Growth Response of Pink Shrimp *Penaeus notialis* (Perez Far Fante) to Protein enhanced Diets

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By

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DECLARATION

I hereby declare that this thesis is entirely the result of research work undertaken under supervision in the Department of Oceanography and Fisheries, University of Ghana. It has not been submitted neither wholly nor partly to any other University for a degree. All forms of assistance received while working on this thesis were duly acknowledged.

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DEDICATION

To my family.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PAGE

LIST OF PLATES

APPENDICES

ABSTRACT

Artificial feeds of different protein levels (20%, 30% and 40%) were formulated and prepared using locally available Agro Industrial By-Products (AIBPs) such as wheat bran, soybean meal, groundnut cake, fish meal, premix and cassava starch. Prepared feeds were fed to three populations of *Penaeus notialis* Post Larval Shrimps (PLs) under semi-intensive pond conditions for a 24 week culture period.

PLs were fed a daily ration administered six hourly at the rate of 10%, 8%, 6%, 4%, and 2%, biomass/body weight. These rates were changed monthly in that order. There was regular water exchange and environmental monitoring.

At the end of the culture period of 24 weeks the final average body weights gained under the three different feed types, were: 12.72 g, 7.697 g and 6.982 g respectively for the 20%, 30% and 40% treatment. The respective growth rates were 12.7 g, 7.7 g and 7.0 g for the 24 week growth period.

Analysis of variance using F-test showed that only 20% crude-protein feed gave a significantly different result at the 95% confidence level.

With this growth rate of 12.7 g/24 week culture period and also with a recorded survival rate of 49%, two culture cycles could be undertaken in a year. For two croppings, a projected yield estimated at 1.29 mt/ha/yr could be obtained.

CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

Shrimps are marine organisms belonging to Sub-kingdom Arthropoda, Class Crustacea, Order Decapoda, Suborder Natantia, Family Penaeidea and Genus Penaeus (Arrignon et al., 1994; Malaysia Technical Corporation Programme, 1990); sizes range from a few millimetres to about 35 centimetres long (Fischer et al.,1981) Nearly 2,500 species have been described but only 300 species are of economic interest. This is mainly on account of their meat, which serves as food for both humans and animals. Of the 300 species of economic interest, 33% of them comprise the most world shrimp catches (Fischer et al., 1981; Bardach et al., 1972).

Generally, shrimps are widely distributed and appear to be cosmopolitan ranging from the equator to the polar regions. Though largely marine, they are also found in brackish and fresh water bodies (Fischer et al., 1981) and occupy a variety of habitats including sandy and muddy bottoms, peats and even the coral reefs at depths ranging from 100 m to 5,700 m. Depths less than 100 m along the continental shelves are areas where most of the commercial species are caught (Dore and Frimodt, 1987; Fischer et al., 1981, Bardach et al., 1972).

Shrimps are active at night feeding on small benthic organisms such as molluscs, polychaetes and echinoderms. They are also known to be sexually active at night (Fischer et al., 1981). Mature male and female mate at night after the female had molted. Fertilisation takes place internally and eggs are spawned between 2200-0200 GMT.

The maximum number of eggs laid at a time is conservatively estimated at 500,000 and 800,000 for *P. notialis* and *P. monodon* respectively (Fischer et al., 1981). Spawned fertilised eggs hatch within 24 hours into larvae which develop into juvenile, sub-adult and adult. The larval stage could also be divided into nauplius, protozoea, zoea, mysis and post larval stages. The juveniles require six months in brackish water to develop into adult (Fischer et al., 1981).

Indigenous penaeid shrimp species occurring in the Atlantic ocean of Africa include *Penaeus kerathurus, P. notialis, Parapenaeus longisrostris and Parapeneopsis atlantica.* In West Africa, particularly Ghana, the most important commercial species are *P. notialis and P. kerathurus.* The former is the most abundant. Female adult of *P. notialis* may grow to a maximum total length (TL) of 23.0 cm while the male may reach a maximum total length (TL) of 17.0 cm (Fischer et al., 1981). *P. notialis* actively feed at night on small benthic organisms such as molluscs, polychaetes, crustaceans and echinoderms. *P. notialis* is commonly fished along the coast of Senegal, Guinea, Sierra Leone, Liberia, La Cote d'Ivoire, Ghana, Nigeria, and Gabon (Fischer et al., 1981)

The total world shrimp production of 3.3 million mt for the year 1996 comprised 2.2 million mt and 1.1 million mt from capture and culture sources respectively (Rosenberry, 1999; FAO, 1998). However, from 1991-1999 shrimp production levels from capture fishery, in terms of landed volume, have been observed to be decreasing. Individual sizes have also been noticed to be reducing systematically.

Based on these observations, analysts have concluded that the stocks have not only reached their maximum sustainable yield but are actually over-exploited (Nauen, 1999; Rosenberry, 1999; Darpaah, 1998; Fast, 1991).

Despite the decline in shrimp supply from capture sources, consumer preference and yearning for foreign exchange, has kept the demand for shrimp high on the world market (Nauen, 1999; Darpaah, 1998; Shang, 1986). The situation thus underscores the need to develop shrimp culture to step up production from this source with the aim of bridging the gap between demand and supply.

Currently, in Africa, the continent's shrimp industry relies mostly on shrimp caught in the wild. The produce is landed mainly by shrimpers. Other trawlers and artisanal fishermen also land shrimp as by-catch. However, the level of production is so low that it does not make any mark on the world market. Production levels for West Africa; Ghana, La Cote d'Ivoire and Nigeria are usually very low making insignificant contribution to the total catch. In Ghana, for example, between 1992-1996 shrimp/prawns contributed 3.97% out of the 37.45% contribution made by fish and fish products to the non-traditional export earnings.

The performance of the shrimp industry between 1986-1996 is illustrated in Fig. 1.1

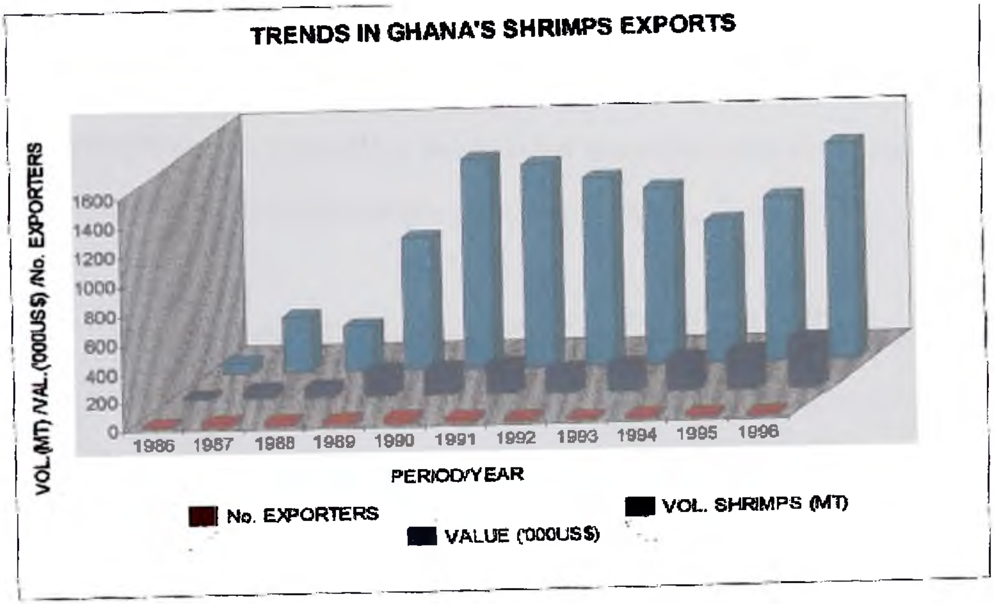


Fig. 1.1 Trends in Ghana's Shrimp Exports, Revenue & Number of Exporters

Source: Darpaah, 1998

In 1998 Ghana exported only 55.75 mt of shrimps. The total value of this exported volume was US$172,409. The price per kg was computed at US$3.09 (Export Promotion Council, 1998).

According to Bardach et al. (1972) shrimp farming dates as far back as 500/600 years in South East Asia where crude farming techniques involved trapping and confinement of young shrimp in brackish water ponds for several months before harvesting. This crude shrimp farming method gave way to a more efficient one when artificial spawning and larval rearing through to market size of *Penaeus japonicus* was successfully undertaken in the laboratory by Motosaku Fujinaga (a graduate student of Tokyo University) in 1934. He later set up a pilot hatchery and farm in 1959. In 1967 the first intensive commercial shrimp farm was established in Japan producing 4,000 mt from 8,500 ha farm. Between late 1960s and early 1990s researchers from France, China and Taiwan began investigating into the potential of shrimp farming on witnessing a decline in fish production levels from commercial fisheries (Shrimp News Brosenberry @ aol.com, 1999).

In Tahiti, South Pacific, French researchers of the Centre Oceanologique Pacifique successfully developed the technique for breeding and raising shrimp species such as *Penaeus japonicus, P. monodon, P. stylirostris and P. vanammei* (Shrimp News Brosenberry @ aol.com, 1999). In China, in the mid-1980s researchers at the Yellow Seas Fishery Research Station discovered ways to grow huge crops of *P. chinensis* in large semi-intensive ponds (Shrimp News Brosenberry @ aol.com, 1999).

In Taiwan researchers at the Tungkang Marine laboratory worked with *P. monodon* and developed a technique for farming shrimp in small intensive ponds (Bardach et al., 1972). Other areas of research work on shrimp species for farming potentials include breeding and spawning techniques, grow-out technologies, nutrition and diseases. In the USA, National Sea Grant College Program funded by Department of Commerce, is noted for backing shrimp farming research at several coastal universities including Texas A & M University and also shrimp virus research at University of Arizona (Shrimp News Brosenberry @ aol.com, 1999).

Currently, scientists in America are working hard to develop specific pathogen free (SPF) shrimp species (Nauen, 1999; Darpaah, 1998). Krishnasamy (1999) noted that in Australia, Thailand and Philippines work had begun on the development of captive broodstocks of *P. monodon* for seed shrimp production since this is the most popular and preferred shrimp species in the Eastern hemisphere.

In India, Ninawe (1999) reported that farmed shrimp production increased from 70,000 mt in 1998 to 100,000 mt in 1999 due to increased expansion of existing farms, increased number of farms, improved culture/management practices and availability of wild seeds. From a research conducted on the impact of shrimp farming on environment, fishery and villagers, Ninawe concluded that the impacts were more positive than negative. Investors, feed millers, researchers and consultants, on realizing the lucrative potentials in shrimp farming ventures carried the shrimp farming technology to Latin America, Honduras, Panama and Ecuador between 1965 – 1975 and teamed up with local entrepreneurs to build farms, hatcheries, feed mills and processing plants. Cumulation of these efforts might be responsible for the increase in the world farmed shrimp production from 660,200 mt in 1997 to 737,200 mt in 1998; a record increase of 12% as recorded by Krishnasamy (1999). Currently notable world farmed shrimp producing countries and their respective production levels are presented in Table 1.1

Table 1.1: World Farmed Shrimp Production – 1998

Country	**Production (mt) (Head on)**
Eastern Hemisphere	
Thailand	210,000
India	70,000
Indonesia	50,000
Philippines	35,000
Malaysia	8,000
Sri Lanka	5,000
Australia	2,200
Others	150,000
Sub total	**530,000**
Western Hemisphere	
Ecuador	130,000
Mexico	17,000
Colombia	12,000
Honduras	12,000
Panama	8,000
Peru	5,000
Belize	4,000
Nicaragua	4,000
Venezuela	3,000
USA	2,000
Others	10,000
Sub-total	**207,000**
Grand total	**737,200**

Source: Rosenberry, 1998
Culled from info fish international 2/99

Countries in which high potentials for shrimp culture have been identified may have to undertake similar development efforts for a fuller realization of the goals and objectives to create job and earn extra income from shrimp exports.

In Africa, research into shrimp farming has not received much attention. However, in West Africa particularly in Ghana scientists, entrepreneurs and organizations have carried out various research work intended for shrimp culture development in the country. According to Dr. Adumoah Bossman, a private aquaculture consultant with MASDAR International Consultants, he had carried out, unsuccessfully, hatchery trials using the larvae of *P. vanammei* as cultured species at Ada in the early 1990s (pers.com). Scientists from Water Research Institute of the Council for Scientific and Industrial Research (CSIR), also, around the same period carried out growth and husbandry trials using the fresh water prawns *Macrobrachium macrobrachion* and *Macrobrachium vollenhovenii* but did not get encouraging results. In Ghana, Darpaah (1998) reported a breakthrough with the culture of *P. notialis* and *P. kerathurus*. He concluded that these two species were culturable with high culture potential under Ghanaian conditions.

Available information seems to suggest that though the culturability of *P. notialis* under Ghanaian condition has been established, more information on their growth with respect to artificially formulated but nutritionally balanced diet is required for a successful farmed shrimp production venture in the country.

Apart from shrimps, prawns, lobsters and crabs also belong to the invertebrate class Crustecea. They are highly exploited world wide for their commercial and economic values. Within this group, penaeid shrimps are the most valuable commercially exploited species (Fischer et al., 1981). The world production figure for crustaceans was estimated at 1.6 million mt (FAO, 1995). Of this figure, 1.0 million mt (63%) represents shrimp landings of which 75% were penaeids (Fig. 1.2)

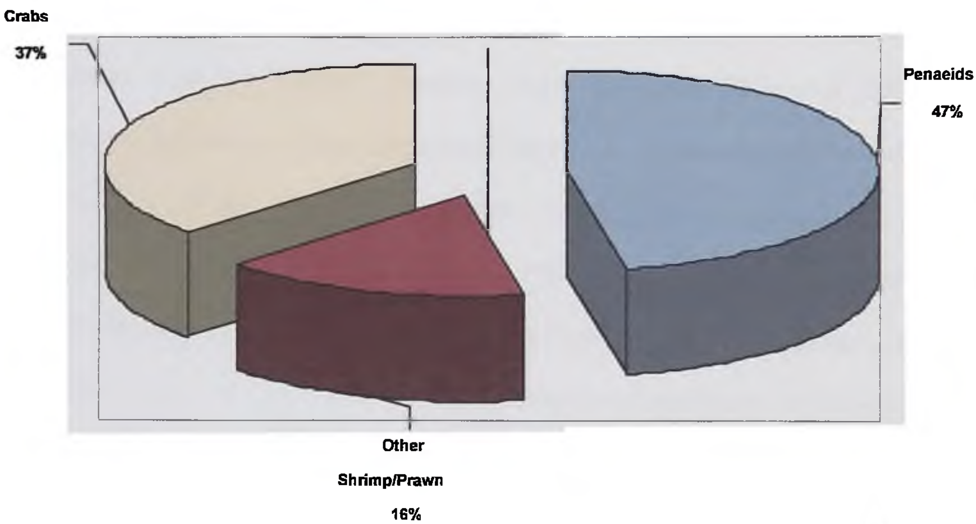


Fig 1.2: World production of crustaceans (1995)

According to Rosenberry (1998) all farm raised shrimp and most of the shrimp caught by fishermen are penaeids. A notable cultured penaeid shrimp species the Giant Tiger Prawn *Penaeus monodon* which forms 50% of the world production (Rosenberry, 1998) is the most preferred and cultured in Eastern hemisphere for its fast growth and high world market price. In the Western hemisphere the most preferred species is *P. vanammei* and forms 25% of the world production.

Other penaeids being cultured include *Penaeus chinesis. P. japonicus and P. indicus.* These species being cultured mainly by the Chinese, Japanese and Indians respectively were all developed from indigenous shrimp species. In Ghana the penaeids are represented by *P. kerathurus* and *P. notialis*.

Penaeids shrimps are considered as commercially important organisms because of the significant roles the shrimp industry plays in the economy of the producing countries such as Thailand, Ecuador, India, Indonesia, Philippines, Mexico, Colombia, Honduras, China, Taiwan and Japan. In these countries, the industry serves as a reliable source of employment, income, foreign exchange and good animals protein. For example based on 1984-5 figures, Tavarutmanakeel and Tookwinas (1995); Humbrey and Kwei Lin (1999) considered Thailand as the world's largest producer of farmed shrimp producing 240,000 mt of shrimp with farm gate values in excess of US$ 1.6 billion from over 20,000 shrimp farms. The industry which is estimated to cover approximately 84,000 ha employ 100,000 people. The industry also supported major processing and input supply industries including hatcheries and feed manufacture.

On both local and international markets penaeid shrimp is one of the highest paid for fisheries resource. In an FAO ranking by volume of the world aquatic species production in 1996, shrimp with production levels well below 0.60 million mt did not make a place in the top ten species. However, in terms of value it was ranked number one with a value of US$ 3.93 million (FAO, 1998).

For this reason most third world countries primarily go into farmed shrimp production for export to the industrialised nations to earn foreign exchange (Shang, 1986).

In Ghana, shrimp catches landed by shrimpers, trawlers and artisanal fishermen are largely sun dried or smoked by women processors. Food processing companies like Ghana Agro Foods Company Ltd (GAFCO), Nestle Ghana Ltd and Unilever Ghana Ltd also process shrimps and market them in different forms like shrimp cubes and shrimp power. The large shrimping companies such as Kiku Ghana Ltd also process and export fresh shrimps; whole and tail to Western European countries like Holland, Italy and France. The small-scale shrimp entrepreneurs also buy fresh shrimps, process them into smoked or sundried whole forms and export them into the neighbouring countries such as Togo, Benin and Burkina Faso.

On the local market one kg of smoked shrimp attracts about ¢40,000.00 ($10.0) whilst the same weight of first class fish like the breams (Sparidae), popularly known as red fish, attracts ¢ 15,000 .00 ($3.75).

Under pond culture conditions, cultured species need to be fed with nutritionally balanced feed to provide needed energy for metabolic activities and growth. In a growth-trial experiment conducted in 1998, Darpaah used the flesh of mangrove oyster (*Ostrea tulipa*) as feed for *Penaeus notialis*. Under semi-intensive culture conditions he obtained an average growth rate of 14/15 g in 32 weeks culture period. He recommended that this growth rate could be enhanced using an artificially formulated but nutritionally balanced diet.

A nutritionally balanced diet is expected to provide cultured species with the right amounts of required food nutrients such as carbohydrates, proteins and lipids (oils and fatty acids) vitamins and mineral salts to enhance health and growth performance (Jobbling, 1994). According to Lovell (1980) marine shrimps and fresh water prawns have nutritional requirements that appear to be similar to that of fin fishes except that besides higher dietary levels of cholesterol which is beneficial to the crustaceans, intestinal synthesis of amino acids appears to be significant in them too.

Diets, in animals generally, are known to vary with development stage, age, sex and seasons. These factors which need to be considered appropriately in formulating feed for cultured species like shrimps might perhaps have supported Hardy's (1980) observation that feed formulation is essentially an applied nutrition. Good knowledge in nutritional requirements of cultured species is therefore an essential tool for feed formulation. Malaysia Technical Cooperation Programme (1990) revealed that for a good penaeid shrimp nutrition the diet must contain the following mineral salts and vitamins (premix) as shown in Table 1.2.

Table 1.2: Composition of Mineral and Vitamin Mixtures for Penaeid Shrimps

Mineral	**mg/kg of dry diet**
Zn	40 mg
Mn	20 mg
Cu	4 mg
Co	0.12 mg
Vitamin	**mg/kg of dry diet**
Thiamine – HCL	120 mg
Riboflavia	40 mg
Pyrodozin – HCL	120 mg
Nicotinic acid	150 mg
Ca-pantothenate	100 mg
Folic acid	5 mg
Biotin	1 mg
Cyanocobalamide	0.02 mg
Inositol	400 mg
Choline chloride	120 mg
Na-Ascorbate	500 mg
Tocopherol	200 mg
Menadiene	40 mg
Vitamin A	5000 I.U
Vitamin D	1000 I.U

Source: Malaysia Technical Cooperation Programme (1990)

Apart from the premix carbohydrates, lipids (oils and fatty acid with poly-unsaturated fatty acids (PUFAs)) and proteins (with all Essential Amino Acids (EAAs) must be provided in the diet so as to promote good health and growth in the cultured species. It is therefore essential that the composition of selected feedstuffs, meant for feed preparation be considered pertinently with the understanding that selected feed materials when put together will play complimentary roles in the provision of PUFAS, EAAs and energy as needed by the culture species.

In the words of Hardy (1980), each selected feedstuff in any diet formulation should be present for a specific reason. It could be a good source of energy, it could be rich in essential amino acids and or poly-unsaturated fatty acids, it could act as an attractant and or binder, it could have laxative properties and or be the least costly alternative for a particular function.

To meet these requirements as much as possible Agro-Industrial By-Products (AIBPs) like wheat bran, soybean meal, groundnut cake, fishmeal and broiler premix (Appendix 1c) were selected and their respective required proportion/quantities carefully calculated.

CHAPTER TWO

2.0 DESCRIPTION OF STUDY AREA

The study site is located on the island of Azizakpe in the Volta delta (Fig. 2.1). It is situated approximately at the intersection of latitude 5^0 33′North of the equator and Longitude 0^0 39′East of the Greenwich Meridian. It is approximately 2.0 km from the mouth of the Volta River. It is also approximately 0.5 km^2 in size. The island's vegetation is made up of mainly mangrove tree stands such as *Rhizophora* and *Avicennia spp* and *Cocos nucifera*. The vegetative undergrowth consists of seedlings of these species and sedges belonging to the family of Graminae. Other commonly found aquatic plants include *Ludwigia sp* and *Typha sp.*

Surrounding this parcel of land are a lot of resource potentials for brackishwater culture facility development. An estimated land surface area of 205,000 ha (Darpaah, 1998; 1991; Rabanal, 1986) located within the Volta delta has been identified as suitable for brackishwater culture purposes. Enormous quantities of good quality seawater and fresh water free of pollutants that could pose environmental problem abound. Within the various habitats of these water bodies live the larval stages of cultivable species like the post larval shrimps (PLs) of *Penaeus notialis* and *P. kerathurus*; crablets of *Callinectes spp*, fingerlings of mullets eg. *Mugil spp*, *Sarotherodon melanotheron*, sea perches eg. *Epinephelus spp* and *Seranus spp*. These could serve as seeds for pond culture purposes be it experimental or commercial. Also found in the area are Agro-Industrial By Products (AIBPs) like thrash fish/shrimp (that could be used as fish meal), coconut chaff, wheat and maize brans which could be turned into feeds for cultured species.

Human activities undertaken by inhabitants of the island include fishing, which is done mainly by the men, fish processing and marketing by the women and generally animal rearing. Animals such as pigs, sheep, goats, ducks and hens are reared on free-range bases. The latter activity (animal rearing) could be pertinently done by housing these animals so that their droppings could be harnessed as an essential material for composting which could in turn be used as manure for pond water fertilization.

At the project site, culture facilities constructed/developed under the pilot/demonstration shrimp project scheme exist. A total land surface area of approximately 3.0 ha had been developed into 18 ponds of varying sizes, water supply and effluent canal systems. The corresponding numbers and sizes of ponds constructed are as follows:

Type of pond	No	Surface area
Nursery ponds	1	0.01 ha
Growth trial ponds	4	0.1 ha
Grow out ponds	3	0.5 ha
Callinectes ponds	2	0.08 ha
Shrimp/mugil poly - culture ponds	8	0.05 ha

Other facilities at the site include one mini-laboratory housing one store, one research laboratory, three concrete tanks to support nursery and grow-out activities including acclimatization of post larval shrimp (PLs) and juveniles. Pond dykes of width 2.5 m, height 1.5 m and side gradients of approximately 1% were enclosed within the pond area by a perimeter dyke of width 3.0 m and height 2.0 m. Outlets were provided as wooden gates fitted at the deeper end of each pond and opened into the effluent canal. Inlets were provided out of 10 cm diameter PVC pipes and open into the water supply canals. Pond bottoms have gradients of approximately 1-2%. Dry feed milling machine to mill locally formulated feed and two pumping machines to facilitate water supply to the farm are also present. The pond layout and distribution of other farm facilities at the project site are shown in Fig. 2.2.

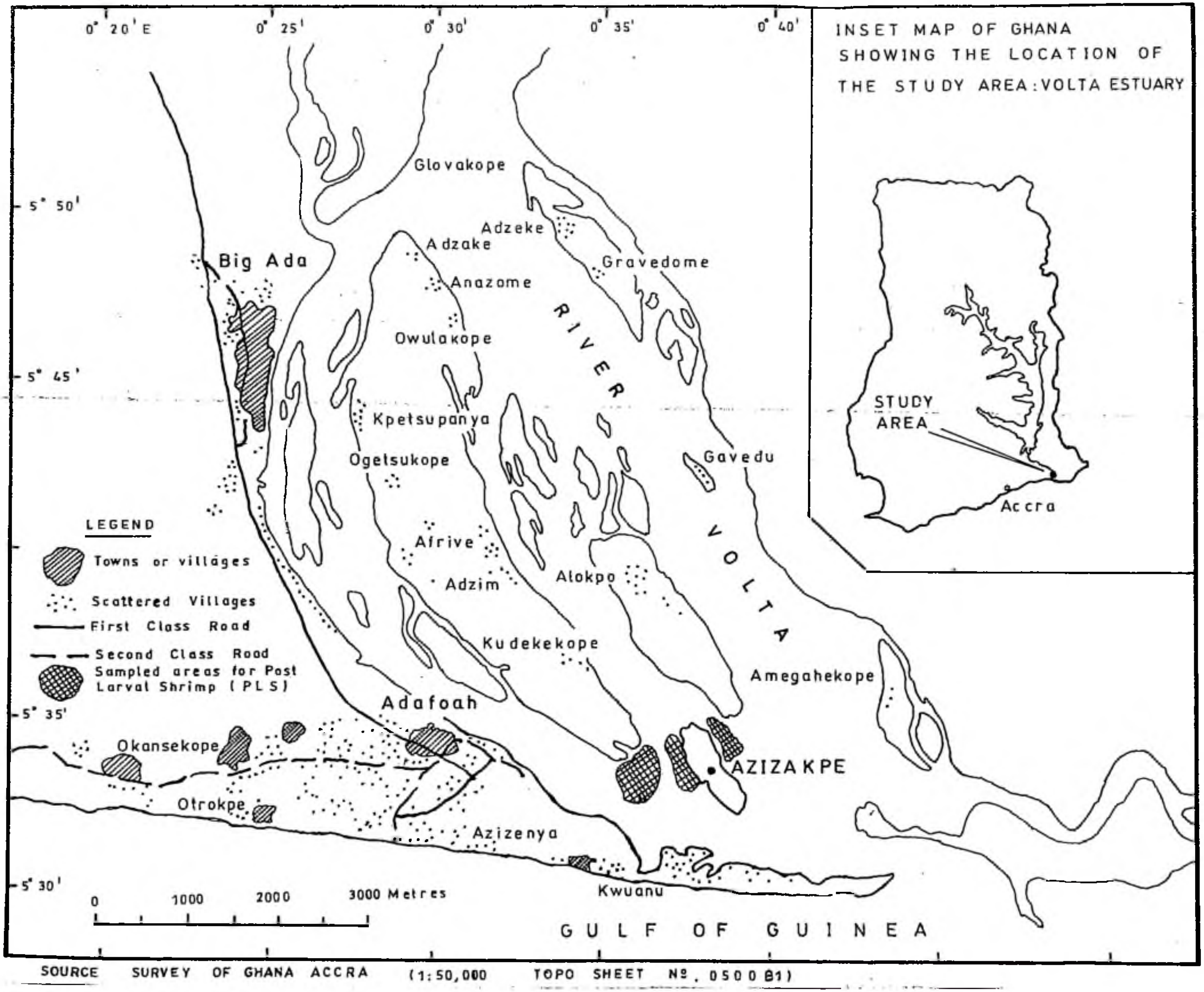


Fig. 2.1 Map of the Volta Estuary showing the project site: Azizakpe

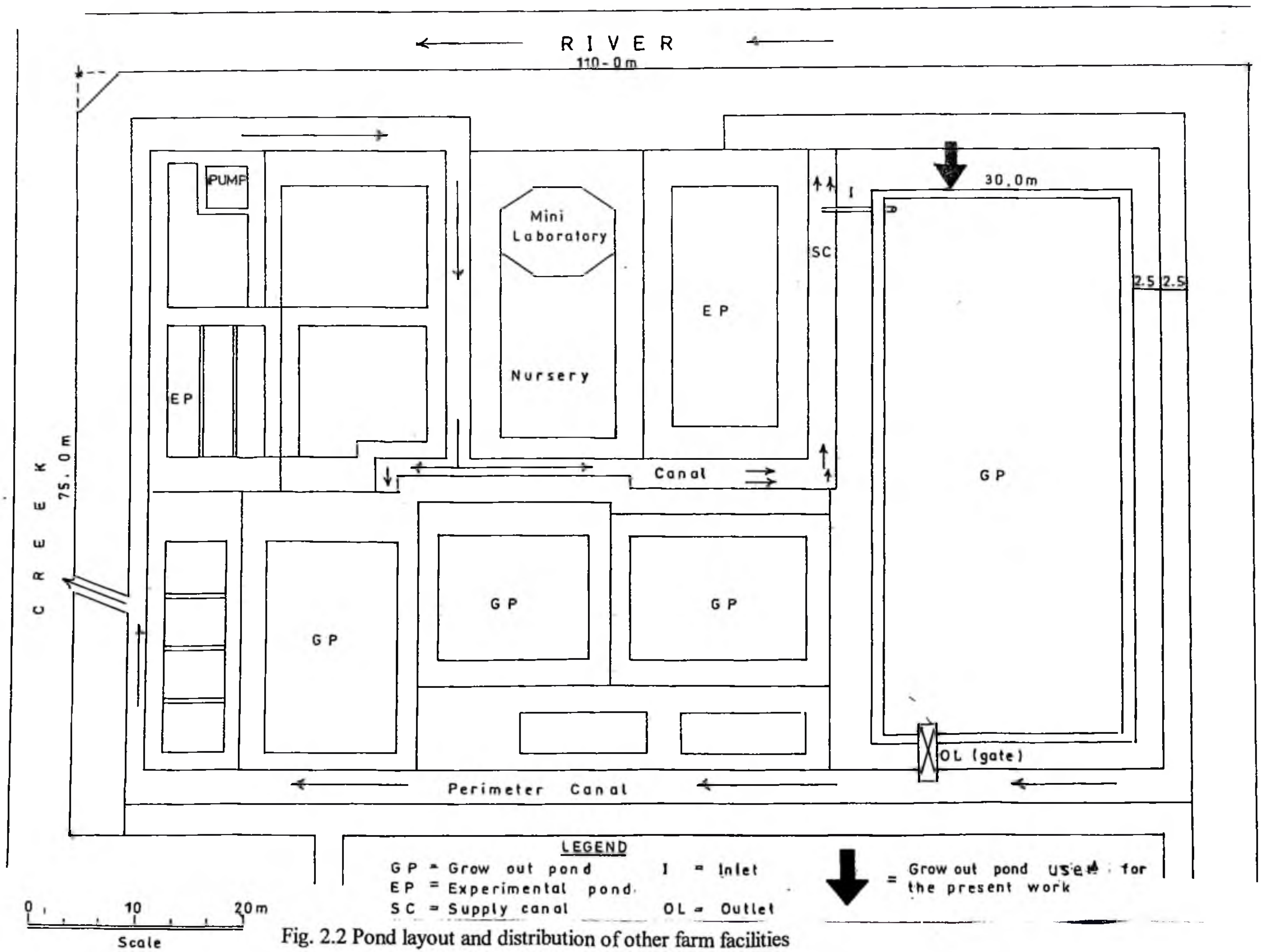


Fig. 2.2 Pond layout and distribution of other farm facilities

CHAPTER THREE

3.0 METHODOLOGY

3.1 Feed Development

3.1.1 Feed formulation

Proximate analysis data sheets (Appendices 1a, 1b, 1c, 1d, 1e) for Agro-Industrial By-Products ((AIBPs) on the Ghanaian market obtained from the Animal Research Institute of the Council for Scientific and Industrial Research (CSIR), Accra; Fateco Ltd., Pokuase and Central Feedmill, Medina were extensively consulted in an attempt to formulate the feed for the shrimps.

From these sheets, protein enhanced AIBPs such as fish meal, groundnut cake, soybean meal and wheat bran were selected as feedstuffs for the preparation of the experimental diet. The high protein content of those feedstuffs was the main criterion used for their selection. Broiler premix (Appendix 1c) was used as the main source of dietary minerals and vitamins in the feed. Cassava starch was used as a binding material.

The computation of the proportion of feedstuffs required in the experimental diet formulation was done using the "SQUARE METHOD" (MTCP,1990; Hardy, 1980). The square method is a series of steps for determining the proper dietary proportion of high and low protein feedstuffs to be added to a feed to meet the dietary requirements of the cultured species (Hardy, 1980).

To use the square method a small square ($2cm^2$) is constructed. The basal feedstuff (high carbohydrate base) and the protein supplement (high protein base) are put on the two left corners along with their respective protein contents. Where more than one feedstuff constitute both the basal feedstuff and the protein supplement, the average protein content of all constituents under basal feedstuff and under protein supplement separately must be calculated and used in the computation for the proportion of all the feedstuffs. The required protein level of the feed being prepared is then placed at the middle of the square. The required protein level of the feed is subtracted from those of the feedstuffs placing the positive value of the results in the opposite corners of the square as illustrated in Fig. 3.1. The feedstuffs and their respective protein levels for the present work are presented in Table 3.1. The quantities of the broiler premix used was based on the manufacturer's recommended rate of 2.5 kg per tonne of dry feed. The cassava starch on the local market was applied as feed binder at a rate of 1.0 kg per 20 kg of feed being prepared.

Table 3.1 Selected feedstuffs and their respective protein contents

Feedstuff types	Feedstuffs	% Protein level	Mean protein level
Basal feedstuff (high carbohydrate base)	Wheat bran	16.76	16.76
Protein supplement (high protein base)	Fish meal	61.5	49.96
	Soybean meal	44.6	
	Groundnut cake	43.8	

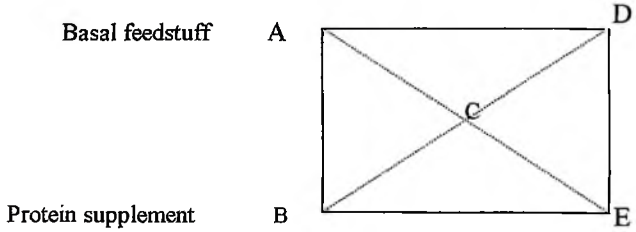


Fig. 3.1 The Square Method
Mathematical relationship and computations

A represents crude protein level of the basal feedstuff

B represents crude protein level of the protein supplement

C represents required crude protein level of the feed being prepared

D represents the positive (+ve) value of the difference between B and C (D= B-C)

E represents the positive (+ve) value of the difference between A and C (E= A-C)

If F and G represent the required proportions of basal feedstuff and protein supplement respectively needed for the diet/feed being prepared then the mathematical relation leading to the computation of F and G is given by

$F = D \div (D+E) \times 100$ and $G = E \div (D+E) \times 100$

This computation was used to obtain the required proportions of both basal feedstuff and protein supplement needed for the preparation of 20%, 30% and 40% crude protein diets as shown in Figures 3.1.1, 3.1.2 and 3.1.3 respectively.

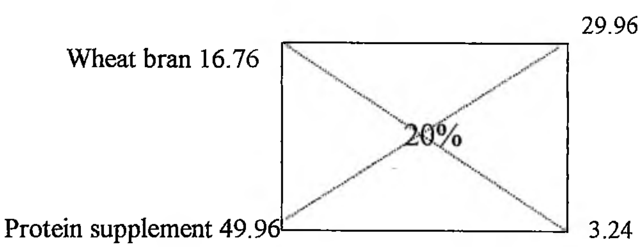


Fig. 3.1.1 Mathematical relationship for 20% crude protein diet

To prepare 20% crude protein diet, 90.24% (29.96 ÷ 33.2 x 100) of wheat bran and 9.76% (3.24 ÷ 33.2 x 100) of protein supplement was required. For each protein supplement constituent – fishmeal, soybean meal and groundnut cake 3.25% (9.76 ÷3) each was required in the diet. Thus to prepare one kilo of 20% crude protein diet, one required 902.4 g (90.24% x 1000 g) of wheat bran, 32.5 g (3.25% x 1000 g) each of fishmeal, soybean meal and groundnut cake to be mixed, milled and blended.

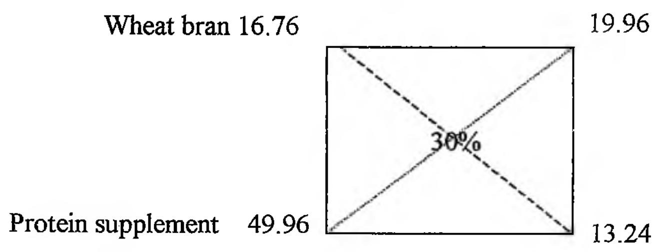


Fig. 3.1.2 Mathematical relationship for 30% crude protein diet

To prepare 30% crude protein diet, 60.12% (19.96÷33.20x100) of wheat bran and 39.88% (13.24÷33.20x100) of protein supplement made up of 13.29% (39.88÷3) each of fish meal, soybean meal and groundnut cake was required. Thus to prepare one kilo of 30% crude protein diet one required 601.20 g of wheat bran, 132.9 g each of fish meal, soybean meal and groundnut cake to be mixed, milled and blended.

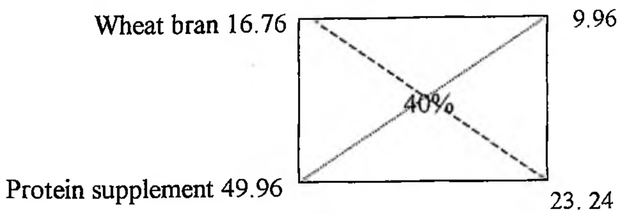


Fig. 3.1.3 Mathematical relationship for 40% crude protein diet

To prepare 40% crude protein diet, 30% (9.96÷33.20x100) of wheat bran and 70% (23.24÷33.20x100) of protein supplement made up of 23.33% (70%÷3) each of fish meal, soybean meal and groundnut cake were required. Thus to prepare one kilo of 40% crude protein diet one required 300 g of wheat bran, 233.3 g each of fish meal, soybean meal and groundnut cake to be mixed, milled and blended.

Table 3.2 Experimental Diet Composition

Based on the "square method" & premix recommended rate

Feed type (% Crude Protein)	Feed stuffs	Proportions (%)	Wt/g for 1 kg feed	Wt/kg for 20 kg feed
20	Soya bean meal	3. 25	32.53	0.65
	groundnut cake	3.25	32.53	0.65
	Fish meal	3.25	32.53	0.65
	Wheat bran	90.24	902.40	18.10
	Premix	0.25	2.50	0.05
	Binder	5.0	50.0	1.00
30	Soya bean meal	13.29	132.93	2.66
	Groundnut cake	13.29	132.93	2.66
	Fish meal	13.29	132.93	2.66
	Wheat bran	60.12	601.20	12.02
	Premix	0.25	2.50	0.05
	Binder	5.0	50.0	1.00
40	Soya bean meal	23.33	233.30	4.60
	Groundnut cake	23.33	233.30	4.60
	Fish meal	23.33	233.30	4.60
	Wheat bran	30.0	300.00	6.00
	Premix	0.25	2.50	0.05
	Binder	5.0	50.0	1.00

3.1.2 Feed preparation

The required quantities of the selected feedstuffs, premix as obtained from the square method for the three experimental diets were separately weighed (Plate 3.1) to the nearest gram. Weighed feedstuffs were manually mixed (Plate 3.2) and milled (Plate 3.3) into a fine and homogenous mixture. Feed binder was then prepared by boiling the colloidal suspension of 1.0 kg of dry cassava starch (Plate 3.4). The volume of this boiled stuff was made up to 10 litres with water. This quantity was enough to bind 20 kg of feed mash. Feed mash was prepared by adding the binder (Plate 3.5) in small quantities, at a time to the dry milled feed mixture accompanied by consistent stirring (Plate 3.6) to form a mash of uniform consistency that could just form a firm ball (Plate 3.7) on squeezing in the palm. In this state the mash is considered ready for pelleting. Pelleting was carried out by feeding the mash into an electric powered pelletizer which extruded the wet feed out through its die as 3.0 mm diameter pellets (Plate 3.8) of variable lengths. The wet feed pellets were then transferred and spread unto polythene sheets (Plate 3.9) and left exposed to sunlight for between 2-3 days to evaporate water associated with it. Depending on the intensity of insolation, water content could be brought down to about 5% within this period. The dried feeds were then bagged (Plate 3.10) in dry polythene sack with water proof lining and stored in a cool place. The feed preparation was done at the Aquaculture Demonstration Centre of the Fisheries Directorate (MOFA) at Ashaiman.

3.1.3 Proximate analysis of feeds

Samples of the dried experimental feeds (Plate 3.11) were sent to Animal Research Institute (CSIR) for proximate analysis.

Plate 3.1 Weighing of feedstuff

Plate 3.2 Manual mixing of feedstuffs

Plate 3.3 Milling of feedstuffs

Plate 3.4 Preparation of feed binder

Plate 3.5 Adding binder to milled feedstuff

Plate 3.6 Manual blending of feed-stuffs, premix and binder

Plate 3.7 Feed mash formed into balls

Plate 3.8 Feed pelleting

Plate 3.9 Drying of feed pellets

Plate 3.10 Bagged feed

Plate 3.11 Samples of dry feeds

3.2 Construction of Experimental Ponds

The grow-out pond arrowed in Fig. 2.2 and Plate 3.12 was built during the pilot shrimp culture development project. It is rectangular with its dyke length and breadth being approximately 60.0 m and 30.0 m respectively, thus creating a water surface area of approximately 0.18 ha.

The slope of its bottom was approximately 0.8% thus creating a shallower and deeper ends with depths of about 1.0 m and 1.5 m respectively.

The inlet (I) as shown in Fig. 2.2 for the pond was constructed out of a cut Poly Vinyl Chloride (PVC) pipe of 10 cm and 3.0 m long. This was fitted into the dyke at the shallower end with both of its two ends jutting out into the supply canal (SC) and the pond (GP) by about 0.5 m. It was fitted at a height of approximately 0.8 m above the pond bottom. The outlet (OL) (Fig. 2.2) which is a sluice gate was constructed out of wooden material. It measures approximately 1.0 m wide, 2.5 m long and 1.5 m high. This was fitted into the dyke and positioned in line with pond bottom at the deeper end of the pond.

The perimeter canal of depth 1.0-1.5 m and bottom slope of 1.2% goes round the pond. It has an opening made of two 3.0 m long cut pieces of 10 cm diameter PVC pipe lying parallel to each other. The openings serve as water discharge point (Outlet) that discharge water into a nearby creek during low tide. The opening can also serve as water intake point (Inlet) at high tide. This pond was left fallow for sometime and therefore became weedy. The pond dykes were dotted with burrows created by burrowing crabs.

To facilitate the needed reconstruction work on the grow-out pond (Fig. 2.2) used for the present work weeds and dead plant roots were cleared manually using cutlasses, digging hoes, shovels and mattock along the dykes, perimeter canal and on the pond and canal bottoms.

The grow-out pond was then reconstructed to obtain six small ponds to allow for two replications for each feed type. The reconstruction work involved demarcation of individual ponds, construction of separating dykes, construction of supply canal, construction of inlet, outlet-overflow units and fitting inlet, outlet-overflow units into the ponds.

The grow-out pond (GP) in Fig. 2.2 was demarcated into six individual pond areas as shown in Fig. 3.2 using tape measure, pegs and ropes. Before the demarcation, the individual pond dimension (length, breath and height) and surface area were computed. Then measurements were taken and positions describing the layout of the individual ponds and separating dykes were marked and pegged. Mason's rope was tied round the pegs to show out each pond layout as well as those of the separating dykes.

The separating dykes as shown in Fig. 3.2 and Plate 3.13 and having varying lengths between 21.0 m and 30.0 m, breath 1.0 m and 1.2 m on the crest and base respectively and height 1.5 m were constructed out of earth materials excavated from the pond and canal bottoms since it was necessary to deepen the pond and canal and also change the orientation of the pond bottom slope. Excavation was carried out using the digging hoe (Kpakpla – (Ga Adangwe)). Excavated materials were piled within the mapped out areas for the separating dykes to a height of 23-25 cm. Piled up earth was then compacted using a ram to make it water tight. The pilling up of earth to 23-25 cm height and subsequent compaction were done alternately till a required height of approximately 1.5 m was attained. The complete construction of the five separating dykes resulted in the creation of six individual ponds. Details of experimental pond morphometry is presented in Table 3.3.

Table 3.3 Morphometry of Ponds used in the Culture Experiments

Pond	Surface Area (m^2)	Bottom slope (%)	Dyke Length (m)	Vol. (m^3)	Dyke breadth (m)	Max. water depth (m)
1	231.4	2	29.1	347.1	7.98	1.5
2	231.6	2	27.9	347.4	8.30	1.5
3	231.3	2	26.4	347.0	8.76	1.5
4	231.3	2	24.5	347.0	9.44	1.5
5	231.4	2	22.6	347.1	10.24	1.5
6	457.6	3	20.7	686.3	22.1	1.5

The supply canal labelled SC in Fig. 3.2 and Plate 3.14 was provided by constructing two bridges at vantage points labelled as B (Fig. 3.2) across the perimeter canal. These bridges were provided with pipes which when left open could permit continuous flow of water when necessary. When the pipes beneath the bridges are closed and fresh saline water is pumped into the supply canal, water level rises till the screened inlet is submerged. Water then flows through the latter into the pond.

The inlets (I) in Fig. 3.2 and Plate 3.15 were constructed out of cut pieces of PVC pipes 10 cm diameter and length between 3.0-4.0 m. This length permits about 0.5 m of its length at both ends to jut into the supply canal and pond. To fit the inlet pipe unto the pond, the dykes at the shallower ends of the ponds were cut open just wide enough for pushing the pipe into position, deep enough to hold the inlet at about 1.0 m above the pond bottom and permit submergence of the end jutting into supply canal. The opening in the dyke is then closed with well-rammed earth to prevent water leakage.

The outlet-overflow unit (OL) in Fig. 3.3; Plate 3.16 was also constructed out of PVC pipes of 10 cm diameter, plastic elbow and T-joints fittings. The PVC pipes were cut at appropriate lengths and fitted together as shown in Fig. 3.3. To fit this unit unto the pond, the dyke at the deeper end of the pond was cut open wide enough to allow passage of the PVC pipe and deep enough for the unit to be aligned with the pond bottom. The unit was arranged so that the elbow end jutted into the effluent canal outside of the pond. The end with the T-connection remained within the pond. The over-flow portion of the unit permits excess water in the pond to flow out while the elbow portion when turned down permits water discharge out of the pond.

With these structures in place, each pond was capable of independent operation for filling and drainage to facilitate easy water exchange at any time

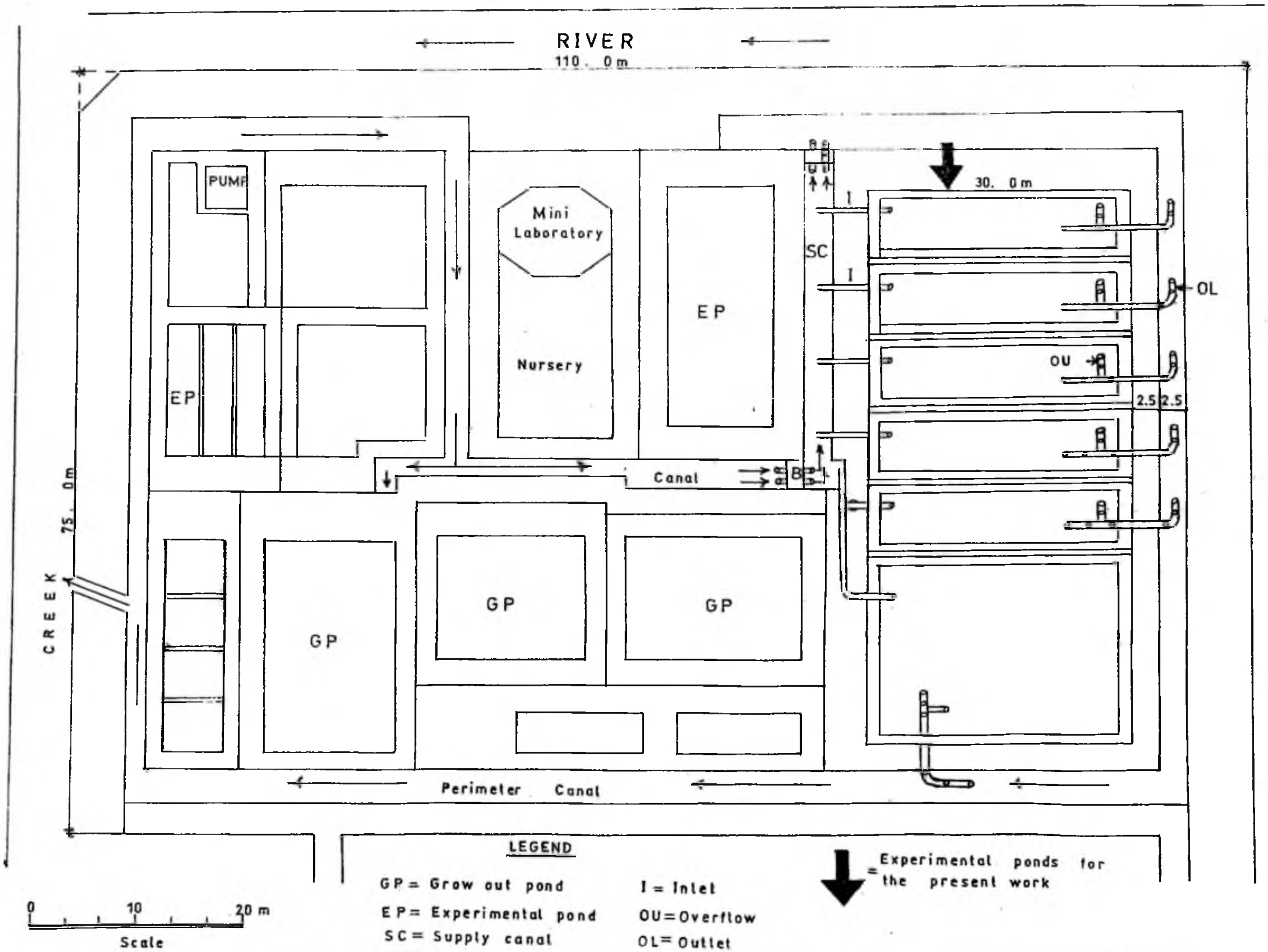


Fig. 3.2 Grow-out pond demarcated into individual ponds

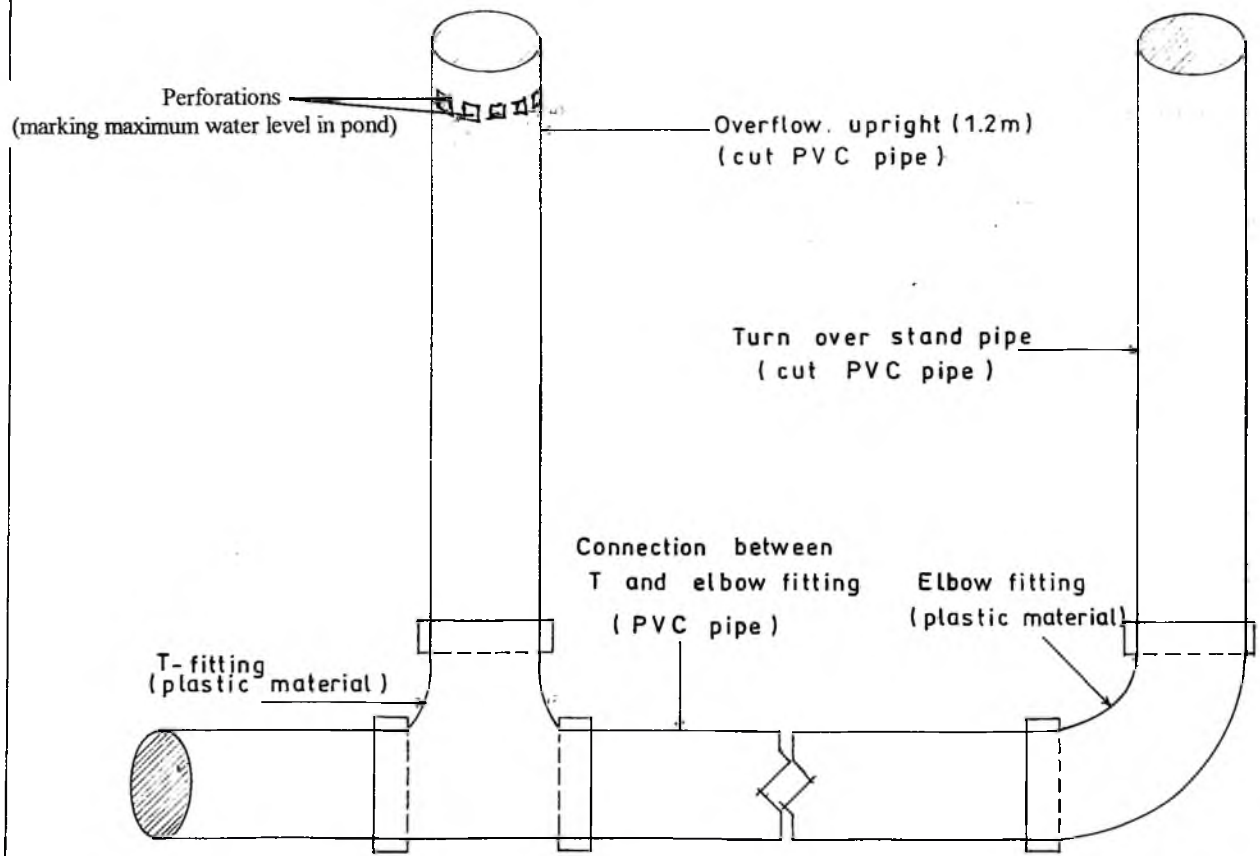


Fig. 3.3 Outlet – overflow unit

Plate 3.12 Grow-out pond used for experiment
Source: Darpaah (1998)

Plate 3.13 Partitioned experimental ponds

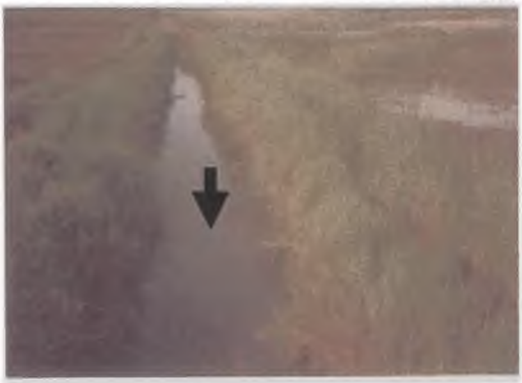


Plate 3.14 Supply canal

Plate 3.15 Pond filling (Inlet pipes at work)

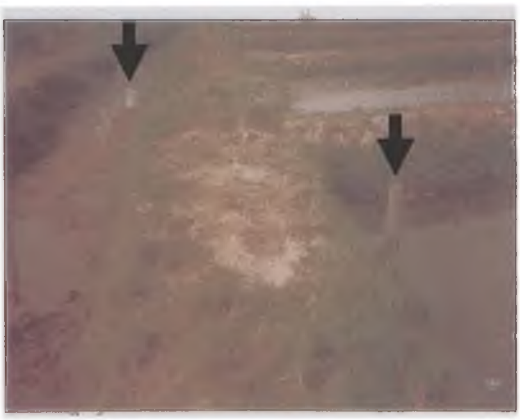


Plate 3.16 Ponds fitted with outlets-overflow (Single unit turn-over stand-pipe)

Plate 3.17 Predators and competitors in shrimp ponds

3.3 Pond Preparation

3.3.1 Pond bottom treatment

Approximately 500 g (25 kg/ha) of ground shell was weighed, dissolved in water and spread uniformly on the pond bottom. This was done to raise the pH of the soil from 6.8 to between 7.5-8.5

3.3.2 Filling

Ponds were filled (Plate 3.15) by pumping fresh saline water of salinity 25-30 parts per thousand ($^0/_{00}$) during high tide into the supply canal (Plate 3.14) into which the screened inlet (Plate 3.15) opened. Water then flowed through the latter into the ponds.

3.3.3 Liming

At a water depth of 10.0 cm liming was carried out using ground shell applied at a rate of 500 kg/ha thus for each pond, approximately 12 kg of ground shell was weighed, dissolved in water and spread on the surface of the water in the pond to maintain pH levels within the range of 7.5 - 8.5.

3.3.4 Fertilisation

Fertilisation was carried out after the water level was raised to 30 cm mark. Inorganic fertiliser (NPK-20:20:0) was applied at a rate of 30 kg/ha. Thus for each pond an amount of 600 g was weighed, dissolved in water and spread on the surface of the pond water. The aim was to encourage growth of natural food in the pond water for the PLs to feed on as well as establishing good water conditions for growth of PLs.

3.4 Sampling of Post Larval Shrimp (PLs)

After a preliminary survey using refractometer and a graduated ranging pole of height 2.0 m to determine salinity levels and water depths respectively, intertidal zones of salinity between 25-30 parts per thousand ($^{0}/_{00}$) and water depths of 60-90 cm along the shorelines of Azizakpe, Alokpeme and Afrive as shown on Fig. 2.1 were identified as suitable habitats for sampling for PLs. Sampling for PLs was carried out by two local fishermen seining through the water with a specially designed post larval net for 15-20 minutes. The catches were then sorted out and counted. Sorted PLs were kept in open glass tanks (previously disinfected with calcium hypochlorite) and half filled with water collected from the pond to be stocked.

3.5 Acclimatization of Post Larval Shrimp

Post larval shrimps (PLs) were kept in the tanks for four to six - hour periods to acclimatize. This was to prevent mortalities in the pond after stocking. Samples of PLs in the tank were taken, weighed and counted to obtain an average body weight at stocking. All PLs in the tank were then transferred into a similar tank containing same amount of same pond water dosed with malachite green at 2.0 parts per million for one hour before stocking to prevent ecto-parasitic infections in the pond.

3.6 Stocking of Post Larval Shrimp (PLs) into Earth Ponds

The glass tank containing PLs was dipped into the pond water; gradually submerged and tilted to lie on one side and consequently permit the PLs to swim freely out of the tank into the pond. All stocking sessions were carried out between 0300-0600 GMT.

Each pond received approximately 2,400 PLs (10 PLs/m^2). In all about 16,800 PLs with an average body weight of 0.67 g were stocked. This gave an initial biomass of 1.6 kg in each pond and a total biomass of 11.26 kg in all the ponds.

3.7 Husbandry of Post Larval Shrimp (PLs) in Experimental Ponds

3.7.1 Feeding regime, Water quality and Growth monitoring

Post larval shrimps were fed on the prepared feeds at a monthly rate of 10%,8%, 6%, 4%, 2% body weights. For the first month total body weight (biomass) of PLs stocked in each pond was 1608 g and 10% of this weight gave 160.8 g as quantity of prepared feed administered daily since PLs were fed at 10% body weight. The daily ration of 160.8 g was weighed to the nearest gram, divided into four equal portions of 40.2 g and each portion spread uniformly on the surface of pond water at six hour intervals. Each feed type; 20%, 30% and 40% crude protein were fed to PLs populations in ponds 1 and 2, 3 and 4 and 5 and 6 as replicates respectively.

Water quality maintenance (Appendix 2)

To maintain good quality water environment for enhanced growth of post larval shrimp temperature, pH, dissolved oxygen, salinity, ammonia nitrogen and nitrite nitrogen levels of pond water were monitored regularly. This was followed by water exchange as soon as deterioration in water condition was detected. Water was exchanged almost every other day and approximately 20%-30% of water in the pond was exchanged on each occasion. It was carried out by dropping the pond water level by a third and then topping it up by pumping fresh good quality saline water from the river into the supply canal and subsequently through the screened inlet into the pond.

Temperature readings of pond water were taken using an alcohol-in-glass thermometer. The instrument was immediately dipped into the water sample which was taken in 250 ml conical flask. On the graduated glass stem of the instrument, the level to which the alcohol column has risen or fallen was read. The process was repeated for three different stations and the average value recorded to 0.1 degree Celsius.

The pH condition of pond water was determined using a set of apparatus made up of Wide Range 4 pH Indicator Solution, pH colour disc, two glass sample tubes and a colour comparator. Pond water samples were taken in the two glass sample tubes filled to the 5 ml mark. Six drops of the Wide Range 4 pH Indicator Solution were added to one of the water samples. This sample was well swirled to mix so that a uniform colour change is obtained. The sample containing the indicator was then inserted into the right opening on the colour comparator while the sample without the indicator was inserted into the left opening. The colour disc was then fixed onto the colour comparator. The latter was then held against a light source, while the former was rotated till a colour match was obtained between the two water samples. At this point pH value of the match was read at a scale window on the apparatus. The process was repeated for three sets of water sample and the average value recorded.

Dissolved oxygen (DO) concentration of pond water was determined using the winkler method. Pond water sample was collected in a clean 60 ml glass stoppered BOD bottle making sure that no air bubble was trapped inside the bottle. The water sample was fixed by adding the contents of one Manganous Sulphate Powder Pillow (DO 1 reagent) and one Alkaline Iodine – Azide Powder Pillow (DO 2 reagent). The bottle was immediately stoppered without trapping air in the bottle. The bottle was then inverted several times to mix for floc formation. The bottle was allowed to stand for 5 minutes for floc to settle. After the 5 minutes, the bottle was inverted again for more floc formation and then left to stand for another 5 minutes for floc to settle. An orange brown floc was observed in the bottle.

The content of one Sulfamic Acid Powder Pillow (DO 3 reagent) was added to the water sample in the bottle and inverted several times to dissolve the floc leaving a clear yellow solution indicative of the presence of dissolved oxygen in water sample.

40 mls of the water sample solution was taken in a measuring cylinder and four 10 mls portions were poured out into 250 ml conical flasks and titrated (one at a time) using 0.025 N Sodium Thiosulphate in a titration cartridge attached to a digital titrator. The colour change was from yellow to pale yellow when two drops of starch indicator solution was added. The titration continued from dark blue colour to colourless end point. Then the number in digits obtained on the digital counter window located on the titrator was noted. This number was then divided by 40 to give the concentration of dissolved oxygen in water sample in milligram per litre (mg/L). The results from the four titrations were pooled and the average value computed and recorded.

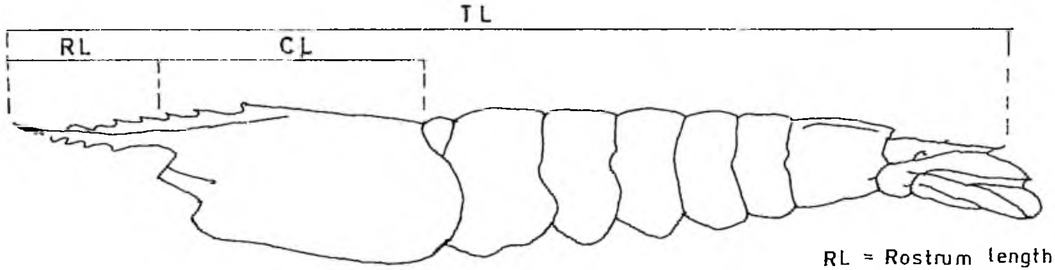
Salinity values of pond water were determined using a refractometer. Located at one end of the instrument is a flat surface. Onto this surface was put a few drops of water sample and then immediately covered by a lid to produce film of water on the surface. The instrument was then held with the flat surface directed to a light source. Salinity values in parts per thousand ($^{0}/_{00}$) of water sample was read against an upright bluish scale background by viewing through the eye piece. This process was repeated for 3 samples and the average value recorded.

Ammonia nitrogen (NH_3-N) concentrations in pond water were determined using Rochelle Salt Solution, Nessler Reagent and Colour comparator. Water samples were taken in two glass sample tubes filled to the 5 ml mark. One drop of Rochelle salt solution was added to each sample tube and swirl to mix. Three drops of Nassler reagent were added to one of the tubes and swirled to mix. The bottle tubes were then stoppered and left for 10 minutes for colour development. A yellow colour indicated the presence of ammonia nitrogen. The two tubes were then inserted into a colour compactor with the colour sample in the right opening while the sample without Nassler regent was in the left. The colour comparator was held against a light source and the colour disc rotated to obtain a colour match. The concentration of ammonia nitrogen in mg per litre (mg/L) was read at the scale window. The average value of three sample was recorded.

Nitrite nitrogen (NO_2-N) concentration in pond water was also determined using Nitriver 3 Nitrite Reagent and Colour Comparator. Water samples were taken in two glass sample tubes filled to the 5 ml mark. The content of one Nitriver 3 Nitrite Reagent Pillow was added to one of the samples leaving the other without the reagent. Water sample with the Nitriver 3 Nitrite reagent was swirled vigorously for 1 minutes for colour development. Red colour development indicates the presence of nitrite nitrogen. Bottle tubes were inserted into the colour comparator. The colour sample was inserted into the right opening while the other was inserted in the left opening. The colour comparator was held against a light source and the colour disc rotated to obtain a colour match. The concentration of nitrite nitrogen in milligram per litre (mg/L) was read at the scale window. The average value for 3 samples was recorded.

Growth monitoring

Shrimps were sampled once every month using cast net. Fifty (50) captured shrimps were measured for rostrum length (RL), carapace length (CL) and total length (TL) as shown in Fig. 3.4 and weighed to obtain body weight (BW). Length measurements were read from a measuring board and recorded to the nearest 0.10 cm Body weights were read from a pan top weighing scale. The average value of body weight readings was computed and recorded to the nearest 0.10 g. Captured shrimps were also sexed by inspecting the body for presence of genitalia: thelycum and petasma (Figs. 3.5 and 3.6) for female and male shrimps respectively. Records on lengths, weight and sex are presented as Appendix 3.



RL = Rostrum length
CL = Carapace length
TL = Total length

Fig. 3.4 Drawing of a shrimp showing length measurements*

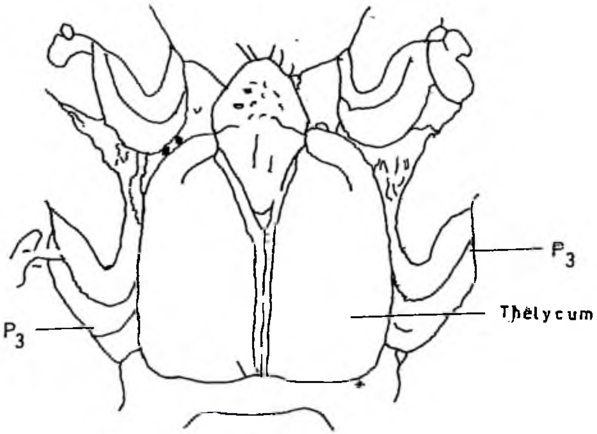


Fig. 3.5 Thelycum of female shrimp*

P_3 = The 3rd pair of pereopod

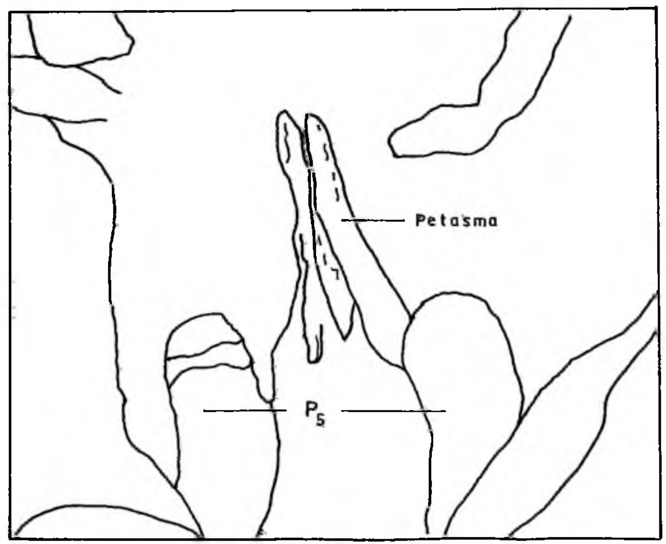


Fig. 3.6 Petasma of male shrimp*

(P_5 = The 5th pair of pereopod)

* SOURCE: Malaysian Technical Cooperation Programme (1990)

3.8 Harvesting

Shrimps were harvested by replacing corking at the outlet pipe opening inside the pond with a screen and outside the pond, turning down the upright arm of the elbow. In this position the outlet discharged water into the drainage canal leaving behind the shrimps which were then hand picked/collected from inside the pond into a bowl.

Predation and competition in the shrimp ponds were as much as possible reduced to minimum by occasional seining through the pond to capture predators and competitors such as *Tilapia sp*, *Hemichromis fasciatus* and crabs (Plate 3.17). Crabs in particular were physically stalked down and slashed with cutlass. The removal of these species was to enhance the availability of feed to shrimp and also enhance shrimp survival.

3.9 Estimation of Survival and Yields

The survival of shrimp in the ponds was estimated using a 1.0 m^2 feed net. The feed net was constructed out of mosquito netting, cut pieces of ceiling buttons, strips of tyre inner tubes, nails and lead shots hooked unto the frame. This was to give added weight to enable the feed net remain at the pond bottom under water.

During feeding time, the feed nets were submerged at 3 points evenly distributed inside the pond before feed was spread evenly on the surface of the water with the hope that each feed net has the required amount of feed per unit area.

Feed nets were then inspected 2 hrs after feed has been spread. The number of shrimp found in the feed nets were noted for two days and the average value computed and expressed as percentage of the initial stocking rate assuming there was uniform distribution of shrimp in the ponds (Chanratchakool, et al., 1995). The figure, let say, a% represents survival of shrimp in the pond. The total number of shrimps present in the pond at a given time then becomes the product of the survival value (a%) obtained and original number of PLs stocked. The estimated shrimp biomass/yield was obtained by multiplying the number of shrimps in the pond by the average body weight for a particular period.

Yields of shrimps produced for the 3 prepared diets were estimated separately. The unit of expression was metric ton per hectare per year (mt/ha/yr). At the end of the experiment, harvested shrimps were counted, weighed and recorded. The average body weight and survival under each feed type computed. These values represented actual biomass, survival and the average body weight at harvest. With these values the yield (mt/ha/yr) for each feed type was computed and presented in Table 4.15.

3.10 Statistical Methods

F – statistic and Chi-square tests were used in significant testing. The mean body weight values obtained at the end of the experiment (i.e. 24 week culture period) were used in the computation involving a Two Factor With Replication Analysis of Variance (Appendix 4). The year 2000 software version of Microsoft Excel Program was used for the analysis. The analysis was to determine whether there was a significant difference between the growth rates of the three shrimp populations.

The differences between the observed and expected crude protein levels of the prepared diets (Table 4.17) were subjected to significance testing using the Chi-square test. This was to determine whether the observed differences were significantly different from the expected.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate analysis of Prepared feeds

Table 4.1 Results of Proximate analysis of Feed samples. A, B and C correspond to 20%, 30% and 40% crude protein feed types respectively.

Feed Component	A	B	C
Moisture	5.99	5.66	5.54
Dry matter	94.01	94.34	94.46
Mineral ash	5.21	6.54	7.84
Crude fibre	7.72	7.62	7.66
Ether extracts	3.66	4.29	5.55
Crude protein	17.62	25.73	35.40
Nitrogen free extract	59.80	50.16	38.01

In Table 4.1, the labels A, B and C represent samples of prepared feeds sent to the laboratory for proximate analysis. The figures represent the corresponding percentage contributions obtained for the feed components for each feed sample. The proximate analysis of the prepared feeds was conducted by Animal Research Institute of Council for Scientific and Industrial Research, Accra.

Proximate analysis is a set of laboratory procedures carried out on feed samples to determine the various component and their respective percentage contribution /proportions in the feed types. This enables one to know exactly what type (chemical composition) of feed is fed to cultured species.

In Table 4.1, the component and their respective proportions (%) were indicated under each sample. Moisture refers to the water content of the feed sample before analysis. Dry matter refers to what is left of the feed sample after it has been dried. Mineral ash refers to mineral content while crude fibre is the chaff. Ether extract refers to Fat and Lipid content while crude protein and Nitrogen free extracts refers to the Protein and Carbohydrate contents respectively.

4.2 Experimental Feed Production

Table 4.2 Cost of experimental feed preparation

Feed type % CP	Feed stuffs	Quantity (g) per kg of feed (2)	Prices (¢) per kilogram	Cost (¢) of feedstuf f per kg of feed	Cost (¢) of feed per kg (¢)	Quantity of feed administered for 24 weeks (kg)	Total cost (¢) of feed administered for 24 weeks
20	Soybean meal	32. 53	1,670.00	54.33	712.27	89.58	63,805.15
	groundnut cake	32.53	1,650.00	53.675			
	Fish meal	32.53	2,400.00	78.072			
	Wheat bran	902.40	500.00	451.200			
	Premix	2.5	10,000.00	25.00			
	Binder	50.00	1,000.00	50.00			
30	Soybean meal	132.93	1,670.00	221.99	1,135.95	79.68	90,512.50
	Groundnut cake	132.93	1,650.00	219.33			
	Fish meal	132.93	2,400.00	319.03			
	Wheat bran	601.20	500.00	300.60			
	Premix	2.5	10,000.00	25.00			
	Binder	50.00	1,000.00	50.00			
40	Soybean meal	233.30	1,670.000	389.61	1559.48	57.73	90,028.78
	Groundnut cake	233.30	1,6509.00	384.95			
	Fish meal	233.30	2,400.00	559.92			
	Wheat bran	300.000	500.00	150.00			
	Premix	2.5	10,000.00	25.00			
	Binder	50.00	1,000.00	50.00			

In Table 4.2, the unit cost (cost per kg) in cedis of preparing 20%, 30% and 40% crude protein levels in prepared feeds for the present work were computed and presented. The values obtained were ¢712.27, ¢1,135.95 and ¢1,559.48 for the 20%, 30% and 40% crude protein feeds respectively.

4.3 Physical and Chemical Parameters

Table 4.3 Temperature (degree Celsius) values in shrimp ponds

	PERIOD																							
POND	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	27.8	27.8	27.9	27.7	30.0	30.0	30.5	29.5	27.7	27.7	28.8	27.0	30.0	30.0	28.8	29.2	29.4	29.4	29.6	29.6	29.2	29.4	29.6	29.8
P_2	30.2	30.0	29.8	30.0	30.0	31.0	25.6	29.0	27.9	27.7	26.6	26.6	29.2	30.0	29.4	29.4	30.0	29.4	29.2	29.4	31.0	29.4	29.6	30.0
P_3	29.2	29.0	28.8	31.0	29.4	28.8	28.8	28.6	27.8	27.9	27.9	30.0	28.7	29.6	29.8	29.9	29.2	30.0	29.4	29.4	29.6	31.0	29.4	30.0
P_4	29.2	29.0	28.8	31.0	30.0	30.0	29.0	29.0	28.0	27.7	30.0	27.9	28.8	29.8	30.0	29.4	29.8	30.2	30.0	30.0	30.0	30.2	29.8	30.0
P_5	30.0	30.0	30.5	29.5	29.0	28.8	29.0	28.8	27.7	28.0	27.7	27.8	30.0	30.0	30.0	28.0	30.0	29.2	29.4	29.4	29.5	30.5	30.5	30.0
P_6	29.5	29.0	28.8	28.7	27.7	27.8	28.0	27.7	30.5	30.5	30.0	31.0	31.0	31.0	30.0	30.0	30.5	29.4	29.6	30.5	31.0	30.0	30.4	31.0

In Table 4.3 the values represent average weekly water temperature readings recorded for each week in degree Celsius from shrimp ponds (P1-P6) during the 24 week culture period

Table 4.4 pH values in shrimp ponds

	PERIOD																							
POND	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	8.0	8.0	8.0	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
P_2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
P_3	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.2	8.2	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
P_4	7.5	8.0	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
P_5	7.5	8.0	8.0	8.5	8.0	8.0	8.0	8.0	8.5	8.2	8.2	8.3	8.0	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
P_6	7.6	8.0	8.0	8.0	7.5	7.5	7.6	7.8	7.7	8.5	8.5	8.5	8.0	8.0	8.0	7.6	7.6	7.6	8.0	7.6	7.6	7.6	7.6	8.0

In Table 4.4, the values represent average weekly water pH readings recorded in shrimp ponds (P1- P6) during the 24 week culture period.

Table 4.5 Salinity ($^0/_{00}$) values in shrimp ponds

POND	PERIOD																							
	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	27	28	30	35	35	35	35	35	28	29	34	25	20	18	20	34	15	10	11	12	10.0	9.0	8.0	9
P_2	35	35	35	35	35	32	35	30	32	28	32	28	15	15	15	15	13	11	13	11	8	8	6	6
P_3	35	35	33	33	35	34	32	35	30	25	25	16	15	11	15	15	10	10	10	10	9	6	6	7.0
P_4	33	35	31	33	33	33	34	34	28	26	25	25	18	15	15	16	13	10	15	10	10	8	10	12
P_5	35	35	35	35	36	36	36	36	30	35	34	33	35	35	25	33	28	24	30	30	30	30	33	31
P_6	28	32	32	32	24	24	20	24	18	18	20	20	35	35	34	28	28	25	25	30	20	20	26	22

In Table 4.5, the values represent average weekly salinity ($^0/_{00}$) readings of water in shrimp ponds (P1- P6) during the 24 week culture period.

Table 4.6 Dissolved Oxygen (DO) concentration in mg per litre in shrimp ponds

POND	PERIOD																							
	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	4.5	4.5	4.6	4.8	5.8	5.2	4.8	5.0	5.0	5.0	5.6	6.0	5.0	5.0	5.2	5.6	5.2	4.8	5.0	5.0	5.0	4.9	4.8	4.9
P_2	5.0	5.4	4.6	5.0	4.5	6.2	5.2	5.3	5.0	5.6	5.0	6.0	5.0	4.8	5.0	4.8	5.0	4.8	5.2	5.0	5.0	4.8	4.8	5.0
P_3	4.5	4.7	5.6	6.0	5.8	5.2	5.2	5.8	5.4	5.0	5.8	5.8	5.0	5.2	5.0	5.2	5.0	5.2	5.2	5.0	5.0	5.2	5.2	5.0
P_4	4.8	4.8	4.8	6.0	5.2	4.8	6.0	5.2	5.6	5.2	5.8	5.8	5.8	5.6	6.0	5.8	5.2	5.2	5.0	5.0	5.0	5.2	5.2	5.4
P_5	4.6	4.8	5.0	5.6	5.8	5.2	5.2	5.4	5.2	5.0	5.4	5.2	5.0	5.2	5.0	5.2	5.0	5.2	4.8	5.0	4.8	5.0	5.0	5.2
P_6	4.6	4.8	5.8	6.0	5.8	5.6	4.4	5.0	5.0	5.8	6.0	6.0	5.2	5.2	5.4	5.4	5.4	5.2	5.2	5.8	5.2	5.2	5.0	5.4

In Table 4.6 the values represent average weekly recordings of dissolved oxygen (DO) concentration in mg per litre in shrimp ponds (P_1-P_6) for the 24 week culture period

Table 4.7 Ammonia Nitrogen (NH_3-N) concentration in mg per litre in shrimp ponds

	PERIOD																							
POND	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In Table 4.7, the weekly average zero recordings represent values obtained for Ammonia Nitrogen (NH_3 -N) conc in shrimp ponds (P1-P6) during the 24 week culture period.

Table 4.8 Nitrite Nitrogen (NO_2-N) concentration in mg per litre in shrimp ponds

	PERIOD																							
POND	JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER			
P_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P_4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In Table 4.8 the weekly average recordings were all zero for Nitrate Nitrogen (NO_2- N) concentration in shrimp pond during the (P1-P6) 24 week culture period

Table 4.9 Monthly mean temperature (°C) values in shrimp ponds

	CULTURE PERIOD - MONTHS					
Pond	July	August	Sept.	Oct.	Nov.	Dec.
P_1	27.8	30.0	27.8	29.5	29.5	29.5
P_2	30.0	28.9	27.2	29.5	29.5	30.0
P_3	29.5	28.9	28.4	29.5	29.5	30.0
P_4	29.5	29.5	28.4	29.5	30.0	30.0
P_5	30.0	28.9	27.8	29.5	29.5	30.0
P_6	29.5	27.8	30.5	30.0	30.0	30.6

TABLE 4.10 Monthly mean pH values in shrimp ponds

	CULTURE PERIOD – MONTHS					
Pond	July	August	Sept.	Oct.	Nov.	Dec.
P_1	7.9	8.0	8.0	8.0	8.0	8.0
P_2	8.0	8.0	8.1	8.0	8.0	8.0
P_3	7.9	8.0	8.1	8.0	8.0	8.0
P_4	8.0	8.0	8.0	8.0	8.0	8.0
P_5	8.0	8.0	8.3	8.1	8.0	8.0
P_6	7.9	7.6	8.3	7.9	7.7	7.7

Table 4.11 Monthly mean dissolved oxygen (DO) values (mg/l) in shrimp ponds

	CULTURE PERIOD – MONTHS					
Pond	July	August	Sept.	Oct.	Nov.	Dec.
P_1	4.6	5.2	5.4	5.2	5.0	4.9
P_2	5.0	5.3	5.4	4.9	5.0	4.9
P_3	5.2	5.5	5.5	5.1	5.1	5.1
P_4	5.1	5.3	5.6	5.8	5.1	5.2
P_5	5.0	5.4	5.2	5.1	5.0	5.0
P_6	5.3	5.2	5.7	5.3	5.4	5.2

Table 4.12 Monthly mean salinity (‰) values in shrimp ponds

	CULTURE PERIOD – MONTHS					
Pond	July	August	Sept.	Oct.	Nov.	Dec.
P_1	30	35	29	23	12	9
P_2	35	33	30	15	12	7
P_3	34	34	24	14	10	7
P_4	33	34	26	16	12	10
P_5	35	36	33	32	28	31
P_6	31	23	19	33	27	22

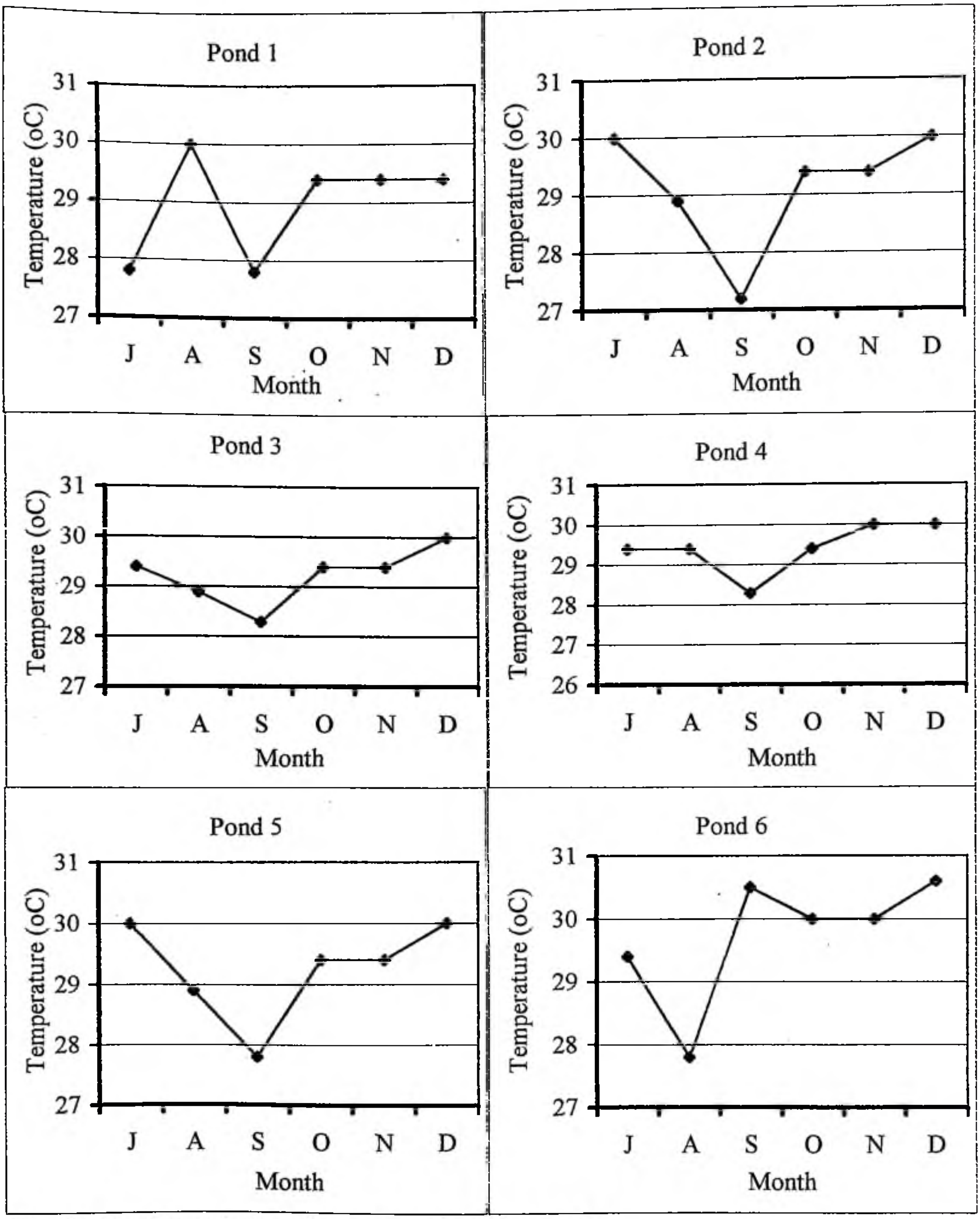


Fig. 4.1 Monthly variation of temperature in shrimp ponds

In Fig. 4.1, the lowest and the highest temperature values recorded were 27.2°C and 30.0°C in ponds 2 and 6 respectively with a range of 2.7°C. Fluctuations in temperature values were observed between July and September. From then on values rose gradually till the end of the study period.

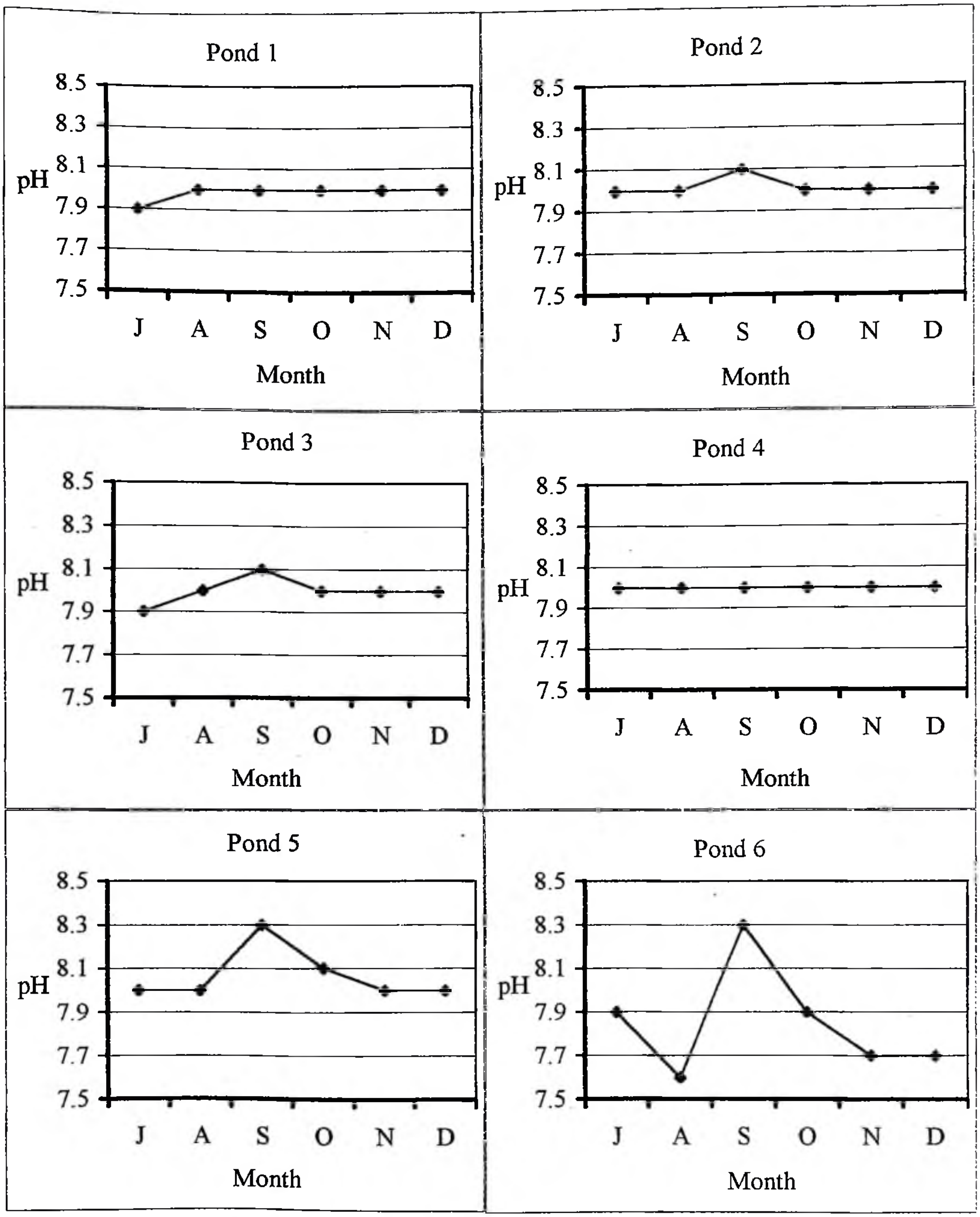


Fig. 4.2 Monthly variation of pH in shrimp ponds

In Fig. 4.2, the most marked pH variation was 7.6-8.3 in pond 6. Generally, pH conditions in the ponds were quite stable during the study period except for increase observed in ponds 2, 3, and 5 in September 2000.

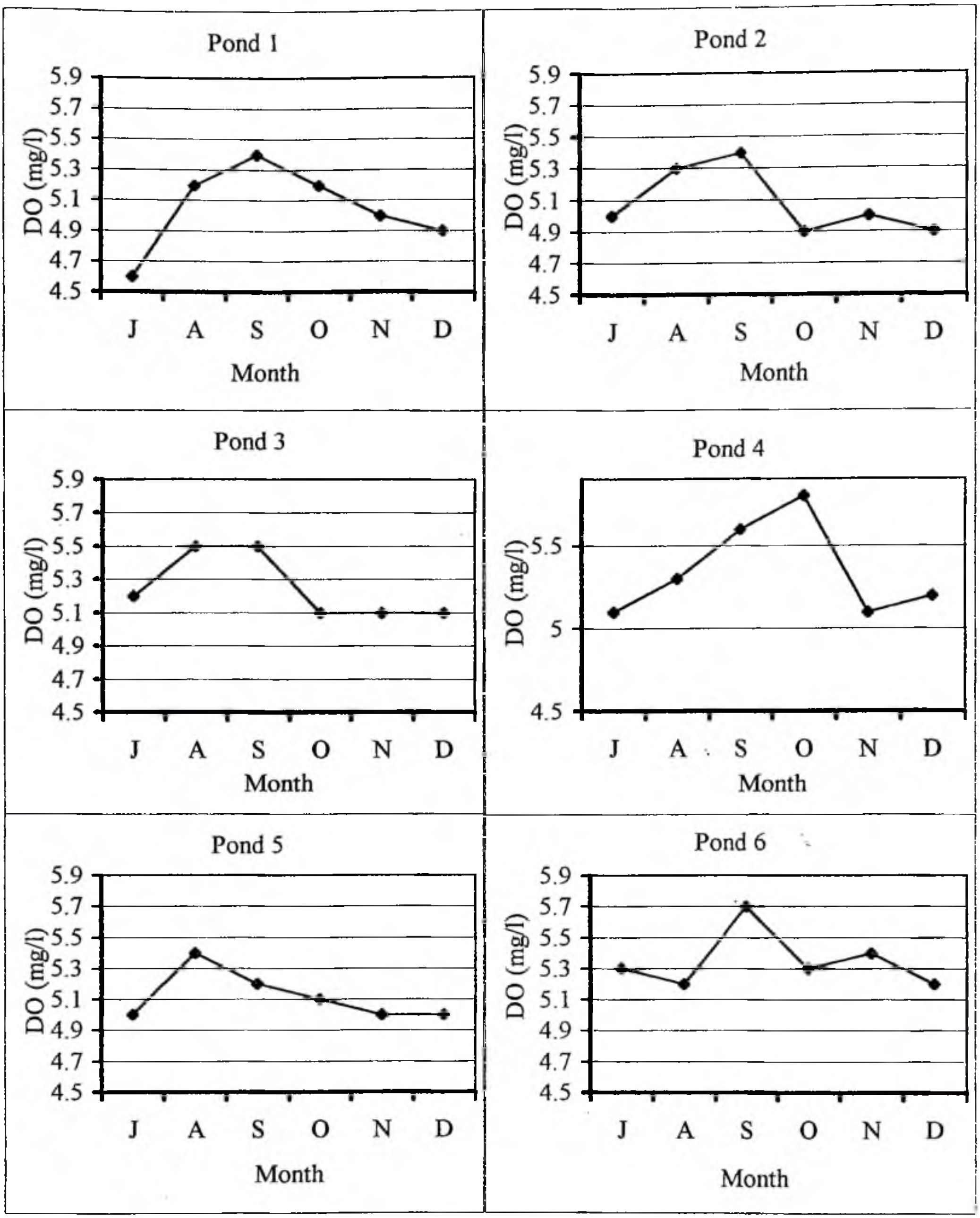


Fig. 4.3 Monthly variation in Dissolved Oxygen levels in shrimp ponds

In Fig. 4.3, the highest DO level of 5.8 mg/L was recorded in pond 4 in October. Generally, DO level increased from July to September and started failing except in Pond 4 where it continued to October before falling to approximately 4.9-5.2 mg/L.

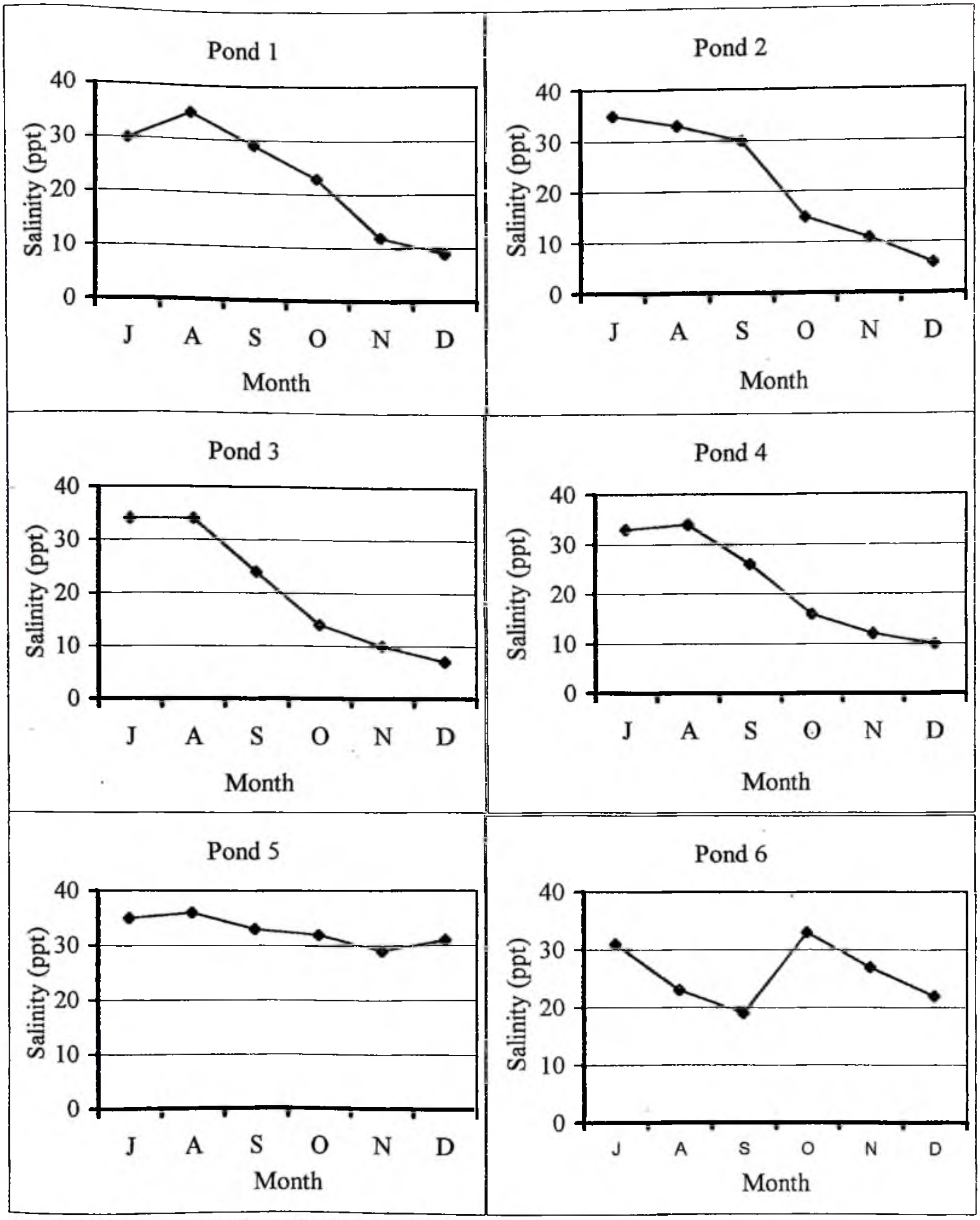


Fig. 4.4 Monthly variation of salinity in shrimp ponds

In Fig. 4.4, salinity values recorded were around 30-35‰. However, the values started falling from August steadily to 6-10‰ in Ponds 1, 2, 3 and 4 at the end of the culture period in December 2000. The most marked fluctuation, which is 18-31‰, was recorded in pond 6 between July and September and increased again to 33‰ in October.

4.4 Growth of Shrimp Populations

Table 4.13 Body weight and length changes of cultured shrimp population with different levels of crude protein during culture period.

Feed type % crude protein	40						
Cultured period, age (No. of days)	0	30	60	90	120	150	180
Average body wt (g) attained	0.67	5.25	5.42	6.21	6.73	6.88	6.98
Average body length (cm) attained	-	6.40	7.17	7.31	7.33	7.35	7.37
Feed type (% C P)	30						
Culture period	0	. 30	60	90	120	150	180
Average body wt (g) attained	0.67	4.93	6.87	7.40	6.53	7.47	7.70
Average body length (cm) attained	-	8.39	9.01	9.35	9.23	9.48	9.60
Feed type (% CP)	20						
Culture period, age (No. of days)	0	30	60	90	120	150	180
Average body wt (g) attained	0.67	8.25	10.71	11.58	11.77	12.60	12.72
Average body length (cm) attained	-	9.98	11.01	11.5	11.91	12.35	12.64

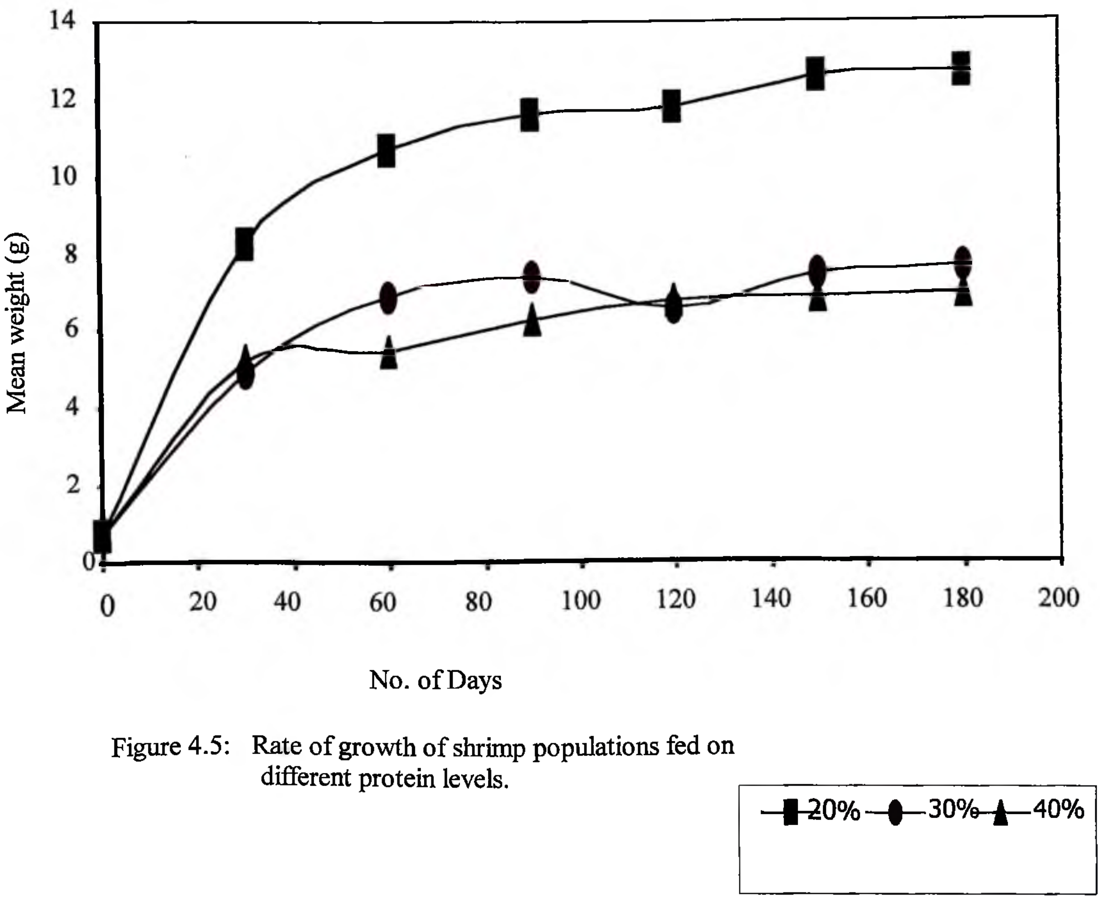


Figure 4.5: Rate of growth of shrimp populations fed on different protein levels.

Monthly mean weights (g) of shrimps and their corresponding culture periods (number of days) as shown in Table 4.13 were plotted for 20%, 30% and 40% crude protein diets (Fig 4.5). Final mean weights attained were 12.7, 7.7 and 7.0g for 20%, 30% and 40% crude protein levels respectively.

The curves (Fig. 4.5) for 20%, 30% and 40% crude protein level had a common intercept on the Y axis at 0.67 g (weight of PLs when the experiment started). From then on each curve described a defined pattern of growth during the 24 week culture period. The patterns show that for the first 60 days, there was fast growth peaking at 10.5 g and 6.5 g for 20% and 30% CP respectively. In the case of 40% crude protein diet there was fast growth peaking at 5.5 g in 40 days but experienced and abnormal drop in growth by approximately 0.3 g before reaching 5.2 g in 60 days. After the 60-day mark the individual curves experienced fluctuations variously but growth was slow and smooth till the end of the culture period.

Length-weight relationship

Table 4.14 Length-weight relationship of the shrimp population (summary table)

Feed type	Gradient (b)	Constant (a)	Equations	
20% CP	2.52	0.05	Log BW = 2.52 Log CL+0.05	$BW=1.12\ CL^{2.52}$
30% CP	2.30	0.11	Log BW=2.30 Log CL+0.11	$BW=1.29\ CL^{2.30}$
40% CP	2.18	0.13	Log BW=2.18 Log CL +0.13	$BW=1.35\ CL^{2.18}$

Length weight relationship in animals is given by $W = aL^b$ where W is body weight (BW); L is carapace length (CL) a and b are constants.

The relationship is exponential but is transformed into a straight line: $y = m x + c$ by double logarithmic transformation thus giving the equation as $\log w = b \log L + a$. By plotting Log BW (y) against log CL (x) a straight line is obtained.

From this line the values b and a are computed as the gradient of the line and intercept on the y axis respectively.

For each month, a double logarithmic plot of mean body weight (BW) g and carapace length (CL) cm of shrimps cultured during the study period were made for 20%, 30% and 40% crude protein levels (Fig 4.6, 4.7 and 4.8). Regression lines as well as their respective equations and regression coefficients are all given. The 'b' and 'a' values vary with the months. To obtain one mathematical relationship for each feed type as shown in Table 4.14, the logarithmic values for body weight and carapace length (Appendices 5, 6 and 7) under each feed type for the period of study (24 week) was pooled and plotted as shown in Figs. 4.6a, 4.7a and 4.8a.

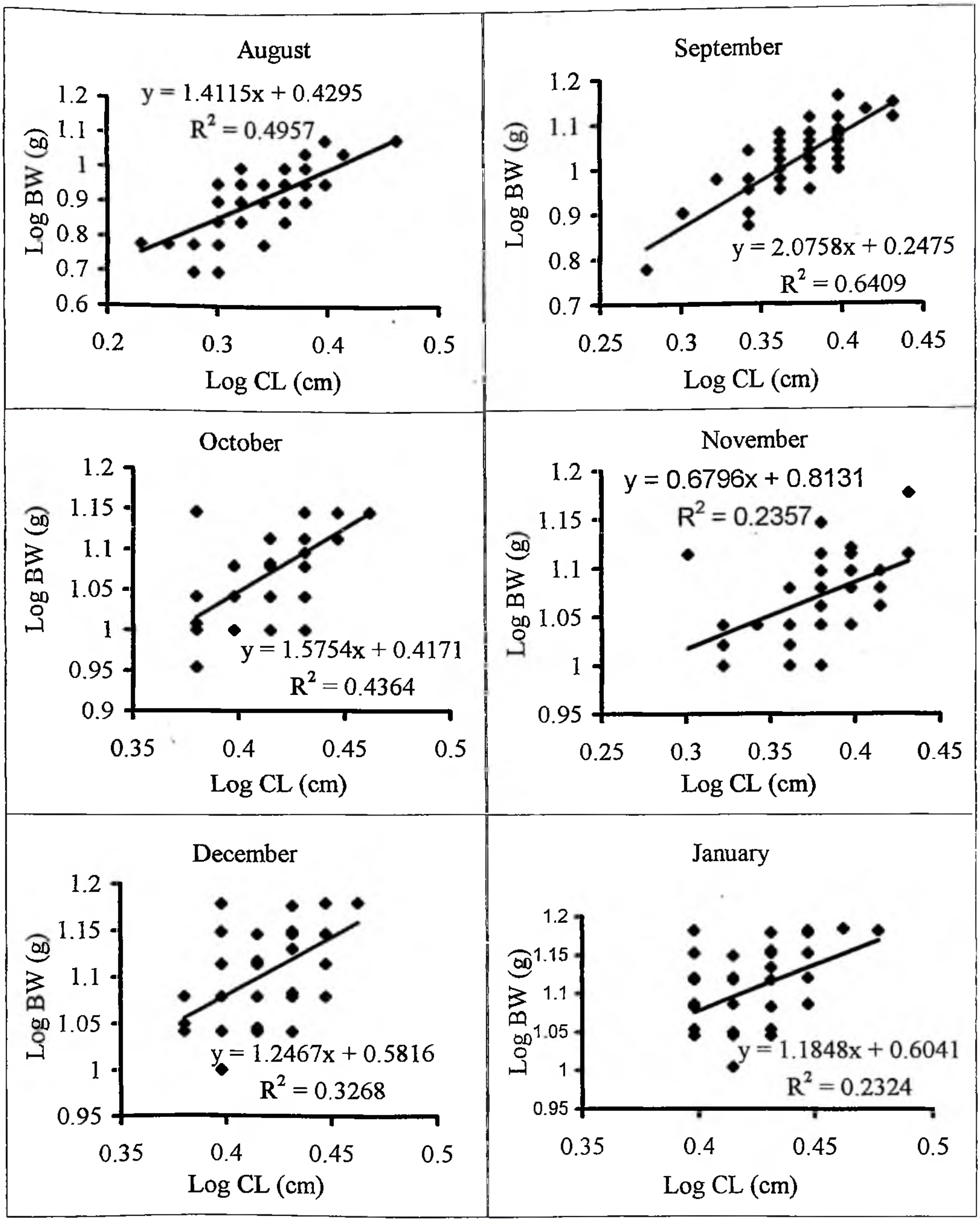


Fig. 4.6 Length-weight relationship of shrimps fed on 20% crude protein diet

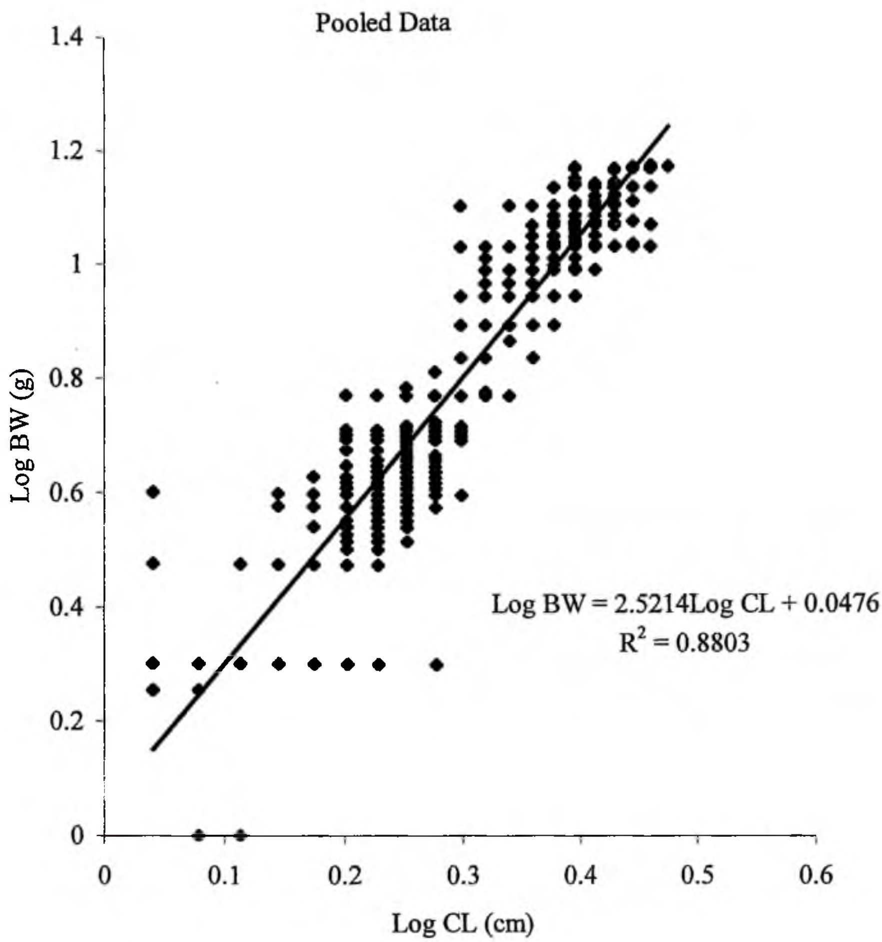


Fig. 4.6 a Pooled Length-weight relationship of shrimps fed on 20% crude protein diet

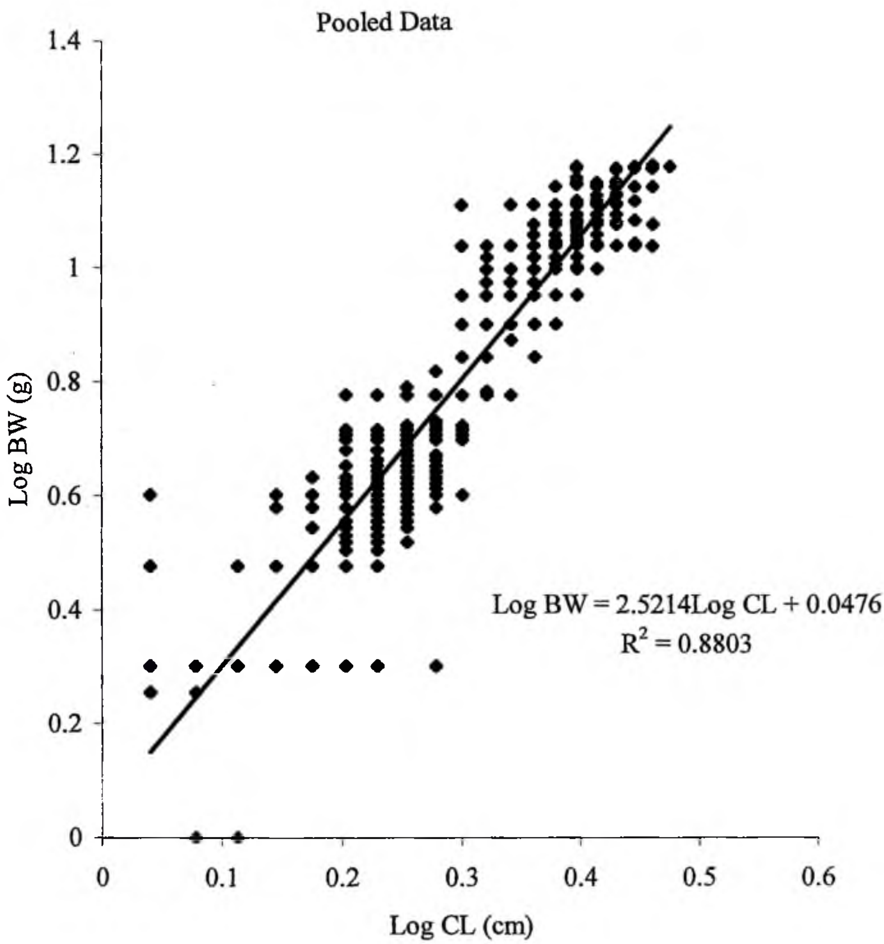


Fig. 4.6 a Pooled Length-weight relationship of shrimps fed on 20% crude protein diet

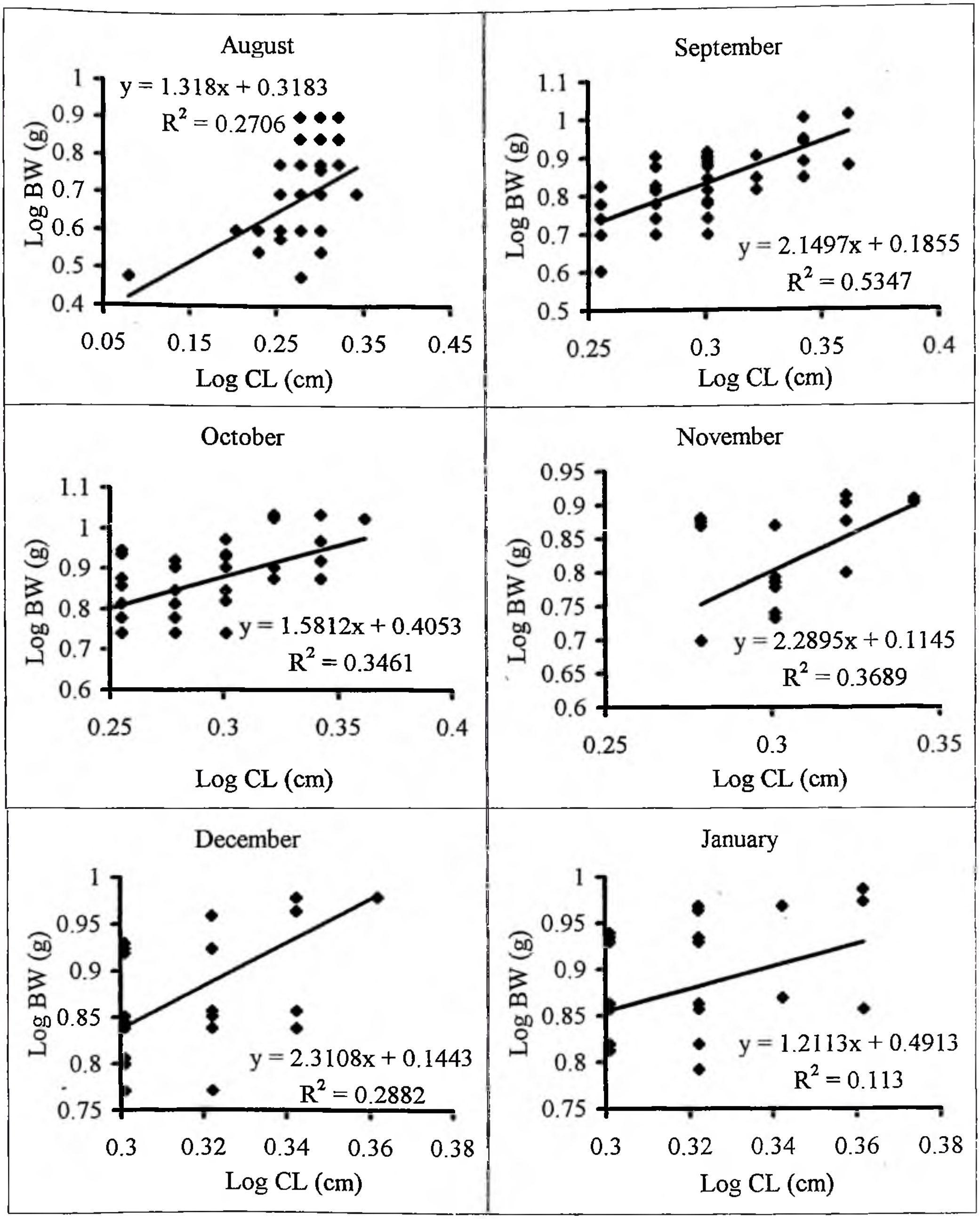


Fig. 4.7 Length-weight relationship of shrimps fed on 30% crude protein diet

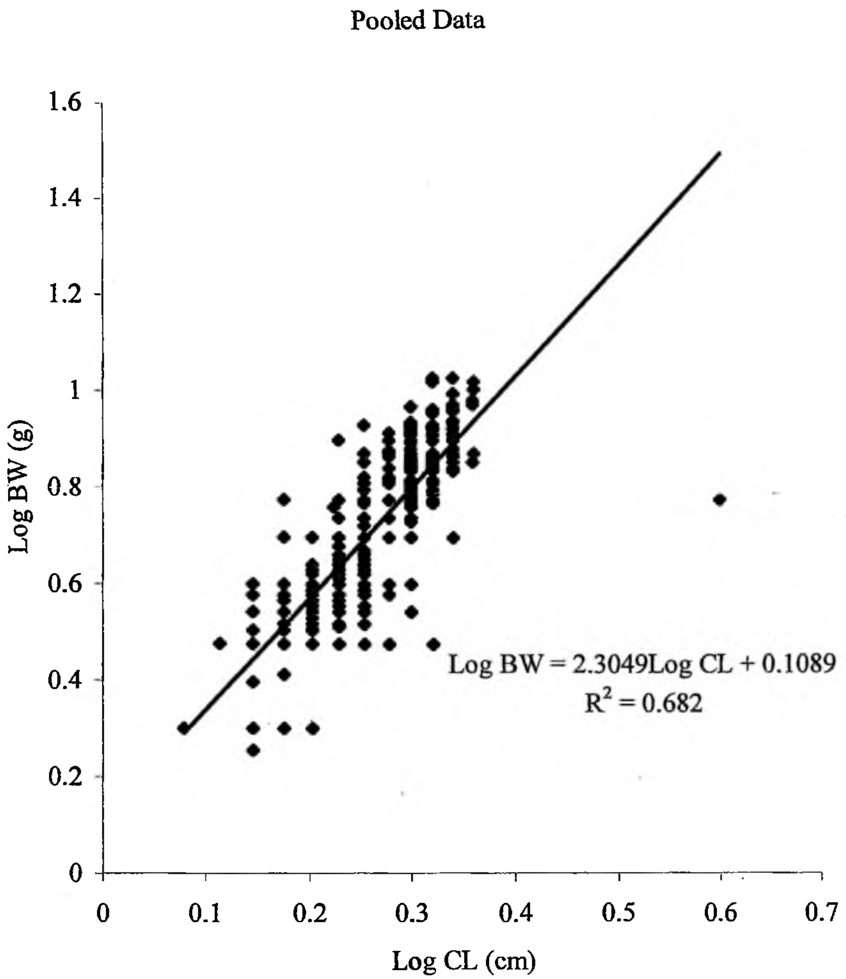


Fig 4.7a Pooled Length-weight relationship of shrimps fed on 30% crude protein diet

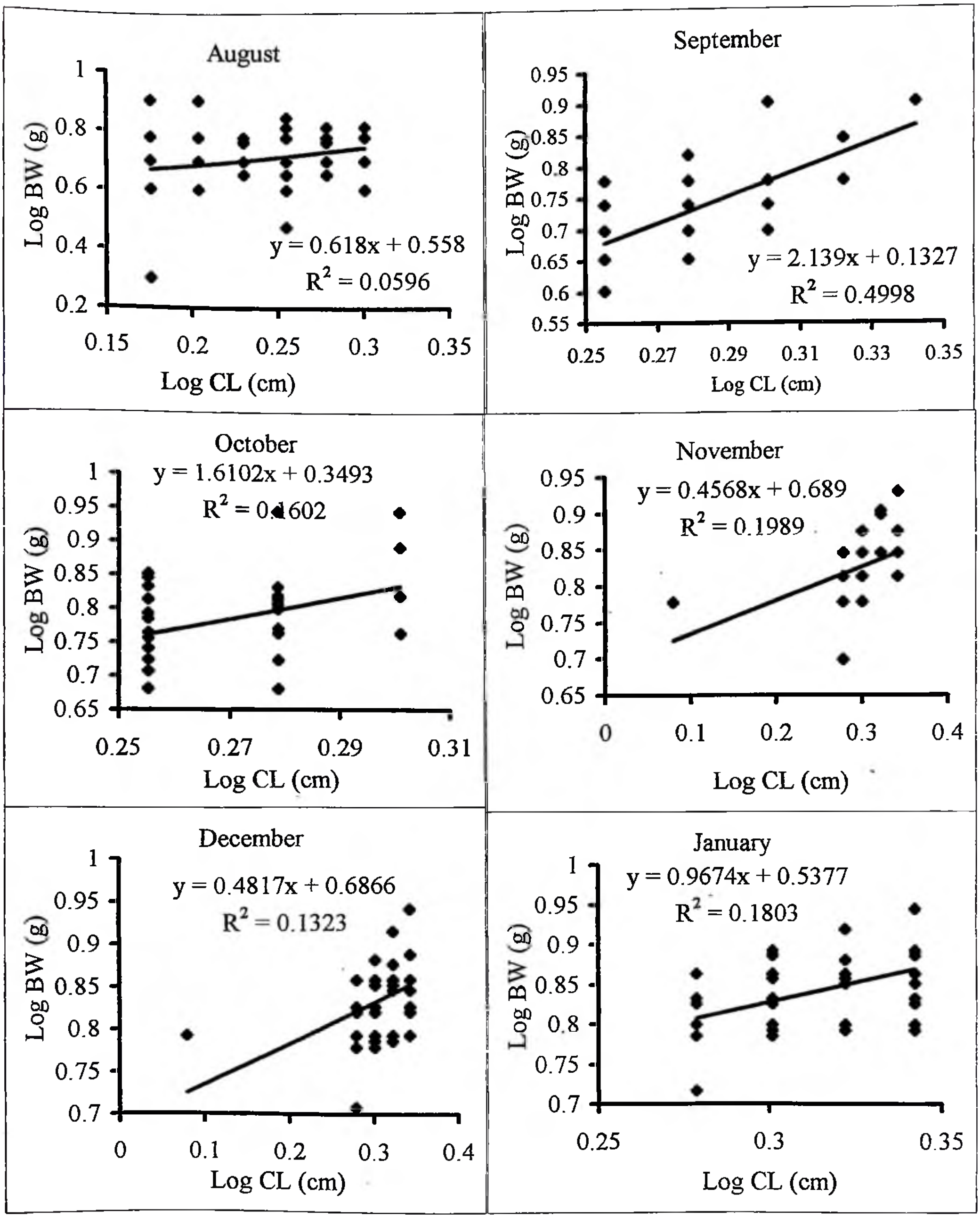


Fig. 4.8 Length-weight relationship of shrimps fed on 40% crude protein diet

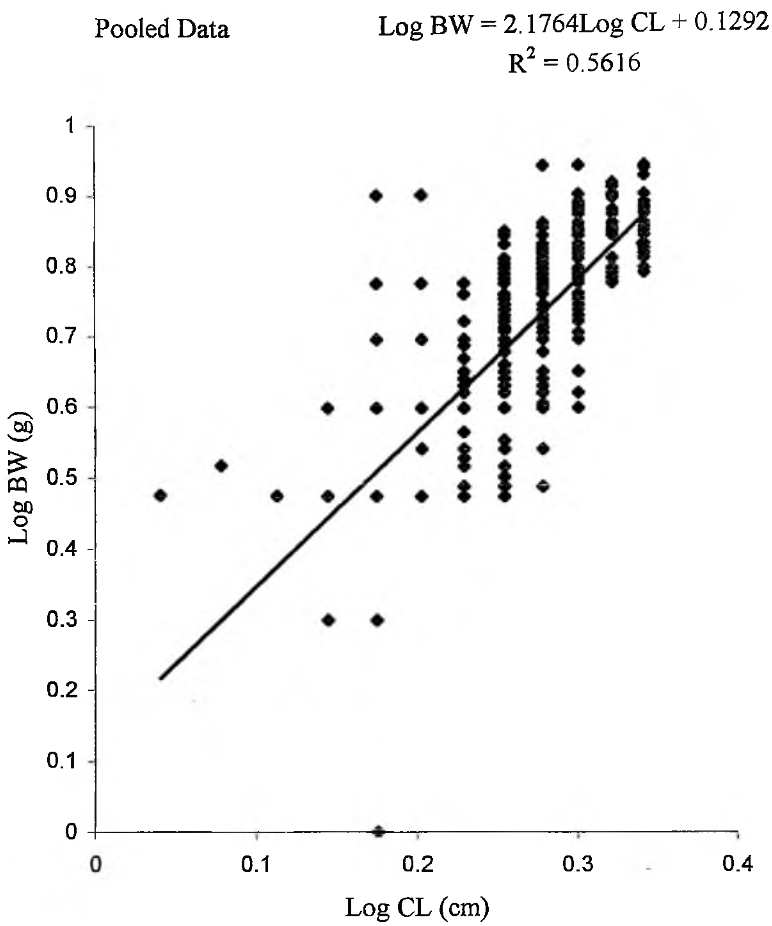


Fig 4.8a Pooled Length-weight relationship of shrimps fed on 40% crude protein diet

4.5 Harvest and Yields

Table 4.15 Shrimp harvest and estimated yields.

Feed types (% CP)	Survival (%)	Average body weight at harvest (g)	Number of shrimps stocked	Number of shrimp counted at harvest	Total weight of shrimp harvested (kg)	Estimated yield mt/ha/yr
40	41.2	6.98	2,400	988	6.97	0.61
30	31.5	7.70	2,400	756	5.8	0.50
20	49.0	12.72	2,400	1,176	14.86	1.29

4.6 Analysis of Data

Table 4.16 Analysis of Variance (ANOVA) Two Factor with Replication

20/30 CP						
Source of Variation	SS	df	MS	F	P-values	F crit
Rows	56.66	1	59.66	194.64	3.4E-05	6.61
Columns	17.41	5	3.43	11.187	0.0096	5.05
Error	1.53	5	0.31			
Total	78.34	11				
20/40 CP						
Source of Variation	SS	df	MS	F	P-values	F crit
Rows	75.92	1	75.92	146.99	6.74E-05	6.61
Columns	13.77	5	2.75	5.33	0.045	5.05
Error	2.58	5	0.52			
Total		11				
30/40 CP						
Source of Variation	SS	Df	MS	F	P-values	F crit
Rows	0.98	1	0.98	3.84	0.011	6.61
Columns	6.77	5	1.35	5.31	0.045	5.05
Error	1.27	5	0.25			
Total		11				

In Table 4.16, the F. values obtained between 20% and 30%, 20% and 40% and 30% and 40% crude protein diet were 194.64, 146.99, and 3. 84 respectively. At significant level of 0.05, the critical value for accepting H_o is 6.61. Comparing the respective F. values to the critical value, one can say that there is no significant difference in growth between shrimp population fed on 30% and 40% crude protein diets. However there is significant difference in growth between shrimp populations fed on 20% and 30% crude protein diet and 20% and 40% crude protein diet.

Table 4.17 Chi-square test analysis of observed and expected crude protein levels in prepared diets

Feed samples	Crude protein levels (%) in feed samples		
	Observed	Expected	Total
A	17.62	20.0	37.62
B	25.73	30.0	55.73
C	35.40	40.0	75.404
Total	78.75	90.0	168.75

The Chi-square formula used for the analysis $X^2 = \sum \frac{(O-E)^2}{E}$ (Bailey, 1981; Montgomery, 1984). O and E represent the observed and expected values and $\sum$ is the sigma notation (summation sign). The observed and expected values were substituted into the formula and computed as shown below:

For sample A, we have $\frac{17.62}{20.0} = \frac{5.6644}{20.0} = 0.28$

Sample B, $\frac{25.73}{30.0} = \frac{18.2329}{30.0} = 0.61$

Sample C, $\frac{35.40}{40.0} = \frac{21.16}{40.0} = 0.53$

$X^2_{cal} = 0.28 + 0.61 + 0.53 = 1.42$

$X^2_{tab} = \alpha$ 0.05, 2 (df) = 5.991 (critical value for accepting H_o)

Comparing the calculated Chi-square value (X^2_{cal}) of 1.42 to the critical value (X^2_{tab} α 0.05, 2) of 5.991 one can say that the difference between the observed and expected crude protein levels of the prepared diets is not significant.

CHAPTER FIVE

5.0 DISCUSSION

From the results of the proximate analysis (Table 4.1) it was obvious that as the quantity of protein supplement was raised, the protein, lipid, vitamins and mineral salts levels in the feed also increased. However the level of nitrogen free extracts (carbohydrates) decreased while crude fibre levels remained the same. The observed crude protein levels were approximately 18%, 26% and 35%. These were found to be lower than their respective expected crude protein levels of 20%, 30% and 40%. The difference between the respective observed and expected crude protein levels was tested using the Chi square test of significance. At a confidence level (α) of 0.05, and degree of freedom (df) of 2 (3-1), it was found to be not significant. This means that there is no difference between the observed and expected crude protein levels of the prepared feed. So one can say that the square method of feed formulation in reliable. A possible explanation of the observed differences could be that the crude protein levels of feedstuffs were approximations and not true values (Chow et al., 1981). In effect, cultured shrimps were fed on 18%, 26% and 35% crude protein levels in the present work.

As expected the cost of production per kg of prepared feed increased with increase in protein content. This is because protein supplements cost higher than the basal feedstuff. The computed values in cedis per kg were ¢712.27, ¢ 1,135.95 and ¢1,559.48 for 20%, 30% and 40% crude protein diets respectively. With these unit costs of production, a 25 kg weight of each feed type (20%, 30% and 40% crude protein) will cost approximately ¢17,800.00, ¢28,400.00 and ¢39,000.00 respectively. These production costs are considered affordable, economical and sustainable for shrimp culture purposes. The use of the flesh of *Ostrea tulipa* as feed for cultured shrimp

(Darpaah, 1998), appears quite an expensive and unsustainable undertaking considering the task involve in capturing the animal in the wild and the competition for the flesh as food by humans.

Pillay (1983), noted that wheat bran has good laxative properties which can promote digestibility of feed but lacks lysine (an EAA) just as groundnut cake. However, this EAA abounds in soybean meal and fishmeal. Soybean meal and groundnut cake have good aromatic smell so act as attractants in shrimp feeds thus enhancing its acceptability. They are also sources of protein but lack methionine and cystine which are readily obtained from fishmeal. These EAAs enhance physiological processes thereby promoting good health and fast growth in cultured species (Halver, 1980). Again, they produce high levels of needed PUFAs in the feed thus making extraneous additions unnecessary. Soya lecithin which is sourced from soybean is well known as growth promoter in shrimps (Krishnasamy, 1997). Fishmeal is a good source of animal protein containing all EAAs. Broiler premix was added to satisfy vitamin and mineral salts requirements.

In feed formulation, the computation of required quantities of feedstuffs needed to balance the protein levels in any diet can be done using electronic devices. Computer hardware – The IBM 370 and Linear programming using standard software packages – IBM MPSX (Chow et al., 1980) respectively were commonly employed successfully in computations involved in feed formulation. The "SQUARE METHOD" (Hardy, 1980) though manual, was also well known to have been employed successfully.

Artificially formulated feeds are prepared out of different feedstuffs which are naturally heterogeneous in chemical composition and particle sizes. Preparation processes like mixing, milling and blending through which these feedstuffs are taken finally renders them as though a homogenous but composite feed material. In this state the feed might perhaps be more nutritious, digestible and or absorbable than in their original states. Pelleting the feed mash enables easy application, ensures higher water stability, minimize loss and leaching during feed administration. It also enhance the feed's sinking factor thereby promotes its accessibility and digestibility to the cultured species especially shrimps which are slow bottom feeders (Lovell, 1980).

Drying and storing enhance the feed's shelf life by eliminating fungal growth. The use of locally available Agro-Industrial By-Products (AIBPs) encourages sustainable feed production and its affordability. The in-cooperation of some locally available aromatic feed material like soybean meal and ground nut cake could enhance feed acceptability to the cultured species.

It is known that pond water conditions under which shrimp is cultured affects their health and growth. Poor or unsuitable water quality is likely to lead to higher incidence of disease, low survival, deformities or even failure of farm operation (Liong, 1990; Ong, et al., 1989). During cultural growth trials and other experiments the water quality requirements for the marine prawns have been well studied (Ting, 1970; Chen, 1976; Cawthrone et al., 1983; Chen, 1985; Liao and Murai, 1985; Chakraborti et al., 1986; Tseng, 1987). The optimal pond water conditions for healthy growth of prawn *Penaeus monodon* were summarised by Law (1988); Ong et al. (1989) and MTCP (1990) as follows: Temperature 28-32°C, pH 8.0, Dissolved oxygen 4.0-5.0 mg/L, Salinity 15-25 ‰, Ammonia nitrogen 0.01 mg/L, and Nitrite nitrogen 0.12 mg/L.

The physical and chemical parameters (Table 4.3 to 4.12 and Fig. 4.1 to 4.4) reflect the environmental conditions under which the shrimps were cultured during the present study. Efforts were made with some difficulty to deliberately control these conditions to provide a stable and growth promoting environment. Consequently, the conditions were maintained within the following ranges – Temperature 26-31°C, pH 7.5-8.5, Salinity 15-35‰, Dissolved oxygen 4.0-6.0 mg/L, Ammonia nitrogen and Nitrite nitrogen 0 mg/L.

In the present work the best growth performance for *P. notialis* was obtained in pond 6. In this pond approximate water conditions were Temperature 28°C, pH 7.6-8.3, Dissolved oxygen 5.2-5.7 mg/L and Salinity 18-33‰. Ammonia nitrogen and nitrite nitrogen levels were zero.

From the curves in Fig. 4.5, it is clear that 20% crude protein diet promoted better growth performance than those of 30% and 40% crude protein diets. This means that shrimp populations fed on 20% crude protein showed better growth than those fed on 30% and 40% crude protein diet. This assertion may be supported by the fact that at the end of culture period growth rates obtained were 12.7g per 24 week, 7.7 g per 24 week and 7.0 g per 24 week culture period for 20%, 30% and 40% crude protein diets respectively.

Comparing the values obtained for survival, average body weight at harvest and yield (Table 4.15) for the three shrimp populations one could say that shrimp populations fed on 20% crude protein diet showed best growth performance. In Darpaah (1998) shrimps were fed on flesh of *Ostrea tulipa* and values obtained for survival, average body weight (at harvest) and yield were 51%, 14/15 g (in 32 weeks) and 0.74 mt/ha per year respectively. Comparing these values correspondingly to those obtained in the present work (Table 4.15) one could say that shrimp populations fed on 20% crude protein diet showed better growth performance than flesh of *Ostrea tulipa*.

The 'b' value theoretically is indicative of the type of growth pattern associated with a particular animal. The pattern is isometric when 'b' is equal to 3 meaning the animal grows uniformly with age. The value below 3.0 is indicative of allometric growth meaning that the animal grows slimmer with time while value above 3.0 means the animal grows fatter with time. The values obtained from the pooled data for the 24 week culture period for each diet were 2.52, 2.30 and 2.18 for 20%, 30% and 40% respectively for the present work (Fig. 4.6a, 4.7a and 4.8a). These values therefore indicated that shrimps cultured during the study period grew slimmer with time. A critical look at the slope (b) revealed a general trend that reduces with higher levels of crude protein. So if 'b' values are indicative of growth performance then using this trend one could say that shrimp populations fed on 20% crude protein showed better growth than those fed on 30% and 40% crude protein diets. It can also be said that, higher dietary protein levels (eg. 30% or 40%) does not necessarily make shrimp feed a balanced diet or growth promoting diet. It is well known that in animals excess protein intake at a time can create physiological problems thereby forcing the animal to deaminate the excess protein. This process of deamination makes the animal expend energy which could result in weight loss.

Comparing the F values, 146.99, 194.64 and 3.84 for 20%/40%, 20%/30% and 30%/40% crude protein respectively one could conclude that there is significant difference between 20% and 30% and 20% and 40% but no significant difference between 30% and 40% crude protein diet. This means that, the 20% crude protein diet is the feed type effecting the significant difference.

Teichert-Coddington and Rodriguez (1996) fed feed of differing protein levels (20% and 40%) to *P. vannamei* to determine the effects on average body weight, survival and yield did not find any significant difference between the two treatments. It was therefore recommended that crude protein level of *P. vannamei* should not exceed 20%.

In the present study it is the 20% protein diet that is effecting the significant difference or promote growth in pond cultured *P. notialis* best and has the least cost of production thus making it uneconomical to use 30% and 40% crude protein diets.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Penaeus notialis the most common indigenous shrimp species in Ghana has been successfully cultured in earthen ponds for six months at Azizakpe-Lower Volta Estuary.

The lower Volta Estuary offered a good source of PLs supply for the present work and may support future similar experimental works but may not reliably support large scale commercial shrimp culture ventures. The capture operation for PLs is tedious and time consuming. It has to be carried out deep into the night, timed and tied to a suitable phase of the moon and level of tides. It depends very much, also, on chance.

For a successful culture of *P. notialis* under semi-intensive conditions in Ghana, pond water conditions or environment must be maintained within an optimum range for optimum growth. The optimum range of pond water conditions are as follows: Temperature 27.8-30.6°C, pH 7.6-8.3, Dissolved oxygen 5.2-5.7 mg/L, Salinity 19-33 ‰, Ammonia nitrogen 0 mg/L and Nitrite nitrogen 0 mg/L. The very presence of predators also threatens the survival of *P. notialis* as they compete for space and feed.

The production of good quality artificially formulated but nutritionally balanced feed of any protein level for shrimps using cheap locally available Agro-

Industrial By-Products (AIBPs) is possible and holds high prospects as a commercial venture in Ghana.

The shrimp population fed on 20% crude protein were confirmed at 0.05 significant level using F statistic test to have better growth rate/performance than 30% and 40% crude protein diets. This means the 20% crude protein diet was a better shrimp feed than the 30% and 40%. It has also the least cost of production.

With the growth rate of 13.0 g per 24 week period, two culture cycles could be undertaken in a year and with a survival rate of 49%, it is possible to attain a yield of 1.29 mt per hectare per year.

Generally, shrimp culture is possible in Ghana and holds high potentials as an economic venture.

6.2 Recommendations

For a smooth and successful take off of future commercial shrimp culture ventures in Ghana, a hatchery must be set up for the production of PLs to satisfy commercial scale demands.

Pond water conditions as spelt out in the conclusion must be maintained and predators excluded for best growth and production of cultured *P. notialis*.

Though the quality of the prepared feeds was able to sustain shrimps in ponds for 24 weeks, there is the need to improve it by developing the right premix for shrimp which is not yet available in Ghana. This will encourage local production of artificially formulated shrimp feed.

Since 20% crude protein diet cost least to prepare and promotes growth of cultured shrimp better than 30% and 40% protein diet, it is recommended as shrimp feed for better economic gain in future shrimp farming ventures in Ghana.

During the culture operations in this present work, "strange shrimp" species suspected to be *Penaeus monodon* an exotic species occurred in the ponds. Under the same pond culture conditions individuals (numbering ten) of this species weighed between 25-35 g in sixteen weeks; a rate which is about 6 times that of *P. notialis*. It is therefore recommended that scientific work be carried out on this species under Ghanaian conditions since it could be of tremendous economic benefits.

LITERATURE CITED

AQUACULTURE DEVELOPMENT AND COORDINATION PROGRAMME (ADCP/REP/80/11) 1999. A brief history of shrimp farming. Retrieved July 21, 1999 from shrimp News database on Worldwide web; http;//www.members.aol.com/brosenberr/History.html

Arrignon, JCV., Huner, J. V Lauernt, P. J., Griessinger, J. M., Lacroix, D., Gonndownm, P and Au tramd, M., 1994. Warm-water Crustaceans. The Tropical Agriculturist. Macmillan Press Ltd London. 159 pp.

Bailey, N. T. J., 1981. Statistical Methods in Bilogy (2nd ed.) Hodder and Stoughton Ltd, London. 214 pp

Bardach, J. E.; Mc Larney, W. O.; Rytter, J. H., 1972. Aquaculture; The Farming and Husbandry of Freshwater and Marine Organisms. John Wiley and Sons, Inc. Canada.

Cawthrone, D. F., Beard, T., Davenport, J., and Wicking, J. F. 1983. Response of Juvenile *penaeus monodon* to artificial and natural sea waters of low salinity. Aquaculture, 32:165-174 pp.

Chakraborti, D. F., Bhowmik, M. L. and Halder, D. D., 1986. Effect of change in salinity on the survival of *Penaeus monodon* post larvae. India J. Fish, 33:484-487.

Chanratechakool, P., J. F. Turnbull., S. Funge-Smith and C. Limsuwan, 1995. Health management in Shrimp ponds: Aquatic Animal Health Research Institute. Bangkok, Thailand. 111 pp

Chen, H. C., 1985. Water quality criteria for farming the grass shrimp *Penaeus monodon*. In: Y. Taki, J. H Primavera and J. A. L10 brera (eds), Proceedings of the First International Conference on the culture of penaeid prawns/shrimp. Aquaculture Department, SEAFDE, I10ilo, Philippines, 165 pp.

Chen, T. P., 1976. Aquaculture practices in Taiwan. Fishing News Book Ltd. Farnham, Surrey, 162 pp.

Chin, T. S. and Cheng, J. C., 1987. Acute toxicity of ammonia to larvae of the tiger prawn, *Penaeus monodon* Aquaculture. 66:247-253.

Chow, K. W., Rumsey, G. L. and Waldroup, P. W., 1980. Linear Programming in Fish Diet Formulation. 242 – 285 pp. In: Pillay, T. R. V (ed). Fish Feed Technology – Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington, Seattle, Washington 9 October – 15 December 1978.

Darpaah, G. A., 1998. Shrimp Culture Development in Ghana. Report on a Pilot shrimp culture project. 69 pp.

Dore, I and C Frimodt, 1987. An illustrated Guide to Shrimp of the world. Osprey Books. USA and Scandinavian Fishing Book, Denmark.

FAO, 1999a. The state of world Fisheries and Aquaculture 1998. Food and Agriculture Organization of the United Nation. Rome. 112 pp.

FAO, 1999b. Year book of Fisheries Statistics (Capture production). Vol. 85, Rome, Italy. 678 pp.

Fast, A. W., 1991, Development of appropriate and economically viable shrimp pond grow-out technology for the United States. Frontiers of Shrimp Research. Elsevier; Development in Aquaculture and Fisheries Science, 22, 197-240 pp.

Fischer, W., Bianchi, G., Scott, W. B (ed), 1981. FAO species identification sheet for fishery purposes. Eastern Central Atlantic; fishing area 34, 47 (in part) .

Halver, J. E., 1980. Proteins and Amino Acids. 31- 40 pp. In: Pillay, T. R. V (ed). Fish Feed Technology – Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington, Seattle, Washington 9 October – 15 December 1978.

Hambrey, J. and C. Kwei Lin., 1999. Shrimp culture in Thailand. Asian Institute of Technology, Bangkok. Retrieved September 20, 1999 from Aquafind database on worldwide web: http:/www.aquafind.com/articles/shmcul.shml

Hardy, R., 1980. Fish Feed Formulation. 233-237 pp In: Pillay, T. R. V. (ed) Fish Feed Technology – Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington, Seattle Washington 9 October – 15 December 1978.

Jobbling, M., 1994. Fish Bioenergetics. Fish and Fisheries series. Chapman and Hall, 2-6 Boundary Row, London SEI, 8HN. UK.

King, M., 1995 Fisheries Biology, Assessment and Management. Fishing News Book, Osney Mead Oxford OX2 OEL, England.

Krishnasamy, N., 1997. Soya Lecithen for better survival. INFOFISH International. An FAO bimonthly publication No. 6/97 (Nov.-Dec) 72 pp.

Krishnasamy, N., 1999; Farmed shrimp production up. INFOFISH International. An FAO bimonthly publication No. 2/99 (March-April) 72 pp.

Law, A. T., 1988. Water quality requirements for prawn farming. In: Tarlochan Single and Agn. KJ. (eds) Marine prawn farming in Malaysia, present problems, future and prospects. Malaysia Fisheries Society, Occasional paper 1, 53-66 pp

Liao. I. C. and Murai, T., 1986. Effect of dissolved oxygen temperature and salinity on the oxygen consumption of the grass shrimp. *Penaeus monodon*. In: J. L. Maclean, L. B. Dizon and L. V. Hosillos (ed). The First Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines, 642 – 646 pp.

Liong, P. C., 1990. Water supply and treatment for marine prawn hatcheries. Jabatan Perikan, Kementerian Pertanian Malaysia 50628 Kuala Lumpur.

Lovell, R. T., 1980. Practical fish diets. 334-350 pp. In Pillay, T. R. V. (ed) Fish Feed Technology – Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington 9 October – 15 December 1978.

Malaysia Technical Cooperation Training Programme, 1990. Brackish water fish and shrimp culture in ponds. Department of Fisheries, Ministry of Agriculture, Kuala Lumpur, Malaysia.

Montgomery, D. C., 1984. Design and Analysis of Experiments; Second Edition. John Wiley and Sons Inc. New York USA. 538 pp.

Nauen, C. E., 1999. Shrimp aquaculture: characterization of immune effectors for further application to disease prophylaxis and section of disease resistant shrimp. Bulletin. A monthly E. C. Fisheries Cooperation Publication. Vol. 12 No. 4 December 1999. 32 pp.

Ninawe, A. S., 1999. Coastal aquaculture versus environment: pros and cons. INFOFISH International. An FAO bimonthly publication No. 2/99 (March-April) 72 pp.

Ong. K. S., Liong, P. C. and Hambal H., 1989. Prawn/shrimp culture technology in Malaysia. Department of Fisheries. Ministry of Agriculture. Malaysia 50628 Kuala Lumpur.

Pillay, T. V. R., 1980. Fish Feed Technology. Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington, Seattle, Washington. 395 pp UNDP/FAO of UN, Rome.

Pillay, T. V. R., 1983. Fish feed and feeding in developing countries. An Interim Report on the ADCP Feed Development Programme. Rome; UNDP/FAO, ADCP/REP/83/18. 97 pp.

Rabanal, H. R., 1986. A Feasibility Report on Brackishwater Aquaculture Development in the Volta Region. A Report submitted to the Volta Region Agricultural Development Project (VORADEP). 164 pp.

Shang, Y. C., 1986. Costal Aquaculture Development in selected Asian countries. Status, potential and constraints FAO Fisheries Circular (No. 799); 63 pp.

Subramaniam, 1990. Biology of Marine Shrimp. Lecture notes prepared for an Introductory course on brackish water aquaculture. Under the Malaysian Technical Cooperation training Programme (MTCP) Malaysia 23 pp

Tavarutmanakeel and Tookwinas, 1995. Aquaculture sustainability and the environment. Thailand Study Report. NACA/ADB. Retrieved July 20, 1999 from Aquafind database on worldwide web: http:// www.aquafind .com/articles//shmcul.shml

Teichert – Coddington, D. R. and R. Rodriguez, 1996. Semi-intensive commercial grow-out of *P. vannamei* feed diets containing differing levels of crude protein during wet and dry seasons in Honduras. CRSP Research Report 96-89. *Journal of the World Aquaculture Society* 26 (1) 1995: 72-79.

Teichert – Coddington, D., 1995. Effects of protein diet and sowing density on the production of *Penaeus vannmei* in land tanks. CRSP Research Report 95-83. revista Latinoamericaca de Aquiculture. 35-29-44.

Ting, W. Y., 1970. Study on the oxygen consumption of the grass shrimp, *P. monodon* and sand shrimp, *Metapenaeus monoceros.* Bulletin. Taiwan Fish Research Institute, 16:111-118.

Tseng, W. Y., 1987. Shrimp mariculure. A practical manual. Chien Cheng Publisher, Taiwan, 305 pp.

APPENDIX 1a

Proximate constituents and gross energy content of some Agro-Industrial By-Products (AIBPs) in Ghana

AIBPs	DM	CP	% EE	ASH	CF	AC	MJ/KG GE
Cotton Seed Cake	87.82	41.79	3.82	7.86	11.46	24.88	18.03
Copra Cake	89.70	19.09	5.48	4.20	16.25	44.68	18.28
Groundnut Cake	87.39	43.75	8.62	5.63	12.29	17.10	17.46
Palm Kernel Cake	89.11	12.78	11.19	3.70	22.39	39.05	19.33
Fish meal(Anchovy)	86.60	47.88	3.71	32.33	1.23	1.45	12.85
WheatbranYeastlage	86.31	24.55	3.50	5.48	9.06	43.72	12.79
Wheat bran	89.67	16.76	5.22	5.36	12.93	49.40	13.09
Soybean meal	89.87	42.97	7.84	5.21	7.53	26.32	17.30
Brewers DiredGrain	89.85	19.65	5.27	7.74	8.48	48.71	13.48
Pito Mash	80.81	13.41	1.88	5.66	21.06	38.80	15.09
Cowpea	91.40	26.96	2.69	2.85	0.77	58.13	15.31
Dried Cocoa Husk	86.31	6.40	1.09	8.11	21.66	49.12	9.73
Rice Bran	89.18	5.23	4.59	12.73	22.28	44.43	10.05
Maize Bran	87.73	10.13	8.58	2.71	4.23	62.08	15.38
Groundnut Husk	90.59	13.58	21.04	9.50	15.07	31.46	15.51
Cocoa Cake	88.77	21.89	18.64	2.90	11.96	30.61	18.41
Wh : PKC (50:50)	83.06	17.36	9.51	5.73	21.29	29.17	14.26
Corn Cob	94.66	1.72	0.14	1.46	39.28	52.06	9.09
Corn Chaff	88.63	11.04	9.09	2.93	7.07	58.50	15.12
White Maize	88.30	8.49	1.97	1.69	2.38	73.47	14.51
Sunflowerseed meal	93.68	25.84	18.49	5.53	17.13	26.69	15.81
Cassava Peel	88.15	3.93	1.29	7.78	11.16	63.91	11.89
Cassava Peel/Yeast	88.89	17.45	12.50	17.28	11.01	30.65	12.81
White Maize	88.30	9.62	2.23	1.91	2.70	71.84	16.49
Maize Leaves	92.14	2.91	0.07	6.64	36.52	46.00	8.24

SOURCE : Animal Research Institute – C. S. I. R., Achimota-Accra

DM=Dry Matter, CP=Crude Protein, EE=Ether Extract, CF=Crude Fibre

AC= Available Carbohydrate, Wh=Wheat, PKC=Palm Kernel Cake

APPENDIX 1b

Proximate constituents of soyabean mean obtained
From Fateco Ltd.

FATECO LIMITED.
FORMER STATE FARMS CORPORATION, POKUASE
OR WRITE TO P.O. BOX 9899, ACCRA. TEL: 663114

ANALYSIS BY REPUTABLE LABORATORIES IN GHANA & EUR

LABORATORY	% PROTEIN	% FAT	% ASH	% FIBRE	% MOISTURE	AFLATOXIN
ANIMAL RESEARCH INSTITUTE (SOY BEAN COCENTRATE)	44.54	10.8	—	—	1.27-1.84	—
FOOD RESEARCH INSTITUTE (FLAKES)	44.5	9.8-14.4	—	—	5.1	—
TEMA FOOD COMPLEX CORP. (SOY BEAN COCENTRATE)	50.4	5.8	6.4	—	9.2	—
HENDRIX EXPORT, HOLLAND (FLAKES)	44.9	—	—	6.3	—	NEGATIVE
ANIMAL HEALTH & PRODUCTION DEPT. (FLAKES & CONCENTRATE)	—	—	—	—	—	NEGATIVE

APPENDIX 1c

Proximate constituents of Broiler Premix
used in the feed preparation

140192 .Ticket No 13
5555400125000915133336

BROILER PREMIX Code 140192

Mineral Feedingstuff For Poultry

Product code 140192 Expiry / Best before 13/10/2000 MAN.DATE 04/99

Batch 915133 Use 2.50 kg/tonne Net Weight 25.00 kg

ORIGIN: UNITED KINGDOM

Ingredients Vitamins, Minerals, Trace Elements and Antioxidant

Contains Analysis per 1 kg

Vitamin A	4,800,000 iu	Vitamin B12	5,000 mcg
Vitamin D3	1,400,000 iu	Biotin	32,000 mcg
Vitamin E	10,000 iu	Cobalt	200 mg
Vitamin K	1,600 mg	Selenium	80 mg
Folic Acid	600 mg	Iodine	400 mg
Nicotinic Acid	10,000 mg	Copper	6,000 mg
Pantothenic Acid	3,200 mg	Manganese	32,000 mg
Vitamin B1	600 mg	Zinc	32,000 mg
Vitamin B2	2,000 mg	Iron	24,000 mg
Vitamin B6	1,500 mg	Choline Chloride	40,000 mg
		Antioxidant-BHT	4,000 mg

Sole & Exclusive Distributor: DANNEX Ltd,
P.O.BOX 5258
ACCRA-NORTH
Tel: 232574/5 GHANA

Store in a cool dry place. Keep out of reach of children. Do not feed direct to animals.
Mix thoroughly in feed. Wear protective clothing when handling.
SPECIAL T PRODUCTS Ltd, Red Lion Building, 1 Liverpool Rd Nth, Maghull, Liverpool, U.K.

Proximate constituents of Fish meal obtained from Central Feed Mill

GHANA STANDARDS BOARD

Our Ref .... Page 1 of 2 Pages

TEST REPORT

To ... THE MANAGING DIRECTOR
KWASHIE FARMS LTD.
PMB CCC4
CANTONMENT

LABORATORY CONDUCTING TEST:
FOOD LAB.

Codes

Generalised Product Code ....
Specific Product Code ....
Officer Responsible for Report ....
Code of Approving Officer ....
Period of Report ....
Lab. No. (Serial No 407 Dept FA . Source Code 2 Year 98)

NAME OF SAMPLE PRO PACK REGULAR .... SAMPLE SIZE ....
DATE RECEIVED ..... 98-07-02 .... DATE OF REPORT 98-07-07 ..
SOURCE/PURPOSE .... QUALITY EVALUATION ....

TEST CODE	TEST CONDUCTED	UNIT	RESULTS	TEST METHODS	SPECIFICATION
	Moisture	%	7,3		
	Fat	%	7,4		
	Protein	%	61,5		
	Ash	%	18,5		
	Acid Insoluble Ash	%	0,5		
	Crude Fibre	%	0,5		
	Aflatoxin		Not Detected		

GHANA STANDARDS BOARD

Our Ref ....

TEST REPORT

To DIRECTOR
CENTRAL FEEDMILL LTD.
P. O. BOX 1576
ACCRA

LABORATORY CONDUCTING TEST: FOOD LAB.

Codes

Generalised Product Code ....
Specific Product Code ....
Officer Responsible for Report ....
Code of Approving Officer ....
Period of Report ....
Lab. No. - [Serial No. 210 Dept FA Source Code 2 Year 95]

NAME OF SAMPLE GROUNDNUT CAKE

SAMPLE SIZE ....

DATE RECEIVED 95-03-29

DATE OF REPORT 95-04-06

SOURCE/PURPOSE QUALITY ASSESSMENT

TEST CODE	TEST CONDUCTED	UNIT	RESULTS	TEST METHODS	SPECIFICATION
	Moisture	%	11,7		
	Total Ash	%	5,5		
	Crude Fat	%	0,73		
	Crude Fibre	%	32,3		
	Protein	%	45,3		
	Aflatoxins		Not Detected		
	Carbohydrate (By difference)		4,5		

APPENDIX 2

Sample of daily record of water quality and feed ration (Record Sheet 1)

POND No: 1 AREA: 0.023 ha STOCK SIZE: 2400 SIZE/ABW: 0.67 gm

STOCKING DATE: 20/06/00 TIME: $3.^{00}$ - $6.^{00}$ hrs FRY SOURCE: Wild FRY CONDITION: Good

DATE	AGE Days	FEED WEIGHT (gm)				TOTAL (gm)	WATER QUALITY						% FEED LEFT				REMARKS
		6:00 PEL	12:00 PEL	18:00 PEL	24:00 PEL		TEM °F	PH	SAL ‰	DO mg/L	NH_3-N	NO_2-N	06:00	12:00	18:00	24:00	
20/06/00	1	40.0	40.0	40.0	40.0	160.0	76	8.0	26	4.0	0	0					
	2	"	"	"	"	"											
	3	"	"	"	"	"											
	4	"	"	"	"	"											
23/06/00	5					"	78	8.0	28	4.0	0	0					H_2o colour-slight green
	6					"											
	7					"											
	8					"											
	9					"											
	10					"											
29/06/00	11	4.0	4.0	4.0	4.0	160.0	84	8.0	30	4.0	0	0					
						"											
						"											
	14					160											
	.					"											
	.					"											
	.					"											
	.					"											
	.					"											
	.					"											
10/06/00						"	84	7.5	35	4.8	0	0					
11/06/00	.	4.0	4.0	4.0	4.0	160	86	8.0	30	5.8	0	0					
	.					"											
	.					"											
	.					160											
						"											
						"											
	.					160											
	.					"											
20/06/00	31					160	84	8.0	32	5.2	0	0					
						4.96 kg											31 Feeding days

APPENDIX 3
Sample of growth monitoring data sheet
(Sample Data Sheet 'A')

EXPERIMENTAL POND POND NO. 3 SAMPLING METHOD CAST NET
SPECIES P. NOTIALIS, NO. SAMPLED 50 DATE/TIME 13/11/00 6.00 A.M.

NO	R. L	C. L	T. L.	B. WT	SEX	G.WT		NO	R.L	C.R	T.L	B. WT	SEX	G.WT
1	1.2	1.7	7.6	4.0	F			31	1.2	1.7	7.3	4.0	F	
2	1.2	1.7	7.5	4.2	F			32	1.2	1.8	7.7	4.2	M	
3	1.2	1.7	7.4	4.5	F			33	1.1	1.7	7.3	4.0	F	
4	1.2	1.7	7.6	4.0	F			34	1.1	1.6	7.4	4.0	M	
5	1.1	1.7	7.5	4.2	F			35	1.2	1.6	7.0	3.5	F	
6	1.2	1.6	7.5	4.0	M			36	1.2	1.7	7.4	4.0	F	
7	1.2	1.7	7.4	4.5	F			37	1.2	1.7	7.1	4.0	F	
8	1.2	1.7	7.7	3.5	M			38	1.2	1.6	7.4	3.5	F	
9	1.1	1.5	7.1	5.0	M			39	1.2	1.7	7.8	4.5	F	
10	1.0	1.5	6.8	4.0	M			40	1.2	1.7	7.6	3.0	M	
11	1.2	1.7	7.3	3.0	F			41	1.2	1.7	7.3	3.5	F	
12	1.3	1.8	7.6	4.0	M			42	1.1	1.6	7.0	3.0	F	
13	1.2	1.6	7.3	4.0	M			43	1.1	1.6	7.0	3.5	F	
14	1.2	1.6	7.0	4.0	F			44	1.1	1.6	7.2	4.0	F	
15	1.1	1.6	7.2	3.2	F			45	1.2	1.7	7.4	4.0	F	
16	1.2	1.7	7.5	4.0	F			46	1.5	1.8	8.6	6.0	M	
17	1.2	1.6	7.3	4.0	F			47	1.2	1.7	7.3	4.0	F	
18	1.1	1.6	7.0	3.0	M			48	1.3	1.7	7.8	4.0	M	
19	1.1	1.5	7.0	4.0	M			49	1.1	1.6	7.0	3.0	F	
20	1.1	1.6	7.2	4.0	F			50	1.1	1.6	7.0	4.0	M	
21	1.1	1.6	7.1	3.5	F			Total			366.3	196.3		
22	1.2	1.7	7.2	4.0	F			Av			7.326	3.926		
23	1.2	1.7	7.2	4.0	M									
24	1.1	1.7	7.3	4.0	M									
25	1.1	1.7	7.2	4.0	M			STRANGE SPECIES SUSPECTED TO P. MONODON						
26	1.1	1.7	7.2	4.0	F			1	2.5	3.7	15.0	27.0	F	
27	1.1	1.7	7.4	4.0	M			2	2.7	3.7	15.8	28.0	F	
28	1.1	1.6	7.0	4.0	M			3	2.4	3.6	14.5	26.0	F	
29	1.2	1.7	7.3	4.0	M									
30	1.1	1.6	7.3	4.0	M									

APPENDIX 4

Analysis of variance (ANOVA): Two factor with replication

20/40

SUMMARY	Count	Sum	Average	Variance
Row 1	6	67.652	11.27533	2.699058
Row 2	6	37.469	6.244833	0.572319
Column 1	2	13.523	6.7615	4.581365
Column 2	2	16.13	8.065	13.99205
Column 3	2	17.782	8.891	14.41845
Column 4	2	18.504	9.252	12.72097
Column 5	2	19.477	9.7385	16.30776
Column 6	2	19.705	9.8525	16.47954

ANOVA

rce of Varia	SS	df	MS	F	P-value	F crit
Rows	75.91779	1	75.91779	146.994	6.74E-05	6.607877
Columns	13.77454	5	2.754908	5.334126	0.044985	5.050339
Error	2.582343	5	0.516469			
Total	92.27467	11				

Anova: Two-Factor With Replication

20/30

SUMMARY	Count	Sum	Average	Variance
Row 1	6	40.895	6.815833	1.036439
Row 2	6	67.652	11.27533	2.699058
Column 1	2	13.203	6.6015	5.601205
Column 2	2	17.578	8.789	7.380482
Column 3	2	18.972	9.486	8.7362
Column 4	2	18.312	9.156	13.70785
Column 5	2	20.062	10.031	13.13794
Column 6	2	20.42	10.21	12.63034

ANOVA

rce of Varia	SS	df	MS	F	P-value	F crit
Rows	59.66142	1	59.66142	194.6425	3.4E-05	6.607877
Columns	17.1449	5	3.42898	11.18688	0.009571	5.050339
Error	1.53259	5	0.306518			
Total	78.33891	11				

Anova: Two-Factor With Replication

30/40

SUMMARY	Count	Sum	Average	Variance
Row 1	6	40.895	6.815833	1.036439
Row 2	6	37.469	6.244833	0.572319
Column 1	2	10.176	5.088	0.0512
Column 2	2	12.288	6.144	1.048352
Column 3	2	13.602	6.801	0.70805
Column 4	2	13.268	6.634	0.018432
Column 5	2	14.351	7.1755	0.171113
Column 6	2	14.679	7.3395	0.255612

ANOVA

rce of Varia	SS	df	MS	F	P-value	F crit
Rows	0.978123	1	0.978123	3.836872	0.107454	6.607877
Columns	6.769154	5	1.353831	5.310656	0.045373	5.050339
Error	1.274636	5	0.254927			
Total	9.021913	11				

APPENDIX 5

Logarithmic values of body weight and length for *P. notialis* fed on 20% crude protein

POND 5:19/08/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.1	0.041	4.0	0.602	26	1.4	0.146	2.0	0.301
2	1.4	0.146	3.0	0.477	27	1.7	0.230	4.0	0.602
3	1.6	0.204	4.0	0.602	28	1.4	0.146	2.0	0.301
4	1.1	0.041	4.0	0.602	29	1.4	0.146	3.0	0.477
5	1.2	0.079	2.0	0.301	30	1.5	0.176	3.0	0.477
6	1.4	0.146	2.0	0.301	31	1.4	0.146	2.0	0.301
7	1.3	0.114	2.0	0.301	32	1.4	0.146	3.0	0.477
8	1.1	0.041	1.8	0.255	33	1.4	0.146	2.0	0.301
9	1.1	0.041	2.0	0.301	34	1.4	0.146	3.0	0.477
10	1.9	0.279	3.0	0.301	35	1.2	0.079	2.0	0.301
11	1.7	0.230	5.0	0.699	36	1.6	0.204	3.0	0.477
12	1.4	0.146	4.0	0.602	37	1.8	0.255	4.0	0.602
13	1.4	0.146	3.0	0.477	38	2.0	0.301	6.0	0.778
14	1.5	0.176	2.0	0.301	39	1.5	0.176	4.0	0.602
15	1.6	0.204	3.0	0.477	40	2.0	0.301	4.0	0.602
16	1.1	0.041	3.0	0.477	41	1.4	0.146	2.0	0.301
17	1.3	0.114	2.0	0.301	42	1.8	0.255	4.0	0.602
18	1.8	0.255	4.0	0.602	43	1.6	0.204	2.0	0.301
19	1.2	0.079	1.8	0.255	44	1.7	0.230	2.0	0.301
20	1.3	0.114	3.0	0.477	45	1.4	0.146	2.0	0.301
21	1.1	0.041	3.0	0.477	46	1.3	0.114	1.0	0.000
22	1.4	0.146	3.0	0.477	47	1.3	0.114	2.0	0.301
23	1.1	0.041	2.0	0.301	48	1.2	0.079	1.0	0.000
24	1.3	0.114	3.0	0.477	49	1.3	0.114	2.0	0.301
25	1.1	0.041	1.8	0.255	50	1.5	0.176	3.0	0.477

POND 5: 29/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.9	0.279	4.0	0.602	26	1.7	0.230	4.0	0.602
2	1.7	0.230	3.0	0.477	27	1.6	0.204	3.5	0.580
3	1.5	0.176	3.0	0.477	28	1.6	0.204	3.5	0.580
4	1.8	0.255	5.0	0.699	29	1.7	0.230	4.5	0.653
5	1.6	0.204	4.0	0.602	30	1.6	0.204	4.0	0.602
6	1.6	0.204	4.0	0.602	31	1.6	0.204	3.0	0.477
7	1.6	0.204	3.5	0.580	32	1.5	0.176	3.0	0.477
8	1.5	0.176	3.5	0.580	33	1.6	0.204	3.5	0.544
9	1.6	0.204	4.0	0.602	34	1.5	0.176	3.5	0.544
10	1.6	0.204	4.5	0.653	35	1.6	0.204	4.0	0.602
11	1.7	0.230	3.5	0.580	36	1.6	0.255	3.5	0.544
12	1.6	0.204	4.5	0.653	37	1.8	0.176	4.0	0.602
13	1.6	0.204	3.0	0.477	38	1.5	0.204	3.8	0.580
14	1.5	0.176	4.0	0.602	39	1.6	0.204	4.0	0.602
15	1.8	0.255	4.0	0.602	40	1.6	0.204	4.0	0.602
16	1.4	0.146	3.5	0.580	41	1.6	0.230	3.0	0.477
17	1.7	0.230	4.2	0.623	42	1.7	0.204	3.5	0.544
18	1.4	0.146	3.0	0.477	43	1.6	0.204	3.5	0.544
19	1.8	0.255	4.0	0.602	44	1.6	0.230	3.8	0.580
20	1.8	0.255	4.2	0.623	45	1.7	0.204	6.0	0.778
21	1.6	0.204	3.0	0.477	46	1.6	0.204	3.0	0.477
22	1.7	0.230	4.0	0.602	47	1.6	0.230	3.0	0.477
23	1.9	0.279	3.5	0.580	48	1.7	0.176	4.0	0.602
24	1.6	0.204	4.0	0.602	49	1.5	0.230	3.8	0.580
25	1.6	0.204	3.0	0.477	50	1.7	0.230	3.8	0.580

POND 5: 17/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.0	0.301	5.0	0.699	26	1.8	0.255	4.3	0.633
2	1.8	0.255	3.3	0.519	27	1.6	0.204	3.8	0.580
3	1.6	0.204	3.3	0.519	28	1.6	0.204	3.8	0.580
4	1.9	0.279	5.4	0.732	29	1.7	0.230	4.8	0.681
5	1.8	0.255	4.3	0.633	30	1.7	0.230	4.3	0.633
6	1.7	0.230	4.2	0.623	31	1.7	0.230	3.3	0.519
7	1.7	0.230	3.9	0.591	32	1.7	0.230	3.4	0.531
8	1.6	0.204	3.8	0.580	33	1.6	0.204	3.2	0.505
9	1.7	0.230	4.4	0.643	34	1.8	0.255	3.8	0.580
10	1.7	0.230	4.6	0.663	35	1.7	0.230	3.7	0.568
11	1.8	0.255	3.8	0.580	36	1.9	0.279	4.4	0.643
12	1.6	0.204	4.8	0.681	37	1.6	0.204	3.8	0.580
13	1.6	0.204	3.4	0.531	38	1.8	0.255	4.3	0.633
14	1.6	0.204	4.3	0.633	39	1.7	0.230	4.3	0.633
15	1.9	0.279	4.4	0.643	40	1.7	0.230	4.3	0.633
16	1.5	0.176	3.8	0.580	41	1.7	0.230	4.3	0.633
17	1.7	0.230	4.5	0.653	42	1.6	0.204	3.4	0.531
18	1.5	0.176	4.3	0.633	43	1.7	0.230	3.8	0.580
19	1.9	0.279	4.3	0.633	44	1.7	0.230	4.1	0.613
20	1.9	0.279	4.5	0.653	45	1.9	0.279	6.6	0.820
21	1.7	0.230	3.4	0.531	46	1.7	0.230	3.3	0.519
22	1.7	0.230	4.4	0.643	47	1.7	0.230	3.2	0.505
23	1.9	0.279	3.8	0.580	48	1.7	0.230	3.2	0.505
24	1.7	0.230	4.3	0.633	49	1.8	0.255	4.1	0.613
25	1.7	0.230	3.5	0.544	50	1.8	0.255	4.3	0.633

POND 5: 14/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	5.0	0.699	26	1.7	0.230	5.0	0.699
2	1.7	0.230	5.0	0.699	27	1.9	0.279	5.0	0.699
3	1.7	0.230	4.0	0.602	28	1.7	0.230	5.0	0.699
4	1.7	0.230	4.0	0.602	29	1.7	0.230	4.0	0.602
5	1.6	0.204	5.0	0.699	30	1.8	0.255	4.0	0.602
6	1.8	0.255	4.0	0.602	31	1.8	0.255	4.0	0.602
7	1.7	0.230	3.5	0.544	32	1.6	0.204	3.8	0.580
8	1.8	0.255	5.0	0.699	33	1.9	0.279	4.5	0.653
9	1.7	0.230	4.0	0.602	34	1.9	0.279	4.3	0.633
10	1.7	0.230	5.0	0.699	35	1.8	0.255	4.0	0.602
11	1.8	0.255	5.0	0.699	36	1.8	0.255	4.0	0.602
12	1.7	0.230	4.0	0.602	37	1.8	0.255	4.5	0.653
13	1.7	0.230	4.0	0.602	38	1.7	0.230	3.8	0.580
14	1.7	0.230	4.0	0.602	39	1.8	0.255	5.0	0.690
15	1.7	0.230	4.0	0.602	40	1.7	0.230	4.0	0.602
16	1.7	0.230	4.0	0.602	41	1.7	0.230	4.0	0.602
17	1.8	0.255	4.0	0.602	42	1.8	0.255	4.0	0.602
18	1.7	0.230	5.0	0.699	43	1.8	0.255	4.0	0.602
19	1.2	0.322	6.0	0.778	44	1.8	0.255	4.0	0.602
20	1.6	0.204	3.8	0.580	45	1.8	0.255	4.0	0.602
21	1.8	0.255	3.5	0.544	46	1.8	0.255	4.5	0.653
22	1.6	0.204	4.0	0.602	47	1.7	0.230	4.2	0.623
23	1.6	0.204	4.0	0.602	48	1.7	0.230	3.5	0.544
24	1.7	0.230	4.0	0.602	49	1.7	0.230	4.0	0.602
25	1.6	0.204	3.5	0.544	50	1.8	0.255	4.5	0.653

POND 5: 17/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	4.6	0.663	26	1.6	0.204	3.6	0.556
2	1.8	0.255	4.1	0.613	27	1.7	0.230	4.1	0.613
3	1.7	0.230	3.7	0.568	28	1.6	0.204	4.1	0.613
4	1.8	0.255	4.3	0.633	29	1.6	0.204	4.1	0.613
5	1.8	0.255	4.7	0.672	30	1.8	0.255	3.6	0.556
6	1.8	0.255	4.1	0.613	31	1.7	0.230	3.9	0.591
7	1.8	0.255	4.1	0.613	32	1.2	0.322	6.1	0.785
8	1.8	0.255	4.1	0.613	33	1.7	0.230	5.1	0.708
9	1.9	0.279	4.1	0.613	34	1.8	0.255	4.1	0.613
10	1.7	0.230	4.1	0.613	35	1.8	0.255	4.1	0.613
11	1.7	0.230	4.1	0.613	36	1.7	0.230	4.1	0.613
12	1.8	0.255	5.1	0.708	37	1.7	0.230	4.1	0.613
13	1.8	0.255	3.9	0.591	38	1.7	0.230	4.1	0.613
14	1.8	0.255	4.6	0.663	39	1.7	0.230	4.1	0.613
15	1.8	0.255	4.1	0.613	40	1.9	0.279	5.1	0.708
16	1.9	0.279	4.1	0.613	41	1.7	0.230	5.1	0.708
17	1.9	0.279	4.5	0.653	42	1.7	0.230	4.1	0.613
18	1.9	0.279	4.6	0.663	43	1.9	0.279	5.1	0.708
19	1.7	0.230	3.9	0.591	44	1.7	0.230	3.6	0.556
20	1.8	0.255	4.1	0.613	45	1.9	0.279	4.1	0.613
21	1.8	0.255	4.1	0.613	46	1.6	0.204	5.1	0.708
22	1.7	0.230	4.1	0.613	47	1.8	0.255	4.1	0.613
23	1.7	0.230	5.1	0.708	48	1.7	0.230	4.1	0.613
24	2.0	0.301	5.1	0.708	49	1.7	0.230	5.1	0.708
25	1.7	0.230	5.1	0.708	50	1.8	0.255	5.1	0.708

POND 5:17/01/01

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.9	0.279	5.3	0.724	26	1.8	0.255	5.3	0.724
2	1.7	0.230	5.2	0.716	27	2.0	0.301	5.2	0.716
3	1.7	0.230	4.2	0.623	28	1.7	0.230	5.2	0.716
4	1.9	0.279	4.3	0.633	29	1.7	0.230	4.2	0.623
5	1.6	0.204	5.2	0.716	30	1.9	0.279	4.2	0.623
6	1.9	0.279	4.2	0.623	31	1.8	0.255	4.2	0.623
7	1.8	0.255	3.8	0.580	32	1.8	0.255	4.1	0.613
8	2.0	0.301	5.3	0.724	33	1.9	0.279	4.7	0.672
9	1.8	0.255	4.2	0.623	34	1.9	0.279	4.6	0.663
10	1.7	0.230	5.2	0.716	35	1.9	0.279	4.2	0.623
11	1.9	0.279	5.2	0.716	36	1.8	0.255	4.2	0.623
12	1.7	0.230	4.2	0.623	37	1.8	0.255	4.7	0.672
13	1.8	0.255	4.2	0.623	38	1.9	0.279	4.1	0.613
14	1.7	0.230	4.2	0.623	39	1.8	0.255	5.2	0.716
15	1.7	0.230	4.2	0.623	40	1.7	0.230	4.2	0.623
16	1.9	0.279	4.3	0.623	41	1.7	0.230	4.2	0.623
17	1.8	0.255	4.2	0.623	42	1.9	0.279	4.2	0.623
18	1.7	0.23	5.2	0.716	43	1.8	0.255	4.2	0.623
19	1.8	0.255	6.2	0.792	44	1.9	0.279	4.3	0.633
20	1.8	0.255	4	0.602	45	1.8	0.255	4.2	0.623
21	1.8	0.255	3.7	0.568	46	1.8	0.255	4.8	0.681
22	1.6	0.204	4.2	0.623	47	1.8	0.255	4.4	0.643
23	1.6	0.204	4.2	0.623	48	1.8	0.255	3.9	0.591
24	1.8	0.255	4.3	0.633	49	1.8	0.255	4.2	0.623
25	1.6	0.204	3.8	0.580	50	1.8	0.255	4.7	0.672

POND 6: 07/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.4	0.380	9.0	0.954	26	2.4	0.380	10.0	1
2	2.3	0.362	8.0	0.903	27	2.1	0.322	10.0	1
3	2.3	0.362	9.0	0.954	28	2.4	0.380	9.0	0.954
4	2.4	0.380	9.0	0.954	29	2.0	0.301	7.0	0.845
5	2.6	0.415	11.0	1.041	30	2.2	0.342	8.0	0.903
6	1.9	0.279	6.0	0.778	31	2.1	0.322	9.0	0.954
7	2.4	0.380	8.0	0.903	32	2.2	0.342	9.0	0.954
8	2.2	0.342	6.0	0.778	33	2.0	0.301	8.0	0.903
9	2.0	0.301	6.0	0.778	34	1.7	0.230	6.0	0.778
10	2.5	0.398	9.0	0.954	35	2.1	0.322	10.0	1
11	2.4	0.380	11.0	1.041	36	2.0	0.301	8.0	0.903
12	2.3	0.362	7.0	0.845	37	2.0	0.301	7.0	0.845
13	2.4	0.380	8.0	0.903	38	2.0	0.301	9.0	0.954
14	2.0	0.301	5.0	0.699	39	2.4	0.380	10.0	1
15	2.3	0.362	9.0	0.954	40	1.8	0.255	6.0	0.778
16	2.2	0.342	8.0	0.903	41	2.2	0.342	9.0	0.954
17	2.4	0.380	8.0	0.903	42	2.1	0.322	7.0	0.845
18	1.9	0.279	5.0	0.699	43	2.1	0.322	9.0	0.954
19	2.9	0.462	12.0	1.041	44	2.0	0.301	8.0	0.903
20	2.5	0.398	9.0	0.954	45	2.0	0.301	8.0	0.903
21	2.3	0.362	10.0	1	46	2.2	0.342	9.0	0.954
22	2.3	0.362	8.0	0.903	47	2.0	0.301	6.0	0.778
23	2.5	0.398	12.0	1.079	48	2.1	0.322	8.0	0.903
24	2.0	0.301	9.0	0.954	49	2.2	0.342	8.0	0.903
25	2.4	0.380	9.0	0.954	50	2.0	0.301	7.0	0.845

POND 6: 30/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.5	0.398	11.5	1.061	26	1.9	0.279	6.0	0.778
2	2.5	0.398	13.0	1.114	27	2.3	0.362	10.0	1.000
3	2.4	0.380	10.0	1.000	28	2.4	0.380	12.0	1.079
4	2.5	0.398	10.0	1.000	29	2.3	0.362	10.0	1.000
5	2.5	0.398	12.0	1.079	30	2.3	0.362	11.0	1.041
6	2.4	0.380	11.0	1.041	31	2.2	0.342	8.0	0.903
7	2.4	0.380	13.0	1.114	32	2.2	0.342	11.0	1.041
8	2.4	0.380	10.0	1.000	33	2.5	0.398	11.8	1.072
9	2.3	0.362	10.5	1.021	34	2.7	0.431	14.0	1.146
10	2.4	0.380	10.0	1.000	35	2.6	0.415	13.5	1.130
11	2.7	0.431	14.0	1.146	36	2.5	0.398	13.0	1.114
12	2.2	0.342	9.0	0.954	37	2.3	0.362	10.0	1.000
13	2.5	0.398	12.2	1.086	38	2.4	0.380	10.5	1.021
14	2.4	0.380	9.0	0.954	39	2.7	0.431	13.0	1.114
15	2.3	0.362	10.5	1.021	40	2.5	0.398	11.0	1.041
16	2.4	0.380	11.5	1.061	41	2.3	0.362	9.0	0.954
17	2.3	0.362	9.0	0.954	42	2.3	0.362	12.0	1.079
18	2.4	0.380	11.5	1.061	43	2.5	0.398	12.0	1.079
19	2.1	0.322	9.5	0.978	44	2.2	0.342	7.5	0.875
20	2.4	0.380	13.0	1.114	45	2.3	0.362	11.5	1.061
21	2.4	0.380	9.0	0.954	46	2.3	0.362	9.0	0.954
22	2.3	0.362	10.5	1.021	47	2.3	0.362	9.5	0.978
23	2.5	0.398	14.5	1.161	48	2.3	0.362	9.0	0.954
24	2.5	0.398	10.5	1.021	49	2.3	0.362	9.0	0.954
25	2.2	0.342	9.5	0.978	50	2.0	0.301	8.0	0.903

POND 6: 12/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.4	0.380	11.0	1.041	26	2.7	0.431	11.0	1.041
2	2.5	0.398	10.0	1.000	27	2.5	0.398	12.0	1.079
3	2.6	0.415	13.0	1.114	28	2.4	0.380	10.0	1.000
4	2.8	0.447	14.0	1.146	29	2.6	0.415	11.0	1.041
5	2.5	0.398	12.0	1.079	30	2.9	0.462	14.0	1.146
6	2.5	0.398	12.0	1.079	31	2.2	0.342	11.0	1.041
7	2.4	0.380	10.0	1.000	32	2.2	0.342	13.0	1.114
8	2.4	0.380	14.0	1.146	33	2.5	0.398	12.0	1.079
9	2.7	0.431	13.0	1.114	34	2.7	0.431	11.0	1.041
10	2.5	0.398	12.0	1.079	35	2.6	0.415	10.0	1.000
11	2.4	0.380	10.0	1.000	36	2.5	0.398	13.0	1.114
12	2.7	0.431	14.0	1.146	37	2.3	0.362	13.0	1.114
13	2.4	0.380	11.0	1.041	38	2.4	0.380	10.0	1.000
14	2.7	0.431	12.5	1.097	39	2.7	0.431	12.0	1.079
15	2.5	0.398	12.0	1.079	40	2.5	0.398	10.0	1.000
16	2.6	0.415	12.1	1.083	41	2.3	0.362	9.0	0.954
17	2.4	0.380	10.2	1.009	42	2.3	0.362	10.0	1.000
18	2.5	0.398	11.0	1.041	43	2.5	0.398	10.0	1.000
19	2.4	0.380	11.0	1.041	44	2.2	0.342	10.0	1.000
20	2.7	0.431	14.0	1.146	45	2.3	0.362	11.0	1.041
21	2.8	0.447	14.0	1.146	46	2.3	0.362	10.0	1.000
22	2.5	0.398	12.0	1.079	47	2.3	0.362	10.0	1.000
23	2.5	0.398	12.0	1.079	48	2.3	0.362	10.0	1.000
24	2.8	0.447	14.0	1.146	49	2.3	0.362	12.0	1.079
25	2.7	0.431	12.0	1.079	50	2.0	0.301	11.0	1.041

POND 6: 14/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.3	0.362	10.0	1	26	2.4	0.380	12.0	1.079
2	2.5	0.398	11.0	1.041	27	2.0	0.301	13.0	1.114
3	2.4	0.380	11.5	1.061	28	2.4	0.380	11.0	1.041
4	2.7	0.431	13.0	1.114	29	2.1	0.322	10.0	1.000
5	2.5	0.398	13.0	1.114	30	2.4	0.380	11.0	1.041
6	2.4	0.380	14.0	1.146	31	2.4	0.380	11.5	1.061
7	2.4	0.380	13.0	1.114	32	2.3	0.362	11.0	1.041
8	2.4	0.380	11.5	1.061	33	2.6	0.415	12.0	1.079
9	2.5	0.398	13.2	1.121	34	2.3	0.362	11.0	1.041
10	2.4	0.380	12.0	1.079	35	2.4	0.380	12.0	1.079
11	2.4	0.380	12.0	1.079	36	2.4	0.380	12.5	1.097
12	2.4	0.380	10.0	1	37	2.6	0.415	12.5	1.097
13	2.7	0.431	15.0	1.176	38	2.5	0.398	12.5	1.097
14	2.4	0.380	12.0	1.079	39	2.3	0.362	12.0	1.079
15	2.1	0.322	11.0	1.041	40	2.5	0.398	12.0	1.079
16	2.2	0.342	11.0	1.041	41	2.1	0.322	10.0	1.000
17	2.6	0.415	11.5	1.061	42	2.6	0.415	11.5	1.061
18	2.4	0.380	11.0	1.041	43	2.3	0.362	10.5	1.021
19	2.4	0.380	11.0	1.041	44	2.4	0.380	11.0	1.041
20	2.4	0.380	13.0	1.114	45	2.6	0.415	12.0	1.079
21	2.4	0.380	13.0	1.114	46	2.1	0.322	10.5	1.021
22	2.2	0.342	11.0	1.041	47	2.4	0.380	13.0	1.114
23	2.3	0.362	11.0	1.041	48	2.4	0.380	11.5	1.061
24	2.4	0.380	12.0	1.079	49	2.3	0.362	11.0	1.041
25	2.3	0.362	12.0	1.079	50	2.4	0.380	13.0	1.114

POND 6: 25/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.7	0.431	12.1	1.083	26	13.0	1.114	13.0	1.114
2	2.7	0.431	13.0	1.114	27	15.1	1.179	15.1	1.179
3	2.6	0.415	11.0	1.041	28	13.0	1.114	13.0	1.114
4	2.7	0.431	11.0	1.041	29	13.0	1.114	13.0	1.114
5	2.6	0.415	11.0	1.041	30	2.9	0.462	15.1	1.179
6	2.5	0.398	12.0	1.079	31	2.7	0.431	15.0	1.176
7	2.7	0.431	11.0	1.041	32	2.4	0.380	12.0	1.079
8	2.5	0.398	11.0	1.041	33	2.6	0.415	12.0	1.079
9	2.6	0.415	11.1	1.045	34	2.4	0.380	11.2	1.049
10	2.6	0.415	10.0	1.000	35	2.6	0.415	13.1	1.117
11	2.5	0.398	11.0	1.041	36	2.6	0.415	13.0	1.114
12	2.4	0.380	13.0	1.114	37	2.7	0.431	13.5	1.130
13	2.6	0.415	11.0	1.041	38	2.4	0.380	12.0	1.079
14	2.5	0.398	14.1	1.149	39	2.7	0.431	15.0	1.176
15	2.7	0.431	14.0	1.146	40	2.4	0.380	11.0	1.041
16	2.8	0.447	11.0	1.041	41	2.5	0.398	13.0	1.114
17	2.5	0.398	12.0	1.079	42	2.5	0.398	14.1	1.149
18	2.5	0.398	13.0	1.114	43	2.5	0.398	15.1	1.179
19	2.6	0.415	14.0	1.146	44	2.4	0.380	11.0	1.041
20	2.7	0.431	12.0	1.079	45	2.5	0.398	13.0	1.114
21	2.7	0.431	15.1	1.179	46	2.5	0.398	13.0	1.114
22	2.9	0.462	12.0	1.079	47	2.8	0.447	15.1	1.179
23	2.7	0.431	11.0	1.041	48	2.6	0.415	14.0	1.146
24	2.5	0.398	13.0	1.114	49	2.5	0.398	11.0	1.041
25	2.5	0.398	12.0	1.079	50	2.4	0.380	12.0	1.079

POND 6: 25/01/01

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.5	0.398	12.2	1.086	26	2.8	0.447	12.2	1.086
2	2.6	0.415	11.1	1.045	27	2.6	0.415	13.2	1.121
3	2.6	0.415	14.1	1.149	28	2.5	0.398	11.1	1.045
4	2.8	0.447	15.2	1.182	29	2.7	0.431	12.1	1.083
5	2.5	0.398	13.2	1.121	30	2.9	0.462	15.3	1.185
6	2.5	0.398	13.1	1.117	31	2.7	0.431	12.1	1.083
7	2.5	0.398	11.1	1.045	32	2.7	0.431	14.2	1.152
8	2.5	0.398	15.2	1.182	33	2.6	0.415	13.1	1.117
9	2.5	0.398	14.2	1.152	34	2.5	0.398	12.1	1.083
10	2.6	0.415	13.1	1.117	35	2.5	0.398	11.1	1.045
11	2.5	0.398	11.1	1.045	36	2.6	0.415	14.2	1.152
12	2.7	0.431	15.1	1.179	37	2.7	0.431	14.3	1.155
13	2.5	0.398	12.2	1.086	38	2.4	0.380	11.1	1.045
14	2.7	0.431	13.6	1.134	39	2.7	0.431	13.1	1.117
15	2.6	0.415	13.1	1.117	40	2.4	0.380	11.1	1.045
16	2.6	0.415	13.2	1.121	41	2.5	0.398	10.1	1.004
17	2.5	0.398	11.3	1.053	42	2.5	0.398	11.3	1.053
18	2.6	0.415	12.2	1.086	43	2.5	0.398	11.1	1.045
19	2.5	0.398	12.1	1.083	44	2.4	0.380	11.1	1.045
20	2.8	0.447	15.1	1.179	45	2.5	0.398	12.1	1.083
21	3.0	0.477	15.2	1.182	46	2.5	0.398	11.2	1.049
22	2.6	0.415	13.1	1.117	47	2.8	0.447	11.1	1.045
23	2.6	0.415	13.2	1.121	48	2.6	0.415	11.1	1.045
24	2.8	0.447	15.2	1.182	49	2.5	0.398	13.1	1.117
25	2.8	0.447	13.2	1.121	50	2.4	0.380	12.2	1.086

APPENDIX 6

Logarithmic values of body weight and length for *P. notialis* fed on 30% crude protein

POND 3: 18/08/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.5	0.176	2.0	0.301	26	1.6	0.204	2.0	0.301
2	1.5	0.176	4.0	0.602	27	1.5	0.176	3.0	0.477
3	1.5	0.176	6.0	0.778	28	1.5	0.176	4.0	0.602
4	1.4	0.146	4.0	0.602	29	1.6	0.204	3.0	0.477
5	1.5	0.176	4.0	0.602	30	1.5	0.176	3.0	0.477
6	1.5	0.176	3.0	0.477	31	1.8	0.225	5.8	0.763
7	1.8	0.255	4.0	0.602	32	1.4	0.146	1.8	0.255
8	1.5	0.176	2	0.301	33	1.4	0.146	3.8	0.579
9	1.5	0.176	3.8	0.579	34	1.4	0.146	3.0	0.477
10	1.3	0.114	3.0	0.477	35	1.8	0.255	6.0	0.778
11	1.4	0.146	2.5	0.398	36	1.4	0.146	3.0	0.477
12	1.8	0.255	4.5	0.653	37	1.5	0.176	4.0	0.602
13	1.5	0.176	4.0	0.602	38	1.5	0.176	3.8	0.579
14	1.5	0.176	3.0	0.477	39	1.7	0.230	6.0	0.778
15	1.4	0.146	3.8	0.579	40	1.5	0.176	4.0	0.602
16	1.7	0.230	5.0	0.699	41	1.6	0.204	4.0	0.602
17	1.5	0.176	3.0	0.477	42	1.6	0.204	5.0	0.699
18	1.4	0.146	3.5	0.544	43	1.8	0.255	4.0	0.602
19	1.8	0.255	4.0	0.602	44	1.5	0.176	2.0	0.301
20	1.2	0.079	2.0	0.301	45	1.4	0.146	2.0	0.301
21	1.6	0.204	3.0	0.477	46	1.6	0.204	3.0	0.477
22	1.4	0.146	3.0	0.477	47	1.6	0.204	3.0	0.477
23	1.5	0.176	3.0	0.477	48	1.8	0.255	2.8	0.477
24	1.5	0.176	3.0	0.477	49	1.6	0.204	3.0	0.477
25	1.6	0.204	3.0	0.477	50	1.6	0.204	3.0	0.477

POND 3: 28/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.7	0.230	6.0	0.778	26	1.3	0.114	3.0	0.477
2	1.5	0.176	3.5	0.544	27	1.6	0.204	3.8	0.580
3	1.5	0.176	3.7	0.568	28	1.5	0.176	3.3	0.519
4	1.7	0.230	5.5	0.740	29	1.7	0.230	4.5	0.653
5	1.5	0.176	3.2	0.505	30	1.5	0.176	3.5	0.544
6	1.5	0.176	3.0	0.477	31	1.5	0.176	3.5	0.544
7	1.7	0.230	3.0	0.477	32	1.5	0.176	3.5	0.544
8	1.5	0.176	3.5	0.544	33	1.5	0.176	3.0	0.477
9	1.6	0.204	3.8	0.508	34	1.5	0.204	3.4	0.531
10	1.8	0.255	3.5	0.544	35	1.6	0.204	3.5	0.544
11	1.8	0.255	3.6	0.556	36	1.6	0.176	3.3	0.519
12	1.5	0.176	4.0	0.602	37	1.5	0.230	3.5	0.544
13	1.6	0.204	3.7	0.568	38	1.7	0.204	3.8	0.580
14	1.7	0.230	4.0	0.602	39	1.6	0.204	3.9	0.591
15	1.9	0.279	6.6	0.820	40	1.6	0.204	3.0	0.477
16	1.6	0.204	3.4	0.531	41	1.7	0.230	3.6	0.556
17	1.5	0.176	3.5	0.544	42	1.6	0.204	3.6	0.556
18	1.6	0.204	3.6	0.556	43	1.5	0.176	3.0	0.477
19	1.5	0.176	3.0	0.477	44	1.6	0.204	4.0	0.602
20	1.6	0.204	4.0	0.602	45	1.6	0.204	3.7	0.568
21	1.6	0.204	3.8	0.580	46	1.5	0.176	4.0	0.602
22	1.5	0.176	3.0	0.477	47	1.5	0.176	3.3	0.519
23	1.4	0.146	3.0	0.477	48	1.7	0.230	4.0	0.602
24	1.6	0.204	3.8	0.580	49	1.6	0.204	3.5	0.544
25	1.4	0.146	2.5	0.398	50	1.6	0.204	4.0	0.602

POND 3: 08/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	6.3	0.799	26	1.4	0.146	3.2	0.505
2	1.6	0.204	3.7	0.568	27	1.7	0.230	4.0	0.602
3	1.6	0.204	3.9	0.591	28	1.6	0.204	3.5	0.544
4	1.8	0.255	5.9	0.771	29	1.8	0.255	4.7	0.672
5	1.6	0.204	3.4	0.531	30	1.6	0.204	3.7	0.568
6	1.6	0.204	3.2	0.505	31	1.6	0.568	3.7	0.568
7	1.8	0.255	3.3	0.519	32	1.6	0.580	3.8	0.580
8	1.6	0.204	3.7	0.568	33	1.6	0.519	3.3	0.519
9	1.7	0.230	4.0	0.602	34	1.6	0.556	3.6	0.556
10	1.9	0.279	3.8	0.580	35	1.7	0.568	3.7	0.568
11	1.9	0.279	3.8	0.580	36	1.7	0.544	3.5	0.544
12	1.6	0.204	4.3	0.633	37	1.6	0.568	3.7	0.568
13	1.7	0.230	4.0	0.602	38	1.8	0.602	4.0	0.602
14	1.8	0.255	4.2	0.623	39	1.7	0.613	4.1	0.613
15	2.0	0.301	6.8	0.839	40	1.7	0.505	3.2	0.505
16	1.7	0.230	3.6	0.556	41	1.8	0.591	3.9	0.591
17	1.6	0.204	3.7	0.568	42	1.7	0.580	3.8	0.580
18	1.7	0.230	3.8	0.580	43	1.6	0.505	3.2	0.505
19	1.6	0.204	3.2	0.505	44	1.7	0.623	4.2	0.623
20	1.7	0.230	4.3	0.633	45	1.7	0.591	3.9	0.591
21	1.7	0.230	4.0	0.602	46	1.6	0.623	4.2	0.623
22	1.6	0.204	3.2	0.505	47	1.6	0.544	3.5	0.544
23	1.5	0.176	3.2	0.505	48	1.8	0.633	4.3	0.633
24	1.7	0.230	4.1	0.613	49	1.7	0.568	3.7	0.568
25	1.5	0.176	2.7	0.413	50	1.7	0.633	4.3	0.633

POND 3: 13/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.7	0.230	4.0	0.602	26	1.7	0.230	4.0	0.602
2	1.7	0.230	4.2	0.623	27	1.7	0.230	4.0	0.602
3	1.7	0.230	4.5	0.653	28	1.6	0.204	4.0	0.602
4	1.7	0.230	4.0	0.602	29	1.7	0.230	4.0	0.602
5	1.7	0.230	4.2	0.623	30	1.6	0.204	4.0	0.602
6	1.6	0.204	4.0	0.602	31	1.7	0.230	4.0	0.602
7	1.7	0.230	4.5	0.653	32	1.8	0.255	4.2	0.623
8	1.7	0.230	3.5	0.544	33	1.7	0.230	4.0	0.602
9	1.5	0.176	5.0	0.699	34	1.6	0.204	4.0	0.602
10	1.5	0.176	4.0	0.602	35	1.6	0.204	3.5	0.544
11	1.7	0.230	3.0	0.477	36	1.7	0.230	4.0	0.602
12	1.8	0.255	4.0	0.602	37	1.7	0.230	4.0	0.602
13	1.6	0.204	4.0	0.602	38	1.6	0.204	3.5	0.544
14	1.6	0.204	4.0	0.602	39	1.7	0.230	4.5	0.653
15	1.6	0.204	3.2	0.505	40	1.7	0.230	3.0	0.477
16	1.7	0.230	4.0	0.602	41	1.7	0.230	3.5	0.544
17	1.6	0.204	4.0	0.602	42	1.6	0.204	3.0	0.477
18	1.6	0.204	3.0	0.477	43	1.6	0.204	3.5	0.544
19	1.5	0.176	4.0	0.602	44	1.6	0.204	4.0	0.602
20	1.6	0.204	4.0	0.602	45	1.7	0.230	4.0	0.602
21	1.6	0.204	3.5	0.544	46	1.8	0.255	6.0	0.778
22	1.7	0.230	4.0	0.602	47	1.7	0.230	4.0	0.602
23	1.7	0.230	4.0	0.602	48	1.7	0.230	4.0	0.602
24	1.7	0.230	4.0	0.602	49	1.6	0.204	3.0	0.477
25	1.7	0.230	4.0	0.602	50	1.6	0.204	4.0	0.602

POND 3: 08/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.6	0.204	4.3	0.633	26	1.8	0.255	4.3	0.633
2	1.7	0.230	3.3	0.519	27	1.7	0.230	4.4	0.643
3	1.7	0.230	4.3	0.633	28	1.7	0.230	4.2	0.623
4	1.7	0.230	4.3	0.633	29	1.7	0.230	4.3	0.633
5	1.7	0.255	6.3	0.799	30	1.6	0.204	3.8	0.580
6	1.8	0.230	4.3	0.633	31	1.7	0.230	4.3	0.633
7	1.6	0.204	4.3	0.633	32	1.6	0.204	4.3	0.633
8	1.7	0.230	3.8	0.580	33	1.7	0.230	3.3	0.513
9	1.6	0.204	3.3	0.519	34	1.6	0.204	4.2	0.623
10	1.7	0.230	3.8	0.580	35	1.7	0.230	4.4	0.643
11	1.7	0.230	3.3	0.519	36	1.7	0.230	3.5	0.544
12	1.7	0.230	4.8	0.681	37	1.6	0.204	4.2	0.623
13	1.6	0.204	3.8	0.580	38	1.6	0.204	4.3	0.633
14	1.7	0.230	4.3	0.633	39	1.8	0.255	4.3	0.643
15	1.7	0.230	4.3	0.633	40	1.7	0.230	3.5	0.544
16	1.6	0.204	3.8	0.580	41	1.6	0.204	4.3	0.633
17	1.6	0.204	4.3	0.633	42	1.8	0.255	5.3	0.724
18	1.7	0.230	4.3	0.633	43	1.7	0.230	3.8	0.580
19	1.8	0.255	4.5	0.653	44	1.7	0.230	4.8	0.681
20	1.7	0.230	4.3	0.633	45	1.6	0.204	4.4	0.643
21	1.7	0.230	4.3	0.633	46	1.7	0.230	4.4	0.643
22	1.7	0.230	4.3	0.633	47	1.7	0.230	4.3	0.633
23	1.6	0.204	4.2	0.623	48	1.7	0.230	4.8	0.681
24	1.6	0.204	4.4	0.643	49	1.7	0.230	4.5	0.653
25	1.7	0.230	4.3	0.633	50	1.7	0.230	4.3	0.633

POND 3: 01/01/01

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.7	0.230	4.4	0.643	26	1.8	0.255	4.3	0.633
2	1.7	0.230	4.5	0.653	27	1.7	0.230	4.4	0.643
3	1.7	0.230	4.8	0.681	28	1.7	0.230	4.2	0.623
4	1.7	0.230	4.3	0.633	29	1.7	0.230	4.3	0.633
5	1.8	0.255	4.6	0.663	30	1.8	0.255	4.3	0.633
6	1.8	0.230	4.6	0.663	31	1.8	0.255	4.3	0.633
7	1.6	0.230	4.8	0.681	32	1.8	0.255	4.5	0.653
8	1.8	0.255	4.0	0.602	33	1.8	0.255	4.5	0.653
9	1.8	0.255	5.3	0.724	34	1.6	0.204	4.3	0.633
10	1.7	0.230	4.5	0.653	35	1.6	0.204	3.9	0.591
11	1.7	0.230	3.7	0.544	36	1.8	0.255	4.3	0.633
12	1.8	0.255	4.6	0.663	37	1.7	0.230	4.3	0.633
13	1.6	0.204	4.3	0.633	38	1.6	0.204	4.0	0.602
14	1.6	0.204	4.2	0.623	39	1.7	0.230	4.8	0.681
15	1.7	0.230	3.6	0.556	40	1.7	0.230	3.7	0.568
16	1.7	0.230	4.4	0.643	41	1.7	0.230	3.8	0.580
17	1.6	0.204	4.3	0.633	42	1.6	0.204	3.5	0.544
18	1.7	0.230	3.8	0.580	43	1.7	0.230	3.8	0.580
19	1.7	0.230	4.3	0.633	44	1.7	0.230	4.5	0.653
20	1.7	0.230	4.3	0.633	45	1.7	0.230	4.3	0.633
21	1.7	0.230	4.0	0.602	46	1.8	0.255	6.3	0.799
22	1.7	0.230	4.3	0.633	47	1.7	0.230	4.3	0.633
23	1.8	0.255	4.2	0.623	48	1.8	0.255	4.6	0.663
24	1.7	0.230	4.4	0.643	49	1.7	0.230	3.5	0.544
25	1.8	0.255	4.3	0.633	50	1.6	0.204	4.3	0.633

POND4:19/08/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.2	0.342	5.0	0.699	26	2.0	0.301	4.0	0.602
2	2.0	0.301	5.0	0.699	27	1.8	0.255	4.0	0.602
3	2.1	0.322	8.0	0.903	28	1.7	0.230	4.0	0.602
4	2.0	0.301	5.0	0.699	29	1.9	0.279	4.0	0.602
5	1.8	0.255	4.0	0.602	30	1.9	0.279	4.0	0.602
6	1.8	0.255	6.0	0.778	31	1.9	0.279	7.0	0.845
7	1.7	0.230	4.0	0.602	32	2.1	0.322	6.0	0.778
8	2.0	0.301	3.5	0.544	33	2.1	0.322	6.0	0.778
9	1.8	0.255	3.8	0.58	34	2.0	0.301	4.0	0.602
10	2.2	0.342	5.0	0.699	35	1.9	0.279	5.0	0.699
11	1.9	0.279	4.0	0.602	36	1.9	0.279	6.0	0.778
12	1.6	0.204	4.0	0.602	37	2.0	0.301	7.0	0.845
13	1.8	0.255	5.0	0.699	38	2.1	0.322	7.0	0.845
14	1.9	0.279	4.0	0.602	39	2.0	0.301	6.0	0.778
15	1.9	0.279	3.0	0.477	40	2.0	0.301	5.8	0.763
16	1.7	0.230	3.5	0.544	41	1.8	0.255	4.0	0.602
17	1.9	0.279	6.0	0.778	42	1.9	0.279	4.0	0.602
18	1.2	0.322	3.0	0.477	43	1.6	0.204	4.0	0.602
19	1.9	0.279	8.0	0.903	44	1.8	0.255	4.0	0.602
20	2.0	0.301	8.0	0.903	45	1.8	0.255	4.0	0.602
21	1.8	0.255	5.0	0.699	46	1.9	0.279	5.0	0.699
22	2.0	0.301	5.0	0.699	47	1.9	0.279	4.0	0.602
23	2.1	0.322	6.0	0.778	48	1.8	0.255	3.8	0.580
24	1.9	0.279	6.0	0.778	49	1.6	0.204	4.0	0.602
25	1.9	0.279	4.0	0.602	50	1.8	0.255	6.0	0.778

POND 4: 28/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	6.7	0.826	26	1.9	0.279	6.5	0.813
2	2.2	0.342	8.8	0.944	27	2.0	0.301	7.0	0.845
3	2.2	0.342	8.7	0.940	28	2.0	0.301	5.5	0.740
4	2.3	0.362	10.2	1.009	29	1.8	0.255	6.0	0.778
5	2.0	0.301	8.2	0.914	30	1.8	0.255	5.0	0.699
6	2.0	0.301	7.9	0.898	31	1.9	0.279	5.5	0.740
7	2.0	0.301	8.0	0.903	32	2.1	0.322	7.0	0.845
8	1.9	0.279	8.0	0.903	33	1.9	0.279	7.5	0.875
9	2.0	0.301	5.0	0.699	34	1.9	0.279	6.7	0.826
10	2.0	0.301	5.5	0.740	35	2.0	0.301	8.0	0.903
11	2.0	0.301	6.5	0.813	36	2.0	0.301	7.5	0.875
12	1.9	0.279	5.0	0.699	37	1.9	0.279	6.0	0.778
13	2.0	0.301	7.0	0.845	38	1.8	0.255	6.0	0.778
14	2.2	0.342	7.7	0.886	39	2.0	0.301	7.5	0.875
15	2.2	0.342	10.0	1.00	40	2.1	0.322	7.0	0.845
16	2.0	0.301	7.0	0.845	41	1.8	0.255	5.5	0.740
17	2.2	0.342	7.0	0.845	42	2.0	0.301	6.0	0.778
18	1.8	0.255	6.0	0.778	43	2.0	0.301	7.7	0.886
19	2.0	0.301	5.5	0.740	44	1.8	0.255	5.0	0.699
20	1.8	0.255	4.0	0.602	45	1.9	0.279	6.0	0.778
21	2	0.301	7.0	0.845	46	1.9	0.279	5.5	0.740
22	2.1	0.322	6.5	0.813	47	2.0	0.301	6.1	0.785
23	1.8	0.255	5.0	0.699	48	2.2	0.342	10.0	1.000
24	1.9	0.279	6.0	0.778	49	2.3	0.362	10.2	1.009
25	2.3	0.362	7.5	0.875	50	2.1	0.322	8.0	0.903

POND 4: 08/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	7.2	0.857	26	2.0	0.301	7.0	0.845
2	2.0	0.301	9.4	0.973	27	2.1	0.322	7.5	0.875
3	2.2	0.342	9.3	0.968	28	1.9	0.279	6.0	0.778
4	2.2	0.342	10.8	1.033	29	1.9	0.279	6.5	0.813
5	1.8	0.255	8.8	0.740	30	1.8	0.255	5.5	0.740
6	2.0	0.301	8.5	0.929	31	1.8	0.255	6.0	0.778
7	2.0	0.301	8.6	0.934	32	2.2	0.342	7.5	0.875
8	1.8	0.255	8.6	0.934	33	1.7	0.230	8.0	0.903
9	1.9	0.279	5.5	0.740	34	1.8	0.255	7.2	0.857
10	1.8	0.255	6.0	0.778	35	2.0	0.301	8.6	0.934
11	1.9	0.279	7.0	0.845	36	1.9	0.279	8.0	0.903
12	2.0	0.301	5.5	0.740	37	1.9	0.279	6.5	0.813
13	2.1	0.322	7.5	0.875	38	1.8	0.255	6.5	0.813
14	2.2	0.342	8.3	0.919	39	2.0	0.301	8.0	0.903
15	2.3	0.362	10.6	1.025	40	2.1	0.322	7.5	0.875
16	1.8	0.255	7.5	0.875	41	1.7	0.230	6.0	0.778
17	2.1	0.322	7.5	0.875	42	1.9	0.279	6.5	0.813
18	1.9	0.279	6.5	0.813	43	1.9	0.279	8.3	0.919
19	1.9	0.279	6.0	0.778	44	1.8	0.255	5.5	0.740
20	1.7	0.230	4.5	0.653	45	1.9	0.279	6.5	0.813
21	1.8	0.255	7.5	0.875	46	1.9	0.279	6.0	0.778
22	2.0	0.301	7.0	0.845	47	2.0	0.301	6.6	0.820
23	1.9	0.279	5.5	0.740	48	2.1	0.322	10.6	1.025
24	1.9	0.279	6.5	0.813	49	2.1	0.322	10.8	1.033
25	2.1	0.322	8.0	0.903	50	2.0	0.301	8.6	0.934

POND 4: 13/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.1	0.322	8.2	0.914	26	5.5	0.301	5.5	0.740
2	2.2	0.342	8.0	0.903	27	7.4	0.279	7.4	0.869
3	2.0	0.301	6.0	0.778	28	7.5	0.322	7.5	0.875
4	2.0	0.301	5.5	0.740	29	8.0	0.322	8.0	0.903
5	2.0	0.301	6.2	0.792	30	5.0	0.279	5.0	0.699
6	1.9	0.279	5.0	0.699	31	2.1	0.322	7.5	0.875
7	2.0	0.301	6.0	0.778	32	2.2	0.342	8.0	0.903
8	1.9	0.279	7.5	0.875	33	2.0	0.301	6.1	0.785
9	2.1	0.322	7.5	0.875	34	2.0	0.301	5.5	0.740
10	2.0	0.301	6.2	0.792	35	2.1	0.322	6.3	0.799
11	1.9	0.279	5.0	0.699	36	1.9	0.279	7.4	0.869
12	2.0	0.301	6.0	0.778	37	2.0	0.301	6.2	0.792
13	1.9	0.279	7.5	0.875	38	1.9	0.279	5.0	0.699
14	2.1	0.322	7.5	0.875	39	2.0	0.301	6.0	0.778
15	2.0	0.301	5.5	0.740	40	2.1	0.322	8.2	0.914
16	2.0	0.301	6.0	0.778	41	1.9	0.279	7.5	0.875
17	2.2	0.342	8.0	0.903	42	2.0	0.601	6.0	0.778
18	2.1	0.322	8.2	0.914	43	1.9	0.279	5.0	0.699
19	1.9	0.279	5.0	0.699	44	2.0	0.301	5.5	0.740
20	2.0	0.301	6.2	0.792	45	2.0	0.301	6.0	0.778
21	2.1	0.322	7.5	0.875	46	2.0	0.301	5.4	0.732
22	1.9	0.279	5.0	0.699	47	2.2	0.342	8.1	0.908
23	1.9	0.279	5.0	0.699	48	2.1	0.322	7.5	0.875
24	2.0	0.301	6.0	0.778	49	1.9	0.279	7.6	0.881
25	2.1	0.322	6.3	0.799	50	2.0	0.301	7.4	0.869

POND 4: 8/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.0	0.301	8.3	0.919	26	2.2	0.342	7.2	0.857
2	2.0	0.301	8.5	0.929	27	2.1	0.322	6.9	0.839
3	2.1	0.322	8.4	0.924	28	2.0	0.301	5.9	0.771
4	2.2	0.342	9.2	0.964	29	2.0	0.301	5.9	0.771
5	2.0	0.301	6.3	0.799	30	2.1	0.322	8.4	0.924
6	2.0	0.301	6.9	0.839	31	2.0	0.301	7.1	0.851
7	2.0	0.301	6.4	0.806	32	2.0	0.301	5.9	0.771
8	2.0	0.301	5.9	0.771	33	2.1	0.322	9.1	0.959
9	2.1	0.322	6.9	0.839	34	2.2	0.342	9.5	0.978
10	2.0	0.301	8.4	0.924	35	2.0	0.301	6.9	0.839
11	2.1	0.322	9.1	0.959	36	2.0	0.301	6.4	0.806
12	2.0	0.301	6.9	0.839	37	2.1	0.322	8.4	0.924
13	2.0	0.301	5.9	0.771	38	2.0	0.301	8.4	0.924
14	2.1	0.322	7.1	0.851	39	2.1	0.322	6.9	0.839
15	2.0	0.301	8.3	0.919	40	2.1	0.322	5.9	0.771
16	2.1	0.322	7.2	0.857	41	2.0	0.301	7.1	0.851
17	2.0	0.301	6.4	0.806	42	2.1	0.322	8.4	0.924
18	2.0	0.301	7.0	0.845	43	2.0	0.301	8.4	0.924
19	2.2	0.342	9.2	0.964	44	2.2	0.342	6.9	0.839
20	2.1	0.322	8.4	0.924	45	2.0	0.301	5.9	0.771
21	2.0	0.301	5.9	0.771	46	2.0	0.301	7.1	0.851
22	2.1	0.322	9.1	0.959	47	2.0	0.301	6.4	0.806
23	2.1	0.322	8.4	0.924	48	2.0	0.301	6.9	0.839
24	2.0	0.301	8.3	0.919	49	2.3	0.361	9.5	0.978
25	2.0	0.301	6.4	0.806	50	2.1	0.322	9.1	0.959

POND 4:08/01/01

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.2	0.342	9.3	0.968	26	2.0	0.301	6.6	0.820
2	2.3	0.361	9.7	0.987	27	2.0	0.301	8.5	0.929
3	2.0	0.301	7.2	0.857	28	2.1	0.322	8.6	0.934
4	2.1	0.322	6.6	0.820	29	2.2	0.342	9.3	0.968
5	2.0	0.301	7.3	0.863	30	2.1	0.322	6.2	0.792
6	2.1	0.322	6.2	0.792	31	2.1	0.322	8.6	0.934
7	2.3	0.361	7.2	0.857	32	2.3	0.342	9.4	0.973
8	2.0	0.301	8.6	0.934	33	2.0	0.342	7.2	0.857
9	2.1	0.322	8.6	0.934	34	2.1	0.301	6.6	0.820
10	2.1	0.322	7.3	0.863	35	2.2	0.322	7.4	0.869
11	2.1	0.322	6.2	0.792	36	2.0	0.342	8.5	0.929
12	2.1	0.322	7.2	0.857	37	2.1	0.301	7.3	0.863
13	2.1	0.322	8.6	0.934	38	2.1	0.322	6.2	0.792
14	2.1	0.322	8.6	0.934	39	2.1	0.322	7.2	0.857
15	2.1	0.322	6.6	0.820	40	2.1	0.322	9.3	0.968
16	2.0	0.301	7.2	0.857	41	2.0	0.301	8.6	0.934
17	2.3	0.361	9.7	0.987	42	2.1	0.322	7.2	0.857
18	2.1	0.322	9.2	0.964	43	2.1	0.322	6.2	0.792
19	2.1	0.322	6.2	0.792	44	2.0	0.301	6.6	0.820
20	2.0	0.301	7.3	0.863	45	2.1	0.322	7.2	0.857
21	2.1	0.322	8.6	0.934	46	2.0	0.301	6.5	0.813
22	2.1	0.322	6.2	0.792	47	2.3	0.301	9.4	0.973
23	2.1	0.322	6.2	0.792	48	2.1	0.322	8.6	0.934
24	2.1	0.322	7.2	0.857	49	2.0	0.301	8.7	0.940
25	2.2	0.342	7.4	0.869	50	2.1	0.322	8.5	0.929

APPENDIX 7

Logarithmic values of body weight and length for *P. notialis* fed on 40% crude protein

Pond 1: 19/08/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.5	0.176	2.0	0.301	26	1.9	0.279	4.0	0.602
2	1.6	0.204	3.0	0.477	27	2.0	0.301	7.0	0.845
3	1.4	0.146	2.0	0.301	28	1.4	0.146	2.0	0.301
4	1.7	0.230	3.0	0.477	29	2.0	0.301	4.0	0.602
.5	1.6	0.204	4.0	0.602	30	1.7	0.230	4.0	0.602
6	1.9	0.279	4.0	0.602	31	1.7	0.230	3.0	0.477
7	1.5	0.176	3.0	0.477	32	1.8	0.255	4.0	0.602
8	2.1	0.322	7.0	0.845	33	1.8	0.255	6.0	0.778
9	1.7	0.230	4.0	0.602	34	1.4	0.146	3.0	0.477
10	1.8	0.255	5.0	0.699	35	1.9	0.279	6.0	0.778
11	1.5	0.176	4.0	0.602	36	1.5	0.176	1.0	0.00
12	1.7	0.230	4.0	0.602	37	1.4	0.146	4.0	0.602
13	1.6	0.204	4.0	0.602	38	1.6	0.204	3.0	0.477
14	2.0	0.301	6.0	0.778	39	1.8	0.255	4.0	0.602
15	1.8	0.255	5.0	0.699	40	1.5	0.176	4.0	0.602
16	1.8	0.255	4.0	0.602	41	1.5	0.176	2.0	0.301
17	1.5	0.176	2.0	0.301	42	1.9	0.279	5.0	0.699
18	1.4	0.146	2.0	0.301	43	1.9	0.279	4.0	0.602
19	1.5	0.176	3.0	0.477	44	1.3	0.114	3.0	0.477
20	1.5	0.176	3.0	0.477	45	2.0	0.301	6.0	0.778
21	1.9	0.279	4.2	0.623	46	1.6	0.204	4.0	0.602
22	1.6	0.204	4.0	0.602	47	1.5	0.176	4.0	0.602
23	1.7	0.230	4.0	0.602	48	1.4	0.146	3.0	0.477
24	1.4	0.146	2.0	0.301	49	1.6	0.204	3.0	0.477
25	1.6	0.204	3.0	0.477	50	1.6	0.204	4.0	0.602

Pond 1: 21/09/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.0	0.301	6.0	0.778	26	1.7	0.230	5.0	0.699
2	1.6	0.204	3.0	0.477	27	1.7	0.230	4.0	0.602
3	1.9	0.279	5.5	0.740	28	1.7	0.230	4.0	0.602
4	1.6	0.204	4.0	0.602	29	1.8	0.255	3.0	0.477
5	1.8	0.255	4.0	0.602	30	2.1	0.322	6.5	0.813
6	1.7	0.230	4.0	0.602	31	1.8	0.255	5.0	0.699
7	1.9	0.279	5.0	0.699	32	1.1	0.041	3.0	0.477
8	1.8	0.255	3.0	0.477	33	1.9	0.279	4.0	0.602
9	1.8	0.255	3.5	0.544	34	1.7	0.230	3.0	0.477
10	1.6	0.204	3.0	0.477	35	2.1	0.322	7.0	0.845
11	1.6	0.204	3.0	0.477	36	1.7	0.230	4.5	0.653
12	1.7	0.230	4.0	0.602	37	1.8	0.255	4.5	0.653
13	1.9	0.279	5.0	0.699	38	1.9	0.279	5.0	0.699
14	1.8	0.255	4.5	0.653	39	1.6	0.204	3.0	0.477
15	1.6	0.204	4.0	0.602	40	1.7	0.230	3.0	0.477
16	1.7	0.230	3.0	0.477	41	2.0	0.301	5.0	0.699
17	1.9	0.279	4.0	0.602	42	1.9	0.279	6.0	0.778
18	1.6	0.204	3.0	0.477	43	1.7	0.230	3.0	0.477
19	1.8	0.255	5.0	0.699	44	1.9	0.279	5.5	0.740
20	1.8	0.255	5.0	0.699	45	1.6	0.204	5.0	0.699
21	1.9	0.279	5.0	0.699	46	2.1	0.322	7.0	0.845
22	1.6	0.204	3.5	0.544	47	1.9	0.279	5.0	0.699
23	1.8	0.255	5.0	0.699	48	1.6	0.204	4.0	0.602
24	1.7	0.230	3.5	0.544	49	1.7	0.230	3.5	0.544
25	1.7	0.230	3.0	0.477	50	1.7	0.230	3.0	0.477

Pond 1: 20/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.4	0.322	6.3	0.799	26	1.8	0.255	5.3	0.724
2	1.2	0.230	3.3	0.519	27	1.8	0.255	4.0	0.602
3	1.4	0.301	5.8	0.763	28	1.8	0.255	4.5	0.653
4	1.1	0.230	4.2	0.623	29	1.9	0.279	3.1	0.491
5	1.1	0.279	4.4	0.643	30	2.2	0.341	6.8	0.832
6	1.3	0.255	4.2	0.623	31	1.8	0.279	5.0	0.699
7	1.4	0.301	5.4	0.732	32	1.1	0.079	3.3	0.519
8	1.2	0.279	5.1	0.708	33	1.9	0.301	4.5	0.653
9	1.3	0.279	3.5	0.544	34	1.7	0.255	3.1	0.491
10	1.2	0.230	3.5	0.544	35	2.1	0.342	7.6	0.881
11	1.3	0.230	3.1	0.491	36	1.7	0.255	4.6	0.662
12	1.2	0.255	4.5	0.653	37	1.8	0.279	4.5	0.653
13	1.3	0.301	5.1	0.708	38	1.9	0.301	5.0	0.699
14	1.3	0.279	4.8	0.608	39	1.6	0.23	3.3	0.519
15	1.1	0.230	4.3	0.633	40	1.7	0.255	3.5	0.544
16	1.2	0.255	3.3	0.519	41	2.0	0.322	6.0	0.778
17	1.3	0.301	4.2	0.623	42	1.9	0.301	6.3	0.799
18	1.1	0.230	3.4	0.531	43	1.7	0.255	3.2	0.505
19	1.3	0.279	5.6	0.748	44	1.9	0.301	5.4	0.732
20	1.4	0.279	5.0	0.699	45	1.6	0.230	4.5	0.653
21	1.2	0.301	5.4	0.732	46	2.1	0.342	7.8	0.892
22	1.2	0.230	3.7	0.568	47	1.9	0.301	5.3	0.724
23	1.3	0.279	5.5	0.74	48	1.6	0.230	4.0	0.602
24	1.3	0.255	3.6	0.556	49	1.7	0.255	3.8	0.580
25	1.2	0.255	3.3	0.519	50	1.7	0.255	3.2	0.505

Pond 1: 11/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.7	0.230	4.0	0.602	26	1.2	0.255	6.0	0.778
2	1.7	0.230	4.2	0.623	27	1.3	0.255	4.0	0.602
3	1.8	0.255	5.2	0.716	28	1.2	0.255	4.0	0.602
4	1.9	0.279	5.3	0.724	29	1.2	0.255	6.0	0.778
5	1.7	0.230	4.5	0.653	30	1.2	0.230	4.0	0.602
6	1.9	0.279	5.2	0.716	31	1.8	0.230	4.5	0.653
7	1.8	0.255	4.0	0.602	32	1.9	0.279	5.2	0.716
8	1.8	0.255	4.2	0.623	33	1.8	0.255	4.0	0.602
9	1.8	0.255	4.5	0.653	34	1.8	0.255	4.2	0.623
10	1.8	0.255	5.0	0.699	35	1.8	0.255	4.5	0.653
11	1.8	0.255	4.0	0.602	36	1.8	0.255	5.0	0.699
12	1.8	0.255	4.0	0.602	37	1.7	0.230	4.0	0.602
13	1.8	0.255	6.0	0.778	38	1.7	0.230	4.2	0.623
14	1.7	0.230	4.2	0.623	39	1.8	0.255	5.2	0.716
15	1.7	0.230	5.3	0.724	40	1.9	0.255	5.3	0.724
16	1.8	0.279	5.3	0.724	41	1.9	0.255	5.3	0.724
17	1.7	0.230	4.0	0.602	42	1.8	0.255	6.0	0.778
18	1.9	0.279	5.2	0.716	43	1.9	0.279	5.2	0.716
19	1.8	0.255	4.0	0.602	44	1.7	0.230	5.3	0.724
20	1.7	0.230	4.5	0.653	45	1.8	0.255	4.0	0.602
21	1.8	0.255	4.5	0.653	46	1.7	0.230	4.0	0.602
22	1.8	0.255	4.2	0.623	47	1.8	0.255	4.5	0.653
23	1.8	0.255	5.0	0.699	48	1.8	0.255	5.2	0.716
24	1.8	0.255	4.0	0.602	49	1.9	0.279	4.5	0.653
25	1.8	0.255	4.0	0.602	50	1.7	0.230	5.3	0.724

Pond 1: 20/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	4.3	0.633	26	1.8	0.255	6.4	0.806
2	1.8	0.255	4.6	0.633	27	1.8	0.255	4.2	0.623
3	1.9	0.279	5.4	0.732	28	1.8	0.255	4.3	0.633
4	2.0	0.301	5.7	0.756	29	1.8	0.255	6.2	0.792
5	1.8	0.255	4.4	0.643	30	1.8	0.255	4.4	0.643
6	2.0	0.301	5.4	0.732	31	1.7	0.230	4.9	0.69
7	1.9	0.279	4.4	0.643	32	1.9	0.279	5.3	0.724
8	1.9	0.279	4.5	0.653	33	1.9	0.279	4.3	0.633
9	1.9	0.279	4.8	0.681	34	1.8	0.255	4.5	0.653
10	1.9	0.279	5.4	0.732	35	1.8	0.255	4.8	0.681
11	1.9	0.279	4.2	0.623	36	1.8	0.255	5.4	0.732
12	1.8	0.255	4.3	0.633	37	1.8	0.255	4.2	0.623
13	1.8	0.255	6.2	0.792	38	1.8	0.255	4.6	0.663
14	1.8	0.255	4.5	0.653	39	1.8	0.255	5.4	0.732
15	1.8	0.255	5.7	0.756	40	2.0	0.301	5.7	0.756
16	2.0	0.301	5.6	0.748	41	1.9	0.279	5.6	0.748
17	1.8	0.255	4.3	0.633	42	1.8	0.255	6.3	0.799
18	1.8	0.255	5.6	0.748	43	1.8	0.255	5.4	0.732
19	1.8	0.255	4.1	0.623	44	1.8	0.255	5.6	0.748
20	1.7	0.255	4.9	0.69	45	1.8	0.255	4.3	0.633
21	1.7	0.230	4.7	0.672	46	1.8	0.255	4.2	0.623
22	1.8	0.230	4.5	0.653	47	1.8	0.255	4.4	0.643
23	1.7	0.255	5.3	0.724	48	1.8	0.255	5.6	0.748
24	1.7	0.230	4.4	0.643	49	1.8	0.255	4.8	0.681
25	1.8	0.230	4.3	0.633	50	2.0	0.301	5.6	0.748

Pond 2: 18/08/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	3.0	0.477	26	2.0	0.301	4.0	0.602
2	1.9	0.279	5.0	0.699	27	1.6	0.204	4.0	0.602
3	1.8	0.255	5.0	0.699	28	2.0	0.301	6.5	0.813
4	1.9	0.279	6.0	0.778	29	1.5	0.176	4.0	0.602
5	1.8	0.255	6.0	0.778	30	1.5	0.176	5.0	0.699
6	1.8	0.255	4.5	0.653	31	1.6	0.204	4.0	0.602
7	1.5	0.176	8.0	0.903	32	1.9	0.279	5.0	0.699
8	1.8	0.255	7.0	0.845	33	1.6	0.204	5.0	0.699
9	1.9	0.279	5.8	0.763	34	2.0	0.301	6.0	0.778
10	1.9	0.279	5.0	0.699	35	2.0	0.301	6.0	0.778
11	1.7	0.23	5.8	0.763	36	2.0	0.301	5.0	0.699
12	1.8	0.255	6.0	0.778	37	1.9	0.279	5.0	0.699
13	1.8	0.255	6.5	0.813	38	2.0	0.301	6.0	0.778
14	1.7	0.23	4.5	0.653	39	1.5	0.176	2.0	0.301
15	1.7	0.23	5.8	0.763	40	1.9	0.279	6.0	0.778
16	1.6	0.204	6.0	0.778	41	1.6	0.204	6.0	0.778
17	1.5	0.176	5.0	0.699	42	1.8	0.255	4.0	0.602
18	1.5	0.176	6.0	0.778	43	1.8	0.255	6.0	0.778
19	1.5	0.176	4.0	0.602	44	1.9	0.279	6.0	0.778
20	1.9	0.279	6.5	0.813	45	1.9	0.279	4.5	0.653
21	1.6	0.204	4.0	0.602	46	1.7	0.23	5.0	0.699
22	1.8	0.255	4.0	0.602	47	1.7	0.23	4.5	0.653
23	1.5	0.176	4.0	0.602	48	1.9	0.279	4.5	0.653
24	1.6	0.204	8.0	0.903	49	1.8	0.255	5.0	0.699
25	1.9	0.279	6.0	0.778	50	1.7	0.23	6.0	0.778

Pond 2: 21/09.00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.8	0.255	5.5	0.740	26	1.9	0.279	5.0	0.699
2	1.9	0.279	4.5	0.653	27	1.9	0.279	6.0	0.778
3	1.8	0.255	5.0	0.699	28	2.0	0.301	5.0	0.699
4	1.9	0.255	6.0	0.778	29	1.9	0.279	5.0	0.699
5	2.1	0.322	6.0	0.778	30	1.8	0.255	4.5	0.653
6	1.8	0.255	5.0	0.699	31	1.9	0.279	5.0	0.699
7	1.9	0.279	5.5	0.740	32	1.8	0.255	4.5	0.653
8	1.9	0.279	6.0	0.778	33	1.9	0.279	5.0	0.699
9	1.9	0.279	5.0	0.699	34	1.9	0.279	5.0	0.699
10	1.9	0.279	6.0	0.778	35	2.1	0.322	7.0	0.845
11	1.9	0.279	5.5	0.740	36	1.9	0.279	5.5	0.740
12	1.8	0.255	5.0	0.699	37	1.9	0.279	5.0	0.699
13	1.8	0.255	4.0	0.602	38	1.9	0.279	5.0	0.699
14	2.0	0.301	5.0	0.699	39	1.8	0.255	5.0	0.699
15	1.9	0.279	6.0	0.778	40	1.8	0.255	5.0	0.699
16	2.0	0.301	8.0	0.903	41	2.2	0.342	8.0	0.903
17	1.8	0.255	4.5	0.653	42	1.9	0.279	5.0	0.699
18	1.8	0.255	5.0	0.699	43	1.9	0.279	5.0	0.699
19	2.2	0.342	8.0	0.903	44	2.0	0.301	6.0	0.778
20	2.0	0.301	5.5	0.740	45	1.8	0.255	5.0	0.699
21	1.8	0.255	5.0	0.699	46	1.9	0.279	6.0	0.778
22	1.8	0.255	6.0	0.778	47	2.0	0.301	6.0	0.778
23	2.0	0.301	5.0	0.699	48	2.0	0.301	6.0	0.778
24	1.8	0.255	5.0	0.699	49	1.8	0.255	4.0	0.602
25	1.8	0.255	4.0	0.602	50	1.9	0.279	6.6	0.820

Pond 2: 18/10/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	1.9	0.279	6.3	0.799	26	1.9	0.279	5.8	0.763
2	1.9	0.279	5.3	0.724	27	1.8	0.279	6.8	0.833
3	1.8	0.255	5.8	0.763	28	1.9	0.279	5.8	0.763
4	1.8	0.255	6.8	0.833	29	1.9	0.279	5.8	0.763
5	2.0	0.301	6.6	0.820	30	2.0	0.279	5.3	0.724
6	1.8	0.255	5.8	0.763	31	1.9	0.279	5.8	0.763
7	1.9	0.279	6.3	0.799	32	1.8	0.255	5.3	0.724
8	1.9	0.279	6.8	0.833	33	1.8	0.279	5.8	0.763
9	1.9	0.279	5.8	0.763	34	1.8	0.279	5.8	0.763
10	1.9	0.279	6.5	0.813	35	1.8	0.301	7.8	0.892
11	1.9	0.279	6.3	0.799	36	2.0	0.279	6.3	0.799
12	1.8	0.255	5.7	0.756	37	1.9	0.255	5.8	0.763
13	1.9	0.279	4.8	0.681	38	1.9	0.255	6.1	0.785
14	1.9	0.279	5.9	0.771	39	1.9	0.255	5.8	0.763
15	1.9	0.279	6.6	0.82	40	1.8	0.255	5.5	0.740
16	1.9	0.279	8.8	0.9440	41	1.8	0.301	8.8	0.944
17	1.9	0.279	5.3	0.724	42	1.9	0.279	5.8	0.763
18	1.8	0.255	5.8	0.763	43	1.8	0.279	5.8	0.763
19	2.0	0.301	8.8	0.944	44	1.8	0.279	6.4	0.806
20	1.9	0.279	6.3	0.799	45	1.8	0.255	6.2	0.792
21	1.9	0.279	5.8	0.763	46	1.9	0.255	7.1	0.851
22	1.9	0.279	6.8	0.833	47	2.0	0.279	6.8	0.833
23	2.0	0.301	5.8	0.763	48	2.0	0.255	6.5	0.813
24	1.8	0.255	5.8	0.763	49	1.8	0.255	5.1	0.710
25	1.8	0.255	4.8	0.681	50	1.9	0.255	7.0	0.845

Pond 2: 11/11/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.0	0.301	6.0	0.778	26	2.2	0.342	8.5	0.929
2	2.1	0.322	7.0	0.845	27	2.1	0.322	7.0	0.845
3	2.0	0.301	6.5	0.813	28	2.2	0.342	7.0	0.845
4	2.1	0.322	7.0	0.845	29	2.2	0.342	6.5	0.813
5	1.9	0.279	5.0	0.699	30	2.1	0.322	7.0	0.845
6	2.0	0.301	6.0	0.778	31	2.0	0.301	6.5	0.813
7	1.9	0.279	6.0	0.778	32	2.2	0.342	8.5	0.929
8	2.0	0.301	6.5	0.813	33	2.1	0.322	7.0	0.845
9	2.1	0.322	7.9	0.898	34	2.1	0.322	7.0	0.845
10	2.2	0.342	6.5	0.813	35	2.0	0.301	7.0	0.845
11	2.2	0.342	7.0	0.845	36	1.9	0.279	7.0	0.845
12	2.1	0.322	7.0	0.845	37	2.0	0.301	7.0	0.845
13	2.2	0.342	8.5	0.929	38	1.9	0.279	6.5	0.813
14	2.0	0.301	7.5	0.875	39	1.9	0.279	6.0	0.778
15	2.2	0.342	7.5	0.875	40	2.0	0.301	6.0	0.778
16	1.9	0.279	7.0	0.845	41	2.0	0.301	6.0	0.778
17	2.0	0.301	7.0	0.845	42	1.2	0.322	6.0	0.778
18	1.9	0.279	6.5	0.813	43	2.1	0.322	8.0	0.903
19	1.9	0.279	6.0	0.778	44	2.0	0.301	6.0	0.778
20	2.0	0.301	6.0	0.778	45	2.1	0.322	7.0	0.845
21	2.0	0.301	6.0	0.778	46	2.0	0.301	6.5	0.813
22	1.2	0.322	6.0	0.778	47	2.1	0.322	7.0	0.845
23	2.1	0.322	8.0	0.903	48	1.9	0.279	5.0	0.699
24	2.2	0.342	7.5	0.875	49	2.0	0.301	6.0	0.778
25	2.0	0.301	7.5	0.875	50	1.9	0.279	6.0	0.778

Pond 2: 08/12/00

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.1	0.322	7.5	0.875	26	2.0	0.301	6.7	0.826
2	2.2	0.342	8.7	0.940	27	1.9	0.279	6.2	0.792
3	2.0	0.301	6.7	0.826	28	2.0	0.301	6.2	0.792
4	2.1	0.322	7.2	0.857	29	1.9	0.279	5.1	0.708
5	2.2	0.342	6.6	0.820	30	2.1	0.322	7.1	0.851
6	2.2	0.342	7.0	0.845	31	2.0	0.301	6.6	0.820
7	2.2	0.342	7.2	0.857	32	2.1	0.322	7.1	0.851
8	2.2	0.342	8.7	0.940	33	2.1	0.322	6.2	0.792
9	2.0	0.301	7.6	0.881	34	1.9	0.279	6.0	0.778
10	2.1	0.322	7.6	0.881	35	2.0	0.301	6.0	0.778
11	2.1	0.322	8.2	0.914	36	1.9	0.279	5.1	0.708
12	1.2	0.322	6.2	0.792	37	2.1	0.322	7.0	0.845
13	2.1	0.322	6.2	0.792	38	2.0	0.301	6.7	0.826
14	2.0	0.301	6.0	0.778	39	2.1	0.322	7.2	0.857
15	2.0	0.301	6.0	0.778	40	2.1	0.322	6.1	0.785
16	1.9	0.279	6.6	0.820	41	2.1	0.322	8.2	0.914
17	2.0	0.301	7.1	0.851	42	2.2	0.342	6.2	0.792
18	1.9	0.279	7.2	0.857	43	2.1	0.322	6.1	0.785
19	2.2	0.342	7.7	0.886	44	2.0	0.301	6.1	0.785
20	2.0	0.301	7.6	0.881	45	2.0	0.301	6.1	0.785
21	2.2	0.342	8.7	0.94	46	1.9	0.279	6.7	0.826
22	2.2	0.342	7.0	0.845	47	2.0	0.301	7.2	0.857
23	2.2	0.342	7.2	0.857	48	1.9	0.279	7.2	0.857
24	2.2	0.342	6.7	0.826	49	2.0	0.301	7.2	0.857
25	2.1	0.322	7.2	0.857	50	2.1	0.322	7.2	0.857

Pond 2: 08/01/01

NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)	NO.	CL (cm)	Log CL (cm)	B. WT (g)	Log B. W (g)
1	2.1	0.322	7.3	0.863	26	2.1	0.322	7.3	0.863
2	2.0	0.301	7.3	0.863	27	2.2	0.342	6.8	0.833
3	1.9	0.279	7.3	0.863	28	2.2	0.342	7.3	0.863
4	2.0	0.301	7.3	0.863	29	2.2	0.342	7.1	0.851
5	1.9	0.279	6.8	0.833	30	2.2	0.342	8.8	0.944
6	2.0	0.301	6.2	0.792	31	2.0	0.301	7.7	0.886
7	2.0	0.301	6.2	0.792	32	2.2	0.342	7.8	0.892
8	2.1	0.322	6.2	0.792	33	1.9	0.279	7.3	0.863
9	2.2	0.342	6.3	0.799	34	2.0	0.301	7.2	0.857
10	2.1	0.322	8.3	0.919	35	1.9	0.279	6.7	0.826
11	2.2	0.342	6.2	0.792	36	2.0	0.301	6.1	0.785
12	2.1	0.322	7.3	0.863	37	2.0	0.301	6.1	0.785
13	2.0	0.301	6.8	0.833	38	2.1	0.322	6.3	0.799
14	2.1	0.322	7.1	0.851	39	2.1	0.322	6.3	0.799
15	1.9	0.279	5.2	0.716	40	2.1	0.322	8.3	0.919
16	2.0	0.301	6.1	0.785	41	2.2	0.342	7.7	0.886
17	1.9	0.279	6.1	0.785	42	2.0	0.301	7.7	0.886
18	2.2	0.342	6.3	0.799	43	2.2	0.342	8.8	0.944
19	2.1	0.322	7.2	0.857	44	2.2	0.342	7.3	0.863
20	2.0	0.301	6.7	0.826	45	2.2	0.342	7.1	0.851
21	2.1	0.322	7.2	0.857	46	2.2	0.342	6.7	0.826
22	1.9	0.279	5.2	0.716	47	2.1	0.322	7.3	0.863
23	2.0	0.301	6.3	0.799	48	2.0	0.301	7.8	0.892
24	1.9	0.279	6.3	0.799	49	2.2	0.342	8.8	0.944
25	2.0	0.301	6.8	0.833	50	2.1	0.322	7.6	0.881