DETERMINATION OF CONDITION FACTOR (CF) AND HEPATOSOMATIC INDEX (HSI) OF *BARBONYMUS SCHWANENFELDII* FROM THE SUNGAI GALAS, DABONG, KELANTAN

by

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DECLARATION

I hereby declare that the thesis of this final year project entitled "Determination of Condition Factor (CF) and Hepatosomatic Index (HSI) of *Barbonymus schwanenfeldii* from the Sungai Galas, Dabong, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________________

Name : ____

Date :____

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

E	East
FAO	Food and Agriculture Organization
HSI	Hepatosomatic index
K	Condition factor
L	Total length
N	North
W	Body weight
WHO	World Health Organization

LIST OF SYMBOL

=	Equality
×	Multiplication
—	Division / fraction
±	Both plus and minus operations
%	Percentage
ºC	Temperature (degree Celsius)
º	Degree
cm	Centimeter
g	Gram
km^2	Square kilometer

Determination of Condition Factor (CF) and Hepatosomatic Index (HSI) of *Barbonymus schwanenfeldii* from the Sungai Galas, Dabong, Kelantan

ABSTRACT

The purpose of this study is to determine the condition factor and hepatosomatic index of freshwater fish from the Sungai Galas, Dabong. The study also aims to assess the knowledge on fish health issues among local communities. The freshwater fish chosen is tinfoil barb (*Barbonymus schwanenfeldii)* of variable sizes ranging from 319.04 - 455.83 g in weight and 28.1 – 35.7 cm in total length which purchased from the different local fishermen of Sungai Galas, Dabong. The condition factor and hepatosomatic index of *Barbonymus schwanenfeldii* in the Sungai Galas was studied for a period of three months (July-September 2016). From a sample size of 20 specimens, the average K value was 1.15 ± 0.21 and the average of HSI value was 2.32 ± 0.13, indicating that the fish species was in poor condition. The heavy metal accumulation could be contributed to the poor condition of fish species where the high concentration of heavy metals can decelerate the growth and development of fish, particularly the developmental stages that resulting in possible changes in fish size. Other than that, majority of the local communities have limited knowledge on fish health issues due to the limited of accessible advisory information and lack of health information exposure.

Penentuan Faktor Keadaan dan Indeks Hepatosomatik bagi *Barbonymus schwanenfeldii* dari Sungai Galas, Dabong, Kelantan

ABSTRAK

Tujuan kajian ini adalah untuk menentukan faktor keadaan dan indeks hepatosomatik bagi ikan air tawar dari Sungai Galas, Dabong. Kajian ini juga bertujuan untuk meniai pengetahuan tentang isu-isu kesihatan ikan di kalangan masyarakat setempat. Ikan air tawar yang telah dipilih ialah ikan lampam sungai *(Barbonymus schwanenfeldii)* yang terdiri daripada pelbagai saiz antara 319.04 – 455.83 g bagi berat dan 28.1 – 35.7 cm bagi jumlah panjang yang telah dibeli daripada nelayan tempatan Sungai Galas, Dabong yang berlainan. Faktor keadaan dan indeks hepatosomatik bagi *Barbonymus schwanenfeldii* di Sungai Galas telah dikaji dalam tempoh tiga bulan (Julai-September 2016). Dari 20 sampel spesimen, purata nilai K ialah 1.15 ± 0.21 dan purata nilai HSI ialah 2.32 ± 0.13, menunjukkan bahawa spesies ikan berada dalam keadaan tidak baik. Pengumpulan logam berat mungkin menyumbang kepada keadaan spesies ikan yang tidak baik dimana kepekatan logam berat yang tinggi boleh memperlahankan pertumbuhan dan kematangan ikan, terutamanya peringkat kematangan yang menyebabkan kemungkinan perubahan dalam saiz ikan. Selain itu, majoriti masyarakat setempat mempunyai pengetahuan yang terhad mengenai isu-isu kesihatan ikan kerana pengaksesan maklumat yang terhad dan kekurangan pendedahan maklumat kesihatan.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Heavy metals exist in the aquatic environment deriving from both natural and anthropogenic sources (Asmah & Biney, 2014). They are the most main pollutants in aquatic network due to their high toxicity, ease of accumulation and very persistent in both aquatic environment and organisms as well (Afshan *et al.*, 2014). Heavy metals tend to accumulate in advanced organisms and exhibit increase concentrations through the food chain (Shumka *et al.*, 2014). So, they may cause serious health risk to human when the contamination contents and exposure are significant. Among aquatic organisms, fish generally has capability of accumulating high levels of contaminants in its body (Alina *et al.*, 2012). Therefore, since many fish species are consumed as food by a large section of population, the health condition of fish is a crucial matter of concern.

Other than that, due to a raising concern about the health benefits and risks of food consumption, the investigation of both essential and non-essential metal contents in foodstuffs has been approached in recent decades (Gue'rin *et al.*, 2011). Some heavy metals such as chromium, copper, iron, iodine, manganese and zinc are essential metals required in small quantities since they play an important role in biological systems of living organisms, whereas other heavy metals such as mercury, cadmium and lead are non-essential metals, as they are toxic which could be detrimental to the health of the organisms (Hussein & Khaled, 2014). However, the essential metals also can become toxic at high concentration (Alturiqi & Albedair, 2012). So, it is crucial for human for keeping intakes of chemical contaminants within safe levels in diet in order to ensure no risk to the health of human from the compounds (Chase, 2015). Thus, the need for early detection and assessment of the adverse effects of contaminants on aquatic organisms with a view to ensuring a healthy environment has required the use of biomarkers in environmental monitoring programmes. Biomarkers can be explained as functional measures of exposure to chemical and physical pollutants at the sub-organism, physiological and behavioral level which enclose molecular, cellular, genetic, immunological and physiological measures (Valavanidis & Vlachogianni, 2010). Hence, as the biomarkers provide evidence of exposure or effects from pollutants (Nkwoji *et al.*, 2014), they have become early diagnostic tools to measure the biological effect of pollutants and assess the aquatic organisms' condition.

In this study, the condition factor and hepatosomatic index of commonly freshwater fish were determined in order to acquire information on the general health condition of the freshwater fish. Condition factor is defined as the well-being of fish (Keyombe *et al.,* 2015). It is one of the most important biological parameters that provides information on fish condition and growth level as well as gives insight into the health of fish (Manorama & Ramanujam, 2014). In addition, condition factor also can be used as an index to assess the status of the aquatic ecosystem in which fish lives (Manorama & Ramanujam, 2014). Meanwhile, hepatosomatic index normally used in fisheries science as a biomarker for examining fish exposed to environmental toxicants (Kumari *et al.*, 2014). So, the condition of the liver and whole body of fish as measured with the hepatosomatic index can give information about the health of fish and a good indicator of fish habitat as well as pollution levels (Lenhardt *et al.*, 2009). Thus, the study of condition factor and hepatosomatic index of the freshwater fish is important for human health risk because it determined the food safety for consumption.

1.2 Problem Statement

It is a known fact that fish provides source of protein for communities throughout the world (Rohasliney *et al.*, 2015). However, communities purchased fishes from supermarkets and neighborhood fish markets may not know the more specific information about their origin and health condition level. The fish information does not always include the safety and health information (Schmitt, 2011). In addition, nowadays, the problem of increasing heavy metal pollutants emission into the aquatic ecosystem has further been aggravated by the rapid progress of aquaculture, agriculture and industrial development activities (Krishna *et al.*, 2014). This is because the activities have resulted in production and usage of toxic chemicals which leading to high rate of heavy metals accumulation in both aquatic environment and organisms.

The heavy metals could be transferred to human body by entering the food chain (Baby *et al.*, 2010). If human consume foods with the high rate of heavy metals contamination, it might not bring any harm directly but it might lead to serious harm to the human health in period of long-term exposure. For instance, heavy metal cadmium, chromium and manganese are among the metals that cause serious health effect in long-term exposure period such as failure in reproduction and fertility, damage to immune system, neurodegenerative disorder and cancer (Afshan *et al.*, 2014). Hence, due to the essence of the heavy metal and its presence that could be detrimental to the health of the organism, it is necessary to determine the health condition of fish in order to avoid the possible health risk to human being by using biomarkers such as condition factor and hepatosomatic index.

The body condition indexes are applied to assist in describing the health and well-being of animal species as well as defining the influence of factors such as environmental degradation and ecological interaction on animal health (Stevenson & Woods, 2006). Condition factor can be accomplished by the use of morphometric data which when combined in an index, provides information on well-being of fish. Even though the condition factor does not give information on specific responses to toxic substances in the environment (Linde-Arias *et al.,* 2008), it can be estimated for comparative purposes to assess the impact of environmental alterations to fish performance (Barton *et al.,* 2002). On the other hand, hepatosomatic index can be accomplished by the use of organosomatic data which when combined in an index, provides information on potential pollution impacts on fish based on the condition of the liver, as the liver is a target for the metabolism in the fish body (Pait & Nelson, 2003). Thus, in this multi-biomarker approach, which consist of the combined use of different biomarkers can both specify exposure to heavy metal contaminants as the quantification of their effects on the health of fish instead provide the fish safety and health information.

1.3 Objectives

There are two objectives:

- To determine the condition factor and hepatosomatic index of freshwater fish from the Sungai Galas, Dabong.
- To assess the knowledge on fish health issues among local communities.

1.4 Significance of the Study

Rapid moving industrialization and economic development in Malaysia has led to polluted rivers where the heavy metals are immobile in the environment and often considered to be conservative pollutants, thus causing potential threat to ecosystems (Amirah *et al.*, 2013). The pollutants may be directly or indirectly toxic to the aquatic flora and fauna (Yujun *et al.*, 2011). So, through direct consumption of water or organisms as well as be potentially accumulated in edible fish, the pollutants can enter the food chain and transfer to human body (Paquin *et al.*, 2003). In addition, currently, fish is considered as one of the main foods to humans and is used in variation of diets which is as a good source of digestible protein, vitamins, minerals and polyunsaturated fatty acids (Carvalho *et al.*, 2005) that sustain healthy living (Ikem & Egiebor, 2005). However, the consumption of fish that contain high intake rate of heavy metals can cause serious health hazard due to the heavy metal accumulation in the human body (Muzyed, 2011).

Thus, as fishes also offer several specific advantages in describing the natural characteristics of aquatic systems and in assessing changes to habitats (Lamas *et al.*, 2007), they are considered to be the most significant bio-indicator in aquatic systems for the estimation of metal pollution level (Authman, 2008). Hence, the study of the condition factor and hepatosomatic index of freshwater fish is significant to the local population in particular, as qualitative information on the freshwater fish consumed by them as well as the aquatic system. In fact, in order to take appropriate curative measures to prevent health risk to the local population, determining the condition factor and hepatosomatic index of freshwater fish also plays a vital role as a primitive warning of heavy metal pollution. Besides that, the knowledge on fish health issues among local communities which is also assessed in this study through participatory interview is significant to the development and implementation of public health programmes in order to promote lifelong healthy eating.

CHAPTER 2

LITERATURE REVIEW

2.1 Fish Species in Research Study

The need for food supply has been increased due to the growing human population. Consumption of fish has been acknowledged as good protein source for human which becomes a crucial part of a well-balanced diet. As evidence, people consumed about 25% of their animal protein from fish in the worldwide (Muzyed, 2011). Thus, as valuable source of protein, the demand for consumption of fish products has increased (Muzyed, 2011). In fact, it also plays essential role in human health as it contains vitamins and minerals. For instance, the importance of consumption of fishes in human diet is that fishes contain omega-3 polyunsaturated fatty acids which is very necessary for human health as well as normal growth, where they may reduce cholesterol levels, inflammation as well as the risk of heart disease, cancer, arthritis and preterm delivery besides of contain high-quality protein (Steven, 2015).

However, aquatic organisms such as fish which is usually at the higher level of the aquatic food chain may accumulate large concentration of heavy metals from food, water and sediments in its soft and hard tissues (El-Moselhy *et al.*, 2014). The heavy metals access to their bodies by three potential ways which are by gills, body surface and digestive track (Afshan *et al.*, 2014). In fact, many factors can influence heavy metal uptake by fish like sex, age, size, reproductive cycle, swimming patterns, feeding behavior and living environment (Zhou *et al.*, 2012). So, due to that reason, fish is also consumed as bio-indicator of metal pollution (Deb *et al.,* 2015). The health condition of fish can clearly describe the pollution status of the aquatic environment in which it lives. Besides that, as fish normally locate at the top of the aquatic food chain, the heavy metals also can pass to human (El-Moselhy *et al.,* 2014). The heavy metals are not destroyed in human body as well like in other organisms. So, the consumption of fish that contain high level of heavy metals can threat human health due to their accumulation in the human body (Muzyed, 2011). Thus, determining fish health condition acts as a primitive warning of heavy metal contamination and enables us to take appropriate curative measures to prevent health risk to human being.

2.1.1 Freshwater Fish Species: *Barbonymus schwanenfeldii*

Barbonymus schwanenfeldii (Bleeker, 1853) (Figure 2.1) is a ray-finned fish genus, which is classified under the family of Cyprinidae and order of Cypriniformes (Mansor *et al.,* 2012). This species also has the same meaning with *Barbus schwanenfeldii* or *Puntius schwanenfeldii*. The common name of *Barbonymus schwanenfeldii* is called as Red Tail Tinfoil Barb and locally known as “Lampam Sungai” (Clarice, 2015). This species is enormously distributed throughout Southeast Asia including the countries Cambodia, Laos, Thailand, Vietnam, Singapore, Indonesia, Brunei Darussalam and Malaysia. *Barbonymus schwanenfeldii* inhabits large waterways including rivers, streams, canals, and ditches which prefers temperature of 22.2 ºC to 25.0 ºC (David & Clarice, 2015). This species spends most of their time between the bottom and the mid-level of the waterways. This species is also fast breeding fish which is three times per year (Gante *et* *al.*, 2008) and have a lifespan of 8 to 10 years (David & Clarice, 2015). So, *Barbonymus schwanenfeldii* is selected in this study because of its wide availability in local freshwater areas and commonly consumed by local communities.

Barbonymus schwanenfeldii is a schooling species with the average fish weight about 200 g – 600 g and length size between 10 cm and 25 cm (Mansor *et al.*, 2012). This species is also can reach a size of up to 35 cm in length which has an adult size of about 20 cm (David & Clarice, 2015). As presented in Figure 2.1, natural scales colour of *Barbonymus schwanenfeldii* is usually silvery with reflective scales that give it a tinfoil effect (David & Clarice, 2015). This species has a highly compressed body, large eyes and the small head with a pointed snout (Gante *et al.*, 2008). Distinguished from other species of the genus, this species has a red dorsal fin with a black blotch at the tip, reddish orange pectoral fin, red pelvic and anal fins, and reddish orange caudal fin with white margin and a black submarginal stripe along each lobe (David & Clarice, 2015). *Barbonymus schwanenfeldii* has omnivorous and detritivorous habit which feeds on plant matters such as leaves, weeds and filamentous algae, small fishes, insects and debris (Mansor *et al.*, 2012).

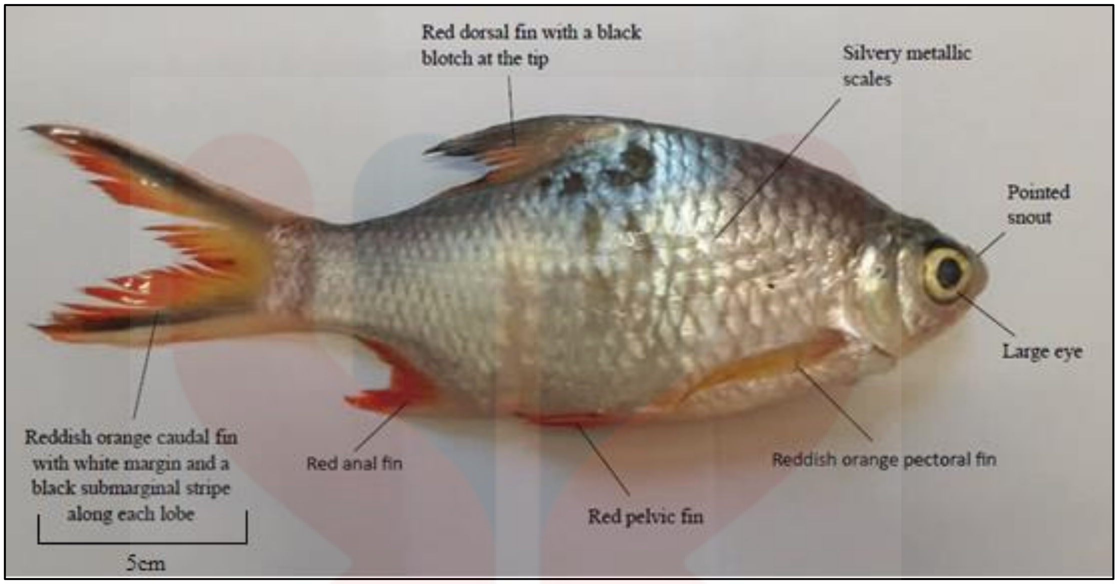

Figure 2.1: *Barbonymus schwanenfeldii*

2.2 Toxicity of Heavy Metals to Human Health

Toxicity of heavy metals has been defined as the toxic effect of certain heavy metals in certain forms and doses on life. In general, the heavy metals are the metals which have a specific density of more than 5 g/cm³ and adversely influence the environment and living organisms (Jaishankar *et al.,* 2014). They are the most main pollutants in aquatic network due to their high toxicity and ease of bioaccumulation by aquatic organisms (Afshan *et al.,* 2014). The heavy metals in the aquatic environment are deriving from both natural and anthropogenic sources (Asmah & Biney, 2014). They are present in aquatic environment as a result of the geological weathering of soils and rocks, and from a variety of human activities involving the mining and industrial effluents, application of pesticides and inorganic fertilizers, domestic waste discharges, leachates from waste dumps and processing or use of metals or substances that contain metal pollutants.

All forms of the heavy metals in aquatic environment may be taken by aquatic organisms and accumulate in various concentrations in the tissues and organs of organisms (Anna *et al.*, 2011). Then, they ultimately enter the aquatic food chains. They are actually crucial to maintain various biochemical and physiological functions in living organisms when in very low concentration, but they become toxic when they exceed certain threshold concentrations (Asmah & Biney, 2014). Thus, when the aquatic organisms such as fishes have been eaten by human, the heavy metals can cause serious harm to human health when the contamination content is significant in which the toxic heavy metals can emulate the action of an essential element in the body, then interfering with the metabolic process to cause illness.

So, even though it is a known fact that aquatic organisms such as fishes play essential role in human health as they contains vitamins, minerals and high-quality protein, but the content of toxic heavy metals in the aquatic organisms can defeat their beneficial effects and cause adverse effects to human health (El-Moselhy *et al.*, 2014). For instance, the toxicity of heavy metal can minimize energy levels and destruct the functioning of the brain, lungs, kidney, liver, blood composition and other crucial organs. In fact, long-term exposure can induce to gradually progressing physical, muscular, and neurological disorder that emulate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy (Jaishankar *et al.*, 2014). Repeated long-term exposure of some metals and their compounds also may even lead to cancer and death (Jaishankar *et al.*, 2014).

2.3 Condition Factor of Fish

The condition factor of fish is a biological parameter which presents information on fish species condition (Ndiaye *et al.,* 2015). In another words, it has been acknowledged as a quantitative parameter of the state of fish well-being. The most widely used in fisheries and fish biology studies is Fulton's condition factor (Manorama & Ramanujam, 2014). This factor is calculated from the relationship between the weight of a fish and its length in order to describe the condition of the individual fish (Muzzalifah *et al.,* 2015). The relationship between body length and weight of fish presents great significance in fisheries biology because size is normally more biologically relevant than age, mainly due to the several ecological and physiological factors which are more size-dependent than age-dependent (Ndome *et al.,* 2012).

The fish species has attained a better condition when the condition factor value is higher (Nehemia *et al.,* 2012). Based on Fulton's condition factor, fish with condition factor value which obtains 1.2 or above means the fish condition is good and unlikely to experienced adverse effect meanwhile if below 1.2 means the fish condition is poor and experience adverse effect (Barnham & Baxter, 1998). In addition, the data on length and weight also can provide important clues on climate and environmental changes, as well as the change in human subsistence practices (Ndiaye *et al.*, 2015). So, the fish condition factor can describe the state of the aquatic ecosystem in which the fish exists in better condition when the condition factor value is higher as it is strongly affected by both biotic and abiotic environmental conditions (Manorama & Ramanujam, 2014). Hence, the measure of fish condition factor enables us to assess fish health status, environmental conditions as well as natural and anthropogenic influences on the fish species.

2.4 Hepatosomatic Index of Fish

Hepatosomatic index is associated with liver energetic reserves and metabolic activity of the fish (Lenhardt *et al.*, 2009). It is normally used in fisheries science as a biomarker for examining fish exposed to environmental toxicants by calculated from the relationship between the weight of fish liver and its body weight (Kumari *et al.*, 2014). As the liver is a target for the metabolism in the fish body as well as the role of liver in detoxification of pollutants, the hepatosomatic index is used as a functional biomarker to detect the hazardous effects of the environmental stressors (Pait & Nelson, 2003). Thus, the hepatosomatic index which expresses the general condition of liver and whole body of fish species can be useful as an indicator of the level of exposure to the bio-available contaminants instead determining the health condition of fish species (Nkwoji *et al.*, 2014). Although this parameter is not very sensitive, the hepatosomatic index still can perform as an initial screening biomarker to indicate exposure and effects of contaminants on aquatic organisms (Van der Oost *et al.*, 2003). Therefore, the use of hepatosomatic index is required in this study for early detection and assessment of the adverse effects of contaminants on fishes with a view to determining whether the fishes are in good condition.

2.5 Participatory Interview

Participatory interview is a qualitative research methodology that requires more understanding and consideration where the qualitative research methods focus on the whole of human experience and knowledge (MacDonald, 2012). It can be variously described as a dynamic educative process, an approach to take action to address a problem and a theoretical approach to social investigation by engage inquiry form and collect data regarding human experiences or knowledges (MacDonald, 2012). So, participatory interview goes beyond a typical interview by seeking the participant into a creative process which provides stimuli that grounds the participant in their current experience or knowledge (Bethany, 2012). In another words, it is a face-to-face communication in which through direct questioning, the researcher attempts to obtain information from the participants. Thus, in research study, participatory interview requires a great willingness on the part of participants to disclose their personal knowledge, opinions and experiences of the circumstances.

Other than that, one of the advantages of participatory interview is strongly value orientated which seeking to address issues of significance concerning the rapidly developing of human (MacDonald, 2012). Besides that, the process of participatory interview helps to encourage individuals' capacity development for being active participants in meaningful research (Cathy, 2012). Participatory interview also can benefit both the participants and the research, which can democratize the research process while mitigating the potential for the misrepresentation through direct questioning (Salmon, 2007). Hence, participatory interview which seeks the people views is crucial method for the process of awareness and knowledge production because it enables us to discover the new aspects of perspective.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

Sungai Galas is one of the channel rivers of the Sungai Kelantan which is formed by the junction of Sungai Nenggiri and Sungai Pergau with 3970 km² of total catchment area and 7770 km² of total area (Baharoma & Ishak, 2015) (Figure 3.1). The geographical coordinates of Sungai Galas is 4°52'22.56" N and 101°57'20.4" E (Baharoma & Ishak, 2015). There are several fishing villages along the Sungai Galas. So, Sungai Galas has been commonly used for transport, irrigation, recreation and fisheries (Rohasliney *et al.*, 2015). Thus, the ecological integrity of this river has been severely altered to suit the anthropogenic activities, resulting in fragmentation and flow regulation, channel modifications, and discharge of heavy metals into the river (Tan & Rohasliney, 2013).

Figure 3.1: The map of sampling site showing Sungai Galas (Source: Google Map, 2016)

3.2 Sample Collection

The slaughtered freshwater fish namely tinfoil barb (*Barbonymus schwanenfeldii)* was purchased from the local fishermen of Sungai Galas, Dabong. After carried out observation in randomly at Kampung Dabong which is one of the fishing villages along the Sungai Galas as sampling station, *Barbonymus schwanenfeldii* has been chosen in this study as this fish species has wide availability in Sungai Galas and the most commonly consumed by local communities. Randomly, 40% of local communities selected *Barbonymus schwanenfeldii* as their favourite freshwater fish. The fish identification was determined according to taxonomic keys by Leo *et al.* (2016) where the taxonomic keys are useful tools used to identify the known name of an organism by using a sequence of alternative choices.

After the fish samples were collected, the total length (cm) and total weight (g) were measured in situ for each fish samples. The length was measured from the tip of snout to the tip of the caudal fin (Nehemia *et al.*, 2012). Meanwhile, the fish samples were mopped by a filter paper before they were weighed to remove excess water from their body in order to ensure accuracy (Nehemia *et al.*, 2012). These measurements are needed for condition factor which show the degree of well-being of the fish in its habitat. Then, the fish samples that have been collected were wrapped individually in the low density polyethylene sampling bag and put in the ice box to sustain their freshness. The samples were brought immediately to the laboratory for further analysis process. There were twenty samples of the slaughtered *Barbonymus schwanenfeldii* which purchased randomly from different local fishermen at different day in order to get representative reading data as well as reduce bias. The fish sampling was done once in a month for a period of three months (July to September 2016).

3.3 Data Analysis

For the determination of condition factor, length and weight of individual fish were measured in situ and recorded (Keyombe *et al.*, 2015). The total length which is from the tip of snout to the tip of the caudal fin (Figure 3.2) of each fish was measured using a meter rule calibrated in centimeters. Fish was measured to the nearest centimeters. The fish weight was then measured after blotted dry with a piece of filter paper to remove excess water from their body in order to ensure accuracy. Weight of each fish was measured using the Kern EMB600-2 weighing balance to the nearest gram. The condition factor (K) value was calculated using the formula (3.1) by Fulcon (1902) as recommended by Manorama and Ramunajam (2014).

$$K = \frac{W \times 100}{L^3} \qquad (3.1)$$

Where W is the body weight of fish in gram and L is the total length in centimeters. The cube of the length is used because growth in weight of fish is proportional to growth in volume (Barnham & Baxter, 1998). Condition factor is used for comparing the condition or well-being of fish. Therefore, fish with K value which obtains 1.2 or above means the fish condition is good and unlikely to experienced adverse effect meanwhile if below 1.2 means the fish condition is poor and experience adverse effect (Barnham & Baxter, 1998).

On the other hand, for the determination of hepatosomatic index, the liver weight and total body weight of individual fish were measured and recorded (Lenhardt *et al.*, 2009). After weighing the total body weight, fish were dissected to remove its liver by using stainless steel dissecting kits. Moisture of the liver was removed with the help of filter paper and then weight of liver was recorded in grams by Kern EMB600-2 weighing balance. The hepatosomatic index (HSI) value of the fish was determined by the use of formula (3.2) cited by Htun-hun (1978) as recommended by Kingdom and Allison (2011).

$$\mathrm{HSI} = \frac{\text{Liver weight} \times 100}{\text{Body weight}} \qquad (3.2)$$

The HSI value gives an idea about the condition of the liver of the fish and body as well as about the impact of water pollution on it. So, increase in HSI value can indicate an increased metabolism capacity of fish liver in the presence of environmental toxicants exposure (Kumari *et al.*, 2014).

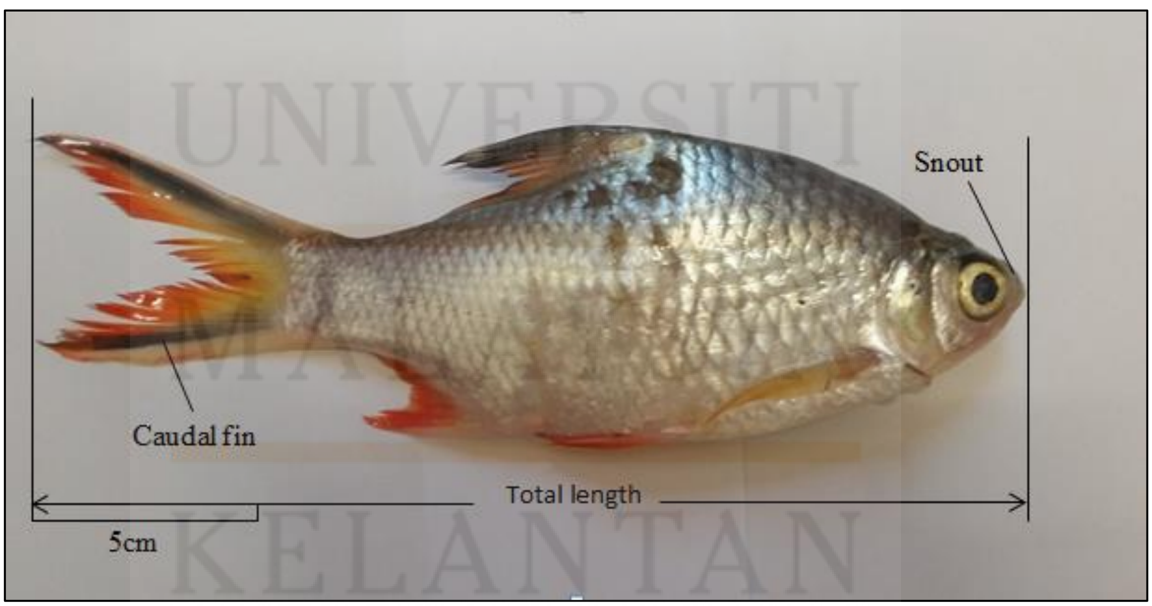

Figure 3.2: The measurement of fish total length

3.4 Participatory Interview

The participatory interview was conducted at Kampung Dabong which is one of the fishing villages along the Sungai Galas as sampling station. It was carried out in August 2016 for the first interview session and completed the last interview session during September 2016 site visit which aimed to assess the knowledge on fish health issues among local communities. The total number of correspondents in the participatory interview was 150 people which is 6% of the local population. These correspondents have been chosen randomly in each territory of Kampung Dabong which are Kampung Dabong Hulu, Kampung Dabong Tengah, Kampung Dabong Hilir and Kampung 38. Thus, these research correspondents will be better representative of the larger community group at Kampong Dabong.

The participatory interview in this study was conducted through direct questioning the correspondents after informed them on the purpose of the interview as well as what they considered important and relevant for this research study to concern. Therefore, by face-to-face interview through direct questioning, it offered the richest data in terms of body language as well as mitigated the potential for the misrepresentation. The questionnaire form contained only three questions in order to reach large numbers of correspondents more easily in residential area particularly:

1. Are you aware about the issue of the safety and health of fish that have been sold?
2. Do you know that the fish which have been contaminated can affect your health?
3. Do you ever have been exposed to heavy metal standard permissible limit which has been justified by national food acts and regulations?

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Condition Factor of Fish

The condition factors of body length and weight of *Barbonymus schwanenfeldii* from the Sungai Galas are showed in Table 4.1. As presented in Table 4.1, from a sample size of 20 fish samples, the average results obtained on the condition factor (K value) is 1.15 ± 0.21. The average of K value obtained for *Barbonymus schwanenfeldii* from the Sungai Galas is below than 1.2 which suggests that the fish species is in poor condition (Barnham & Baxter, 1998). This poor condition might be due to the elevated amount of heavy metals accumulation in the fish body. Normally, heavy metals occur in low concentrations at the nanogram to microgram per liter level in natural aquatic ecosystems (Abdel-Baki *et al.*, 2011). However, in recent times, this situation has arisen likely consequence of the rapid growth of population, increased urbanization, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices, as well as the expansion of recreation and fisheries activities (Gebremedhin & Berhanu, 2015). Thus, the high occurrence of heavy metals in aquatic ecosystems can affect the bioaccumulation of heavy metals in aquatic organisms, resulting in potential high concentration of heavy metals in fish body.

Table 4.1: Biometric parameters of *Barbonymus schwanenfeldii* from Sungai Galas.

No. of samples	Body length (cm)	Body weight (g)	Liver weight (g)	Condition factor (K)	Hepatosomatic index (HSI)
1	35.1	350.01	8.40	0.81	2.40
2	34.4	450.22	9.49	1.11	2.11
3	35.7	455.61	9.86	1.00	2.16
4	35.7	395.67	9.31	0.87	2.35
5	35.2	455.83	9.88	1.05	2.17
6	34.4	354.13	8.33	0.87	2.35
7	34.5	335.36	8.24	0.82	2.46
8	30.7	355.04	8.76	1.23	2.47
9	28.9	323.79	8.07	1.34	2.49
10	35.1	455.00	9.77	1.05	2.15
11	28.3	324.19	7.37	1.43	2.27
12	29.5	325.55	8.14	1.27	2.50
13	28.7	319.59	7.34	1.35	2.30
14	34.9	450.30	9.61	1.06	2.13
15	25.1	208.88	5.11	1.32	2.45
16	34.3	455.80	9.79	1.13	2.15
17	28.6	323.51	7.30	1.38	2.26
18	25.9	208.97	5.01	1.20	2.40
19	28.9	324.27	7.86	1.34	2.42
20	28.1	319.04	7.66	1.44	2.40
Mean (± S.D)	**31.6 ± 3.62**	**359.54 ± 76.16**	**8.27 ± 1.42**	**1.15 ± 0.21**	**2.32 ± 0.13**

Mean ± S.D., *n* = 20

This assumption is supported well by many field studies of metal accumulation in fish living in polluted waters which showed that considerable amounts of various heavy metals deposited in fish tissues. One of the examples of the studies is the study on determination of heavy metal levels in fishes from the lower reach of the Sungai Kelantan, conducted by Rohasliney *et al.*, (2014). This previous study determined that the fish species caught in the Sungai Kelantan were contaminated with non-essential heavy metals (cadmium and lead). For instance, in this previous study, the mean concentration of cadmium in *Chitala chitala* (0.076 mg/kg) was above the critical limit values of the World Health Organization (WHO) and Food and Agriculture Organization (FAO). The mean concentrations of cadmium in *Barbonymus gonionatus* and *Tachysurus maculatus* were also already at the level of concern, whereas the other species were approaching the limits of permissible levels. Meanwhile, *Osteochilus hasseltii* (0.169 mg/kg) and *Tachysurus maculatus* (0.156 mg/kg) showed high lead concentrations in this previous study. So, the high concentration of heavy metals can decelerate the growth and development of fish, particularly the developmental stages that resulting in possible changes in fish size (Kasimoglu, 2014).

Besides that, the elevated amount of heavy metals concentration also could be due to the fact that the temperature of the river was not within the optimal temperature for growth of *Barbonymus schwanenfeldii* which should ranges from 22.2 ºC to 25.0 ºC. This is because the heavy metals in aquatic ectotherms may show increased toxicity at elevated temperatures (Sokolova & Lannig, 2008). The increased toxicity of heavy metals at elevated temperatures may be explained by the higher uptake rate and thus high internal concentrations of heavy metals (Sokolova & Lannig, 2008). So, generally the increasing temperature can affect heavy metals uptake and accumulation rates. The increasing temperature of the river might be due to the lack shadow effects caused by decreased nearby trees which affected by the development of anthropogenic activities.

The mean condition factor of *Barbonymus schwanenfeldii* from the Sungai Galas varied slightly with the results from other studies (Table 4.2) with average K value of 1.15. For instance, according to studies on condition factor of tilapia species grown in freshwater pond collected from Pangani River, Morogoro, Tanzania, conducted by Nehemia *et al.* (2012), K value was higher in *Tilapia zillii* which is 2.07 meanwhile *Oreochromis urolepis urolepis* obtained K value that below 1.00 which is 0.86. These results indicate that *Tilapia zillii* was in excellent condition whereas *Oreochromis urolepis urolepis* was in extremely poor condition. So, these results are not the same as those obtained in the present study which might be due to the different ecological conditions and also being different species. In fact, the reason for *Tilapia zillii* has a higher K value than *Oreochromis urolepis urolepis* in the previous study also due to the fact that these are different species even though in the same habitat (Nehemia *et al.*, 2012). This could be due to the average temperature of freshwater ponds was not within the optimal temperature for growth of *Oreochromis urolepis urolepis* which should ranges from 29 ºC to 31 ºC (Nehemia *et al.*, 2012).

Table 4.2: Comparison of K value and HSI value in freshwater fish collected from different parts of the world.

Freshwater fish species	Region	Condition factor (K)	Hepatosomatic index (HSI)	References
Barbonymus schwanenfeldii	Kelantan, Malaysia	1.15	2.32	This present study
Tilapia zillii	Morogoro, Tanzania	2.07	-	Nehemia *et al.*, 2012
Oreochromis urolepis urolepis	Morogoro, Tanzania	0.86	-	Nehemia *et al.*, 2012
Ilisha Africana	Niger Delta, Nigeria	0.99	-	Abowei, 2010
Clarias gariepinus	Kenya	0.55	-	Keyombe *et al.*, 2015
Channa striatus	Orissa, India	0.74	-	Kumar *et al.*, 2013
Channa maurulius	Orissa, India	0.71	-	Kumar *et al.*, 2013
Puntius shalynius	Meghalaya, India	1.25	-	Manorama & Ramanujam, 2014
Pristolepis fasciata	Perak, Malaysia	2.19	-	Muzzalifah *et al.*, 2015
Cyclocheilichthys apogon	Perak, Malaysia	1.33	-	Muzzalifah *et al.*, 2015
Hampala macrolepidota	Perak, Malaysia	1.12	-	Muzzalifah *et al.*, 2015
Labiobarbus leptocheilus	Perak, Malaysia	0.97	-	Muzzalifah *et al.*, 2015

Osteochilus hasseltii	Perak, Malaysia	1.22	-	Muzzalifah *et al.*, 2015
Oxygaster anomalura	Perak, Malaysia	0.65	-	Muzzalifah *et al.*, 2015
Tilapia zilli	Abuja, Nigeria	2.00	-	Dan-kishiya, 2013
Tilapia mariae	Abuja, Nigeria	1.90	-	Dan-kishiya, 2013
Oreochromis niloticus	Abuja, Nigeria	1.91	-	Dan-kishiya, 2013
Barbus occidentalis	Abuja, Nigeria	1.26	-	Dan-kishiya, 2013
Anguilla Anguilla	Mugla, Turkey	0.26	-	Kasimoglu, 2014
Acipenser ruthenus L.	Belgrade, Serbia	0.53	3.91	Lenhardt *et al.*, 2009
Macrognathus aral	West Bengal, India	0.37	1.70	Dutta & Banerjee, 2016
Clarias gariepinus	Ondo State, Nigeria	1.00	1.06	Odedeyi *et al.*, 2014
Oreochromis mossambicus	Vadodara, India	-	2.14	Sadekarpawar & Parikh, 2013
Melanotaenia boesemani	West Papua, Indonesia	-	1.70	Hismayasari *et al.*, 2015
Oreochromis niloticus	Terengganu, Malaysia	-	0.49	Ighwela *et al.*, 2014
Pellonula Leonensis	Niger Delta, Nigeria	-	1.14	Kingdom & Allison, 2011

4.2 Hepatosomatic Index of Fish

As presented in Table 4.1, from 20 fish samples, the average results obtained on the hepatosomatic index (HSI value) is 2.32 ± 0.13. The average HSI value obtained for *Barbonymus schwanenfeldii* from the Sungai Galas is in higher value range which in contrast to the K value that reduced significantly, indicating that the liver as well as body of fish species was in poor condition due to exposure to the environmental toxicants. So, as hepatosomatic index is related with liver energetic reserves and metabolic activity, the increase in the HSI value in the present study might be referring to the high metabolization of heavy metals in liver caused by pollution of the aquatic environment. As one of the functions of liver is the biotransformation and elimination of pollutants, the capacity of the liver to metabolize heavy metals increased in the presence of pollution which caused the liver size increased, thus increase in the HSI value (Kumari *et al.*, 2014). Hence, the increase in HSI value in the present study can indicate an increased capacity of the liver to metabolize heavy metals in the presence of pollution. In fact, this high increase of HSI proves that HSI also can be considered as a biomarker of metal toxicity (Kumari *et al.*, 2014).

The mean HSI value of *Barbonymus schwanenfeldii* from the Sungai Galas varied slightly with the results from other studies (Table 4.2). For instance, Lenhardt *et al.* (2009) conducted study on hepatosomatic index in sterlet *(Acipenser ruthenus L.)* collected from the Danube River, Belgrade, Serbia. In this previous study, the mean HSI value is higher compared to the mean HSI value in present study with the value of 3.91. Besides that, based on research conducted by Ighwela *et al.* (2014), it was found that *Oreochromis niloticus* collected from Terengganu showed lower mean HSI value compared to the mean

HSI value in present study with the value of 0.91. So, these results might be due to the different ecological conditions and also being different species.

4.3 Comparison of Fish Body Length from Different Months

The total fish body length was separately grouped by monthly collection (Figure 4.1). The lowest value of fish body length is found for month September, meanwhile the highest value of fish body length is mostly found for July. *Barbonymus schwanenfeldii* fish species collected in September shows shorter body length which might be due to the seasonal change that could be affected a slight drop of temperature. Being cold-blooded animal, fish is influenced by the temperature of the surrounding water which affected the body temperature and growth rate where the optimal temperature for growth of *Barbonymus schwanenfeldii* should be ranged from 22.2 ºC to 25.0 ºC (David & Clarice, 2015). Thus, the fish growth rate was affected which is retarded the fish body length due to the lower temperature than optimal temperature for growth of *Barbonymus schwanenfeldii* in September. Meanwhile, mostly in July, the fish body length was longer due to the warmer environment which influenced faster growth rate.

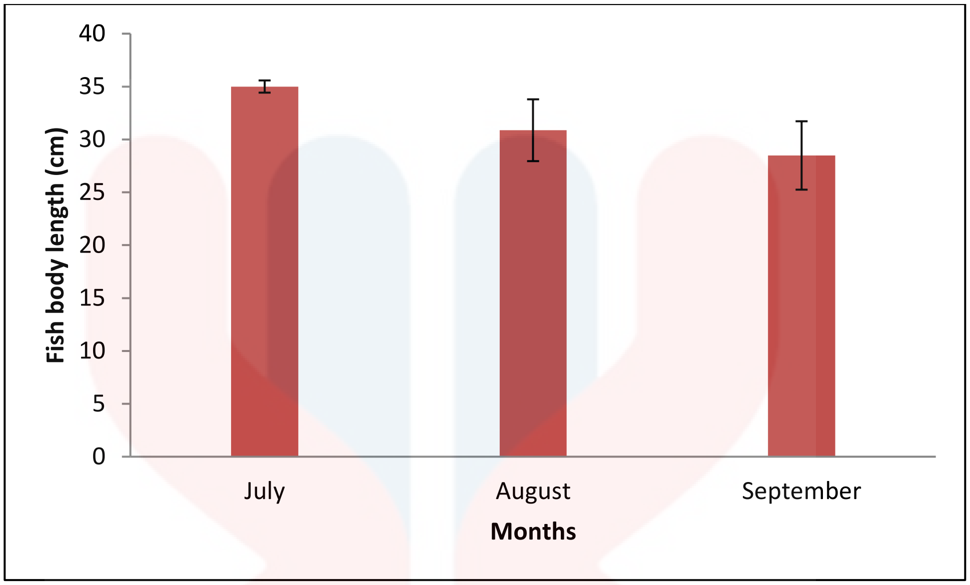

Figure 4.1: Fish body length collected from different months

4.4 Comparison of Fish Body Weight from Different Months

The total fish body weight was separately grouped by monthly collection (Figure 4.2). *Barbonymus schwanenfeldii* fish species collected in July shows higher value of fish body weight whereas *Barbonymus schwanenfeldii* fish species collected in September shows lower value of fish body weight. The higher value of fish weight in July might be due to high availability of food items, as amount of food can influence the fish growth and energy (Muzzalifah *et al.*, 2015). *Barbonymus schwanenfeldii* has detritivorous and omnivorous habit which feeds on debris, insects, small fishes as well as plant matters such as leaves, weeds and filamentous algae (Mansor *et al.*, 2012). Thus, due to the warmer temperature in July caused by seasonal change, the plant matters such as leaves, weeds and filamentous algae can increase their availability as warmer temperatures and sunlight may activate their spores and surviving cells. So, because of that mostly this fish species has high value of body weight in July than other months.

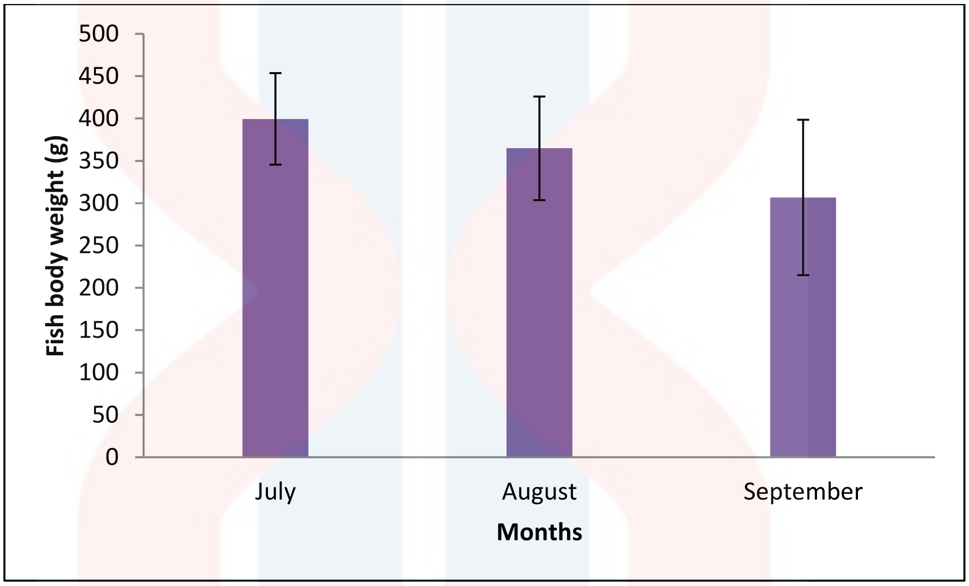

Figure 4.2: Fish body weight collected from different months

4.5 Comparison of Condition Factor between Fish Samples

Barnham & Baxter (1998) proposed that if the K value is 1.20 and above, it indicates that the fish would has moderate condition and acceptable to many anglers. Then, a good and well-proportioned fish would has a K value that is 1.40 and above, also reach an excellent condition if fish has a K value that is approximately 1.60. Meanwhile, if the K value is below 1.20, it indicates that the condition of the fish is poor, long and thin, also reach extremely poor condition if fish has a K value that is below 0.80. Thus, based on Figure 4.3, the sampled fishes from the Sungai Galas are mostly below 1.20

which indicates poor condition of fish except for the nine sampled fishes in this study that passed above 1.2 which indicates moderate condition of fish. Then, two of them have passed above 1.4 which indicates good condition and well-proportioned fish.

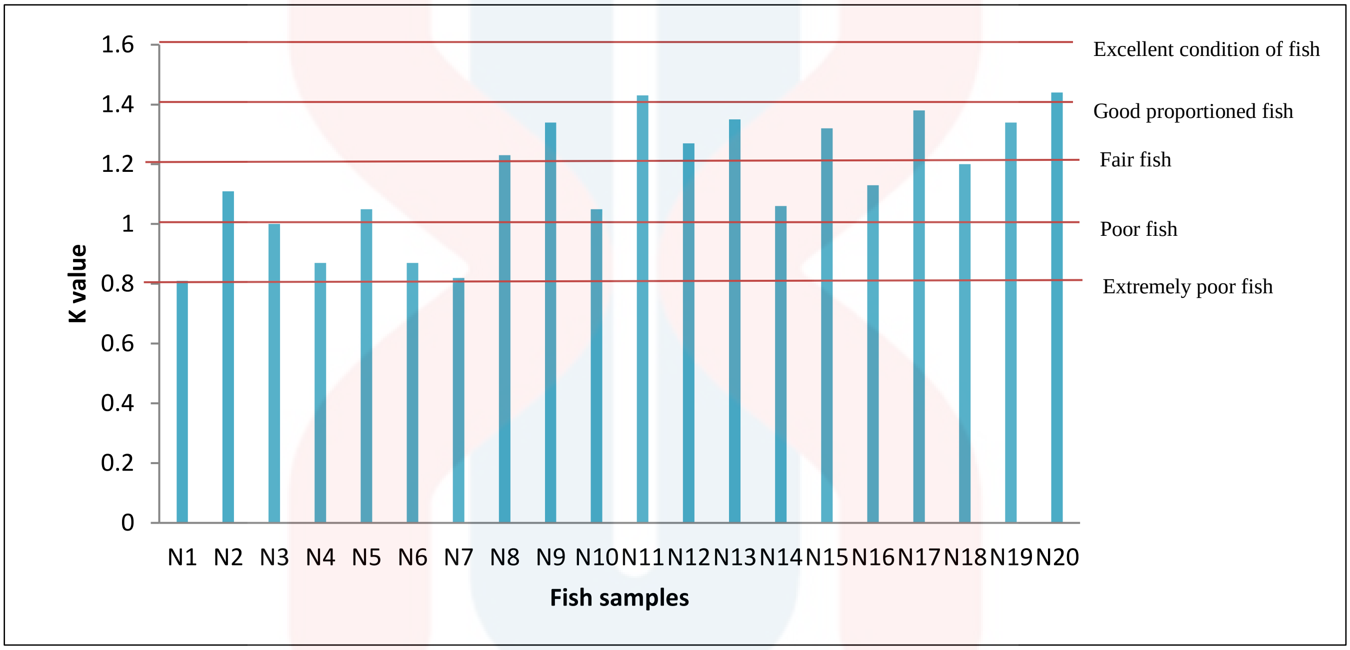

Figure 4.3: Comparison of condition factor between fish samples

Since Fulton's condition factor, K value is a measurement requiring the length and weight for a particular fish, thus it could be influenced by the same factors that affect fish body length and weight. Therefore, the lower K values that presented in Figure 4.3 which is below the K value 1.2 might be due to the high amount of heavy metals accumulated in the fish body. This high heavy metals accumulation could be caused by the effects of human activities such as poorly managed agriculture and recreation activities which encompassed the detrimental water quality. Other than that, this high metals accumulation also could be caused by natural feeding type of *Barbonymus schwanenfeldii* which is detritivorous and omnivorous which consumes waste, debris and other food sources such as insects, small fishes as well as plant matters such as leaves, weeds and filamentous algae that increases potential heavy metals exposure. So, because of that reason, most of *Barbonymus schwanenfeldii* which presented in Figure 4.3 have lower K value. Meanwhile, the higher K values that presented in Figure 4.3 which is passed above the K value 1.2 might be due to the lower temperature that decreased the metals uptake rate and thus affect the lower internal concentrations of metals in fish body, where the lower temperature could be caused by the seasonal change.

4.6 Participatory Interview

Towards the end of the study, the participatory interview was conducted to the correspondents who are the local communities of Kampung Dabong, where the participatory interview contained three questions which assessing the knowledge on fish health issues among local communities. Six percents of the local communities which is 150 correspondents from 2500 communities at Kampung Dabong completed the participatory interview. The results of the participatory interview are showed in Figure 4.4.

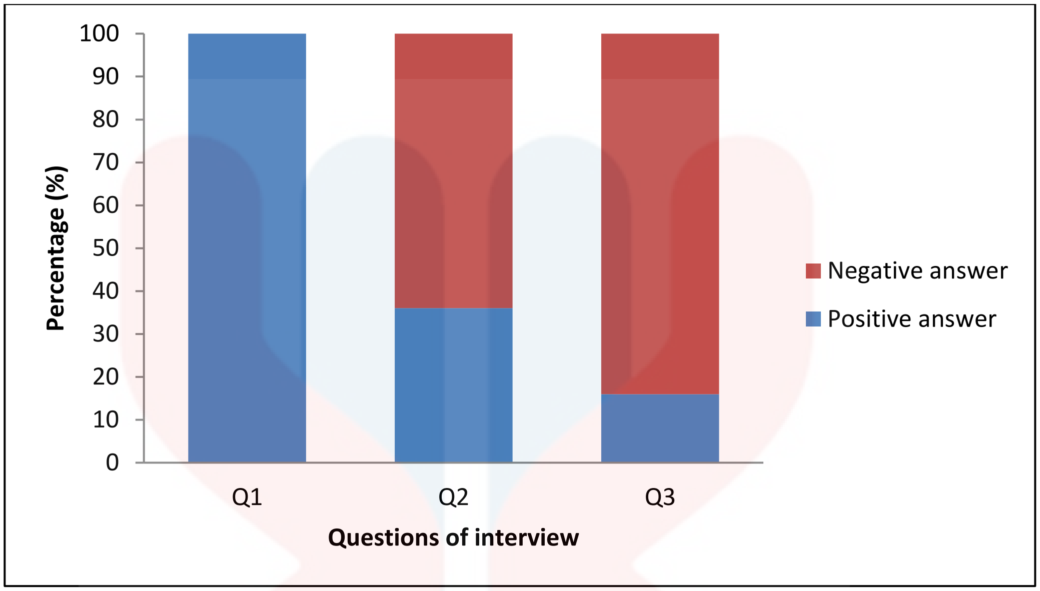

Figure 4.4: Percentage of participatory interview answer

Firstly, as presented in Figure 4.4, 100% of correspondents expressed that they are aware about the issues of the safety and health of fish that have been sold. This is because most correspondents might felt that it is important to concern and make choice on the healthiness of fish before purchased. However, based on the correspondents' perceptions in the interview, the correspondents rather focused on the external safety and health of fish than the internal safety and health of fish. So, through this first question, generally it can be assumed that all of the correspondents are aware on the issues of the safety and health of fish that have been sold but only judged about how healthful the fish through external appearance observation rather than concerned that the fish contained potentially harmful pollutants.

Secondly, according to the Figure 4.4, responses from the second question which is about the knowledge on human health which can be affected by contaminated fish showed that 64% of the correspondents gave negative answers. So, majority of correspondents did not know about contaminated fish that can affect their health. This happened may due to the limited of accessible advisory information and reminder about the heavy metals contaminants contained in some species of fish from the fish consumption advisories in clear manner which means in language that majority communities can read. Only 36% of correspondents know about contaminated fish that can affect their health as they might be obtained the information through internet access or education from institution. Thus, through this second question, generally it can be assumed that despite all the correspondents are aware on the issues of the safety and health of fish, most of them did not know about contaminated fish that can affect their health.

Lastly, as referred to Figure 4.4, 84% of correspondents also replied negative answers to the third question which is about the knowledge on heavy metal standard permissible limit that has been justified by national food acts and regulations. The strict regulations and acts such as Food and Agriculture Organization (FAO), World Health Organization (WHO), Food Act 1983 and Food Regulation 1985 which provided guidelines for heavy metal standard permissible limit in food were important to determine food level contaminants and food safety for consumption. Thus, this information is valuable to communities regarding their body health. However, the majority of them do not know about this issue which is also happened due to the lack of exposure of the health information from the authorities regarding heavy metal standard permissible limit to the communities.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study was undertaken to determine the condition factor and hepatosomatic index of freshwater fish species which collected from the Sungai Galas, Dabong as well as to assess the knowledge on fish health issues among the local communities. Overall it was observed in this study that the fish species has a low average of condition factor which exhibited K value below than 1.2, suggested that the fish species is in poor condition (Barnham & Baxter, 1998). This could probably due to the elevated amount of heavy metals accumulation in the fish body which has arisen likely consequence of the anthropogenic activities, high temperature as well as the nature of *Barbonymus schwanenfeldii* feeding habits. Besides that, it was observed in this study that the fish species has higher HSI value range which in contrast to K value that reduced significantly, indicating that the liver as well as body of fish species is in poor condition which also due to exposure to the environmental toxicants. Therefore, based on the results of this study, it was revealed that the freshwater fish species from the Sungai Galas, Dabong is in poor condition. However, the condition of the fish species is not extremely poor because some of them have higher K values which are passed above the K value 1.2 and lower HSI value which might be due to the lower temperature caused by seasonal change.

Besides that, as the health condition of fish can clearly describe the pollution status of the aquatic environment in which it lives, thus according to the health condition of

Barbonymus schwanenfeldii which is in poor condition in this present study, it was revealed that the Sungai Galas, Dabong also might be in poor condition. Therefore, in summary, all living organisms within a similar ecosystem are possibly contaminated along their cycles of food chain. So, as a consequence to the human health, local population in particular are in turn exposed to heavy metals by consuming the contaminated fish and this has been known to result in various biotoxicity disorders. Other than that, based on the participatory interview results, majority of the local communities have limited knowledge on fish health issues due to the limited of accessible advisory information and lack of health information exposure from the authorities.

5.2 Recommendations

Biotic samples should be collected from two different areas for comparable. This is to enable the observation and explanation on condition factor and hepatosomatic index of same biotic species at different areas as well as enable to compare them with different concentration of pollutants. Besides that, it is required that biological monitoring of the edible fish should be done regularly to ensure constant safety of the fish consumption, in view of the significance of fish to human diet. Then, the safety and health information of fish from the biological monitoring should be conveyed to the communities. Other than that, in order to reduce the concentration of the heavy metals in the aquatic environment, safe disposal of industrial, agricultural and domestic effluents should be practiced besides of recycling practice. In fact, laws, acts as well as regulations enacted to protect our environment and human health should be enforced and explained to the communities through mass media in order to enhance their knowledge and awareness on the environment and health.

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APPENDIX A

Questionnaires

Instruction: Please tick (√) in the appropriate box.

1. Are you aware about the issue of the safety and health of fish that have been sold?

   Yes ☐ No ☐

2. Do you know that the fish which have been contaminated can affect your health?

   Yes ☐ No ☐

3. Do you ever have been exposed to heavy metal standard permissible limit which has been justified by national food acts and regulations?

   Yes ☐ No ☐

APPENDIX B

The Sungai Galas, Dabong.

The fish samples that have been collected were kept in the sampling polyethylene bag and put in the ice box

The liver sample of *Barbonymus schwanenfeldii* after dissected