GASTRIC EVACUATION AND INTESTINAL PASSAGE OF FOOD IN RELATION TO TIME IN NILE TILAPIA (*Tilapia niloticus*), REARED AT DIFFERENT SALINITIES

Submitted to

The Faculty of

Philippine Science High School

Western Visayas Campus

In partial fulfillment

of the requirements

In Science Research 2

By:

Allen Michael Gurrea

Annia Rae Nicolasora

Hannah Valencia

Philippine Science High School- Western Visayas Campus
January 2003

APPROVAL SHEET

This research paper hereto entitled:

"Gastric Evacuation and Intestinal Passage of food in relation to time in Nile Tilapia (*Tilapia niloticus*), reared at different salinities" prepared and submitted by Allen Michael Gurrea C., Annia Rae Nicolasora M., and Hannah Valencia C. in partial fulfillment of the requirements in Science Research 2 has been examined and is recommended for acceptance and approval.

Dr. Josette Biyo Ph.D.
Research Chair

Approved by the committee on Oral Examintaion with a grade of Passed on November 2002.

Mrs. Virna Jane Navarro
Member

Ms. Rowena Magno
Member

Ms. Josephine Cordero
Member

Accepted in partial fulfillment of the requirements for Science Research 2.

Rebecca V. Yandog
Director III

ACKNOWLEDGEMENTS

This research paper would not have been possible without the help and support of particular people. We would like to thank our respective families for the all-out support and financial assistance.

To Tita Grace Gurrea, thank you for all the help and prayers. We could not have started this research without you.

To the people in the Research Division of SEAFDEC, thank you for allowing us to conduct our experiment in your institution. Thank you also to the concerned and ever-supportive people of SEAFDEC especially the following:

- Manong Steve and Manang Angie for helping us canvas and obtain our experimental fish
- Manong Teddy for lending us a hand in cleaning the tanks
- Manong Prime for sharing his astonishing strength to help us in our stocking and sampling of the tilapias
- Manong Melvin and Manong Kenneth for allowing us to use the analytical balance

- Ma'am Olaguer for the concern and the time to check up on the work

Thank you all!

A heartfelt thanks to our supervisor, Ma'am Neila Chavoso. Thank you Ma'am for being with us all throughout the experiment. Thank you for the patience and guidance.

To Haydee Dumaran and family, thank you for warmly accommodating us into your home.

To Ma'am Josette Biyo, our thesis adviser, thank you for guiding us and sharing with us your knowledge to help us improve our research.

Above all, thank you to GOD Almighty for wisdom, direction, and the strength to go on. To GOD be the glory!

Nicolasora, Annia Rae M., Gurrea, Allen Michael C., Valencia Hannah C. "Gastric evacuation and intestinal passage of food in relation to time in nile tilapia (*Tilapia niloticus*) reared at different salinities."

ABSTRACT

Gastric evacuation rates and intestinal passage of food in relation to time in tilapia (*Tilapia nilotica*) reared at different salinities were evaluated. Tilapia broodstock(approximately 200g) were stocked and acclimated at one ton capacity holding tanks. Fish were fed with commercial feed (4% bodyweight) for one week and starved for one-day prior to the dissection. Stomach and intestine were weighed and measured. The gastric evacuation rates were calculated using the regression model ($y= ae^{-bx}$).

Results of the study showed that gastric evacuation in tilapia reared in brackishwater was faster (slope= -0.7844) compared to those reared in freshwater (slope= -0.3709) as determined by the slope of the regression line. Intestinal filling time was determined by testing for the rate of food movement and intestinal passage time using One-way ANOVA at 0.05α. Intestinal passage time and rate of food movement has no significant difference in relation to salinity.

TABLE OF CONTENTS

Page

Chapter

I. INTRODUCTION

II. REVIEW OF RELATED LITERATURE

B. Tilapia

III. METHODOLOGY

B. Methods

IV. RESULTS and DISCUSSION

APPENDICES

LIST OF TABLE

LIST OF PLATES

LIST OF FIGURE

Chapter I

INTRODUCTION

A. Background of the Study

The gastric evacuation time (GET) and the passage of food through the intestines was investigated in Nile Tilapia (*Tilapia niloticus)* fish in response to different salinities. In this study, voluntary feeding was imposed and markers were not used. The passage of food through the stomach was described by the exponential model.

Jobling (1986) hypothesized that the pattern of emptying is influenced by feedback signals from the receptors located in the upper intestinal tract and by factors affecting the rate of physical/ chemical breakdown of food particles. It was also hypothesized that different mathematical expressions would best fit to empirical data from gastric evacuation studies, independent upon the experimental conditions employed (Jobling, 1986).

In this study, the researchers determined if there is significant difference in the gastric evacuation and intestinal passage of food in Nile tilapia reared at different salinities using mathematical expressions.

B. Statement of the Problem

Will there be a significant difference in the gastric evacuation and intestinal passage of Nile tilapia reared in different salinities?

C. Hypothesis of the Study

There will be no significant difference in the gastric evacuation and intestinal passage of Nile tilapia reared in different salinities.

D. Objectives of the Study

1. To measure quantitatively the rate of gastric evacuation and intestinal passage of food in Nile tilapia (*Tilapia niloticus)* adult fish using the exponential method.
2. To determine if the gastric evacuation and intestinal passage of food differ with salinities.

E. Significance of the Study

This study aims to determine the gastric evacuation time and intestinal passage of food in adult Nile tilapia (*Tilapia niloticus)*. With this reason, our study will help in determining the exact time of feeding Nile tilapia. This will help people who grow Nile tilapia to estimate the exact time for feeding. This will also be of great help to fish farm owners to determine the time or time interval in feeding Nile tilapia broodstock. This will help them save money, time, and energy in feeding.

We aim to help improve finding efficiency and increase Nile tilapia production.

F. Scope and Limitations of the Study

This study was conducted at SEAFDEC/AQD for one month. In this study, fish was reared at three salinity levels (0, 16, and 32 ppt),and sampled at maximum of eight time intervals (0, 1, 2, 4, 6, 8, 10, 12) and with three fish per time and salinity.

G. Definition of Terms

Tilapia nilotica

- Herbivorous
- Feed predominantly on small invertebrates
- Weighing from 70-300g
- Distinguished by gray stripes on its scales

Temperature

- State of a body with respect to sensible heat
- Degree of heat or cold

Salinity

- The degree of saltiness
- Amount of salt in aquatic environments

Gastric Evacuation Time

- The time for food to leave the stomach
- The time when stomach will be empty
- Emptying of a meal from fish stomachs

Intestinal passage

- Passage of food through the intestines

Acclimatization

- To accustom to a new climate

Chapter II

Review of Related Literature

A. Cichlids

Cichlids (family Cichlidae) are perchlike freshwater fishes found in South America, Africa, Sri Lanka, and India, with more than 200 species in Lake Malawi (Africa) alone. They are more closely related to one another than to any other fish. The dwarf cichlid (*Nannacara anomala*) and the blue acara (*Pelmatochromis pulcher*) are popular aquarium fish, and *Tilapia cichlids* (ranging in length up to 50 cm/20 in) are important commercial fish. Because of their behavioral patterns, cichlids are of interest in behavioral research. Some species of *Tilapia*, exhibit mouth-brooding, in which the eggs are fertilized either in the spawning pit or in the mother's mouth, where the brood then remains until hatched. (First the female lays the eggs in a spawning pit dug by the male; then she picks them up with her mouth; authorities disagree as to whether she takes up the sperm released by the male into the pit or picks up the eggs after they have been fertilized.) After hatching, the young remain in the mother's mouth until they can swim independently. At this time the young stay close to the mother, fleeing back into her mouth when danger threatens. Eventually the mother resists receiving the young into her mouth, and the offspring are forced to fend for themselves (Grolier, 1993).

Two types of parental strategies are known in tilapias, namely bottom-spawners and mouth-breeders. The eggs and embryos of the first one are spawned and attached within a nest and are less protected and more exposed to external dangers than those of mouth-breeders, that are incubated in the pharyngeal cavity of one or both parents. While mouth-breeders lay generally less and larger eggs, providing the embryo with a higher yolk content, bottom-spawners lay a larger brood of smaller eggs, each containing less yolk (Fishelson).

B. Tilapia

B.1 BIOLOGY AND TAXONOMY

All the tilapias, in the broad sense, have in common a mainly herbivorous diet, in distinction to the majority of fishes which feed predominantly on small invertebrates or on young or small-sized fishes. They are therefore only one step from the primary producers (plant life) and as they grow to a good size they are valuable food source of man, the omnivore.

Structural adaptations to this diet are the long, coiled intestine, which may be up to fourteen times the body length, the bicuspid and tricuspid teeth of the jaws and the small, sharp pharyngeal teeth used to prepare the food by shredding the coarser materials and breaking some of the cell walls before passing it on to the stomach. Since the preferred diet of the different species varies from the coarse vegetation (grasses, young shoots, and leaves of water weeds) to a unicellular algae and even bacteria, the teeth also vary in the degree of coarseness and movability (Trewavas,1982).

Tilapias all exhibit a high degree of parental care and in its function they are sharply divided into substrate-spawners and guarders of the brood on the one hand and the mouthbrooders on the other (Lowe-McConnell 1959).

The mouthbrooding of the species of *Sarotherodon* is two main types, biparental or parental in subgenus *Sarotherodon* (in the restricted sense) and maternal brooding with mating of a lek pattern in the rest. The maternal mouthbrooders have been divided into several (5 to 7) subgenera: *Oreochromis, Danakilia, Alcolapia, Nyasalapia, and Neotilapia* (Trewavas, 1982).

B.2 FEEDING BEHAVIOR

Tilapias of the genus *Tilapia,* especially *T. rendalli, T. zilli, T. sparmanni* and *T. tholloni* are macrophyte-feeders in which the adults feed preferentially on filamentous algae, aquatic macrophytes and vegetable matter of terrestrial origin (leaves, plants, etc.); but this specialization does not exclude certain stages of development (alevins) at certain times of year (winter), and in certain waters poor in aquatic vegetation, taking small animal food (Spataru, 1978).

In the genus *Sarotherodon,* certain species (often endemic lacustrine species) seem very specialized feeders, notably *S. variabilis* of Lake Victoria (fine benthic sediments, Fryer and Iles 1972), *S. alcalicus grahami* of Lake Magadi (epilithic blue-green algae), *S. esculentus* (phytoplankton) and *S. macrochir* (phytoplankton and epilithic algae). But many species have a much more diversified feeding regime with a dominant vegetable component (epilithic, epiphytic, and filamentous algae, phytoplankton, vegetable debris and fine sediments rich in diatoms and bacteria) and an animal component (zooplankton and benthic organisms such as insects larvae, crustaceans and molluscs)(Bruton and Boltt, 1975). In general, a comparison of feeding in the same species of tilapia in a large range of water bodies reveals a very great variability of feeding regime. This is an element of the remarkable plasticity and ecological adaptability of tilapias (Trewavas, 1982).

B.3 FEEDING PERIODICITY

According to Man and Hodgkiss (1977), *S. mossambicus* feeds during the day. The feeding intensity (measured by an index of stomach fullness) is maximal between 12:00 P.M. and 3:00 P.M. and then slows progressively so that stomachs are completely empty between 12:00 A.M. and 3:00 A.M.

Tilapia feeding activity varies seasonally according to various factors: temperature, reproduction, interspecific competition. In Plover Cove Reservoir, Hong Kong, the seasonal cycle of feeding activity follows the temperature cycle. The minimum activity is during January-February (16 to 17°C) and maximum in July- September (27 to 30°). In Lake Kinneret, Israel, the feeding activity of *S. aureus* (measured by index of stomach fullness) is maximum in summer and autumn whereas that of *T. zillii* is maximum in spring and relatively constant at other seasons (Spataru, 1978).

C. Environmental Physiology of Tilapias

Fish of the genera *Tilapia* and *Sarotherodon* are native to Africa and Israel, the northern limit of their distribution. The tropical origin of tilapias is clearly expressed in their ecological physiology, especially in their temperature preference during their reproductive period.

Tilapias become inactive at water temperatures below 16°C, which is the minimal temperature for normal growth. Reproduction occurs above 22°C. Their adaptation to stable ambient temperature regimes has limited their natural distribution to tropical areas.

In recent years tilapias have been distributed all over the world where temperatures are suitable for their growth and reproduction. In many parts of the world tilapias have been introduced for vegetation control, pond culture and recreational fishing. They have become established in numerous lakes in Florida, California and Texas where winter temperatures are not limiting.

They also occur in other regions of the U.S.A. in water bodies, which are warmed above normal ambient temperature during the winter by geothermal water sources or artificial heating in conjunction with the operation of power plants. Some tilapias have excellent aquaculture potential because of their fast growth, herbivorous or omnivorous feeding habits, high food conversion efficiency, high tolerance to low water quality, ease of spawning, ease of handling, resistance to disease and parasites and good consumer acceptance.

Tilapias are euryhaline and are able to survive, grow and some species even reproduce in seawater up to 40% salinity. Tilapias are able to tolerate a pH range of 5 to 11 (Chervinski, 1982).

D. The Feeding Apparatus and Digestive Tract

It is important to begin with consideration of the feeding apparatus and digestive tract since these structures limit the range of potential food items that can be consumed and digested efficiently. Compared to the haplochromis cichlids, the feeding apparatus of tilapias is simple and unspecialized (Fryer and Iles, 1972). The role of the pharyngeal apparatus is to prepare food for digestion. In many species this is done by breaking or cutting the food into smaller sized units.

The esophagus is short with a small diameter and leads to a small sac-like stomach. Some investigators have questioned the identification of this latter structure (Kama Pasha, 1964; Man and Hodgkiss, 1977b) but its separation from the intestine by a sphincter, the low pH of the fluid it contains (Moriarity, 1973; Bowen, 1976b; Caulton, 1976) and the pH optima of proteases extracted from its mucosa (Fish, 1960; Nagase, 1964; Moriarity, 1973) all attest to its gastric function. Immediately behind the pyloric sphincter, the intestine receives a common bile duct. The first, short intestinal segment is thin-walled and of greater diameter than the remainder. Perhaps the most striking feature of the digestive tract of tilapias is the exceptional length of the intestine. Quantitative data for *T. rendalli, S. melanotheron and S. mossambicus* show that the ratio of intestinal length to fish standard length is between 7:1 and 10:1. The intestine ends in an anal sphincter (Caulton; Pauly; Bowen, 1976).

E. Digestion in Tilapias

Digestion in tilapias is a two-step process with distinct gastric and intestinal components. The mechanism for gastric digestion found in tilapias appears to be unique among animals. In other animals, the pH fluids in an actively digesting stomach ranges from about 2.0 to 2.2 (Barrington, 1957). This is the pH at which vertebrate gastric digestive enzymes, including those of tilapias (Fish, 1960; Nagase, 1964; Moriarty, 1973) show maximum activity. In contrast, the pH of stomach fluid in actively digesting tilapias is frequently as low as 1.25 (Moriarty, 1973; Bowen, 1976; Caulton, 1976) and values as low as 1.0 has been recorded (Payne, 1978). Moriarty(1973) was the first to describe the role of gastric acid in digestion by tilapias. He studied the population of *S. niloticus* in Lake George, Uganda, which feeds on phytoplankton dominated by colonial and filamentous blue-green species. As the algae pass from the esophagus they may travel either of two routes through the stomach. Peristaltic movement carries the food in a posterior direction along the ventral wall, up the posterior wall and back along the top to the pyloric sphincter. Some algae take a shorter route passing across the anterior of the stomach from the esophagus directly to the pyloric sphincter (Trewavas, 1982).

F. Gastric Evacuation Time

Studies on the importance and relevance of gastric evacuation, intestinal passage related to digestion and other aspects on different species has been done (Coindel, 1967). However, the heterogeneity of the results obtained in such studies need further investigations. Gastric evacuation time for *Sarotherodon niloticus* & *S. aureus* hybrids have been investigated (Ross and Jauncey, 1981) and the need for further investigations in the commercially more important species has been suggested. Studies to quantify food consumption rates have been conducted by Kitchell, McComosh (1970) and Baumann (1972). Requisite for most of these studies was knowledge of the rate of gastric evacuation (Pandian, 1967; Magnuson; 1969). The modified sacrificed method remains the only method applicable for fish by GET estimates (Perera and De Silva, 1978).

G. Gastric Evacuation Time in Nile Tilapia

Gut passage time can be a useful parameter for the estimation of the rate of food consumption of a fish population. Much information is available about stomach and gut evacuation in fish (Fäng and Grove, 1979). However, as discussed by Hofer et al. (1982), the findings obtained under artificial conditions do not necessarily apply to natural feeding conditions. By interrupting the diurnal feeding cycle for a short time during which the labeled food is offered, natural gut passage rates may be obtained (Hofer et al., 1982). Despite the increasing importance of cichlids, only few data are available on evacuation and gut passage time in this group of fish (Moriarity and Moriarity, 1973; Ross and Jauncey, 1981).

H. Control of Gastric Evacuation and Intestinal Passage

The detailed structure of the alimentary canal of fish was reviewed (Kapoor, Smit, Verighina 1975; Fäng and Grove, 1979) and the general pattern emerged that the major divisions of this organ system, and its histology, conform to the patterns seen in other vertebrates. The digestive tube consists of an inner mucosa, supporting submucosa, smooth muscle coat and outer serous layer. Major adaptations occur in different fish according to their feeding habits and greatest variation is seen in the structure of the mouth, pharynx, stomach (when present), and the length of the intestine and in the enzyme complement associated with mucosal- and digestive gland-cells. This enteric nervous system coordinates peristalsis, mixing movements, blood flow and other complex activities of the canal. In addition, mucosal cells are present which produce hormones to affect both nearby and distant segments of the gut, whilst nerves and hormones from other parts of the body can modify gastrointestinal function when such need arises(Fang & Grover).

I. Factors affecting Gastric Evacuation and Intestinal Passage

The emptying of a meal from fish stomachs has been shown influence by a number of factors. The emptying rate of the stomach depends on the species and also on such factors as temperature, food type, meal size, fish size and even method and frequency of feeding. Other factors such as reproductive state of the fish, photoperiod, stock density and diseases are also likely to affect digestion. Most workers sampled the stomach contents at various times after a meal so that emptying curves could be constructed and so allow measurements of emptying rate. Others have not quantified the rate of emptying in this way, but have confined themselves to observing the time taken for the meal to be emptied. The reason for such studies depends on the idea that the fish will eat available food in amounts depending on the present stomach fullness and at intervals determined by the rate of stomach emptying.

Grove, Lozoides and Nott (1978) for example, found that appetite returns in the rainbow trout not only in close proportion to the decline in stomach content, but that increased daily rates of feeding observed in fish fed on low-energy diets were achieved by more frequent meals and were accompanied by more rapid rates of gastric emptying. Jobling (1980) concluded that the overall energy content of the diet, and not deficiency of a specific nutrient, was the factor monitored by the fish. However, not all fish possess stomachs and the question arises of how appetite in these species is controlled (S. Holmgren, D.J. Grove, D.J. Fletcher). Furthermore, chemical and physical composition of the food has been reported to affect gastric emptying rate (GER) measured as weight per unit time (Karpevitch and Bokova, 1973; Pandian, 1967; Windel et al., 1969; Rosenthal and Hampel, 1970). An attempt was made to compare the rate of gastric evacuation and intestinal passage of a diet containing 45% protein, reared at different salinities done in two size groups of fingerlings.

Measurement of the rate of gastric evacuation and intestinal passage can provide information for the direct computation of food rations for any period (Darnell and Meierotto, 1962; Popova, 1967; Seaburg and Moyle, 1964). Such can provide data for direct estimates of rate of food intake and therefore provide a check on indirect bioenergetic approaches. Gastric emptying has been related to fish size (Swenzon and Smith, 1973; Jones, 1974; Jobling et al., 1977).

Chapter III

METHODOLOGY

A. Materials

Nile tilapia fish

Fiberglass tanks

Siphoning hose

Refractometer

Ruler

Mettler balance

Forceps

Graduated cylinder

Dissection tools

B. Methods

B.1 Experimental Fish

Nile tilapia fish with mean weight of 200g were obtained in Dumangas, Iloilo and reared under laboratory conditions at the Southeast Asian Fisheries Development Center, Tigbauan, Iloilo. Immediately after transport to the laboratory, the fish were allowed to recover in a one ton capacity holding tank with aerated water. Fish were measured and weighed by the use of a ruler (cm) and Mettler Balance (g), respectively during stocking.

B.2 Acclimatization

All fish were acclimated to 0, 16, and 32 ppt salinity for one week. Salinity was gradually increased by 5 ppt everyday until it reached 16 and 32 ppt. During this time, fish were slowly adapted to pelletized commercial feeds.

B.3 Experimental Design, Set-up and Treatment

A design to compare the effects of the different salinities was carried out. Three one-ton capacity fiberglass tanks were used with three salinity levels (0, 16, and 32 ppt) each, having eight time intervals (0,1, 2, 4, 6, 8,10, 12hr) with three replicates per level and treatment. Around 30 fishes were stocked/ tanked so that a total of 90 fishes were used.

B.4 Feeding Management

A maintenance diet which corresponds to 4% body weight was introduced during the acclimatization on a period of two weeks. After one week, fish were retained in their respective tanks corresponding to their salinity levels (0, 16, 32 ppt) After which, a 24-hour fasting period was imposed to ensure the complete absence of food remains from the alimentary canal. This starvation period was determined from previous studies, the water being replenished until all uneaten food particles and feces were removed from the tanks. Then fish were allowed to consume a diet previously mentioned given to satiation until no signs of feeding will be observed. Feces and excess food were siphoned out and fish were sampled at 0, 1, 2, 4, 6, 8, 10, 12 hour thereafter.

B.5 Sampling/ Analysis of Samples

Batches of fish were sampled at time intervals ranging from 0, 1, 2, 4, 6, 8, 10, 12 hours, removed from the tanks and sacrificed. Samples were kept and analyzed. The fish that did not eat were not included in the analysis. Autopsy of samples will be performed according to Windel (1966; 1967; 1968). The body cavity was opened and the esophagus and pyloric valve ligated with forceps. After which, the stomach was removed and likewise, the intestine.

B.6 Gastric evacuation rates

The empty stomach of each individual fish was weighed to the nearest grams on a Mettler Balance and the stomach content was obtained by subtracting the weight of the stomach with that of the empty stomach. An exponential model ($y= ae^{-bx}$; where y is the amount of food remaining in the stomach per weight of fish and time was used to ascertain the evacuation rate for each treatment.

B.7 Intestinal filling time

Length of the intestine was likewise measured. When the food reached the anal opening, the intestine was considered 100% full. Data were discarded when distance traveled by food equaled the total length of the intestine. The intestinal passage time (IPT) and rate of food movement (RFM) were then calculated as

$RFM= D/T$

$IPT= L(T)/D$

Where, L= total length of the intestine (cm), T= time since feeding (min), D= distance traveled by food from the junction of the stomach and intestine (cm) (Hofer et al., 1982).

B.8 Statistical Analysis

The test used in the statistical analysis for the Gastric Evacuation Rate was exponential regression model and One-way ANOVA test for unequal samples for Intestinal Passage Time and Rate of Food Movement.

Chapter 4

RESULTS and DISCUSSION

GASTRIC EVACUATION RATES

Gastric evacuation rates were determined from the exponential relationship between the amount of food remaining in the stomach per weight of fish and the time(Fig. 1). The amount of food remaining in the stomach per fish weight was used to determine gastric evacuation time. This was used to correct the variability in sizes of fish so that fish size will not matter in gastric evacuation rate. The rate for Tilapia reared in brackishwater was faster (slope = -0.7844) compared to Tilapia reared in freshwater (slope = -0.3709).

The gastric evacuation rates for freshwater and brackishwater can be described by the equation: $y= 0.01327e^{-0.3709x}$ $r^2= 0.93$ and $y= 0.01926e^{-0.7844x}$ $r^2= 0.97$ respectively, where y = amount of food remaining in the stomach per weight of fish and x = time.

No rate was determined for Tilapia reared in seawater because of several factors. Nile Tilapia obtained was reared at freshwater. Brackishwater and seawater was acclimatized until it reached their corresponding ppt. The fishes in seawater did not show trend in their gastric evacuation. This can be caused by the small span of time that they were acclimatized to 32ppt.

Factors which affect gastric evacuation may also affect appetite and food intake, at least in short term. However, control of food intake may also depend on metabolic and behavioral factors (Beukema,1968; Rozin and Myar,1961,1964; Colgan, 1973).

INTESTINAL FILLING TIME

The intestines of Tilapia in brackishwater were full after 95 min after onset of feeding, but only after 155 min in freshwater and after 395 min in seawater, so that intestinal passage time took longer in seawater than in freshwater and brackishwater (Table 1). The intestinal passage in brackishwater was not significantly faster than freshwater and seawater (P >0.05). The rate of food movement in brackishwater was not significantly faster than that in freshwater and seawater. The rate of food movement was not affected by salinity (P >0.05). The very long intestines of tilapias complicate the determination of intestinal filling time. Although fish were starved before the dissection, some feed were still left in the intestine.

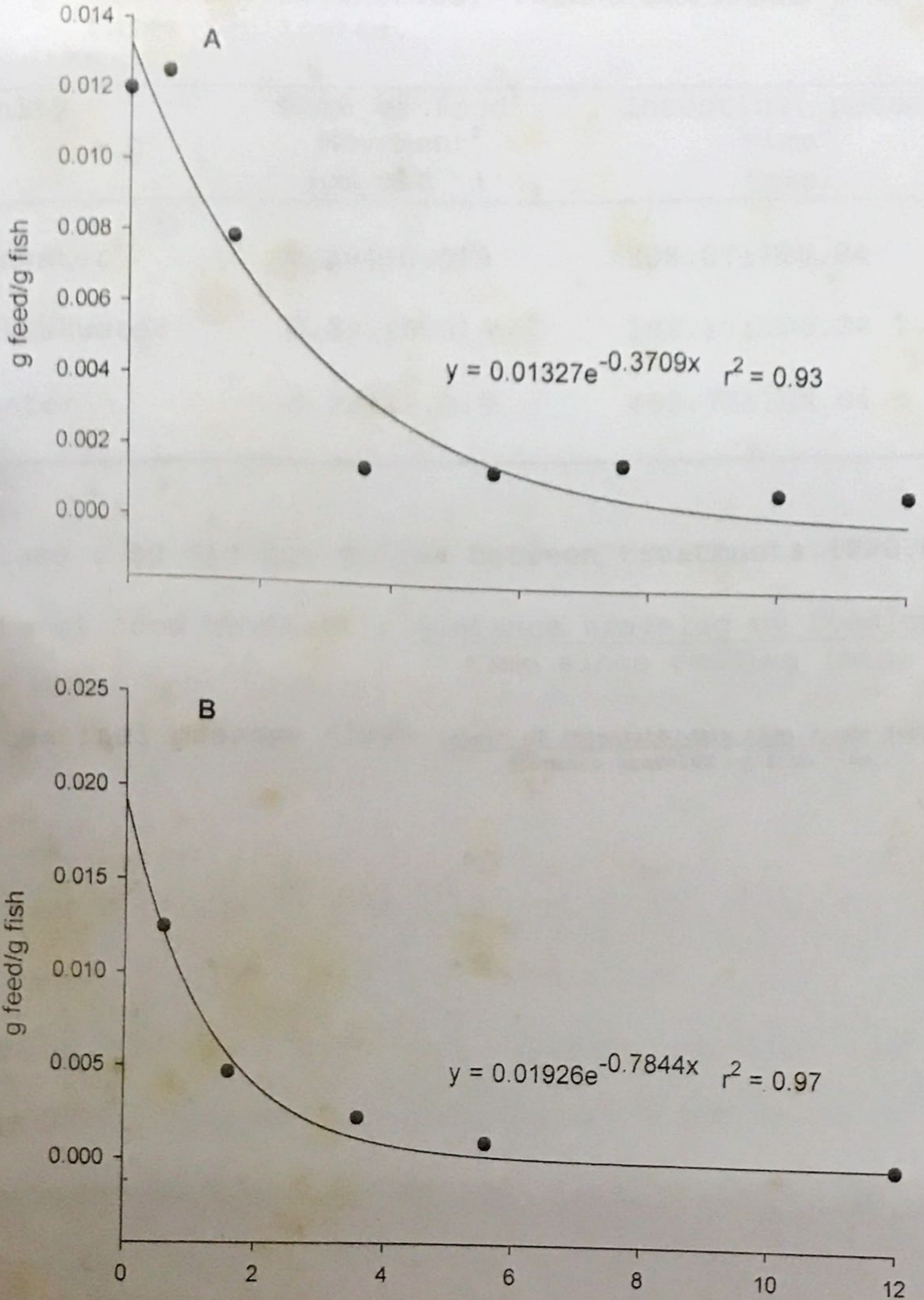


Figure 1. Gastric evacuation of tilapia reared in freshwater (A) and brackishwater (B)

Table 1. Rate of Food Movement(RFM) and Intestinal Passage Time(IPT) of *Tilapia nilotica* reared at different salinities.[1] Values are means ± sd of three replicates.

Salinity	Rate of food Movement[2] ($cm\ min^{-1}$)	Intestinal passage time[3] (min)
Freshwater	0.294±0.019	308.07±109.04
Brackishwater	0.321±0.019	186.17±109.04
Seawater	0.285±0.019	403.73±109.04

[1] Values ± sd did not differ between treatments (P>0.05)

[2] Rate of food movement = $\frac{\text{distance traveled by food(cm)}}{\text{time since feeding (min)}}$

[3] Intestinal passage time= $\frac{\text{length of intestine(cm) x time since feeding(min)}}{\text{distance traveled by food (cm)}}$

Chapter 5

SUMMARY, CONCLUSION, RECOMMENDATIONS

The gastric evacuation time was determined by the exponential relationship between the amount of feed remaining in the stomach per fish weight versus time. The gastric evacuation rate of tilapia reared in brackishwater was faster compared to tilapia reared in freshwater determined by their slope.

The intestinal passage time and rate of food movement in brackishwater was not significantly faster than that in freshwater and seawater. Consequently, the rate of food movement and intestinal passage time was not affected by salinity.

Based on the results obtained that no gastric evacuation rate was determined for seawater, acclimatization time for *Tilapia nilotica* should be lengthened. Acclimate fish by adding 5 ppt salinity every 3 days instead of one day so that fish has more time to adapt to the salinity.

In this study, fish were sampled every 2 hours both for the gastric evacuation rate and intestinal passage time. We suggest that samples for the intestinal passage time be separated from the gastric evacuation rate.

Intestinal passage time should be sampled every 10 minutes instead of every 2 hours with the gastric evacuation time. In this study, the space gap of time intervals for intestinal passage time is too far (0,1,2,4,6,8,10 and 12 hr) that analysis is not so significantly different.

LITERATURE CITED

Brutton, M.N., Boltt, R.E., 1975. Aspects and the Biology of *Tilapia mossambica* peters in a natural freshwater lake. Journal of Fish Biology; 7:423-446.

Chervinski, J. 1982. Environmental Physiology of tilapias, p.119-128. In R.S.V. Pullin and R.H. Lowe-Mc Connell (eds.) The Biology and Culture of Tilapias. ICLARY Conference Proceedings 7.432p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Duggan, R.T., Pitcher, TJ., Rankin, J.C. editor, 1983, Control Processes in Fish Physiology, Wiley-Interscience, a division of John Wiley and sons, Inc. NY. 23-31

Fänge, R. and Grove, D.J. 1979. 'Digestion' in Hoar, W.S., Randall D.J. & Brett, J.R. Fish Physiology, Vol. VIII: 162- 260. New York, Academic Press.

Fryer, G., Iles, T.P. 1972 the Cichlid Fishes of the Great Lakes of Africa: their Biology and evolution. T.F.H. Publication. Neptune City, New Jersey.

Grolier Encyclopedia of Knowledge. 1993. Grolier Incorporated. Volume 4.

Grove, D.J. and Crawford, C. 1980. Correlation between digestion rate and feeding frequency in the stomach teleost, *Blennius pholis L.* Journal of Fish Biology, 16: 235- 47.

Grove, D.J., Lozoides, L. and Nott, J. 1978. Satiation amount, frequency of feeding and Gastric Evacuation Rate in *Salmo gairdneri*. Journal of Fish Biology, 12: 507-16

Hoar, W.S., Randall, D.J. and Brett, J.R. 1979. Fish Physiology, Vol. VIII. Academic Press, New York.

Hofer, R. and Schiemer, F. 1981. Proteolytic activities in the digestive tract of several species of fish with diff. Feeding habits. Oecologia, 48: 342- 345.

Holmgren, S. 1982. The effects of VIP, substance P and ATP on isolated muscle strips from the stomach of the rainbow trout, *Salmo gairdneri*. Acta Physiologica Scandinavica, 114: 39A.

Jobling, M. 1980. Gastric evacuation in plaice, *Pleuronectes platessa L.* Effect of dietary energy level and food composition. Journal of Fish Biology, 17: 187-96.

Jobling, M. Gwyther, D. and Grove, D.J. 1977. Some effects of temperature, meal size, and body weight in the dab, *Limanda limanda*. Journal of Fish Biology. 10: 292-298.

Jones, R. 1974. The rate of elimination of food from the stomach in Laddock, *Melanogrammus aeglefinus,* cod, *Gadus morhua* and whiting, *Merlangius merlangus.* J. Cons. Perm. Int. explor. Mer 35: 225-243.

Kapoor, B.G., Smit, H. and Verighina, I.A. 1975. The alimentary canal and digestion in teleosts. Advances in Marine Biology, 13: 109- 239.

Karpevitch, A.F. and Bokova, E. 1973. Rates of Digestion in marine fishes. Zoology Zh. 16: 28-44.

Kitchell, J.F. 1970. The daily ration for a population of bluegill sunfish, *Lepomis macrochirus.* Ph.D. Thesis. University Colorado, Boulder, Colo. 83 p.

Lowe-Mc Connell,R.H.,Pullin, P.S.V., Editors. 1982. The Biology and Culture of Tilapias. ICLARM Conference Proceedings 7. International Center for Living Aquatic Resources Management, Manila, Philippines. 3-147.

Magnuson, J. 1969. Digestion and Food consumption by Skipjack tuna (*Katsuwunos pelamis)*. Trans. Am. Fish. Soc. 98: 379-392.

Man, H.S.H., Hodgkiss, I.J. 1977b. Studies on the ichtxofaunain Plover Goove Reserior, Hongkong: Feeding and Food Relations. Journal of Fish Biology. 11: 1-3.

McComish, T.S. 1970. Laboratory experiments on growth and food conversion by bluegill. Ph.D. Thesis University Missouri Columbia, Mo. 185 p.

Moriarity, D.J.W. and Moriarity, C.M. 1973. The assimilation of carbon from phytoplankton by two herbivorous fishes: *Tilapia nilotica* and *Haplochromis nigripinnis*. J. Zool., Lond. 171: 41-55

Murillo, D.P., Gastric Evacuation and Intestinal Passage in Relation to time in Seabass (*Lates calcarifer)*Bloch fingerlings, reared at different salinities. SEAFDEC, Iloilo, Philippines: Thesis.

Murillo, D.P., Gastric Evacuation and Intestinal Passage in Relation to dietary protein in Seabass (*Lates calcarifer)*Bloch fingerlings, reared at different salinities. SEAFDEC, Iloilo, Philippines: Thesis.

Pandian, T.J. 1967. Intake, digestion, absorption and conversion of food in fishes. *Megalops cyprinoides* and *Ophiocephalus striatus*. Marine Biology. 1: 16-32

Perera, P.A.B. and De Silva, S.S. 1978. Studies on the biology of young grey mullet, *Mugil cephalus* L. Digestion. Marine Biology. 44: 383-387.

Rosenthal, H. and Hampel, G. 1970. Experimental studies in feeding and food requirements of herring larvae (*Clupea harengus* L.). In: Marine Food Chains (J.H. Steele ed.). Edinburgh: Oliver and Boyd. 344-364 p.

Sumagaysay,N.S. Growth, daily ration, and gastric evacuation rates of Milkfish(*Chanos chanos*)fed supplemental diet and natural food.1991. SEAFDEC,Tigbauan,Iloilo,Philippines: Thesis.

Swenson, W.A. and Smith, L.L. 1973. Gastric digestion, food consumption, feeding periodicity and food conversion efficiency in the walleye (*Stizostedion vitreum.* J. Fish. Res. Bd Can. 30: 1327-1336.

Windel, J.T. and Norris, D.O. 1969. Gastric evacuation in rainbow trout. Prog. Fish. Cult. 31: 20-26

GASTRIC EVACUATION RATES
(Raw Data)

TIME	SALINITIES	WEIGHT OF FISH (g)	WEIGHT OF STOMACH (g)	WEIGHT OF FEED (g)	RATIO OF FEED WT. OVER FISH WT.
0hr	FW	191.1	2.14	0.59	0.0072
	BW	19 4.3	1.22	0.54	0.0041
	SW	182.2	0.8	0.59	0.0013
.58hr	FW	235.2	2.95	0.52	0.0102
	BW	217.1	3.07	0.45	0.023
	SW	164.2	0.45	0.41	0.00029
1.58hr	FW	199.7	2.27	0.47	0.0079
	BW	137.3	0.54	0.36	0.00103
	SW	156.2	1.04	0.39	0.0031
3.58hr	FW	172.5	0.67	0.4	0.0015
	BW	234.1	1.17	0.6	0.0023
	SW	188.8	0.59	0.46	0.0007
5.58hr	FW	262.1	10.29	0.61	0.0026
	BW	250.8	0.7	0.58	0.0005
	SW	234.6	0.81	0.54	0.0013
7.58hr	FW	211.8	0.96	0.47	0.0018
	BW	202.7	1.16	0.46	0.0035
	SW	215.7	1.14	0.79	0.0016
10.0hr	FW	176.8	1.33	0.45	0.0056
	BW	207.6	1.62	0.51	0.0053
	SW	148.6	0.89	0.56	0.0022
12.0hr	FW	224.8	1.62	0.63	0.0018
	BW	231.3	0.55	0.55	0
	SW	182.1	0.87	0.58	0.0018

INTESTINAL FILLLING TIME
(Raw Data)

TIME	SALINITIES	Intestine length (cm)	Feed	Intestinal Passage Time (min)	Rate of Food Movement (cm/min)
0hr	FW	46.8	22.64	124.03	0.377
	BW	58.52	30.06	116.81	0.501
	SW	49.63	46.44	64.12	0.774
.58hr	FW	71.25	62.44	108.4	0.678
	BW	56.5	37.75	142.19	0.397
	SW	50.69	36.5	131.93	0.384
1.58hr	FW	51.75	37.75	212.48	0.244
	BW	45.03	35.63	195.89	0.229
	SW	54.79	33	257.35	0.213
3.58hr	FW	82.19	51.69	437.27	0.188
	BW	45.13	43	289.77	0.156
	SW	63.48	26.63	655.54	0.0968
5.58hr	FW	62.81	59.81	414.81	0.151
	BW	Full	Full		
	SW	73.57	68.66	423.25	0.174
7.58hr	FW	71.94	67.19	551.41	0.13
	BW	Full	Full		
	SW	Full	Full		
10.0hr	FW	Full	Full		
	BW	Full	Full		
	SW	59.94	44.44	890.19	0.067
12.0hr	FW	Full	Full		
	BW	Full	Full		
	SW	Full	Full		

Plate 1. *Tilapia niloticus* reared in Freshwater.

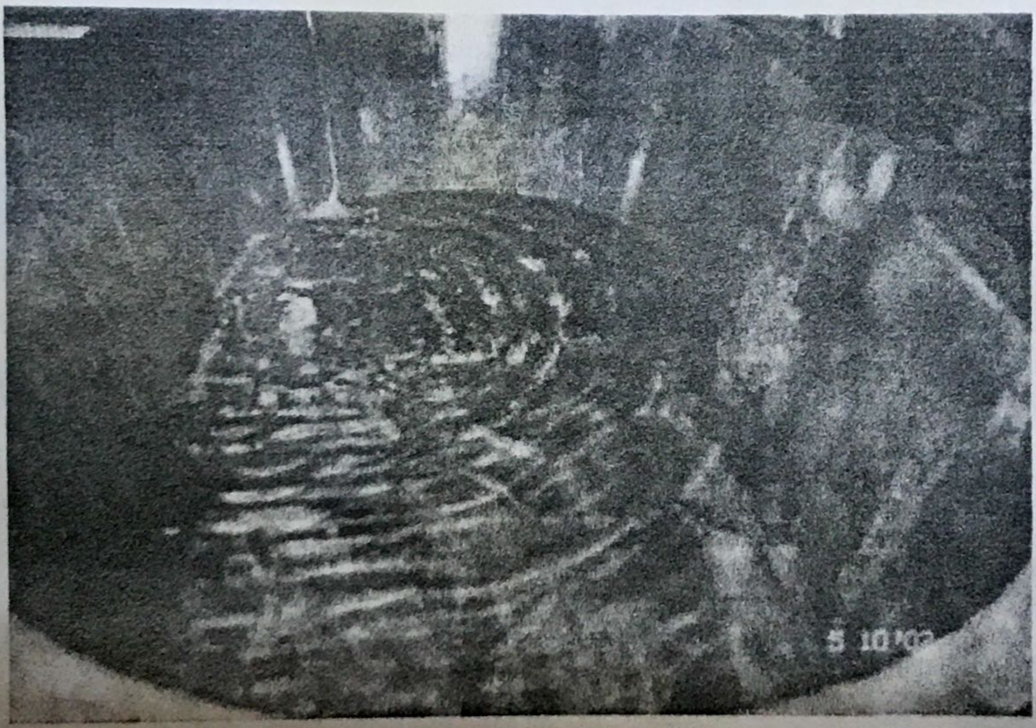


Plate 2. *Tilapia niloticus* reared in Brackishwater

Plate 3. Cleaning and siphoning feces and excess feed from tanks

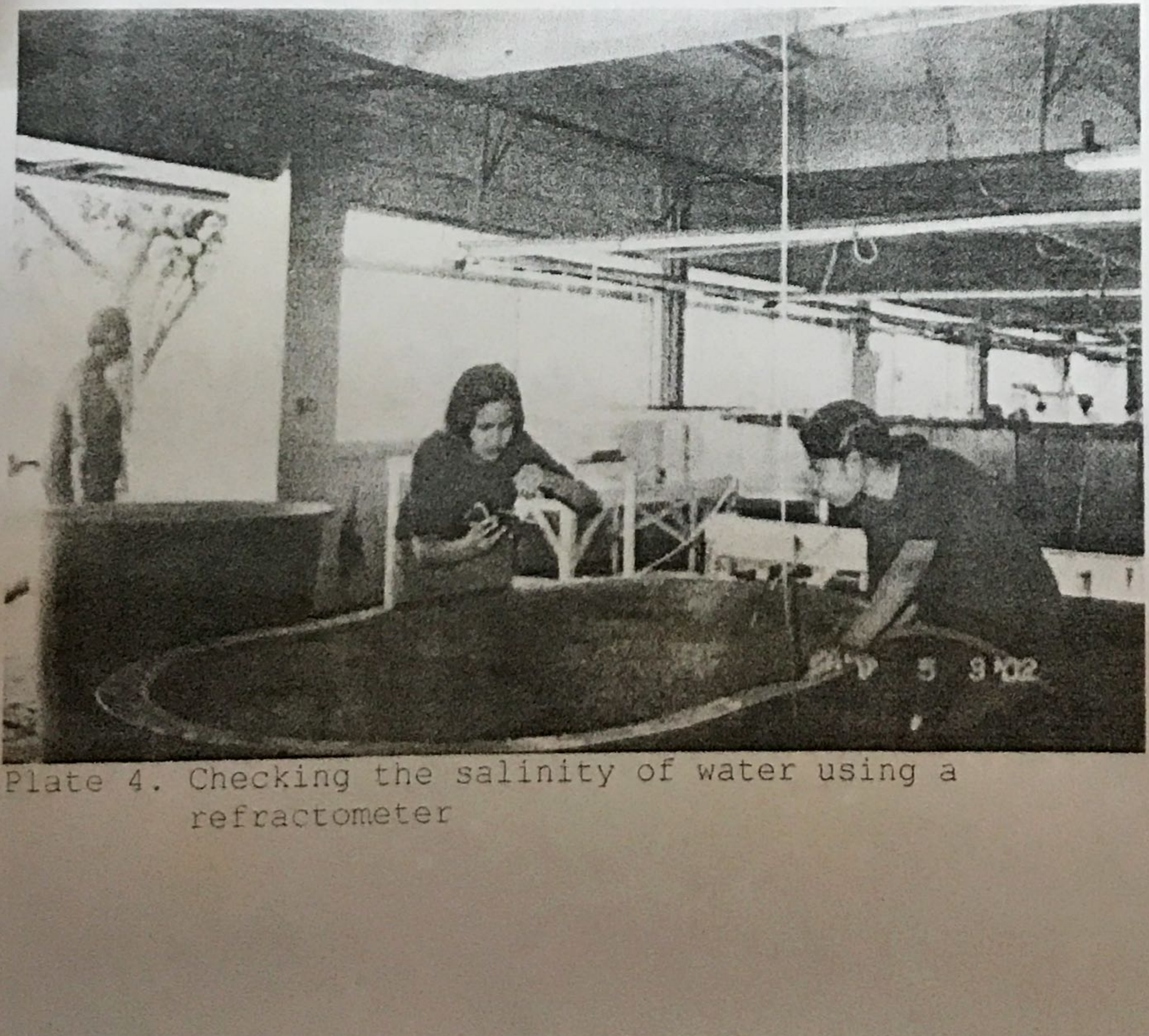


Plate 4. Checking the salinity of water using a refractometer

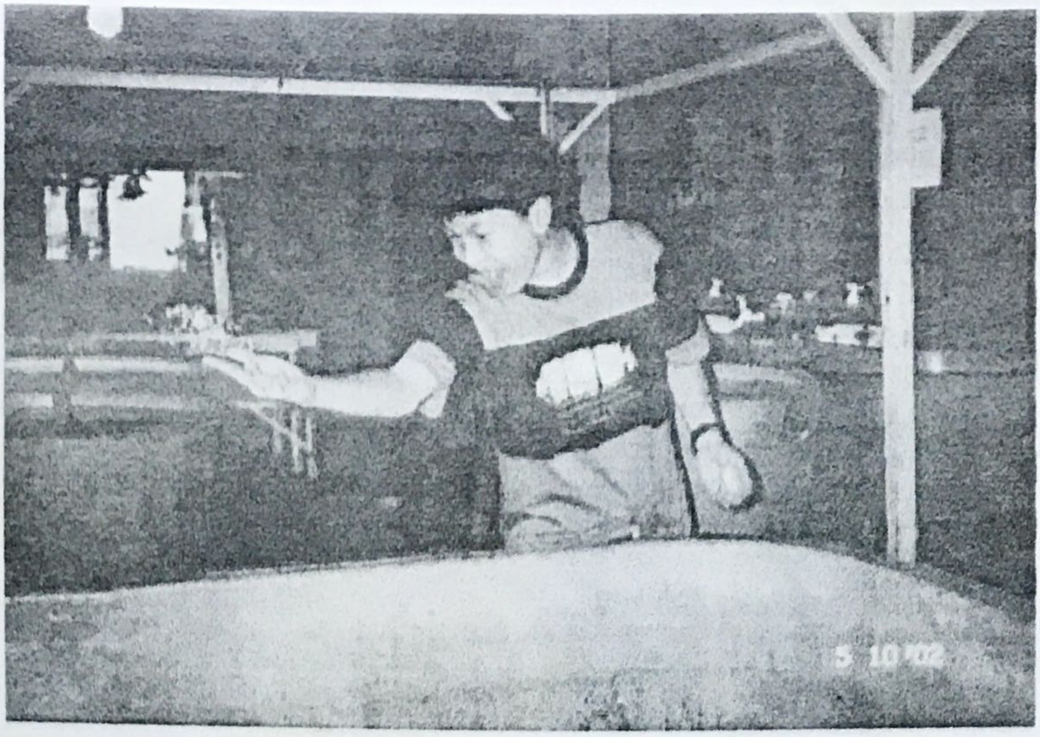


Plate 5. Feeding tilapia with commercial feed.

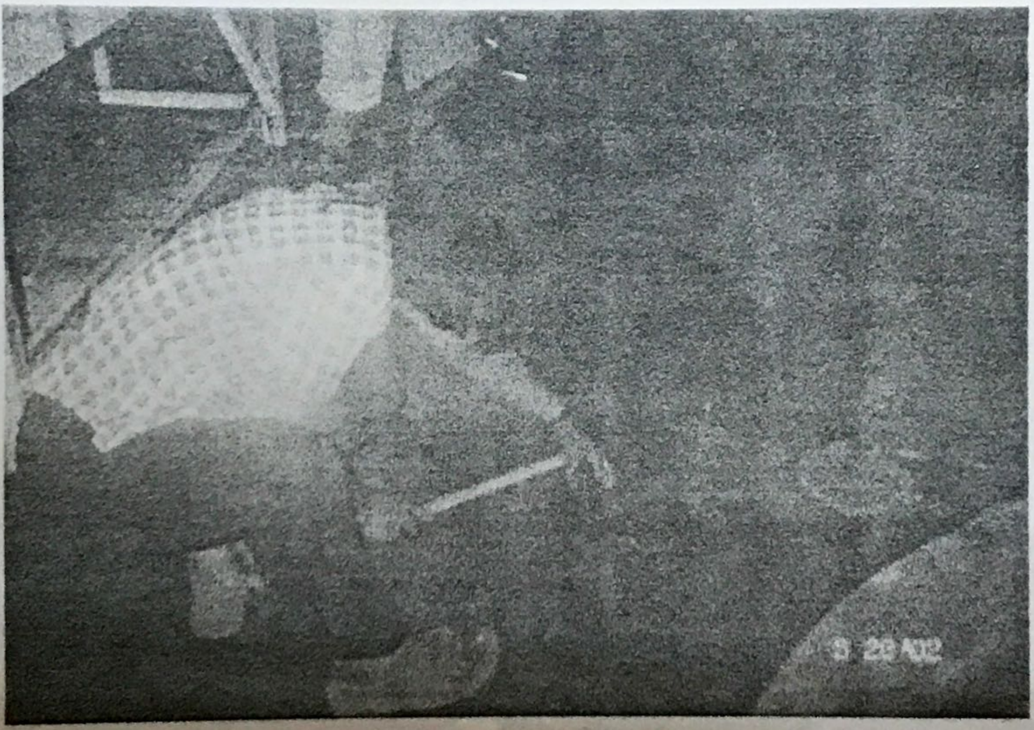


Plate 6. Sampling fish every 2 hours.

Plate 7. Dissection of *Tilapia niloticus*.

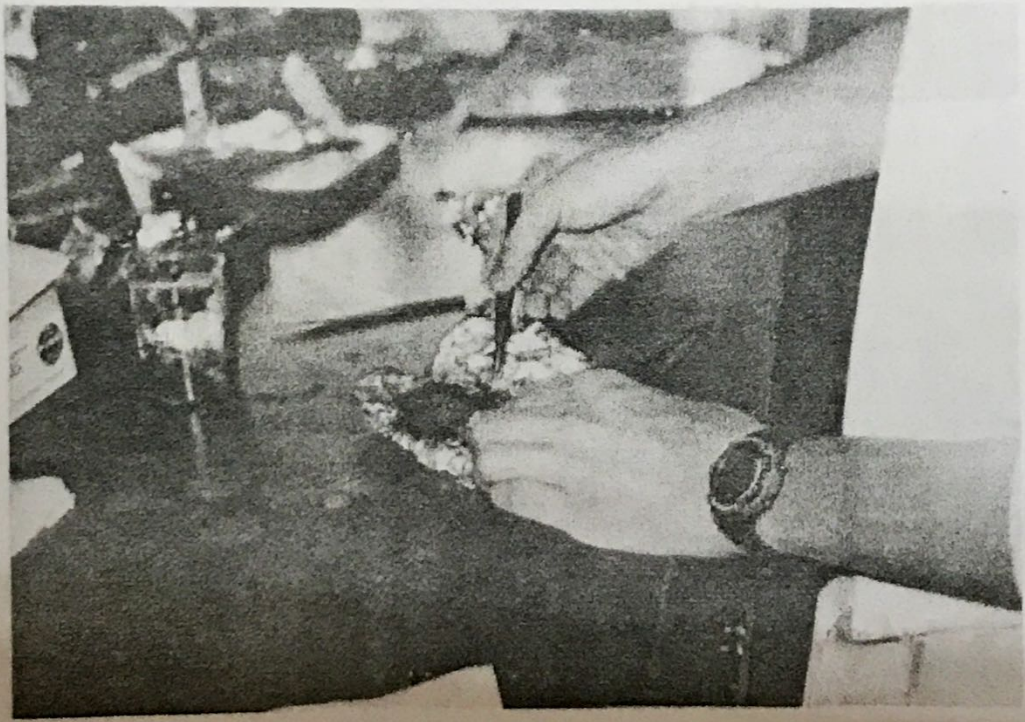


Plate 8. Separating the stomach and the intestine from other body organs of tilapia

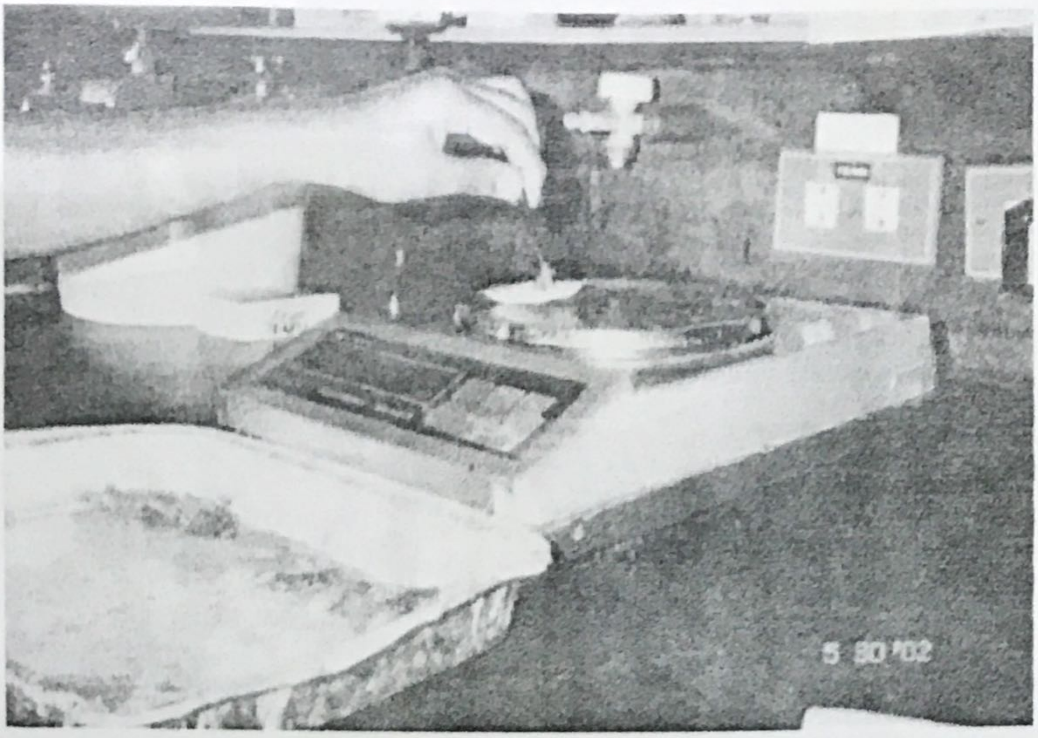
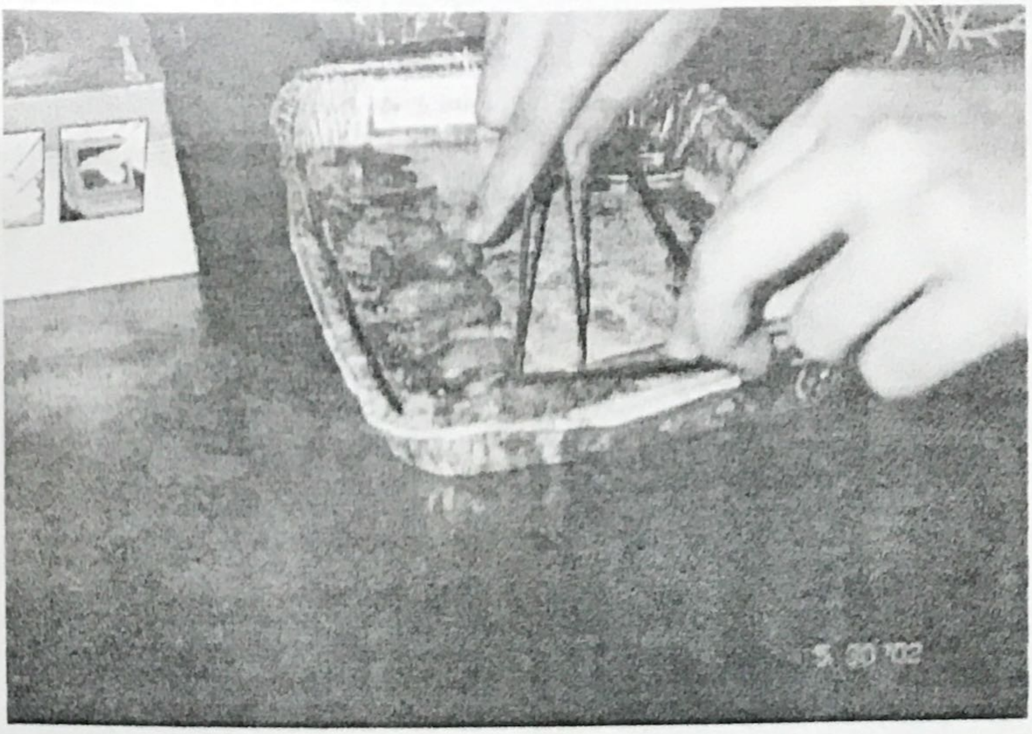


Plate 9. Weighing the stomach of *Tilapia niloticus* using analytical balance.

Plate 10. Opening the stomach of *Tilapia niloticus*.



5 30 '02

Plate 11. Scraping food from the stomach of *Tilapia niloticus*.

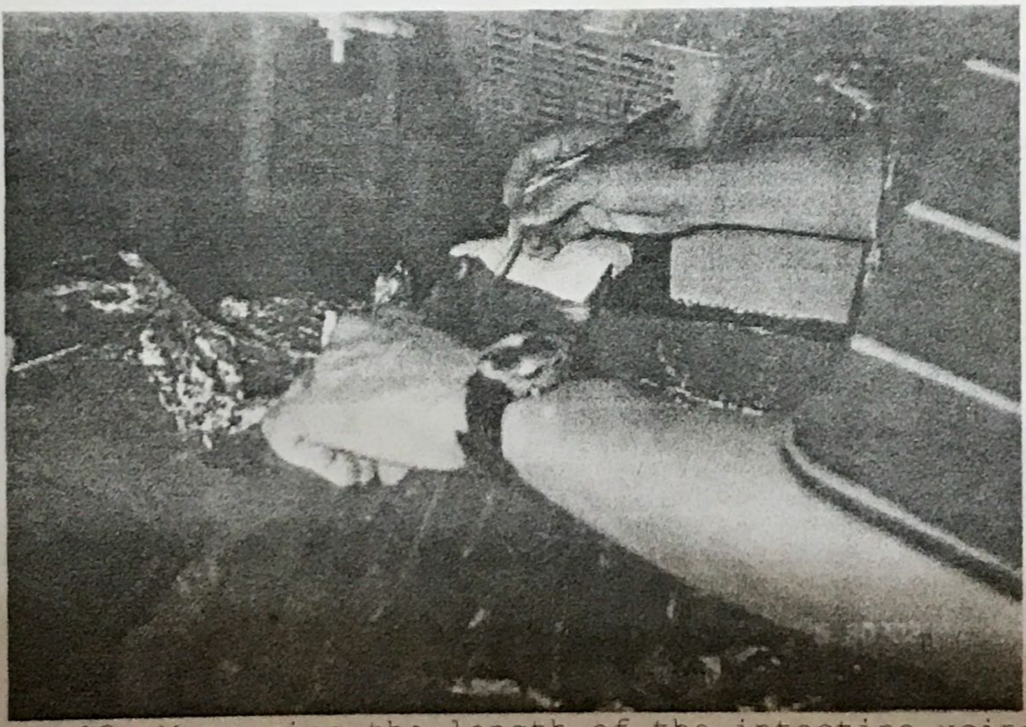


Plate 12. Measuring the length of the intestine using a ruler.