LENGTH WEIGHT RELATIONSHIP OF *Rhinogobius giurinus* IN EX-TIN MINING PONDS AT UTAR PERAK CAMPUS

By

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ABSTRACT

LENGTH WEIGHT RELATIONSHIP OF *Rhinogobius giurinus* IN EX-TIN MINING PONDS AT UTAR PERAK CAMPUS

Lee Phui Kuan

The *Rhinogobius giurinus* from ex-tin mining ponds at Kampar, Perak was studied for its length-weight relationships and relative condition factor, K_n for total length and standard length. The sampling period was carried out from October 2012 to December 2012 at five distinct sites/ponds. A total of 1214 samples were collected during the sampling period. Length-weight relationships for Site 1 (isolated pond located beside UTAR Sport Complex) was $W = 8.365L^{2.975}$ (total length) and $W = 15.488L^{2.992}$ (standard length); for Site 3 (small pond beside parking lot of UTAR Sport Complex) was $W = 7.178L^{3.083}$ (total length) and $W = 11.535L^{3.195}$ (standard length); for Site 4 (large pond located beside block B; in front of block C) was $W = 7.482L^{3.102}$ (total length) and $W = 12.735L^{3.188}$ (standard length); for Site 5 (fast running stream between block E and block F) was $W = 7.145L^{3.156}$ (total length) and $W = 12.445L^{3.207}$ (standard length). The *R. giurinus* exhibited isometric growth in Site 1 and positive allometric growth in Sites 3, 4 and 5. The mean of K_n obtained among sites was 1.005 ± 0.107 (total length) and 1.006 ± 0.123 (standard length), indicating fishes in ex-tin mining ponds were in good

condition. One-Way ANOVA and Tukey's Honestly Significant Difference (HSD) show that the mean of K_n among sites was similar. For length and weight, the mean in every site was different from each other as shown in One-Way ANOVA and Tukey's HSD.

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Last but not least, I'm grateful to my family and friends for their moral support and encouragement that helped me in completing this research.

DECLARATION

I hereby declare that the project report is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

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(LEE PHUI KUAN)

APPROVAL SHEET

This project report entitled "**LENGTH WEIGHT RELATIONSHIP OF *Rhinogobius giurinus* IN EX-TIN MINING PONDS UTAR PERAK CAMPUS"** was prepared by LEE PHUI KUAN and submitted as partial fulfilment of the requirements for the degree of Bachelor of Science (Hons) in Biotechnology at Universiti Tunku Abdul Rahman.

Approved by:

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Date: ___________________

PERMISSION SHEET

It is hereby certified that **LEE PHUI KUAN** (ID No: **09ADB03582**) has completed this final year project entitled "**LENGTH WEIGHT RELATIONSHIP OF *Rhinogobius giurinus* IN EX-TIN MINING PONDS UTAR PERAK CAMPUS**" under supervision of Dr. Gideon Khoo from the Department of Biological Science, Faculty of Science.

I hereby give permission to my supervisors to write and prepare manuscript of these research findings for publishing in any form, if I did not prepare it within six (6) months time from this date provided that my name is included as one of the author for this article. Arrangement of the name depends on my supervisors.

Yours truly,

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(LEE PHUI KUAN)

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LIST OF ABBREVIATIONS

a	Regression constant
ANOVA	Analysis of Variance
b	Regression coefficient
K_n	Relative condition factor
L	Total length
LWR	Length-weight Relationship
r	Correlation of coefficient
R^2	Correlation of determination
SL	Standard length
SPSS	Statistical Package for Social Science
TL	Total length
Tukey’s HSD	Tukey’s Honestly Significant Difference
W	Weight
W’	Expected weight

CHAPTER 1

INTRODUCTION

Gobiidae is one of the largest fish families, with more than 230 genera and 1600 species discovered and described (Nelson 1994). The primary habitat for goby is marine environment; yet there are some species fully adapted to freshwater environment. *Rhinogobius giurinus*, which is also known as oriental river-goby or barcheek goby is an introduced or non-native species in freshwater system Malaysia (Chong et al., 2010). Introduced species has large effect on the behavior, distribution and abundance of native species thorough competition, predation and habitat alternation (Workman and Merz 2007; Strayer 2010). As this species is highly adaptive to various types of habitats, it brings up a question on how well this species adapt to living in ex-tin mining ponds around UTAR, Perak campus which have higher mineral content. A study which investigates the growth condition of *R. giurinus* by length-weight relationship study can determine how well this species survives in freshwater ecosystem of ex-tin mining ponds.

The ex-tin mining ponds in this study located at Kinta Valley used to be one of the major and biggest tin mines in Perak (Hamzah et al., 2009). Large numbers of abandoned tin mining ponds resulting from mining activity have formed an artificial freshwater ecosystem over time (Yusof et al., 2000). Although the characteristics of these ponds in the aspect of water parameters and geographic factors are different from natural ponds, native as well as introduced species are able to survive and adapt to the environment. As an introduced species *R. giurinus* may act as a primary consumer or secondary consumer in the food-chain. It is important to understand that the general well-being or condition of this species have a direct influence on the food-chain, especially when it acts as food source for larger predator.

The length weight relationship has become one of the most important standard analyses or assessment in fishery biology studies. It shows population dynamics, growth pattern and condition of a species (Dar et al., 2012). Using LWR data, one can estimate unknown weight for a given length in yield assessment, estimate biomass and determine fish condition (Cherif et al., 2008). It can also be applied to determine the deviation of expected weight from accepted length weight standard for a certain fish species. This acts as an indication of robustness, feeding state, maturity and breeding of a species population (Le Cren 1951). Condition factors calculated using LWR data functions as an indicator whether the population is experiencing slow growth rate due to environment factor such as disease and high population density (Zakeyuddin et al., n.d.).

In this present study, *R. giurinus* was captured from different ex-tin mining ponds in UTAR, Perak campus. This study aims to study the growth pattern and condition of *R. giurinus* in different abandoned tin-mining ponds around

UTAR, Perak campus using length weight relationship and relative condition factor, K_n. ANOVA analysis was carried out to investigate the niche effect on *R. giurinus* by comparing the mean of relative condition factor of each site. Tukey's Honestly Significant Difference (HSD) is performed to confirm which group has significant difference with other groups. In the meantime, the sustainability of abandoned tin-mining ponds in natural growth of ideal fish where b = 3 can be determined from LWRs data.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of Ex-Tin Mining Ponds

2.1.1 History of Tin Mining Activities

In the past, Malaysia was one of the largest exporters in tin mining industry. Kuala Lumpur, Perak and Selangor are well-known tin mining states in Malaysia. Ipoh, Gopeng, Kampar and Batu Gajah are major tin mining cities in Perak (Chin 1999). This industry became popular since the immigration of the Chinese in the early 1820s. The majority of these Chinese immigrants are Hakka and Cantonese. In the 18^{th} century, British colonized Malaysia which was driven by chaotic political conditions or Malay Civil War between organized Chinese miners, Malay sultans, minor rulers and villagers. During colonization, tin-mining industries were expanded by having imported pumping machine and larger number of immigrants (Chin 1999). Sir Andrew Clarke developed a communication system by constructing state roads between principal mining towns. The system includes a railway line built from Taiping to Port Weld and trunk roads from Seremban, Kuala Lumpur, Ipoh and Taiping. This system functioned to transport tin and other resources from states to ports to be shipped to United Kingdom. Earlier, the tin industry was monopolized by the Chinese. Towards the end of the 19^{th} century, British began taking control over the tin industry by introducing colossal dredging machines. During the 19th century, Malaysia shared 55% of total world tin production, proving that Malaysia was the main tin producer in the world (Chin 1999). In the year 1985, a tin crisis occurred including failing tin prices, demand and high production costs lead to the collapse of tin mining industry in Malaysia (Chin 1999).

2.1.2 Uses of Tin Tailings

Extensive mining activities have resulted in tin tailings, defined as tracts of waste and barren land by washed water products of alluvial mining (Ashraf et al., 2010; Majid 1994). Ang (1994) stated there are about 113700 ha of tin tailings from mining activities throughout Peninsula Malaysia, a majority of which are contributed by Perak (63%) and Selangor (22%).

These tin tailings are high in sand, low in nutrients, low in organic matter, low in moisture and high in ground temperature, making it highly infertile (Ang 1994). In order to make use of these tin tailings for agriculture, a high amount of fertilizers are needed for investment (Ang and Ho 2002). This unfavourable factor caused these tin tailings to remain unproductive. At 1990, only 9.7% of the ex-mining ponds had been used for agriculture, housing, recreational parts and farms (Chan 1990, cited in Ang and Ho 2002).

Over time, heavy metal toxicity in abandoned tin mining ponds became lesser and resulted in ecological succession (Down and Stocks 1977). These ponds form an artificial freshwater ecosystem over time (Yusof et al., 2001). Some of these ponds were utilized for aquaculture and cultivation of freshwater species. Example of these cultured species are nile tilapia (*Oreochromis niloticus*), marble goby (*Oxyeleotris marmorata*), giant gourami (*Osphronemus goramy*) and others (Luong and Lin 2004; Le Mare 1948). Although the characteristics of these ponds in the aspect of water parameters and geographic factors are different from natural ponds, native as well as introduced species such as *Rhinogobius giurinus* are able to survive and adapt to the environment.

2.2 Background of Gobiidae

Under the suborder Gobiodei of the order Perciformes, there are eight families include Eleotridae, Gobiidae, Microdesmidae, Kraemeriidea, Xenisthmidae, Rhyacichthyidae, Odontobutidae and Schindleriidae. Among these families, Gobiidae is the largest fish family with more than 2000 species discovered (Nelson 1994; Staby and Krakstad 2005). The name “goby” is an ancient Greek word which was used as an English vernacular name in 1769 (Larson and Lim 2005). For older classification, the name “Gudegeon” was used for small fishes such as gobies and gudgeons (Larson and Lim 2005). Definite fossil gobies of *Rhinogobius giurinus* and *Rhinogobius brunneus* were discovered at diatomite beds at Kusu Basin, Oita Prefecture, Japan (Yabumoto 1987).

2.2.1 General Characteristics

It is difficult to define gobies as there are many variations in colour, body shape and size. The general features of a goby were shown in Figure 2.1. To classify a goby under Gobiidae, it should have a few distinct characteristics that are specific for Gobiidae. One of the obvious differences is the presence of fused pelvic fins. Gobies lack swim-bladders and the fusing of their pelvic fins form a sucker device, enabling them to stick or cling onto an object, wall either vertically, horizontally or upside down (Lim and Ng 1990; Staby and Krakstad 2005). Therefore, these gobies can be seen "hanging" on the sides of ponds or rivers. Another characteristic is relatively large pectoral fins which help gobies to swim (Lim and Ng 1990). Compared to other fishes, gobies have two soft dorsal fins that lack in spines. In other fish such as spiny dogfish, their dorsal fins have spines for protection. For gobies that are absent of these characteristics, they are classified under other families such as Eleotridae, Microdesmidae based on their own features. For instance, Eleotridae have wide-separated pelvic fins, short-based second dorsal and anal fins (Larson and Lim 2005).

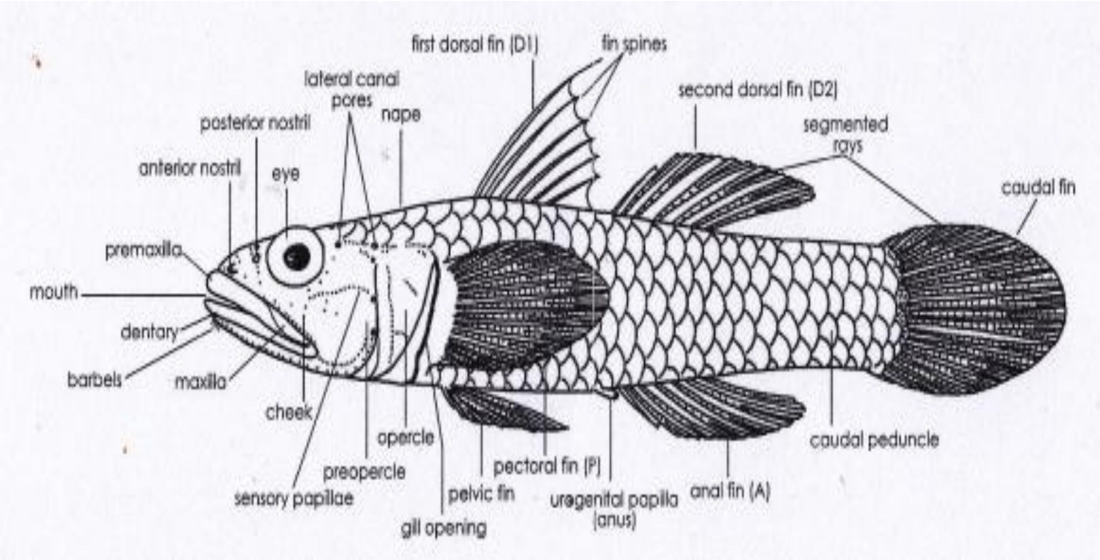


Figure 2.1 Basic features of generalised gobies. (Larson and Lim 2005)

2.2.2 Habitat

Gobies can be found in marine, brackish and freshwater environment, predominantly in marine environment. They are euryhaline (adaptable to wide range of salinities) in nature, yet some species are fully adapted to freshwater environment. This includes *Pseudogobiopsis oligactic*, *Pseudogobiopsis siamensis* and species discussed in this topic, *Rhinogobius giuriruns.* Larson and Lim (2005) summarized that gobies can be seen in various distinct habitats such as mangroves, mudflats, seagrass, reservoirs, rocky shores, sandy shores, concretised channels, streams and coral reef. There are no clear-cut boundaries between two habitats such as mudflats and seagrass are often associated with mudflats and sandy shores respectively (Larson and Lim 2005).

Mangroves and mudflats are always associated with each other. The former habitat is extremely muddy with waterlogged saline soils while the latter is extremely low relief and has little vegetation (Larson and Lim 2005). Examples of gobies that inhabit these environments are mangrove gobies (*Mugilogobius*) for former habitat; mudskippers (*Boleophthalmus*) and arrow gobies (*Clevelandia ios*) for latter habitat (Anderson 2003; Larson and Lim 2005). Marine environments including the seashore; seagrass and coral reefs are common habitats for marine-adapted gobies. In the aspect of seashore, it can be further divided into sandy and rocky seashore. An example of sandy seashores is beaches along the East Coast at Malaysia and sand gobies (*Favonigobius*) can be found here (Larson and Lim 2005). Rocky shores have sedimentary rocks that are constantly hit by high energy waves (Larson and Lim 2005). Common gobies that live here are sand gobies and fillfin gobies (*Bathygobius).* Meanwhile, coral-reef gobies including starry gobies (*Asterroputryx*) and shrimp gobies (*Cryptocentrus*) can be seen in coral reef habitats. On the other hand, gobies can also be found in freshwater habitats including reservoirs, streams and concretised channels. Common gobies that are found in reservoirs are river gobies (*Rhinogobius*) and stream gobies (*Pseudogobiopsis*). Streams are natural drainages found in forested areas that have sandy floors. Both river and stream gobies can be seen in this habitat. Concretised channels or drains used to be natural streams but are lined with concrete to prevent soil erosion. Night gobies (*Stigmatogobius*), snakehead gudgeon (*Ophiocara*) and sand gobies live in these channels or drains.

2.2.3 Reproduction

Gobies are classified into amphidromous and non-amphidromous species (McDowell 1988, cited in Chang). Amphidromous species reproduce in freshwater while newly hatched larvae will move to sea to grow until the juvenile stage after which they return back to the freshwater for grow-out and reproduction (Chang et al., 2008). Gobies are oviparous which means eggs are produced and hatched outside the body. They can produce up to few hundred eggs depending on the species. The eggs are attached to an object or substrate such as rocks and corals. After the female produces the eggs, the male will fertilize and guard the eggs from predators. The fish larvae take a few months to years to reach adult size. The grow-out period depends on the species.

2.2.4 Ecological and Economic Roles

As an abundant species, gobies become an important food source for most fishes. It plays an important role in the food-chain especially in freshwaters of small islands because they are one of the few fish species that exist in these areas (Allen and Robertson, 1994; Helfman et al., 1997). Gobies do exhibit symbiotic relationships with other species such as relationship between gobies (shrimp-gobies) and shrimp (Helfman et al., 1997; Staby and Krakstad 2005). The shrimp which has poor eyesight is alerted by gobies when there is a threat. Meanwhile, gobies get a safe house for protection and eggs deposition built by shrimps. Another example is neon gobies (*Elacatinus*) that play a role as cleaner fishes (Zimmerman 2001). The neon gobies remove parasites form larger fish. In return, those parasites became food source for these gobies.

Species such as marble goby is obtained for human consumption. This species is highly valued due to its slow grow-out period. Gobies such as neon goby and shrimp goby are bred and traded as aquarium pets.

2.2.5 Background of *Rhinogobius giurinus* (Rutter, 1897)

The common name for *R. giurinus* is oriental river goby or barcheek goby. The etymology of this species is Rhinogobius, which is a combination of Greek (Rhinos) and Latin (gobius) words. The basic characteristic of this species is a slightly depressed head and a series of 6 to 7 black spots on the sides of its yellowish green body (Lee et al., 2004). *Rhinogobius giurinus* is distributed in the western Pacific from China to Japan (Larson and Lim, 2005). It is not a native species in Malaysia (Chong et al., 2010). Introduced species can cause the extinction of native species by predation, competition, habitat alternation and alternation in nutrient cycling (Workman and Merz 2007; Strayer 2010). This species may be responsible for the disappearance of *Pseudogobiopsis* species in Singapore (Larson and Lim, 2005; Larson et al., 2008). This species is euryhaline which is adaptive to a wide-range of water salinity, from freshwater to marine habitats. They are omnivorous which means their food sources are animals and plants (Masuda et.al., 1984). This species is an amphidromous species and spawning season for this species is during summer from July to October (Chang et al., 2008). The male are territorial in which they guard their territory from other males, especially those males which are more colourful (Lim and Ng 1990). In a study on reproduction of this species by Chang et al (2008), they found that this species in Taiwan did not disperse far from its original estuary or to seawater. *R. giurinus* can be found in shallow waters over sandy bottoms at a few places including canals, streams, drains, ponds and reservoirs (Lim & Ng 1990; Serov et al., 2006). This species is assessed at least concern under IUCN Red List Status as it has a large distribution area and not threatened currently (IUCN 2012).

2.3 Length and Weight Measurement

2.3.1 Length Measurement

In the fish industry, length acts as the assessment method in defining the length to harvest the fishes. Fish length measurement can be divided into two types: whole body measurement and body parts measurement (Anderson and Neumann 1996). The measurement of body parts is rarely used and is only applied when intact fish is unavailable or not obtainable. Full body measurements, consist of total length, fork length and standard length. Total length is the maximum length of fish starting from the anterior-most part of the fish to the tip of the longest caudal fin rays. In Europe, the caudal fins are left "open" or in its natural orientation when taking measurement; meanwhile in America, they prefer to close or compress the caudal fins (Anderson and Neumann 1996). To measure total length, it is suggested to push the fish's snout up against a vertical surface and pinch the tail fin closed on a tape measure (myfwc.com, 1999). Fork length is defined as the length from the most anterior part of the fish to the tip of the median caudal fish rays (Anderson and Neumann 1996; fishbase.org n.d.). This length measurement is usually applied for fish species whose dorsal and ventral rays are longer than median rays. The standard length is taken from the tip of the upper jaw to the posterior end of the hypural plate (Anderson and Neumann 1996). This measurement is widely used in taxonomic studies of fishes as the data is not affected by caudal fin anomalies (Anderson and Neumann 1996).

Various devices or tools can be used in length measurement. This includes measuring boards (with linear scale), tape measures and callipers. The choice of tool depends on the size of fish studied. Vernier callipers give precise readings for small fish although they are more time-consuming compared to other devices. The length measurements of goby are shown in Figure 2.2.

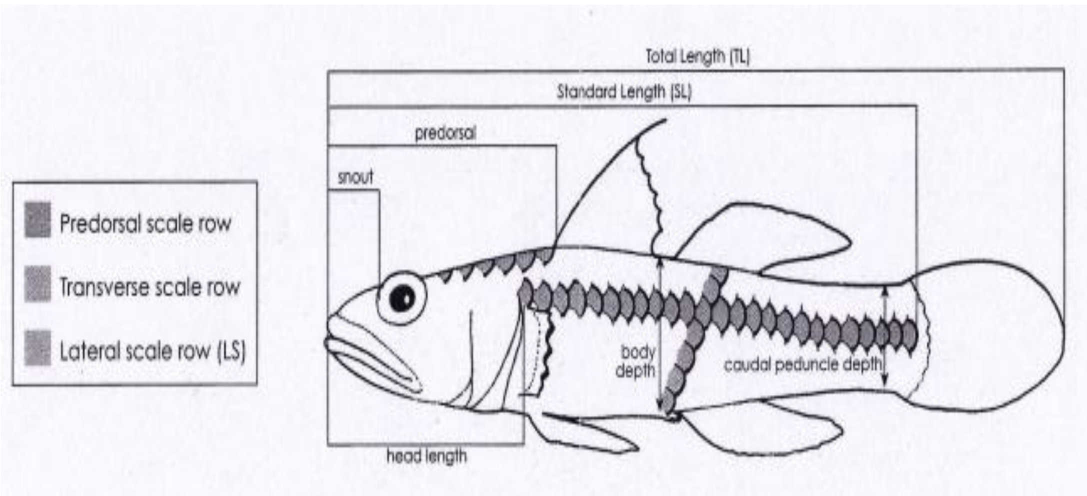


Figure 2.2 Length measurements of a goby. (Larson and Lim 2005)

2.3.2 Weight Measurement

Weight acts as another assessment tool that describes the fish growth process. Anderson and Neumann (1996) stated that annual weight increment in useful in investigating how fish of various size gain in value to fishery, while annual weight gain can be studied to estimate the consumption of foods in rearing fishes.

There are a few types of weighing apparatus such as spring-loaded scales, electronic scales, electronic balance etc. In laboratory, an electronic balance is commonly used for small fishes as it is more sensitive and accurate. Errors in weight measurement can be caused by presence of water in body surface and buccal cavity of fish (Anderson and Neumann 1996). To minimize this error, Anderson and Neumann proposed to remove as much as possible water from fish by letting the water drips from fish or blot the fish dry before weighing. Same method was also used by Anibeze (2000). Another potential error is caused by motion. Weighing devices are very sensitive to motion, especially wind motion. Besides, fish movement during measurement can be solved by anesthetizing the fish (Anderson and Neumann 1996).

2.4 Length-Weight Relationship (LWR)

The analysis of length weight data is very useful. Firstly, it can describe precise relationship between length and weight of a species mathematically, so that one can be converted to another conveniently (Morey et al., 2003).

Secondly, it can be used to measure the deviation of measured weight from expected weight for a particular length group. Thirdly, it can estimate the expected weight of a fish for a given length (Froese 2006; Schneider et al., 2000). Le Cren (1951) proposed that LWR may be a character for differentiation of small taxonomic units as b is often constant for fish similar in these aspects such as habitat, sex, maturity. The LWR data is used in determining condition factors in which it can measure the change of robustness of a particular population over time (Morey et al., 2003; Schneider et al., 2000). It can also be studied to investigate the effect of abiotic and biotic factors on the condition of fish (Cone 1989). Last but not least, it is useful for comparison of condition of studied fish species to state-wide standards (Schneider et al., 2000).

The LWR can be described by this formula,

$$W = aL^b \tag{2.1}$$

where W = weight, L = length, a and b are constants (Le Cren 1951). The parameter b is also known as the allometric factor. The equation 2.1 can be log-transformed into equation 2.2 for ease of investigation.

$$\log_{10} W = \log_{10} a + b \log_{10} L \tag{2.2}$$

A linear regression line of weight and length can be generated using equation 2.2. When comparing it with a linear equation (y = mx + c), the parameter a and b can be estimated easily.

For an ideal fish that maintain the same shape as it grows, the *b* will be equal to 3 which means the cube law is obeyed (Le Cren 1951). However, most of the fish species do not obey the cube law as they change their shape throughout their life. Thus, it is best to assume that *b* is not equal to 3 for basis of investigation, proposed by Le Cren (1951). If the *b* is less than 3 or negative allometric growth, it means the fish becomes thinner or elongates as length increases. In the opposite case where *b* is more than 3 (positive allometric growth), it indicates an increase in height or weight with respect to increased length (Anderson and Neumann 1990; Hile 1936; Morey et al., 2003). Samat et.al (2008) deduced that the value of *b* for most temperate and tropical fishes ranged from 2.7 to 3.3, while Gayanilo and Pauly (1997) suggested that the common range of *b* is within 2.5 to 3.5.

The value *b* can be affected by external and internal factors. External factors include habitat, temperature and food availability while internal factors include sex, fish activities, health, maturity, seasonal growth rates and food habits (Cazorla 2008; Froese 2006; Isa et al., 2010; Le Cren 1951). The condition of fish upon capture such as stomach fullness, health, and maturity can affect length-weight relationships (Cherif et al., 2008; Schneider et al., 2000). The LWR can be influenced by a few factors such as sampling error and population variability (Frota et al., 2004). The sampling error can be reduced through effective sampling where researchers should apply non-selective sampling and sample size should be large. The value of *b* is different based on type of length measurements. Frota et al. (2004) stated that the standard length yield lower b value then total length.

2.5 Relative Condition Factor (K_n)

The length weight data is used in determining the condition factor. It can also refer to "ponderal index", "coefficient of condition", "condition factor" and "length-weight factor" (Le Cren 1951; Williams 2000). It is used as an indicator of the condition, well-being and fatness of a fish (Tesch 1968). In general, a high condition factor indicates favourable environmental conditions such as habitat and food availability; in contrast, a low condition factor indicates less favourable environmental condition factor (Blackwell et al., 2000). Murphy et al. stated that the condition factor is useful in comparative measure of fish plumpness. For a given length, fatter fish are in better condition (Froese 2006; Sivashanthini and Abeyrami 2003). Moreover, condition factor can be applied to determine stocking density (Barnham and Baxter 1998). When a decrease in condition factor due to high stocking densities stress the fishes, the stocking density can be reduced until the condition factor returns to optimum level.

The Fulton's condition factor, K is calculated using formula 2.3.

$$K = \frac{W}{L^3} \qquad (2.3)$$

This condition factor can be affected when the cube law is not obeyed. This is because this formula is created based on an ideal fish where b=3 (as seen in L^3). To solve this problem, the relative condition factor, K_n is introduced as shown in formula 2.4 (Le Cren 1951). This relative condition factor expresses better differences in weight of fishes for a given length compared to the condition factor (Bariche et al., 2006). For K_n value greater than 1, it indicates good condition of fish (Dourado and Davies 1987; Le Cren 1951). For K_n value less than 1, it indicates slow growth rate in a fish which may be caused by disease, high population density (Dourado and Davies 1987; Zakeyuddin et al., n.d.)

$$K_n = \frac{W}{W'} \tag{2.4}$$

where K_n = relative condition factor, W = observed weight, W' = calculated weight. The relative condition factor measures the deviation of an individual from calculated weight for a length group (Le Cren 1951).

Williams (2000) and (Froese 2006) concluded that variation in condition factors of fish is primarily due to maturity state, degree of nourishment, food availability, spawning, age as well as sex of fish. In addition, it can also be affected by fullness of gut, type of food source, amount of fat reserved and degree of muscular development (Barnham and Baxter 1998). In the case of spawning, the condition factor decreases rapidly when females produce eggs. To compare condition factor of fishes from different population, William (2000) proposed that the fish samples should be obtained within same species, length, age and sex under constant sampling time. He further pointed out that for comparison between samples from same population, the fish samples have to be collected on the same date. The same suggestion was also recommended by Barnham and Baxter (1998) that studied fish samples should be obtained at the same time or year so that the condition factor is not affected by the stage of development of fish gonads.

CHAPTER 3

MATERIALS AND METHODS

3.1 Sampling Site

Five abandoned tin mining ponds were chosen for sampling in UTAR, Perak campus. Three sites located apart from each other were chosen around each pond. Figure 3.1 shows the sampling locations and sites in Google Map image. Detailed images of locations in each site are shown in Figure 3.2. Table 3.1 tabulates the GPS coordinates of each sampling location.

Sampling was carried out at three locations per pond per day. One hour was allocated for sampling in each location. The field trip was performed from approximately 0700 to 1000. The first sampling trip was carried out on the 8^{th}, 9^{th}, 10^{th}, 11^{th} and 12^{th} of October; the second trip was done on the 1^{st}, 5^{th}, 6^{th}, 7^{th} and 8^{th} of November; and the third trip on the 3^{rd}, 4^{th}, 5^{th}, 6^{th}, and 7th of December.

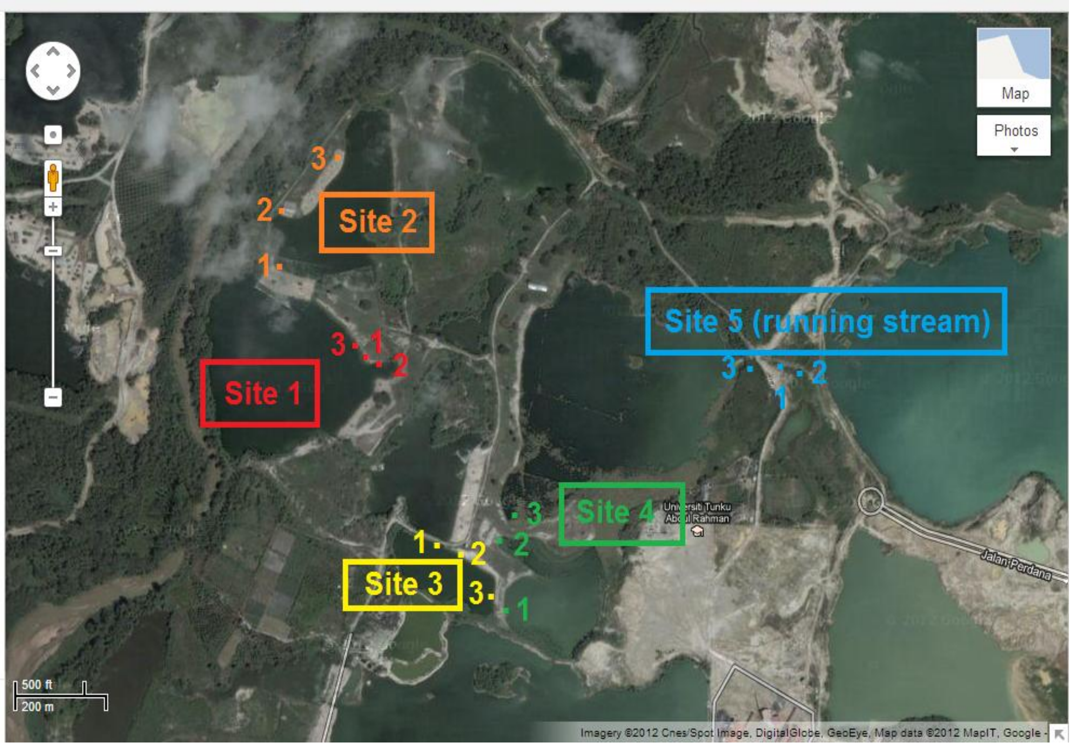


Figure 3.1 Sampling locations and sites in UTAR, Perak campus (Google Map Image). Three locations per sites were labeled as 1, 2 and 3 respectively.

(a)

(b)

(c)

(d)

(e)

(f)

Figure 3.2 Detailed location photos of locations in each site.

Site 1 – (a) Location 1 (b) Location 2 (c) Location 3

Site 2 – (d) Location 1 (e) Location 2 (f) Location 3

(g)

(h)

(i)

(j)

(k)

(l)

Figure 3.2 Detailed location photos of locations in each site (cont.).

Site 3 – (g) Location 1 (h) Location 2 (i) Location 3

Site 4 – (j) Location 1 (k) Location 2 (l) Location 3

(m)

(n)

(o)

Figure 3.2 Detailed location photos of locations in each site. (cont.)

Site 5 – (m) Location 1 (n) Location 2 (o) Location 3

Table 3.1 GPS coordinates of each location in all sites.

Sampling sites	Location	Latitude	Longitude
Site 1	1	N 4º 20’ 22.6”	E 101º 08’ 7.5”
	2	N 4º 20’ 22.3”	E 101º 08’ 7.8”
	3	N 4º 20’ 22.7”	E 101º 08’ 7.0”
Site 2	1	N 4º 20’ 28.8”	E 101º 08’ 0.7”
	2	N 4º 20’ 32.6”	E 101º 08’ 1.0”
	3	N 4º 20’ 35.0”	E 101º 08’ 5.3”
Site 3	1	N 4º 20’ 10.1”	E 101º 08’ 13.2”
	2	N 4º 20’ 9.3”	E 101º 08’ 14.1”
	3	N 4º 20’ 6.4”	E 101º 08’ 16.9”
Site 4	1	N 4º 20’ 5.6”	E 101º 08’ 16.9”
	2	N 4º 20’ 10.3”	E 101º 08’ 17.3”
	3	N 4º 20’ 12”	E 101º 08’ 17.8”
Site 5	1	N 4º 20’ 21.2”	E 101º 08’ 38”
	2	N 4º 20’ 21.3”	E 101º 08’ 37.5”
	3	N 4º 20’ 21.1”	E 101º 08’ 35.4”

3.2 Sampling Method

Random sampling around the shallow area of the ponds was carried out repeatedly. The apparatus used were hand nets and pails. Three hand nets differing in the aspect of mesh size, width, net length and total length were used as shown in Figure 3.3. Fishes and shrimps caught were placed in pails supplied with oxygen by air pumps. They were then brought back to the laboratory for species identification. The number of species collected were counted and recorded for species distribution. *Rhinogobius giurinus* was separated from others species for measurement purposes. After data collection is completed, all fishes and shrimps were released back to their original sites so as not to disturb the ecosystem.

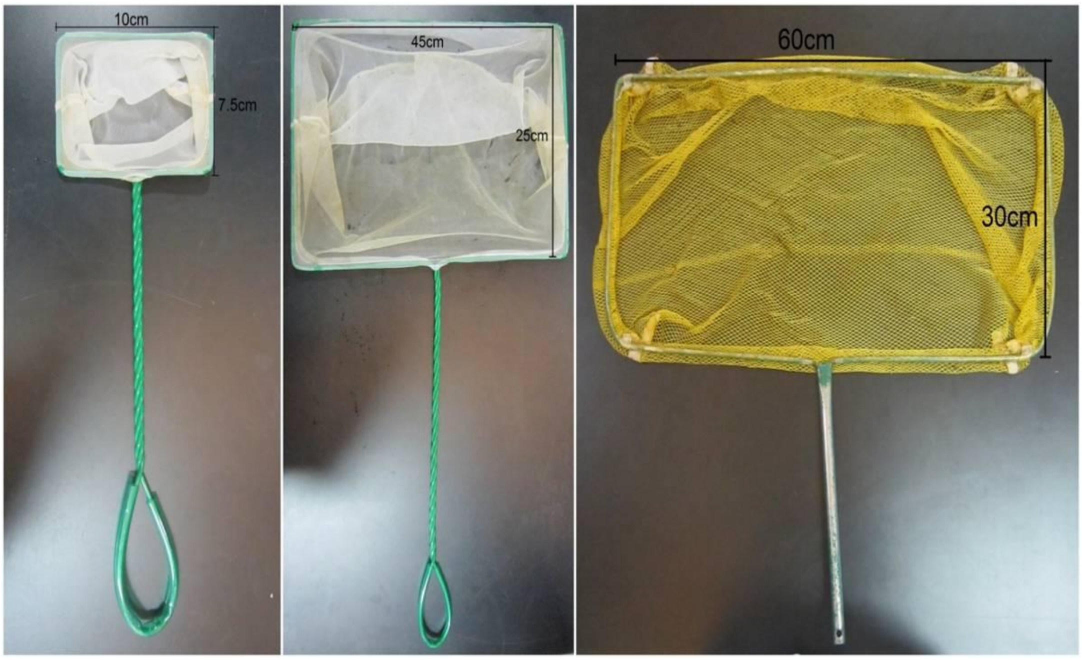


Figure 3.3 Types of hand nets used. The mesh size and total size of net (length and width) increases from left to right.

3.3 Measurement

3.3.1 Length Measurement

The length of *R. giurinus* was measured using a Vernier caliper which was calibrated prior to usage. Two types of measurement were taken: total length and standard length (Figure 2.1). For total length, the measurement started from the mouth of fish until the tip of caudal fin which has been closed. For standard length, the measurement was taken from mouth of fish until the end of fish body (exclusion of caudal fin).

3.3.2 Weight Measurement

The weight of *R. giurinus* was measured using an analytical balance, "Sartorius: CP225D". Calibration was carried out to ensure accuracy and reliability of readings. The fish was blotted with tissue paper first to remove excess water. It was then placed on a petri dish which has been set to zero on the analytical balance.

3.4 Statistical Analysis

3.4.1 Length-Weight Relationship (LWR)

The data collected were first log-transformed and entered into Statistical Package for Social Science (SPSS) software (Appendix B). A graph of $\log_{10} W$ against $\log_{10} L$ and its linear regression line (y = mx + c) was generated. By comparison to LWR linear equation ($\log_{10} W = \log_{10} a + b \log_{10} L$), the constants a and b was determined. The LWR analysis was performed per site in the aspect of total length and standard length, so in total there were five LWR equations for total length and five LWR equations for standard length. The LWR among sites was performed as well, generating another two LWR equations. By comparing the parameter b between sites, it was deduced which site is able to sustain isometry or allometry growth in *R. giurinus*.

In each graph, the correlation of determination, R^2 was generated as well. It indicated how much correlation exists between length and weight. The closer the R^2 value to 1, the more correlation exists between these variables. The square root of R^2 produces the correlation coefficient value, R.

3.4.2 Relative Condition Factor, K_n

The relative condition factor, K_n of total length and standard length in each site was calculated based on this formula, $K_n = W/W'$ where W = observed weight, W' = calculated weight. The observed weight, W was determined by substituting respective values obtained from LWR equation into this formula, $W = aL^b$. The value of K_n obtained indicated the fish condition in a particular site. The higher the value of K_n, the better the condition of fish in that site.

3.4.3 One-Way Analysis of Variance (ANOVA)

One-Way ANOVA was performed at 95% confidence level using SPSS to determine significant differences between mean of total length, standard length, weight and K_n (total length, standard length) between sites (Appendix B). The null hypothesis, H_0 for this test is that there is no significant difference in mean of tested variables (length, weight, K_n) between sites. The alternative hypothesis, H_1 is that there is significant difference in mean of tested variables (length, weight, K_n) between sites. If the significance value is greater than 0.05, the null hypothesis will be accepted. If the significance value is less than 0.05, the null hypothesis will be rejected and it can be concluded that there is significant difference in the mean of K_n between sites.

3.4.4 Tukey's Honestly Significant Difference (HSD)

When the null hypothesis in one-way ANOVA test is either rejected or accepted, Tukey's HSD test will be performed using SPSS to determine which site is different from each other (Appendix B). In the former case, Tukey's HSD can confirm which site is significantly different from other sites. For the latter case, it can further support the results of ANOVA in which there is no difference in mean between sites. Two assumptions were made: observations being tested are independent and there are equal variations across observations. The null hypothesis for Tukey's HSD is that there is no significant difference in means of tested variables between sites. The alternative hypothesis is that there is significant difference in means of tested variables between sites. The test was performed at 95% confidence level and if the significance value of a particular group in the result is less than the critical value ($p = 0.05$), it indicates that the mean of that particular group is different from each other.

3.5 Rainwater Collection

Three 5 liter water bottles tied to a funnel were set up at three locations to collect rainwater (Figure 3.4). The funnel functions to increase surface area for rainwater collection. Small stones were placed inside the bottle to avoid the bottle from tipping over due to strong wind. The measurement of rainwater was carried out once per week for three consecutive months (October to December) using measuring cylinder. For standardization purpose, the rainwater was measured every Monday. The volume of rainwater collected per week was summed up and recorded in ml/month. The rainwater from Location 1 was used for water quality analysis conducted once per month. Table 3.2 shows the GPS coordinates of the locations.

Figure 3.4 A 5 liter water bottle, tied to funnel was set up for rainwater collection.

Table 3.2 GPS coordinates of rainwater collection locations.

Location	Latitude	Longitude
1	4.339042	101.135577
2	4.334900	101.138041
3	4.339232	101.143894

3.6 Water Quality Analysis

Water parameter analysis test of pond water was conducted for all sites after each sampling trip. The temperature was taken immediately at all 3 locations per site using a mercury thermometer. The salinity of water samples were measured using ATAGO master – S/Millα Automatic Compensation Salinity Refractometer while the pH of the sample was measured using Eutech Instruments pH 700 meter. Other parameters include dissolved oxygen, iron, nitrate, nitrite, nitrogen ammonia, phosphorus, sulfate, turbidity and suspended solids were measured using Hach 890 Colorimeter based on step-by-step procedures given in the manual. The Hach 890 Colorimeter measures the absorbance of a particular light wavelength by a specific solution, whereby the amount of absorbance is proportional to concentration of the solute present in the solution. Table 3.3 summarises the methods and apparatus used for the water parameter analysis.

Table 3.3 List of methods and apparatus for water parameter analysis.

Parameter	**Apparatus**	**Method**
Dissolved oxygen	Hach 890 Colorimeter	HRDO method
Iron	Hach 890 Colorimeter	TPTZ method
Nitrate	Hach 890 Colorimeter	Cadmium Reduction method
Nitrite	Hach 890 Colorimeter	Diazotization method
Nitrogen ammonia	Hach 890 Colorimeter	Salicylate method
Phosphorus	Hach 890 Colorimeter	PhosVer3 (Ascorbic Acid) method
pH	Eutech Instrument pH 700 meter	-
Salinity	ATAGO master	-
Sulfate	Hach 890 Colorimeter	SulfaVer4 method
Suspended solid	Hach 890 Colorimeter	Photometric method
Temperature	Mercury thermometer	-
Turbidity	Hach 890 Colorimeter	Absorptometric method

CHAPTER 4

RESULTS

4.1 Number of *Rhinogobius giurinus* Sampled among Sites (October to December)

R.giurinus obtained in UTAR, Perak campus was shown in Figure 4.1. A total of 1214 *R. giurinus* were sampled in all sites from October to December (Table 4.1). Site 3 had the highest number of fish samples which were 378 in total, followed by Site 4 with 363 samples, Site 5 with 299 samples and Site 1 with 174 samples. None of the *R. giurinus* were obtained at Site 2 in three sampling months. The total number of samples obtained was highest in October (697 samples), decreased by half in November (395 samples) and by three-quarters in December (125 samples).

Figure 4.1 *Rhinogobius giurinus* obtained in UTAR, Perak campus.

Table 4.1 Numbers of *R. giurinus* sampled in sites 1, 2, 3, 4 and 5 from October to December 2012.

Site	**Month**			**Total**
	October	**November**	**December**	
1	57	91	26	174
2	0	0	0	0
3	313	44	21	378
4	120	224	19	363
5	207	36	56	299
Total	697	395	125	1214

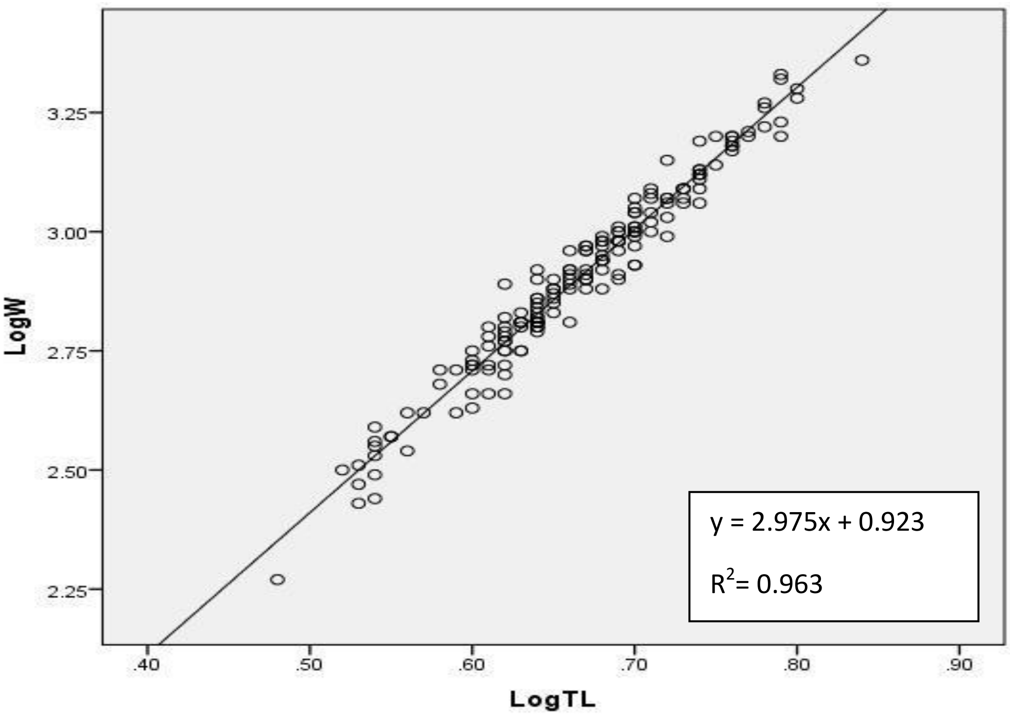
4.2 Length-Weight Relationships (LWR) of *Rhinogobius giurinus* in Different Sites.

4.2.1 LWR of *R. giurinus* in Site 1.

A total of 174 samples were collected from Site 1, each represented by white points in both graphs. The LWR graph for total length of *R. giurinus* from Site 1 is shown in Figure 4.2 (A). A linear relationship equation of *log W = 2.975 log TL + 0.923* is obtained. The coefficient of determination, R^2 is 0.963, indicating 96.3% of fish samples have variation in weight affected by total length.

Figure 4.2 (B) compares the relationship between weight and standard length of fish and is represented by *log W = 2.992 log SL + 1.19*. The R^2 value is 0.949, showing that 94.9% of samples have variation in weight influenced by standard length.

(A)



(B)

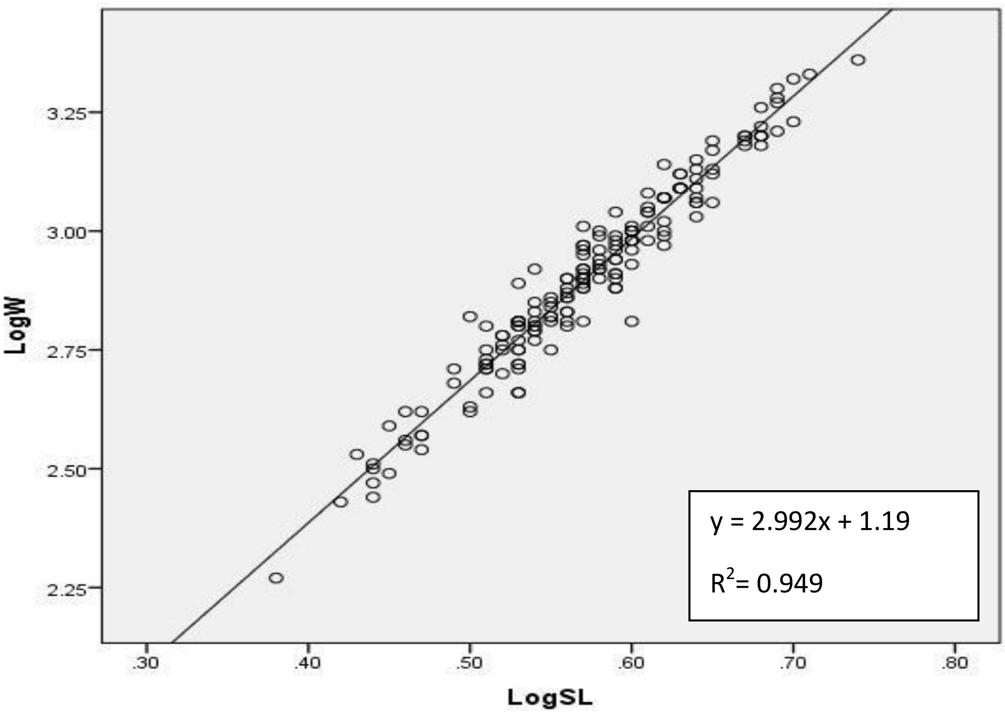


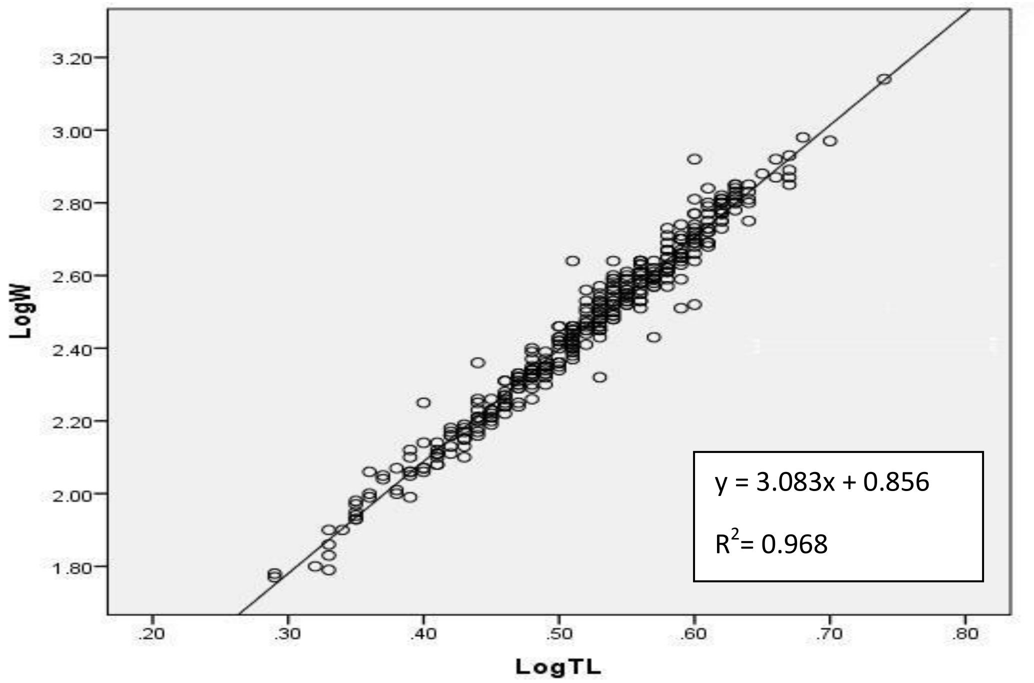
Figure 4.2 Length-weight relationship graphs of *Rhinogobius giurinus* in Site 1 in the aspect of (A) total length (B) standard length.

4.2.2 LWR of *R. giurinus* in Site 3.

In Site 3, a total of 378 samples were collected from October to December. Each individual sample is represented by white points in the graphs. The LWR equation in the aspect of total length is *log W = 3.083 log TL + 0.856* as shown in Figure 4.3 (A). The corresponding R^2 value is 0.968, showing that 96.8% of the variation in weight can be explained by total length.

A linear graph between weight and standard length expressed in logarithm form is shown in Figure 4.3 (B). The equation is *log W = 3.195 log TL + 1.062*, while the R^2 value is 0.942. Thus, 94.2% of the variability observed in weight can be explained by the standard length of the sample.

(A)



(B)

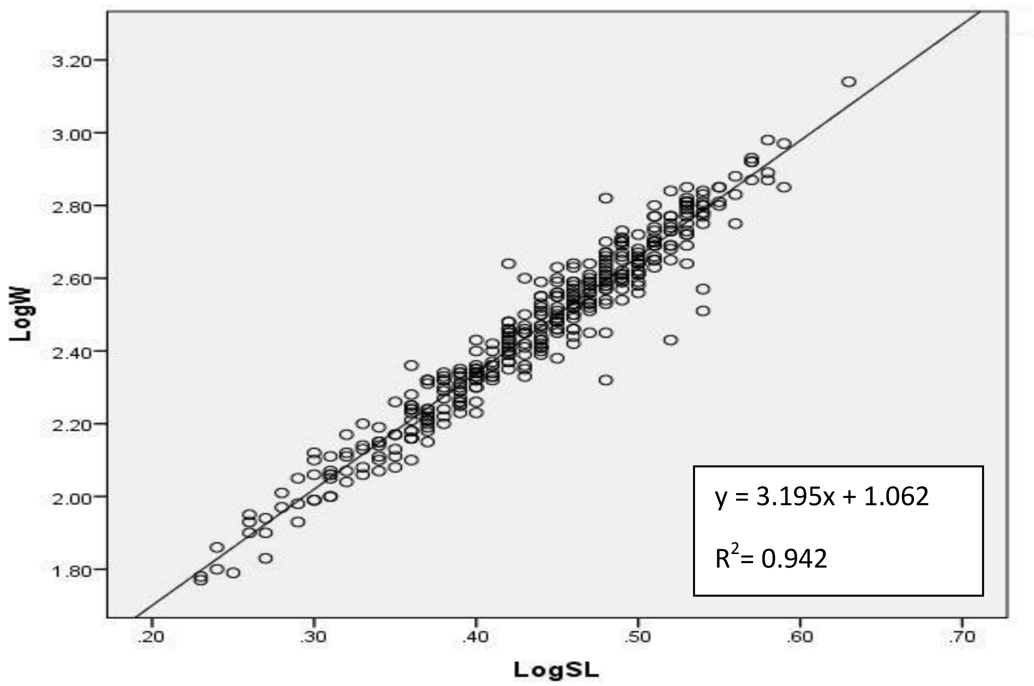


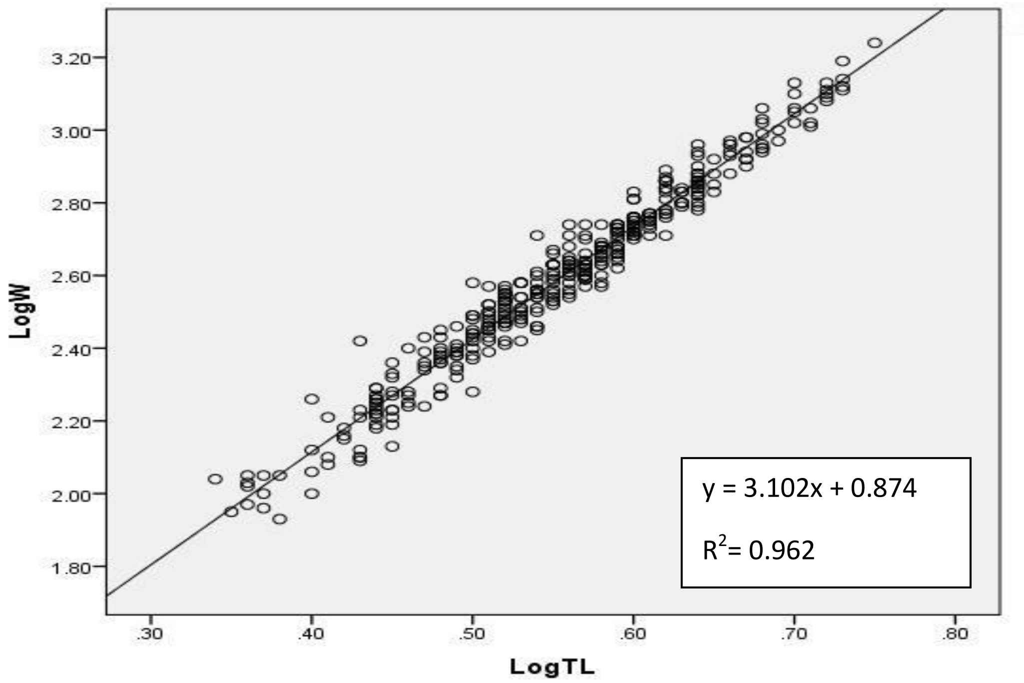
Figure 4.3 Length-weight relationship graphs of *Rhinogobius giurinus* in Site 3 in the aspect of (A) total length (B) standard length.

4.2.3 LWR of *R. giurinus* in Site 4.

For Site 4, 363 samples were obtained and represented by white points in graphs. The relationship between weight and total length in logarithm form is shown in Figure 4.4 (A) and represented by *log W = 3.102 log TL + 0.874*. The coefficient of determination (R^2) is 0.962 which means that 96.2% of the variation in weight can be explained by total length.

Figure 4.4 (B) shows the LWR graph in the aspect of standard length of *R. giurinus* from Site 4. The linear regression equation in the graph is *log W = 3.188 log SL + 1.105*, whereas the R^2 value is 0.959. This indicates that 95.9% of the variability in weight is influenced by standard length.

(A)



(B)

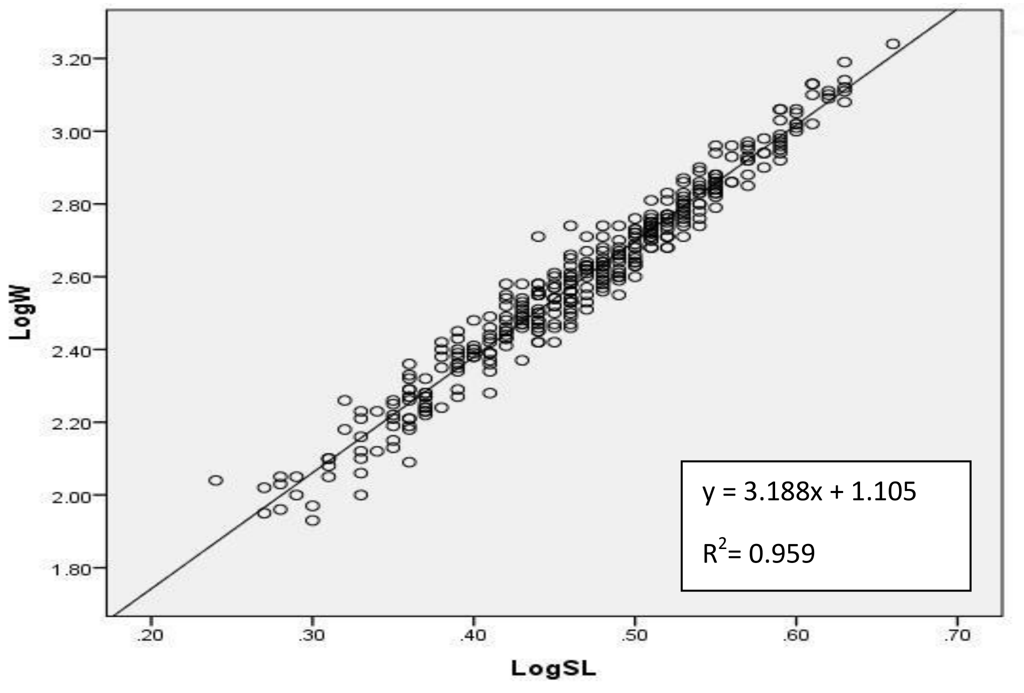


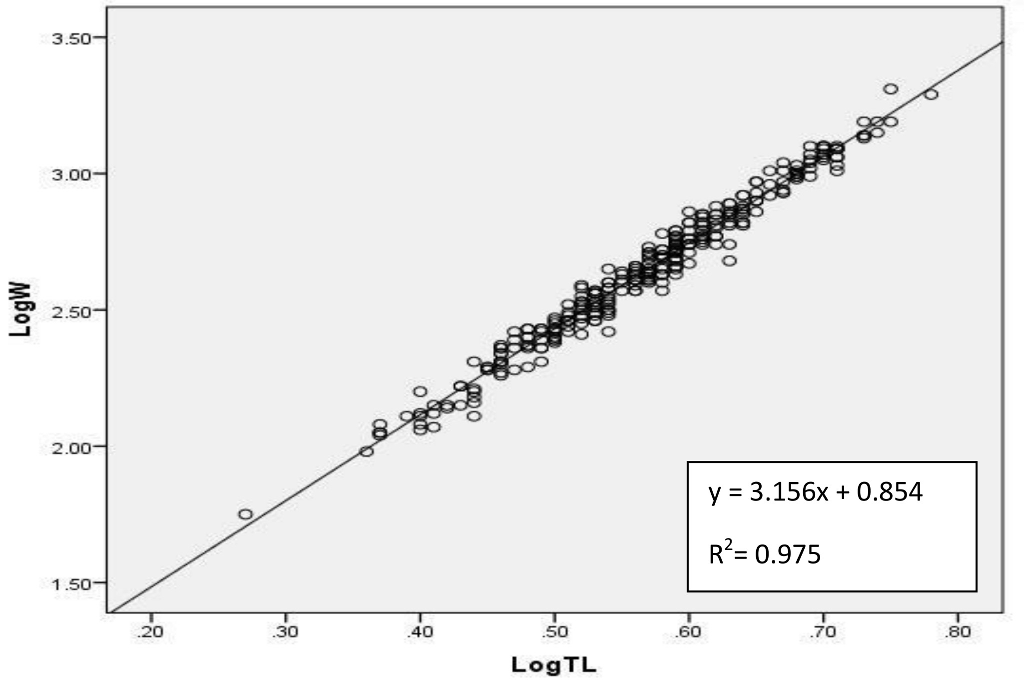
Figure 4.4 Length-weight relationship graphs of *Rhinogobius giurinus* in Site 4 in the aspect of (A) total length (B) standard length.

4.2.4 LWR of *R. giurinus* in Site 5.

For Site 5, a total of 299 *R. giurinus* were sampled, each represented by white point in graphs. Figure 4.5 (A) shows a linear graph of log W against log TL, represented by *log W = 3.156 log SL + 0.854*. The coefficient of determination is 0.975, showing that 97.5% of fish samples have variation in weight influenced by total length.

Figure 4.5 (B) compares the relationship between weight and standard length, represented by *log W = 3.207 log SL + 1.095*. The R^2 value is 0.971, indicating that 97.1% in variation of weight is affected by standard length.

(A)



(B)

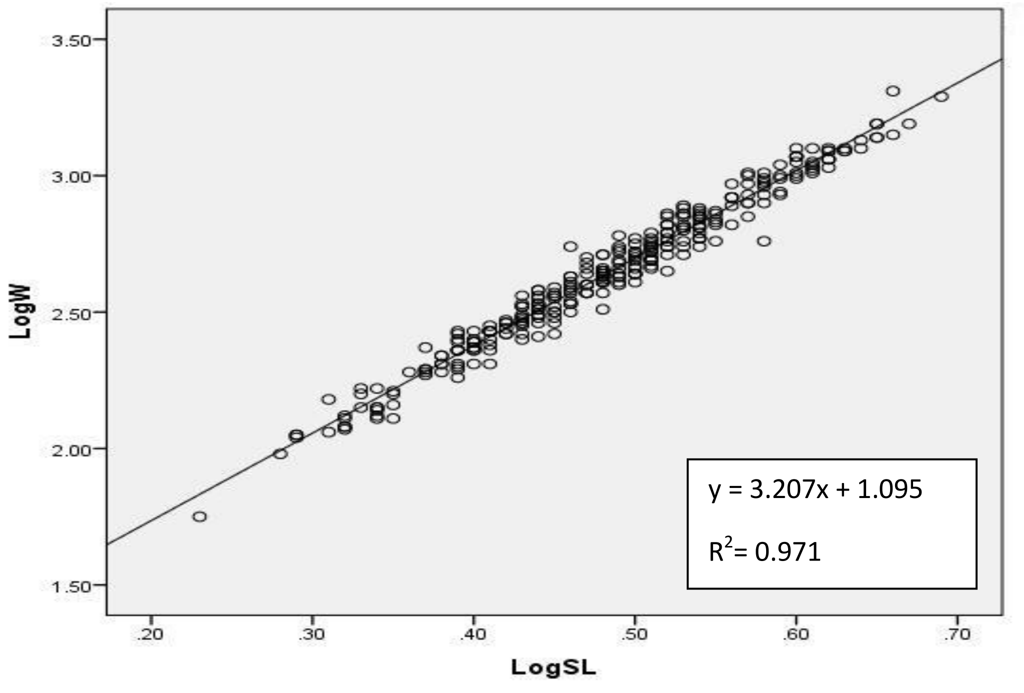


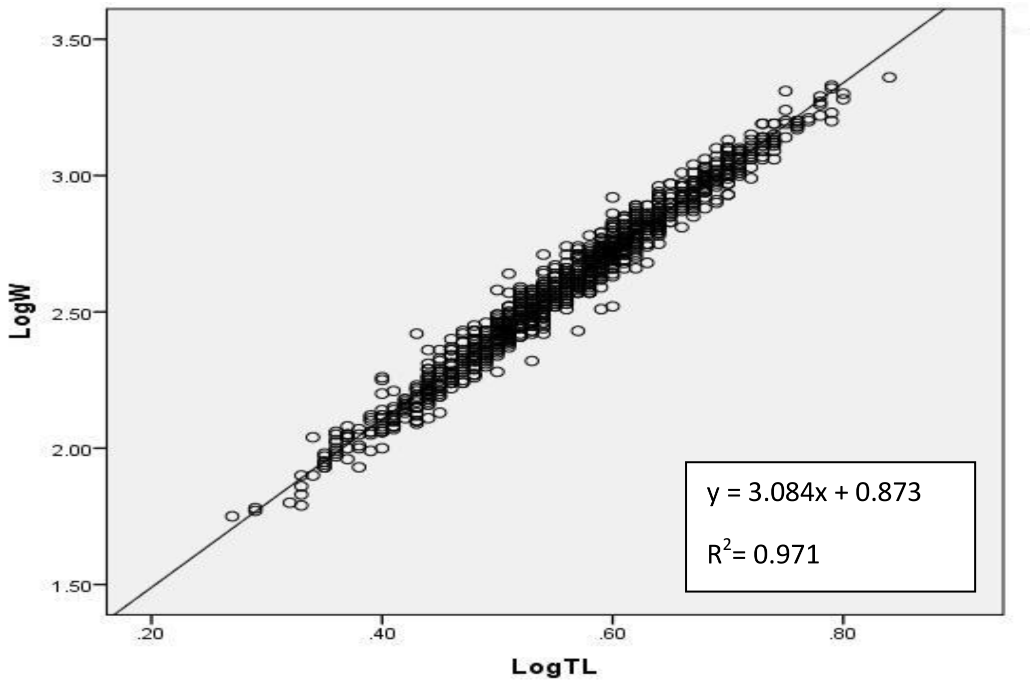
Figure 4.5 Length-weight relationship graphs of *Rhinogobius giurinus* in Site 5 in the aspect of (A) total length (B) standard length.

4.3 Overall Length-Weight Relationship (LWR) of *Rhinogobius giurinus* in All Sites.

Overall, 1214 samples in total were collected from all sites in three months. Each white point in the graph represents one individual sample. The LWR graph for total length of *R. giurinus* from all sites is shown in Figure 4.6 (A). The linear relationship equation is $log\ W = 3.084\ log\ TL + 0.873$, while the R^2 value is 0.971. This indicates that 97.1% of variation in weight can be explained by total length.

The LWR graph in the aspect of standard length is shown in Figure 4.6 (B), represented by $log\ W = 3.192\ log\ SL + 1.086$. There is a 96.2% of variation in weight which can be explained by standard length as $R^2 = 0.962$.

(A)



(B)

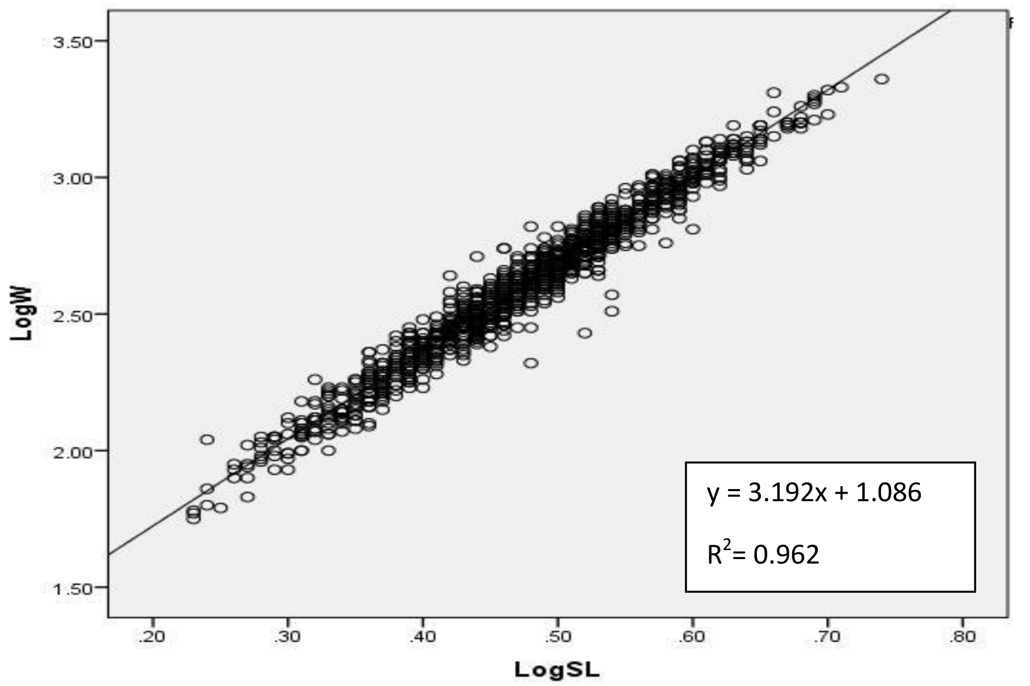


Figure 4.6 Length-weight relationship graphs of *Rhinogobius giurinus* in all sites in the aspect of (A) total length (B) standard length.

4.4 Parameters and Length-Weight Relationships in Each Site.

Parameters including constants *a*, *b*, R^2, r are tabulated in Table 4.2 for total length and standard length according to each site. The constants *a* and *b* are equivalent to the gradient (m) and y-intercept in linear equations. By substituting the respective value into $W = aL^b$, the calculated *W'* can be determined and applied to obtain the condition factor, K_n for each sample in all sites.

Table 4.2 Parameters and length-weight relationships in each site.

Site	Length	a	b	R^2	r	$W = aL^b$
1	TL	8.375	2.975	0.963	0.981	$W = 8.365L^{2.975}$
	SL	15.488	2.992	0.944	0.974	$W = 15.488L^{2.992}$
3	TL	7.178	3.083	0.968	0.984	$W = 7.178L^{3.083}$
	SL	11.535	3.195	0.942	0.970	$W = 11.535L^{3.195}$
4	TL	7.482	3.102	0.962	0.981	$W = 7.482L^{3.102}$
	SL	12.735	3.188	0.959	0.979	$W = 12.735L^{3.188}$
5	TL	7.145	3.156	0.975	0.987	$W = 7.145L^{3.156}$
	SL	12.445	3.207	0.971	0.985	$W = 12.445L^{3.207}$

*TL= total length; SL=standard length.

4.5 Relative Condition Factor, K_n

The relative condition factor, K_n is calculated by dividing the measured weight with calculated weight. The mean of K_n between and among sites is calculated and shown in Table 4.3. The mean for each site is approximately 1.0 ± 0.1 for both total length and standard length. The highest mean of K_n obtained is 1.008 for both length types in Site 4, while the lowest mean is 0.999 and 1.000 for total length and standard length in Site 1.

Table 4.3 The mean and standard deviation of K_n between and among sites.

Site	Length	Mean	Std. Deviation
1	TL	0.999	0.105
	SL	1.000	0.120
3	TL	1.005	0.102
	SL	1.008	0.135
4	TL	1.008	0.120
	SL	1.008	0.125
5	TL	1.006	0.099
	SL	1.005	0.108
All	TL	1.005	0.107
	SL	1.006	0.123

4.6 One-Way Analysis of Variance (ANOVA) and Tukey's Honestly Significant Difference (HSD) tests.

4.6.1 One-Way ANOVA and Tukey's HSD Tests for Total Length.

Table 4.4 Comparison of means of total length in all sites with (A) One-Way ANOVA test (B) Tukey's HSD test.

(A)

ANOVA

TotalLength

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	212.864	3	70.955	153.379	.000***
Within Groups	559.756	1210	.463		
Total	772.620	1213			

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

(B)

TUKEY'S HSD

Sampling site	Site 1	Site 3	Site 4	Site 5
Site 1	-	0.000***	0.000***	0.000***
Site 3	0.000***	-	0.000***	0.000***
Site 4	0.000***	0.000***	-	0.131
Site 5	0.000***	0.000***	0.131	-

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

Null hypothesis, H_0: there is no significant difference in means of total length between sites.

The result of the ANOVA test is shown in Table 4.4 (A) which includes the results of the analysis for omnibus hypothesis at 95% confidence level. The first row labeled ‘between groups’ gives variability due to sampling sites; second row labeled ‘within groups’ gives variability due to random error, third row sums up the total variability. The F-value is 153.379 and corresponds to p-value given as 0.000. The null hypothesis is rejected and it can be concluded that there is a significant difference in means of total length in all sites, $F(3, 1310) = 153.379$, $p < 0.001$.

The Tukey’s HSD analysis results are shown in Table 4.4 (B). The p-value for Site 4 - Site 5 is 0.131, whereas it is 0.000 for the rest of the sites comparison. Sites 1, 3 and 4 show significant difference in means of total length with other sites. There is no significant difference in average total lengths between Site 4 and Site 5.

4.6.2 One-Way ANOVA and Tukey's HSD Tests for Standard Length.

Table 4.5 Comparison of mean of standard length in all sites with (A) One-Way ANOVA test (B) Tukey's HSD test.

(A)

ANOVA

StandardLength

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	121.100	3	41.367	140.337	.000***
Within Groups	356.667	1210	.295		
Total	480.767	1213			

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

(B)

TUKEY'S HSD

Sampling site	Site 1	Site 3	Site 4	Site 5
Site 1	-	0.000***	0.000***	0.000***
Site 3	0.000***	-	0.000***	0.000***
Site 4	0.000***	0.000***	-	0.022*
Site 5	0.000***	0.000***	0.022*	-

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

Null hypothesis, H_0: there is no significant difference in means of standard length between sites.

The ANOVA test table shows the results of analysis for omnibus hypothesis at 95% confidence level in Table 4.5 (A). The ‘between groups’ row gives variability due to sampling sites; ‘within groups’ gives variability due to random error; both variabilities are summed up in the third row. The F-value is 140.337 and its p-value is given as 0.000. The null hypothesis is rejected and it can be concluded that there is a significant difference in means of total length in all sites, $F(3, 1210) = 140.337$, $p < 0.001$.

Tukey’s HSD analysis is conducted at 95% confidence level and the result is tabulated in Table 4.5 (B). From the result, all sites have significant differences in means of standard length with each other, with p-value less than 0.05.

4.6.3 One-Way ANOVA and Tukey's HSD Tests for Weight.

Table 4.6 Comparison of weight in all sites with (A) One-Way ANOVA test (B) Tukey's HSD test.

(A)

ANOVA

Weight

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	36874561.33	3	12291520.44	140.471	.000***
Within Groups	105877401.1	1210	87501.984		
Total	142751962.4	1213			

Note: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

(B)

TUKEY'S HSD

Sampling site	**Site 1**	**Site 3**	**Site 4**	**Site 5**
Site 1	-	0.000***	0.000***	0.000***
Site 3	0.000***	-	0.000***	0.000***
Site 4	0.000***	0.000***	-	0.015*
Site 5	0.000***	0.000***	0.015*	-

Note: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

Null hypothesis, H_0: there is no significant difference in means of weight between sites.

In Table 4.6 (A), ANOVA analysis results in comparing means of weight between sites at 95% confidence level is shown. The ‘between groups’ row indicates variability due to sampling sites; and the ‘within groups’ row represents variability due to random error. For this analysis, the F-value and p-value are 140.471 and 0.000 respectively. As the p-value is less than the significant value, the null hypothesis is rejected and it is concluded that there is a significant difference in means of weight in all sites, $F(3, 1210) = 140.471$, $p < 0.001$.

Table 4.6 (B) shows the analysis results of Tukey’s HSD at 95% confidence level. The p-values for all site comparison are less than the significant value (0.05). This indicates that all sites have significant differences in means in weight with each other.

4.6.4 One-Way ANOVA and Tukey's HSD Tests for Relative Condition Factor (K_n) of Total Length.

Table 4.7 Comparison of relative condition factor (K_n) of total length in all sites with (A) One-Way ANOVA test (B) Tukey's HSD test.

(A)

ANOVA

KnTL

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	0.010	3	0.003	0.285	0.836
Within Groups	13.971	1210	0.012		
Total	13.981	1213			

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

(B)

TUKEY'S HSD

Sampling site	**Site 1**	**Site 3**	**Site 4**	**Site 5**
Site 1	-	0.933	0.806	0.883
Site 3	0.933	-	0.981	0.997
Site 4	0.806	0.981	-	0.988
Site 5	0.883	0.997	0.998	-

Note: * p < 0.05, ** p < 0.01 and *** p < 0.001

Null hypothesis, H_0: there is no significant difference in means of relative condition factor (K_n) of total length between sites.

The One-Way ANOVA result is shown in Table 4.7 (A). The first row labeled ‘between groups’ represents variability due to sampling sites while the second row labeled ‘within groups’ represents variability due to random error. In the result, F-value is 0.285 and the corresponding p-value is given as 0.836. As p-value is greater than the significant value (0.05), the null hypothesis is accepted and it can be concluded that there is no significant difference in means of relative condition factor (K_n) between sites, $F (3, 1210) = 0.285$, $p > 0.05$.

The Tukey’s HSD result is shown in Table 4.7 (B). The p-values for all site comparison are greater than the significant value (0.05). Thus, there is no significant difference in means of relative condition factor (K_n) between all sites.

4.6.5 One-Way ANOVA and Tukey's HSD Tests for Relative Condition Factor (K_n) of Standard Length.

Table 4.8 Comparison of Total Relative Condition Factor (K_n) of Standard Length in all sites with (A) One-Way ANOVA test (B) Tukey's HSD test.

(A)

ANOVA

KnSL

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	0.009	3	0.003	0.205	0.893
Within Groups	18.420	1210	0.015		
Total	18.430	1213			

Note: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

(B)

TUKEY'S HSD

Sampling site	**Site 1**	**Site 3**	**Site 4**	**Site 5**
Site 1	-	0.907	0.885	0.972
Site 3	0.907	-	1	0.994
Site 4	0.885	1	-	0.988
Site 5	0.972	0.994	0.988	-

Note: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$

Null hypothesis, H_0: there is no significant difference in means of relative condition factor (K_n) of standard length between sites.

The ANOVA test table (Table 4.8 (A)) shows results of analysis in comparison of means of relative condition factor (K_n) in the aspect of standard length at 95% confidence level. The ‘between groups’ row gives variability due to sampling sites; ‘within groups’ gives variability due to random error; both variabilities is summed up in third row. The F-value is 0.205 and its p-value is given as 0.893. The null hypothesis is accepted and it can be concluded that there is no significant difference in means of relative condition factor (K_n) of standard length in all sites, $F (3, 1210) = 0.205$, $p > 0.05$.

The Tukey’s HSD analysis is conducted at 95% confidence level and the analysis result is shown in Table 4.8 (B). From the result, all sites have no significant differences in means of relative condition factor (K_n) of standard length with each other, with p-value greater than 0.05.

4.7 Rainfall Measurement in Three Sampling Sites in Three Months.

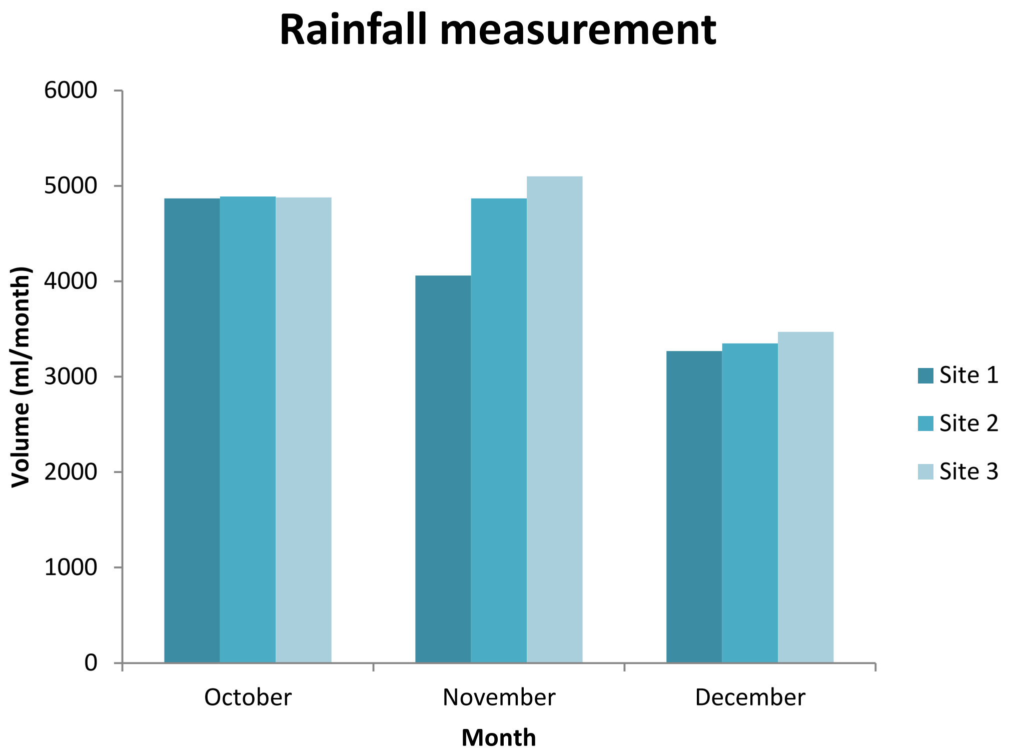


Figure 4.7 Rainfall measurements for site 1, 2 and 3 for three consecutive months from October to December 2012.

In Figure 4.7, it is observed that there is a decreasing trend in volume from October to December in Sites 1 and 2, while a fluctuating trend is observed in Site 3. All three sites have lowest volume of rainfall in December which was 3270 ml (Site 1), 3350 ml (Site 2) and 3470 ml (Site 3). The highest rainfall volume recorded for Site 1 and 2 were 4870 ml and 4890 ml respectively in October, while the highest rainfall volume for Site 2 is 5100 ml in November.

4.8 Water Parameter Analysis

Water analysis was carried out to investigate parameters include nitrate, nitrite, ammonia, phosphorus, sulphate, ferum, dissolved oxygen, turbidity, suspended solid, salinity, temperature and pH in each site. The results for these parameters in each site were tabulated in Table 4.7. Nitrate concentration was highest in site 5 (1.09 mg L^{-1}) and lowest in site 3 (0.22 mg L^{-1}), meanwhile result of nitrite concentration was similar in all sites. The ammonia concentration for site 2, 3 and 4 was less than 0.1 mg L^{-1}, but was higher than 0.3 mg L^{-1} in site 1 and 5. Phosphorus concentration was highest in site 3 (0.08 mg L^{-1}), lowest in site 1, 2 and 4 (0.02 mg L^{-1}). For sulphate, it was recorded highest in site 1 (4.67 mg L^{-1}), lowest in site 3 (0.00 mg L^{-1}). Ferum concentration was highest in site 5 (0.72 mg L^{-1}), lowest in site 2 (0.24 mg L^{-1}). For dissolved oxygen, it was lowest at site 2 (5.27 mg L^{-1}) and highest at site 1 (8.70 mg L^{-1}). Turbidity was highest in site 3, 4 and 5 with 42.33 FAU, 45.21 FAU and 31.56 FAU, was lowest in site 1 and 2 with 20.09 FAU and 21.78 FAU. On the other hand, suspended solid in site 1 and 2 was lower than rest of the sites. In site 1 and 2, the suspended solid was 10.43 mg L^{-1} and 12.22 mg L^{-1} respectively. For site 3, 4 and 5, the reading was 28.1 mg L^{-1}, 29.9 mg L^{-1} and 25.56 mg L^{-1} respectively. Salinity was zero for all sites. The temperatures for all sites are relatively equal with approximately 29 ℃. The pH for all sites ranged from the lowest at site 5 (7.30 mg L^{-1}) to highest at site 1 (8.22 mg L^{-1}).

Table 4.9 Average water parameter analysis according to each site.

Water parameter	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Nitrate (mg L^{-1})	0.93	1.06	0.22	0.61	1.09
Nitrite (mg L^{-1})	0.01	0.01	0.01	0.00	0.01
Ammonia (mg L^{-1})	0.34	0.03	0.06	0.09	0.36
Phosphorus (mg L^{-1})	0.02	0.02	0.01	0.02	0.06
Sulphate (mg L^{-1})	4.67	0.67	0.00	0.67	0.33
Ferum (mg L^{-1})	0.26	0.24	0.38	0.42	0.72
Dissolved oxygen (mg L^{-1})	8.70	5.93	7.53	7.60	5.27
Turbidity (FAU)	20.09	21.78	42.33	45.21	31.56
Suspended solid (mg L^{-1})	10.43	12.22	28.1	29.99	25.56
Salinity (mg L^{-1})	0	0	0	0	0
Temperature (℃)	29.77	29.99	29.43	29.21	29.6
pH	8.22	7.62	7.85	8.18	7.30

CHAPTER 5

DISCUSSION

5.1 Fish Sampling

The sampling period was carried out from October to December. The number of species sampled per month decreased by half from month to month. This may be due to the water level of the pond. The water levels in November and December were higher than in October. The shallow area around the pond became flooded thus restricting the sampling area. The *Rhinogobius giurinus* lives in sandy area at the bottom of the pond. As the sampling area is restricted, the chance of getting R. giurinus is greatly reduced, leading to a decrease in sample size in November and December.

The highest number of *R. giurinus* was obtained in Site 3 followed by Site 4. Both of these pond sites are located beside each other. This could be due to suitable habitat and food abundance which increases species abundance in these ponds. In Site 2, none of *R. giurinus* was caught for all three months. This pond is different from others as the base of the pond floor is rocky instead of sandy. Considering the geographic characteristic of this pond, *R. giurinus* may not able to adapt here as its usual habitat is sandy area.

5.2 Length-Weight Relationship

The length-weight relationship graphs between and among sites showed a linear relationship between length (total length, standard length) and weight. This implies that when the length of a fish increases, its weight increases too. The value of *b* between sites ranged from 2.975 (lowest) to 3.156 (highest) for total length; and 2.992 (lowest) to 3.207 (highest) for standard length. The common range of *b* is within 2.5 to 3.5 (Gayanilo and Pauly 1997). Samat et.al (2008) deduced that the value of *b* for most temperate and tropical fishes ranged from 2.7 to 3.3. The *b* value in this study is within both ranges.

With $b = 3$, it indicates isometric growth in fishes, while values deviating significantly from 3 indicates allometric growth. When $b < 3$, the fishes are said to be in negative allometric growth pattern (Isa et al., 2010). When $b > 3$, the fishes are experiencing positive allometric growth. Isometric growth pattern was observed in Site 1 with $b = 2.975$ for total length and $b = 2.992$ for standard length. In other sites including Sites 3, 4 and 5, fishes are experiencing positive allometric growth. This implies that these sites are able to sustain positive allometry growth in *R. giurinus*. Overall, the LWR among sites showed a positive allometry growth in *R. giurinus* with $b = 3.084$ for total length and $b = 3.192$ for standard length. Thus, it can be concluded that ex-tin mining ponds are able to sustain isometry or positive allometry growth in *R. giurinus*. Ye et al. (2007) reported this species in Niushan Lake, China having isometric growth with *b* value of 2.983 for a sample size of 27. A related species, *Glossogobius giuris* in Ganges of Northwestern Bangladesh has isometric growth (Hossain et al., 2009). The differences in values of *b* could be due to external factors such as habitat, temperature, food availability and internal factors such as fish activities, seasonal growth rates and food habits (Le Cren 1951; Isa et al., 2010).

In comparison of sex, the *b* value of a female is greater than male for a given species. This condition has been observed in *Gerres oblongus* (Sivashanthini and Abeyrami 2003), *Schizopyge esocinus* (Dar et al., 2012), *Blicca bjoerkna* (Yilmaz et al., 2012), *Glossogobius giuris* (Hossain et al., 2009). The condition of fish upon catching such as stomach fullness, health, and maturity can affect length-weight relationship (Cherif et al., 2008). The length-weight relationship between sites in this study is found to be different from each other for same species. Hossain (2010) stated that variation in *b* for same species could be due to differences in sampling, sample size, length range, age, maturity, food and environmental factor.

The difference in length-weight relationship occurs between species as well as among species (Kimmerer et al., 2005). They summarized that there were three categories: biological, procedural and statistical, which lead to differences in length-weight relationship in single species of fish. Biological differences refer to the real differences in length and weight; procedural differences include differences in sample collection and measurements; statistical differences are the differences due to analysis method. Differences in LWR for a single fish species can occur when the sampling is carried out at different places as well as times (Kimmerer et al., 2005). The constant *b* can also act as indicator of the body shape of fish. When *b* is greater than 3, the fish tends to be fatter and it tends to be thinner when *b* values are less than 3 (Offem et al. 2009). Thus, fishes from Site 3, 4 and 5 are fatter than they should be while fishes in Site 1 have normal bodies that are isometric to their length.

In addition, the values of *b* in samples collected from Site 5 are the highest for both length types. Site 5 is a fast-running stream and this may contribute to faster growth rate in fishes in this area. Mustafa (1978) stated in his findings that fishes living in running water have a higher growth rate in comparison to those in static water. In the study of spiny eel, *Macrognathus pancalus* by Pathak et al. (2013), the value of *b* was higher in fishes collected from river than from ponds. They suggested that this may be due high oxygen concentration, water circulation and forage organisms to fish. In a study of *Lateolabrax japonicas* by Shahidul et al, (2006), the fishes caught upstream had better condition than downstream.

In the aspect of length-length comparison, it was observed that the *b* value in total length was lower than in standard length. Different length types such as total length, fork length and standard length will influence the length-weight relationship. Frota et al. (2004) reported that *b* value from standard length tends to be lower than total length when compared between different species. However, in the same studies, the total length data yielded smaller *b* value than standard length data in comparison between same species. For example, *Anchovia clupeoides, Genidens genidens, Urophycis cirrata* had a higher *b* value for standard length compared to total length (Frota et al., 2004).

The parameter *a* is relatively unstable or differ from site to site as well as in the aspect of length type. The *a* value ranged from 7.145 to 8.375 for total length; 11.535 to 15.488 for standard length. Its value was much lower for total length compared to standard length. For site to site comparison, the value of *a* obtained in Site 3 was lowest: 7.178 for total length, 11.535 for standard length. Meanwhile, the highest value was obtained in Site 1 with 8.375 for total length, 15.488 for standard length. For parameter *b*, it was relatively stable for either site-site or length type comparison. It ranged from 2.975 to 3.156 for total length and 2.992 to 3.207 for standard length. The difference of *b* value was relatively small with deviation less than 0.3. The parameter *a* may vary temporally as well as between habitats while the value for parameter *b* remains relatively constant for a given life phase (Bagenal and Tesch, 1978).

Ratner (n.d.) defined correlation coefficient, r as the measure of strength or linear relationship between two variables. It has the range from -1 to +1, in which -1 means there is a perfect negative linear relationship between the variables, 0 indicates no linear relationship, while 1 shows there is a perfect positive linear relationship between variables. In this study, the correlation coefficient of LWR obtained ranged from 0.981 to 0.987 (total length) and 0.970 to 0.985 (standard length). These values suggest that there is a strong positive linear relationship between length and weight via a firm linear rule (Ratner n.d.). Correlation of determination, devoted by R^2 is obtained by square of correlation coefficient, r. It is defined as the percentage of variation in one variable explained by another variable (Ratner n.d.). It is an indicator of the quality of the linear regression (Scherrer 1984, cited in Hossain et al., 2009). The higher the value of R^2, the more reliable is the obtained data. The correlation of determination obtained in this study is relatively high with $R^2 > 0.9$. This indicates that more than 90% of *R. giurinus* had variation in weight can be explained by the linear relationship between length and weight. Thus, the length data can provide a lot of information on the weight of *R. giurinus* and it can be used to predict expected weight for a given length based on linear regression equation.

5.3 Mean of Length and Weight

In the aspect of mean of total length and standard length, it was concluded that the means of these length among sites were significantly different based on One-Way ANOVA result. From the Tukey's HSD result, it clearly showed that the means of both length types in every site were different from each other. This may be due to sampling method and time, population density and environment of studied site (Yilmaz et al., 2012). For this study case, the differences of length may be due to fish size or the length range caught in each pond is different from each other. In some ponds, the goby obtained is larger or greater in length as compared to others. For instance, the range for total length in Site 1 was 2.990 to 6.870 cm; in Site 3 was 1.944 to 5.470 cm; in

Site 4 was 2.180 to 5.590 cm; in Site 5 was 1.848 to 6.080 cm. As the weight is affected by length, it is expected that the mean of weight among sites will be significantly different given that the mean of length is significantly different. This statement is proven by ANOVA and Tukey's HSD result on mean of weight.

5.4 Relative Condition Factor, K_n

The relative condition factor was studied to determine the general well-being or condition of fish (Le Cren 1951). The underlying hypothesis for this factor is that for a given length, a heavier fish is said to be in a better condition (Froese 2006; Sivashanthini and Abeyrami 2003). The K_n for any species will have the value of 1, regardless of the unit measurement (Anderson and Neumann 1996). For K_n value more than 1, it indicates good condition of fish (Le Cren 1951). For K_n value less than 1, it indicates slow growth rate in a fish which may be caused by disease and high population density (Zakeyuddin et al., n.d.). In this study, the mean of K_n obtained among sites were 1.005 ± 0.107 for total length and 1.006 ± 0.123 for standard length, indicating fishes in ex-tin mining ponds are in good condition. Based on One-Way ANOVA, there was no difference in mean of relative condition factor among sites for both length types. This result was supported by Tukey's HSD analysis. This concluded that there was no difference in the aspect of environment conditions such as food availability that affect the fish condition.

The condition factor of a species can be affected by factors such as gonad development, pollution, spawning, sex and food abundance (Froese 2006; Williams 2000; Shafi and Yousuf 2012). Isa et al. (2010) attributed the variability of K_n in *Devario regina* in four sampling sites to food availability and habitat. In a study on *Puntius conchonius*, Shafi and Yousul (2012) suggested that variability in relative condition factor in six species may be due to gonad development, food abundance and gastral activity. Dars et al. (2010) found out that the relative condition factor was different for male and female of *Labeo gonius* and females tend to be in better conditions than male. Similar condition was observed in *Heterobranchus longifilis* carried out by Anibenze (2000) at Idodo River, Nigeria. The relative condition factor in female *Gerrus oblongus* was found to be decreased during spawning season (Sivashanthini and Abeyrami 2003). Similar trend has been observed in *Schizopyge esocinus* (Dar et al., 2012).

5.5 Rainfall

Obtained rainfall volume was different in three sites where the rainfall volume in Sites 1 and 2 was decreasing over months, whereas in Site 3 the rainfall volume was increasing in November followed by decreasing in December. Rainfall volume measurements may have significant spatial variability even in small sampling areas (Hayashi and van der Kamp 2007) .To achieve more accurate results, multiple rainfall collectors should be distributed in the study area (Hayashi and van der Kamp 2007). Overall, the rainfall in Kampar, Perak achieved highest volume in October with total volume of 14640ml from all three sites, followed by November and December with total of 14030ml and 10090ml respectively. This data is considered reliable as the average rainfall in Kampar, Perak over the past ten years (2002 to 2012) provided by worldweatheronline.com (Appendix 3) shows similar result in which October had the highest rainfall volume, followed by a slight decrement of volume in November as well as in December.

Rainfall volume is directly related to the monsoon season in Malaysia. According to General Climate of Malaysia from met.gov.my, the rainfall pattern is two periods of maximum rainfall separated by two periods of minimum rainfall. The maximum rainfall periods are in April to May and October to November. Meanwhile, minimum rainfall periods are in January to February and June to July.

The rainfall volume is related to water level in the pond. In November and December, the water level was relatively higher than in October. The first field sampling was carried out on the first week of October while the raining season has not begun. Therefore, the water level of the pond was lower in October than in following months. When the raining season started, rainwater increased the water volume in pond. Evaporation rate also affects the pond water volume and it is affected by temperature and humidity (Malaysian Meteorological Department n.d.). During rainy months, the evaporation rate is lower, while in dry season, the rate is higher (Malaysian Meteorological Department n.d.). As the humidity during raining season was relatively high, the evaporation rate of pond water became slower, resulting in a higher pond water level and flooding of shallow area around pond.

5.6 Water Parameter Analysis

The dissolved oxygen level in these pond waters ranged from 5.93 mg L^{-1} to 8.70 mg L^{-1}. It was within normal range of a healthy pond (Sallenave 2012). For a closed water system, the oxygen is contributed by phytoplankton (chap 5). The higher the temperature, the lower the concentration of dissolved oxygen (Sallenave 2012). However, temperature in all sites are similar, thus it was not a factor affecting concentration of dissolved oxygen in pond water. Theoretically, site 5 should have higher dissolved oxygen compared to other sites because oxygen is more diffusible in flowing water than stagnant water (Allan and Castillo 2007). However, dissolved oxygen in site 5 was relatively low and this may due to death of algae. Decomposition of algae and dead materials by bacteria reduced oxygen (Sallenave 2012; Swistock et al., 2006).

Ammonia is a form of nitrogen that produced by fish and decomposition of organic matter (Sallenave 2012). It exists in two interchangeable forms: unionised form (NH3) and ionized form ammonium (NH4+) (Sallenave 2012). The former form is toxic and formed when water is alkaline, while latter form is non-toxic, formed when water is acidic. Ammonia concentration in site 1 and 5 were higher than other sites. For site 1, it was due to poor phytoplankton bloom. For site 5, it may due to human waste products discharged from nearby buildings. In comparison of mean of relative condition factor among sites, *R.giurinus* seems to tolerate high ammonia level in site 1 and 5. The ammonia can be broken down into nitrite and nitrate by nitrifying bacteria in the presence of oxygen. Nitrite is more toxic compared to nitrate. Normally, the concentration of nitrite is much lower than nitrate (Sallenave 2012). This statement was supported by water parameter analysis.

Turbidity was highest in site 3 and 4. These two ponds have a muddier floor compared to other ponds. Besides, algae bloom was contributed to high turbidity in these ponds. Suspended solid is defined as fine particles of soil to which bacteria and viruses attached to. Suspended solid and turbidity are close related to each other. Hence, high suspended solid indicated high amount of soil for bacteria attachment and leaded to high turbidity. The pH values of ponds were relatively consistent, ranged from 7.62 to 8.22. The value is above 7 indicate alkaline or basic condition of the water (Sallenave 2012). Slight alkalinity of pond water was due to presence of limestone in pond (Tan 2006).

Phosphorus present in pond water was in the form of phosphate (Sallenave 2012). According to Sallenave (2012), one gram of phosphorus will produce 100g of algal biomass. Phosphorus level was highest in site 5. Algal bloom was observed in this pond. In site 3 and 4, algal bloom was also observed but the phosphorus level was low compared to site 5.

5.6 Future Study

As an introduced species, *R. giurinus* is well-adapted to freshwater in Malaysia given that LWR in this study shows positive allometry growth (Chong et al., 2010). In this study, a high number of this species was caught in ex-tin mining ponds. This situation could be worrying as in previous studies, this species may be responsible for the extinction of *Pseudogobiopsis oligactis* and *Eugnathogobius siamensis* in Singapore (Larson et al., 2008). During this project, this species was observed to feed on juveniles of snakehead. If this situation continues to be neglected, there will be a risk that juveniles or native small species will decline or even be extinct.

In addition, not many studies have been done on this species in Malaysia. Future studies on influence of monsoon, dry season, gender and gonad development on the growth pattern of this species can be carried out. Besides, study could be done to investigate the impact of this introduced species on other native species. Meristic features, body shape and specific coloration patterns on this species could be studied to compare the differences of this species between Malaysia and other countries such as China and Korea.

CHAPTER 6

CONCLUSIONS

The species studied in this research was *Rhinogobius giurinus*, also known as barcheek goby or oriental river goby which was an introduced species in Malaysia (Chong et al., 2010). The length-weight relationship was studied to determine the growth condition of *R. giurinus* in freshwater ecosystem of ex-tin mining ponds. SPSS software was used to carry out analysis on length-weight relationship, One-Way ANOVA and Tukey's HSD. A graph of $\log_{10}$ W against $\log_{10}$ TL or $\log_{10}$ SL and respective linear regression equation were generated. The LWR for site 1 (isolated pond located beside UTAR Sport Complex) was $W = 8.365L^{2.975}$ for total length, $W = 15.488L^{2.992}$ for standard length. For site 3 (small pond besides parking lot of UTAR Sport Complex), the LWR equation was $W = 7.178L^{3.083}$ for total length, $W = 11.535L^{3.195}$ for standard length. The LWR equation of total and standard length obtained was $W = 7.482L^{3.102}$ and $W = 12.735L^{3.188}$ respectively for fishes in Site 4 (large pond located beside Block B; in front of Block C). Meanwhile, the LWR equation for Site 5 (fast running stream between Block E and Block F) was $W = 7.145L^{3.156}$ for total length, $W = 12.445L^{3.207}$ for standard length. The parameter *b* is an indicator of growth pattern in fishes. The fishes are in isometric growth pattern when b = 3, while in negative allometric growth when b < 3, positive allometric growth when b > 3. Overall, the *R. giurinus* exhibited isometric growth in Site 1 and positive allometric growth pattern in

Sites 3, 4 and 5. The correlation coefficient (r) and coefficient of determination (R^2) in this study were high (greater than 0.9), suggesting that the data and LWR equations obtained were reliable.

Relative condition factor, K_n in each site was found to has the value of approximately one with 1.005 ± 0.107 for total length and 1.006 ± 0.123 for standard length. One-Way ANOVA test was carried out to compare the mean of K_n among sites and it was concluded that there was no significant difference in the mean of K_n among sites. Tukey's HSD results further supports One-Way ANOVA results that the mean of K_n was similar in all sites. This suggested that the environmental factor was similar in each site, thus the condition of fishes was similar. In addition, One-Way ANOVA and Tukey's HSD analyses were also performed to compare means of total length and standard lengths and weight. The results show that the means of both length and weight in every site were different form each other, due to differences in length and weight range obtained in each site.

The number of samples obtained was reduced by half from month to month. This may be related to the water level of the pond which became higher during rainy season. High humidity during rainy season reduced evaporation rate, resulting in high pond water level, which directly restricted the sampling area.

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Appendix A

Example of raw data in Site 1

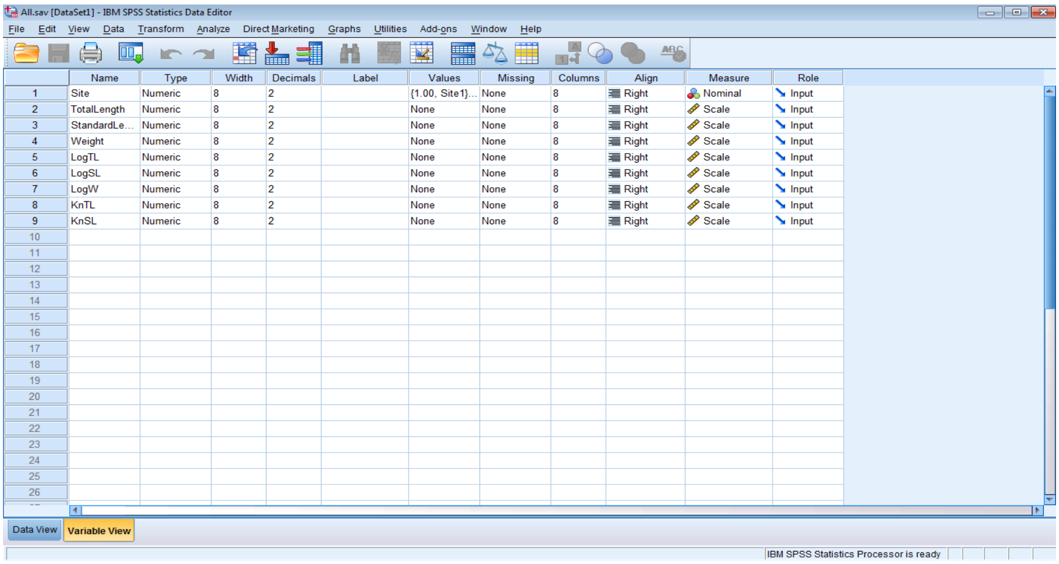
Total Length (cm)	Standard Length (cm)	Weight (mg)	LogTL	LogSL	LogW	KnTL	KnSL
5.78	4.80	1505.20	0.76	0.68	3.18	0.97	0.89
6.21	4.97	2090.00	0.79	0.70	3.32	1.09	1.11
5.11	4.12	1207.30	0.71	0.61	3.08	1.13	1.13
4.64	3.74	925.60	0.67	0.57	2.97	1.15	1.15
6.30	4.95	2015.30	0.80	0.69	3.30	1.01	1.09
6.04	4.83	1662.20	0.78	0.68	3.22	0.94	0.96
5.21	4.18	978.00	0.72	0.62	2.99	0.86	0.88
5.11	4.31	231.00	0.71	0.63	3.09	0.22	0.19
4.35	3.61	717.60	0.64	0.56	2.86	1.08	1.00
6.87	5.44	2267.70	0.84	0.74	3.36	0.88	0.92
5.76	4.47	1468.00	0.76	0.65	3.17	0.96	1.07
4.93	3.95	950.20	0.69	0.60	2.98	0.99	1.01
5.46	4.38	1295.00	0.74	0.64	3.11	0.99	1.21
5.68	4.21	1385.90	0.75	0.62	3.14	0.94	1.21
5.28	4.41	1423.00	0.72	0.64	3.15	1.20	1.08
6.18	4.98	1705.70	0.79	0.70	3.23	0.90	0.90
5.78	4.79	1593.00	0.76	0.68	3.20	1.03	0.95
4.66	3.71	789.50	0.67	0.57	2.90	0.97	1.01
4.99	4.15	935.50	0.70	0.62	2.97	0.93	0.85
4.96	3.74	1024.30	0.70	0.57	3.01	1.04	1.28
4.89	3.97	991.80	0.69	0.60	3.00	1.06	1.03
4.89	3.97	945.60	0.69	0.60	2.98	1.01	0.99
5.04	3.90	1092.20	0.70	0.59	3.04	1.06	1.21
4.36	3.95	647.10	0.64	0.60	2.81	0.97	0.69
6.14	5.18	2124.20	0.79	0.71	3.33	1.15	1.00
5.22	4.35	1074.20	0.72	0.64	3.03	0.94	0.85
5.12	4.11	1089.50	0.71	0.61	3.04	1.01	1.03
3.97	3.26	459.30	0.60	0.51	2.66	0.90	0.86
5.89	4.90	1625.60	0.77	0.69	3.21	0.99	0.91
3.47	2.88	361.90	0.54	0.46	2.56	1.07	0.99
4.52	3.69	648.10	0.66	0.57	2.81	0.87	0.84
4.63	3.87	902.30	0.67	0.59	2.96	1.13	1.02
3.69	2.91	413.90	0.57	0.46	2.62	1.02	1.09
4.08	3.39	454.30	0.61	0.53	2.66	0.83	0.76
4.44	3.90	755.70	0.65	0.59	2.88	1.07	0.83
3.43	2.71	336.30	0.54	0.43	2.53	1.02	1.10
4.15	3.40	523.10	0.62	0.53	2.72	0.90	0.87
4.68	3.91	785.80	0.67	0.59	2.90	0.95	0.86
4.67	3.64	931.50	0.67	0.59	2.97	1.13	1.26
4.58	3.87	817.60	0.66	0.59	2.91	1.06	0.92
4.19	3.40	562.50	0.62	0.53	2.75	0.94	0.94
4.41	3.53	655.90	0.64	0.55	2.82	0.95	0.97

APPENDIX B

Method of using SPSS (version 20)

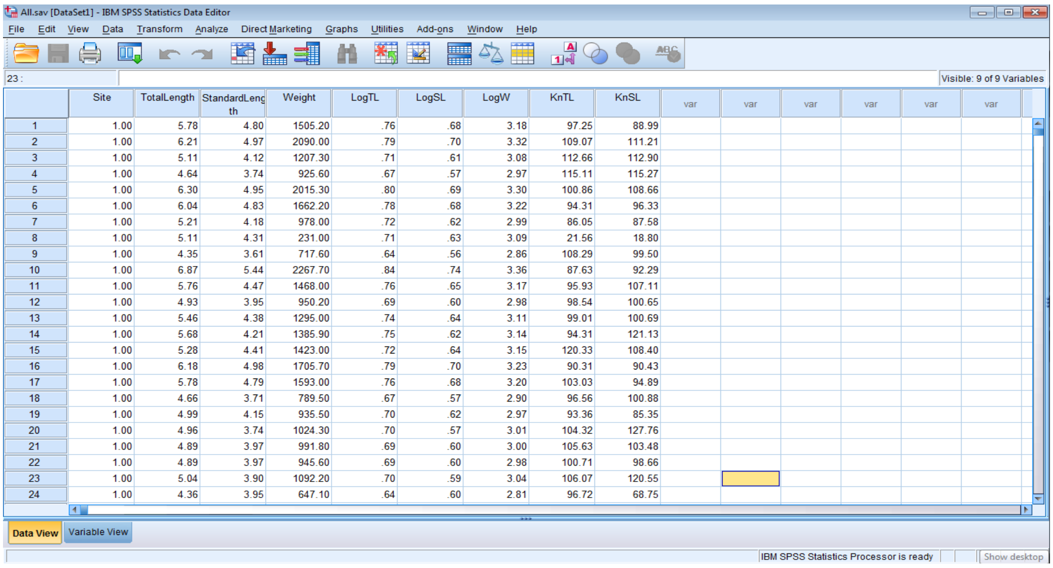
Enter Data.

Select “Variable View” at bottom left of SPSS to enter variables.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Site	Numeric	8	2		{1.00, Site1}...	None	8	Right	Nominal	Input
2	TotalLength	Numeric	8	2		None	None	8	Right	Scale	Input
3	StandardLe...	Numeric	8	2		None	None	8	Right	Scale	Input
4	Weight	Numeric	8	2		None	None	8	Right	Scale	Input
5	LogTL	Numeric	8	2		None	None	8	Right	Scale	Input
6	LogSL	Numeric	8	2		None	None	8	Right	Scale	Input
7	LogW	Numeric	8	2		None	None	8	Right	Scale	Input
8	KnTL	Numeric	8	2		None	None	8	Right	Scale	Input
9	KnSL	Numeric	8	2		None	None	8	Right	Scale	Input

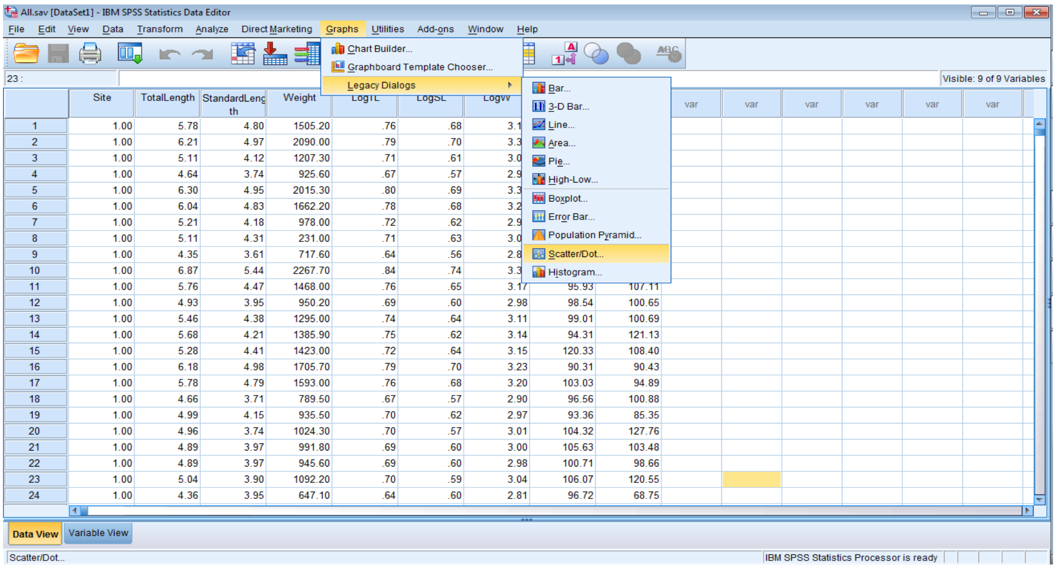
Enter data according to variables.



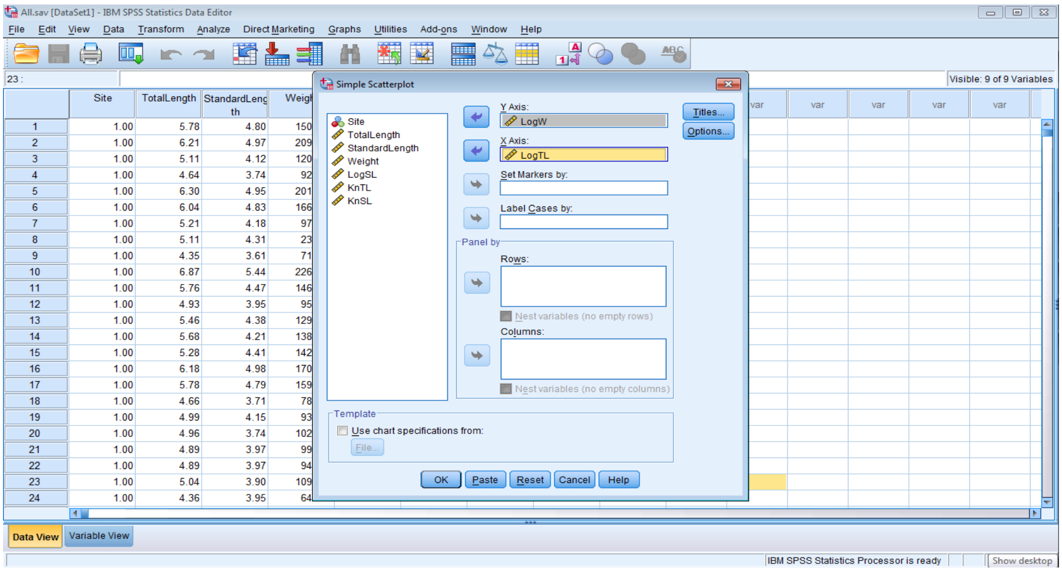
	Site	TotalLength	StandardLength	Weight	LogTL	LogSL	LogW	KnTL	KnSL
1	1.00	5.78	4.80	1505.20	.76	.68	3.18	97.25	88.99
2	1.00	6.21	4.97	2090.00	.79	.70	3.32	109.07	111.21
3	1.00	5.11	4.12	1207.30	.71	.61	3.08	112.66	112.90
4	1.00	4.64	3.74	925.60	.67	.57	2.97	115.11	115.27
5	1.00	6.30	4.95	2015.30	.80	.69	3.30	100.86	108.66
6	1.00	6.04	4.83	1662.20	.78	.68	3.22	94.31	96.33
7	1.00	5.21	4.18	978.00	.72	.62	2.99	86.05	87.58
8	1.00	5.11	4.31	231.00	.71	.63	3.09	21.56	18.80
9	1.00	4.35	3.61	717.60	.64	.56	2.86	108.29	99.50
10	1.00	6.87	5.44	2267.70	.84	.74	3.36	87.63	92.29
11	1.00	5.76	4.47	1468.00	.76	.65	3.17	95.93	107.11
12	1.00	4.93	3.95	950.20	.69	.60	2.98	98.54	100.65
13	1.00	5.46	4.38	1295.00	.74	.64	3.11	99.01	100.69
14	1.00	5.68	4.21	1385.90	.75	.62	3.14	94.31	121.13
15	1.00	5.28	4.41	1423.00	.72	.64	3.15	120.33	108.40
16	1.00	6.18	4.98	1705.70	.79	.70	3.23	90.31	90.43
17	1.00	5.78	4.79	1593.00	.76	.68	3.20	103.03	94.89
18	1.00	4.66	3.71	789.50	.67	.57	2.90	96.56	100.88
19	1.00	4.99	4.15	935.50	.70	.62	2.97	93.36	85.35
20	1.00	4.96	3.74	1024.30	.70	.57	3.01	104.32	127.76
21	1.00	4.89	3.97	991.80	.69	.60	3.00	105.63	103.48
22	1.00	4.89	3.97	945.60	.69	.60	2.98	100.71	98.66
23	1.00	5.04	3.90	1092.20	.70	.59	3.04	106.07	120.55
24	1.00	4.36	3.95	647.10	.64	.60	2.81	96.72	68.75

Generate length-weight relationship graphs.

Select: Graph > Legacy Dialogs > Scatter/Dot > Simple Scatter

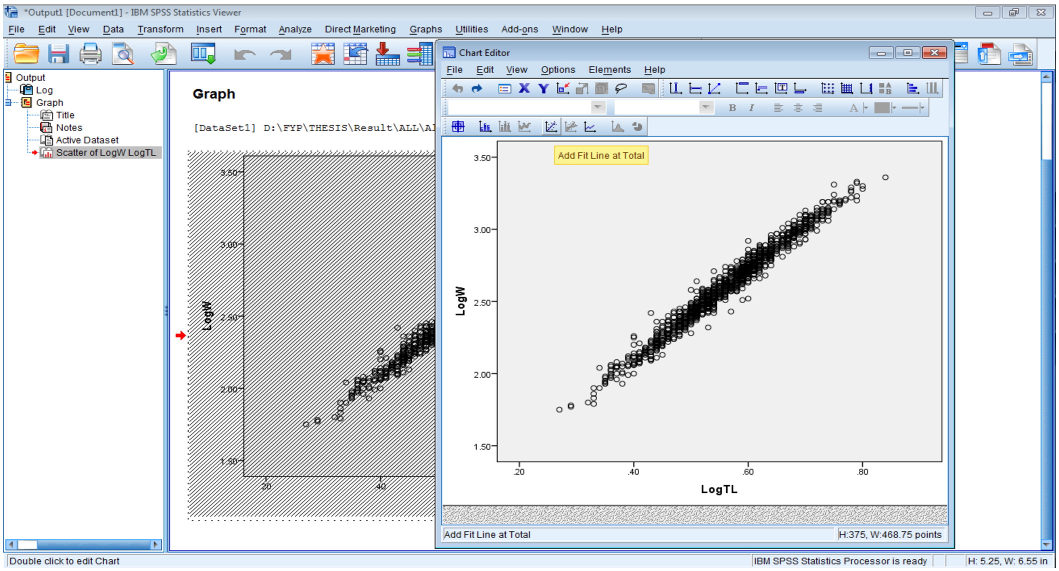


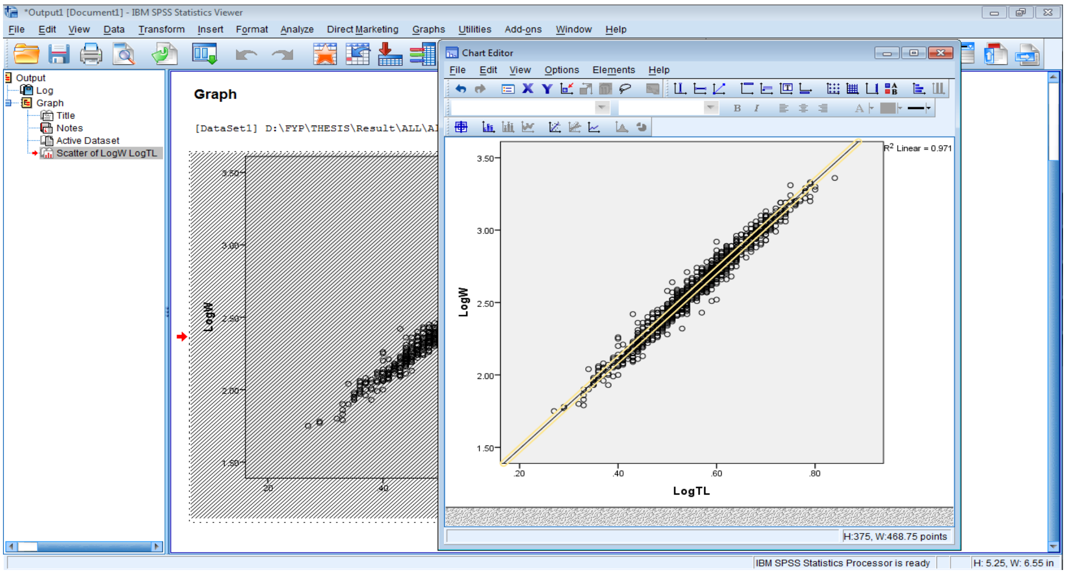
Select "LogW" in Y axis, "LogTL" at X axis.



Double-click on the graph generated. A chart editor will pop up.

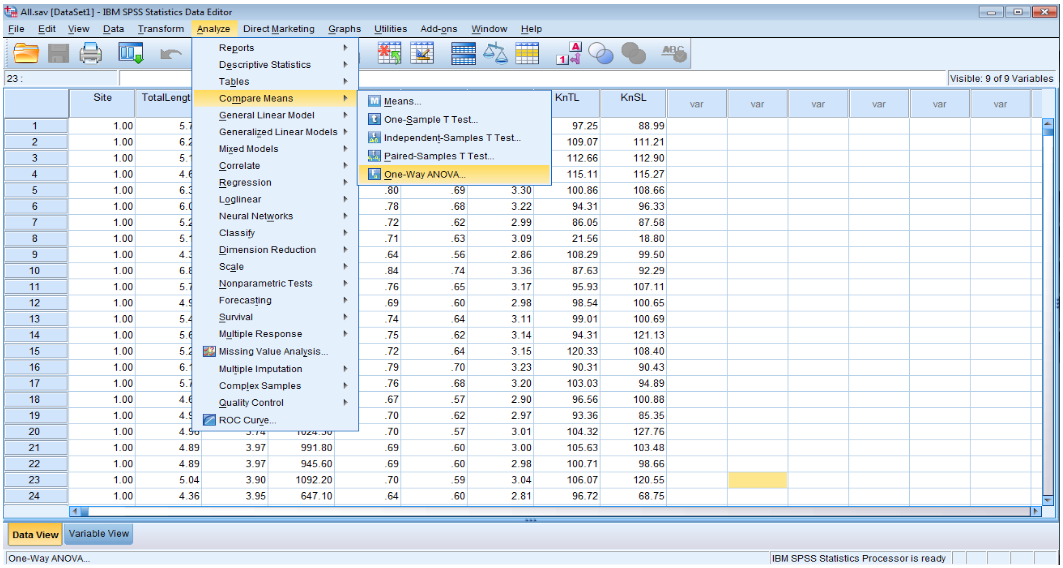
Click “add fit line”. A fit line and R^2 value will be generated.



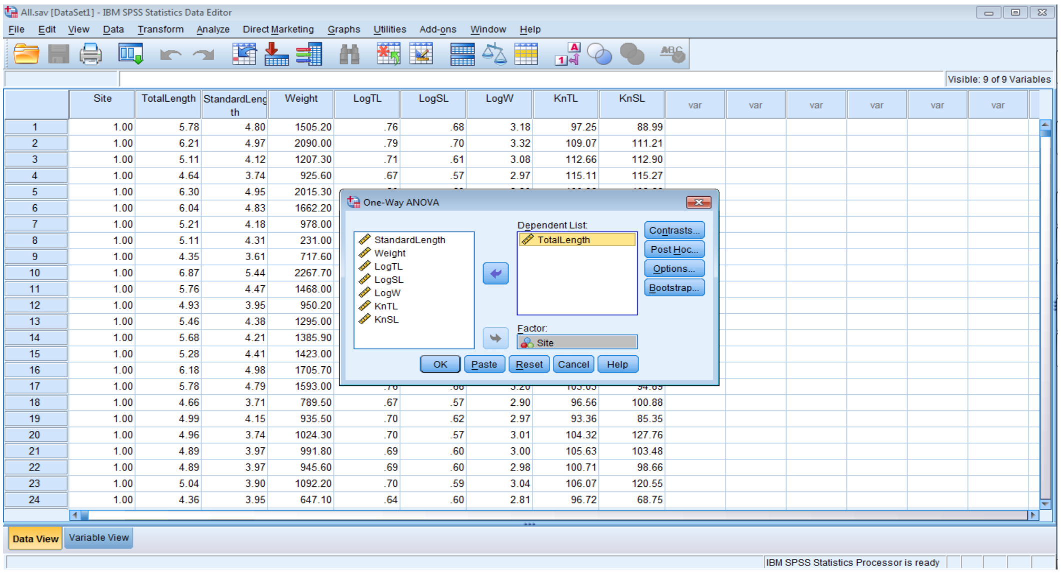


Perform One-Way ANOVA and Tukey's HSD.

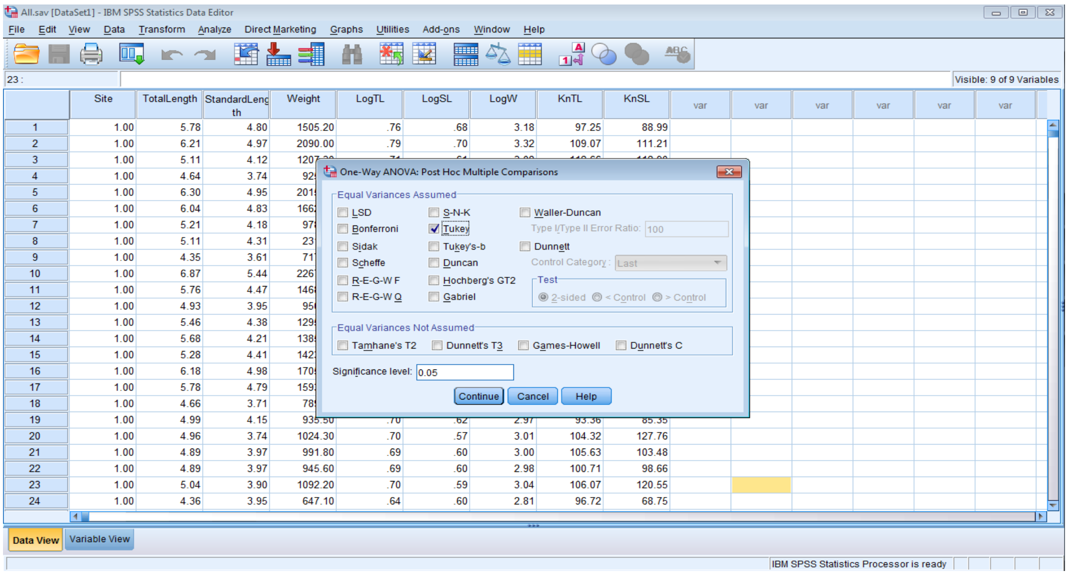
Select: Analyze > Compare Means > One-Way ANOVA



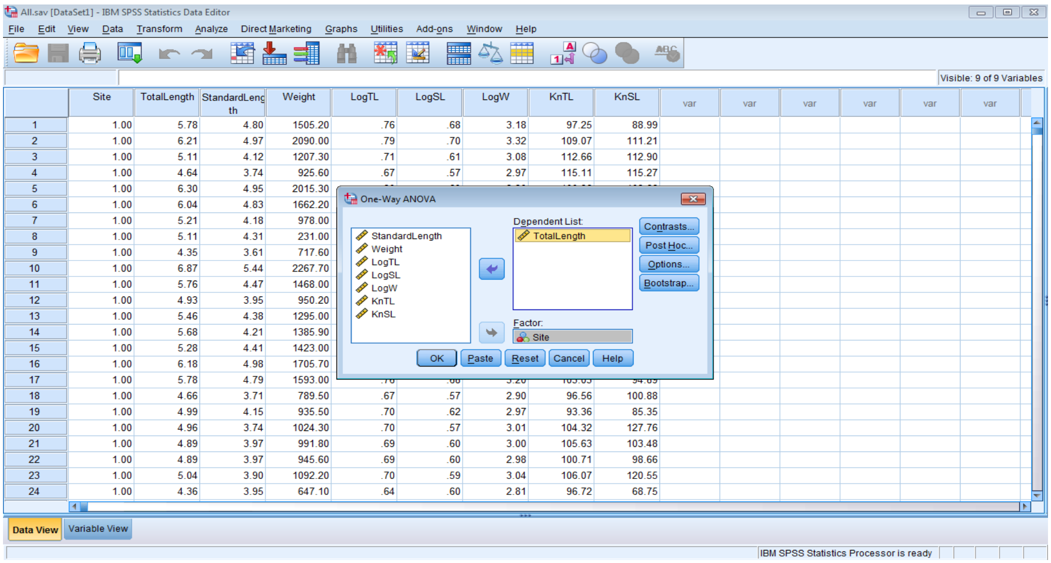
Click "Post-Hoc" at the right side of the One-Way ANOVA.



Choose “Tukey” and click “continue”



Select “Total Length” in Dependent List, “Site” in Factor. Click “OK” to perform analyses.



APPENDIX C

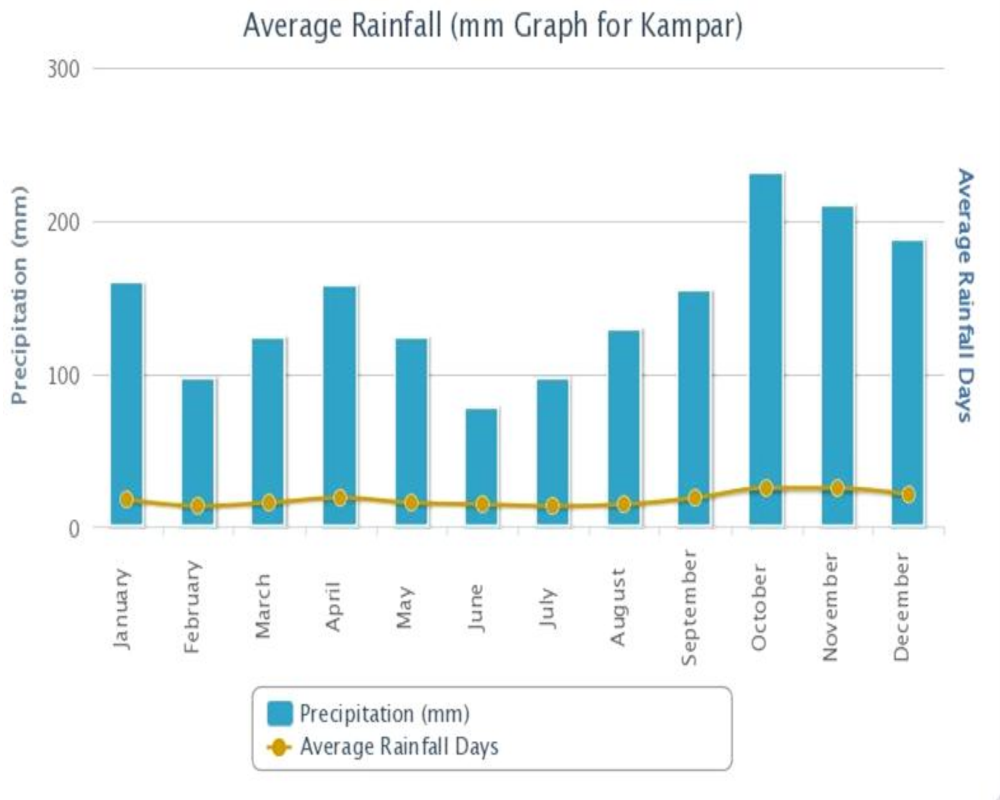


Figure A Average monthly rainfall volume (mm) in Kampar, Perak from 2002 to 2012. (Worldweatheronline 2013)