A Study on the Meristic and Morphometric Characteristics of Thailand strain and GIFT strain of Nile Tilapia (*Oreochromis niloticus*)

Rholine Gem Martin S. Veto
Daniel S. Tismal II

Submitted to the
Department of Biology
College of Arts and Sciences
University of the Philippines Manila
Padre Faura st., Ermita, Manila

In partial fulfillment of the requirements
For the degree of
Bachelor of Science in Biology
February 2002

Department of Biology

College of Arts and Sciences
University of the Philippines Manila
Padre Faura, Ermita, Manila

Announcement of
Undergraduate Thesis Presentation

RHOLINE GEM MARTIN S. VETO
DANIEL S. TISMAL II

Entitled

A Study on the Meristic and Morphometric Characteristics of
Thailand strain and GIFT strain of Nile Tilapia
(*Oreochromis niloticus*)

For the Degree of
Bachelor of Science in Biology

1:00 P.M., March 25, 2002

THESIS ADVISER
Samuel Go, MSPH
Professor
Department of Biology CAS
U.P. Manila

THESIS READER
Dennis E. Dantic, MPH
Assistant Professor
Department of Biology CAS
U.P. Manila

Endorsed by:

Elisa Co
Chairperson, Thesis Committee
DB, CAS
U.P. Manila

Authorized by:

Rosario R. Rubite
Chairperson
DB, CAS
U.P. Manila

This certifies that the undergraduate thesis entitled "A Study on the Meristic and Morphometric Characteristics of Nile Tilapia (*Oreochromis niloticus*)" submitted by Rholine Gem Martin S. Veto and Daniel S. Tismal II for the Degree of Bachelor of Science in Biology has been approved and accepted by the Department of Biology at the College of Arts and Sciences, University of the Philippines Manila, this 1st day of April 2002.

Prof. Samuel Go
Thesis Adviser

Prof. Dennis Dantic
Thesis Reader

Prof. Rosario Rubite
Chair
Department of Biology

Dr. Marilou Nicolas
Dean
College of Arts and Sciences

CURRICULUM VITAE

Personal Information

Name:	Rholine Gem Martin Veto y Sindingan
Date of Birth:	November 5, 1980
Place of Birth:	Batangas City
Civil Status:	Single
Citizenship:	Filipino
Address:	B-4 L-38 J. Hernandez st, SAV7, Pulanglupa II, Las Piñas City
Father's Name:	Roger D. Veto
Mother's Name:	Lina S Veto
Contact Numbers.	826 – 4091 0919 – 3552053
E - mail Address:	rholinedwn@yahoo.com

Educational Background

Elementary:	Don Bosco Technical Institute Makati 1986 – 1993
Secondary:	Manila Science High School 1993 – 1997
College:	University of the Philippines Manila 1997 – 2002

Affiliations

Biological Sciences Society:	Auditor (2001 – 2002) Member (2000 – Present)
Ugnayang Pahinungod:	Member (1997 – Present)
UP Cell Society:	Auditor (2000 – 2001) Member (1999 – 2001)
UP Peer Facilitators:	Member (1997 – 1998)

CURRICULUM VITAE

Personal Information

Name:	Daniel Tismal y Santiago II
Date of Birth:	August 13, 1979
Place of Birth:	Quezon City
Civil Status:	Single
Citizenship:	Filipino
Address:	#30 Chico st., Project 2, Quezon City
Father's Name:	Daniel M. Tismal Jr.
Mother's Name:	Editha S. Tismal
Contact Numbers:	921 – 9793 0917 – 8991292
E-mail Address:	daniel98@edsamail.com.ph

Educational Background

Elementary:	La Salle Greenhills 1986 – 1992
Secondary:	Philippine Science High School 1992 – 1996
College:	University of the Philippines Manila 1996 – 2002

Affiliations

Upsilon Sigma Phi: Fellow Batch '98

ACKNOWLEDGEMENTS

We would like to thank...

...God, first and foremost, for His divine guidance throughout the trying times of our study. We would never have done anything without Him.

...our parents, for their all-out support. Thank you for raising us to be fine the young sons that we are now.

...Professor Go, for being very patient with us inspite of his very demanding schedule. Other advisers wouldn't have taken us on. ☺

...Professor Dantic, for his constructive comments on our thesis. We wish you all the best on your future endeavors sir.

...Mang Joe Capistrano of Joanne's fishfarm, for the GIFT Tilapia and the background to get us started. *Tenk yu mang Ju!* ☺

...Mang Telok Manarpaak of Jobski fishfarm, for providing us with tilapia for our study at a very reasonable price.

...the people of BFAR, for accommodating us and answering all our questions on aquaculture. Thank you all for being warm to us.

...Ate Tess Apostoles, Kuya Edgardo Acantillado, and Kuya Rogelio Pascual Jr., for being kind in lending us equipment when we needed, and for good times when we needed as well.

...our siblings: Francis, Ian, and Colleen (Rholine's); Trissa and Sherry (Daniel's) for understanding why their brothers had to hog the computers 'til they finished.

Daniel thanks...

...Bley, for being there through aches and pains.

...Ken, for his high-tech computer.

...Anadel for being alert for me.

...Aileen, for your unselfish contribution of your time and effort.

Rholine thanks...

...the Biological Sciences Society (BSS), for keeping me preoccupied from the hell of performing the study. ☺ B-S-S, Bayan ng Superstars!!!

...Terry, for helping me drive myself to be the best that I can be. You know what I mean.

...my fellow Southern Sons (Jude, Luke, and Vince), for being great drinking buddies. I'm looking forward to our next sessions.

...Jhason, for being the barkada member I haven't mentioned. May girlfriend ka namang bago eh.

...Inna, for being bossy. You've been very helpful.

...the sophie girls (Sarrie, Joyce, and Cesca), your friendships gave me a breath of fresh air.

...and to all the others I failed to mention, text me 0919-3552053 for all your violent reactions.

TABLE OF CONTENTS

List of Tables

LIST of PLATES

LIST of APPENDICES

ABSTRACT

Thirteen biometric characters were used to differentiate and compare the Thailand-strain and the GIFT-strain of Nile Tilapia (*Oreochromis niloticus*). Meristic and morphometric data from 30 samples for each strain were subjected to descriptive and statistical analysis. The study showed that there are no significant differences in all meristic characters (number of dorsal fin rays, number of pectoral fin rays, number of pelvic fin rays, and number of anal fin rays) as well as the horizontal eye diameter between the Thailand-strain and GIFT-strain of *O. niloticus*. Generally, the GIFT-strain of *O. niloticus* has greater values for the other morphometric characters (head length, preorbital distance, postorbital distance, orbital depth of the head, occipital depth of the head, total body length, standard length, and total body weight) compared to the Thailand-strain *O. niloticus*.

INTRODUCTION

1.1 Background of the Study

The increase of demand for food to provide to an increasing population has turned the industry of aquaculture to a science. Aquaculture serves its purpose of providing the population food. Beyond its growing importance for urban Philippine consumers as a relatively cheap source of protein, tilapia aquaculture is beginning to assume a more important role as a source of additional income and protein for rural farmers and communities (Fermin, 1985).

Tilapia species are cultured because of their potential in the food industry as a cheap protein source that can be easily raised and harvested. These features have contributed to the suitability of tilapia in pond cultures. In fact, tilapia species have been used extensively for this purpose throughout East and Central Africa, as well as in other parts of the world (Payne, 1970). Most of them feed on plankton and can utilize natural food sources that develop in the ponds (Fishelson and Loya, 1969) such as phytoplankton and detritus. One of these species is *Oreochromis niloticus*, commonly known as the Nile Tilapia.

The genital papilla of the breeding male is not tassellated. The jaws of the mature male are not greatly enlarged (length of lower jaw 29-37% of head length). The most distinguishing characteristic of the species is the presence of regular vertical stripes throughout the depth of the caudal fin. The margin of the dorsal fin may either be gray or black. The number of vertical bars in the caudal fin ranges from 7-12 (Fishbase, 2002).

O. niloticus are grown in fishponds that are fertilized with organic and inorganic fertilizers such as ammonium phosphate, urea, and muriate of potash to increase primary

production and fish growth (Diana *et al*, 1988). *O. niloticus* also has a wide natural distribution in Africa and has been introduced in tropical and subtropical regions for aquaculture and research purposes (Carino and Casauay, 1988). The most distinguishing characteristic of this species is the presence of regular vertical stripes in its caudal fin.

The existing strain was first introduced into Southeast Asia by the United Nations International Children Emergency Fund (UNICEF) in 1974, and later by the Bangladesh Research Institute (BFRI) from Thailand (Gupta, 1992). In 1989, the government introduced the GIFT (Genetically Improved Farm Tilapia) program, wherein wild strains of tilapia were obtained from Egypt, Ghana, Kenya, and Senegal and tested for their suitability for Philippine fishpond cultivation. *O. niloticus* can live on different foods. Aside from being a versatile feeder, *O. niloticus* has a short maturation period of only 3-4 months. *O. niloticus* also has a brief generation interval of only 6-10 months. As a result, a 20% increase in terms of total body weight and total length was observed in the GIFT tilapia.

In the GIFT program implemented by the Bureau of Fisheries and Aquatic Resources (BFAR), the 'Thailand-strains' used were placed together with the African strains and observed for their performance in fishpond environments as well as in other environments such as cages and waste-fed ponds. The interbreeding of the different strains produced a faster-growing culture that is now grown in different fishponds around the Philippines.

Some researches have been done regarding the evaluation of the tilapia strain from the GIFT program as compared to the Thailand-strain of tilapia originally cultured in the Philippines. In order to evaluate the GIFT strain in other Asian countries, a

research program has been initiated in Bangladesh, China, Philippines, Thailand and Vietnam under the auspices of an ICLARM project entitled "Dissemination and Evaluation of the Genetically Improved Tilapia in Asia (DEGITA). In the present study the meristic and morphometric characteristics of both 'Thailand-strain' and GIFT-strain of *O. niloticus* were obtained for purposes of documentation and statistical evaluation.

1.2 Statement of the Problem

Is there a significant difference in the meristic and/or morphometric characteristics of the Thailand strain and Genetically Improved Farm Tilapia (GIFT) strain of *Oreochromis niloticus*?

1.3 Hypotheses

Null Hypothesis: There is no significant difference in the meristic and morphometric characteristics of the Thailand strain and GIFT strain of *O. niloticus*.

Alternative Hypothesis: There is a significant difference in one or more of the meristic and/or morphometric characteristics between the Thailand strain and GIFT strain of *O. niloticus*.

1.4 Research Objectives

General Objective: To compare the meristic and morphometric characteristics of the local Thailand-strain of *O. niloticus* and GIFT-strain of *O. niloticus*.

Specific Objectives:

1. To measure the meristic characteristics (number of rays of the dorsal, pectoral, ventral, and anal fins) of the Thailand strain and GIFT strain of *O. niloticus*.
2. To measure the morphometric characteristics (head length, preorbital distance, postorbital distance, horizontal eye diameter, orbital depth of the head, occipital depth of the head, total body length, standard length, and total body weight) of the Thailand strain and GIFT strain of *O. niloticus*.
3. To determine significant differences in the mean values of either the meristic and/or morphometric values of the Thailand strain and GIFT strain of *O. niloticus*.

1.5 Significance of the Study

The GIFT program resulted in an increase in body length and body weight measurements as well as faster growth rate for the GIFT strain of *O. niloticus*. The difference(s) in tilapia strains would show the extent of variation among strains of tilapia. The meristic and morphometric characteristics that will be measured here can provide additional information for the taxonomic characterization of the two strains of *O. niloticus*. The results of this study may be useful information in the field of aquaculture.

1.6 Scope and Limitations

The present study aims to determine the meristic and morphometric differences between the Thailand-strain and GIFT strain of *O. niloticus* only. The Thailand-strain tilapia samples were obtained from Los Baños, Laguna only. The GIFT-strain tilapia samples were obtained from Tanay, Rizal only. The interpretation of the results are

based on the following assumptions: (a) that the difference in meristic and/or morphometric characteristics of the GIFT strain of *O. niloticus* is the result of the interbreeding through several generations of selection from a base population involving eight different strains of *O. niloticus*; and (b) no inbreeding among the strains has occurred which would result to a presence of another strain different from the strains which will be used in the study (Eknath, 1992).

1.7 Definition of Terms

1. Meristic characters – features involving modification in number or in geometrical relation of body parts. Examples of meristic features commonly used are fin rays or spines, gill-rakers, and scales.
2. Morphometric characters – features involving the measurement of external form. Examples of methods used in this category are truss patterns, and shape of scales.
3. Aquaculture – the cultivation of the natural produce of water. More specifically, it is the raising of fish for food in protected ponds or other enclosures (Lazard *et al*, 1988).

Review of Related Literature

2.1 The Development of the Genetically-Improved Farmed Tilapia (GIFT)

A promising Genetically Improved Farmed Tilapia strain known as GIFT was introduced in 1980. The GIFT strain was developed by the International Center for Living Aquatic Resources Management (ICLARM) through several generations of selection from a base population involving eight different strains of *O. niloticus* (Eknath et al, 1993). In on-station trials, the synthetic GIFT strain was reported to show an average 60% faster growth and 50% better survival at harvest than the 'Thailand strain' the most commonly farmed strain in the Philippines (Eknath, 1992).

A study by Hussein (2000) discussed in detail the results of GIFT and existing *O. niloticus* production in five test environments. For the nursery trial, ANOVA indicated significant differences ($P < 0.05$) between the mean values of length and weight of both the strains. For growout trials in cisterns and hapas, the final mean weights of GIFT and existing strains were significantly different ($P < 0.05$) under both conditions. For growout trials in net cages, the average growth performance of GIFT strain was significantly better ($P < 0.05$) than that of existing strain in both mixed and separate treatment groups, but the mean weight of GIFT individuals was not significantly different ($P < 0.05$) between the two treatment groups. Finally, in growout trials in ponds, total yield of the GIFT was significantly higher ($P < 0.05$) than that of the existing strain. Hussain and Mazid (1996) also reported significant differences in growth performance between GIFT and existing strains in Bangladesh. In China , Indonesia, Thailand, and Vietnam, where there are longer histories of tilapia farming, greater climatic variation, and the possibility of both natural and artificial selection of local strains to their

environments, the GIFT strain appears to be about 10-15% superior to the local strains in terms of growth (Dey, 1996). In on-farm trials in the Philippines, the GIFT strain showed 60% better growth than the other local strains (Eknath, 1992; ICLARM, 1994).

2.2 Morphometric Studies on *O. niloticus*

Morphometric data can also implicate feeding behavior of *O. niloticus*. An example of which takes place during sex-reversal of *O. niloticus* by feeds. In monosex populations, males are preferred as they grow faster than females (Holden and Reed, 1972). In the feminization of *O. niloticus* study by Vera Cruz (1996) and collaborators, greater exposure of undifferentiated fry to diethylstilboestrol (DES) showed greater mean length for the samples over different duration treatment periods.

A study by Brzeski and Doyle (1988) utilized morphometric criterion for sex discrimination of *O. mossambicus*. People working with *O. mossambicus* often distinguish the sexes by their general body and jaw part sizes. Male tilapias have a faster growth rate of the lip width and of the body depth at the eye level in relation to the size of the fish. As have been noted by other authors, tilapia males grow larger than females (Pruginin and Shell, 1962; Chervinski, 1983).

Little research has been conducted on meristic and morphometric comparison of the 'Thailand-strain' and GIFT strain of *O. niloticus*. The present study aims to make a contribution on the matter.

MATERIALS AND METHODS

3.1 Origin of test strains

The GIFT strain of *O. niloticus* were obtained from Joanne's Fish farm in Tanay, Rizal. The 'Thailand-strain' *O. niloticus* to be used in this study come from the descendants of a pure strain "Chitralada strain" originally collected from the National Inland Fisheries Institute (NIFI) in Bangkok, Thailand in 1987. The 'Thailand-strain' of *O. niloticus* used in this study were obtained from Jobski Fish farm in Los Baños. Laguna.

3.2 Collection of Materials

Thailand strain and GIFT strain *O. niloticus* 4 months old were obtained from local fishponds located at Tanay (Rizal), and Los Baños (Laguna). A total of 60 samples were collected, that is 30 samples for each strain where 'Thailand-strain' *O. niloticus* were sampled from Los Baños. Laguna while GIFT strain *O. niloticus* was sampled from Tanay, Rizal. The first 20 samples (10 for each strain) were sampled on January 21, 2002 and the next 40 samples (20 for each strain) were sampled on February 4, 2002. Thailand-strain *O. niloticus* sampled in the study is in the immature stage of their sexual maturity while GIFT-strain *O. niloticus* have reached the intermediate or early maturing stage of their sexual maturity.

The culture conditions for each strain were also studied. The size of fish enclosures, type of enclosure, stocking, feeding and maintenance of the cultures were also noted.

After every sample collection, the samples were stored in an ice-cooled container and were brought to room RH-327 of the College of Arts and Sciences of the University of the Philippines Manila for measurement of their meristic and morphometric characteristics.

3.3 Measurement of Meristic and Morphometric Characteristics

The meristic characters of the wild-type and genetically-improved tilapia were determined with the aid of a hand lens. The meristic characters that were considered are: 1) the number of rays of the dorsal fin; 2) the number of rays of the pectoral fin; 3) the number of rays of the pelvic fin and; 4) the number of rays of the anal fin.

The morphometric characters that were considered are: 1) head length; 2) preorbital distance; 3) postorbital distance; 4) horizontal eye diameter; 5) orbital depth of the head; 6) occipital depth of the head; 7) total body length; 8) standard length; and 9) total body weight. The total body length is the length from the mouth to the tip of the tip of the tail while the standard length is the length from the mouth to the base of the tail. From the ice-cooled container, the tilapia samples were allowed to thaw for a period of 30 minutes. The length measurements for this study were taken with the use of a vernier caliper. After which total body weight measurements were then determined using a triple beam balance.

3.4 Analysis of Data

The meristic and morphometric data were summarized and the mean, median, mode, range, minimum values, maximum values, and coefficient of variation computed.

The z-test was used to compare the means of the meristic and morphometric data between the Thailand-strain and GIFT-strain *O. niloticus* at $\alpha = 0.05$. Comparisons were made using the z-test for two means of unequal variance. The means of the meristic and morphometric characteristics of Thailand strain and GIFT strain *O. niloticus* were compared with African strain *O. niloticus* which served as the standard species data. The standard data for *O. niloticus* is shown on Table 1. The standard data was obtained from www. Fishbase.org.

RESULTS and DISCUSSION

4.1 Characteristics of Thailand-strain *Oreochromis niloticus*

The meristic characteristics of the Thailand-strain *O. niloticus* are as follows: number of dorsal fin rays ranges from 27 to 29; the number of pectoral fin rays ranges from 12 to 15; the number of anal fin rays from 11 to 13; and the number of pelvic fin rays were 6. The pelvic fin rays have the least coefficient of variation (CV=0.00) making it the most consistent meristic character of Thailand strain *O. niloticus*.

The morphometric characteristics of the Thailand-strain *O. niloticus* are as follows: the head length ranged from 4.0cm to 5.9cm; the preorbital distance ranged from 1.1cm to 2.1cm; the postorbital distance ranged from 2.0cm to 2.9cm; the horizontal diameter of the eye ranged from 0.6cm to 1.1cm; the orbital depth of the head ranged from 2.9cm to 4.4cm; the occipital depth of the head ranged from 5.4cm to 6.1cm; the total body length ranged from 16.4cm to 18.9cm; the standard body length ranged from 12.9cm to15.9cm; the total body weight ranged from 105.7grams to 159.5grams. The total body length has the least coefficient of variation (CV=3.52333). The meristic and morphometric values of Thailand-strain *O. niloticus* are shown on Table 1.

4.2 Characteristics of GIFT-strain *O. niloticus*

The meristic characteristics of GIFT-strain *O. niloticus* are as follows: the number of dorsal fin rays ranged from 27 to 30; the number of pectoral fin rays ranged from 12 to14; the number of anal fin rays ranged from 11 to 14; and the

number of pelvic fin rays were 6. The pelvic fin rays have the least coefficient of variation (CV=0.00) making it the most consistent meristic character of GIFT strain *O. niloticus*.

The morphometric characteristics of GIFT-strain *O. niloticus* are as follows: the head length ranged from 5.1cm to 6.6 cm; the preorbital distance ranged from 1.4cm to 2.3cm; the postorbital distance ranged from 2.5cm to 3.2cm; the horizontal eye diameter ranged from 0.6cm to 1.3cm; the orbital depth of the head ranged from 3.5cm to 5.0cm; the occipital depth of the head ranged from 6.4cm to 7.9cm; the total body length ranged from 21.0cm to 26.0cm; the standard body length ranged from 16.6cm to 18.8cm; and the total body weight ranged from 234.0grams to 340.3grams. The standard body length has the least coefficient of variation (CV=3.23439). The meristic and morphometric values of GIFT strain *O. niloticus* are shown on Table 2.

4.3 Comparison of Meristic and Morphometric Values of Thailand strain and GIFT strain *Oreochromis niloticus*

The z-test applied on the means on the meristic and morphometric characteristics of Thailand strain and GIFT strain *O. niloticus* gathered revealed that only two characters had equal means with respect to each other (Table 3). These characters were the number of pectoral fin rays and the number of pelvic fin rays.

As the data shows, the GIFT strain *O. niloticus* in the study showed to be superior on the average, in terms of morphometric characteristics, to the Thailand

strain *O. niloticus*. Also, it was observed that there was little difference in the means of the meristic characters between Thailand strain and GIFT strain *O. niloticus*. The difference in the means of the morphometric characteristics may be explained by the interbreeding of the eight strains of *O. niloticus* after several generations of selection as conducted in the GIFT program (Dept of Agriculture-Bureau of Agricultural Research, 2000). Aside from the GIFT program, the difference in environments could have also affected the morphometric characteristics of Thailand strain *O. niloticus*. The Thailand strain *O. niloticus* used in the study were grown in Laguna lake in Los Baños, Laguna, whereas GIFT strain *O. niloticus* used in the study were grown in fishponds in Tanay, Rizal. The variation in the two strains may have also been brought about by difference in the culture settings of Thailand strain and GIFT strain *O. niloticus*. The culture settings the two strains only differ in their culture types. Thailand strain *O. niloticus* used in this study were raised in cage culture settings in a lake while GIFT strain *O. niloticus* used in this study were raised in fishpond grow-out settings. Put differently, one may say tilapia grow better in culture settings than in natural settings (Pauly, 1988). However, although the size of the fish enclosures were different, the stocking densities were adjusted. Both strains had the same feeding treatment by induction of plankton growth in fishponds through organic fertilizers with the addition of inorganic fertilizer – Ammonium phosphate – periodically (Refer to Appendix). The similarity of the culture settings lessens the effects of environment on differences of the morphometrics of Thailand strain and GIFT strain *O. niloticus*.

4.4 Comparison of Mean Meristic and Morphometric values of Thailand strain and GIFT strain *O. niloticus* with African strain *O. niloticus*

When the mean meristic and morphometric characteristics of *O. niloticus* were compared with African strain *O. niloticus*, which served as standard species data, the meristic and morphometric values were different except for the number of pelvic fin rays which matched the data from the study. For the rest of the meristic and morphometric characteristics, the Thailand strain and GIFT strain *O. niloticus* in the study were inferior to the African strain *O. niloticus*.

Table 1. Meristic and Morphometric Values of Thailand-strain *O. niloticus*

CHARACTERS	SUM	N	MEAN	SD	MIN.VALUE	MAX.VALUE	CV
Meristic							
1. Rays of dorsal fin	839	30	27.96	0.718395	27.00	29	2.56876
2. Rays of pectoral fin	383	30	12.76	0.773854	12.00	15	6.06152
3. Rays of anal fin	362	30	12.06	0.449776	11.00	13	3.72743
4. Rays of pelvic fin	180	30	6.00	0.00	6.00	6	0.00
Morphometric							
1. Head length	147.64	30	4.92	0.480515	4.00	5.9	9.76392
2. Preorbital distance	48.0	30	1.60	0.262613	1.10	2.1	16.4133
3. Postorbital distance	72.7	30	2.42	0.290877	1.70	2.9	12.0032
4. Horizontal eye diameter	24.9	30	0.83	0.120773	0.60	1.1	14.5510
5. Orbital depth of head	104.9	30	3.49	0.371839	2.90	4.4	10.6341
6. Occipital depth of head	175.0	30	5.83	0.244009	5.40	6.1	4.18301
7. Total body length	542.9	30	18.09	0.637605	16.40	18.9	3.52333
8. Standard body length	448.2	30	14.94	0.795938	12.90	15.9	5.32756
9. Total weight	4306.9	30	143.56	15.46566	105.70	159.5	10.7727

Table 2. Meristic and Morphometric Values of GIFT-strain *O. niloticus*

CHARACTERS	SUM	N	MEAN	SD	MIN.VALUE	MAX.VALUE	CV
Meristic							
1. Rays of dorsal fin	846	30	28.20	0.8 46901	27	30	3.00319
2. Rays of pectoral fin	383	30	12.76	0.727932	12	14	5.70181
3. Rays of anal fin	368	30	12.26	0.583292	11	14	4.75510
4. Rays of pelvic fin	180	30	6.00	0.00	6	6	0.00
Morphometric							
1. Head length	173.7	30	5.79	0.316609	5.10	6.6	5.46821
2. Preorbital distance	60.6	30	2.02	0.190099	1.40	2.3	9.41088
3. Postorbital distance	85.2	30	2.84	0.183077	2.50	3.2	6.44638
4. Horizontal eye diameter	27.9	30	0.90	0.157895	0.60	1.3	16.9878
5. Orbital depth of head	129.3	30	4.31	0.340739	3.50	5.0	7.90579
6. Occipital depth of head	218.8	30	7.29	0.406781	6.40	8.1	5.57744
7. Total body length	664.3	30	22.14	0.905417	21.00	26.0	4.08890
8. Standard body length	532.4	30	17.75	0.573995	16.60	18.8	3.23439
9. Total weight	8067.2	30	268.91	26.85211	234.00	340.3	9.98566

Table 3. Mean Meristic and Morphometric Comparison Table for Thailand strain and GIFT strain *O. niloticus*

CHARACTERS	THAILAND STRAIN		GIFT STRAIN		z-test
	N	MEAN	N	MEAN	
Meristic					
1. Dorsal fin rays	30	27.96	30	28.2	0.929516
2. Pectoral fin rays	30	12.76	30	12.76	0.00
3. Anal fin rays	30	12.06	30	12.26	0.774596
4. Pelvic fin rays	30	6.0	30	6.0	0.00
Morphometric					
1. Head length	30	4.92	30	5.79	3.369495
2. Preorbital distance	30	1.60	30	2.02	1.626653
3. Postorbital distance	30	2.42	30	2.84	1.626653
4. Horizontal eye diameter	30	0.83	30	0.90	0.271108
5. Orbital depth of the head	30	3.50	30	4.31	3.137116
6. Occipital depth of the head	30	5.83	30	7.29	6.654555
7. Total body length	30	18.10	30	22.14	15.646852
8. Standard body length	30	14.94	30	17.75	10.883083
9. Total body weight	30	143.56	30	268.91	485.47846

Table 4. Mean Meristic and Morphometric Value Comparison Table for Thailand strain and GIFT strain *O. niloticus* with wild African strain *O. niloticus
*(Source : www.fishbase.org)**

CHARACTERS	THAILAND STRAIN	GIFT STRAIN	AFRICAN STRAIN
Meristic			
1. Dorsal fin rays	27.96	28.2	31
2. Pectoral fin rays	12.76	12.76	14
3. Pelvic fin rays	6.0	6.0	6
4. Anal fin rays	12.06	12.26	14
Morphometric			
1. Head Length	4.92	5.79	6.94
2. Preorbital distance	1.60	2.02	2.16
3. Postorbital distance	2.42	2.84	3.39
4. Eye diameter	0.83	0.90	1.38
5. Orbital depth of the head	3.50	4.31	
6. Occipital depth of the head	5.83	7.29	10.14
7. Total length	18.10	22.14	28.0
8. Standard length	14.94	17.75	23.15
9. Total weight	143.56	268.91	

CONCLUSION

The GIFT strain used in this study showed larger measurements for the means of the morphometric characters compared to Thailand strain *O. niltocus*. However, little difference was observed when the meristic characters of both strains were compared.

The results of the study suggest that the GIFT program was successful in developing a strain of *O. niloticus* capable of reaching greater sizes compared to the strains of *O. niloticus* first introduced to the country. At 4 months, the GIFT strain *O. niloticus* was able to attain greater morphometric measurements compared to Thailand strain *O. niloticus*.

RECOMMENDATIONS

Several studies are recommended to provide more information regarding *Oreochromis niloticus*. With the knowledge that GIFT strain grown locally possess superior morphometric characteristics, GIFT strains introduced to other countries from the Philippines are needed to be studied to determine whether environmental differences will also be a factor in the growth and development of GIFT strain *O. niloticus* in other countries. Further study of *O. niloticus* anatomy can also be conducted: scales, gonads, and reproductive structures can be studied to create a generalization on the physical characteristics of Thailand strain and GIFT strain *O. niloticus*. In addition, further environmental analysis of the Laguna Lake and Tanay fishponds may provide information on the response of strains of *O. niloticus* to environmental factors.

Literature Cited

Alvendia-Casauay, A., V.S. Cariño. 1988. Gonadal sex differentiation in *Oreochromis niloticus*. *The Second International Symposium on Tilapia in Aquaculture*. Department of Fisheries, Thailand. pp. 121-124.

Diana, J.S., P.J. Schneeberger and C. Kwei Lin. 1988. Relationships between primary production and yield of tilapia in ponds. *The Second International Symposium on Tilapia in Aquaculture*. Department of Fisheries, Thailand. pp. 1-7.

Department of Agriculture-Bureau of Agricultural Research. (no date). *GIFT: Programa sa Pagpapabuti ng Lahing Pagmumulan ng semilyang Inaalagaang Tilapia*. Manila: Fisheries Sector Program – Research and Extension Component.

Duponchelle, F., J. Panfili. 1997. Variations in age and size at maturity of female Nile Tilapia, *Oreochromis niloticus*, populations from man-made lakes of Cote d'Ivore. *Env. Biol. Fish.* 52: 453-465.

Edwards, P. 1991. Integrated Fish Farming. *Infofish International*, pp. 45-51.

Edwards, P. 1988. Tilapia raised on septage as high protein animal feed. *The Second International Symposium on Tilapia in Aquaculture*. Department of Fisheries. Thailand. pp. 7-13.

Edwards, P. 1985. Aquaculture: A component of low cost sanitation technology. *World Bank Technical Paper No. 36*. World Bank, Washington, DC, USA.

Eknath, A.E. 1992. In 'Genetic Improvement of Farmed Tilapia-GIFT Phase 1 Final Report'. International Center for Living Aquatic Resources Management (ICLARM), Metro Manila, Philippines.

Gonzales-Corre, K. 1988. Polyculture of the Tiger Shrimp (*Penaeus monodon*) with Nile Tilapia (*Oreochromis niloticus*) in brackishwater fishponds. *The Second International Symposium on Tilapia in Aquaculture*. Department of Fisheries. Thailand. pp. 15-20.

Guerrero, R. and Guerrero, L. 1976. Culture of *Tilapia nilotica* and *Macrobrachium* species separately and in combination in fertilized freshwater fishponds. *Phil J. Fisheries*. 14 (2): 232-235.

Hepher, B. 1978. Ecological aspects of warm-water fish pond management. *In* S.D. Gerking (ed.) Ecology of freshwater fish production. Blackwell Sci. Publ., Oxford, UK. pp. 447-468.

Hepher, B. and Y. Pruginin. 1981. Commercial fish farming, with special reference to fish culture in Israel. John Wiley & Sons, New York, USA.

International Center for Living Aquatic Resources Management. 1999. *International Center for Living Aquatic Resources Management Strategic Plan 2000-2020.* International Center for Living Aquatic Resources Management, Manila.

Lannan, J.E., R.O. Smitherman and G. Tchobanoglous. 1986. Principles and practices of pond aquaculture. Oregon State University Press, Corvallis, Oregon, USA.

Lazard, J., P. Morissens, P. Parrel. 1988. Artisanal Aquaculture of Tilapia in West Africa: Comparative Analysis of Different Culture Systems and their Level of Development. *The Second International Symposium on Tilapia in Aquaculture.* pp. 41-52.

Lopez, E., Szyper, J.P., Hopkins, K.D., Circa, A. (1996). On-Farm Production Trials with Nile Tilapia in Fertilized Ponds in Highland and Lowland Areas of the Philippines. *Pond Dynamics/Aquaculture Collaborative Research Program 14th Annual Technical Report.* pp. 164-167.

Loya, Y. and Fishelson, L. 1969. Ecology of Fish Breeding in Brackish Water Ponds near the Dead Sea(Israel). *J. Fish Biol.* 1:261-278.

Pauly, D., J. Moreau, M. Prein. 1988. A Comparison of Overall Growth Performance of Tilapia in Open Waters and Aquaculture. *The Second International Symposium on Tilapia in Aquaculture.* pp. 469-479.

Payne, A.I. 1970. An Experiment on the culture of *Tilapia esculenta* (Graham) and *Tilapia zilli*(Gervais) (Cichlidae). *J. Fish Biol.* 3:325-340.

Reich, K. 1975. Multispecies fish culture (polyculture) in Israel. Bamidgeh 27(4): 85-89.

Szyper, J.P. and Hopkins, K.D. 1996. Carp/Tilapia Polyculture on Acid-Sulfate Soils. *Pond Dynamics/Aquaculture Collaborative Research Program 14th Annual Technical Report.* pp. 162-163.

PLATES

Plate 1. The Thailand strain (L) and GIFT strain (R) *O. niloticus*

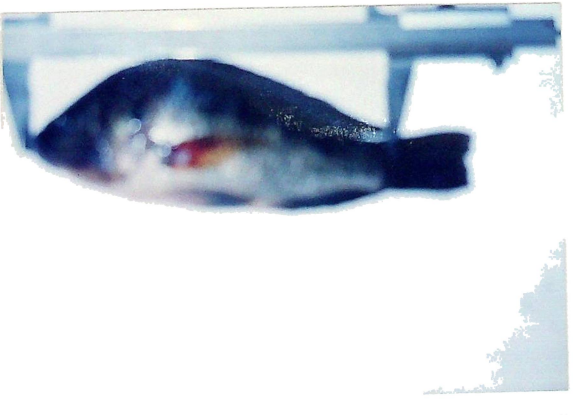


Plate 2. Measuring length characteristics with the use of a Vernier caliper

Plate 3. Weighing the samples with the use of a triple beam balance

APPENDICES

Appendix A.
Culture Settings for Thailand strain *O. niloticus* in Jobski fishfarm in Los Baños, Laguna.

Culture type: Cage culture

Size of fish enclosure: 8m x 12m x 3m

Type of enclosure: Floating type

The cage is made of synthetic netting. The bamboo framework holds the cage in place and also serves as the catwalk during feeding. The bamboo framework also serves as floats. The floats keep the cages and framework above the water surface so fish cannot escape.

Stocking density: 25 pcs / cubic meter

Fingerlings are acclimatized before stocking. Stocking is done in the early morning or late afternoon.

Feeding:

Plankton is readily abundant in lake setting. For promotion of plankton growth, organic fertilizer (chicken manure) is applied.

Supplemental feeding of Ammonium phosphate is utilized. As fish become older, a feeding program is followed. For newly-stocked fingerlings, 10-15% biomass is given 2-4 times daily; juvenile, 6-10% biomass is given 2-4 times daily and market size, 3-5% biomass given 2 times daily. Amount of feeds is adjusted periodically (approx 2 weeks).

Maintenance:

Feeding is done regularly daily together with supplemental feeding if necessary. Regular inspection of net breakage/tears is carried out. Net cleaning is also performed.

Appendix B.
Culture Settings for GIFT strain *O. niloticus* in Joanne's Fishfarm in Tanay, Rizal.

Culture type: Fishpond

Size of fish enclosure: 8m x 12m x 1m

Type of culture system used: Semi-intensive

This is a culture system whereby fish depend on the natural food and supplemental feeds. Only moderate stocking density and feeding is applied. Water quality monitoring is necessary in this system to avoid water pollution that may affect the fish.

Stocking density: 8pcs / square meter

Stocking is done early in the morning or late in the afternoon. During stocking, the temperature of the pond water where the fish is to be stocked and the water temperature of the container of fingerlings is monitored. Acclimatization is performed to avoid thermal shock to the fish.

Feeding:

Growth of plankton is induced by basal fertilization with chicken manure during pond preparation. To maintain the fertility of the pond, weekly application of fertilizers is performed. Organic (chicken manure) and inorganic manure (Ammonium phosphate) is applied. Feeding rates are adjusted depending on the natural productivity of the pond. A greenish coloring of the water indicates the presence of natural food and fertility of water in the pond.

Maintenance:

Daily feeding with Ammonium phosphate is performed. Also weed monitoring is conducted to prevent affecting the photosynthetic activity of the plankton in the fishpond. Water quality monitoring is also conducted. Factors that are monitored include water level, temperature, and turbidity.

Appendix C.
List of Formulas

Coefficient of Variation

$$CV = [(SD) / m] (100)$$

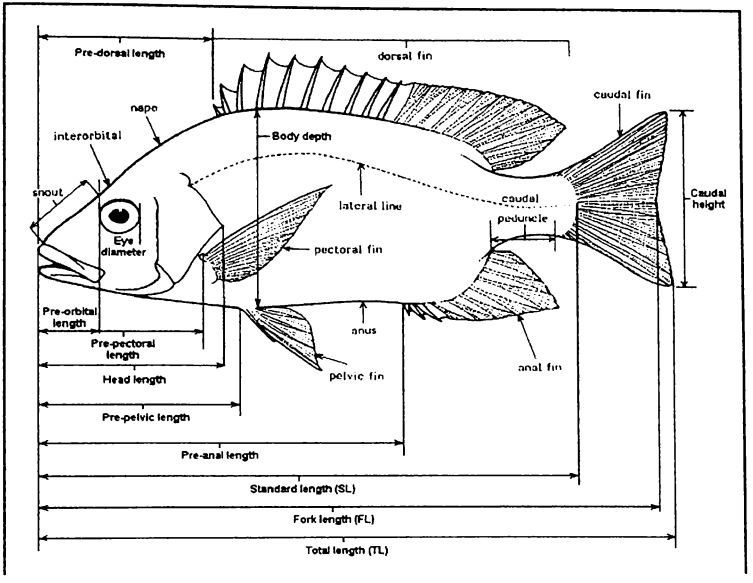
m = mean
SD = standard deviation

z-test

$$z = [(x1 - x2) - (\mu 1 - \mu 2)] / \sqrt{[(sp2 / n1) + (sp2 / n2)]}$$

x = mean
sp2 = variance
n = number of population

Appendix D.
Meristic and Morphometric Characters of *O. niloticus*
(Source: www.fishbase.org)



Appendix E.
Raw Data for Thailand strain *O. niloticus*

CHARACTERS	1	2	3	4	5	6	7	8	9	10
Meristic										
1. Dorsal fin rays	28	27	28	27	29	28	29	27	29	28
2. Pectoral fin rays	12	13	13	12	12	13	13	12	12	13
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	12	13	13	13	12	12	12	12	11
Morphometric										
1. Head length	4.4	4.4	4.0	4.2	5.0	4.3	5.1	4.3	4.2	4.6
2. Preorbital distance	1.3	1.5	1.1	1.2	1.7	1.4	1.4	1.2	1.3	1.4
3. Postorbital distance	2.3	2.0	2.1	2.2	2.4	2.3	2.4	2.3	2.2	2.4
4. Eye diameter	0.8	0.9	0.8	0.8	0.9	0.6	0.9	0.8	0.7	0.8
5. Orbital depth of the head	3.2	3.2	3.1	3.3	3.4	2.9	3.1	3.3	2.9	3.2
6. Occipital depth of the head	6.0	5.4	5.7	5.4	6.0	5.9	5.6	6.1	5.6	5.7
7. Total length	18.4	17.6	17.7	17.6	17.9	17.4	18.5	18.5	16.4	18.3
8. Standard length	15.3	14.2	14.3	13.5	14.4	14.4	14.6	14.6	12.9	14.6
9. Total weight	148.9	105.7	134.1	150.2	132.5	131.4	139.3	146.2	129.7	138.4

Appendix E.
Continued

CHARACTERS	11	12	13	14	15	16	17	18	19	20
Meristic										
1. Dorsal fin rays	28	27	28	28	27	28	28	28	28	28
2. Pectoral fin rays	12	12	12	13	13	12	12	13	12	13
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	12	12	13	12	12	12	12	12	12
Morphometric										
1. Head length	4.6	4.5	5.00	5.0	5.2	4.9	5.5	4.9	4.9	4 8
2. Preorbital distance	1.4	1.3	1.7	1.7	1.8	1.5	2.0	1.7	1.8	1.8
3. Postorbital distance	2.1	2.4	2.4	2.4	2.6	2.5	2.6	2.6	2.4	2 8
4. Eye diameter	1.1	0.8	0.9	0.9	0.8	0.9	0.9	0.6	0.7	0.8
5. Orbital depth of the head	3.1	3.4	3.6	3.4	3.9	3.5	3.5	3.5	3.5	3.7
6. Occipital depth of the head	5.4	5.5	6.1	5.8	6.1	6.0	6.0	6.1	5.8	6.1
7. Total length	16.4	17.2	18.0	17.9	18.2	18.9	18.9	18.8	18 0	18.4
8. Standard length	13.5	14.1	14.3	14.6	15.6	15 5	15.5	15.6	14 5	15.6
9. Total weight	106.3	118.5	143.5	132.6	157.8	157.4	157.4	153.8	122 0	151.4

Appendix E.
Continued

CHARACTERS	21	22	23	24	25	26	27	28	29	30
Meristic										
1. Dorsal fin rays	28	27	27	29	28	29	27	28	29	29
2. Pectoral fin rays	13	14	12	13	13	14	13	15	13	14
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	12	13	12	12	12	11	12	12	12
Morphometric										
1. Head length	5.4	5.9	5.60	5.3	5.2	5.5	5.2	5.1	5.2	5.4
2. Preorbital distance	2.0	2.1	1.6	1.5	1.7	2.0	1.7	1.7	1.7	1.8
3. Postorbital distance	2.9	2.6	2.2	2.8	1.7	2.0	2.7	2.8	2.7	2.9
4. Eye diameter	1.0	0.9	1.0	1.0	0.8	0.9	0.8	0.6	0.8	0.7
5. Orbital depth of the head	3.7	4.4	3.4	3.4	3.5	4.4	3.8	3.9	3.5	4.0
6. Occipital depth of the head	6.1	6.1	5.8	6.1	5.9	6.0	5.7	5.65	5.6	5.7
7. Total length	18.1	18.4	17.8	18.4	18.9	18.8	18.6	18.2	18.7	18.4
8. Standard length	15.2	15.7	15.2	15.7	15.9	15.6	15.8	15.3	15.3	15.5
9. Total weight	151.8	156.6	145.8	155.1	155.9	157.8	150.6	159.5	159.5	159.1

Appendix F.
Raw Data for GIFT strain *O. niloticus*

CHARACTERS	1	2	3	4	5	6	7	8	9	10
Meristic										
1. Dorsal fin rays	28	27	28	28	27	28	28	28	28	28
2. Pectoral fin rays	12	13	13	12	12	12	12	13	12	13
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	12	12	12	12	12	12	12	12	12
Morphometric										
1. Head length	5.1	6.6	5.90	5.5	5.8	5.6	5.6	5.4	5.5	5.1
2. Preorbital distance	1.4	2.2	1.9	1.9	2.2	2.0	1.8	1.9	2.0	1.6
3. Postorbital distance	2.7	3.2	2.7	2.8	2.9	2.8	2.9	2.7	2.9	2.8
4. Eye diameter	1.0	1.2	1.3	0.8	0.7	0.8	0.9	0.8	0.6	0.7
5. Orbital depth of the head	3.5	4.9	4.2	4.4	4.6	4.0	3.7	4.2	4.5	4.8
6. Occipital depth of the head	7.5	8.1	7.1	7.7	7.7	7.1	7.4	7.4	7.9	7.7
7. Total length	23.0	22.4	22.2	22.5	22.4	22.4	21.9	21.7	21.1	21.6
8. Standard length	18.3	17.6	18.7	17.9	17.9	18.3	17.7	16.9	17.7	17.74
9. Total weight	295.6	340.3	300.9	296.6	265.7	278.5	290.8	234.0	258.7	278.0

Appendix F.
Continued

CHARACTERS	11	12	13	14	15	16	17	18	19	20
Meristic										
1. Dorsal fin rays	28	27	29	29	29	27	29	28	29	28
2. Pectoral fin rays	12	13	13	12	12	13	12	13	12	12
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	12	13	13	13	12	12	12	12	11
Morphometric										
1. Head length	6.0	6.2	5.7	6.1	6.0	6.0	5.9	5.7	5.8	5.7
2. Preorbital distance	2.3	2.2	1.9	2.2	2.0	2.1	2.0	2.1	2.1	2.1
3. Postorbital distance	2.7	3.2	2.8	3.1	3.0	3.1	2.9	2.7	2.6	2.7
4. Eye diameter	1.0	0.8	1.0	0.8	1.0	0.8	1.0	0.9	1.1	0.9
5. Orbital depth of the head	5.0	4.4	4.2	4.3	4.1	4.6	3.8	4.4	4.2	4.1
6. Occipital depth of the head	6.8	7.4	7.7	7.1	7.2	7.7	6.7	7.2	7.5	6.7
7. Total length	21.8	23.2	21.5	21.8	26.0	22.5	22	21.8	21.9	22.1
8. Standard length	17.8	18.5	17.6	17.4	17.4	18.2	18.2	16.6	17.7	17.7
9. Total weight	242.6	306.9	235.3	267.6	299.4	281.2	258.7	237.6	272.4	239.1

Appendix F.
Continued

CHARACTERS	21	22	23	24	25	26	27	28	29	30
Meristic										
1. Dorsal fin rays	28	29	28	30	27	29	29	30	28	27
2. Pectoral fin rays	13	13	14	13	14	14	13	13	14	14
3. Pelvic fin rays	6	6	6	6	6	6	6	6	6	6
4. Anal fin rays	12	14	13	12	12	13	12	13	13	12
Morphometric										
1. Head length	6.1	6.2	5.7	5.8	6.0	5.5	5.9	5.6	5.9	5.8
2. Preorbital distance	2.1	2.0	2.1	2.2	2.1	1.8	2.1	2.0	2.2	2.1
3. Postorbital distance	3.0	3.1	2.6	2.7	2.9	2.8	3.0	2.7	2.5	2.7
4. Eye diameter	1.0	1.1	1.0	0.9	1.0	0.9	0.8	0.9	1.2	1.0
5. Orbital depth of the head	4.6	4.4	3.9	4.2	4.6	4.3	4.1	4.3	4.3	4.7
6. Occipital depth of the head	7.8	7.3	6.9	7.3	7.6	6.4	7.0	6.8	7.1	7.0
7. Total length	22.9	21.7	21.3	21.9	22.8	21.9	21.8	21.9	21.0	21.4
8. Standard length	18.4	17.1	17.2	18.8	18.6	17.1	17.7	16.9	17.0	17.8
9. Total weight	280.1	260.7	237.2	266.3	303.8	240.4	257.2	248.0	256.9	236.7