REPRODUCTIVE BIOLOGY, GROWTH AND MORTALITY OF THE INTRODUCED RED CLAW CRAYFISH, *Cherax quadricarinatus* IN KAFUE FLOODPLAIN FISHERY

BY

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A dissertation submitted to the University of Zambia in partial fulfillment of the requirements of the degree of Master of Science in tropical ecology and biodiversity

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AUTHOR'S DECLARATION

I, Geofrey Makwelele, do hereby declare that this research represents my own work and that it has not previously been submitted for a Degree at the University of Zambia or at any other University.

Signature: ………………………………….

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APPROVAL

This study by Geofrey Makwelele is approved as partial fulfilment of the requirement for the award of the Master of Science in Tropical Ecology and Biodiversity by the University of Zambia.

Examiners:

1. Examiner: …………………………………….. Signature: ………………………..

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DEDICATION

This study is dedicated to my wife Christine H.M. Makwelele and children, Fungai and Farai, Lecturers, especially supervisors for their support, guidance, patience, endurance and encouragement during my study period. I also dedicate my research to Thandiwe Mahombe who provided social, emotional and physical support during my work. I thank God, the almighty for his grace and blessings without which this would not have been a success.

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ACRONYMS

ANOVA: Analysis of Variance

BW: Body Weight

CL: Carapace Length

E: Exploitation rate or ratio

F: Fishing mortality coefficient

FAO: Food and Agriculture Organization of the United Nations

GIS: Geographical Information System

GENSTAT: General Statistical Software

KRB: Kafue Road Bridge

M: Natural mortality coefficient

MS: Microsoft

TL: Total Length

VBGE: Von Bertalanffy Growth Equation

Z: Total mortality coefficient

ABSTRACT

A study of the reproductive biology, growth and mortality of the introduced red claw crayfish, *Cherax quadricarinatus* species in the Kafue floodplains was undertaken from September to November 2015. Samples of red claw crayfish were collected from three different stations / parts of the floodplains: station I, Kafue Road Bridge; station II, Namalyo in Monze; and station III, Kakuzu in Namwala. The parameters measured and recorded included carapace length (CL), total length (TL) and body weight (BW) from each specimen in the sample.

Breeding seasonality of the crustacean was assessed using length frequency histograms from data compiled from the samples collected. Analysis and comparison of growth and determination of growth performance indexes of the red claw crayfish in different parts of the Kafue floodplains were done through one-way analysis of variance (ANOVA) and growth curves, and empirical equation by Pauly and Munro (1984), respectively. The Von Bertalanffy growth parameters $L\infty$ and k were determined using Pauly's equation of 1979 and Ford-Walford (1946) method. Mortality rates were computed using mean length method of Beverton and Holt equation of 1952 and Pauly's equation of 1980.

Length frequency histograms constructed showed distinct peaks indicating that the species has well-defined spawning seasons. Further, the investigation observed that there were no significant differences in growth and growth performance indices of red claw crayfish in different parts of the Kafue Floodplain fishery. Mortalities are due to natural causes and fishing.

CHAPTER 1: INTRODUCTION

1.1 Background

There are three families of crayfish worldwide: Astacidae; Cambaridae and Parastacidae; with two in the Northern Hemisphere and one in the Southern Hemisphere (Wikipedia, 2015). Members of the Parastacidae family are found in South America, parts of Africa, Madagascar and Australia. Members of the Astacidae family are found in western Eurasia and western North America while those of the family Cambaridae are indigenous to eastern Asia and eastern North America (Fig 1.1). The species *Cherax quandricarinatus* belongs to the family Parastacidae.

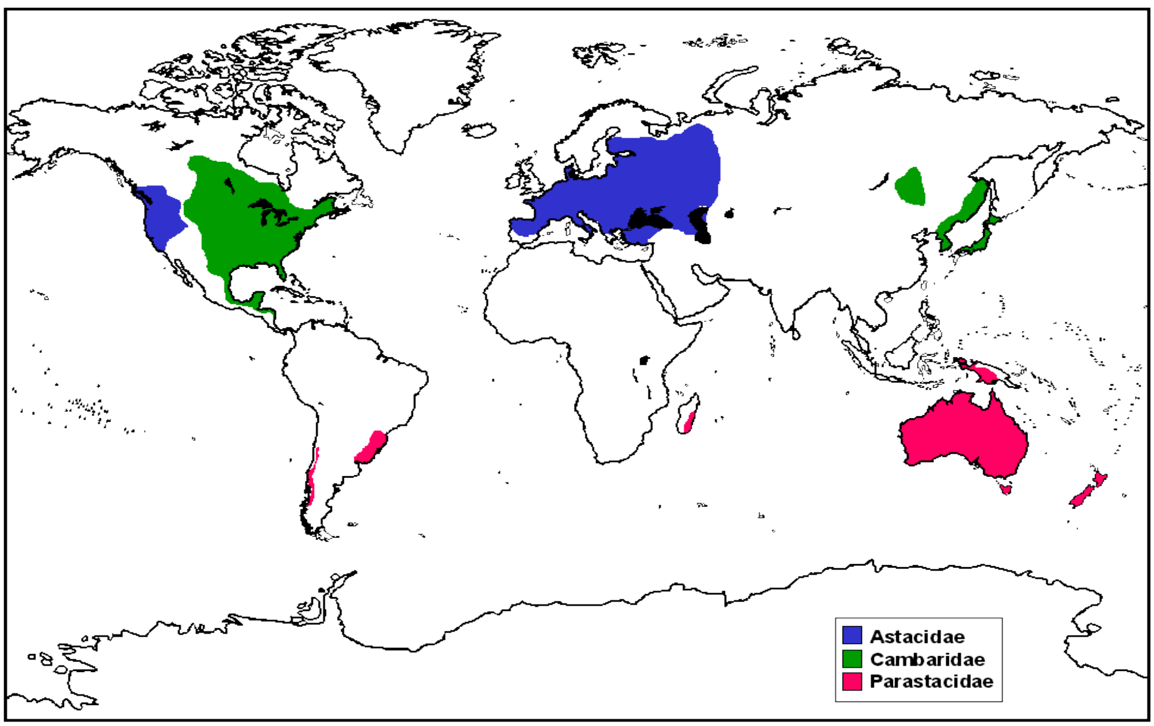

Figure: 1.1 Global geographical distributions of three families of crayfish (**Source:** http://www.crayfish.gr/en/geografikikatanomiEN.html, Retrieved January 24, 2015)

In Australia, many crustacean are of the genus *Cherax*, and include the marron (now believed to be two species, *Cherax tenuimanus* and *Cherax cainii*), red claw crayfish (*Cherax quadricarinatus*), common yabby (*Cherax destructor*) and western yabby (*Cherax preissii*) (Wikipedia, 2015). The marrons are some of the largest crayfish in the world. Australia is home to the world's two largest freshwater crayfish: the Tasmanian giant freshwater crayfish *Astacopsis gouldi*, which can achieve a mass of up to 5 kilograms and is found in the rivers of northern Tasmania, and the Murray crayfish *Euastacus armatus*, which can attain a weight of 2 kilograms and is found in much of the southern Murray-Darling basin (Wikipedia, 2015).

The red claw crayfish, *Cherax quadricarinatus* (Fig 1.2) is found in permanent freshwater rivers, streams and lakes. It is a freshwater crayfish indigenous to the northern territory of Australia and parts of Papua New Guinea (FAO, 2006 and Wangari, 2008). Through translocation by humans, the range spread down to Southern Queensland, and into the far North of West Australia. Although well known to the local inhabitants of the Australian region, it remained effectively unknown to the rest of the world until the late 1980s, when it was tried out for aquaculture (FAO, 2006 and Wangari, 2008). This tropical and sub-tropical crustacean is very tolerant to environmental changes, and is primarily a detritivorous organism. Feeding on small invertebrates and aquatic plants make it suitable for aquaculture.

Although indigenous to Australia, the red claw crayfish has been exported to many other countries such as Mexico and Singapore where commercial production has now been established (Heiko, 2007). Further reports indicate that red claw crayfish is an invasive species which has established feral populations in Jamaica, South Africa, Puerto Rico, Zimbabwe and Zambia. The red claw crayfish was introduced as an aquaculture species in Zimbabwe and Zambia in the early

1990s. Wangari (2008) points out that in 1992, the red claw crayfish, *Cherax quadricarinatus* species was introduced to a fish farm in Livingstone from South Africa, and from there to another farm near Kafue town. Wangari (2008) further reports that the red claw crayfish's presence in the Kafue River floodplains was first noted in 2005; and supplementary observations indicate that the species has now spread more than 200 km upstream up to the Itezhi-tezhi dam and perhaps beyond. The species has been known to have existed for several years in the Kafue River and has established a large and rapidly growing population in Lake Kariba as well (Wangari, 2008). Tyser and Douthwaite (2014) and Moonga and Musuka (2014) reported that fishers in the Kafue floodplains were concerned at the rate the crayfish was increasing in the fishery. Fishers have expressed concern that something should be done to reduce the negative effects of the organism, for example disfiguring fish caught in fishers' gill nets resulting in reducing fish value.

A study using semi-structured questionnaires, interviews and focus group discussion, was conducted to assess the effect of accidentally introduced red swamp crayfish (*Procambarus clarkii)* in Stratum IV (Namwala district) of the Kafue fishery (Moonga and Musuka, 2014). The study revealed that gillnets of 2 inches (50mm) and above were more effective in capturing *Procambarus clarkii*. Tyser and Douthwaite (2014) also indicated that fishers in the floodplains (in Namwala area) caught crayfish species as by-catches. It is clear that fishers face greater challenges due to the emergency of crayfish as part of their by-catch since most of them do not consider crustaceans as food and therefore, either returned them into the water or threw them away (Tyser and Douthwaite, 2014). The numbers of crayfish caught have shown strong seasonal variation with the highest numbers caught in the hot season, and least in the cold season (Douthwaite, 2014). The numbers also depended on where the nets are set, with more caught in bottom set nets and less in top set nets, and more caught in nets set close to the shore than those set further out.

Douthwaite (2014) points out that, interestingly, fishers have also associated the arrival of crayfish with a decline in traditional finfish catches and a reduction in crab abundance. Although the red claw crayfish is reported to be highly invasive, there is limited information available for its management in the waters of Zambia on reproductive biology, growth and mortality, even in Lake Kariba where they are also known to be well established. According to Heiko (2007), red claw crayfish breeding is dependent upon water temperature and day length, and normally occur between September and April within natural range in northern Australia freshwater bodies. Fish length frequency histograms from research surveys are of prime importance for identifying of different life stages (Petitgas *et al.*, 2011). Therefore it is necessary to carry out the investigation because the organism is alien in the fisheries of Zambia where it has been reported.

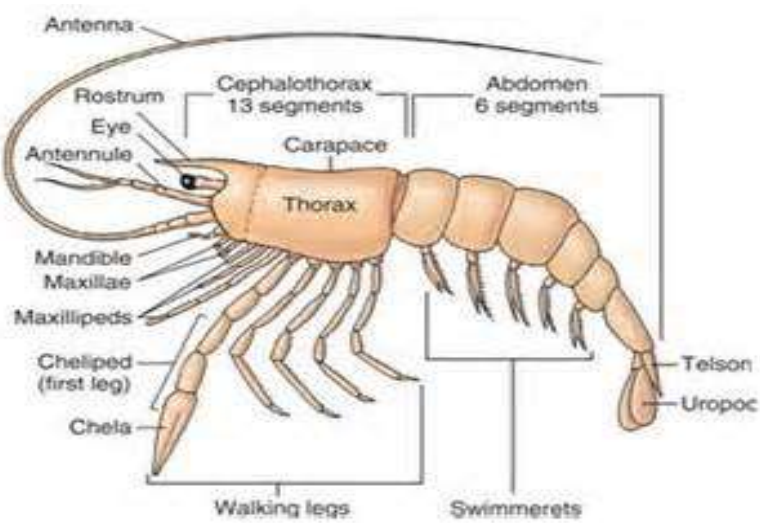

Figure 1.2 The red claw crayfish (**Source**: http://www.bing.com/images, Retrieved November 24, 2014)

The Kafue River is a multi-species and multi-gear fishery. Some notable fish of this fishery include *Oreochromis andersonii, Oreochromis macrochir, Oreochromis niloticus, Tilapia rendalii, Clarias gariepinus, Clarias ngamensis, Serranochromis angusticeps, Synodontis macrostoma, Macusenius macrolepidotus and Mormyrus larceda* (Department of Fisheries, 1993).

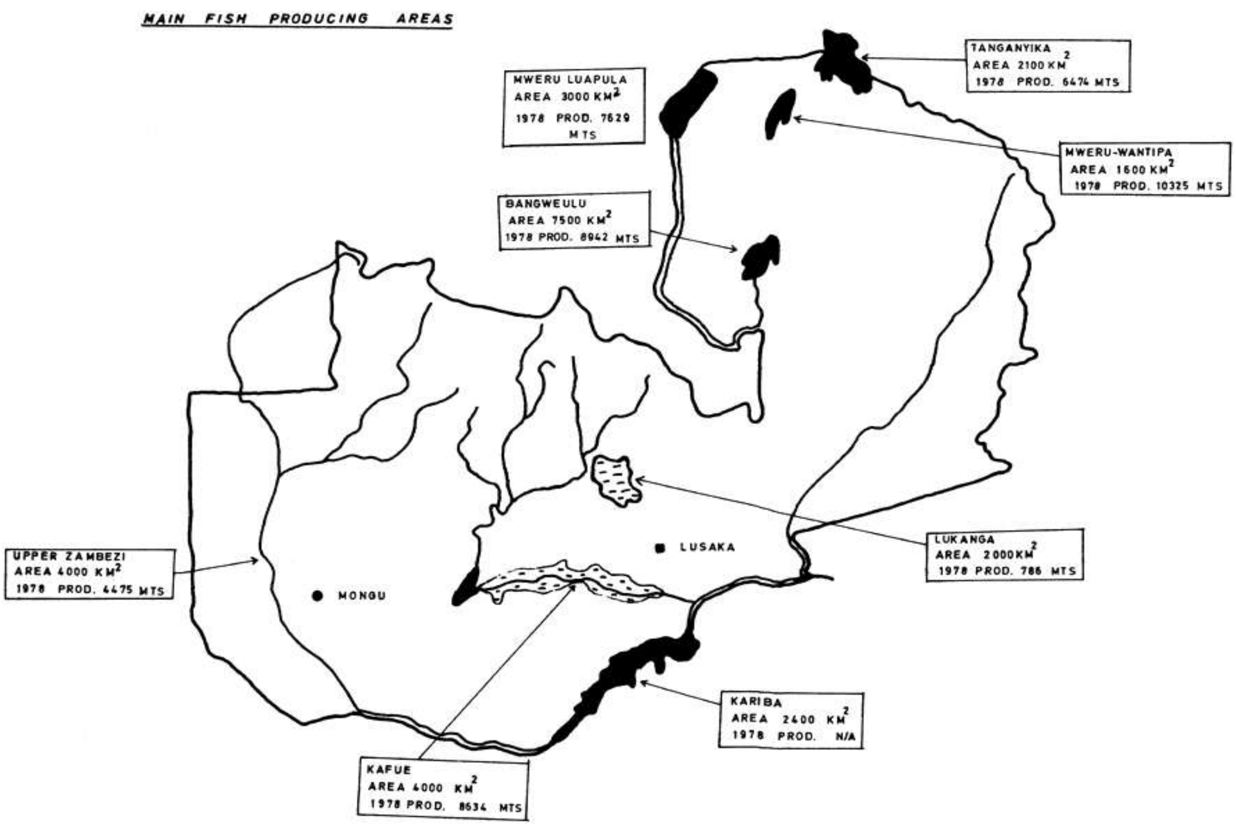

Figure 1.3 Main fish producing areas in Zambia (**Source**: https://www.bing.com/images/search?q=map+of+Zambian+fisheries, Retrieved December 10, 2014)

Zambia has several major and minor fisheries (Fig 1.3). Among them are Lake Tanganyika, Lake Bangweulu, Lake Kariba, Lake Mweru, Lake Mweru-wantipa, Lukanga swamps, upper Zambezi and Kafue floodplains. The floodplains is a large wetland area in which both fishing and agricultural activities occurs. People in the fishery utilize the fish resources on a subsistence and commercial basis (Balasubrahamanyam and Abou-Zeid, 1983).

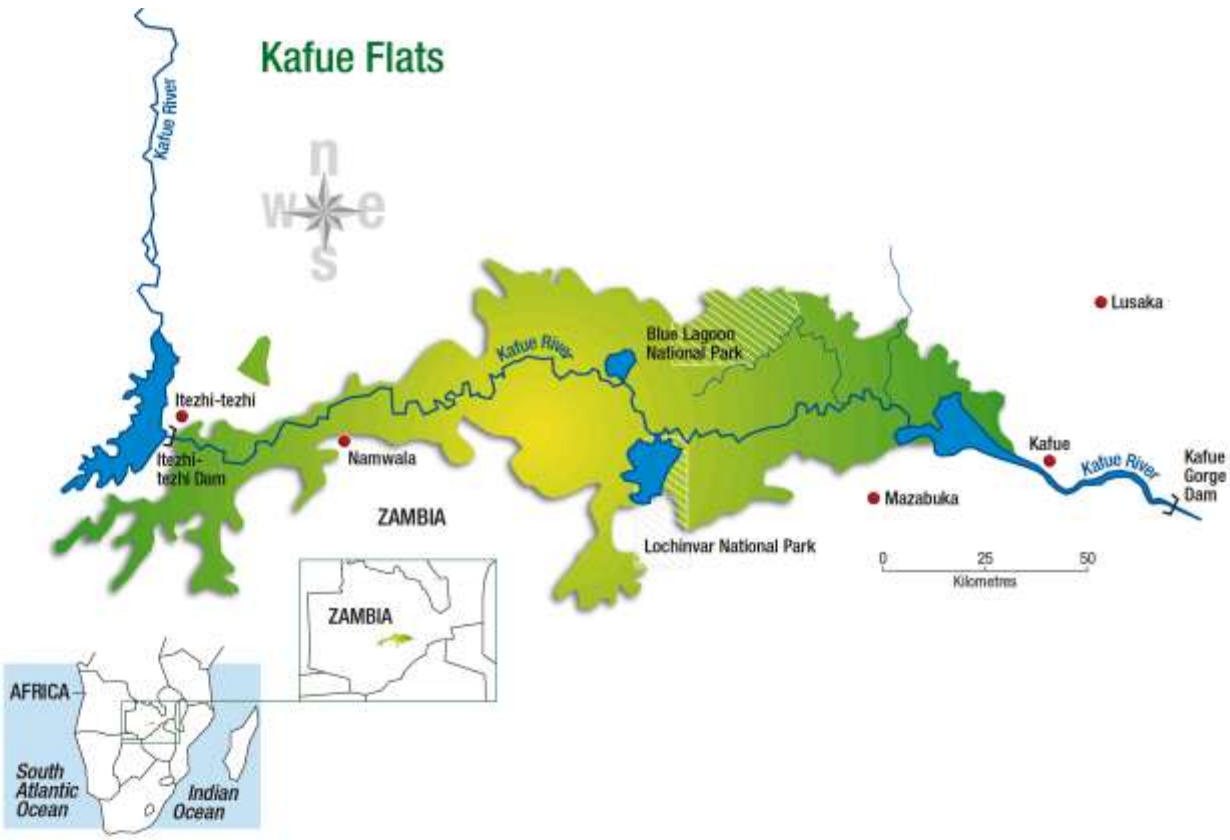

Figure 1.4 The Kafue floodplains (**Source:** http://www.bing.com/images, Retrieved December 10, 2014)

The Kafue floodplain fishery is the fourth largest fishery in Zambia (Department of Fisheries, 1993). The fishery is endowed with numerous fish biodiversity. A total of seventy-seven (77) fish species have been recorded in this ecosystem, out of which twenty-three (23) species are of economic importance (Muyanga and Chipungu, 1978). Cichlids account for eighty percent (80%) of all economically important fishes in the Kafue floodplains (Department of Fisheries, 1993). The floodplains support tourism, agricultural and fishing activities (Edgar, 2007).

1.2 Statement of the Problem

The red claw crayfish is an alien species in the Kafue floodplain fishery. Previous studies on red claw crayfish did not investigate the reproductive biology, growth and mortalities of the species in the fishery. It is for this reason that this study focussed on these aspects.

The introduction of the red claw crayfish in the water body might have posed challenges to the biodiversity and probably economic development of the fishery. The ecosystem interactions and effects of invasive red claw crayfish on the native fauna are largely unknown (Tyser and Douthwaite, 2014). The levels of threats posed among stakeholders including fishers are considered limited. Karplus *at el* (1997) argue that it is important that studies be conducted before any new species is introduced to ensure that there will not be negative impacts on the native environment. Therefore, there is need to generate knowledge and insights on the introduced species, especially in the Kafue floodplain fishery and other fisheries where it has been reported.

Unless more knowledge and insights on new introductions of species is known, it poses some challenges to develop appropriate and effective management strategies of the fishery. The red claw crayfish is not targeted for exploitation in this fishery but is being caught as by-catch by fishers. The study on the red claw crayfish potentially provides an alternative species, source of food and revenue to the local communities and nation at large. Besides being a potential source of income, it can provide employment opportunities to local people. According to Rooyen (2013) red claw crayfish is found in abundance in South Africa’s rivers and provides a lucrative income, while taking pressure off of the ocean’s stock.

1.3 Study Objectives

1.3.1 General Objective

To investigate the reproductive biology, growth and mortality of the introduced red claw crayfish, *Cherax quadricarinatus,* in the Kafue floodplain fishery.

1.3.2 Specific Objectives

(i) To determine if there is breeding seasonality of the introduced red claw crayfish, *Cherax quadricarinatus* in the Kafue floodplain fishery.

(ii) To compare the growth and growth performance indexes of red claw crayfish in different parts of the Kafue floodplain fishery.

(iii) To assess mortality of red claw crayfish in the Kafue floodplain fishery.

1.4 Hypotheses of the Study

(i) The introduced red claw crayfish, *Cherax quadricarinatus* does not spawn throughout the year in the Kafue floodplain fishery.

(ii) There is no significant difference in the growth and growth performance index of red claw crayfish in different parts of the Kafue floodplain fishery.

(iii) There is low mortality of red claw crayfish in the Kafue floodplain fishery.

1.5 Significance of the Study

The Kafue floodplain offers several significant resources to the local communities, surrounding areas and country at large. The resources range from fishing, agriculture (both crop and livestock) and tourism in Lochinvar and Blue Lagoon National parks. Fishing of native fin fishes in Zambia's fisheries, including Kafue floodplains, has been experiencing tremendous pressure. Fishers have complained of low catches in most cases. In 1969 the total fish catch from Kafue floodplain fishery was 9,938 metric tonnes while in 1983 the total fish catch had reduced to 3,605 metric tonnes (FAO Fisheries Department, 2010). This decrease is despite the abundance of the exotic fish resource, *Oreochromis niloticus* in the fishery (Chikopela, et al, 2011). Reasons for the decline in fish harvests have not been properly understood and investigated. However, the popular opinion regarding this fishery is that the fish stocks along the Kafue flats are being over-exploited and fish stocks have decreased. Such opinion is supported by the study of Williams (1960) which is mainly an analysis of the catch and effort data; and the study of Muncy (1976). Both researchers presented evidence that the Kafue floodplain fishery is being exploited beyond the Maximum Sustainable yield.

Fishing and farming are actively practiced in the floodplains. The introduction of red claw crayfish in the fishery is important because it has potential to provide an alternative source of food and can probably contribute significantly to improvement of rural livelihood in terms of employment, income generation and reducing poverty levels to the local people (Chimba and Musuka, 2014). Additionally it might lessen the exploitation pressure on the indigenous fin fishes. The crustacean is an important source of animal protein especially where meat is scarce. In the agricultural sector, Kafue River water is used for commercial irrigation of sugar cane in

Nega-nega, Nanga and Mazabuka. There are also peasant farmers who practice subsistence crop and vegetable growing in the flats.

The introduction of the crayfish is a significant aspect in the Kafue floodplain fishery. The red claw crayfish is primarily detritivorous, they prefer to eat decaying plant or animal matter. Therefore it may not be costly to grow in aquaculture. Like other introduced fish species such as *Oreochromis niloticus* in the Kafue River, red claw crayfish is a new species for fish farmers or fishers to exploit and diversify in aquaculture or/and target the crayfish in order to reduce pressure on indigenous fish species. If the levels of education regarding the new organism are raised and promoted the new species may add to the satisfaction on the market demand for protein and fishery products. Most of the fishers in the floodplains consider crayfish a nuisance as they do not regard them as food (Douthwaite, 2014). Crayfish feed on fish caught in their gill nets damaging the catch and reducing its value. Disentangling them sometimes damages the nets and results in injury.

The Kafue floodplain fishery is also of great importance owing to its proximity to urban centers such as Choma, Monze, Mazabuka, Kafue and Lusaka city. The urban centres provide a readily available market for fish and other wetland resources provided by the Kafue floodplain fishery (Appelvan and Van de Meerendonk, 1980). Lusaka and Kafue have a relatively high number of people who are familiar with crayfish and would want to buy for home consumption.

CHAPTER 2: LITERATURE REVIEW

According to the Fish Site (2012) red claw crayfish, *Cherax quadricarinatus* is a tropical and sub-tropical species endemic to north-eastern Australia and its surrounding areas. The organism's preferred temperature range is 18ºC to 35ºC (Michael and David, 1997).

2.1 Reproductive Biology

Wangari (2008) reports that introductions of new fish species and other aquatic organisms in Zambia have been noted in various parts of the country and these introductions were made from as far back as the 1940s. Many attempts were made to introduce alien species in water bodies where those organisms were not indigenous; not all species that were introduced survived and proliferated, probably because of environmental differences (Moonga and Musuka, 2014). One such species introduced in the Kafue and Lake Kariba fisheries is the red claw crayfish. Heiko (2007) reported that the species *Cherax quadricarinatus* breeding is dependent upon water temperature and day length, and normally spawns between September and April within their natural range in Northern Australia freshwater bodies. According to Karplus *at el* (1997) red claw crayfish are multiple spawners capable of spawning several times (3 to 5 times) each year as long as water temperatures remain above 18°C.

Levi *at el* (1997) reported that the annual spawning and molting cycles of the Australian red-claw crayfish was studied in the laboratory over a period of 13 months. The inquiry reviewed females spawned three times and molted twice a year on average. Most spawning occurred during spring and summer, and molting occurred mainly after the breeding season but also between spawns. Variable sequences of spawning and molting were evident during the breeding months. The most common sequences were spawn-molt-spawn and spawn-spawn-molt, with the females as likely to spawn and to molt following the first spawning. An intervening spawning elongated the time interval between molts but did not affect the molt increment. The number of juveniles per spawn was positively correlated with female size, whereas juvenile weight was not (Levi *at el*, 1997). According to Queensland Government (2016) the female broods the eggs for 6-10 weeks, depending on temperature. The larger the female, the more eggs she can produce. Most females produce 300-800 eggs per brood. Red claw crayfish may produce 3-5 broods during the breeding season.

According to the Fish Site (2012) red claw crayfish reproduction usually occurs when water temperature remains above 18ºC. Petitgas *et al* (2011) reported that histograms of fish length are useful for various purposes in fisheries science, including estimating ecological understanding of life cycle patterns and age structures. The life cycle of any living organism embraces reproductive stages or patterns; therefore this report is linked to the first objective of the study which is aimed at determining breeding seasonality of red claw crayfish in local water bodies where the species has been reported.

2.2 Growth

According to Mark (2003) all species of crayfish have a hard exoskeleton. The segmented exoskeleton provides protection and allows movement, but limits growth. As a result, the crayfish regularly gets too big for its skeleton, sheds it and grows a new larger one. This phenomenon occurs several times during the first year of rapid growth, but less often during the subsequent period.

Michael and David (1997) and Wangari (2008) indicate that red claw crayfish growth takes place in a considerable range of temperatures that is, between 18°C and 35°C. Maximum growth of hatchlings occurs when the temperature is about 30°C and growth rate becomes negligible when the temperature falls below 18°C or rises above 35°C (Thompson *et al.*, 2004). Mortalities might occur when temperatures are below 18°C and above 35°C. Water temperatures below 18°C might be lethal and will limit red claw crayfish production especially in outdoor environments (Michael and David, 1997).

Heiko (2007) argue that fast growth rates, achievement of high (600g) maximum weight, relative ease of reproduction, lack of any free-living larval stages, gregariousness, and the ability to tolerate poor water quality conditions are characteristics that make red claw crayfish, *Cherax quadricarinatus* an ideal species for aquaculture. Rooyen (2013) made similar observation and noted that the red claw crayfish has evolved to tolerate a relatively high population density and poor water quality. Although red claw crayfish will tolerate a range of water quality conditions, rapid growth and viability will only be achieved if water quality is managed and maintained within optimal temperature ranges (Rooyen, 2013). This phenomenon makes the red claw crayfish a highly attractive aquaculture organism. This species tolerate low oxygen levels and a wide range of other water quality parameters (physical and chemical) including ammonia, nitrite, hardness, alkalinity, salinity, turbidity and pH range of 6.5 - 9. Red claw crayfish is able to survive under conditions of very low dissolved oxygen (>1 ppm), and in extreme cases will migrate to the edge of water where oxygen levels are mostly higher and may eventually move on land (Michael and David, 1997).

Webster (2004) gives tolerable water quality parameters and recommended range for red claw crayfish as follows: temperature of between 18°C to 35°C, dissolved oxygen of 5.0 ppm (mg/L) or above, total ammonia of 0.5 ppm (mg/L) or less, nitrite of 0.3 ppm (mg/L) or less, pH of between 7.5 and 8.0, alkalinity of above 100 ppm (mg/L), total hardness of above 50 ppm (mg/L) and chloride of 50 ppm (mg/L) or above.

Barki *et al.* (2005) reported that many studies in crayfish have demonstrated an inverse relationship between density and growth, in both wild and cultured populations. The effect of crowding may result in deterioration of water quality, decrease of essential resources such as food and shelter, or increased frequency of behavioral interactions. Whereas environmental factors and resource availability may be fairly well controlled in intensive facilities, social interactions are unavoidable in communal culture. The social factor has a particular impact in crustaceans since their growth is associated with vulnerability to cannibalism which may happen or take place during molting.

2.3 Mortality

According to Rooyen (2013) red claw crayfish are susceptible to many diseases and parasites, but none have been responsible for significant commercial mortalities in South African rivers where the species has been reported. Sorensen (2010) points out that in Europe and the Americas, a devastating fungal disease called crayfish plague caused mortalities in both cultured and wild freshwater crayfish stocks, and warn that this situation should be taken into account elsewhere. Research has shown that the red claws crayfish is susceptible to the fungus, “crawfish plague” (Webster, 2004). The fungus grows best at temperatures below 18°C and does not appear to be active or pathogenic above 35°C. Webster (2004) further report that since red claw crayfish need temperatures above 18°C for good growth, careful attention to stocking and harvesting temperatures may reduce potential problems. There are no known methods of prevention and treatment of the plague (Webster, 2004).

Eaves (1994) reported that there are no infectious diseases which have caused significant mortalities in Australian red claw crayfish. According to Sorensen (2010) stock losses have been primarily due to problems associated with site selection, water quality and management. Parasites and diseases of red claw crayfish are not fully known nor their impacts fully understood (Sorensen, 2010).

Red claw crayfish farming, like any type of agricultural enterprise, is a risky venture. FAO (2012) report that red claw crayfish farming is even more risky since little is known about full scale commercial production problems, diseases, and potential markets. Failures, to some degree, are still the rule and not the exception in aquaculture when it involves new species.

CHAPTER 3: METHODS AND MATERIALS

3.1 Research Design

The study area was Kafue floodplain fishery. The study design was both ecological and descriptive. Data collection was conducted from three sampling stations within the Kafue floodplains. Analysis of the data collected was quantitatively done while interpretation of the quantitative analysis of the results was qualitative. Quantitative aspects included calculations using empirical equations and application of statistics involving both analysis of variance (ANOVA) and construction of length frequency histograms. Qualitative aspects took the narrative form of interpreting the results, discussion, conclusion and recommendation.

3.2 Study Area

The Kafue flats are an extensive area of wetlands and floodplains along the Kafue River between Itezhi-tezhi in the west and Kafue Road Bridge in the east. The study area (Fig 3.1), the Kafue floodplain fishery is approximately 2,400 Km^2 (Muncy, 1976). The area lies between longitude of 26°E and 28°E, and latitude of 14°S and 16°S of Zambia. The study area consisted of three stations. Geographical Positioning System (GPS) was used to get co-ordinates of the sampling stations. Station one (I), was Kafue Road Bridge, grid reference 28° 14′ 110″ East and 15° 50′ 218″ South in Kafue district, representing the lower floodplain. The middle floodplain was represented by station two (II), at Namalyo fishing camp, grid reference 28° 14′ 126″ East and 15° 50′ 185″ South in Lochinvar National Park in Monze district, while station three (III), Kakuzu fishing camp, grid reference 28° 14′ 149″ East and 15° 50′ 166″ South in Namwala district represented the upper floodplain. The three sampling stations are about 40km, 200km and 300km south of Lusaka, the capital city of Zambia, respectively.

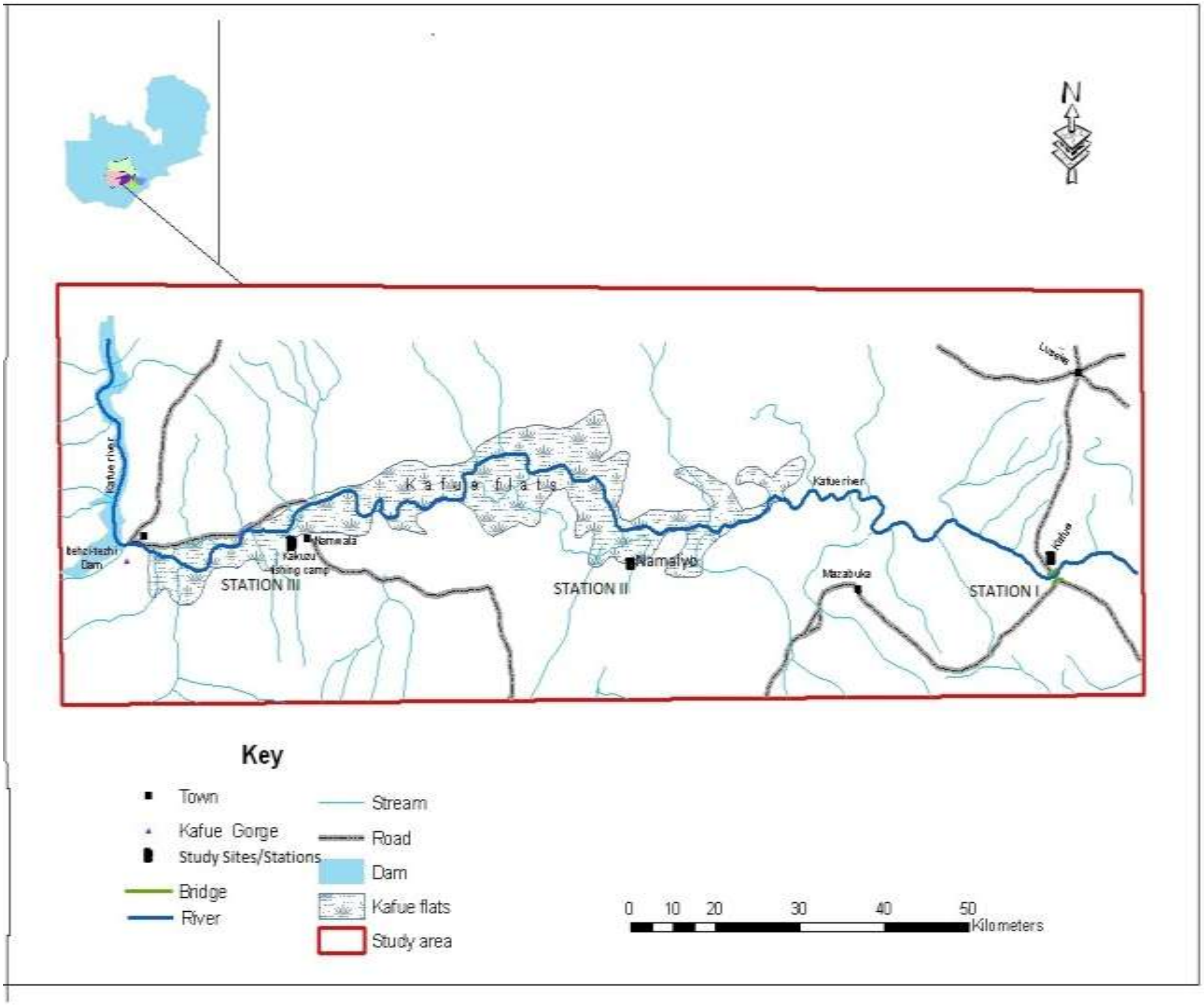

Figure 3.1 The Kafue floodplain fishery with the three sampling stations (**Source**: University of Zambia, Geography Department)

The three sampling stations were Kafue Road Bridge in Kafue district representing the lower floodplains, Namalyo in Monze district representing the middle floodplains and Kakuzu in Namwala district representing the upper floodplains.

3.3 Data Collection Procedure

Fish traps locally known as Kamono (Fig 3.2) were used to trap sample crayfish. Traps were acquired from local fishers. Baited fish traps (100cm long x 30cm with a mesh size of 10mm) were then set up along the shores of the floodplains to catch crayfish at each of the three sampling stations. Two hundred and fifty (250) red claw crayfish were collected from each sampling station. The trapped crayfish were collected and stored in 20 litre plastic buckets half filled with 10% formalin. Each sampling station was assigned two (2) labeled 20 litre plastic buckets with 10% formalin for storage of crayfish. The crayfish were then brought into the laboratory at the University of Zambia, Department of Biological Sciences for measuring and recording carapace length (CL), total length (TL) and Body weight (BW) using 30cm fish measuring board and electronic balance. Samples were collected during the month of September, October and November, 2015.

Figure 3.2 A Kamono fish trap used in the capture of red claw crayfish. (**Source:** http://www.bing.com/images/, Retrieved December 28, 2015)

Figure: 3.3 Picture after setting baited fish traps during sample collection at Kakuzu

3.4 Data Analysis

Data analysis of red claw crayfish was presented through the construction of length frequency histograms to determine spawning seasons, application of one way analysis of variance (ANOVA) using GENSTAT 14^{th} version 2011 and growth curves using MS excel 2010 (for growth comparison), Pauly and Munro's 1984 equation (Pauly and Munro, 1984) for growth performance indexes and Gulland's 1982 equation (Gulland, 1982) for mortalities. The analyses were worked out under the following sub-headings: breeding seasonality (3. 4. 1), comparing growth rate (3. 4. 2) and determining growth performance indexes (3. 4. 3) in different parts of the Kafue floodplain fishery and mortality rate (3. 4. 4) of the red claw crayfish.

3.4.1 Breeding Seasonality

Breeding seasonality of the red claw crayfish in the Kafue floodplain fishery was assessed using the length frequency histograms from data compiled from the catch samples by means of statistics MS excel 2010. Histograms of sample frequency against length intervals of the samples were constructed to determine if there was distinctive spawning or breeding seasons. Well defined histogram peaks represented breeding seasons of the cohort.

3.4.2 Growth:

The growth of the red claw crayfish for the three sampling stations were calculated and compared whether or not there were significant differences in different parts (i.e. three sampling stations) of the Kafue floodplain fishery using one-way analysis of variance (ANOVA) (GENSTAT 14^{th} version 2011) and growth curves using Von Bertalaffy's growth equation of 1936 (Sparre and Venema, 1998) expressed as:

$L_t = L\infty \, [1 - \exp^{-k(t-to)}]$, where;

L_t is length of the organism at any given time, $L\infty$ is asymptotic length, k is growth coefficient, t is time expressed as age and t_0 is time when the organism has zero length.

3.4.3 Growth Performance Index:

In order to obtain growth performance indexes of red claw crayfish for each sampling station, the Von Bertalanffy growth parameters k and $L\infty$ were estimated using Ford-Walford 1946 (Sparre and Venema, 1998) method and Pauly's equation of 1979 (Sparre and Venema, 1998), that is, $k = -\frac{1}{\Delta t} \times \ln b$ (Sparre and Venema, 1998); where b is a constant obtained by regression analysis of L (t) values of the sample size for each station and Δt is change in time and $L\infty = \frac{L\,max}{0.95}$ (Sparre and Venema, 1998); where L_{max} is the maximum total length measurement recorded for each sampling station. Growth performance indexes (Φ') for the three sampling stations were then estimated using the following empirical equation by Pauly and Munro of 1984 (Pauly and Munro, 1984) expressed as:

$\Phi' = \log_{10}(k) + 2\log_{10}(L\infty)$, where;

k = Von Bertalanffy growth coefficient and

$L\infty$ = Von Bertalanffy asymptotic length (cm).

3.4.4 Mortality

To assess the mortality rate of red claw crayfish in the Kafue floodplain fishery, instantaneous natural mortality coefficient (M) was estimated using Pauly's 1980 equation (Sparre and Venema, 1998) expressed as: $\ln(M) = 0.066 - 0.279 \ln(L\infty) + 0.6543 \ln(k) + 0.4634 \ln(T)$; where $L\infty$ is the Von Bertalanffy asymptotic length for the species, k is the growth coefficient and T is the mean water temperature of the water body where fish is found. While total mortality coefficient (Z) was determined using Berverton and Holt equation of 1956 (Sparre and Venema, 1998) expressed as: $Z = \mathrm{k}\left[\frac{L\infty - \bar{l}}{\bar{l} - L'}\right]$; where $\bar{l}$ is mean length of sample and L' is lower limit of length of sample. Mortalities of red claw crayfish, *Cherax quadricarinatus* species were then estimated using Gulland's equation of 1982 (Gulland, 1982) expressed as:

M + F = Z where;

M = Natural mortality coefficient,

F = Fishing mortality coefficient and

Z = Total mortality coefficient.

Exploitation rate or ratio (E) due to fishing = F/Z was computed using Baranov's equation of 1918 (Sparre and Venema, 1998).

CHAPTER 4: RESULTS OF THE STUDY

Data collection sheets (Appendix I) were used for recordings of the appropriate parameters of red claw crayfish, *Cherax quadricarinatus* species, that is, carapace length (CL), total length (TL) and body weight (BW). The data of the variables recorded were categorized according to dates and sampling stations of the study area that is, station I, Kafue Road Bridge; station II, Namalyo in Monze; and station III, Kakuzu in Namwala. The analysis of the results of the study was done chronologically with specific objectives. The analysis was computed out under the subsequent sub-headings: breeding seasonality (4.1), growth rate (4.2), growth performance indexes (4.3) and mortality rate (4.4) of the red claw crayfish. Spawning times results will be presented in form of histograms, growth rate by both carapace and total length, and growth curves. Both growth performance indices and mortalities will be presented in form of variables.

4.1Breeding Seasonality

The spawning seasonality of red claw crayfish was assessed by means of length frequency histograms using data collected, recorded and compiled from the samples of the three sampling stations by means of MS excel 2010. Histograms of sample frequency against length intervals of the samples were constructed to determine spawning or breeding seasons of the organism. The analysis was done month by month for all three sampling stations and then overall or combined data set for all the three sampling stations.

Length frequencies of red claw crayfish sample from all the three sampling stations for the month of September, 2015 were computed as shown in figure 4.1(Appendix III a).

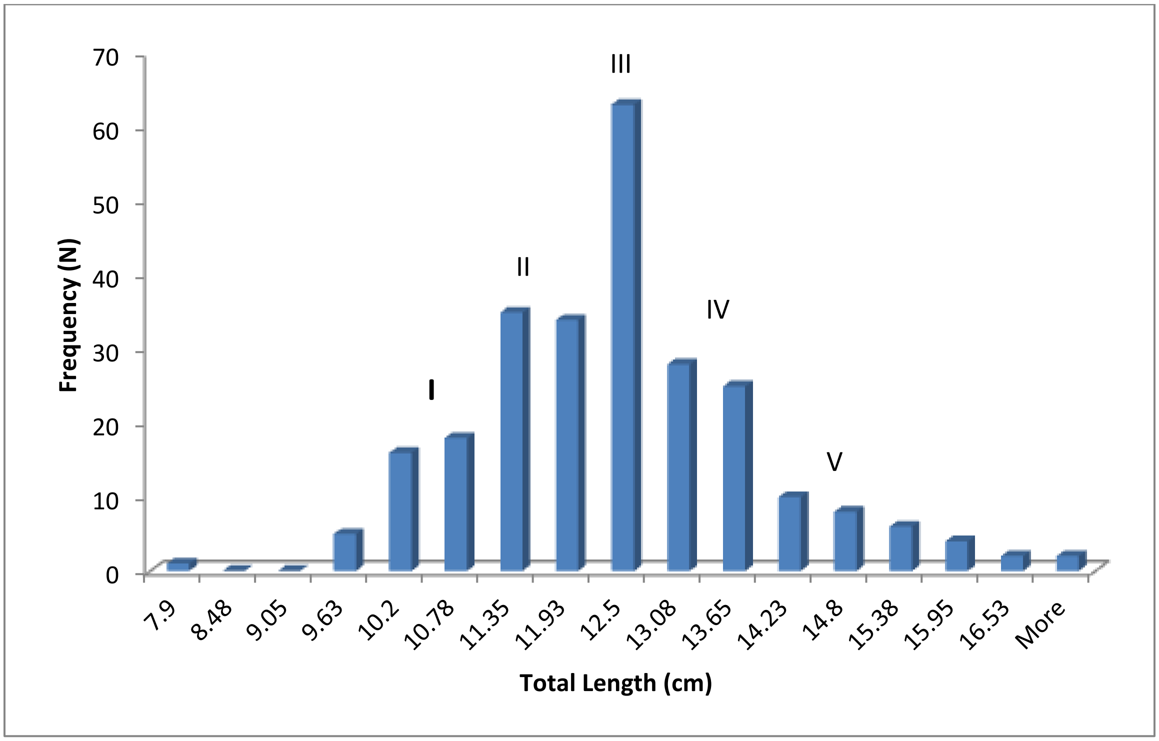

Figure: 4.1 Length frequency histograms of the red claw crayfish sample collected in September, 2015 from all the three sampling stations

The display of the length frequency histograms in the figure demonstrates defined peaks of the histograms, an indication that the red claw crayfish, *Cherax quadricarinatus* species has well-defined spawning seasons.

Length frequencies of red claw crayfish sample from all the three sampling stations for the month of October, 2015 were computed as shown in figure 4.2 (Appendix III b).

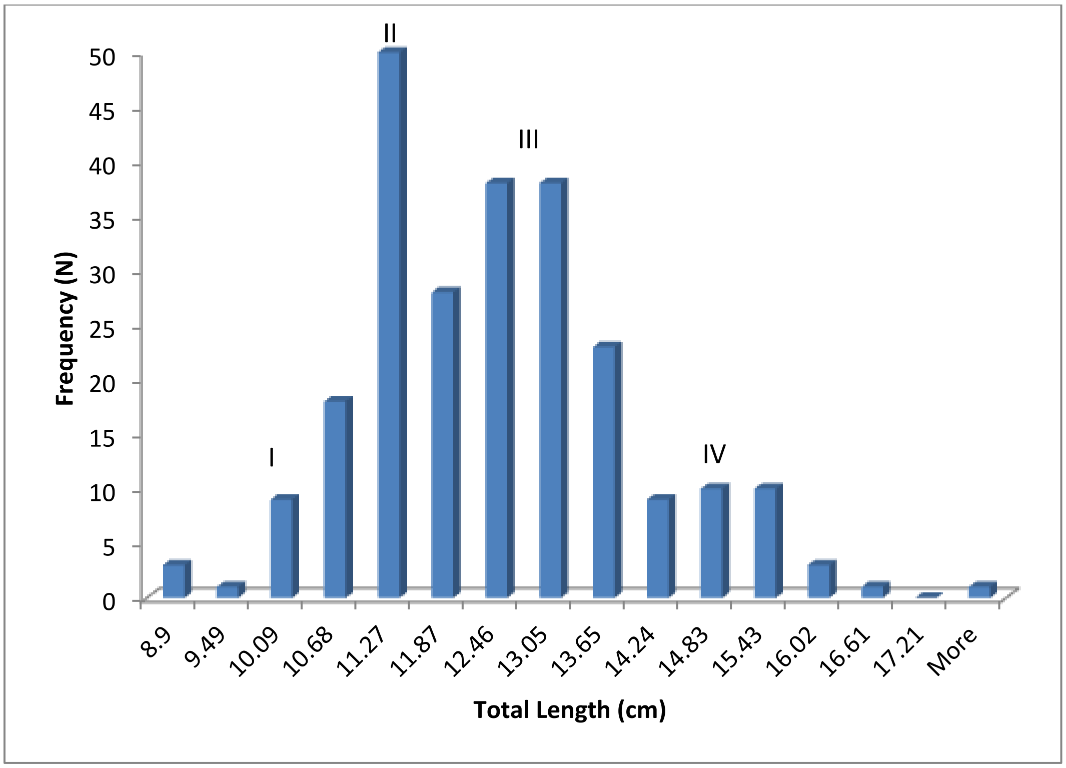

Figure: 4.2 Length frequency histograms of the red claw crayfish sample collected in October, 2015 from all the three sampling stations

The length frequency histograms illustrated in figure 4.2 for the red claw crayfish sample collected during the month of October shows a gradual increase in peaks that is, the frequencies of the length. There is a steady shift in the distinctive peaks, a scenario that may be indicating an increase in the number of productive red claw crayfish age groups spawning.

Length frequencies of red claw crayfish sample from all the three sampling stations for the month of November, 2015 were computed as shown in figure 4.3 (Appendix III c).

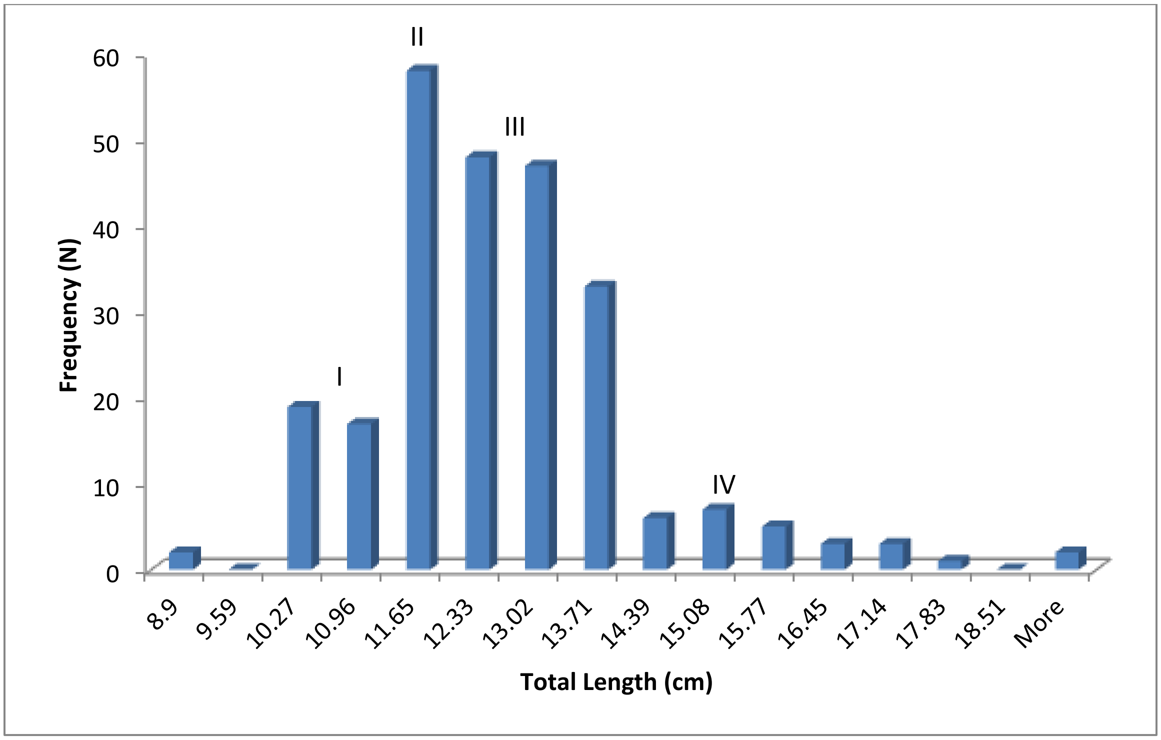

Figure: 4.3 Length frequency histograms of the red claw crayfish sample collected in November, 2015 from all the three sampling stations

The figure 4.3 has equally well-defined peaks like figure 4.1 and 4.2. There is also an observable steady increase in the heights of peaks, that is, length frequencies of the species, most likely because of the increase in the productive age group. The length frequencies of the likely aging groups are low.

Below are the overall length frequencies of red claw crayfish sample from all the three sampling stations for the month of September, October and November, 2015 as shown in figure 4.4 (Appendix III d).

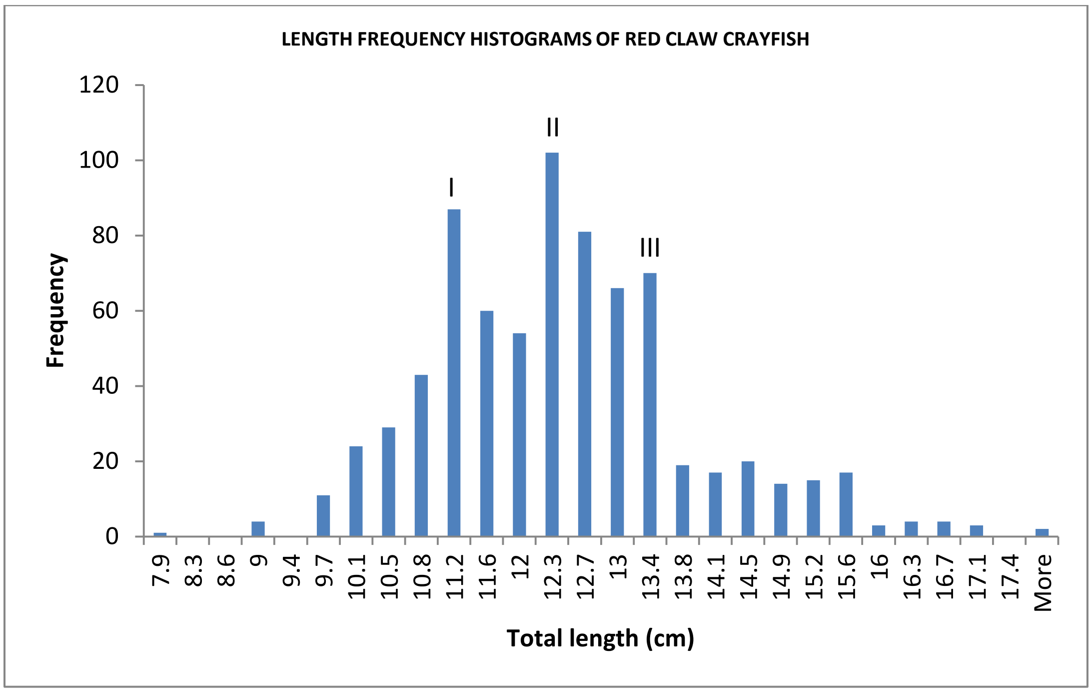

Figure: 4.4 The overall length frequencies of the red claw crayfish from Kafue Floodplains for the months of September – November, 2015

The combined length frequency histograms of the red claw crayfish were constructed to determine the breeding seasonality of the target species in the Kafue Floodplain fishery for the months of September, October and November, 2015 (Fig 4.4). Length frequency histograms for each month of the three sampling stations showed distinct peaks. The combined length frequency histograms for all the three sampling stations equally showed distinct peaks of the length frequencies of the crustacean.

4.2 Growth

The mean water temperature of the fishery was found to be 22.3°C. The mean water temperature was computed by averaging the recorded temperatures of the three sampling stations. The temperature is within the growth range of the crustacean as reported by Michael and David (1997) and Wangari (2008). Growth analysis involved comparing carapace length, total length and computed values via Von Bertalaffy's growth equation of 1936 (Sparre and Venema, 1998) by means of one way analysis of variance (ANOVA) using GENSTAT 14th version 2011. Further, growth rate patterns or curves of the species were constructed.

Carapace length:

Table 4.1 Summary of ANOVA for carapace lengths of red claw crayfish in different parts of the Kafue floodplain fishery.

ANOVA- Single Factor

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.668507	2	2.834253	2.488998	0.083681	3.0077784
Within Groups	850.6182	747	1.138712			
Total	856.2867	749				

The calculated carapace length probability (p) value is 0.083681. This value is greater than the critical probability (p) value of 0.05.This suggests that there is no significant difference in the carapace length of red claw crayfish in different parts of the Kafue floodplains.

Total length:

Table 4.2 Summary of ANOVA for total lengths of red claw crayfish in different parts of the Kafue floodplain fishery.

ANOVA- Single Factor

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.446	2	0.723	0.333854	0.716265	3.007778
Within Groups	1617.717	747	2.165618			
Total	1619.163	749				

The calculated total length probability (p) value is 0.7163. This value is greater than the critical probability (p) value of 0.05. Therefore the null hypothesis (H_0) is accepted. The computation indicates that there is no significant difference in the total length of red claw crayfish in different parts of the Kafue floodplains.

In addition to one way analysis of variance (ANOVA) using MS excel 2010; growth rate patterns or curves of red claw crayfish were constructed.

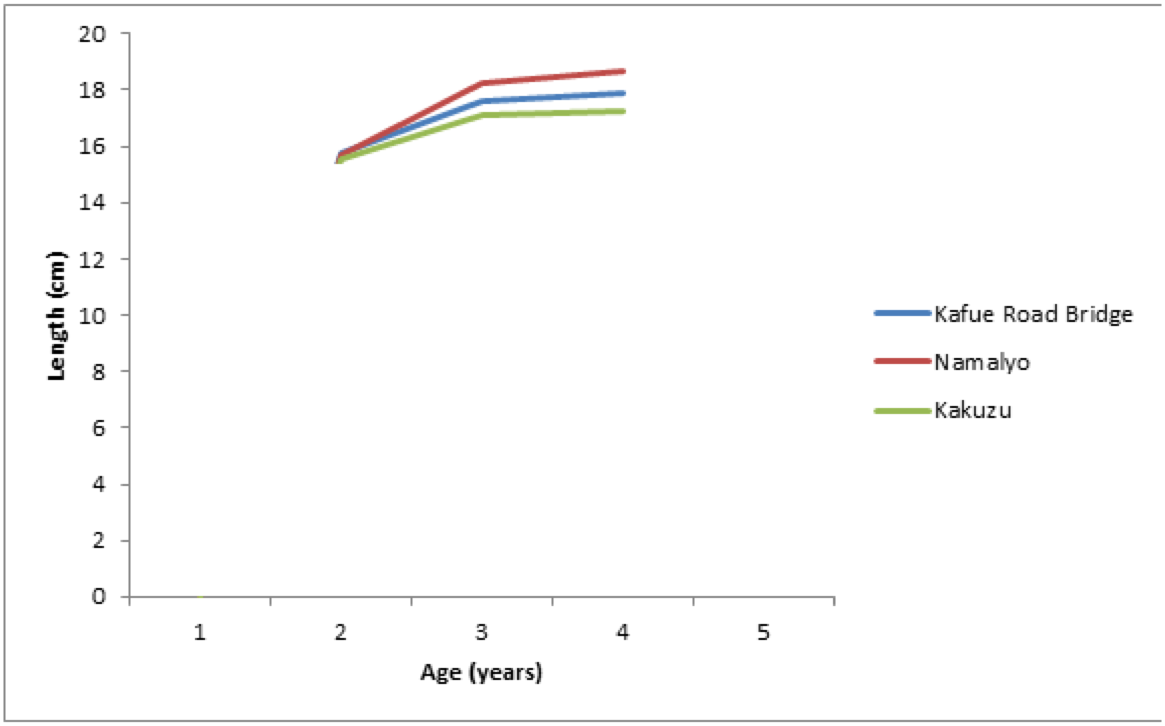

Figure 4.5 Growth rate patterns or curves of red claw crayfish in three sampling stations

The growth pattern of red claw crayfish as shown in the graphs (Fig 4.5) indicates insignificant differences among the three sampling stations. The patterns correlate with the results of the one way analysis of variance (ANOVA) for both carapace and total length. Further, the finding correlate with the outcome of the statistical one way analysis of variance (ANOVA) with GENSTAT 14^{th} version 2011 the computed values (Appendix II) of the species from the three sampling stations using Von Bertalanffy growth equation of 1936. Table 4.3 displays the result.

Von Bertalanffy's growth equation of 1936 values (Appendix II)

Table 4.3 Summary of ANOVA using Von Bertalanffy's growth equation of 1936 values of red claw crayfish.

ANOVA- Single Factor

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.21052	2	0.60526	0.375091	0.702275	5.14325285
Within Groups	9.681807	6	1.613634			
Total	10.89233	8				

The statistically calculated probability (p) value is 0.7023. The value is greater than the critical probability (p) value of 0.05. Therefore the null hypothesis (H_0) is accepted. The computation indicates that there is no significant difference in the growth rate of red claw crayfish in different parts of the Kafue floodplain fishery.

4.3 Growth Performance Index

The growth performance indexes (Φ') for the red claw crayfish for the three sampling stations that is, Kafue Road Bridge, Namalyo (Monze) and Kakuzu (Namwala) were estimated using an empirical equation. The constants k and $L\infty$ for each sampling site were estimated as outlined under materials and methods, and are shown in table 4.4.

Table 4.4 shows L∞ and k for each sampling station

Station	L∞	k
Kafue Road Bridge	17.89	2.1387
Namalyo – (Monze)	18.74	1.8048
Kakuzu – (Namwala)	17.26	2.2975

The growth performance indexes (Φ′) for each sampling site were then calculated by making substitutions in an empirical equation. The following values were obtained.

Table 4.5 shows growth performance indexes (Φ′) for each sampling station

Station	Growth Performance Index (Φ′)
Kafue Road Bridge	2.8062
Namalyo – (Monze)	2.8466
Kakuzu – (Namwala)	2.7750

The growth performance index for Kafue Road Bridge station was found to be 2.8062, Namalyo station, 2.8466 and that of Kakuzu station is 2.7750. The indexes from the three sampling stations show negligible differences among them, and a statistical test by means of one way ANOVA using GENSTAT 14th version 2011 gave a calculated probability (p) value of 0.9998. This value is greater than the critical probability (p) value of 0.05. Therefore there is no significant difference in growth performance index of red claw crayfish in different parts (i.e. three sampling stations) of the Kafue floodplain fishery.

4.4 Mortality

Using the equations outlined in the methodology, the mortalities and exploitation rate of the red claw crayfish for each sampling station were estimated as shown in table 4.6 below.

Table 4.6 The mortality and exploitation of red claw crayfish at Kafue Road Bridge, Namalyo and Kakuzu sampling sites

Station	Natural (M)	Fishing (F)	Total (Z)	Exploitation (E)
Kafue Road Bridge	0.0698	2.4506	2.5204	0.9723
Namalyo – (Monze)	0.0576	3.8701	3.977	0.9731
Kakuzu – (Namwala)	0.0791	2.9419	3.0210	0.9738

Based on table 4.6, it is clear that natural mortality of red claw crayfish is low in all the three (3) sampling stations while the numbers caught as by-catches is high.

CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The Kafue floodplains stocks exotic invasive fish species, among them is *Oreochromis niloticus*. Other alien organisms that have invaded the fishery are crustaceans' such as red claw crayfish. Fishers from the three sampling stations revealed that the population of *Oreochromis niloticus* in the fishery has increased compared to the native species. This information is based on the reduced catches of native species compared to *Oreochromis niloticus*. Further, they said a similar trend is being observed with crayfish. They indicated that the number of crayfish caught in gillnets is gradually increasing. The general increase in the population of crayfish in the Kafue floodplain fishery could be attributed to the crustacean lacking a strong predator to reduce its population (Moonga and Musuka, 2014). The absence of diseases (so far no official reports have been made or recorded) could also be a reason for the increase of the crayfish in the river. In addition to that, the organism is perceived not to have a strong competitor for food in the fishery.Moonga and Musuka (2014) reports that the crayfish can as well change or switch diets based on whatever food is available.

On the reproductive biology of red claw crayfish, the study found that the species has well-defined spawning seasons. The overall results of length frequency histograms of the sample showed distinct peaks, an indication that the species has distinct spawning seasons. A similar situation was observed in all three sampling stations. The finding of the study confirms results of Heiko (2007) who reported that crayfish normally breeds between September and April within their natural range in northern Australia freshwater bodies. Karplus *at el* (1997) also reported that red claw crayfish are multiple spawners capable of spawning several times (3 to 5 times) each year as long as water temperatures remain above 18°C.

In addition to the arguments by Heiko (2007) and Karplus *at el* (1997), the Fish Site (2012) also describes that red claw crayfish reproduction will only occur while water temperature remains above 18 ºC, and that breeding and production of seed occurs naturally during the summer months, when temperatures are >20 ºC. Levi *at el* (1997) adds that the annual spawning and molting cycles of the Australian red-claw crayfish was studied in the laboratory over a period of 13 months. The investigation revealed that females spawned three times and molted twice a year on average. Most spawning occurred during spring and summer, and molting occurred mainly after the breeding season but also between spawns. These arguments by Heiko (2007), Karplus *at el* (1997), the Fish Site (2012) and Levi *at el* (1997) can be related to the mean water temperature of the Kafue Floodplain fishery which was found to be 22.3°C. Levi *at el* (1997) further reports that nevertheless, the breeding rates tend to reduce during the cold season most likely due to unfavourable environmental conditions, among them low temperatures.

Both calculated carapace and total length probability (p) values (0.083681 and 0.7163) were found to be greater than the critical probability (p) value of 0.05. Therefore the null hypothesis (H_0) that there was no significant difference in the growth of the red claw crayfish in different parts (i.e. three sampling stations) of the Kafue Floodplain fishery is accepted. This implies that there is no significant difference in the growth of red claw crayfish in different parts of the Kafue floodplain fishery. Further, the constructed growth patterns or curves and the calculated probability (p) value (0.7023) using Von Bertalanffy growth equation of 1936 showed that there is no significant difference in the growth rate of the species in different parts of the Kafue floodplains fishery. This could be attributed to the fact that the environment at the three sampling sites was similar.

Based on calculated probability (p) value of 0.9998, it shows that there is no significance difference among the sampling stations, an indication that the red claw crayfish has a similar growth performance index in different parts of the Kafue floodplains. This finding is related to the observed insignificance difference in the growth of the organism in different parts of the fishery. The mean water temperature of the fishery was found to be 22.3°C. The finding lies within the range reported by Wangari (2008), Michael and David (1997) and Thompson *et al* (2004) in which they argued that red claw crayfish growth takes place in a considerable range of temperatures that is, between 18°C and 35°C.

The study found that fishing mortality coefficient (F) of red claw crayfish in the Kafue floodplain fishery is 2.9263. This result on (F) is similar to the findings of Moonga and Musuka (2014) where they reported that the number of crayfish caught as by-catches in gillnets of fishers is greater than the crayfish that were dying due to natural causes. Based on the mortalities values, it can be said that the crayfish mortality in the fishery is largely due to exploitation (as by-catches). The crustaceans dying due to natural causes are low. This could be as a result of no reported diseases, competitors, spawning stress and other severe environmental factors. Fishers in the fishery, especially Namwala and Namalyo area have associated crayfish to being supernatural / mystical organisms (Malende) which have led to reductions in catches of fin fish in the floodplains. Moonga and Musuka (2014) argued that the presence of crayfish as a by-catch has caused a lot of operational challenges to the fishers in that their fish were being eaten or disfigured, hence lowering the quality of the saleable product, nets were damaged and a lot of time was spent in removing the organisms from their nets.

Besides being by-catches, crayfish can be caught using baited traps. The traps were set close to the shoreline of the floodplain with nshima (cooked mealie-meal paste) being used as alternative bait. During the study it was observed that station I, Kafue Road Bridge had people especially from Lusaka who wanted to buy crayfish for home consumption. Even though crayfish is not formally exploited in the fishery, some fishers at Kafue Road Bridge were actively involved in catching crayfish using baited fish traps locally known as Kamono. The observation at Kafue Road Bridge station matches with Moonga and Musuka (2014) whose report argues that crayfish seems to be gaining popularity as food among many Zambians although marketing of the crustacean to the hospitality industry seems not to be well developed. Figure 5.1 and 5.2 show pictures of some activities carried out during sample collection.

5.2 Conclusion

The study was undertaken in the Kafue floodplains where the species red claw crayfish has been reported. Based on the peaks of the histograms, the investigation showed that the species has more than one defined spawning seasons. The study also revealed that there were no significant differences in both the growth and growth performance indexes of the organism in different parts of the Kafue floodplains fishery. On mortalities, the investigation revealed that the species is dying largely due to fishing that is, as by-catches.

5.3 Recommendation

(i) There is need for further research for a longer period of time by interest academicians and researchers to ascertain and validate more information and knowledge on this alien species in the Kafue Floodplains and other fisheries such as Lake Kariba where species has been reported.

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APPENDICES

Appendix I

The University of Zambia
School of Natural Sciences
Department of Biological Sciences
Species: *Cherax quadricarinatus*
Sampling Station: KAFUE ROAD BRIDGE

Data Collection Sheet / instrument

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
25/09/15	1	4.9	12.0	38.0
,,	2	6.2	13.2	67.5
,,	3	4.8	11.0	41.4
,,	4	4.2	10.5	26.4
,,	5	5.4	12.5	50.9
,,	6	4.0	10.4	29.4
,,	7	6.3	13.3	57.1
,,	8	6.2	13.0	55.0
,,	9	5.8	11.9	39.3
,,	10	5.3	12.4	12.6
,,	11	4.8	11.5	31.2
,,	12	5.1	12.2	49.5
,,	13	5.5	12.4	40.7
,,	14	5.0	11.9	36.3
,,	15	3.6	9.5	17.4
,,	16	5.0	12.1	39.0
,,	17	4.8	11.0	54.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	18	5.0	11.9	39.2
,,	19	5.1	12.1	55.0
,,	20	6.6	13.5	54.9
,,	21	5.5	12.4	55.1
,,	22	4.0	10.5	26.5
,,	23	5.1	11.9	44.0
,,	24	4.9	11.4	27.0
,,	25	6.7	14.3	74.5
,,	26	4.7	11.3	27.5
,,	27	4.2	10.9	33.6
,,	28	5.3	11.2	41.0
,,	29	3.9	10.5	28.0
,,	30	3.8	10.4	29.1
,,	31	2.5	7.9	15.0
,,	32	5.4	12.5	20.1
,,	33	6.3	13.3	73.7
,,	34	5.1	11.1	31.5
,,	35	4.3	10.0	22.3
,,	36	5.2	11.4	19.6
26/09/15	37	6.5	13.0	39.0
,,	38	5.4	12.3	56.5
,,	39	4.5	12.5	37.5

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	40	4.9	11.2	25.0
,,	41	5.1	12.0	35.0
,,	42	6.0	13.0	50.0
,,	43	6.3	13.1	49.9
,,	44	3.5	10.8	27.5
,,	45	4.7	11.6	22.1
,,	46	5.3	12.5	45.0
,,	47	6.2	13.0	40.0
,,	48	5.1	12.0	37.1
,,	49	5.2	12.5	50.0
,,	50	5.0	11.3	42.5
,,	51	5.7	12.8	36.5
,,	52	5.3	12.5	40.0
,,	53	4.8	11.1	30.0
,,	54	5.3	12.3	45.0
,,	55	5.2	12.2	51.0
,,	56	4.2	10.4	15.1
,,	57	5.3	12.4	34.1
,,	58	5.2	12.8	33.8
,,	59	5.3	12.5	37.0
,,	60	5.2	12.4	49.0
,,	61	5.4	12.6	46.1

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
26/09/15	62	5.2	12.4	42.5
,,	63	6.7	13.3	75.0
,,	64	5.2	12.0	37.1
,,	65	4.1	10.0	24.5
,,	65	6.8	14.7	67.1
,,	66	4.0	10.8	27.0
,,	67	6.6	13.2	62.5
,,	68	6.1	13.0	45.0
,,	69	5.3	12.2	37.2
,,	70	6.4	13.4	49.0
,,	71	4.7	11.5	30.0
,,	72	6.9	15.0	93.1
,,	73	4.1	10.3	20.0
,,	74	4.3	10.4	24.8
,,	75	3.8	9.8	20.1
,,	77	5.4	12.4	40.1
,,	78	6.8	14.2	60.0
,,	79	5.2	12.0	30.0
,,	80	4.8	11.8	30.0
,,	81	5.0	11.9	30.0
,,	82	6.4	13.5	40.0
,,	83	4.3	11.3	37.5

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
23/10/15	84	5.3	12.4	30.1
,,	85	6.2	13.0	47.0
,,	86	4.5	11.2	27.5
,,	87	3.9	10.8	25.0
,,	88	5.4	12.6	35.0
,,	89	4.5	11.7	35.1
,,	90	4.9	11.8	26.1
,,	91	4.9	11.9	32.1
,,	92	6.7	15.0	110.0
,,	93	5.3	12.5	35.0
,,	94	3.9	10.7	27.1
,,	95	6.7	14.0	50.2
,,	96	6.9	14.3	52.5
,,	97	6.5	13.0	77.3
,,	98	5.5	12.5	45.0
,,	99	6.7	13.9	43.2
,,	100	4.9	11.0	28.1
,,	101	6.4	13.1	36.8
,,	102	5.4	12.5	34.9
,,	103	6.3	13.1	45.0
,,	104	6.5	13.4	45.5
,,	105	5.5	12.3	42.5

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	106	7.0	15.4	97.1
,,	107	6.3	13.0	37.2
,,	108	5.1	12.2	45.0
,,	109	5.4	12.7	47.1
,,	110	6.4	13.4	50.0
,,	111	5.2	12.5	42.1
,,	112	6.5	13.1	50.3
,,	113	5.3	12.7	60.0
,,	114	6.3	13.2	51.3
,,	115	6.4	13.2	50.1
,,	116	4.7	11.7	37.2
24/10/15	117	5.2	12.6	39.0
,,	118	3.6	8.9	15.0
,,	119	4.0	10.5	25.4
,,	120	5.4	12.8	45.3
,,	121	5.0	10.2	27.5
,,	122	4.7	11.0	30.0
,,	123	5.0	12.1	33.0
,,	124	4.0	10.4	25.5
,,	125	4.8	10.9	26.0
,,	126	6.7	14.8	70.6
,,	127	4.8	11.4	36.1

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	128	4.7	11.2	26.0
,,	129	5.1	12.2	48.3
,,	130	6.5	13.2	65.0
,,	131	4.4	11.5	32.0
,,	132	5.2	12.6	50.2
,,	133	6.4	13.0	50.0
,,	134	5.4	12.1	49.8
,,	135	6.6	14.0	66.2
,,	136	4.9	11.5	37.5
,,	137	6.9	14.2	85.0
,,	138	3.9	10.3	25.0
,,	139	6.4	13.2	42.5
,,	140	3.7	10.4	25.1
,,	141	5.6	12.7	45.0
,,	142	5.4	12.5	49.8
,,	143	5.0	11.9	30.0
,,	144	4.4	11.0	27.2
,,	145	3.9	10.7	22.5
,,	146	6.4	13.2	50.0
,,	147	5.3	12.4	57.5
,,	148	6.1	13.0	52.0
,,	149	4.1	10.5	22.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
21/11/15	150	5.4	12.5	40.0
,,	151	5.1	12.0	35.0
,,	152	6.5	13.5	60.1
,,	153	5.4	12.0	52.5
,,	154	6.5	13.2	53.5
,,	155	6.8	14.0	48.5
,,	156	7.4	16.1	115.0
,,	157	6.5	13.6	45.0
,,	158	6.2	13.2	50.0
,,	159	6.5	13.5	55.2
,,	160	6.6	13.7	60.2
,,	161	6.3	13.2	51.4
,,	162	6.4	13.3	52.0
,,	163	5.6	12.8	37.5
,,	164	6.3	13.1	40.0
,,	165	8.4	18.8	118.0
,,	166	5.2	12.5	40.0
,,	167	6.5	13.4	67.5
,,	168	5.1	12.3	48.9
,,	169	7.4	15.2	80.0
,,	170	4.7	11.0	27.1
,,	171	3.9	10.3	25.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	172	5.4	12.5	48.2
,,	173	4.6	11.5	35.0
,,	174	4.3	11.3	35.4
,,	175	6.8	14.2	70.0
,,	176	7.1	17.0	98.5
,,	177	6.7	14.4	65.0
,,	178	5.2	12.0	45.0
,,	179	6.3	14.1	54.3
,,	180	5.5	12.2	43.0
,,	181	6.4	13.1	60.0
,,	182	6.9	15.3	85.1
,,	183	5.4	12.7	50.0
,,	184	3.8	10.5	17.5
,,	185	6.5	13.4	50.2
,,	186	8.5	19.2	160.0
,,	187	4.6	11.6	30.0
,,	188	5.5	12.7	50.2
,,	189	5.7	12.9	45.0
,,	190	3.8	10.0	20.0
,,	191	4.4	11.4	25.0
,,	192	5.4	12.7	52.5
,,	193	5.1	12.0	49.8

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	194	5.6	12.7	52.5
,,	195	2.8	9.7	19.9
,,	196	6.4	13.1	52.5
,,	197	6.7	13.6	57.5
,,	198	5.3	12.3	32.5
,,	199	6.8	14.2	74.3
,,	200	5.1	12.4	45.5
,,	201	6.6	13.5	56.3
,,	202	2.6	9.6	23.0
,,	203	4.5	11.1	34.2
,,	204	5.3	12.6	54.5
,,	205	5.1	12.0	40.0
,,	206	5.2	12.5	43.0
,,	207	3.9	10.2	29.5
,,	208	4.0	10.4	37.4
,,	209	2.7	9.8	18.2
,,	210	3.5	10.0	26.4
,,	211	6.3	13.1	53.0
,,	212	5.1	12.3	45.1
22/11/15	213	5.2	12.2	53.4
,,	214	4.9	11.5	27.5
,,	215	6.3	13.4	50.2

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	216	6.5	13.3	60.5
,,	217	4.8	11.6	35.0
,,	218	5.7	12.7	40.2
,,	219	5.8	12.9	48.8
,,	220	4.4	11.3	29.5
,,	221	4.5	11.4	35.0
,,	222	5.5	12.7	54.5
,,	223	5.4	12.5	49.5
,,	224	5.2	12.7	52.5
,,	225	2.7	9.9	22.9
,,	226	5.4	12.5	42.5
,,	227	6.9	14.6	61.5
,,	228	5.2	12.3	37.5
,,	229	5.5	12.6	56.4
,,	230	5.3	12.5	44.5
,,	231	5.0	12.1	52.0
,,	232	4.5	11.5	38.3
,,	233	3.8	10.0	29.5
,,	234	5.3	12.2	48.4
,,	235	5.2	12.1	56.2
,,	236	5.6	12.7	50.0
,,	237	5.1	11.9	40.5

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	238	3.9	10.6	35.6
,,	239	4.0	10.2	28.5
,,	240	5.3	12.1	45.5
,,	241	5.4	12.7	47.0
,,	242	5.3	12.3	45.1
,,	243	4.8	11.7	30.0
,,	244	3.7	10.6	18.5
,,	245	5.4	12.4	53.2
,,	246	6.5	13.2	44.0
,,	247	4.7	11.6	38.0
,,	248	5.2	12.2	44.2
,,	249	5.3	12.4	45.0
,,	250	3.7	10.2	52.5

Sampling Station: NAMALYO - MONZE

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
28/09/15	1	5.3	12.2	41.5
,,	2	4.4	10.7	35.0
,,	3	6.1	13.0	47.4
,,	4	6.8	14.2	73.2
,,	5	4.7	11.7	39.3
,,	6	7.9	15.4	110.1
,,	7	6.3	13.1	44.3
,,	8	6.8	14.0	55.0
,,	9	5.5	12.5	45.2
,,	10	5.6	12.7	56.2
,,	11	4.6	11.5	41.3
,,	12	6.6	13.2	51.2
,,	13	5.5	12.6	43.5
,,	14	3.8	10.1	30.3
,,	15	4.6	11.8	38.0
,,	16	5.3	12.2	40.4
,,	17	5.4	12.6	57.5
,,	18	5.5	12.7	44.9
,,	19	5.1	12.2	50.1
,,	20	4.6	11.3	37.8
,,	21	7.9	15.3	85.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	22	4.3	11.5	38.2
,,	23	3.8	10.3	35.0
,,	24	4.4	11.5	37.6
,,	25	4.3	13.2	67.2
,,	26	7.2	16.1	94.5
,,	27	6.0	13.0	55.6
,,	28	6.7	14.0	54.2
,,	29	6.7	14.0	57.3
,,	30	7.1	15.2	65.8
,,	31	4.5	11.2	47.5
,,	32	5.0	12.0	35.0
,,	33	3.7	9.8	23.4
,,	34	4.2	10.6	35.5
,,	35	4.4	10.9	28.1
,,	36	6.7	14.6	71.6
29/09/15	37	4.5	11.6	46.1
,,	38	5.1	12.2	36.0
,,	39	5.2	12.2	46.3
,,	40	6.7	13.9	65.9
,,	41	2.8	9.5	22.0
,,	42	5.4	12.7	54.2
,,	43	5.7	12.9	50.8

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	44	5.2	12.4	49.4
,,	45	6.0	13.0	56.2
,,	46	6.9	15.5	74.5
,,	47	7.0	15.8	85.0
,,	48	5.0	10.8	27.1
,,	49	5.3	12.2	43.5
,,	50	3.7	9.4	19.1
,,	51	5.3	12.7	45.6
,,	52	5.4	12.8	59.8
,,	53	3.4	10.4	30.5
,,	54	4.4	11.0	37.2
,,	55	3.9	10.7	24.5
,,	56	4.7	11.2	43.4
,,	57	6.4	13.4	57.5
,,	58	6.6	14.0	62.0
,,	59	3.8	10.5	25.0
,,	60	5.4	12.5	46.7
,,	61	5.0	12.0	48.0
,,	62	6.2	14.2	67.5
,,	63	5.7	11.8	41.4
,,	64	5.3	11.5	46.4
,,	65	6.2	14.5	80.9

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	65	4.4	10.4	32.4
,,	66	6.2	13.3	57.1
25/10/15	67	6.6	15.1	85.8
,,	68	5.4	11.2	49.3
,,	69	3.7	9.4	18.6
,,	70	3.0	10.5	34.2
,,	71	5.1	12.2	47.5
,,	72	5.5	12.4	46.7
,,	73	5.0	11.0	46.3
,,	74	3.6	9.5	19.4
,,	75	5.0	12.1	39.8
,,	77	5.9	13.0	64.0
,,	78	4.7	11.9	39.2
,,	79	5.0	12.1	45.0
,,	80	6.1	13.0	54.9
,,	81	6.3	13.2	55.1
,,	82	3.7	10.5	36.5
,,	83	5.0	11.9	44.3
,,	84	3.7	10.4	27.0
,,	85	6.3	14.3	74.5
,,	86	5.2	11.3	47.5
,,	87	5.1	10.9	33.6

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	88	5.2	11.2	41.0
,,	89	3.8	10.5	38.0
,,	90	5.3	12.4	49.1
,,	91	4.3	11.4	54.2
,,	92	2.9	10.1	33.0
,,	93	3.7	10.9	42.1
,,	94	6.5	13.6	78.4
,,	95	7.0	15.0	83.2
,,	96	2.9	10.0	36.8
,,	97	5.1	12.0	52.0
,,	98	5.4	12.8.	45.2
,,	99	3.6	8.9	18.7
,,	100	5.2	12.4	38.9
,,	101	5.4	12.7	57.2
,,	102	6.2	13.0	64.0
,,	103	7.3	15.6	98.3
,,	104	4.9	11.8	49.0
,,	105	4.2	11.0	38.3
,,	106	4.3	11.1	53.0
,,	107	3.1	10.6	36.2
,,	108	6.7	14.7	84.2
,,	109	7.2	15.4	103.1

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	110	6.4	13.6	68.4
,,	111	5.1	12.0	44.0
,,	112	4.0	11.0	38.3
26/10/15	113	4.2	11.3	41.0
,,	114	6.0	13.0	57.2
,,	115	5.8	12.7	48.9
,,	116	4.4	11.6	43.2
,,	117	4.8	11.8	39.0
,,	118	3.9	10.2	24.8
,,	119	3.6	8.9	19.0
,,	120	5.3	12.0	46.1
,,	121	4.4	11.5	40.0
,,	122	7.0	14.3	72.5
,,	123	5.5	12.5	48.5
26/10/15	124	7.3	16.5	105.0
,,	125	6.6	13.5	50.1
,,	126	7.0	14.5	63.0
,,	127	6.8	14.4	60.0
,,	128	5.3	12.4	49.0
,,	129	5.6	12.5	49.5
,,	130	7.2	15.5	88.0
,,	131	6.7	14.4	60.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	132	4.1	11.3	30.1
,,	133	5.6	12.5	40.0
,,	134	6.3	13.3	43.2
,,	135	3.6	10.7	25.0
,,	136	6.4	13.2	50.1
,,	137	6.5	13.5	55.4
,,	138	3.2	10.5	24.5
,,	139	4.3	11.0	27.5
,,	140	6.1	13.0	49.5
,,	141	6.7	14.2	60.0
,,	142	5.3	12.5	37.0
,,	143	4.3	11.1	30.0
,,	144	4.3	11.3	32.1
,,	145	3.9	10.0	25.0
,,	146	4.6	11.7	46.2
,,	147	4.1	11.2	30.2
,,	148	5.2	12.5	42.5
,,	149	7.8	17.8	115.0
,,	150	4.2	11.0	34.5
,,	151	4.3	11.3	31.0
,,	152	6.4	13.1	52.5
,,	153	5.2	12.2	37.4

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	154	4.4	11.4	26.0
,,	155	5.4	12.3	48.5
,,	156	3.6	10.6	24.5
23/11/15	157	5.2	12.0	37.5
,,	158	4.5	11.0	26.9
,,	159	5.2	12.0	32.0
,,	160	5.8	12.9	45.0
,,	161	6.2	14.2	55.0
,,	162	4.5	11.4	25.0
,,	163	4.1	11.4	25.2
,,	164	3.8	10.5	20.5
,,	165	5.7	12.8	39.5
,,	166	6.5	13.3	42.4
,,	167	6.8	14.7	74.5
,,	168	3.6	10.7	25.0
23/11/15	169	5.6	12.8	42.5
,,	170	5.3	12.0	33.0
,,	171	3.7	10.5	20.0
,,	172	6.6	13.8	57.5
,,	173	6.3	13.0	48.5
,,	174	3.1	9.9	20.0
,,	175	5.2	12.2	44.4

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	176	6.6	13.2	58.0
,,	177	3.0	10.8	38.6
,,	178	4.2	10.7	37.8
,,	179	5.5	12.5	39.8
,,	180	5.3	12.3	41.3
,,	181	3.8	10.2	23.4
,,	182	3.9	10.4	24.3
,,	183	4.2	11.2	32.5
,,	184	4.1	11.1	34.0
,,	185	5.4	12.0	37.4
,,	186	7.1	15.3	67.2
,,	187	6.3	13.0	56.0
,,	188	3.9	9.9	19.5
,,	189	5.8	11.8	32.8
,,	190	5.2	11.0	34.2
,,	191	5.3	11.2	35.1
,,	192	5.3	11.4	34.5
,,	193	4.2	11.0	32.6
,,	194	6.7	13.7	59.0
,,	195	7.2	16.6	81.2
,,	196	6.6	13.5	72.5
,,	197	5.4	12.4	45.6

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	198	4.1	11.2	38.9
,,	199	5.4	12.0	36.0
,,	200	6.1	13.0	47.2
,,	201	5.2	11.2	35.4
,,	202	4.5	11.6	36.2
,,	203	3.1	10.8	22.5
,,	204	3.7	8.9	18.6
,,	205	5.1	11.1	31.0
,,	206	5.2	11.3	32.0
,,	207	5.5	12.1	37.5
,,	208	7.8	15.5	73.2
,,	209	5.2	12.0	40.0
,,	210	5.3	12.3	41.3
,,	211	4.2	11.0	31.2
,,	212	4.3	11.3	33.4
,,	213	5.2	12.2	35.0
,,	214	6.3	13.1	42.5
,,	215	5.1	11.2	38.0
24/11/15	216	3.8	10.9	24.5
,,	217	5.3	11.1	29.8
,,	218	6.6	13.6	58.5
,,	219	6.9	14.8	70.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	220	7.3	17.8	123.5
,,	221	5.2	11.1	34.1
,,	222	7.1	16.5	67.5
,,	223	5.1	11.0	28.0
,,	224	5.6	11.7	45.3
,,	225	5.5	12.5	52.4
,,	226	5.4	11.4	36.5
,,	227	5.3	11.1	33.0
,,	228	5.0	10.8	20.1
,,	229	5.2	11.0	34.5
,,	230	6.6	13.3	56.3
,,	231	5.5	12.6	48.1
,,	232	7.0	15.5	60.0
,,	233	6.6	13.6	55.0
,,	234	3.9	10.0	22.5
,,	235	3.1	10.1	19.5
,,	236	6.2	13.2	58.9
,,	237	5.2	11.0	36.4
,,	238	5.2	11.0	36.0
,,	239	5.4	11.2	37.2
,,	240	6.2	13.2	56.5
,,	241	5.4	11.5	36.4

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	242	4.6	11.8	36.7
,,	243	5.5	12.5	45.2
,,	244	5.2	12.1	40.0
,,	245	4.3	10.6	20.0
,,	246	3.5	10.0	18.0
,,	247	4.1	11.0	32.5
,,	248	4.3	11.4	38.5
,,	249	5.4	12.2	43.2
,,	250	6.3	13.4	54.0

Sampling Station: KAKUZU - NAMWALA

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
29/09/15	1	5.2	12.1	44.1
,,	2	5.3	12.4	42.3
,,	3	6.8	15.1	75.0
,,	4	5.1	11.0	38.1
,,	5	4.0	10.1	25.5
,,	6	7.2	15.6	87.2
,,	7	4.3	10.6	28.0
,,	8	6.7	14.8	63.5
,,	9	6.2	13.1	47.0
,,	10	5.3	12.2	39.2
,,	11	6.4	13.1	49.0
,,	12	4.7	11.5	33.7
,,	13	6.9	15.0	73.1
,,	14	3.9	10.3	20.0
,,	15	3.8	10.3	25.8
,,	16	3.7	9.8	20.1
,,	17	5.3	12.4	42.1
,,	18	6.2	13.2	50.0
,,	19	3.9	10.0	30.0
,,	20	4.8	11.8	41.0
,,	21	4.9	11.9	38.2

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	22	5.4	12.5	40.0
,,	23	5.3	12.3	39.5
,,	24	5.3	12.4	38.1
,,	25	6.2	13.2	47.0
,,	26	4.5	11.0	29.5
,,	27	4.1	10.8	25.0
,,	28	5.2	12.1	35.0
,,	29	4.6	11.7	37.1
,,	30	4.7	11.8	38.1
,,	31	4.4	11.3	37.2
,,	32	4.0	10.2	25.3
,,	33	6.3	13.0	50.0
,,	34	3.7	9.9	18.0
29/09/15	35	5.3	12.0	36.7
,,	36	6.6	13.5	55.1
,,	37	7.7	16.1	71.4
,,	38	5.3	12.2	56.0
,,	39	5.7	12.8	58.2
,,	40	5.4	12.4	49.8
,,	41	5.1	12.2	45.0
,,	42	7.8	16.7	77.2
,,	43	5.1	12.3	44.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	44	4.2	11.0	38.0
,,	45	4.3	11.2	41.1
,,	46	5.4	12.3	39.0
,,	47	6.4	13.3	63.1
,,	48	3.9	10.0	23.4
,,	49	3.8	9.7	18.6
,,	50	3.9	10.2	22.5
,,	51	4.0	11.0	37.2
,,	52	5.4	12.1	42.1
,,	53	8.4	17.1	72.5
,,	54	5.3	12.6	43.2
,,	55	5.2	11.8	39.1
,,	56	4.4	11.1	38.0
,,	57	4.5	11.6	45.5
,,	58	6.2	13.0	52.1
,,	59	3.7	9.6	19.3
,,	60	6.6	13.4	58.9
,,	61	4.2	11.4	39.4
,,	62	6.1	13.0	47.3
,,	63	5.4	12.3	46.5
,,	64	5.0	11.2	42.1
,,	65	5.3	12.4	46.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	65	5.0	11.3	41.6
,,	66	4.2	10.1	29.8
,,	67	3.8	9.6	17.9
,,	68	5.2	12.1	36.2
,,	69	6.2	13.2	48.1
,,	70	6.6	13.8	52.4
,,	71	5.3	12.3	56.4
,,	72	5.0	11.6	47.0
30/09/15	73	6.5	13.4	75.7
,,	74	5.0	11.8	43.4
,,	75	6.5	14.7	95.2
,,	77	6.1	13.2	64.3
,,	78	4.7	11.3	38.8
,,	79	5.2	12.1	39.0
,,	80	5.7	12.8	43.8
,,	81	5.3	11.9	37.9
,,	82	5.4	12.3	41.0
,,	83	4.6	11.5	35.0
,,	84	7.2	15.3	72.1
,,	85	6.6	13.4	86.2
,,	86	3.9	10.2	33.1
,,	87	5.1	11.0	36.4

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	88	5.2	11.3	39.0
,,	89	5.0	10.9	37.5
,,	90	5.9	12.7	58.0
,,	91	5.4	12.2	54.0
,,	92	4.3	11.1	52.2
,,	93	3.9	10.7	38.0
,,	94	6.1	13.2	62.8
30/11/15	95	4.2	11.0	42.1
,,	96	4.5	11.6	47.2
,,	97	5.2	12.1	46.3
,,	98	5.0	11.8	43.0
,,	99	4.1	11.4	39.8
,,	100	3.2	14.8	87.9
,,	101	6.6	13.7	68.5
,,	102	5.3	12.0	43.5
,,	103	4.1	11.0	41.0
,,	104	6.0	13.0	54.6
,,	105	5.1	12.1	38.2
,,	106	5.2	12.4	42.0
,,	107	5.4	12.6	52.2
,,	108	6.5	14.8	76.4
,,	109	3.8	9.7	18.5

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
27/10/15	110	4.0	10.2	23.5
,,	111	4.5	11.2	43.0
,,	112	4.5	11.3	40.4
,,	113	6.8	13.5	75.6
,,	114	6.2	13.2	69.5
,,	115	5.3	12.2	56.0
,,	116	5.0	12.1	41.0
,,	117	3.7	10.0	30.2
,,	118	7.3	15.0	63.2
,,	119	7.1	15.2	68.5
,,	120	5.2	12.1	53.3
,,	121	3.7	10.0	29.5
,,	122	4.1	11.1	43.0
,,	123	5.2	12.2	54.3
,,	124	4.7	11.8	48.5
,,	125	6.2	13.0	61.0
,,	126	4.0	10.9	39.5
,,	127	4.1	11.2	33.2
,,	128	6.2	13.1	68.4
,,	129	7.0	15.0	84.2
,,	130	3.9	10.9	36.5
,,	131	4.2	11.2	41.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	132	5.2	12.0	43.2
,,	133	3.9	10.2	29.5
,,	134	4.1	11.1	32.0
,,	135	3.8	10.2	35.5
,,	136	6.1	13.2	56.3
,,	137	4.3	11.5	42.2
,,	138	4.2	11.0	43.5
,,	139	5.6	12.8	50.1
,,	140	7.2	15.5	64.4
,,	141	4.2	11.4	40.0
,,	142	4.0	10.9	36.9
28/10/15	143	5.5	12.6	45.3
,,	144	5.7	12.6	46.0
,,	145	5.0	11.9	38.5
,,	146	4.1	11.2	35.8
,,	147	3.9	10.8	36.7
,,	148	3.6	9.8	20.9
,,	149	5.1	12.1	41.0
,,	150	5.4	12.4	43.5
,,	151	4.0	11.0	43.4
,,	152	3.7	9.7	24.2
,,	153	4.7	11.8	35.4

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	154	4.0	11.1	34.9
,,	155	5.5	12.8	47.5
,,	156	6.8	14.6	79.0
,,	157	4.1	11.1	53.3
,,	158	7.0	15.1	65.4
,,	159	5.3	12.1	46.5
,,	160	6.8	13.9	46.2
,,	161	3.7	10.0	30.0
,,	162	4.2	11.0	38.9
,,	163	5.1	12.1	49.7
,,	164	4.2	11.3	52.0
,,	165	4.0	11.2	47.4
,,	166	4.0	11.1	45.5
,,	167	4.1	11.2	47.9
,,	168	5.3	12.2	48.9
,,	169	4.0	11.1	46.0
,,	170	4.2	11.2	47.6
,,	171	5.4	12.2	56.3
,,	172	6.9	13.8	81.0
,,	173	4.5	11.4	47.3
,,	174	4.1	11.3	41.8
,,	175	5.3	12.5	58.8

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	176	3.8	10.4	39.8
,,	177	3.6	9.6	35.0
28/10/15	178	4.7	11.9	40.0
,,	179	6.1	13.2	68.4
,,	180	4.5	11.7	46.5
,,	181	6.8	14.8	54.5
,,	182	5.1	12.2	45.0
,,	183	6.5	13.4	52.5
,,	184	4.0	11.0	48.4
,,	185	5.0	12.2	51.0
,,	186	5.3	12.1	52.1
,,	187	5.0	11.8	46.7
,,	188	5.4	12.5	54.2
,,	189	5.2	12.2	50.0
,,	190	5.0	11.0	48.0
,,	191	3.7	9.8	32.5
,,	192	7.6	16.1	55.3
,,	193	6.9	15.7	56.4
,,	194	6.7	13.5	49.4
,,	195	5.3	12.4	58.2
,,	196	4.2	11.6	51.4
,,	197	5.0	12.0	53.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	198	6.5	13.3	67.5
,,	199	5.4	11.8	48.9
,,	200	4.0	11.5	41.3
,,	201	5.3	12.0	44.5
,,	202	4.2	11.5	48.6
,,	203	4.1	11.3	46.5
,,	204	5.2	12.3	54.3
,,	205	5.1	12.0	43.5
,,	206	4.5	11.6	39.9
,,	207	6.1	13.2	52.1
,,	208	4.3	11.6	41.2
,,	209	3.5	8.9	17.5
,,	210	4.1	11.4	41.0
,,	211	4.2	11.1	39.0
,,	212	5.5	12.4	42.2
,,	213	6.2	13.0	53.4
25/11/15	214	4.0	11.0	39.7
,,	215	4.1	11.3	41.1
,,	216	3.7	10.0	32.0
,,	217	5.3	12.2	38.9
,,	218	4.2	11.4	37.6
,,	219	4.1	11.1	34.8

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	220	4.0	11.0	35.4
,,	221	3.8	9.7	18.0
,,	222	5.5	12.6	47.3
,,	223	5.5	12.4	52.0
,,	224	7.0	15.8	57.5
,,	225	6.8	14.9	49.5
,,	226	5.2	12.0	46.0
,,	227	3.8	10.8	29.2
,,	228	5.4	12.7	67.8
,,	229	4.3	11.5	43.5
,,	230	4.1	11.2	38.7
,,	231	5.4	12.3	42.2
,,	232	4.2	11.2	37.9
,,	233	7.1	16.4	59.5
,,	234	6.9	14.5	55.8
,,	235	5.5	12.7	56.0
,,	236	5.3	12.2	42.1
,,	237	5.0	12.0	38.7
26/11/15	238	4.3	11.1	39.6
,,	239	5.2	12.3	41.2
,,	240	5.5	12.4	44.3
,,	241	5.8	12.6	42.0

Date	S/N	Carapace Length (cm)	Total Length (cm)	Body Weight (g)
,,	242	5.1	12.0	38.9
,,	243	6.6	13.4	49.6
,,	244	6.9	14.6	57.5
,,	245	5.1	12.2	53.2
,,	246	3.8	10.0	30.0
,,	247	5.2	12.4	32.1
,,	248	5.3	12.5	37.4
,,	249	6.2	13.0	45.5
,,	250	5.8	12.6	43.6

Appendix II

Von Bertalanffy Growth Equation of 1936 Values

STATION	YEAR 0	YEAR 1	YEAR 2	YEAR 3
Kafue Road Bridge	0	15.7826	17.6413	17.8617
Namalyo – (Monze)	0	15.6571	18.2328	18.6566
Kakuzu – (Kakuzu)	0	15.5252	17.0856	17.2425

Appendix III

(a) Length frequencies of the red claw crayfish sample collected in September, 2015 from all the three sampling stations

Total Length (cm)	*Sample Frequency*
7.9	1
8.48	0
9.05	0
9.63	5
10.2	16
10.78	18
11.35	35
11.93	34
12.5	63
13.08	28
13.65	25
14.23	10
14.8	8
15.38	6
15.95	4
16.53	2
More	2

(b) Length frequencies of the red claw crayfish sample collected in October, 2015 from all the three sampling stations

Total Length (cm)	*Sample Frequency*
8.9	3
9.49	1
10.09	9
10.68	18
11.27	50
11.87	28
12.46	38
13.05	38
13.65	23
14.24	9
14.83	10
15.43	10
16.02	3
16.61	1
17.21	0
More	1

(c) Length frequencies of the red claw crayfish sample collected in November, 2015 from all the three sampling stations

Total Length (cm)	*Sample Frequency*
8.9	2
9.59	0
10.27	19
10.96	17
11.65	58
12.33	48
13.02	47
13.71	33
14.39	6
15.08	7
15.77	5
16.45	3
17.14	3
17.83	1
18.51	0
More	2

(d) Length frequencies of the overall red claw crayfish sample collected in the months of September, October and November, 2015 from all the three sampling stations

Total Length (cm)	*Sample Frequency*
7.9	1
8.27	0
8.63	0
9	4
9.37	0
9.73	11
10.1	24
10.47	29
10.83	43
11.2	87
11.57	60
11.93	54
12.3	102
12.67	81
13.03	66
13.4	70
13.77	19
14.13	17
14.5	20
14.87	14
15.23	15
15.6	17
15.97	3
16.33	4
16.7	4
17.07	3
17.43	0
More	2