Trans. Nat. Acad. Sci. Technol. 14: 433-444, 1992

GROWTH ESTIMATION OF *OREOCHROMIS NILOTICUS* (L.) CULTURED IN RICE-PADDIES USING CIRC TECHNIQUE

Jocelyn P. Cabrera
College of Fisheries
Nueva Vizcaya State Institute of Technology
Bayombong, Nueva Vizcaya

ABSTRACT

The study was conducted to evaluate the viability of the CIRC (circulus spacing) technique as estimator of growth of *Oreochromis niloticus* cultured in rice-paddies. It was based on two studies conducted simultaneously and funded by the ADB Project. The first study was entitled "Evaluation of Pig and Chicken Manure and its Methods of Application in Rice-Fish Culture", and the second, "Selected Strains of *Oreochromis niloticus* Cultured in Rice-Paddies Using Various Stocking Density".

Fish samples were collected from each paddy. Standard length and weight were measured. Scales were removed from each fish sample. Two measurements per scale were taken.

Results fo the first study revealed that CIRCe CIRCm measurements used as estimator of growth rates and length increment were nearly the same, but not the gain in weight of *Oreochromis niloticus* cultured in rice-paddies.

Study 2 showed that the estimated growth from CIRCe and CIRCm showed no obvious trend in terms of variance in growth in tree stocking densities of 5,000/ha, 8,000/ha and 10,000/ha for *Oreochromis niloticus*. However, the estimated growth rates from circulus spacing of the scale of red tilapia strain were found to be significantly associated to length and weight increment. Thus, circulus spacing can be used as an indirect assessment of growth of fish at a particular period of time when regular sampling is not feasible as in the rice-fish culture system.

Introduction

Importance of the Study

Nile tilapia, formerly known scientifically as *Tilapia nilotica,* is now called *Oreochromis niloticus* (14). This fish is acceptable to fish farmers and consumers alike due to its high palatability, attractiveness, big size and faster growth.

Experiments on the culture of tilapia species in irrigated paddies with or

without rice conducted by the Freshwater Aquaculture Center (FAC) have become the basis of a nation-wide field testing scheme for rice-fish culture (3). Findings indicated the suitability of rice-paddies for the culture of *Oreochromis niloticus* even under varied conditions.

Growth measurements are the most accurate indicator of increase in production. Knowledge of the rate of growth of *Oreochromis niloticus* cultured in rice-paddies is extremely useful to management, and is of great interest to biologists and culturists.

In general, the use of scales once it has been proven applicable to a species, can be the simplest and the most accurate means of studying age and growth (8), especially when sampling is not feasible. When information on individual variation in growth is required, the new CIRC (scale circulus spacing technique) (5) makes it possible to evaluate the individual growth rates of *Oreochromis niloticus* without recognizing individual fish in an aquaculture system as in rice-paddies.

Statement of the Problem

There are many excellent studies on the culture of *Oreochromis niloticus*, but no detailed work on the estimates of their individual growth rates even in rice-paddies has been reported. Since the exact age of individual tilapia is often unknown in aquaculture systems, estimation of growth rates is very difficult. This problem can be solved if a technique is developed to estimate growth rate when the age of the fish is not yet known. Fish growth estimators, such as the CIRC (scale-circulus spacing) measurement, are useful in this cae. It is within this context, that CIRC appears to open a new avenue of research as fish growth estimator, replacing previously unavailable or costly ones.

Fish scales provide an alternative method of obtaining individual growth rates without considering each individual fish in a population of mixed ages and size. It is possible to obtain quantitative estimates of growth rates by appropriate interpretation of scale features like the number of circuli and spacing between circuli.

CIRC measurement may prove to be the practical technique for growth rate estimation of *Oreochromis niloticus* cultured in rice-paddies. It is on this premise that this study was conducted.

Objectives of the Study

The general objective of the study is to evaluate the viability of the CIRC (scale-circulus spacing) technique as growth estimator for *Oreochromis niloticus* cultured in rice-paddies.

The specific objectives are as follows:

1. To measure the current growth rate of *O. niloticus* in rice-paddies using the CIRC technique; and

2. To determine the effects of pig and chicken manure applications and various stocking densities on the growth rate of *O. niloticus* in rice-paddies as measured by the CIRC technique.

Time and Place of the Study

The study was conducted at the experimental rice-paddies of the Freshwater Aquaculture Center (FAC), Central Luzon State University, Munoz, Nueva Ecija, from June 1989 to February 1990.

Review of Literature

Simultaneous rice-fish culture (2) is the simultaneous culture of rice and fish in the same field. This system, commonly practiced in most of the rice-growing countries, is sometimes known as "paddy-cum-fish culture". Simultaneous rice-fish and the rotational cropping of rice and fish are the two generally accepted methods. However, the tri-commodity approach integrating rice-fish-pig was also tried at the Freshwater Aquaculture Center (FAC) at the Central Luzon State University (12). To facilitate efficiency some kind of harmony and balance in these modifications is needed (3).

Fish scales have long been used to determine both growth rates and ages of fish, although knowledge of the development of the various structures upon which these methods are based is by no means complete (10). The generally accepted opinion among the early investigators is that there is regularity in both formation and spacing of circuli in the scales of the fish. Thus, CIRC (circulus spacing) is by no means the only technique available to estimate growth rate of fish without prior determination of an animal's age (5).

Materials and Methods

The study evaluated the use of the CIRC technique as an indirect measure of growth rate of *O. niloticus* cultured in rice-paddies based on two studies.

Study I was an evaluation of pig and chicken manure and methods of application in rice-fish culture.

The treatments evaluated are presented in Table 1.

Study 2 was on selected strains of *Oreochromis niloticus* cultured in rice-paddies using varied stocking densities.

The treatments tested are shown in Table 2.

Table 1. Treatments Used in Study 1

Treatment	*Basal*	*Top Dress After One Month (30 DAT)**	*Top Dress Weekly Application*
I	Urea; 66.67 kg/ha	Urea; 33.33 kg/ha plus Inorganic Fertilizer (14-14-14) 107.14 kg/ha	–
II	Same as I	Urea; 33.33 kg/ha plus Pig Manure; 2,400 kg/ha	–
III	Same as I	Urea; 33.33 kg/ha	Pig Manure; 2,400 kg/ha
IV	Same as I	–	Pig Manure; 2,400 kg/ha
V	Same as I	Urea; 33.33 kg/ha	
VI	Same as I	Urea; 33.33 kg/ha	Chicken Manure; 1,500 kg/ha
VII	Same as I	–	Chicken Manure; 1,500 kg/ha

Stocking density: 5,000/ha (200/plot)
Stocking size: 15-20 grams
*DAT – days after transplanting

Table 2. Treatments Used in Study 2

Treatment	*Stocking Density*	
I	5,000/ha	(2,500 ON + 2,500 RT)
II	8,000/ha	(4,000 ON + 4,000 RT)
III	10,000/ha	(5,000 ON + 5,000 RT)

Note: ON – *Oreochromis niloticus*
RT – red tilapia strain
Stocking size: 20 grams

Land Preparation

The areas for the experiments were prepared according to common wetland preparation practices. Seedlings of IR 64 rice variety were transplanted at 25-30 days old. Fingerlings were stocked 14 days after transplanting. Fish harvesting was done 14 days before rice hrvest.

Collection of Scale for CIRC (circulus) Measurement

Scales were removed from the specific area in the caudal peduncle one row below the intersection of the lateral line connecting the insertion of the dorsal fin to the insertion of the anal fin of each fish sample (Figures 1 and 2). Scales collected were preserved in vials with formalin to protect the fragile outer margin.

Removal of scales from individual fish necessitated the use of a dissecting microscope set at magnification of approximately 6 x 10 for viewing the individual scale. A damp paper towel was positioned in the microscope to blot the body of the fish and to avoid glare from excess water. This also keeps the fish from moisture and restricts its movement.

The fish was observed through the microscope focused on the location of the selected scale. Forceps were used to pull out the scales that were immediately placed in neutral buffered formalin-filled sample vials which were capped and labelled with permanent markers.

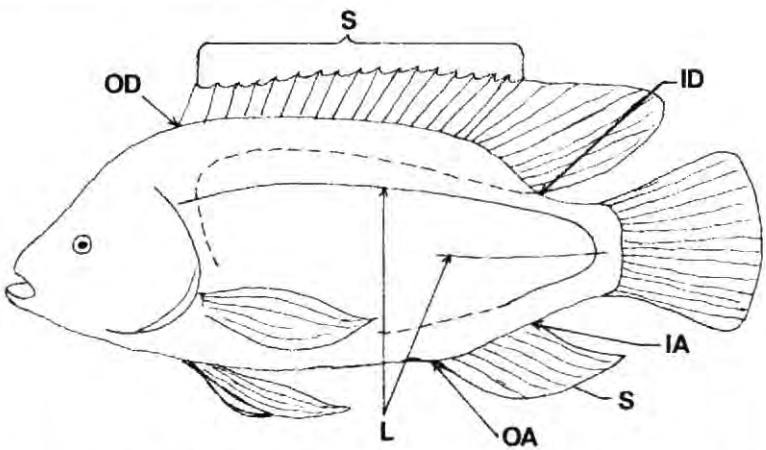

Figure 1. Diagram of tilapia showing the suggested scale sample sites. Scales may be sampled inside the broken line but not on the lateral lines (L.). The insertions (ID, IA) and origins (OD, OA) of the dorsal and anal fins as well as the spines (S)' and lateral lines may be used as reference points to sample specific scales.

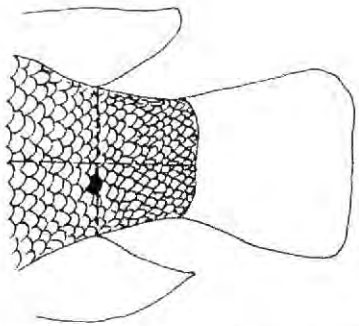

Figure 2. A specific scale (shaded) on the caudal peduncle was sampled one row below the intersection of the lateral line (large broken line) and an imaginary line (small broken line) connecting the insertion of the dorsal fin to the insertion of the anal fin.

Mounting Scales

Microscope slides (Fisherbrand) measuring 75 mm x 25 mm with drop(s) of water were used in mounting the scales. Cover slips were slowly lowered at 45° on the edge of the slide to avoid the trapping of air in the mount.

Measurements of the Scale

Two measurements per scale were taken (Figure 3) for CIRCm (circulus spacing at the marginal edge of the scale) and CIRCe (circulus spacing at the edge of the scale) within scale variance known for the observed population. Regenerated scales (Figure 4) were discarded. A compound microscope was used at the highest magnification, without sacrificing precision, by having the scale much larger than the field of view. Only one magnification was used in all the scale samples to avoid error in measurement. An ocular micrometer was used in measuring circulus spacing on the scale. Measurements were converted from the ocular units to a suitable absolute unit (usually microns for circulus spacing) for data analysis.

Data Gathered

1. Standard length – length of the individual fish sample taken from the tip of the caudal peduncle to the tip of the head.
2. Weight – weight of the individual fish sample taken at the start and at the termination of the study.
3. CIRCe – measurement taken from the edge of the scale to the first circulus.
4. CIRCm – measurement taken from the first circulus to the fourth annulus.

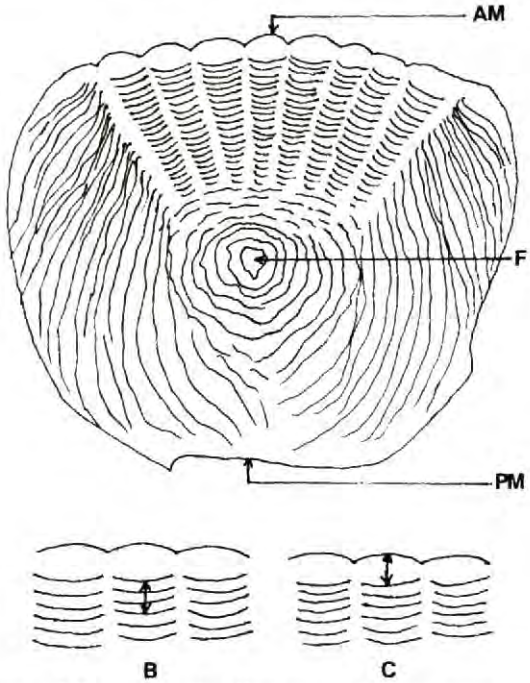

Figure 3. Anatomy of *Oreochromis niloticus* scale, consisting of focus (F), posterior margin (PM), anterior margin (AM) and CIRCm (margin measurement) (B), CIRCe (edge measurement) (C)

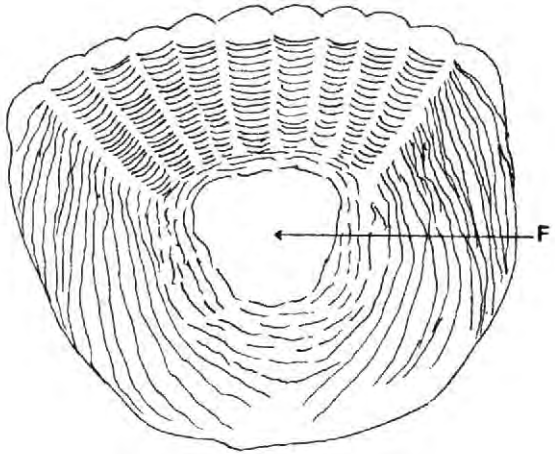

Figure 4. The large and misshaped focus (F) indicating a regenerated scale. This was disregarded in this study.

Results and Discussion

Study I

The mean length increment and mean gain in weight of *O. niloticus* during the 120-day culture period as affected by the application of pig and chicken manure in rice-fish culture are presented in Table 3. Results showed that the different methods of application of pig and chicken manure either at monthly or weekly intervals with and without inorganic fertilizers did not influence significantly the length increment and gain in weight of *O. niloticus* when replicate scores were analyzed by simple analysis of variance. These findings supported those of Guerrero (7), that mixed sexes of Nile tilapia grow well under rice-fish culture conditions.

Table 3. The mean length increment and gain in weight of *O. niloticus* cultured in rice-paddies

Treatment	*Mean Length Increment (In mm)*	*Mean Gain in Weight (in grams)*
I	8.70	11.43
II	6.53	17.66
III	12.78	26.15
IV	7.00	20.04
V	4.48	18.42
VI	11.86	19.99
VII	5.75	19.46
	CV – 66.24%	CV – 33.52%

CIRCe and CIRCm as Growth Estimator

The mean of estimated growth obtained from CIRCe and CIRCm measurements are shown in Table 4. Results of the study revealed that the different methods of application of pig and chicken manure significantly influenced the estimated growth of *O. niloticus*. The highest estimated growth was observed in T_5 both for CIRCe and CIRCm (basal application of urea; 66.67 kg/ha; top dress after one month with 33.33 kg/ha urea and 1,500 kg/ha of chicken manure; no top dressing at weekly application).

Table 4. The mean CIRCe and CIRCm measurement used as growth estimator of *O. niloticus* cultured in rice-paddies

Treatment	*Mean CIRCe Measurement (in microns)*	*Mean CIRCm Measurement (in microns)*
I	14.12[b]	14.08[b]
II	23.84[a]	20.18[a]
III	25.22[a]	20.01[a]
IV	24.95[a]	18.46[a]
V	25.60[a]	20.40[a]
VI	23.67[a]	19.47[a]
VII	25.20[a]	19.85[a]
	CV – 11.27%	CV – 10.92%

Means with the same letter superscript are not significantly different at 5% level of Duncan's Multiple Range Test.

Correlation analysis of CIRCe and CIRCm which is used as growth estimator of *O. niloticus* was found to be nearly the same as the length increment (r – .1352; r – 0.0319). However, the observed growth obtained from gain in weight revealed a significant degree of association to the growth estimator (r – .5843; r – .4781). These findings support those of limited studies conducted on the formation and spacing of circuli; that is, given the conditions of growth, there is regularity in circuli formation which is useful in the interpretation of records of growth (15).

Study 2

Length Increment and Gain in Weight of O. niloticus and red tilapia strain

The observed growth (change in size and weight) of *O. niloticus* and red tilapia strain in a combined culture at various stocking densities in rice-paddies is presented in Table 5. The treatments at varied stocking densities of 5,000/ha, 8,000/ha and 10,000/ha did not differ significantly in the length increment and gain in weight of both species as a result of analysis of variance. These findings showed that regardless of stocking density used, variation in length and gain in weight for both species in all treatments evaluated were statistically insignificant. Other non-experimental variables like availability of food resources equally available to the stocked fishes might have indirectly contributed to the measured change in size and weight for both species. This result conformed with that proven by Gerking (6).

Table 5. The mean length increment and gain in weight of *O. niloticus* and red tilapia strain (in mm) in combined culture in rice-paddies as affected by varied stocking densities

	Length Increment		*Gain in Weight*	
Treatment	*(ON)*	*(RT)*	*(ON)*	*(RT)*
5,000/ha	30.84	105.92	27.14	27.53
8,000/ha	39.63	108.39	33.01	38.10
10,000/ha	23.49	92.26	14.32	15.92
	CV – 42.37%	CV – 8.54%	CV – 42.19%	CV – 33.84%

Note: ON – *Oreochromis niloticus*
RT – Red tilapia strain

CIRCe and CIRCm Measurement used as Growth Estimator of O. niloticus and Red Tilapia Strain

Table 6 showed no obvious trend in terms of variance in the estimated growth using CIRCe and CIRCm measurements from the stocking densities of 5,000/ha., 8,000/ha and 10,000/ha for *O. niloticus*. However, the estimated growth using CIRCm measurements for red tilapia strain revealed significant differences in all the stocking densities tested. Other non-experimental variables which possibly influenced the estimated growth of red tilapia strain based on CIRCm measurements is individual heterozygosity (10, 11).

Length increment and gain in weight of red tilapia strain are found to be significantly corelated to CIRCe.

Table 6. The mean CIRCe and CIRCm measurements used as growth estimator of *O. niloticus* and red tilapia strain in combined culture in rice-paddies as affected by various stocking densities

	CIRCe Measurement (in microns)		*CIRCm Measurement (in microns)*	
Treatment	*(ON)*	*(RT)*	*(ON)*	*(RT)*
5,000/ha	33.14	27.52	24.94	24.81[a]
8,000/ha	31.88	35.86	25.76	25.36[a]
10,000/ha	32.12	31.93	21.98	22.14[b]
	CV – 14.90%	13.79%	7.98%	3.20%

Note: ON – *Oreochromis niloticus*
RT – Red tilapia strain

Means with the same letter superscript are not significantly different at 5% level of significance using Duncan's Multiple Range Test.

(r – 0.8368; r – 0.8368).

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

The study was conducted to evaluate the viability of the CIRC (circulus spacing) technique as growth estimator for *O. niloticus* and red tilapia strain in rice-fish culture based on two studies. The first study entitled "Evaluation of Pig and Chicken Manure and Methods of Application in Rice-Fish Culture" had seven treatments with three replications and the second study entitled "Selected Strains of *O. niloticus* Cultured in Rice-Paddies Using Various Stocking Density" had three treatments replicated three times. Both were laid out in the field using Randomized Complete Block Design (RCBD).

Study 1 revealed that regardless of the method of application of pig and chicken manure in ricefish culture, the length increment and gain in weight of *O. niloticus* are statistically the same in all the treatments evaluated. On the other hand, the highest estimated growth of *O. niloticus* using CIRCe and CIRCm measurements was calculated in T_5 (basal application of urea; 66.67 kg/ha; top dress after one month with 33.33 kg/ha urea and 1,500 kg/ha of chicken manure; no top dressing at weekly application).

The gain in weight of *O. niloticus* cultured in rice-paddies was found to be highly associated with the growth estimator. It shows that circuli spacing can be used to estimate growth rate of fish cultured in rice-fish culture system.

Study 2 showed that stocking densities at 5,000/ha, 8,000/ha and 10,000/ha in combined culture of *O. niloticus* and red tilapia strain in rice-paddies failed to show significant differences in terms of length increment, gain in weight and CIRCe measurement for both species. However, CIRCm was significantly influenced by various stocking densities tested for red tilapia strain alone. Stocking density of 8,000/ha (T_2) obtained the highest estimated growth of 25.36 microns while the lowest 22.14 microns was obtained from stocking density of 10,000/ha (T_3).

CIRCe measurements which are used to estimate the growth rate of both species were found to be significantly correlated to length increment and gain in weight of red tilapia strain but not of *O. niloticus* (r – .8368; r – .8368).

Recommendations

More studies on the use of the CIRC technique as growth estimator for fish in rice-fish culture system are recommended. Evaluation of scale samples taken at various positions from the body of the fish, such as those below the dorsal, caudal

and pectoral fins before stocking and after the termination of the study is also recommended. Scales should be taken and measured at the start and termination of the study in each fish stock to determine some growth patterns throughout the culture period.

The study of the growth rate of fish in integrated farming systems using the scale margin technique is also recommended; so is the comparison of CIRCe and CIRCm as growth estimators for *O. niloticus* and other selected strains cultured in rice-paddies.

Literature Cited

1. ARCE, R.G. 1986. Rice-fish culture farming systems. In: Farm Management Notes for Asia and the Far East. Bangkok, Thailand: FAO Regional Commission on Farm Management for Asia and the Far East. pp. 31-39.
2. _____ and C.R. Dela Cruz. 1978. Improved ricefish culture in the Philippines. Int. Comm. on Irrigation and Drainage (ICID). 2nd Regional Afro-Asian Conference. Technical Paper No. 10, Manila, Philippines. 136-145.
3. CRUZ, C.R. Dela. 1979. Integrated Agriculture-Aquaculture Farming Systems in the Philippines. Paper presented during the ICLARM-SEARCA conference on integrated agriculture-aquaculture farming systems, 6-9 August 1979. Metro Manila, Philippines. 30 pp.
4. CRAWFORD, V. 1987. Scale circulus measurement for growth rate estimation procedural notes. 2nd International Symposium on Tilapia in Aqua. (ISTA II). pp. 136-158.
5. DOYLE, R.W. and A.J. TALBOT. 1987. Repeatability of relative size-specific growth in tilapia. 2nd International Symposium on Tilapia in Aqua. (ISTA II). Bangkok, Thailand, March 16-20, 1987.
6. GERKING, S.D. 1978. Ecology of freshwater fish production. Oxford, London: Blackwell Scientific Pub. 102-110 pp.
7. GUERRERO, R.D. III. 1980. Introduction to Fish Culture. in the Philippines. Manila, Philippines: PECO.
8. HOAR, W.S., D.J. RANDALL and J.R. BRETT. 1979. Bioenergetic and growth. Fish Physiology. Vol. VIII. New York: Academic Press. 786 pp.
9. McNAUGHTON, A.E.L. 1986. Use of scale circulus spacing (CIRC) to detect growth-rate differences between carp (*Cyprinus carpio*) farming systems in Indonesia. MS Thesis (Unpublished), School for Resource and Environmental Studies, Dalhousie University, Halifax, N.S. Canada.
10. POWELL, A.B. 1982. Annulus formation on otoliths and growth of young Summer Flounder from Pamlico Sound, North Carolina. Transactions of the American Fisheries Society. III:688-693.
11. PULLIN, R.S.V. and R.H. LOWE-McCONNEL (ed.). 1982. The Biology and Culture of Tilapias. Proceedings of International Conference. 2-5 September, 1980, at the Study and Conference Center Rockefeller Foundation, Bellagio, Italy. International Center for Living Aquatic Resources Management, Makati, Metro Manila. 432 pp. (ICLARM) Conference Proceedings: 7
12. SEVILLEJA, R.C., A.V. CIRCA and R.L. ENCARNACION. 1984. Preliminary trial on integrated rice-pig-fish farming systems – A Status Report. Freshwater Aquaculture Center, Central Luzon State University, Munoz, Nueva Ecija.
13. TALBOT, A.J., T.K. HAY, R.W. DOYLE and A.E.L. McNAUGHTON. 1987. Current growth estimators in tilapia. The 2nd International Symposium on Tilapia in Aquaculture (ISTA II). Bangkok, Thailand March 16-20, 1987. pp. 122-134.
14. TREWAVAS, E. 1982. Tilapias: Taxonomy and speciation. p. 3-13. In: R.S.V. Pullin and R.H. Shehadeh of Tilapias. ICLARM Proceedings 7, 432 pp. International Center for Living Aquatic Resource Management. Manila, Philippines.
15. VAN UTRECHT, W.L. and E.J. SCHEKKAN. 1972. On the analysis of the periodicity in the growth of scales, vertebrae and other structure in the teleost. Aqua. 1(3):293-316.