic particles that have been produced by the shredders, microorganisms and by physical processes. They comprise Ephemeroptera (mayfly) nymph, mussels, water fleas, some fly larvae and worms. The scrapers graze on

algae and other organic matter which are attached to rocks and plants. They include are snails, limpets and Ephemeroptera larvae. Predators are organisms that can be found at the area where collectors and shredders are existed. Predators feed on live prey such as Odonata (dragonfly and damselfly) larvae, Coleoptera (adult beetles and beetle) larvae, midge larvae and stonefly larvae. The extinction of aquatic insects may give result in adverse effect to the whole population in the habitat as they act as an important food source for many invertebrates and also fish in the river (Mohd Rasdi *et al.*, 2012).

2.1.1 Diversity of Aquatic Insects

Aquatic insects are not only numerous but also divergent in taxonomic composition. They consist of the orders Ephemeroptera (mayflies), Odonata (damselflies and dragonflies), Plecoptera (stoneflies), Blattodea (cockroaches), Hemiptera (water bugs), Megaloptera (alderflies), Neuroptera (spongiflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), Lepidoptera (moths) and Diptera (midges). Eggs, larvae, pupae and adults of these insects spend time in water. All immature stages of Ephemeroptera, Odonata, Plecoptera, Trichoptera, Lepidoptera and Diptera usually live in water while only the larval stages of Megaloptera and Neuroptera live in water. In addition, the adults of Hemiptera and Coleoptera are found in water and on the surface of water (Yule & Yong. 2004).

Ephemeroptera (mayflies) occur widely in lotic and lentic habitats. Odonata (dragonflies and damselflies) are widely distributed and abundant in almost all permanent fresh and brackish water. They are mainly abundant in warmer waters such as those in lowlands of tropical and subtropical regions. Stoneflies are distributed globally which is mainly in cold mountain streams. As stated by Fottit & Adler (2009), Coleoptera (beetles) can be found in in a wide range of lentic and lotic habitats but some species of beetles are

found only in marine intertidal habitat. All Trichoptera (caddisflies) are aquatic insects with eggs, larvae, and pupae occurring in a wide variety of freshwater habitats and adults flying nearby terrestrial habitats. All Diptera (midges) require moist environment to live, such as coastal marine and brackish waters and brine pools (Fottit & Adler, 2009).

2.1.2 Aquatic Insects as Biological indicators

Biomonitoring also known as biological monitoring can be defined as the systematic use of biological responses to evaluate the changes that happen due to anthropogenic sources in the environment with the intention to use water quality information in a quality control program (Mathews *et al.,* 1982). According to Wahizatul *et al* (2011), the concept of biological indicators by using aquatic insects such as Ephemeroptera, Plecoptera and Trichoptera determines the diversity, abundance and distribution of the aquatic insects in relation to the physical and chemical conditions of the habitat. The baseline data provided by the indicator organisms can be used to estimate the level of environmental impact and its risk for the living organisms (Wahizatul *et al.,* 2011).

Indicator species are those taxa that are found to be sensitive to specific environmental factors. Changes in their abundance will reflect the environmental changes that occur (Wahizatul *et al.,* 2011). The existence of some organisms in the water indicates the quality of the water and provides an overall assessment about the physical and chemical properties of the water (Mohd Rasdi *et al.,* 2012). Aquatic insects are often used as indicators on the effect of human activity on water system and provide information on habitat and water quality (Payakka & Prommi, 2014).

Pollution has been defined as the changes that occur in the physical, chemical and biological characteristics of water, air or soil that can affect the health and activities of

living organisms (Mohd Rasdi et al., 2012). Traditionally, chemical analyses were used to monitor the water pollution where water samples were taken at certain points and analysed for some suspected chemical pollutants. Pollution is best recognized in living organisms. According to Mohd Rasdi *et al* (2012), scientist in many countries especially developed countries, have been using macroinvertebrates communities in freshwater including insects as an alternative method to monitor the water biologically.

The freshwater seems to respond more meaningfully to the effect of the biologically relevant substances. Biomonitoring efforts that use aquatic insects and other macroinvertebrates have a number of benefits and they are good indicator of localized condition unlike fish where they do not migrate significantly. Some species of aquatic insects such as Ephemeroptera, Plecoptera and Trichoptera are very sensitive to pollution and live in high quality environment with good water quality and thus they are used as bioindicators. Pollution tolerant organisms that can adapt to poor water quality are Odonata and Diptera (Mohd Rasdi *et al.*, 2012).

2.2 Classification of Aquatic Insect Drift

Drift can acts as a primary source of recolonizing organisms in aquatic habitat. Williams and Hynes (1976) defined colonization as the invasion of species into disturbed and newly created habitats. Drift has been observed to be a main source of recolonizing organisms. Drift loss can happen when the stream flow is directed into a lake or large pool. Drift has been found to be affected and influenced by abiotic and biotic factors (Nowinszky *et al.*, 2012). Large areas of water with low velocity of current can act as catching basins for drifting organism. Drifting insects are often a very important source of food supply for certain fish taxa (Gray, 2003.). Aquatic insects show different distributions

in spatial and temporal scale that vary in accordance with the morphology and environmental conditions including physical and chemical conditions. Drift is important to stream systems in the recolonization, mainly as a food source for visual predators.

2.2.1 Classes of Drift

Drift can be divided into three classes which are catastrophic drift, constant or natural drift and behavioural drift. Catastrophic drift occur due to unusual physical disturbance to the environment such as flooding (Pearson & Franklin, 1968). Catastrophic drift are usually influenced by abiotic factors. These factors create an unfavourable habitat for some order of insects and it may result in drifting of invertebrates without choice. The insects must move simply as it may affect their survival. These include high discharge or drought, ice, pesticides, oil spills and poor water quality. These factors can be an unfavourable habitat for the insects and it may contribute to the death of the organisms. Human activities can change the normal development of these fragile ecosystems (Wahizatul *et al.*, 2011). The small changes in the environment will have significant effect on the community and it can be useful to measure the degree of pollution (Eh Rak *et al.*, 2010). Discharge is one of the main factors which affect the degree of invertebrate drift. Catastrophic drift is also considered as passive drift which results from sudden increases in velocity of the water current and water discharge of the stream.

Behavioural drift is considered as an active drift. Active entry into the water current is seen to be a mechanism to avoid predators, competitors or overloaded condition while it also can be said that the insects are moving into a better habitat or food source (Saltveit *et al.*, 2001). Behavioural drift has received most attention in ecological studies as it is thought to be the result of some diel behavioural pattern of the individuals in the stream

(Schreiber, 1995). Behavioural drift is also influenced by light intensity in several organisms (Pearson & Franklin, 1968). Taxa which occur in active drift are Ephemeroptera, Plecoptera, Trichoptera, Diptera and Amphipoda (Gray, 2003.).

Constant drift is natural drift that occurs due to ordinary accidental dislodgement of individuals which is losing contact with the substrate and entering the drift. There are several biotic factors which influence constant drift of invertebrates. Constant drift is not generally taxa specific. Biotic factor such as competition for food resources, piscine predator avoidance, invertebrate predator avoidance and dispersal affect constant drift (Gray, 2003.).

2.2.2 Factors influencing Aquatic Insect Drift

2.2.2.1 Abiotic Factor

The abiotic factors that affect macroinvertebrates population are current speed, temperature and substratum, level of oxygen, salinity, hardness and general water chemistry. Many invertebrates need current as they rely on it for feeding purposes and for respiration. Temperature tolerances for aquatic insects are varied according to their order. Substratum is also a main contribution of abiotic factor as certain species live in different types of substratum. Level of oxygen can also become a factor in polluted river and streams (Chapman, 1996).

The distribution and diversity of aquatic insects in a river are influenced by physical factors such as oxygen, temperature and light (Mohd Rasdi *et al.*, 2012). Oxygen is one of the most important factors for water quality and associated aquatic life. Oxygen is required by all aerobic organisms for respiration. Water temperature influences the rate of