LENGTH WEIGHT RELATIONSHIP AND CONDITION FACTOR OF PERIWINKLE (*Tympanotonus fuscatus*) FROM KOKO ESTUARY, WARRI, DELTA STATE, NIGERIA

BY

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BENIN CITY, NIGERIA.

JANUARY, 2023

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE, B. AGRIC (FISHERIES)

JANUARY, 2023

CERTIFICATION

This is to certify that this project was carried out by **Obehi Mercy EHIAGWINA**, **AGR1600429** in the Department of Aquaculture and Fisheries Management in the Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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PROF. F.A.R. EHIGIATOR **DATE**

Project Supervisor

_____ _____

DR. O.M WANGBOJE **DATE**

Head of Department

DEDICATION

I dedicate this work project to God Almighty for his grace, guidance and provision throughout my program in the University of Benin. I also dedicate it to my parents, Mr & Mrs Michael Ehiagwina, and to my awesome guardian, Barr & Mrs Lawrence Asirawede for their unending support and Love.

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To G0D Almighty, the giver of life who has kept me thus far, who despite all odds has led me to the successful completion of this project I say thank you. I wish to specially appreciate my project supervisor Prof .F .A. R. Ehigiator, for the guidance, advice and corrections, and also for making the course of the completion of this research smooth and successful.

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CHAPTER ONE

1.0 Introduction

Shellfish is a fisheries and culinary term for exoskeleton-bearing aquatic invertebrates used as food (Ehigiator and Oterai, 2012) including various species of molluscs, crustaceans, and echinoderms. Despite the name, shellfish are not fish. Most shellfish are low on the food chain and eat a diet composed primarily of phytoplankton and zooplankton. Shellfishes comprises of invertebrate animals such as periwinkle, rock snail, oyster and crabs which possesses exoskeleton called shells which may be single or double over the body (Amadi, 2015).

Shellfishes have been reported to be a major source of protein to both riverine communities and the general population, as they occur abundantly in the brackish and fresh waters of Nigeria (Adebayo-Tayo *et al*., 2008). They also provide other nutrients such as minerals and vitamins and they are in abundance in the Niger Delta region of South-South Nigeria and contribute greatly to the diets of the people (Davis and Jamabo, 2016).

Periwinkles are univalve invertebrates belonging to the Phylum; Mollusca, Class; Gastropoda, Sub-class; Prosobranchia and family*; Potamididae*. Univalves are mollusc with a single shell consisting of one valve such as a snail, cone, whelk, abalone, or limpet. Univalves belong to the subclass Prosobranchia. Their shells are usually spiral and can hold the whole animal inside. They usually inhabit soft substratum or mudflats rich in decaying organic matter and detritus (Jamabo and Chinda, 2010; Iboh *et al*., 2015). It is a relatively cheap source of animal protein, it is also used as bait by fishermen and the shell is commonly used as source of calcium and phosphate in livestock feed and as ornaments (Jamabo *et al*., 2009; Asunkkwari and Archibong,

2011). These species also have some medicinal values and have been used for the treatment of endemic goitre because of its high iodine content (Bob-Manuel, 2012).

The two species of periwinkles commonly found in creeks, estuarine habitats and benthos of the Niger Delta are *Tympanotonus fuscatus* and *Pachymelania aurita* (Jamabo and Chinda, 2010; Bob-Manuel, 2012). These species are commonly referred to as periwinkle. The genus *Tympanotonus fuscatus* comprises of a single specie which has two varieties; *T. fuscatus var fuscatus* and *T. fuscatus var radula*. *T. fuscatus var fuscatus* is characterized by turreted, glandular and spiny shells with tapering ends (Jamabo *et al*., 2009). While *T. fuscatus var radula* is distinguished from the other variety by the absence of spiny tubercules on the shell. *T. fuscatus* are deposit feeders. They feed on microscopic algae, detritus matter and diatoms. They occur in the littoral habitat such as mangrove swamp. it migrate to the coastal edge where it congregates under tufts of grasses and breathing roots of mangrove plants such as; *Avicenia nitida, rhizophora mangle* among others which shades it from the direct rays of the sun during the dry season (Cariton and Cohen, 2002). Periwinkle can make regular feeding excursions and trace paths back to their former ecological niches, hence remain within a short distance for many weeks (Bob-Manuel, 2012). *T. fuscatus* can survive for a long period in the absence of water, by making use of their reserve food. The nature of bottom deposit, water depth and current are the major factors controlling the distribution of this shellfish in the estuaries.

Length - weight relationship (LWR) and its accompanying parameters are tools used for practical assessment of stock of aquatic species including fin and shell fishes. An Estimation of the length-weight relationship of organisms is essential for assessing the relative wellbeing of fish and other species/population (Udo, 2013) and for inter and intra-species morphological comparisons. This also allow for the estimation of the average weight of the fish of a given

length group by establishing a mathematical relationship between the length and weight. Nwosu *et al*., (2007), listed several stock assessment situations where LWR may be needed; These includes; the conversion of length of individual fish to weight, estimating the mean weight of the fish of a given length class, conversion of growth equation for length into a growth equation for weight and also for morphological comparisons between populations of the same specie or between species.

Condition Factor (CF) is an estimation of general well-being of fish (Oribhabor *et al*., 2011) and is based on the hypothesis or assumption that heavier fish (at a given length) are in better condition than the lighter ones (Ogamba *et al*., 2014). The condition factor of 1.0 or greater indicates the good condition of fish while less than 1.0 shows bad condition (Abobi, 2015). The condition factor can be influenced by season, sex, type of food organism consumed by fish, age of fish, amount of fat reserved and environmental conditions (Anene, 2005; Abowei, 2009).

1.1 Justification of the study

One of the classic signs of imminent problems for a fishery is the ploriferation of an undersized catch. For some time now periwinkle wholesalers have found a shortage of the medium to large size periwinkle (more than 16mm in size). Hence, Length-Weight relationship and condition factor are important tools in fisheries biology, fish management and stock assessment to support data about standing stock biomass, understand their well-being, compare ontogeny of fish population and growth pattern studies of different regions, understand their life cycle and span, construct ecosystem modeling and can be used as index to assess the status of the aquatic environment where the fish lives (lmam *et al*., 2010; Lawson *et al*., 2013; Ogamba *et al*., 2014). Few studies have been conducted on the length-weight relationship and condition factor of periwinkles in some parts of the Niger-delta which is where majority of the *estaurines* in Nigeria

are found. (Jamabo, 2007; Jamabo and Chinda, 2010; Udoh, 2013; Iboh *et al*., 2015) Niger-Delta is the crude-oil reservoir of Nigeria and all aspects of the industrial activities, from exploration, production to waste discharge, have adverse effects on the ecosystems (Uzoma and Mgbemena, 2015). The impact of environmental damage in the region cannot be quantified (Baghebo *et al*., 2012).

There is no published research on some of the aspects of the biology of periwinkle (*T. fuscatus*) in the highly polluted, environmentally-unfriendly Koko estuary. This study is therefore aimed at providing first hand and baseline information on the aspects of the ecology (length-weight relationship and condition factor) of this specie in the Koko estuary.

1.2 Objectives of the study

The aim of this study is to determine the length-weight relationship and condition factor of periwinkle; *T. fuscatus var fuscatus* and *T. fuscatus var radula*.

The objectives of this study were to determine the:

1. Total length and weight relationship of the periwinkle shells of both varieties
2. Relationship between total length and the girth , number of whorls, weight of the flesh(edible portion) and the empty shell.
3. The condition factor of the periwinkle from koko estuary and
4. The growth pattern of the periwinkle from koko estuary

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Growth Pattern and Morphology of Gastropods

Gastropods are a large and highly diversified class within the phylum Mollusca. Many gastropods possess a shell whereas some are without shells. The shelled gastropods are also called univalves. Some of these gastropods are terrestrial while other gastropods live in marine or freshwater habitat. There are approximately 85,000 - 100000 described species of molluscs (Strong et al., 2008) found throughout the world from the garden to deep-water hydrothermal vent colonies. Current estimates place the total number of molluscs including undescribed species as high as 240,000 species (Appeltan et al., 2011). Gastropods are considered as the oldest known fossils with their shells being evolved in rocks 540 million years ago. Many of the today's gastropod species have continued unaltered for over 350 million years.Many gastropods possess a shell that protects the soft body of the animal. In most species, the coiled shell opens on the right-hand side (dextral). Rarely, right-hand coiled species will produce left-hand coiled (sinistral) shells and vice versa. Many species bears an operculum that assists to protect the animal in addition to the shell. During early larval stage development, gastropods display the most characteristic feature - torsion that means the visceral mass rotates 180º to one side, placing the anus above the head. Gastropods posses a distinct head with 2 - 4 sensory tentacles. They bear eyes that are located near the base of the tentacles or on separate eye stalks. Although most species (herbivorous /carnivorous) use a radula (tongue like apparatus) for feeding, the feeding habits of them are varied. Other species may be detritus feeder, scavengers or ciliary feeders. Gastropod reproduction differs very much among species. Hermaphroditism is common in all

gastropods but in the marine gastropods, one individual serves as either male or female during mating. Nevertheless, all gastropods reproduce through internal fertilization.Many gastropods are used as food items throughout the world. Abalone, conchs, and periwinkle gastropods etc. are the popular food items. From the time immemorial, seashells have been used as ornamentation, cooking utensils, oil lamps, musical instruments, currency among others.

Growth is an integrated physiological response encompassing external environmental conditions such as; food quality and quantity, temperature, water quality and internal physiological status including; health, stress or reproductive state. The changes can be in size (weight and/ or length), in tissues, chemical composition and number of cells.

Shells are a remarkable example of the diversity that can arise as natural selection shapes animal morphology to various ecological and functional demands. Their basic functions are structural support and protection, and shells have adapted for these roles in various ways (McDougall and Degnan 2018; Okabe and Yoshimura 2017). Soft body parts are attached to internal shell surfaces to maintain the organization of the body, and external structures can be withdrawn into shells for protection from predators or desiccation. Shell shapes often have other functions, including pelagic locomotion, burrowing, hunting, and thermal management (Denny and miller 2006; Levine *et al.,* 2014). these reasons, mollusc shells are important models for studying morphological evolution in extant and fossil populations (Lemanis *et al.,* 2016). Gastropods generally have one helically coiled shell; with immense variation in shape, size, ornamentation, coiling direction, and pigmentation. Having a single shell for the lifetime of the animal often means that the same basic morphology must function over several orders of magnitude in size, from a planktonic larval stage to a large benthic animal. Gastropod shells grow by increasing their number of coils, or whorls, by exclusively growing at their aperture. A whorl is a single,

complete 360° revolution or turn in the spiral or whorled growth of a mollusc shell. A spiral configuration of the shell is found in numerous gastropods, but it is also found in shelled cephalopods including Nautilus, Spirula and the large extinct subclass of cephalopods known as the ammonites. It helps to prevent dessication when the snail is inactive for long periods. A consequence of this growth pattern is that previous whorls are retained, recording the ontogenetic pattern of growth. Despite this morphological diversity, and their utility for studies of morphological evolution, the mechanisms that underlie shell morphogenesis are not known. The differential deposition of shell material that ultimately creates shell morphology is likely driven, at least in part, by differential growth of the mantle epithelium. However, the patterns of cell division and growth of the mantle have received little attention. Some developmental regulatory genes are expressed in the mantle epithelium that generates the shell (Hinman *et al.*, 2003; Jackson and Degnan, 2016). While the developmental basis of shell morphogenesis remains obscure, the process has been studied extensively using mathematical modeling.

2.2 Concept of Allometric and Isometric Growth

Allometry, in its broadest sense, describes how the characteristics of living creatures change with size. The term originally referred to the scaling relationship between the size of a body part and the size of the body as a whole, as both grow during development. However, more recently the meaning of the term allometry has been modified and expanded to refer to biological scaling relationships in general, be it for morphological traits (e.g., the relationship between brain size and body size among adult humans), physiological traits (e.g., the relationship between metabolic rate and body size among mammal species) or ecological traits (e.g., the relationship between wing size and flight performance in birds) (Singhleton, 2010). Allometric relationships can be described for almost any co-varying biological measurements, resulting in broad usage of

the term. However, a unifying theme is that allometry describes how traits or processes scale with one another.

The study of allometry concerns the functional mechanisms that generate these scaling relationship, how they impact ecology, and how they respond to and influence evolutionIn addition to studies that focus on growth, allometry also examines shape variation among individuals of a given age (and sex), which is referred to as static allometry. (Bondunriansky and Day,2003).

Isometric scaling happens when proportional relationships are preserved as size changes during growth or over evolutionary time (Jaiswar and Kulkarni, 2002). It is the opposite of allometric growth, Animals with regression coefficient 'b' closer to 3 indicate isometric growth, whereas those deviating significantly from 3 are considered to indicate allometric growth. It has been shown that in isometric growth, increase in weight of animal is proportionate to the cube of its length and they maintain specific body shape throughout their life, whereas in allometric growth, increase in weight of an animal is not proportionate to the cube of its length. However, they maintain specific body shape throughout their life (Oluwatoyin *et al.,* 2013).

2.3 Length-Weight Relationship

Organisms generally increase in size (length, weight) during development. This growth could be allometric growth which refers to the unequal growth rate in different parts of the body in comparison to the growth rate of the body as a whole or isometric growth which refers to the equal growth rate of body parts in comparison to the growth rate of the body as a whole. Allometric growth and Isometric growth are two types of relationships between the growth rates

of different body parts in comparison to the growth rate of the whole body, the growth rate is unequal in allometric growth while it is equal in isometric growth.

Fish body length and body weight are two useful empirical measures used in stock assessment. It is also used in population ecology, community and ecosystem ecological studies (Giarrizzo *et al.,* 2015; Baitha *et al*., 2018). Fish growth is generally measured by increase in length and weight, which are used to determine population development. The length-weight relationship (LWR) is a mathematic model that allows for the conversion of length into weight, and weight into length in stock assessment models, as well as for the estimation of biomass from the length frequency distribution. Length-Weight relationship can be used to determine possible differences between separate stock units of a species, provided all units are studied with the same fully standardized sampling methodology (Dieb-Magalhães *et al.,* 2015; Freitas *et al.,* 2017; Baitha *et al*., 2018). Length-Weight is also used for estimating the condition factor of fish, which is used to compare the health of fish populations. A high condition factor indicates that a fish is heavier than a fish of the same length with a lower condition factor, and thus always refers to a deviation from the average length-weight for a population (Froese, 2006; Freitas *et al.* 2017).

Length-weight relationship and condition factor of fish populations are important tools to support the rational management of fishing resources, and may help in the implementation of public policies (Giarrizzo *et al.*, 2015).

2.4 Condition Factor

Condition factor (K) of a fish reflects physical and biological circumstances and fluctuations by interaction among feeding conditions, parasitic infections and physiological factors (Le Cren 1951). This also indicates the changes in food reserves and therefore an indicator of the general

fish condition. Moreover, fish body condition provides an alternative to the expensive in vitro proximate analyses of tissues (Sutton *et al.,* 2000). Condition factor can be influenced by season, sex, type of food eaten by the organism and environmental condition (Anene, 2005; Abowei, 2009).

Several studies have been carried out on length-weight relationship and condition factors of periwinkle. Some of the published work on length-weight relationship and condition factor include; Ogunola *et al.,* (2018) studied the Assessment of length-weight relationship and condition factor of Periwinkle, *T. fuscatus,* from Okrika estuary. The study was conducted from October, 2015 to February, 2016 and a total of 120 samples of the species were hand-picked from the mangrove ecosystem of Okrika. The results obtained showed that the gastropod species had negative allometric growth patterns with a growth exponent, b value of 2.18. This value was confirmed as negative allometric, because it was significantly different ($p<0.05$) from 3 when a t-test was carried out. The mean condition factor, K of the species was 18.9, which indicated that they were in good condition during the sampling period.

Rasheed olatunji Moruf and Aderonke omolara lawa-are (2015) also studied Growth Pattern, Whorl and Girth Relationship of the Periwinkle, *T. fuscatus var radula* (Linnaeus, 1758) from a Tropical Estuarine Lagoon, Lagos, Nigeria. The size composition and growth pattern of the periwinkle, *T. fuscatus var radula* in a tropical estuarine lagoon were investigated. The Shell length ranged from 2.5cm to 5.9cm and weight from 0.02g to 9.42g.The periwinkle showed a uni-modal size distribution. Also, there was a strong significant correlation between whorl number and increase in shell length ($r = 0.625$, $P < 0.01$), suggesting that the higher the shell length the more whorls an individual possesses. The girth-length and weight-girth relationships were positively correlated with calculated “b” of 0.65 and 0.40 respectively. The pattern of growth (negative allometric) was verified from the value of $b < 3$. The condition factor ranged between 4.6 and 10.3 and decreased with size, indicating that the species were in good condition.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

Koko Estuary (Fig 1) is located in Warri North Local Government Area of Delta state. It lies between the co-ordinates of Latitude 5°59'0"N and Longitude 5°26'0"E and covers a land area of 17,687 square km. It is a collecting point for palm oil and kernels, as well as timber. The town serves as an agricultural trade centre for the Itsekiri people. The port is well known for its fishing and shrimping operations. The community is divided into different settlements, which include; Koko Beach, Aja-Ogbugbu, Nanna Town and Aja-Olugbeti. The entirety of Koko by virtue of its location is very cosmopolitan with a very large population.

3.2 Description of Sample

The two varieties of *T. fuscatus* used in this study are morphologically different. *T. fuscatus var fuscatus* is characterized by turreted, glandular and spiny shells with tapering ends (Jamabo and Chinda, 2009). While *T. fuscatus var radula* is distinguished from the other variety by the absence of spiny tubercules on the shell. See (Fig 2 and 3)

3.3 Data Collection

Freshly caught periwinkles were purchased from fishermen at the sampling site. The samples were hand picked randomly or caught using baskets at low or ebb tide by these fishermen. All samples purchased were transported to the laboratory on ice in a cold chest and the mud on the samples washed off on getting there. In the laboratory they were identified to the species level using the fish catalogue of FAO (Food and Agriculture Organization) (Fischer *et al*., 1981; FAO, 1990; Schneider 1990) .

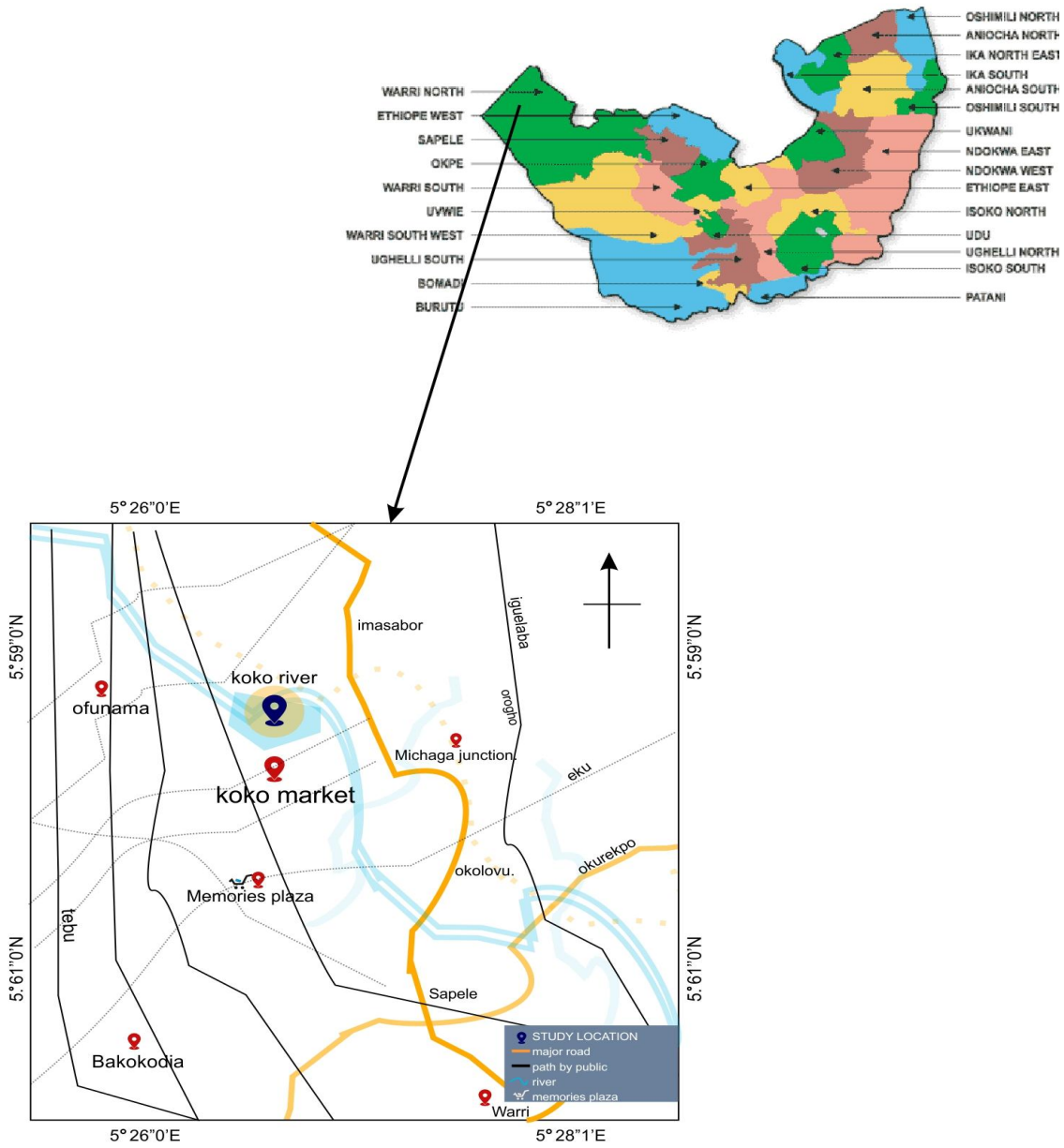

Figure 1: Map of study area

Source: Goggle Map

Fig 2: *T. fuscatus var fuscatus*

Source: Ogunola *et al*. (2013)

Fig 3: ***T. fuscatus var radula***

Source: Ogunola *et al*. (2013)

Morphometrics of shell total length (STL), total body weight (BWt),the shell girth/ width and the edible portion weight of the two varieties of the sample were measured using a graduated measuring board and vernier caliper for the lengths while an electronic sensitive scale (Kern 440-35A model) was used to take the weights (Moruf and Lawal-Are, 2015). All length and weight were measured in centimeters and grams respectively. The data gathered was used to evaluate the relationship between the shell total length (STL) and weight (BWt) of *T. fucastus.*

3.4 Duration of Study

Sampling was done twice monthly in the months of October/November, 2021 and January/February, 2022.

3.5 Sampling Procedure

Periwinkle samples were collected from koko estuary. The samples were collected twice monthly from three fisher folks in each collection for a period of 4 months. This is a total of 24; purchases or collections were made .

3.6 Materials used for this Study

The materials used for this study include; Venier caliper(Gaging IP54 electronic digital caliper), Measuring tape, Transparent rule, Standard taxonomic key, sensitive scale(kern 440-35A model), Measuring board(, Hand gloves and Writing materials for recording values.

3.7 Length-Weight Relationship (LWR)

The raw data of shell total lengths (STL), weight (BWt) of the periwinkles collected was used to compute the length-weight relationship with the formula (Le cren, 1951 and Ricker, 1973);

$$W = aLb \quad \text{---------- (Equation 1)}$$

Where; W = body weight

L = total length,

a = intercept on the length axis

b=slope or regression coefficient which usually ranges from 2 - 4.

Equation (1) is transformed to logarithm to give a linear relationship (Le cren 1951, Parson 1988);

$$\text{Log } W = \text{Log } a + b \text{ Log } L \quad \text{..... (Equation 2)}$$

When Log W is plotted against Log L, the regression coefficient or growth exponent, b, and intercept will be obtained.

For each species, the growth exponent (b) was compared to equation 3, using student's t-test to ascertain whether species grow isometrically or not (Sokal and Rohlf, 1987). This will be achieved using the formula (Morey *et al.,* 2003);

$$t_s = b - 3 / s_b \quad \text{---------- (Equation 3)}$$

Where;
t_s = students t-test

b = slope

s_b =standard error of the slope.

3.8 Condition Factor

This was computed for each species, using Fultons equation (Ricker, 1971; Pauly, 1983)

$$K = 100 \times \frac{W}{L^b}$$

Where; K = condition factor

W = body weight

L = total length

3.9 Statistical Analysis and Experimental Design

The data obtained from the morphometric analysis was subjected to statistical analysis using R-Studio Version 0.98.1083 (2009-2014) and Excel version. Analysis of variance (ANOVA) was used to test whether the calculated regression line was significant (Ogbeibu, 2005). All statistical analyses was considered at significant level of 5% ($p<0.05$). 3 fisher folks x twice monthly x 4 months = 24.

CHAPTER FOUR

4.0 RESULTS

4.1 The Abundance of *T. fuscatus*

A total of 1012 periwinkle species were collected that is 510 *T. fuscatus var fuscatus* and 502 *T. fuscatus var radula* were collected during the sampling period. 263 females and 247 males were collected for *T. fuscatus var fuscatus* while 266 females and 236 males were collected for *T. fuscatus var radula*. (Table 1)

4.2 Meristics and morphometrics features of *T. fuscatus var fuscatus*

Total length: The total length for the females ranged between 25.8mm and 77.3mm for the females, and between 25.1mm and 63.1mm for the males, while for the combined sexes the total length ranged from between 25.1mm and 77.3mm.(Table 2)

Girth/Width: The girth/ width ranged from 14.2mm and 56.7mm for females, between 13.9mm and 34.3mm for males, and ranged from between 13.9mm and 56.7mm for the combined sexes

Total weight: The total weight for the females ranged between 1.91g and 7.77g for the females, and between 1.86g and 7.53g for the males while for the combined sexes the total weight ranged from between 1.86g and 7.77g

Flesh weight: The flesh weight for the females ranged between 0.24g and 7.82g for the females, and between 0.22g and 7.82g for the males while for the combined sexes the total weight ranged from between 0.22g and 7.82g

Shell weight: The shell weight for the females ranged between 1.52g and 6.85g for the females, and between 1.28g and 6.32g for the males while for the combined sexes the total weight ranged from between 1.28g and 6.85g

Table 1: Species Composition of periwinkle From Koko Estuary

Species	Male	Percentage(%)	Female	Percentage
T. fuscatus var fuscatus	247	48.4%	263	51.6%
T. fuscatus var radula	*236*	*47%*	*266*	*52.9%*

Table 2: Summary of meristics and morphometric features for *T. fuscatus var fuscatus*

	Female		Male		Combined sexes	
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**
Total length (mm)	25.8-77.3	50.32±4.69	25.1-63.1	50.45±4.25	25.1-77.3	50.38±4.47
Girth (mm)	14.2-56.7	26.30±2.56	13.9-34.3	26.27±1.76	13.9-56.7	26.29±2.21
Total weight (g)	1.91-7.77	4.13±0.89	1.86-7.53	4.16±0.87	1.86-7.77	4.14±o.88
Weight of the flesh (g)	0.24-7.82	0.77±0.51	0.22-2.82	0.77±0.29	0.22-7.82	0.77±0.42
Weight of the shell (g)	1.52-6.85	3.35±0.83	1.28-6.32	3.37±0.80	1.28-6.85	3.36±0.81
Number of whorls	6-12	8.18±1.16	6-12	8.23±1.15	6-12	8.20±1.16

Number of whorls: The number of whorls for the females ranged between 6 and 12 for the females, while for the males ranged between 6 and 12 while for the combined sexes ranged between 6 and 12.

4.3: Length-weight relationship

4.3.1 Total length-total body weight relationship for *T. fuscatus var fuscatus*

The total length of *T. fuscatus var fuscatus* ranged between 25.8mm and 77.3mm for females while the total weight ranged from 1.91g to 7.77g. While for the males, the total length ranged from 25.1mm to 63.1mm and weight ranged from 1.86g to 7.53g.

Following the conversion of length and weight to logarithm form, the linear relationship was found to be as follows:

Female : logTBWT= log a+b logTL
=-4.892+0.179Log TL

Male: logTBWT= log a+b logTL
=-5.714+0.195

Combined sexes: logTBWT= log a+b logTL
=-2.945+2.089TL

Figure 4-6 shows the length weight relationship for male and female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.195), female(0.179) and combined sexes(2.089), indicating a negative allometric growth also “r” value were 0.89, 0.91 and 0.88 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and total body weight of periwinkle.

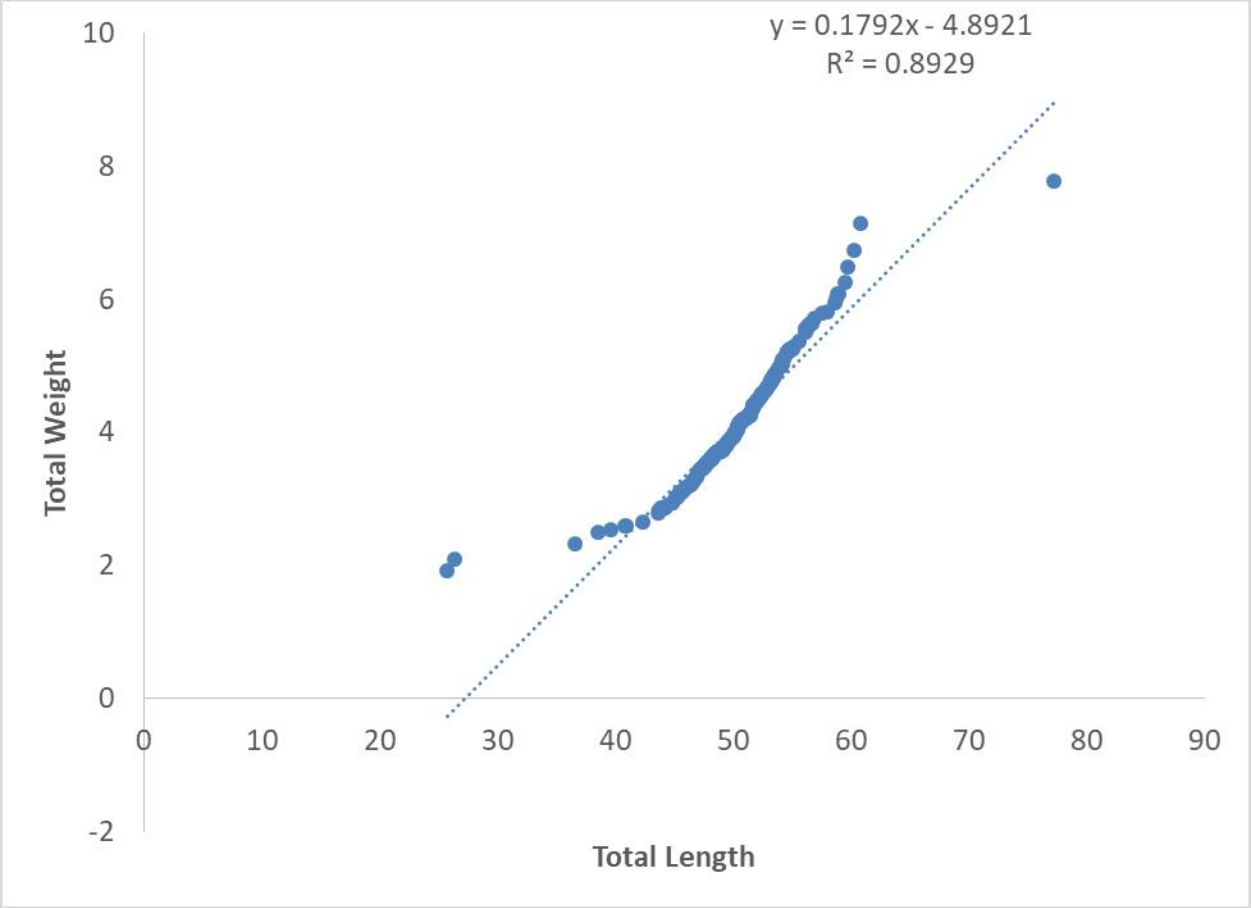

Figure 4: Total Length- Total Body Weight Relationship for Female *T. fuscatus var fuscatus*

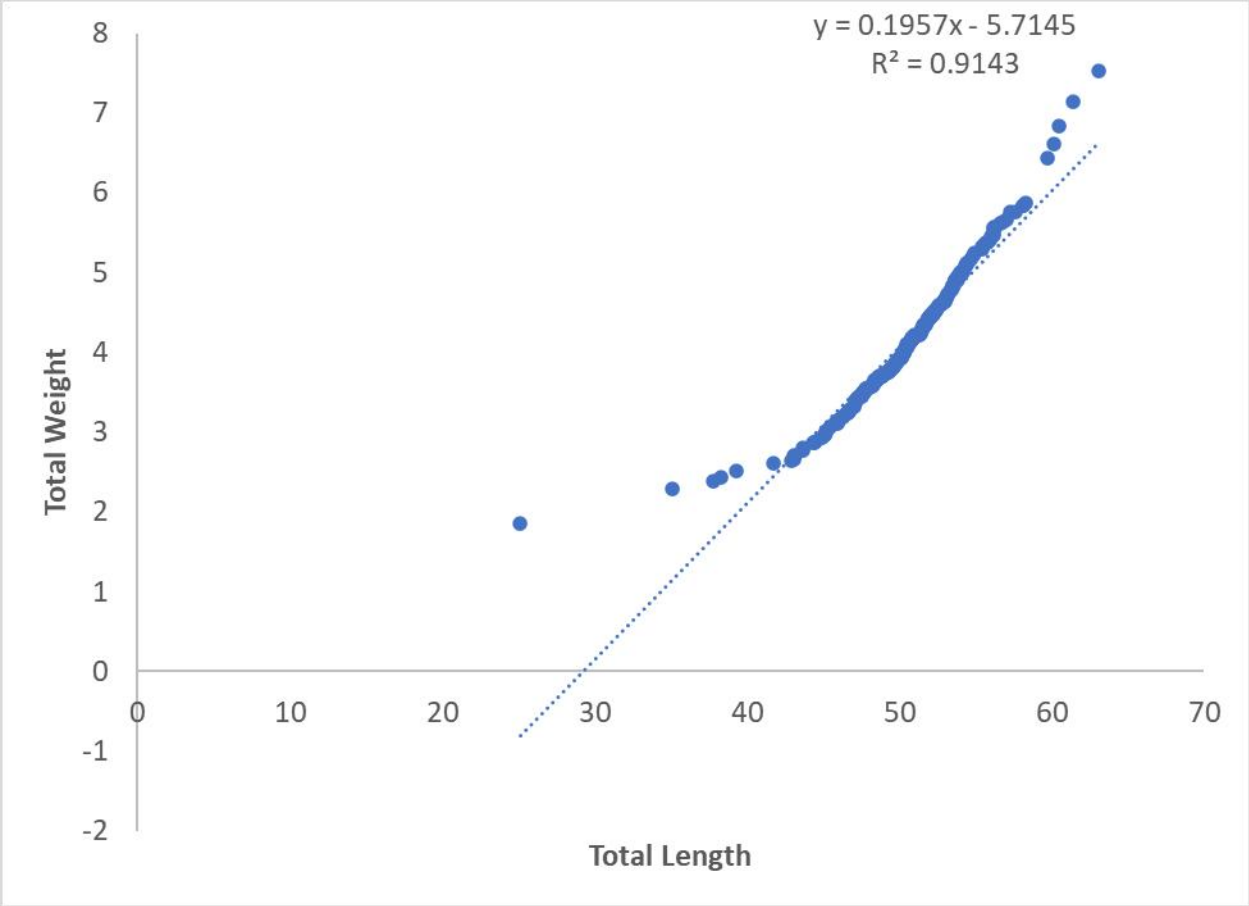

Figure 5: Total Length- Total Body Weight Relationship for Male *T.fuscastus var fuscastus*

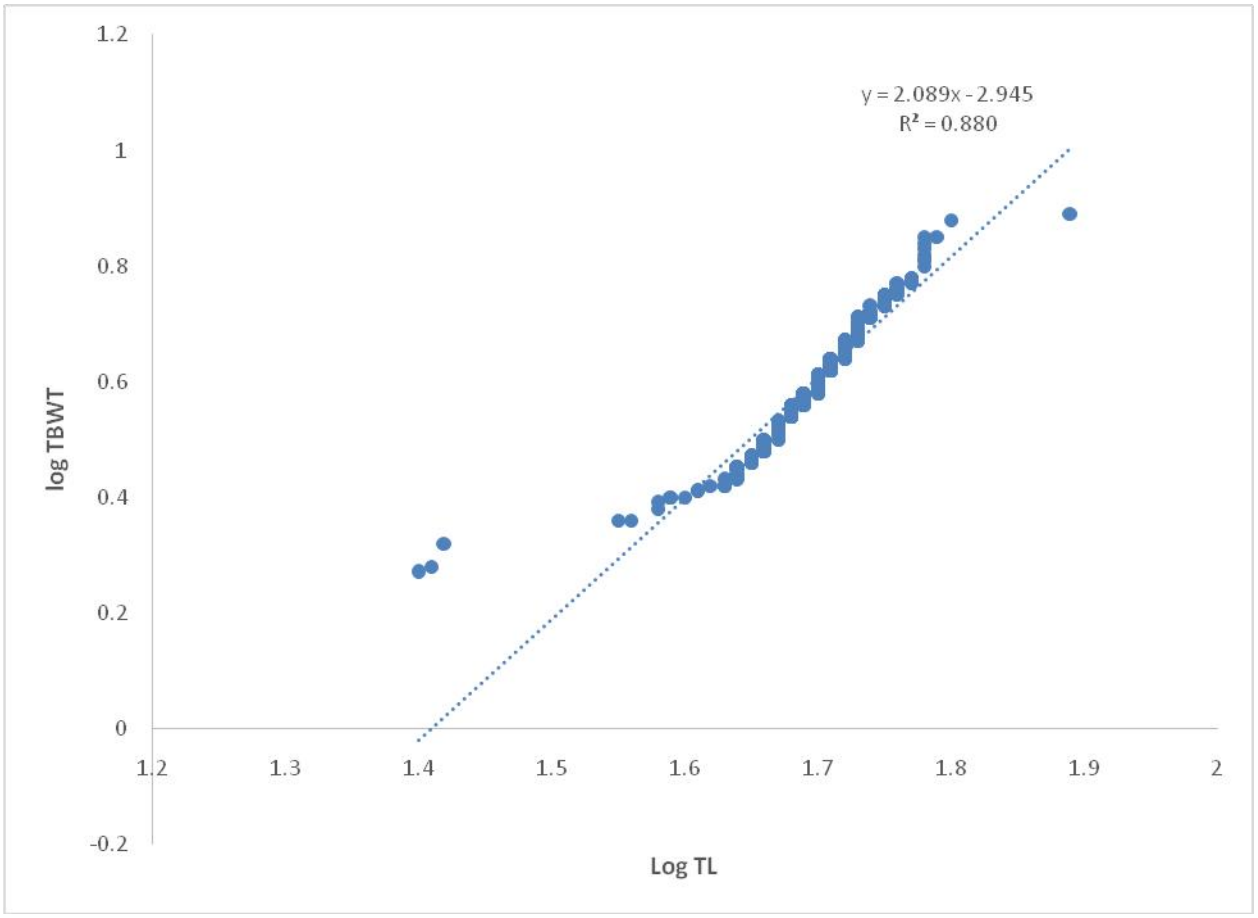

Figure 6: Total Length- Total Body Weight relationship for combined sexes of *T.fuscatus var fuscatus*

4.4 Length- girth relationship

4.4.1 Total length- girth relationship of *T. fuscatus var fuscatus*

The total length of *T. fuscatus var fuscatus* ranged between 25.8mm and 77.3mm for females while the Girth/width ranged from 14.2mm to 56.7mm. While for the males, the total length ranged from 25.1mm to 63.1mm and girth/width ranged from 13.9mm to 34.3mm while for the combined sexes total length ranged from 22.3mm and 64.6mm and the girth 12.3mm and 47.9mm The. The relationship between length and girth was estimated using equation:

$$G=a+b\times L$$

Female: 2.085+0.481 x L

Male: 5.974+4.402 x L

Combined:3.779+0.447 X L

G is the observed girth, L is the observed length and a and b are the intercept and regression coefficient (slope) respectively (Santos *et al*., 2006)

Figure 7-9 shows the length-girth relationship for male, female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.40), female(0.48) and combined sexes (0.44), indicating a negative allometric growth, also "r" value were 0.77, 0.94 and 0.82 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and girth of periwinkle.

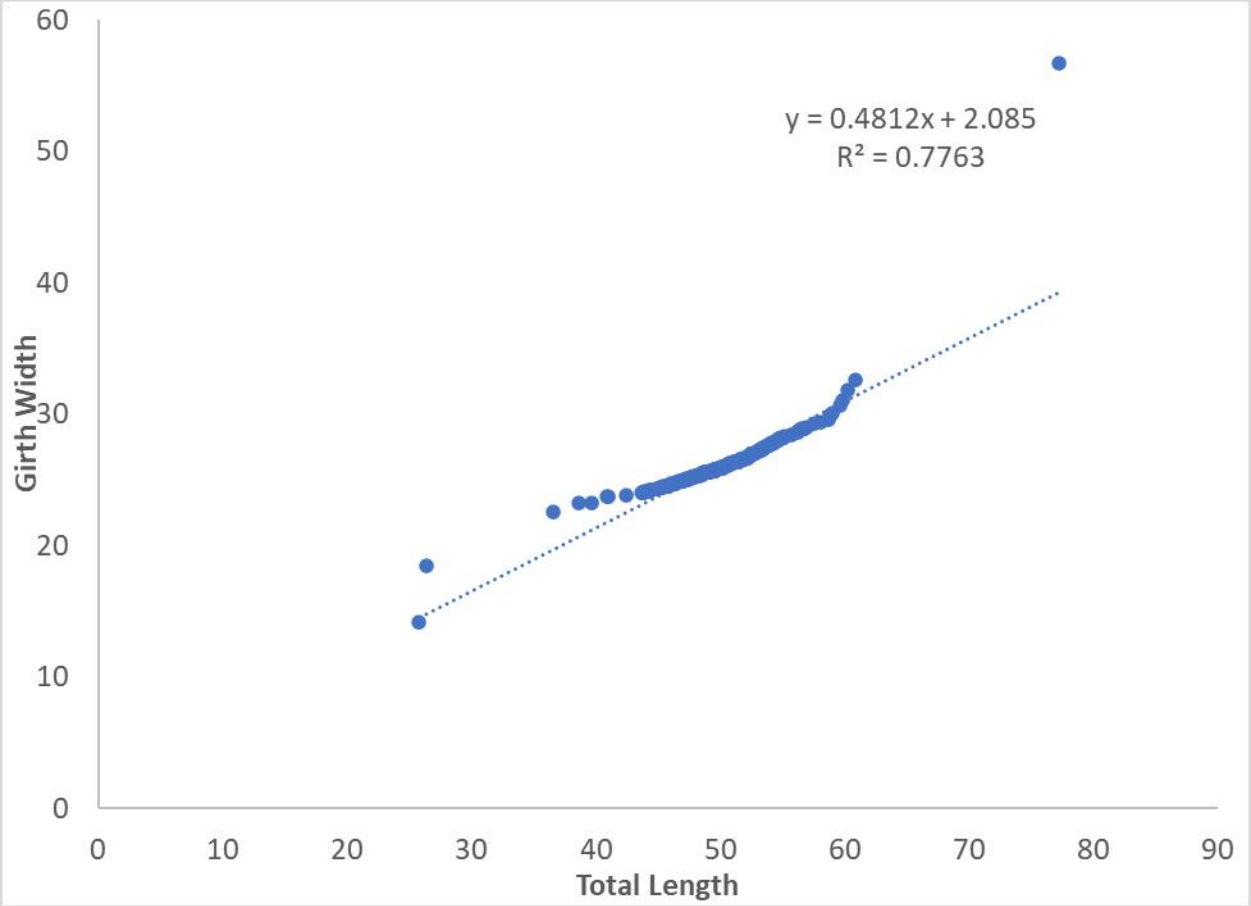

Figure7: Total Length- Girth relationship for female *T. fuscatus var fuscatus*

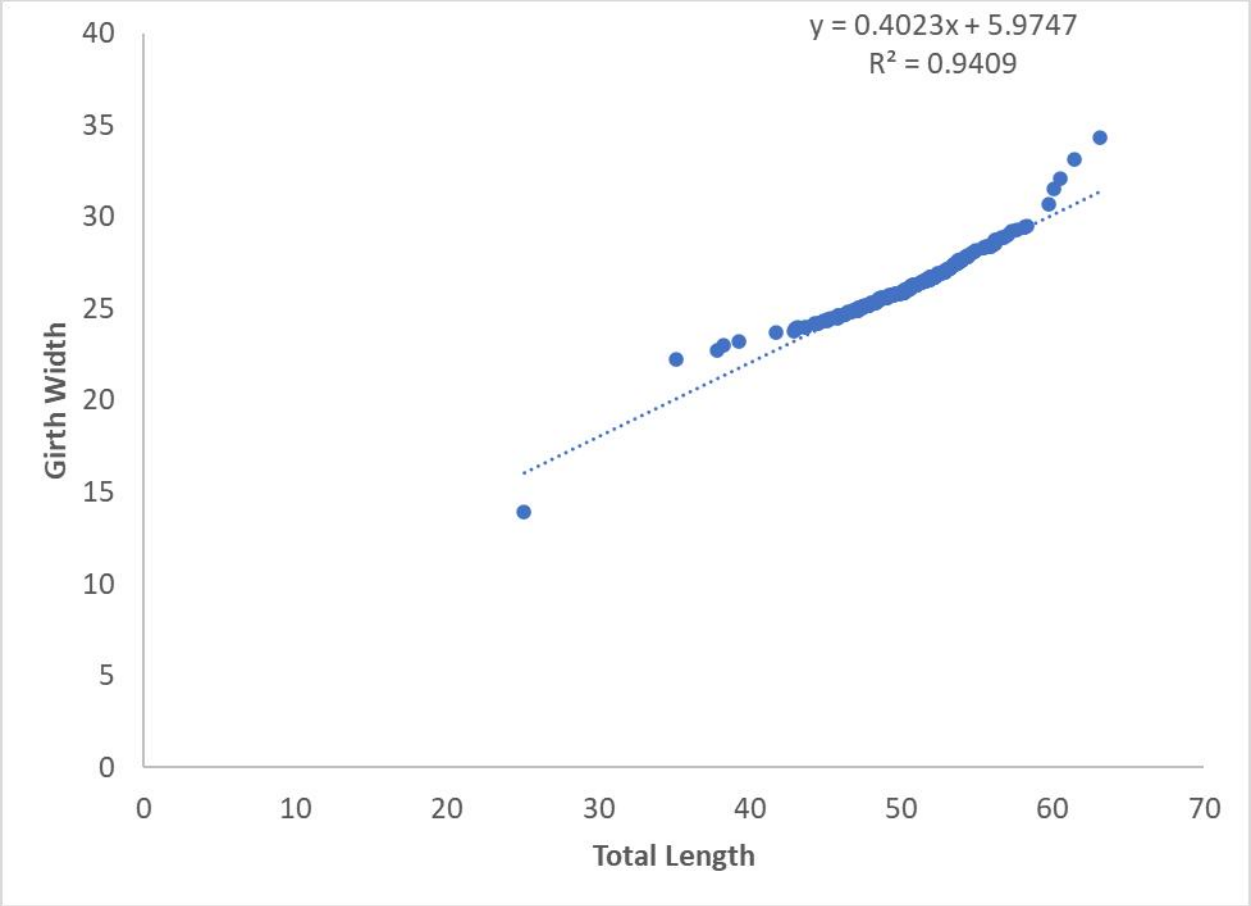

Figure 8: Total length-girth relationship of male *T.fuscatus var fuscatus*

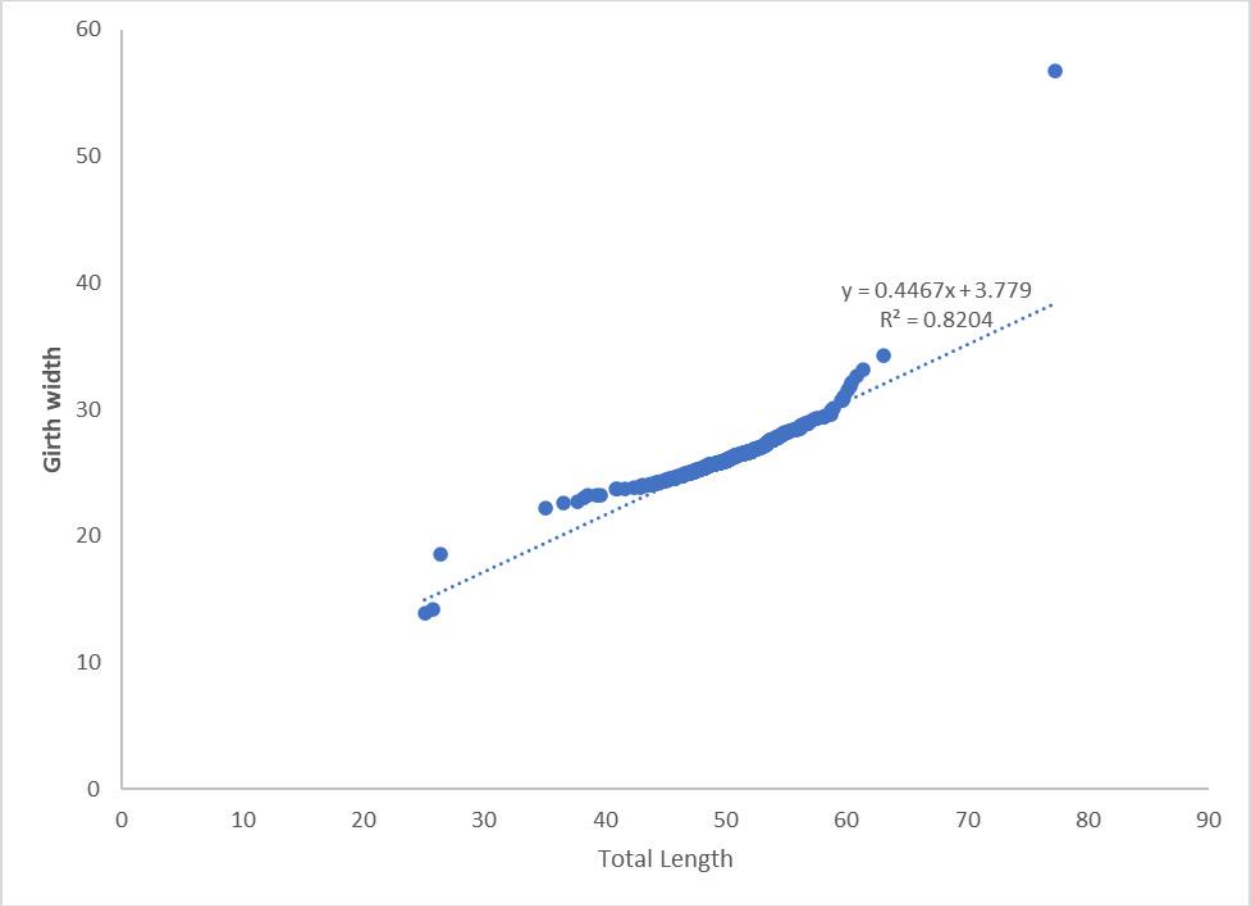

Figure 9: Total length-girth relationship for combined sex of *T.fuscatus var fuscatus*

4.5 Length-Edible Portion Relationship

4.5.1 Total length-edible portion of *T. fuscatus var fuscatus*

The total length for the females ranged between 25.8mm and 77.3mm for the females, while the weight of the edible portion(flesh) ranged from 0.24g and 7.82g for the males the total length ranged between 25.1mm and 63.1mm and the weight of the edible portion (flesh) ranged from 0.22g and 2.82g while for the combined sexes the total length ranged from between 25.1mm and 77.3mm and the weight of the edible portion ranged between 0.22g and 7.82g.

Following the conversion of length and weight to logarithm form, the linear relationship was found to be as follows:

FEMALE : logTBWT= log a+b logTL
=0.081+3.340TL

MALE: : logTBWT= log a+b logTL
=-2.342+0.062 TL

Combined sexes: logTBWT= log a+b logTL
=-2.906+0.073

Figure 10-12 shows the length-edible portion relationship for male and female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male (0.06), female(0.08) and combined sexes(0.07), indicating a negative allometric growth also “r” value were 0.57, 0.83 and 0.61 for female, male and combined sexes respectively which showed a positive correlation between the total length and edible portion weight of periwinkle.

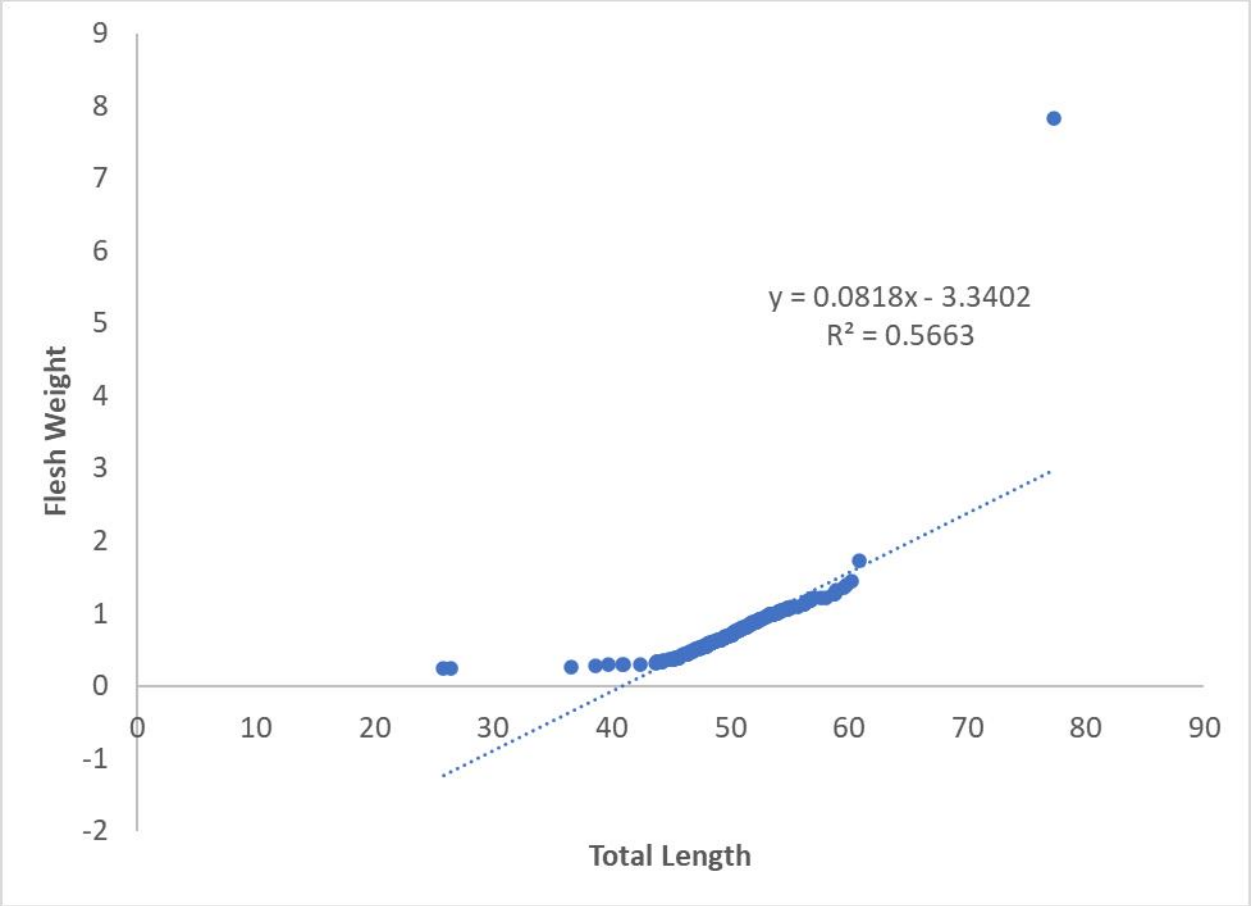

Figure 10: Total length- edible portion of female *T.fuscatus var fustatus*

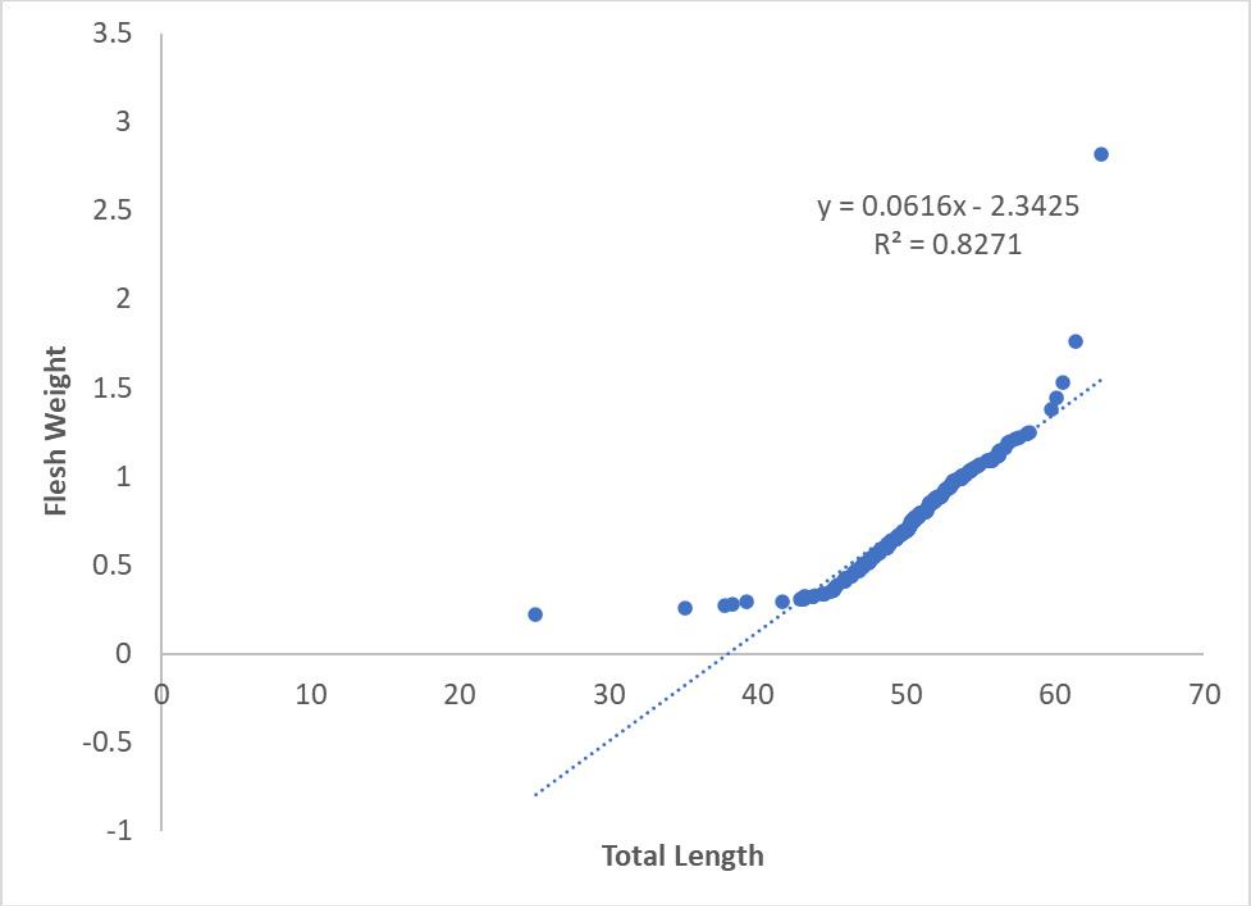

Figure 11: Length - edible portion weight of male *T. fuscatus var fuscatus*

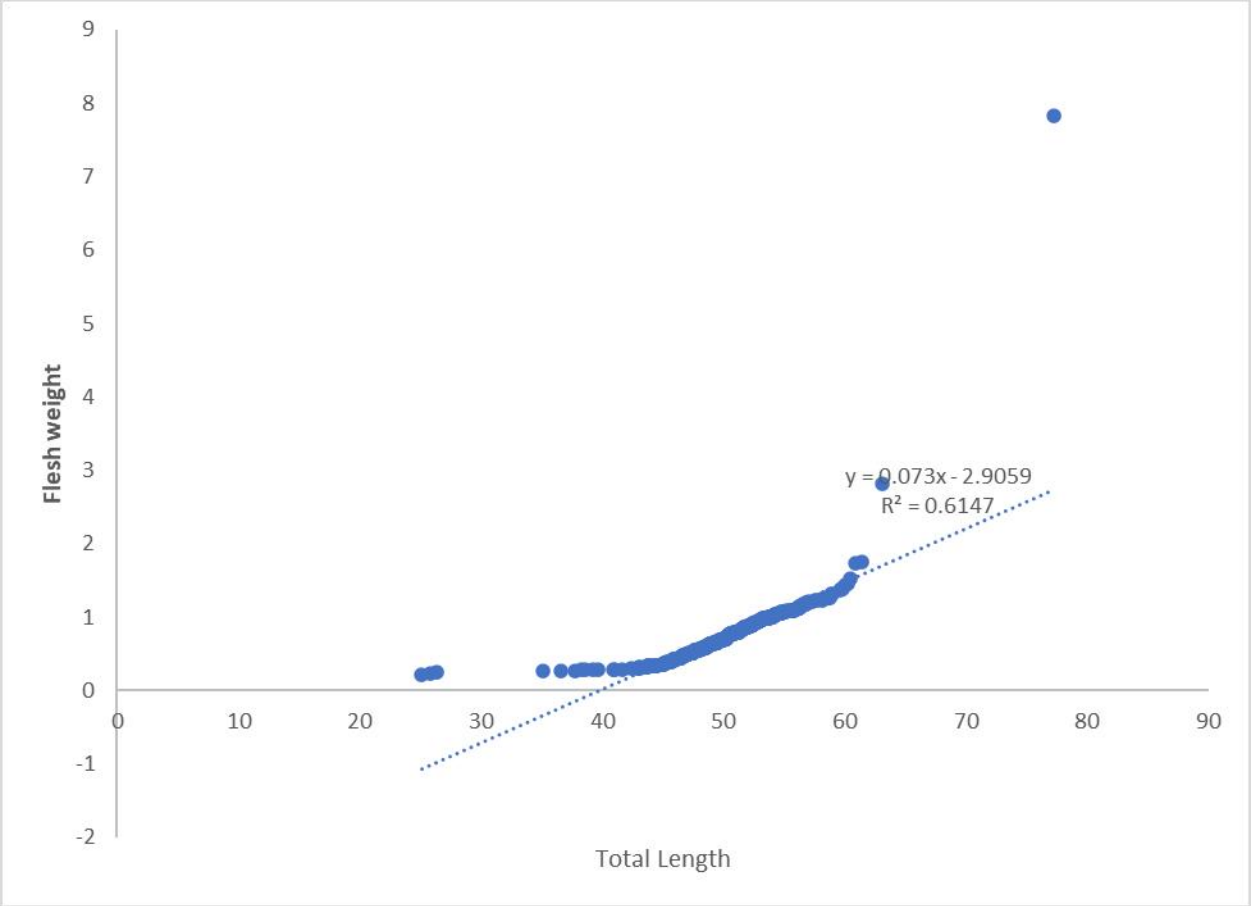

Figure 12: Length - edible portion weight of combined sexes of *T. fuscatus var fuscatus*

4.6 Relationship between Total Length- Shell Weight

4.6.1 Relationship between Total Length and shell weight of *T. fuscatus var fuscatus*

The total length for the females ranged between 25.8mm and 77.3mm for the females, while the shell weight ranged from 1.52g and 6.85g. for the males the total length ranged between 25.1mm and 63.1mm and the shell weight ranged from 1.28g and 6.32g while for the combined sexes the total length ranged from between 25.1mm and 77.3mm and the shell weight ranged between 1.28g and 6.85g.

Following the conversion of length and weight to logarithm form, the linear relationship was found to be as follows:

Female : logTBWT= log a+b logTL
=4.99+0.166 TL

Male: : logTBWT= log a+b logTL
=--5.745+0.181 TL

Combined sexes: logTBWT= log a+b logTL
=-5.321+0.172 log TL

Figure 13-15 shows the length-shell weight relationship for male and female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.16), female(0.18) and combined sexes(0.17), indicating a negative allometric growth also "r" value were 0.88, 0.91 and 0.89 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and shell weight of periwinkle.

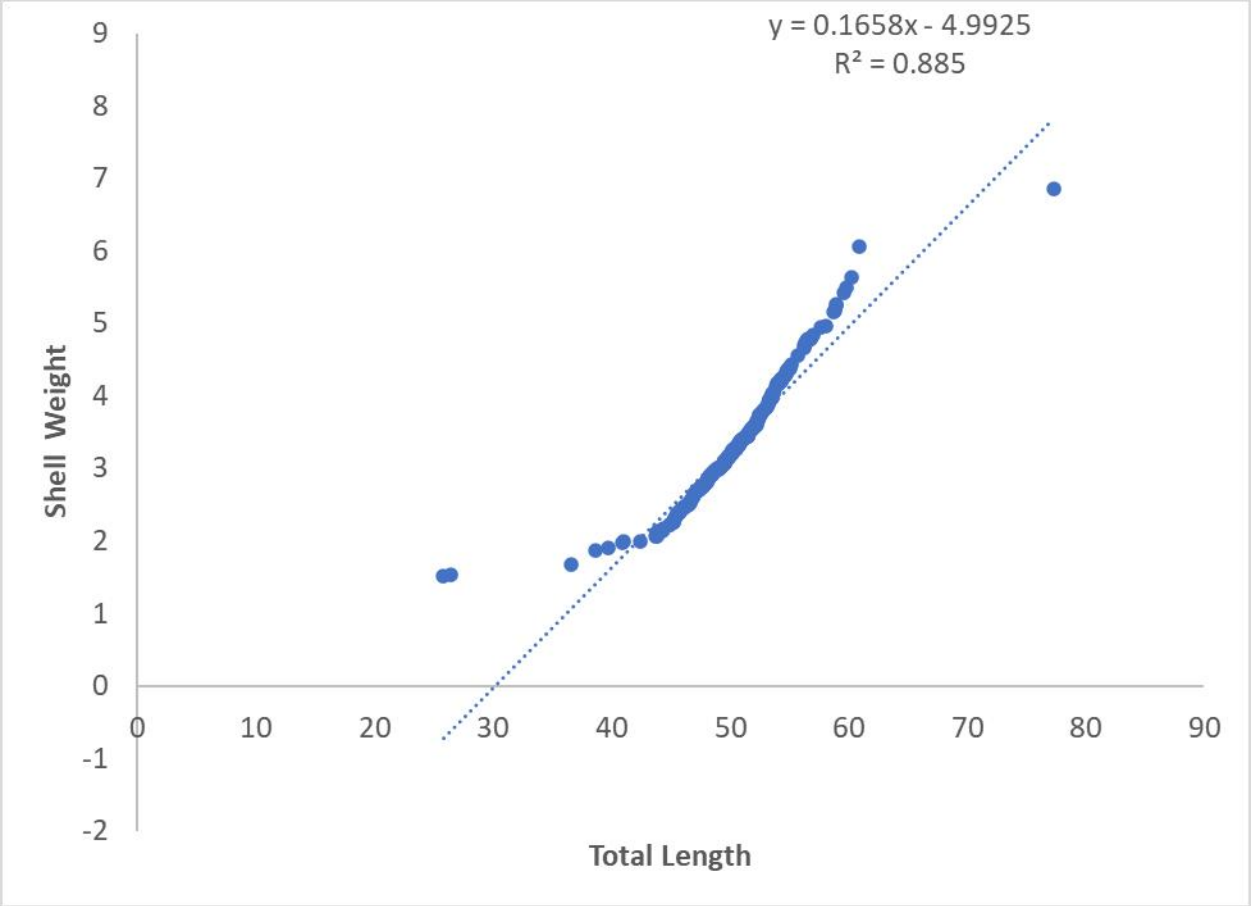

Figure 13: Length - shell weight relationship of female *T. fuscatus var fuscatus*

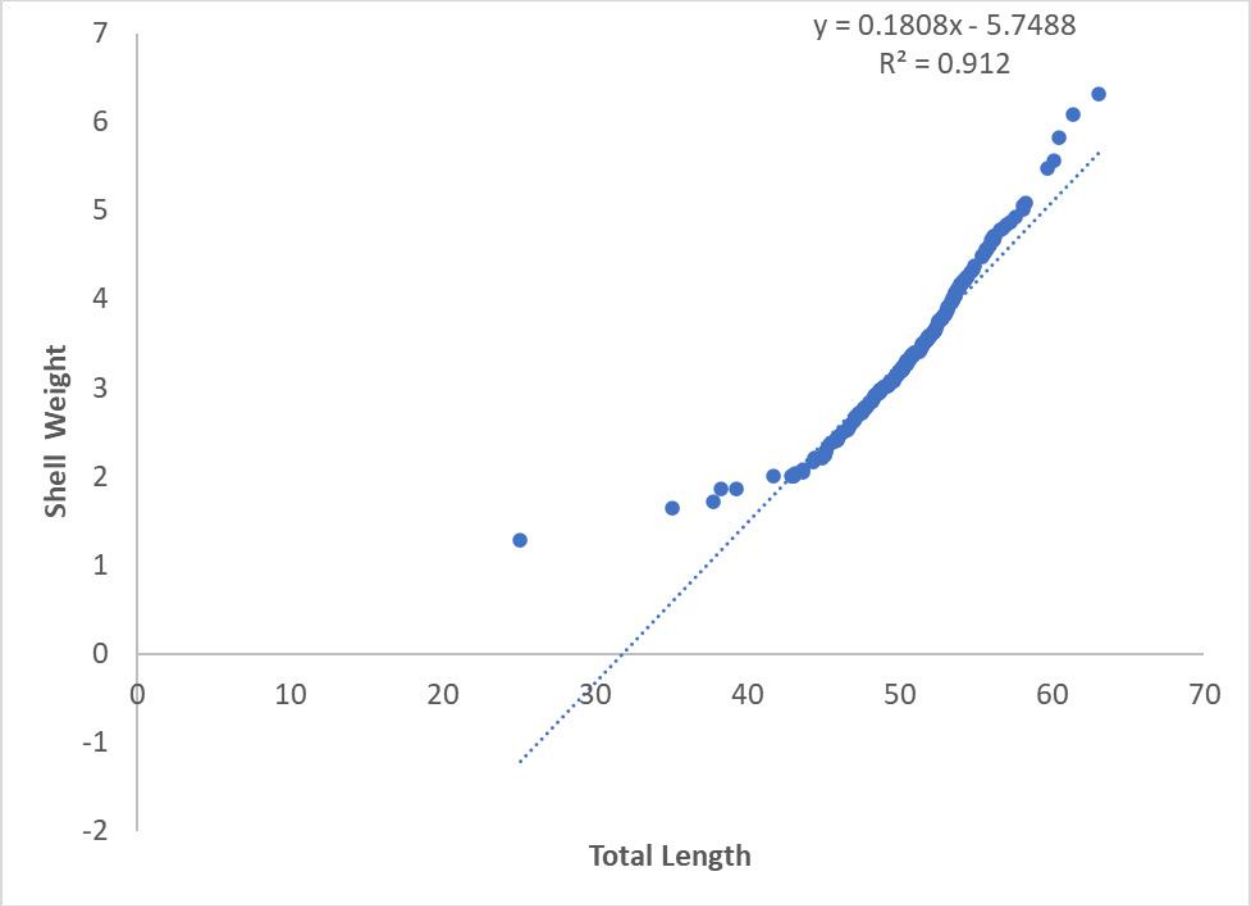

Figure 14: Length - shell weight relationship of male *T. fuscatus var fuscatus*

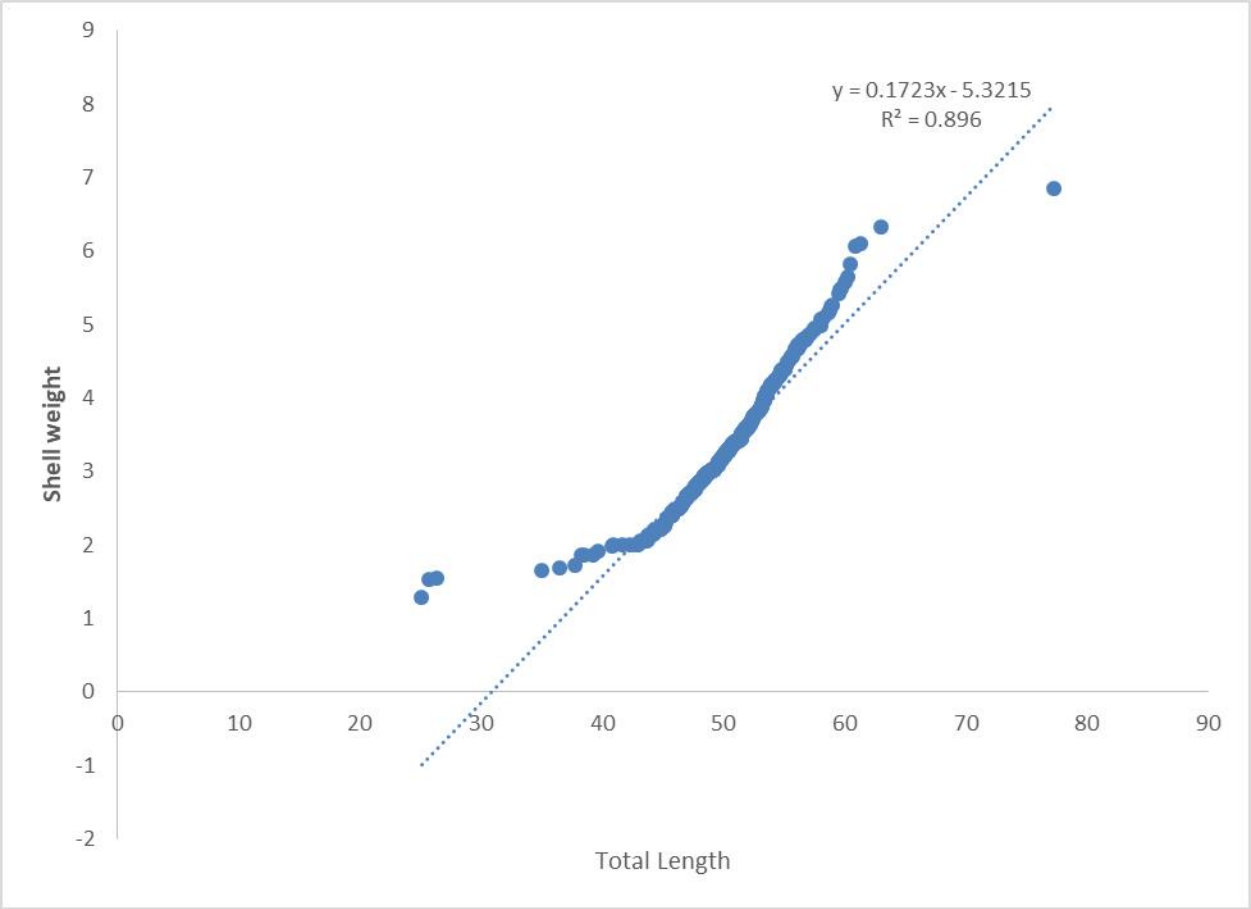

Figure 15: Total Length - shell weight relationship of combined sex of *T. fuscatus var fuscatus*

4.7 Relationship between total Length- number of whorls of *T. fuscatus var fuscatus*

The total length of the female ranged between 25.8mm and 77.3mm,while the number of whorls ranged between 6 and 12, for the males the total length ranged between 25.1mm and 63.1mm and the number of whorls ranged between 6 and 12 while for the combined sexes the total length ranged between 25.1 and 77.3 while for the number of whorls it ranged between 6- 12

Figure 16-18 shows the length-number of whorls relationship for male, female and combined sexes were not determined or affected by sex of the specie, the values of b was less than 3 for male(0.19), female(0.22) and combined sexes(0.23), indicating a negative allometric growth also "r" value were 0.79, 0.74 and 0.81 for female, male and combined sexes respectively which showed a positive correlation between the total length and number of whorls of periwinkle.

4.8 Meristics and Morphometrics features of *T. fuscatus var radula*

Total length: The total length for the females ranged between 22.3mm and 64.6mm for the females, and between 19.5mm and 62.2mm for the males while for the combined sexes the total length ranged from between 19.5mm and 64.6mm.(Table 3)

Girth/Width: The girth/ width ranged from 12.3mm and 47.9mm for females, between 12.6mm and 33.8mm for males, and ranged from between 12.3mm and 47.9mm for the combined sexes

Total weight: The total weight for the females ranged between 1.41g and 7.63g for the females, and between 1.11g and 7.29g for the males while for the combined sexes the total weight ranged from between 1.11g and 7.63g

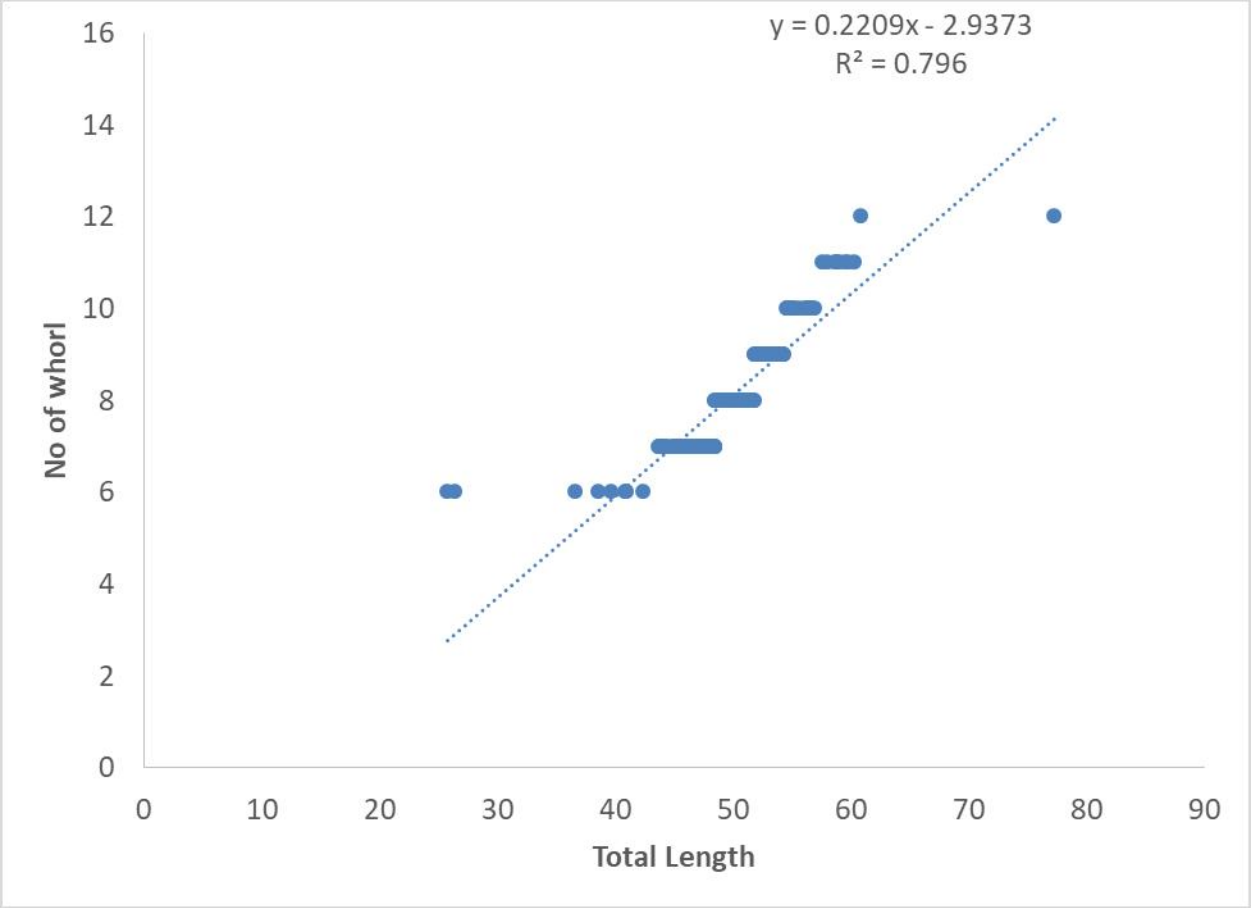

Figure 16: Total length-number of whorl relationship of female *T. fuscatus var fuscatus*

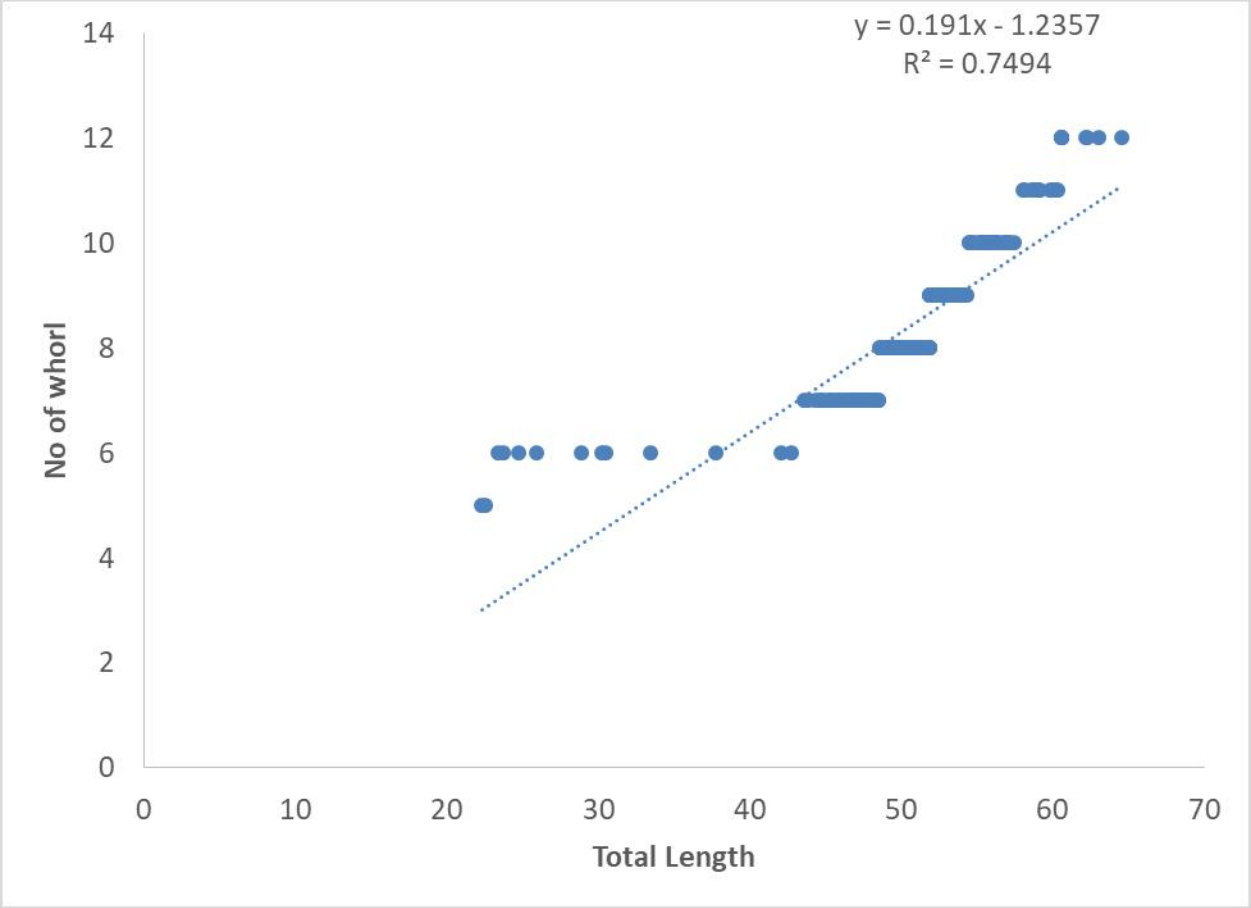

Figure 17: Total length-number of whorl relationship of male *T. fuscatus var fuscatus*

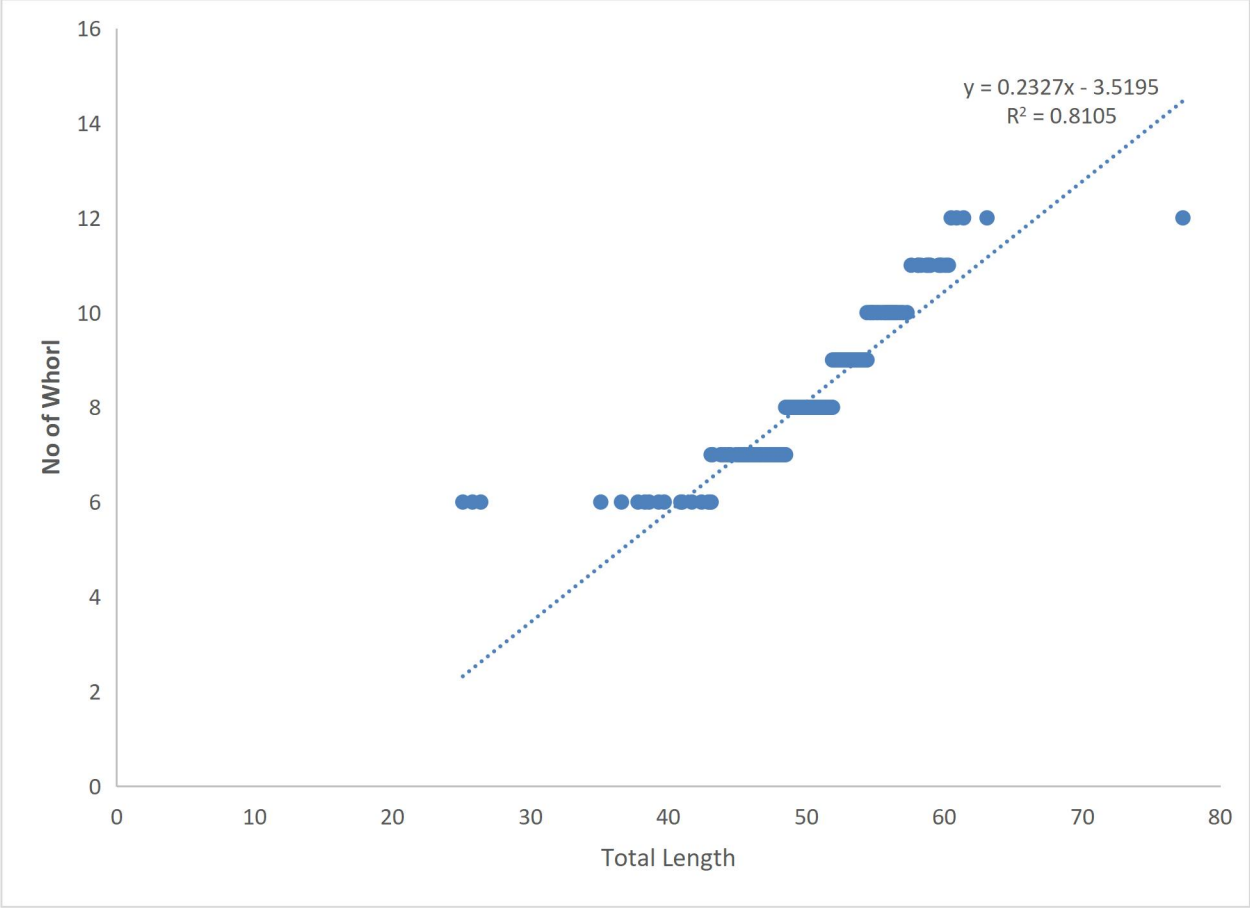

Figure 18: Total length-number of whorl relationship of combined sexes for *T. fuscatus var fuscatus*

Table 3: Summary of Meristics and Morphometric features for T. *fuscatus var radula*

	Female		**Male**		**Combined sexes**	
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**
Total length (mm)	22.3-64.6	50.8±6.34	19.5-62.2	50.23±5.96	19.5-64.6	50.57±6.17
Girth (mm)	12.3-47.9	26.56±3.11	12.6-33.8	26.26±2.42	12.3±47.9	26.42±2.81
Total weight (g)	1.41-7.63	4.35±110	1.11-7.29	4.19±1.01	1.11±7.63	4.28±1.06
Weight of the flesh(g)	0.15-3.91	0.84±0.39	0.12-2.14	O.78±0.31	0.12±3.91	O.81±0.35
Weight of the shell (g)	0.63-6.63	3.56±1.02	0.44-6.23	3.41±0.94	0.44±6.63	3.49±0.98
Number of whorls	5-12	8.48±1.40	4-12	8.27±1.37	4-12	8.38±1.39

Flesh weight: The flesh weight for the females ranged between 0.15g and 3.91g for the females, and between 0.12g and 2.14g for the males while for the combined sexes the total weight ranged from between 0.12g and 3.91g

Shell weight: The shell weight for the females ranged between 0.63g and 6.63g for the females, and between 0.44g and 6.23g for the males while for the combined sexes the total weight ranged from between 0.44g and 6.63g

Number of whorls: The number of whorls for the females ranged between 5 and 12 for the females, while for the males ranged between 4 and 12. while for the combined sexes ranged between 4 and 12.

4.8.1 : Total Length-Total Body Weight Relationship For *T. fuscatus var radula*

The total length of female *T. fuscatus var radula* ranged between 22.3mm and 64.6mm and the total weight ranged from 1.41g and 7.63g. For the males, the total length ranged from 19.5mm and 62.2mm while the total weight ranged from 1.11g and 7.29g.

Following the conversion of length and weight to logarithm form, the linear relationship was found to be as follows:

FEMALE : logTBWT= log a+b logTL

=-4.892+0.179 TL

MALE: : logTBWT= log a+b logTL

=-5.714+0.196 TL

Combined sexes: logTBWT= log a+b logTL

=-2.181+1.646 TL

Figure 19-21 shows the length-total body weight relationship for male and female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.19), female(0.17) and combined sexes (1.64), indicating a negative allometric growth also “r” value were 0.89, 0.91 and 0.85 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and total body weight of periwinkle.

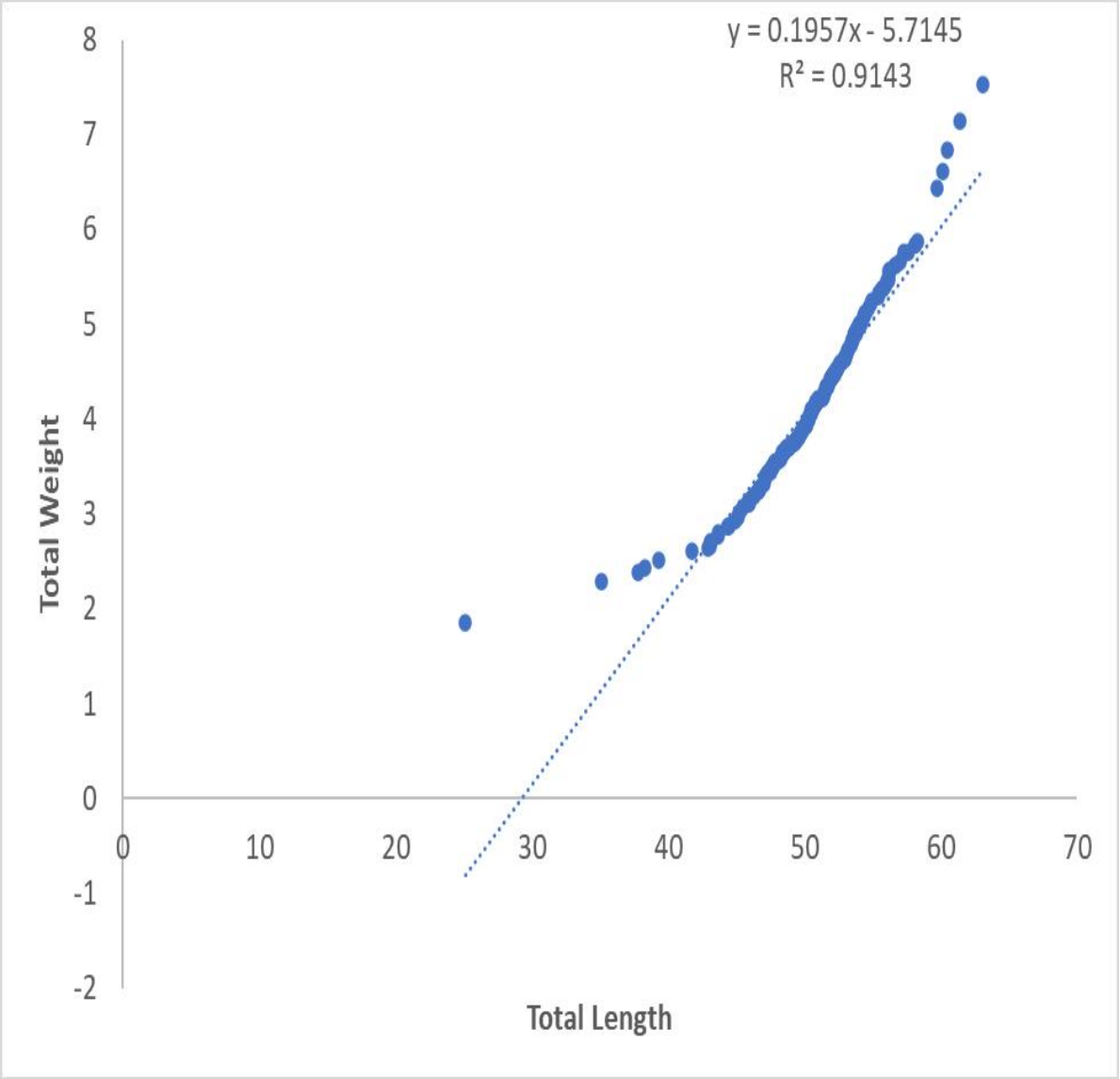

Figure 19: Length-weight relationship for male *T. fuscastus var radula*

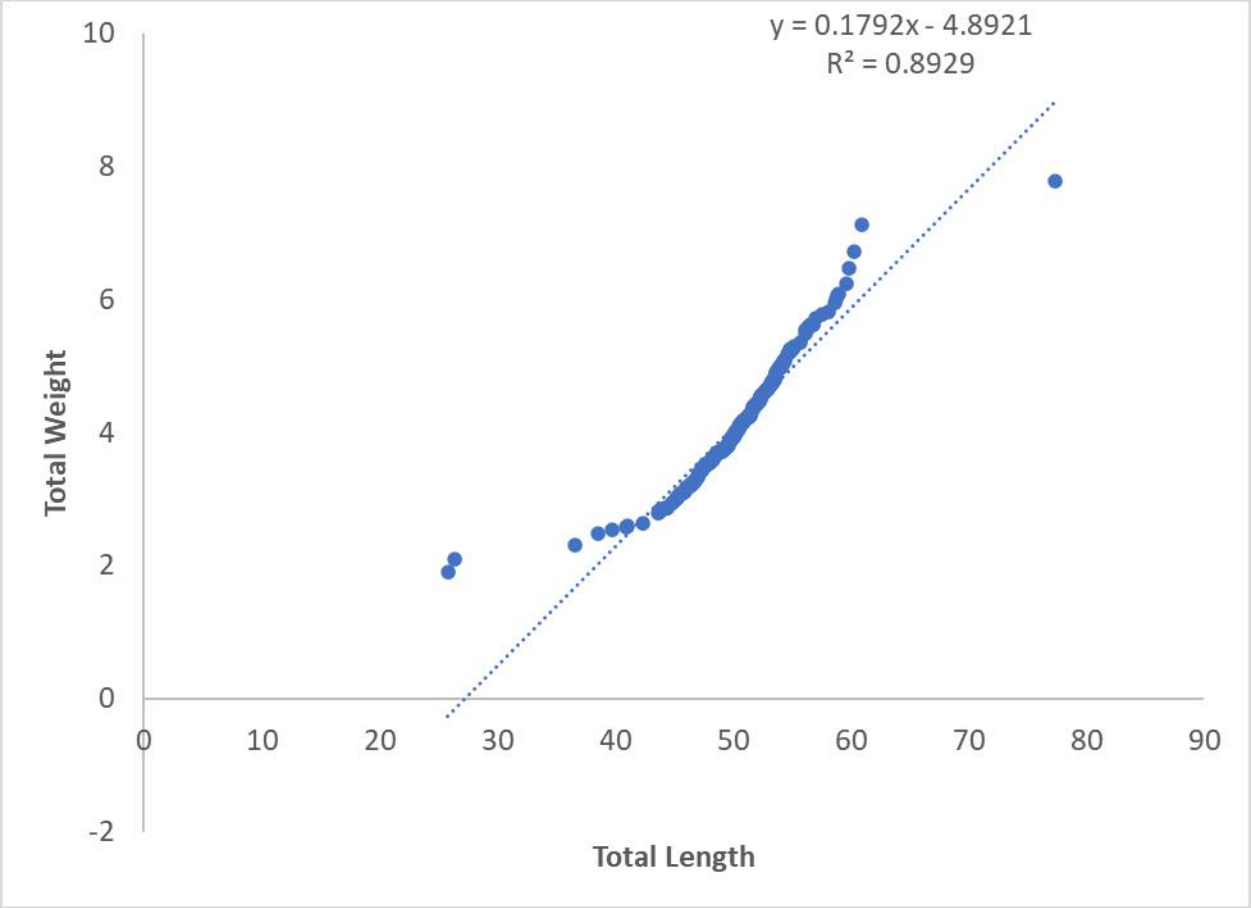

Figure 20:length-weight relationship for female *T. fuscastus var radula*

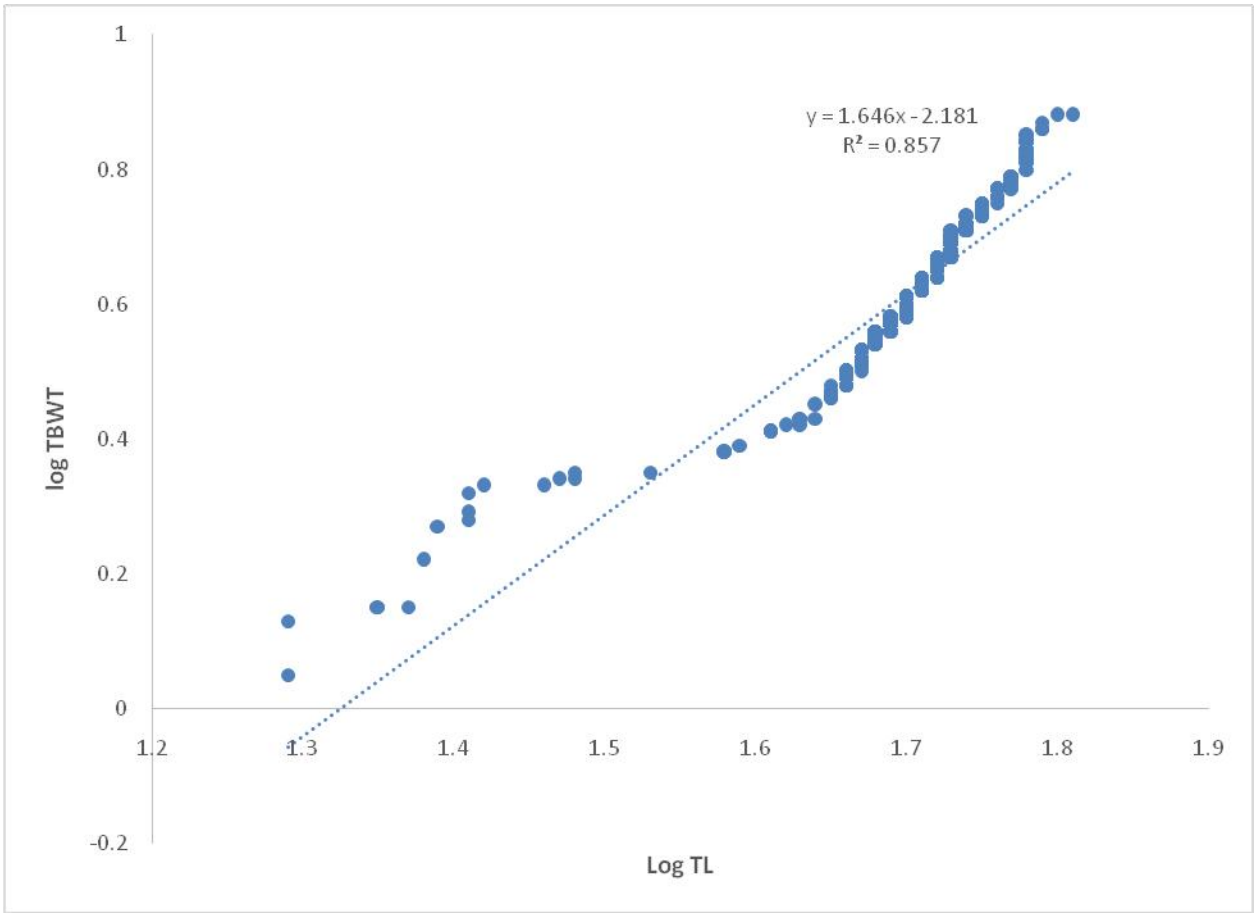

Figure 21:length-weight relationship for combined sexes of *T. fuscastus var fuscastus*

4.8.2 Total length- girth relationship of *T. fuscatus var radula*

The total length of *T. fuscastus var fuscastus* ranged between 25.8mm and 77.3mm for females while the Girth/width ranged from 14.2mm to 56.7mm. While for the males, the total length ranged from 25.1mm to 63.1mm and girth/width ranged from 13.9mm to 34.3mm.The relationship between length and girth was estimated using equation:

$$G=a+b\times L$$

Female: 3.57+0.45 xL

Male: 6.58+0.39 xL

Combined:3.77+0.44 xL

G is the observed girth, L is the observed length and a and b are the intercept and regression coefficient (slope) respectively (Santos *et al*., 2006)

Figure 22-24 shows the length-girth relationship for male, female and combined sexes. a significant linear relationship was established, the values of b was less than 3 for male(0.39),female(0.45) and combined sexes(0.44), indicating a negative allometric growth, while b was greater than 3 for females indicating positive allometric growth also "r" value were 0.84, 0.93 and 0.82 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and girth of periwinkle.

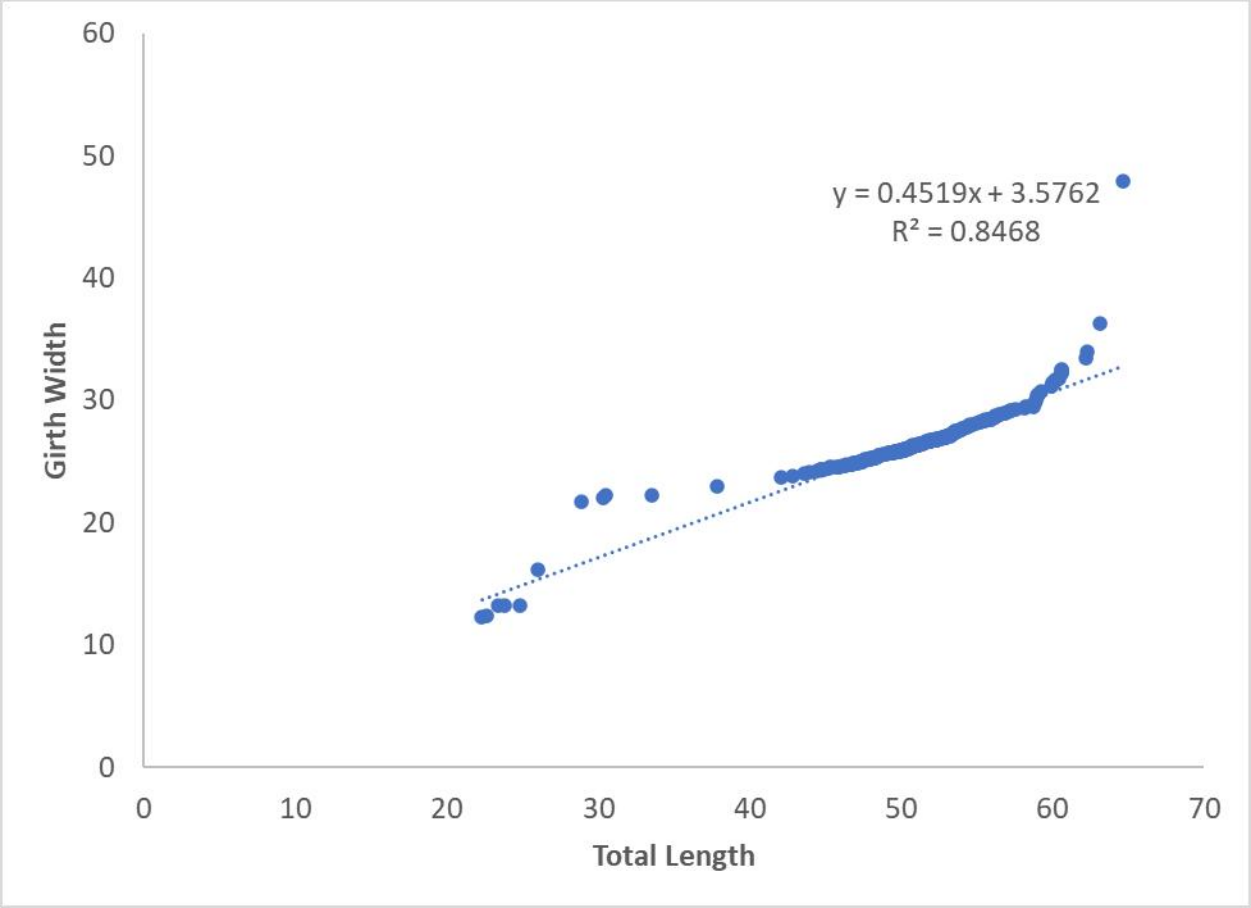

Figure 22: length- girth relationship for female *T. fuscatus var radula*

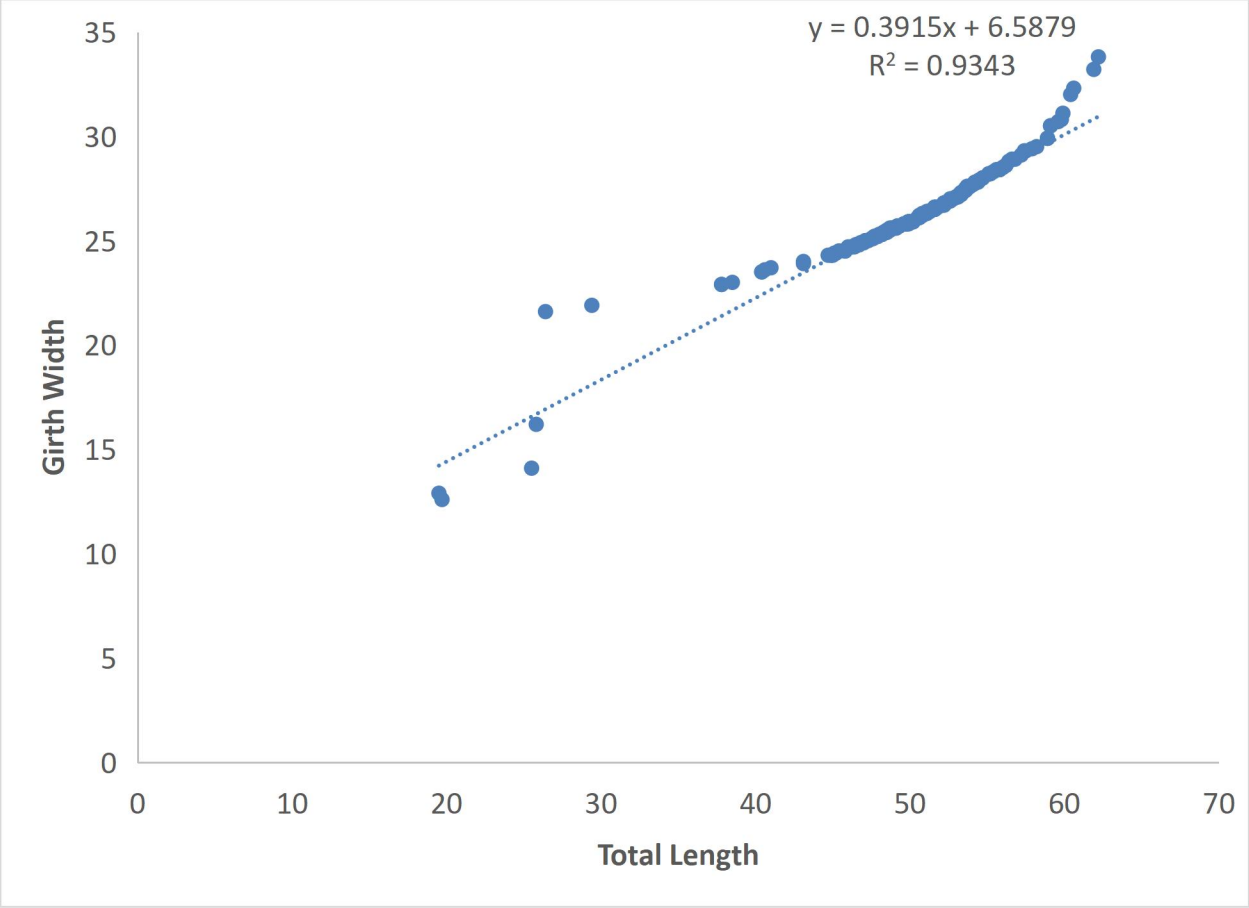

Figure 23: Length-girth relationship for male *T. fuscatus var radula*

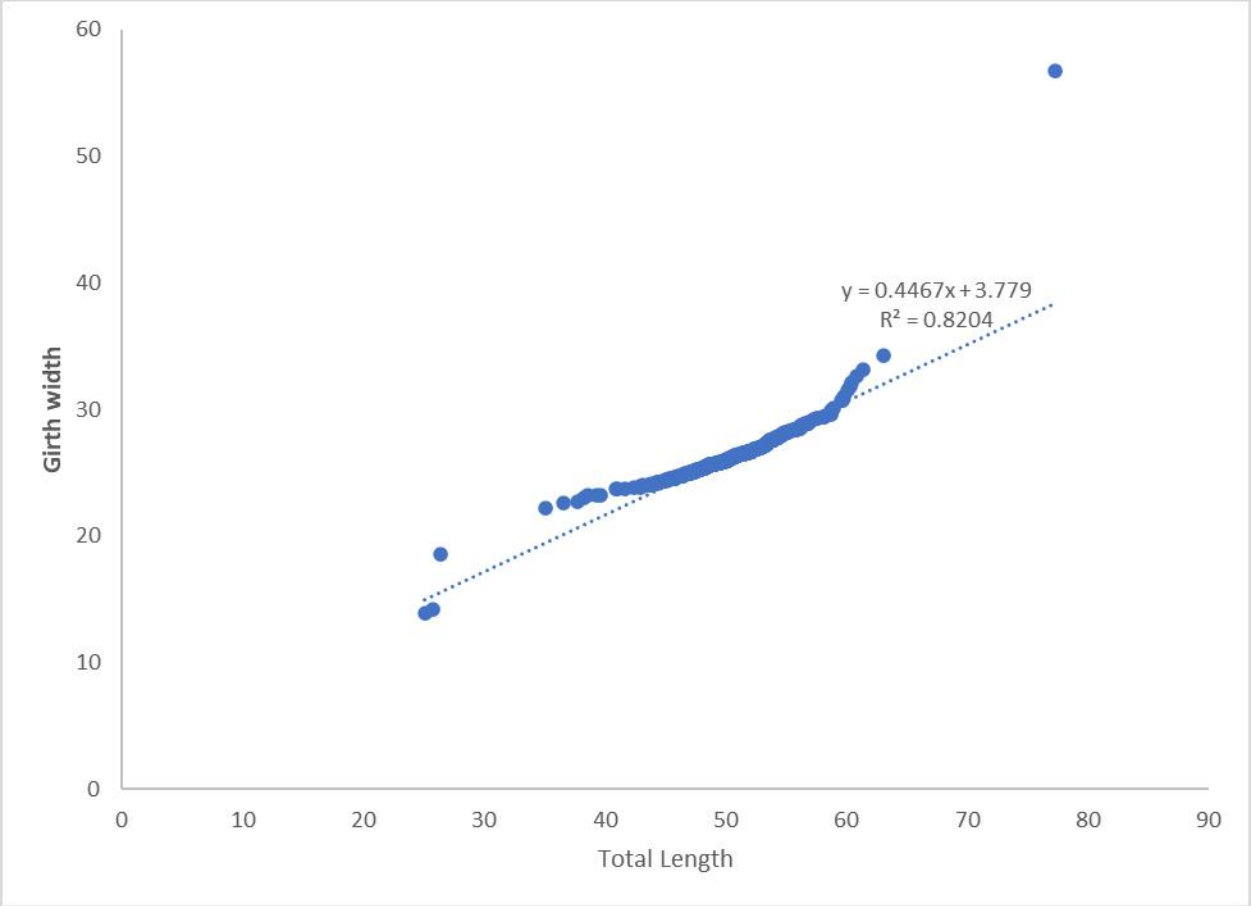

Figure 24:Length- girth relationship of combined sexes of periwinkle.

4.8.3 Total length-edible portion of *T. fuscatus var radula*

The total length for the females ranged between 25.8mm and 77.3mm for the females,while the weight of the edible portion(flesh) ranged from 0.15g and 3.91g for the males the total length ranged between 25.1mm and 63.1mm and the weight of the edible portion (flesh) ranged from 0.12g and 2.14g while for the combined sexes the total length ranged from between 25.1mm and 77.3mm and the weight of the edible portion ranged between 0.12g and 3.91g.

Following the conversion of length and weight to logarithm form, the linear relationship was found to be as follows:

FEMALE : **logTBWT= log a+b logTL**
=1.629+0.485TL

MALE: : **logTBWT= log a+b logTL**
=1.457+0.0445 TL

Combined sexes: logTBWT= log a+b logTL

=-2.1259+ 0.1112 TL

Figure 25-27 shows the length-edible portion relationship for male,female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.044), female(0.044) and combined sexes(0.111), indicating a negative allometric growth also “r” value were 0.62, 0.75 and 0.78 for female, male and combined sexes respectively which showed a positive correlation between the total length and edible portion weight of periwinkle.

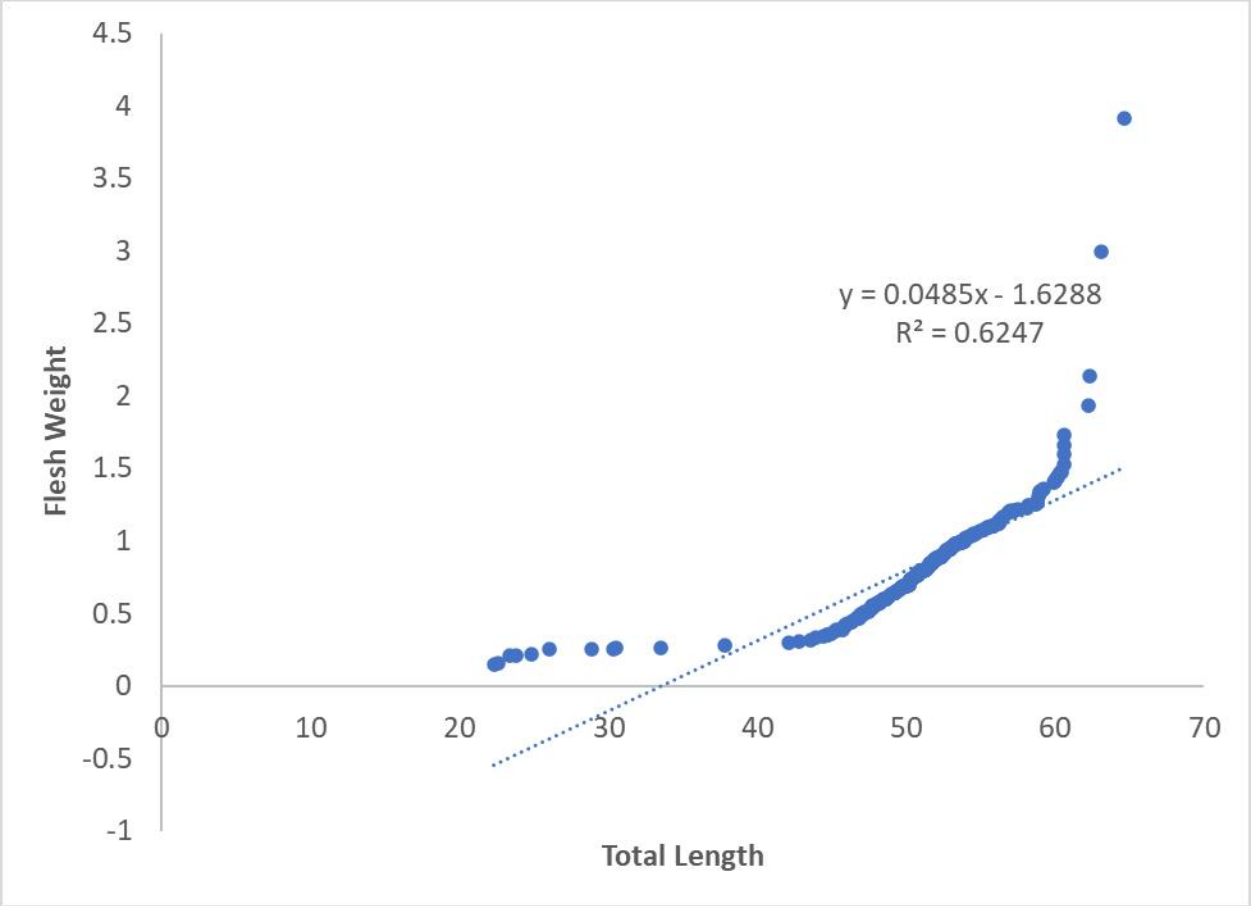

Figure 25: Length- edible portion of female *T.fuscastus var radula*

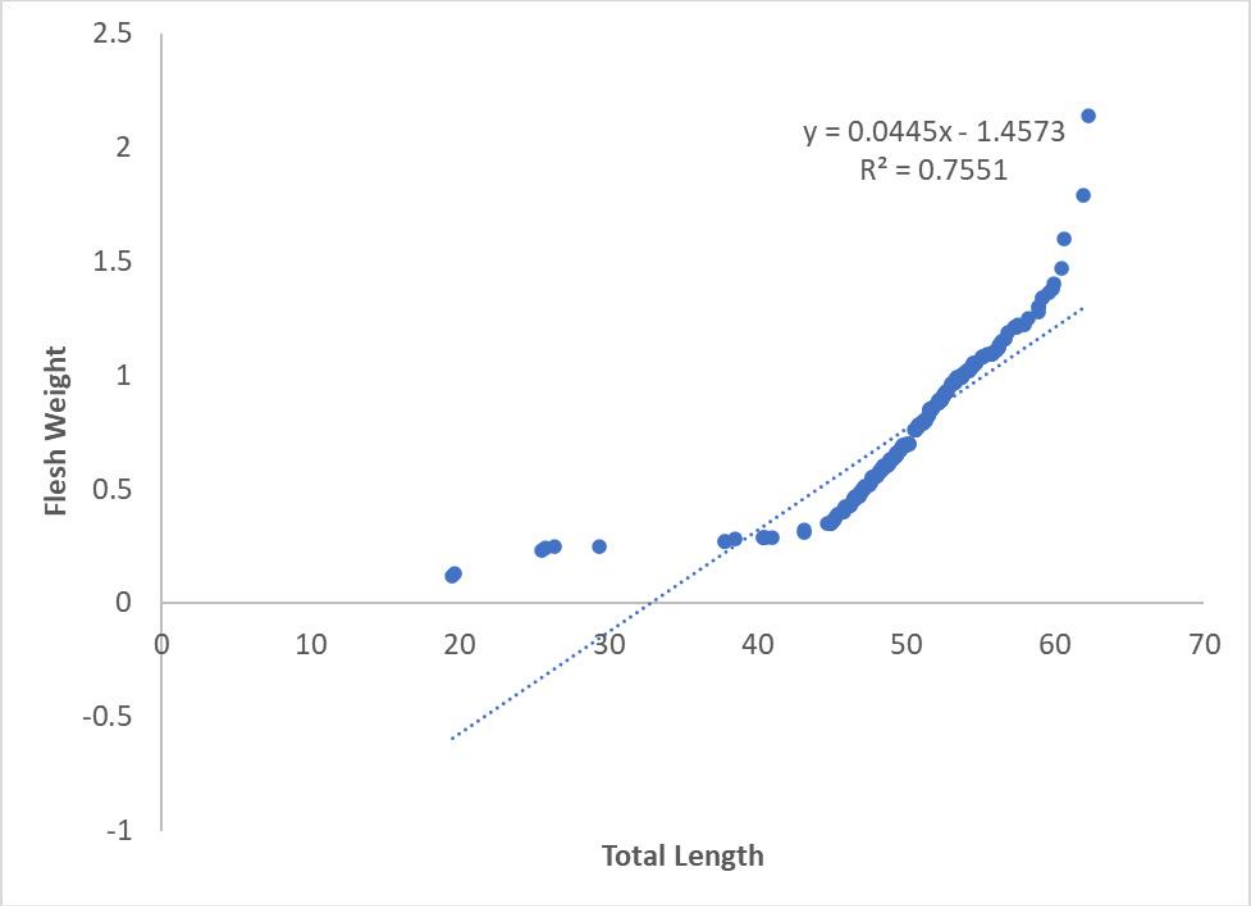

Figure 26: Length-edible portion relationship for male *T. fuscastus var radula*

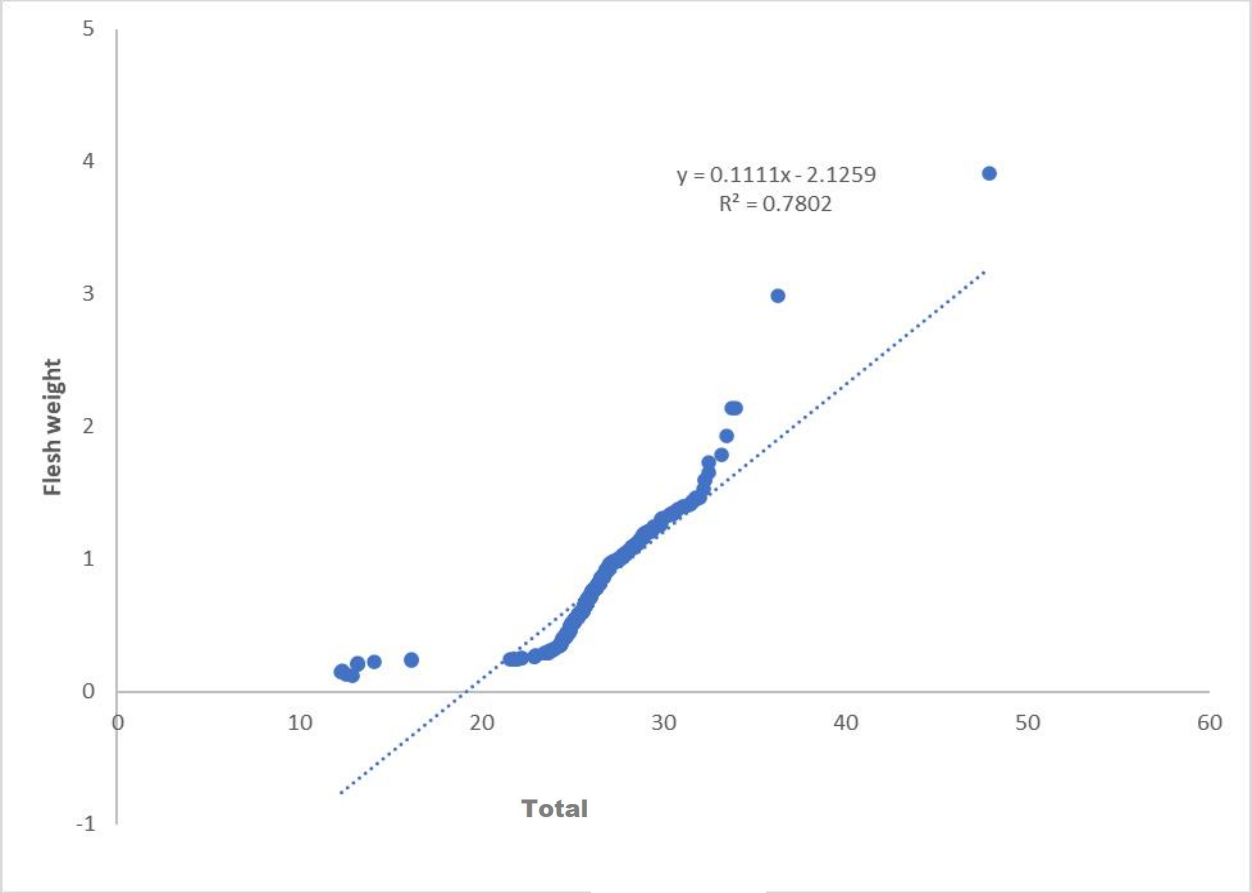

Figure 27: Length- edible portion relationship for combined sexes of *T.fuscastus var radula*

4.8.4 Relationship between Total Length and shell weight of *T. fuscatus var radula*

The total length for the females ranged between 22.3mm and 64.6mm for the females, while the shell weight ranged from 0.63g and 6.63g. for the males the total length ranged between 19.5mm and 62.2mm and the shell weight ranged from 0.44g and 6.23g while for the combined sexes the total length ranged from between 19.5mm and 64.6mm and the shell weight ranged between 0.44g and 6.63g.

Following the conversion of length and weight to logarithm for, the linear relationship was found to be as follows:

FEMALE : logTBWT= log a+b logTL

=-3.8912+0.146 TL

MALE: : logTBWT= log a+b logTL

=-3.841 + 0.1444TL

Combined sexes: logTBWT= log a+b logTL

=-4.837+0.315 TL

Figure 28-30 shows the length-edible portion relationship for male,female and combined sexes a significant linear relationship was established, the values of b was less than 3 for male(0.144), female(0.146) and combined sexes(0.315), indicating a negative allometric growth also “r” value were 0.831, 0.837and 0.808 for female, male and combined sexes respectively which showed a very high positive correlation between the total length and shell weight of periwinkle.

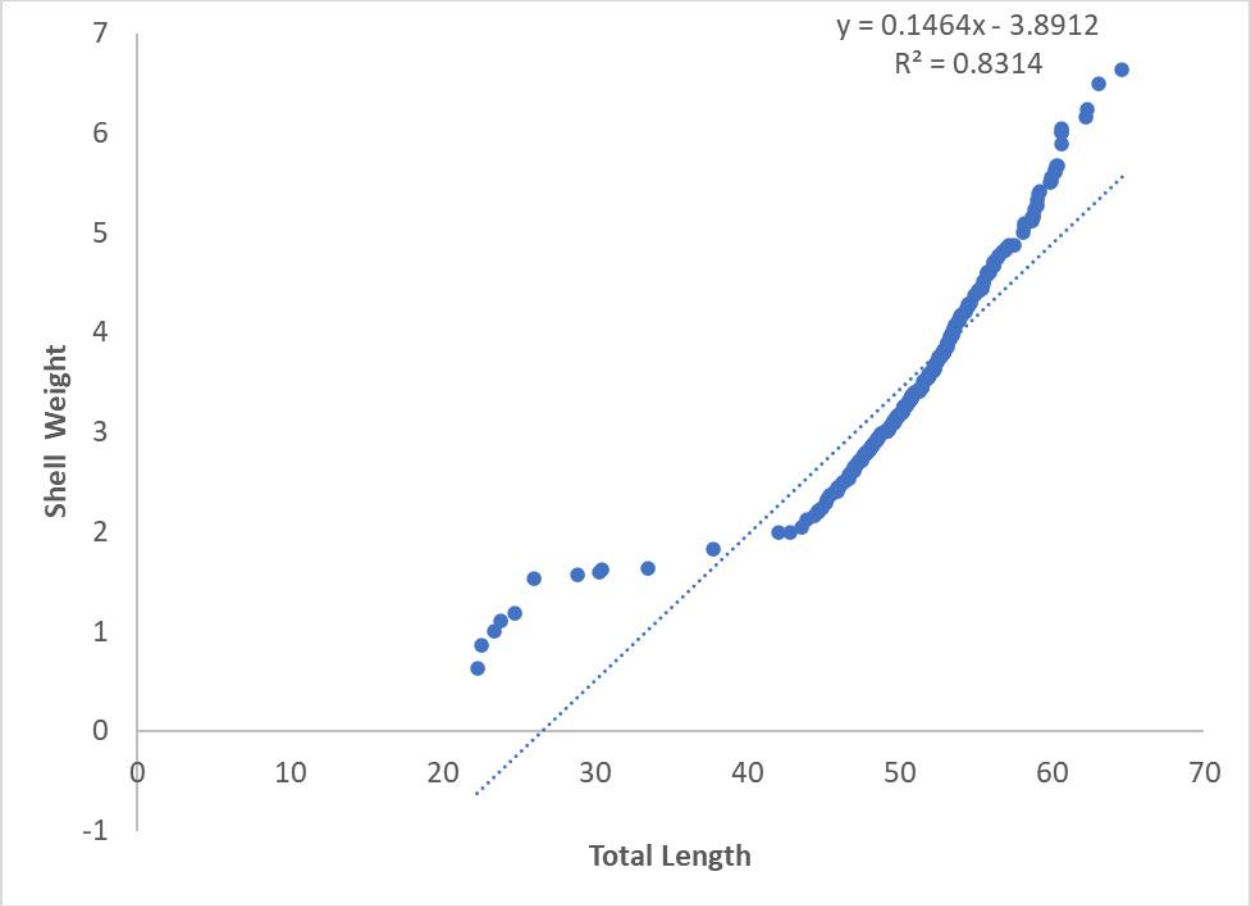

Figure 28: Total length-shell weight relationship of female *T. fuscatus var radula*

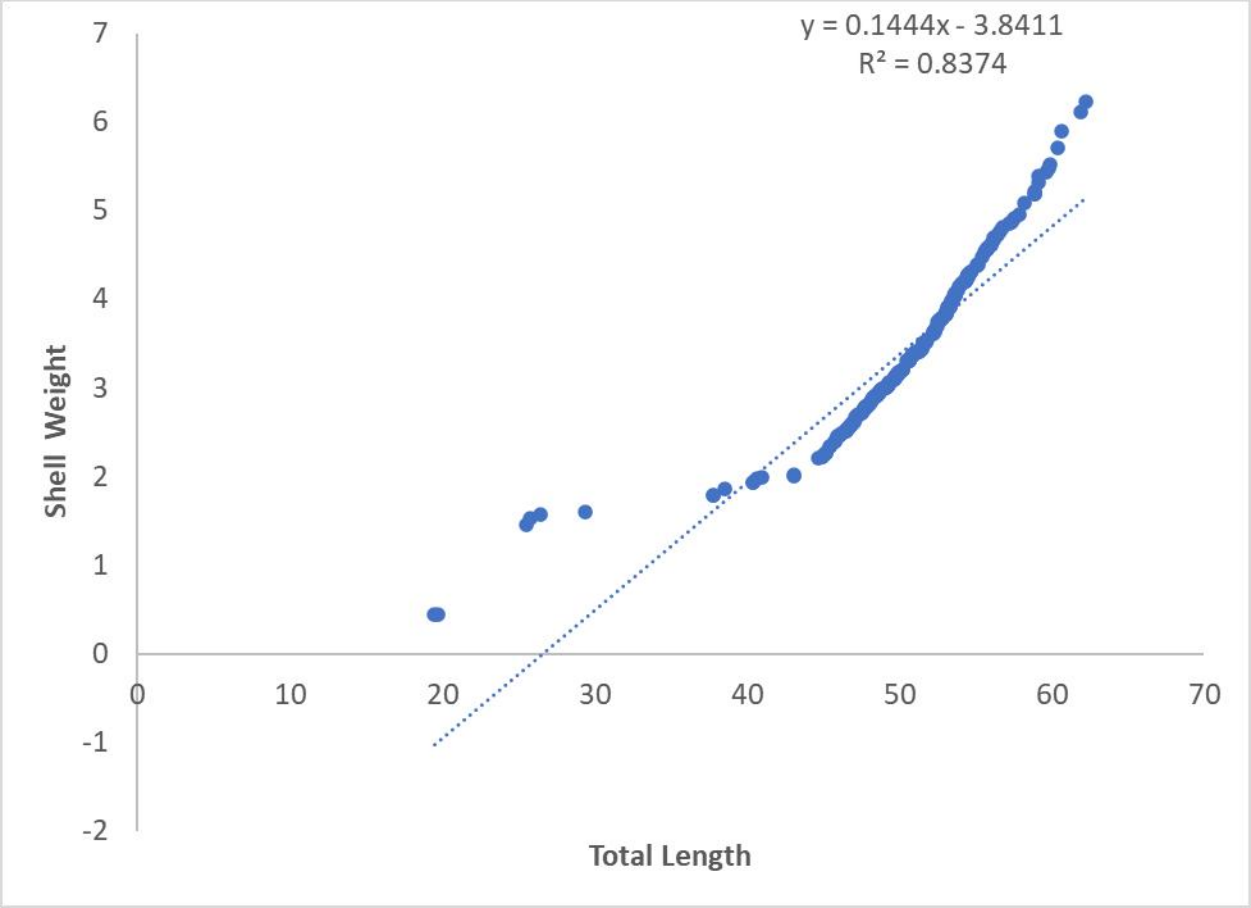

Figure 29: Total length-shell weight relationship of male of *T. fuscatus var radula*

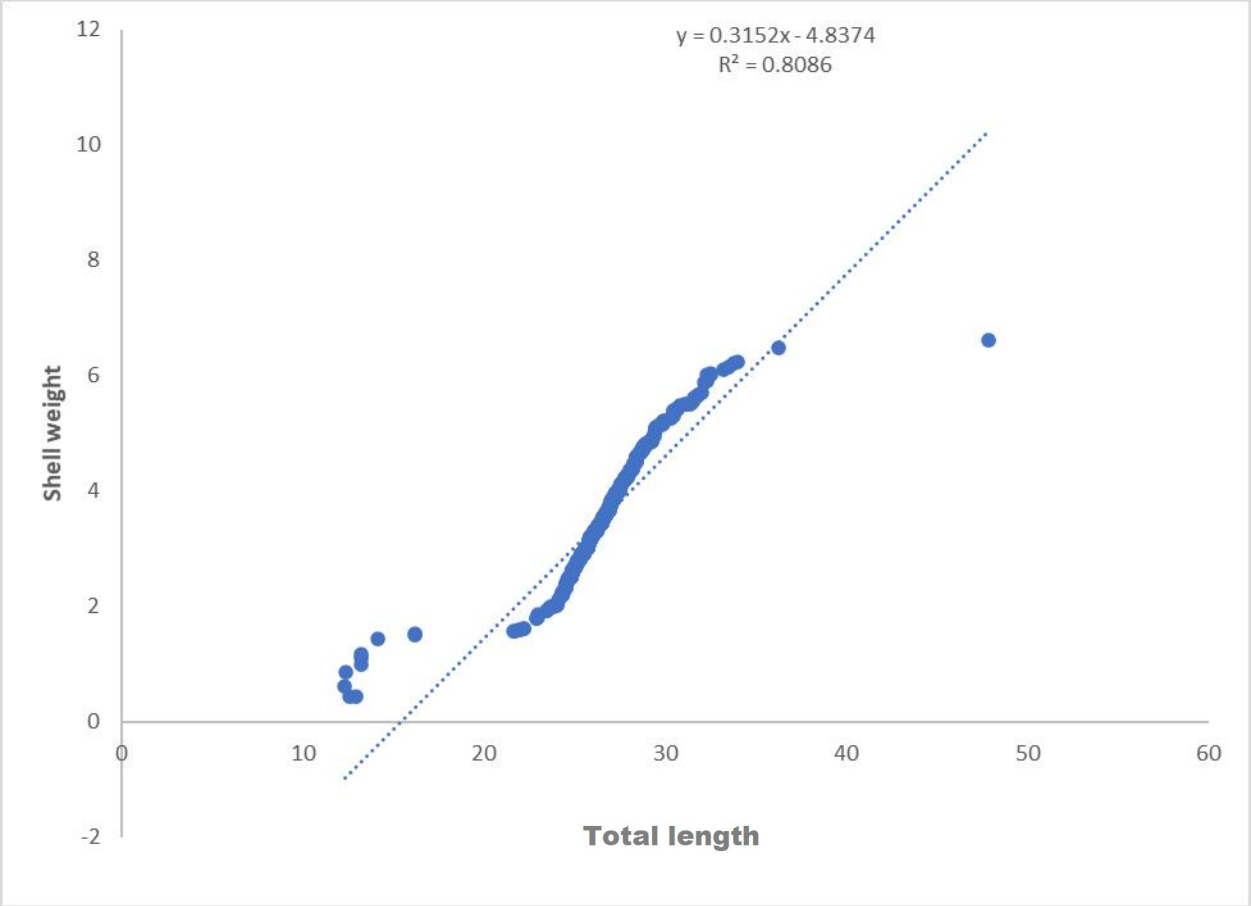

Figure 30: Total length-shell weight relationship of combined sex of *T. fuscatus var radula*

4.9 Relationship between total Length- number of whorls of *T. fuscatus var radula*

The total length of the female ranged between 19.5mm and 62.2mm,while the number of whorls ranged between 5 and 12, for the males the total length ranged between 25.1mm and 63.1mm and the number of whorls ranged between 4 and 12 while for the combined sexes the total length ranged between 19.5 and 64.6 while for the number of whorls it ranged between 4- 12

Figure 31-33 shows the length-number of whorls relationship for male and female and combined sexes were not determined or affected by sex of the specie, the values of b was less than 3 for male (0.20), female (0.19) and combined sexes (0.15), indicating a negative allometric growth also "r" value were 0.74, 0.77 and 0.83 for female, male and combined sexes respectively which showed a positive correlation between the total length and number of whorls of periwinkle. (Table 4) shows the relationship between total length and the other features of *T. fuscatus var fuscatus* and *T. fuscatus var radula*.

4.10 Condition factor of *T. fuscatus var. fuscatus*

Condition factor is an indicator of the environmental suitability for any resource. Condition factor (k) of *T. fuscatus var fuscatus* was used to evaluate variations across sexes.

The summary of condition factor for *T. fuscastus* as presented in figure 34. It shows that the female of *T. fuscatus var fuscatus* is in a better condition having the highest k value with the range of 3.164 and 3.284(mean = 3.25) for females while that of male ranged from 3.175 and 3.322(mean = 3.23) whereas range between 3.18 to 3.32(mean = 3.24) for combined sexes

T. fuscatus var radula also recorded higher condition factor in females with range between 3.15 to 4.19(mean = 3.43) for the females. For male ranged from 3.15- 3.59(mean= 3.03). Where, range of between 3.15- 3.91 (mean=3.45) for combined sexes.

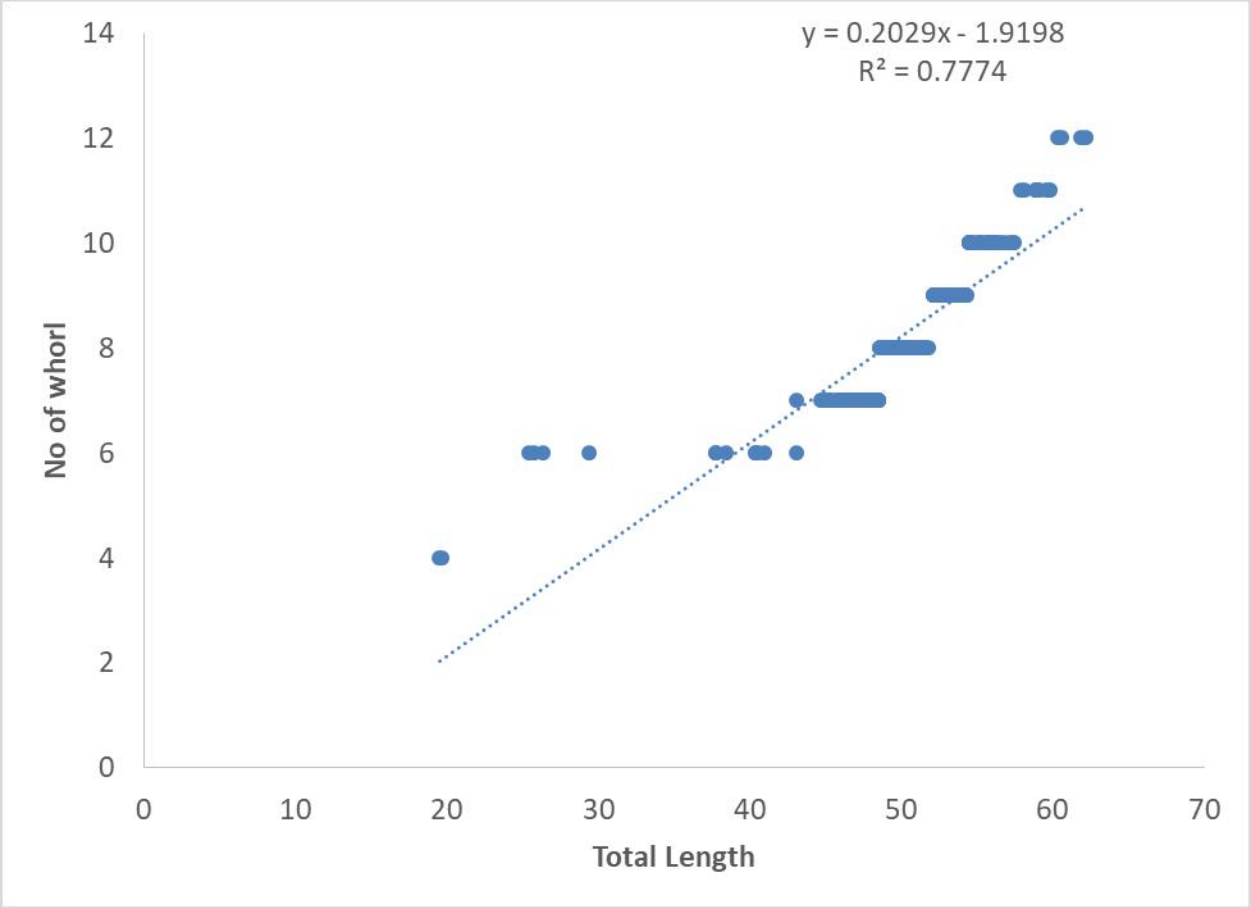

Figure 31: Total Length- number of whorls relationship of male *T. fuscatus var radula*

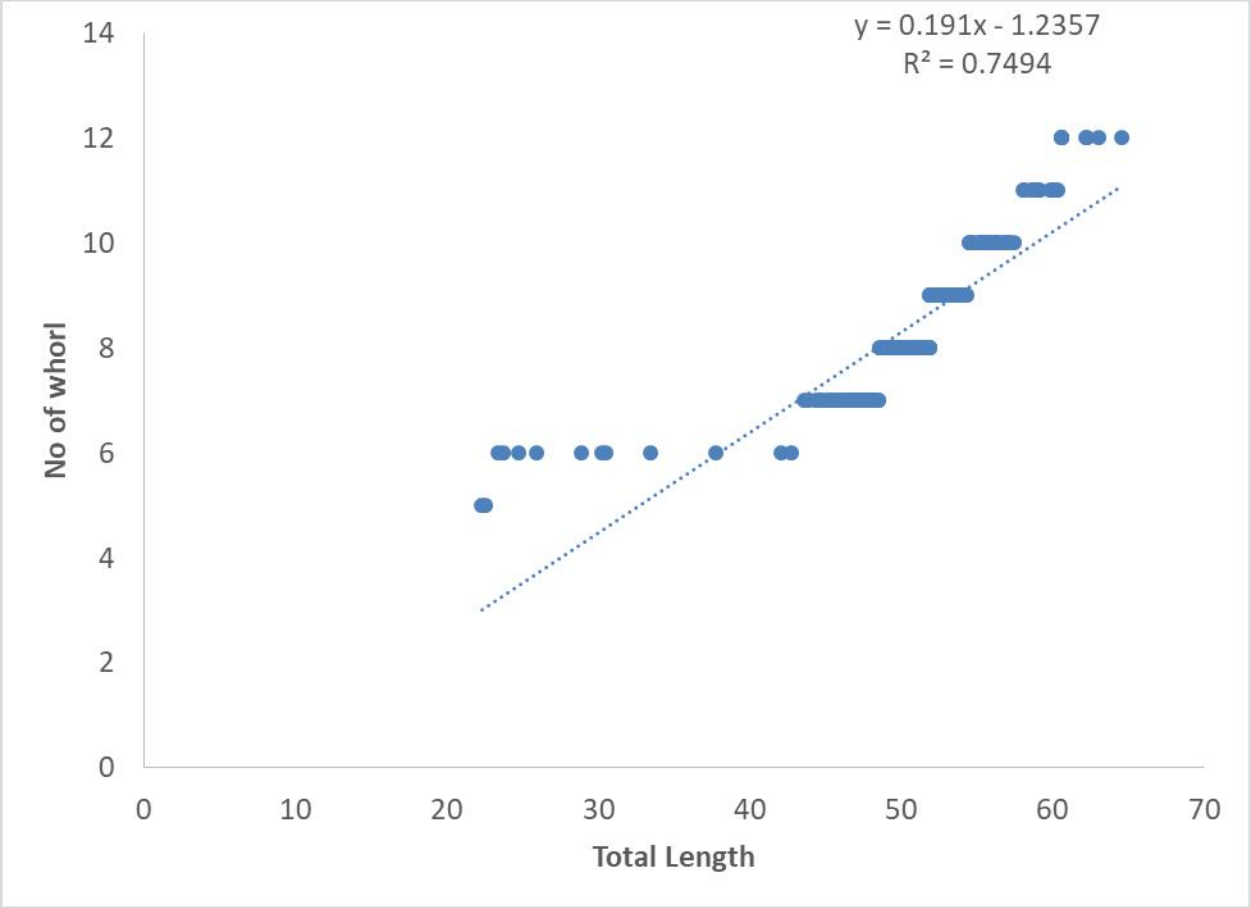

Figure 32: Total Length- number of whorls relationship of female *T. fuscatus var radula*

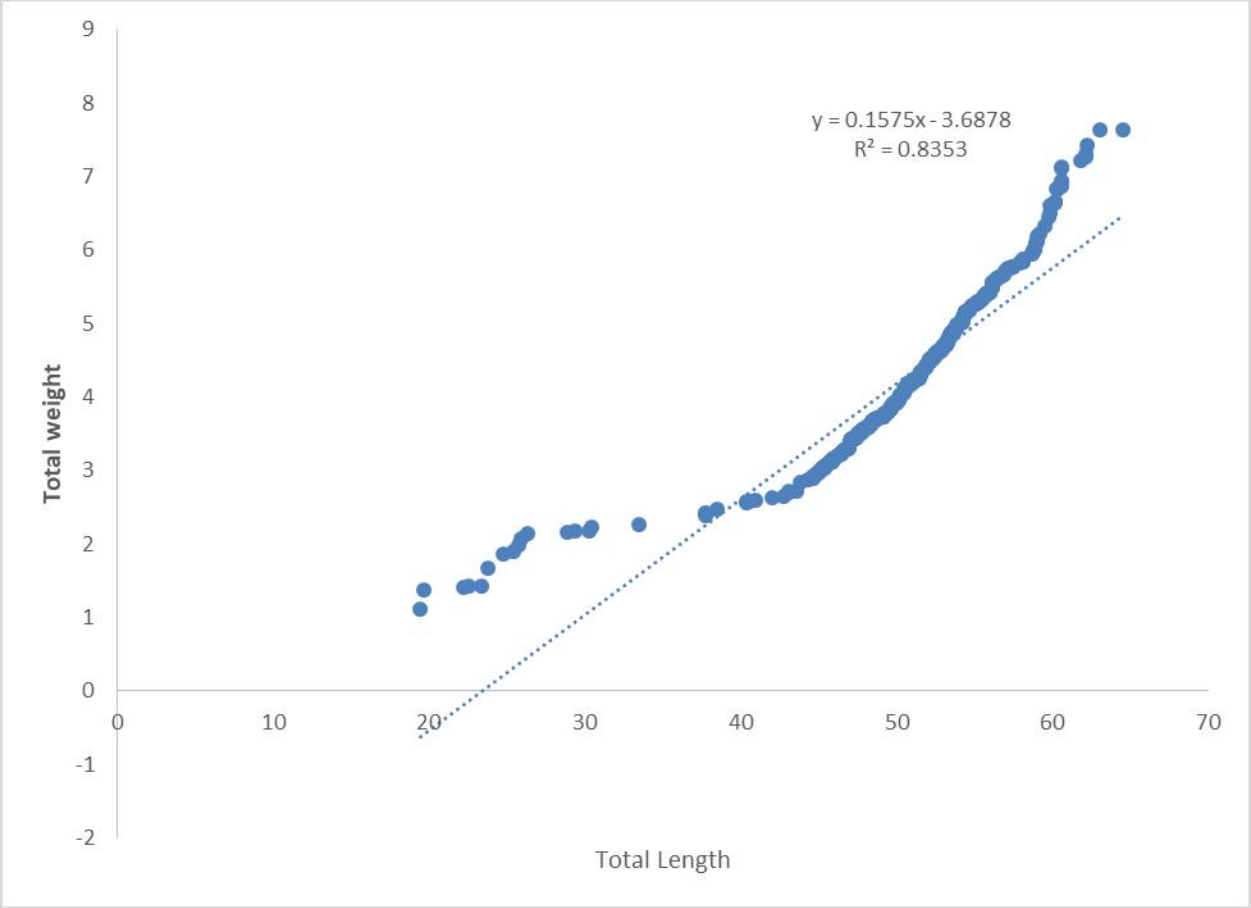

Figure 33: Total Length- number of whorls relationship of combined sex of *T. fuscatus var radula*

Table 4: Summary of the relationship between Total length and the meristic and morphometric features of *T. fuscatus radula* and *T. fuscatus var fuscatus*

	Radula			*Fuscatus*		
	elevation	**slope**	**R^2**	**elevation**	**slope**	**R^2**
Combined						
Total Weight	-4.438	0.172	0.835	-5.751	0.196	0.901
Girth Width	3.392	0.455	0.873	1.437	0.493	0.820
Flesh weight	-2.087	0.057	0.670	-3.919	0.093	0.615
Shell weight	-4.581	0.160	0.834	-5.811	0.182	0.896
No of whorl	-3.005	0.225	0.762	-4.818	0.258	0.811
Female						
Total Weight	-4.485	0.174	0.833	-5.417	0.190	0.893
Girth Width	1.583	0.491	0.847	-1.183	0.546	0.776
Flesh weight	-2.283	0.061	0.625	-4.693	0.109	0.566
Shell weight	-4.612	0.161	0.831	-5.518	0.176	0.885
No of whorl	-2.743	0.221	0.749	-4.280	0.248	0.796
Male						
Total Weight	-4.345	0.170	0.838	-6.167	0.205	0.914
Girth Width	5.908	0.405	0.934	5.347	0.415	0.941
Flesh weight	-1.794	0.051	0.755	-2.652	0.068	0.827
Shell weight	-4.514	0.158	0.837	-6.179	0.189	0.912
No of whorl	-3.287	0.230	0.777	-5.482	0.272	0.832

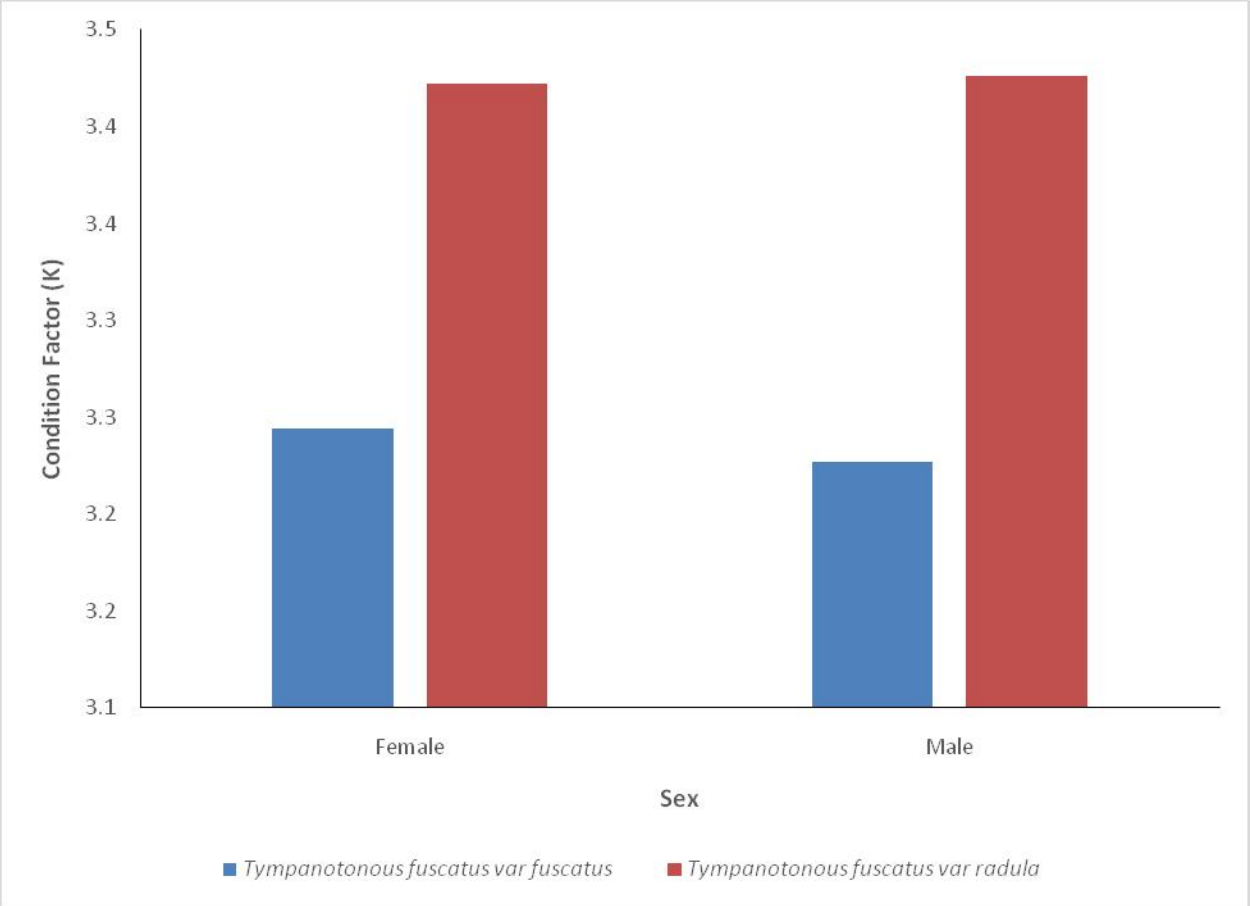

Fig 34: Condition factor of *T. fuscatus var.fuscatus*

CHAPTER FIVE

5.0 DISCUSSION

The specie is commonly referred to by its common name “periwinkle” by the native people. The species identified in the area *T. fuscatus* has two varieties *T. fuscatus var fuscatus* and *T. fuscatus var radula* which are morphologically different. *T.fuscatus var fuscatus* have spines and *T. fuscatus var radula* lack spines. *T. fuscatus* falls under the family *Potamididae*. There are general features which are common to the two varieties such as turreted and glandular shells with whorls.

In the course of the study, the maximum size of *T. fuscatus var fuscatus* of length 5.0387cm and weight 4.18g was lesser than those reported for the same sample in Lagos Lagoon by Moruf *et al*. (2018), which had a total length of 5.37cm and 7.4g weight. The result indicated that male for both *T.fuscatus var fuscatus* were larger and for *T .fuscatus var radula* the females were larger than the males, growth normally manifest through increase in size i.e, by increasing their number of coils, or whorls and also by increase in volume or weight.. The sex of the species could not be determined externally and that was done only after dissection. This is in line with the findings of Egonmwan (2007) on *Pachymelina* who stated that the species does not exhibit external sexual dimorphism. sex is only determined by the appearance and colour of the gonad.

Length - weight relationship (LWR) and its accompanying parameters are tools used for practical assessment of stock of aquatic species including fin and shell fishes. The correlation coefficient r for length-weight relationship (LWR) in *T. fuscastus var fuscastus* was higher in males(0.914) rather than females (0.89) while the correlation coefficient for combined sexes was 0.88 in *T. fuscatus var radula* the highest correlation coefficient value was recorded in males also (0.91) rather than males(0.89). The r value for the combined sexes was recorded as 0.85.the correlation

coefficient r value (0.88) was higher in *T. fuscatus var fuscatus* than that of *T. fuscatus var radula* (0.85) .

The correlation coefficient r for length-girth relationship in *T. fuscatus var fuscatus* was higher in males(0.94) rather than females (0.77) while the correlation coefficient for combined sexes was 0.82 in *T. fuscatus var radula* the highest correlation coefficient value was recorded in males(0.93) rather than females (0.84) The r value for the combined sexes was recorded as 0.82. the correlation coefficient r value was equal (0.82) in *T. fuscatus var fuscatus* and *T. fuscatus var radula*

The correlation coefficient r for length-shell relationship in *T. fuscastus var fuscastus* was higher in males(0.91) rather than females (0.88) while the correlation coefficient for combined sexes was 0.89 in *T. fuscatus var radula* the highest correlation coefficient value was recorded in females(0.837) rather than males(0.831). The r value for the combined sexes was recorded as -0.80. the correlation coefficient r value was higher in *T. fuscatus var fuscatus*(0.89) than that of *T. fuscatus var radula*(0.80)

The correlation coefficient r for length-edible portion (flesh) relationship in *T. fuscastus var fuscastus* was higher in males(0.82) rather than females (0.57) while the correlation coefficient for combined sexes was 0.61. In *T. fuscatus var radula* the highest correlation coefficient value was recorded in males also (0.75) rather than females (0.62). The r value for the combined sexes was recorded as 0.78. the correlation coefficient r value (0.78)was higher in *T. fuscatus var radula* than that of *T. fuscatus var fuscatus*(0.62).

The correlation coefficient r for length-number of whorls relationship in *T. fuscastus var fuscastus* was higher in females(0.79) rather than males (0.74) while the correlation coefficient for combined sexes was 0.81. In *T. fuscatus var radula* the highest correlation coefficient value

was recorded in males (0.77) rather than females (0.74). The r value for the combined sexes was recorded as 0.83. the correlation coefficient r value was higher in *T. fuscatus var radula (0.83)* than that of *T. fuscatus var fuscatu s*(0.81).

Length-weight relationship, Length-edible portion relationship, Length-shell relationship, length- number of whorls relationship all shows negative allometric growth and a very strong correlation coefficient. T. *fuscatus var fuscatus* and both *T. fuscatus var radula* indicated a strong correlation and allows a fair prediction of weight for a given length. This agrees with earlier studies involving the same species from different parts of Niger-Delta (Jamabo *et al.,* 2009; Udoh, 2013).

The growth pattern of female *T. fuscatus var fuscatus* and *T. fuscatus var radula* was found to be negative allometric for both male, female and combined sexes with b values all < 3 for all parameters. This indicates that the mollusc; *T. fuscatus* increases in weight as it increases in length. This finding agrees with Jamabo *et al.* (2009), Udoh (2013) and Moruf and Lawal-Are (2015), who reported the same growth pattern for this species in the Port-Harcourt area, Bonny and Cross River Estuaries (Niger-Delta) and Lagos Lagoon.

It was observed in this study that adult *T. fuscastus* did not have full Whorls as the last Whorls were always broken and the opening covered with a film like substance.

Condition factor is a tool used to assess the physiological wellbeing of gastropods in its environment. The mean condition factor of 3.24 and 3.45 (for *T. fuscatus var fuscatus* and *T.fuscastus var radula*) calculated for this specie is less than 7.7 reported by Moruf *et al*., 2018, and 10.3 reported by Moruf and Lawal-Are (2015)

The Conceivable reason for this discrepancy in condition factors could be differences in the ecological parameters of the study sites, foraging ability and conservation of stored food energy

in adult. mean condition factor value recorded in this study indicates a good physiological condition of the gastropod (*T. fuscatus*). K-values of less than 1 indicates a poor condition. If the K-value is one and above the shell fish is in good condition and receives adequate food to maintain optimal condition and growth (Barnham and Charles, 1998).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study provided information on an aspect of the biology i.e the length-weight relationship, Length- girth relationship, Length-shell relationship, Length-number of whorls relationship, condition factor and the growth pattern of a commercially important mollusc, *T. fuscatus*, in Koko Estuary in Delta State. The findings of this study suggest that the condition of the estuary is favorable to the growth and development of this mollusc in terms of availability and abundance of food resources. In addition, they might have developed a strategy to cope and adapt to an environment that is well known for its crude oil exploitation and refining activities.

6.2 Recommendations

The brackish ecosystem of Koko River produces a valuable shellfish species for the local population and even surrounding states. Therefore, measures must be taken to reduce the pollution impact on the aquatic ecosystem in order to preserve the specie.

It could also be said that; sex determination without harming the living individuals often is a problem. Usually, the animals hide inside the shell and this makes it impossible to determine its sex. More studies should be done to enable the identification of sexes without having to kill the specie to help distinguish between the sexes based on morphological features.

More studies should be carried out regularly in order to provide current data on the periwinkle status from the area.

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APPENDIX

Specie = Tympanotonous fuscatus var fuscatus

Variables Entered/Removed[a,b]

Model	Variables Entered	Variables Removed	Method
1	logTL[c]	.	Enter

a. Specie = Tympanotonous fuscatus var fuscatus
b. Dependent Variable: logTW
c. All requested variables entered.

Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[b]	.887	.887	.03112

a. Specie = Tympanotonous fuscatus var fuscatus
b. Predictors: (Constant), logTL

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.858	1	3.858	3982.604	.000[c]
	Residual	.492	508	.001		
	Total	4.350	509			

a. Specie = Tympanotonous fuscatus var fuscatus
b. Dependent Variable: logTW
c. Predictors: (Constant), logTL

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-2.962	.057		-52.355	.000
	logTL	2.099	.033	.942	63.108	.000

a. Specie = Tympanotonous fuscatus var fuscatus
b. Dependent Variable: logTW

Specie = Tympanotonous fuscatus var radula

Variables Entered/Removed[a,b]

Model	Variables Entered	Variables Removed	Method

1	logTL[c]	.	Enter

a. Specie = Tympanotonous fuscatus var radula
b. Dependent Variable: logTW
c. All requested variables entered.

Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[b]	.861	.860	.04338

a. Specie = Tympanotonous fuscatus var radula
b. Predictors: (Constant), logTL

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.810	1	5.810	3087.406	.000[c]
	Residual	.941	500	.002		
	Total	6.751	501			

a. Specie = Tympanotonous fuscatus var radula
b. Dependent Variable: logTW
c. Predictors: (Constant), logTL

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-2.199	.051		-43.365	.000
	logTL	1.657	.030	.928	55.564	.000

a. Specie = Tympanotonous fuscatus var radula
b. Dependent Variable: logTW

Tympanotonous fuscatus var fuscatus

		Mean	Std. Deviation	Minimum	Maximum
Female	Total length	50.32	4.69	25.8	77.3
	Girth/width	26.30	2.56	14.2	56.7
	Total Weight	4.13	0.89	1.91	7.77
	Flesh weight	0.77	0.51	0.24	7.82
	Shell weight	3.35	0.83	1.52	6.85
	No.of.whorl	8.18	1.16	6	12
Male	Total length	50.45	4.25	25.1	63.1
	Girth/width	26.27	1.76	13.9	34.3
	Total Weight	4.16	0.87	1.86	7.53
	Flesh weight	0.77	0.29	0.22	2.82
	Shell weight	3.37	0.80	1.28	6.32
	No.of.whorl	8.23	1.15	6	12
Combined	Total length	50.38	4.47	25.1	77.3
	Girth/width	26.29	2.21	13.9	56.7
	Total Weight	4.14	0.88	1.86	7.77
	Flesh weight	0.77	0.42	0.22	7.82
	Shell weight	3.36	0.81	1.28	6.85
	No.of.whorl	8.20	1.16	6	12

Tympanotonous fuscatus var radula

		Mean	Std. Deviation	Minimum	Maximum
Female	Total length	50.87	6.34	22.3	64.6
	Girth/width	26.56	3.11	12.3	47.9
	Total Weight	4.35	1.10	1.41	7.63
	Flesh weight	0.84	0.39	0.15	3.91
	Shell weight	3.56	1.02	0.63	6.63
	No.of.whorl	8.48	1.40	5	12
Male	Total length	50.23	5.96	19.5	62.2
	Girth/width	26.26	2.42	12.6	33.8
	Total Weight	4.19	1.01	1.11	7.29
	Flesh weight	0.78	0.31	0.12	2.14
	Shell weight	3.41	0.94	0.44	6.23
	No.of.whorl	8.27	1.37	4	12
Combined	Total length	50.57	6.17	19.5	64.6
	Girth/width	26.42	2.81	12.3	47.9
	Total Weight	4.28	1.06	1.11	7.63
	Flesh weight	0.81	0.35	0.12	3.91
	Shell weight	3.49	0.98	0.44	6.63
	No.of.whorl	8.38	1.39	4	12

	T.f var fuscatus	T.F. var radula	t	p
Female				
Total length	50.32	50.87	-1.124	0.262
Girth/width	26.30	26.56	-1.066	0.287
Total Weight	4.13	4.35	-2.599	0.010
Flesh weight	0.77	0.84	-1.680	0.093
Shell weight	3.35	3.56	-2.588	0.010
No.of.whorl	8.18	8.48	-2.672	0.008
Male				
Total length	50.45	50.23	0.460	0.646
Girth/width	26.27	26.26	0.086	0.931
Total Weight	4.16	4.19	-0.418	0.676
Flesh weight	0.77	0.78	-0.331	0.741
Shell weight	3.37	3.41	-0.466	0.641
No.of.whorl	8.23	8.27	-0.351	0.726
Combined				
Total length	50.38	50.57	-0.548	0.584
Girth/width	26.29	26.42	-0.836	0.403
Total Weight	4.14	4.28	-2.225	0.026
Flesh weight	0.77	0.81	-1.620	0.106
Shell weight	3.36	3.49	-2.249	0.025
No.of.whorl	8.20	8.38	-2.199	0.028

	Oct' 21	November	Jan '22	February	F	p
Tympanotonous fuscatus var fuscatus						
Total length	51.11±4.87[a]	49.41±4.16[b]	50.04±4.80[ab]	51.08±3.64[a]	4.689	0.003
Girth/width	26.65±3.11[a]	25.95±1.69[b]	26.07±1.93[ab]	26.49±1.44[ab]	3.082	0.027
Total Weight	4.29±0.90[a]	3.93±0.89[b]	4.09±0.85[ab]	4.27±0.80[a]	5.228	0.001
Flesh weight	0.85±0.64[a]	0.70±0.32[b]	0.74±0.26[ab]	0.80±0.24[ab]	3.508	0.015
Shell weight	3.51±0.84[a]	3.16±0.82[b]	3.31±0.79[ab]	3.48±0.75[a]	5.356	0.001
No.of.whorl	8.38±1.19[a]	7.92±1.14[b]	8.14±1.10[ab]	8.42±1.13[a]	5.394	0.001
Tympanotonous fuscatus var radula						
Total length	48.67±8.25[a]	51.56±4.16[b]	51.60±4.18[ab]	50.11±7.17[a]	6.677	0.000
Girth/width	25.49±3.62[a]	26.87±2.57[b]	26.77±1.67[b]	26.44±2.96[b]	6.480	0.000
Total Weight	4.02±1.07[a]	4.39±1.01[b]	4.42±0.91[b]	4.25±1.25[ab]	3.663	0.012
Flesh weight	0.74±0.29[a]	0.85±0.40[b]	0.84±0.27[b]	0.81±0.43[ab]	2.564	0.054
Shell weight	3.25±0.99[a]	3.59±0.93[b]	3.62±0.84[a]	3.46±1.15[ab]	3.736	0.011
No.of.whorl	8.08±1.35[a]	8.52±1.36[b]	8.55±1.21[b]	8.33±1.61[ab]	3.128	0.026