Aquacultural research in Asia: management techniques and nutrition

Proceedings of the Asian seminar on aquaculture organized by IFS, Málang, Indonesia, 14-18 November 1988

E.A. Huisman, N. Zonneveld & A.H.M. Bouwmans (Editors)

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FOREWORD

Aquaculture has been recognized by the International Foundation for Science (IFS) as a promising area for multi-disciplinary and inter-disciplinary scientific research and since its inception in 1972 the Foundation has given 228 aquaculture research grants to young scientists in over 50 countries.

The workshop held at the Brawijaya University in Malang, East Java, Indonesia, in November 1988 was the 7th organized by the IFS for its aquaculture scientists.

The IFS would like to thank the Indonesian Government (LIPI) and the local Organizing Committee from the Brawijaya University for their invaluable support.

Sincere thanks are also due to the IFS scientific advisors who attended and contributed substantially to the Malang workshop: Dr. Chua Thia-Eng, Philippines; Dr Barry A. Costa-Pierce, Indonesia; Dr Rafael D. Guerrero III, Philippines; Professor A.J. Matty, United Kingdom, and Professor E.A. Huisman and Ir N. Zonneveld, The Netherlands.

The proceedings of this workshop are contained in this volume which is the 3rd in a series on Aquaculture Research published by Pudoc Press, Aquaculture Research in the African respectively the Latin American Region being the first respectively the second volume in this series, published in 1986 and 1987.

A special word of thanks goes to Professor E.A. Huisman, Ir N. Zonneveld and Mrs A.H.M. Bouwmans for editing all the papers and for - once again - arranging with Pudoc Press for publication. Our thanks also go to Mr W. Heije, who redrew all the figures as he did also for the two previous volumes.

Nonetheless, IFS wants to express its greatest gratitude to the IFS grantees themselves for attending the workshop, for discussing their research results and - in that way - for their contribution to this volume.

June 1989

Jaan Teär
Director
International Foundation for Science

Opening address by the Director General of Fisheries, R. Soeprapto, Ministry of Agriculture, Republic of Indonesia

Distinguished Participants and Guests,

Ladies and Gentlemen,

It is a great pleasure for me to share with the Governor of East Java in welcoming you to Malang, Indonesia, and to the IFS (International Foundation for Science) Workshop on Fish Culture Management Techniques and Nutrition.
I do believe that the workshop which is sponsored by the University of Brawijaya in collaboration with the International Foundation for Science (IFS) is a very auspicious occasion to discuss growth and progress achieved and problems encountered in the aquacultural industry in the respective countries. I feel particularly honoured to be present, because I shall be able to share experiences and to learn from other countries, which will certainly be useful for the development of aquaculture in Indonesia.

Ladies and Gentlemen,

Aquaculture in Indonesia progressed and plays an important role, particularly in supporting rural economy and in increasing foreign exchange earnings from the non-oil commodities. The contribution of aquaculture to the overall fish production is very much less than that from capture fisheries, however, its contribution in terms of value and socio-economic benefits to the rural and coastal communities is becoming increasingly significant. Moreover, recent developments in shrimp culture have increased significantly foreign exchange earnings from the fisheries sector.

In Indonesia, the average annual fish consumption is still relatively low (15 kg/caput/year in 1987). It is obvious, that there is an urgent need to increase fish supply, especially for rural people. The Government of Indonesia is, therefore, placing greater emphasis on aquaculture development.

During the last four years the production of aquaculture in Indonesia has increased with an average of 9.2 percent per annum. Its total production in 1987 attained about 362,800 metric tons, of which 176,600 metric tons from freshwater culture and 186,200 metric tons from brackishwater culture. During the same period shrimp culture production increased with an average of 18.6 percent per annum, i.e. an increase from 32,000 metric tons in 1984 to 53,240 metric tons in 1987.

In terms of foreign exchange earnings, the export value of fisheries products also increased significantly and amounted to US $ 475.2 million in 1987, of which US $ 252.4 million or 74.2 percent was contributed by shrimp. Thereby export value increased with an average of 24.2 percent per annum since 1984.

Ladies and Gentlemen,

Aquaculture development can be accelerated by the application of new or improved technologies derived from intensive research, which makes aquaculture a more cost-effective undertaking. We have observed over the years the progress and growth of the aquaculture industry. It evolves from extensive culture systems to increasingly intensive ones, towards the era of a science based aquaculture industry, which should be backed up by several disciplinary programmes in the fields of fish nutrition, fish diseases and parasites, fish genetics, socio-economics and other essential areas.

A strong and well founded aquaculture industry, therefore, can only be established on a solid basis of knowledge accumulated through scientific research and experimentation. I feel particularly happy to learn that this workshop will discuss those essential areas required.

I understand that different countries may be at a different level of aquaculture development, and that many countries still face various constraints in this respect, such as lack of facilities and skilled manpower required to carry out those essential activities.
In this respect, exchange of information among scientists working in universities, government institutions, private institutions and aquaculture industries is quite needed. Collaboration among participating countries to share the responsibilities of research, training and information exchange would be an effective way of expanding aquaculture development. I am confident that this Workshop on Fish Culture Management Techniques and Nutrition will contribute by generating ideas which are useful in building a strong and resilient aquaculture.

Finally, I would like to express my gratitude for this excellent opportunity to share with you some of my thoughts on the development of aquaculture. I hope that you will have a successful and fruitful discussion during your delibirations and I wish you all a pleasant stay in Malang, Indonesia.

Thank you.

Welcome address from the Governor of East Java Province, Mr.Soelarso, delivered by the Deputy-Governor Drs.Masduki

Mr. Director-General of Fisheries,
Mr. President of the International Foundation for Science,
Rector of the Brawijaya University,
Participants of the Workshop,
Distinguished Guests,
Ladies and Gentlemen,

First of all allow me to extend my congratulations and my great appreciation on the occasion of the opening of the workshop on Fish Culture Management Techniques and Nutrition, and on choosing Malang as the place of this Workshop.
The Indonesian Archipelago stretches over almost 5,000 km from the Asian Mainland into the Pacific Ocean like a string of jewels in a coral sea with more than 1,300 islands, whereas East Java is one of the twenty-seven provinces.

I am very proud and delighted that this distinguished meeting is held at the Brawijaya University in cooperation with the International Foundation for Science. I do hope that this meeting will prove very useful for the participants in increasing their managerial and technological skills, since it provides an excellent opportunity to exchange expertise and experiences in fish culture and related subjects.

In East Java Province inland fish culture is developed in wet rice-fields, ponds and pools. During the last ten years the productivity has increased from 16,036 tonnes to 36,191 tonnes. The fish pond area increased from 44,500 ha to 48,500 ha and at present amounts to some 22,5 % of the total fish pond area in Indonesia.
Many species are in cultivation such as milkfish, penaeid shrimps and many other fresh water fish species.
It is very significant that in East Java shrimp cultivation nowadays developes very rapidly. This is achieved through introduction of technological intensification of culture systems encouraged by the the Government, because shrimp have great potential as export commodities. In the past, the shrimp production was very low, because of the traditional culture systems and merely relied on catch from the sea. However, since the operation of trawls is not allowed anymore the Government encourages its cultivation.

Participants, Ladies and Gentlemen,

To increase fish productivity the Government has built pilot projects for intensification of pond culture systems with emphasis on fish nutrition, fish health control and water management, in order to supply sufficient good quality fish for human consumption. At present, the Government and the private sector have managed to build many hatcheries.
The fish culture production in irrigated rice fields and other fish pools in East Java has reached 24,004 tonnes or 10.5 % from the total fish production. Fish ponds have been constructed at small scale and spread all over the province

especially in areas with an elevation of 450 m to 800 m above sea level. There are many species under cultivation and much progress has been made but still our prime concern is quality of the fish as well as the fish health control aspect.

In rice-cum-fish culture - be it concomitently or alternating - high mortalities and both quantitative and qualitative water problems are faced.

Apart from the fish culture activities, I want to stress that East Java also avails over about 36,100 ha of lakes, rivers, swamps, water reservoirs and dams, which can be utilized for capture fisheries.

Participants, Ladies and Gentlemen,

The Government has many programs for intensification and extensification, developing hatcheries, disseminating information and research in cooperation with Universities.

Notwithstanding our vast resources we still face problems, and, therefore, this scientific workshop is very important because here we have the opportunity to exchange experiences and to formulate possible solutions for these problems. Furthermore we expect that this workshop will be of much benefit to all participants as well as to the fishery sector in Indonesia, and East Java in particular.

At last, I wish you all the best and an enjoyable stay in East Java!

Thank you.

Welcome address by the Rector of Brawijaya University,
Drs. Z. Arifin Achmady MPA

Distinguished Guests,
Participants,
Ladies and Gentlemen,

It is my great pleasure to welcome you to the Campus of Brawijaya University for the Workshop on Fish Culture Management Techniques and Nutrition. I was honoured to have been trusted as host for conducting this workshop. Hence, I wish to express my deep appreciation that this workshop of the International Foundation for Science could be held in Malang.

During the last few years, the role of fish culture in Indonesia has increased considerably. Due to the available resources and the government support in enhancing production, a considerable increase in national export of fishery commodities contributing significantly to the foreign exchange earnings of this country has been achieved. We learn that fish culture has some advantages over capture fisheries from the sea. It can be carried out in areas which are not suitable for agricultural practices, both under - more or less - natural conditions and under environmentally controlled conditions.
Through controlled production, fish farmers can garantee quality and quantity of their production and are able to supply the markets when natural supplies are seasonally low or not available. Fish culture as part of the fisheries subsector also plays an important role in providing employment opportunities.
Nevertheless, the production of fishermen and fish farmers is still lower than that of other sectors like agriculture.
It is anticipated that fish culture development can be enhanced through knowledge transfer and technological improvement. Therefore, fundamental and applied research in fish culture technology are of utmost importance for Indonesia to reap the benefits of its vast aquacultural resource potential.

I hope that this workshop provides an excellent forum to all participants, representing so many countries, to exchange information and ideas about their respective research fields, in particular the fields of fish culture management techniques and fish nutrition.
Furthermore, I hope that this workshop encourages the development of the Faculty of Fisheries of Brawijaya University, which is relatively young but noted a remarkable progress in terms of facilities and activities.

I trust that your discussions and deliberations will be interesting and rewarding, and that your stay with us will be enjoyable. I hope you will have fruitful discussions and arrive at a meaningful contribution to the society as a whole, and the fish farmers community in particular.

Thank you.

Welcome address by Dr.Carl-Heinz Schiel, President of the International Foundation for Science (IFS)

Distinguished Guests,
Dear Participants,
Ladies and Gentlemen,

The IFS is very honoured to start this regional workshop in the presence of so important guests as the Director General of Fisheries, the representative of the Governor of this region, the deputy Chairman of the Indonesian Institute of Science and the Rector of the University.
We take this as an indication that the work of the IFS is not only recognized by the scientific community, but also by the authorities concerned. We take this as an encouragement to continue with our work supporting young scientists and bringing them together, so that they have the opportunity of exchanging their experience among themselves and with their peers.

As the president of the International Foundation for Science, it is a great pleasure for me to welcome you all to this opening ceremony of the workshop on "Fish Culture Management Techniques and Nutrition".

I would also like to take this opportunity to present the International Foundation for Science to those present who might not be very familiar with our activities.
IFS is a non-governmental organization which was founded in 1972 with the aim to counteract the "brain drain" from developing countries and to stimulate the building up of scientific competence in these countries.
We are not a large organization; our annual budget is about 4.5 million US dollars and the total staff of the secretariat consists of 18 persons working in our office in Stockholm, Sweden.
IFS has Member Organizations, consisting of scientific academies, research councils and in some cases universities in 70 countries. It also has sectoral sponsoring agencies, that provide the organization with the necessary funds.
IFS works in seven scientific areas all connected with Agriculture. These are: Aquaculture, Animal Production, Crop Science, Forestry, Food Science, Natural Products and Rural Technology.

Since 1974, IFS has awarded grants to 1,397 researchers who are spread all over the world in 88 countries in Africa, Asia, Oceania and Latin America. More than one third of these have received one or more renewal grants.
The IFS grants are given to enable promising young scientists who are born in a developing country to do research projects in their home countries. The upper limit of a grant is at present approximately 12,000 US dollars, and if the projects progress well, three renewals can be given to the same researcher. The grant should be used to purchase equipment, expendable supplies and literature. It cannot be used for salaries or honorarium for the grantee which means he has to

be employed by a university or research institute which can provide salaries and other basic facilities. In return for this our rules say that when the project work is finished, all equipment bought with the IFS money belongs to the institute.

One of the main aims of IFS is to promote scientific contacts and create regional networks between our grantees and other scientists working in the same field. To do this, IFS can give its grantees travel grants to participate in scientific meetings and to a limited extent, we also arrange expert visits to the grantee's institution. However, one of the most efficient ways to promote this kind of contacts are the IFS workshops and training courses on specific research themes where we bring together grantees from one region as well as international experts within the specific field as the one, that has brought us together today. The possibility for our grantees to present their work, discuss their problems and form personal contacts with other researchers is considered to be an important part of their scientific training, and we hope it will help them to enter the international scientific community.

IFS has to date organized 32 workshops within our seven areas and out of these, six have been on aquaculture topics. The previous aquaculture workshops were in Malaysia 1974, Ivory Coast 1979, Thailand 1980, Colombia 1981, Kenya 1985, and Peru 1986. Now it is time for Asia again. Although aquaculture originated in this part of the world some 3,500 years ago, development of the industry is very rapid demanding ever increasing research efforts.

To keep this workshop in Malang within a reasonable size and with an informal atmosphere, it will focus on management techniques and nutritional aspects of fish culture, but we have already started to plan for another aquaculture workshop in Asia, on Fish Reproduction and Diseases.

The participants in this workshop today come from 12 countries, Bangladesh, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Federal Republic Germany, The Netherlands, United Kingdom, USA and Sweden. It is my hope that the week will prove beneficial to all of you, that you will have useful and interesting discussions and that you will go back home feeling that some of your questions have been answered and that you have formed contacts that will be useful in the future.

Before I finish, I would like to thank all those who have helped us to organize this meeting, especially the organizing committee which has been appointed by the University of Brawijaya, and to Ir.Zonneveld who has served as our local contact person.

I welcome all of you again and wish you a pleasant stay in Malang.

Broodstock exchange technique for maximum production of *Oreochromis niloticus* egg and fry in hapas

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Summary

This study was carried out to evaluate the influence of broodstock exchange on the production of eggs and fry of *O. niloticus* in spawning hapas.

In a 500 m^2 earthen pond 16 spawning hapas were installed, each with a surface of 1.3 m^2. These hapas were stocked with 3 female and 1 male *O. niloticus* broodfish.

The treatments tested were no broodstock exchange, female exchange, male exchange and female and male exchange.

Replaced broodfish were allowed to rest for 21 days before reuse and fed a pelleted feed with 25% crude protein.

Results showed that exchange of female and male broodstock gave significantly higher numbers of eggs and fry throughout the duration of the study.

Introduction

The Nile tilapia (*Oreochromis niloticus*) is a popular cultured fish in warmwater aquaculture. Like most tilapia species, *O. niloticus* meets the requirements of an ideal aquaculture species, such as fast growth, consumer acceptability, and easy reproduction. They feed efficiently on natural food and utilize a variety of artificial diets.

Tilapia is a source of low-priced animal protein. It can be farmed with high profits under different situations from backyard enterprises to high technology systems and can be marketed in a number of value added products (Maclean, 1984). The potential of the tilapia industry in the Philippines is not fully tapped because of the 450,000 hectares of lakes, dams, reservoirs and swamplands only some 20,000 hectares are utilized for pens and cages mainly at Laguna Lake (Anonymous, 1982; Guerrero, 1982; Santiago, 1983; Bautista, 1986). The utilization of these resources for the expansion of the tilapia industry is indispensable to increase the protein supply to - at present - more than fifty million Filipinos.

The adoption of an efficient hatchery system for tilapia is necessary to meet the increasing demand for tilapia fingerlings which goes along with the expansion of the industry. An efficient method is the use of concrete tanks but the operational costs of this system are prohibitive. A common system of mass production of tilapia fry is the use of fine mesh (1.6 mm) hapas with dimensions ranging from 1.5 x 1 x 1 m to 3 x 2 x 2 m (Guerrero, 1977; Hughes and Behrends, 1983; PCARRD, 1985; Bautista, 1986). The use of hapas facilitates fry collection, requires small capital, minimizes mortality of fry and facilitates egg collection from the female's mouth (Loveshin & Ibrahim, 1987).

Several studies have been conducted to improve techniques for mass production of fry. These included manipulation of broodstock density, control of broodstock sex ratio and periodic fry removal from the spawning units, which have resulted in increased seed production per square meter and per female as opposed to the more traditional pond reproduction methods (Berrios-Hernandez, 1978; Balarin and Haller, 1982; Coche, 1982; Behrends, 1983; Snow et al., 1982). Lovshin and Ibrahim (1987) reported that male and female exchange in O. niloticus breeders gave significantly higher numbers of eggs and fry in comparison to no broodstock exchange and female exchange. However, the influence of male exchange on the production of fry was not recorded.

The present study was designed to test the influence of no broodstock exchange, female, male, and male and female exchange on O. niloticus egg and fry production in spawning hapas under Philippine conditions. The study was conducted at the Freshwater Aquaculture Center, Central Luzon State University, Munoz, Nueva Ecija, Philippines from September 15, 1987 to January 27, 1988.

Materials and methods

Preparation of experimental pond

Before the experiment started, a 500 m^2 earthen pond was drained and cleaned from debris, plants and animals. The pond bottom was sprayed with Gusathion insecticide and dried until the bottom cracked to completely eradicate predators and other undesired organisms.

The inlet and outlet gate screens were installed before flushing the pond bottom with water for three successive days. After flushing, the pond was filled with the desirable volume of water for experimental use.

Treatments

The treatments tested in this study were

Treatment I	no broodstock exchange (control)
Treatment II	female exchange
Treatment III	male exchange
Treatment IV	male and female exchange

Each treatment was replicated four times, sothat 16 spawning hapas were used. The spawning hapa used is an inverted single-size, blue nylon mosquito net (1.96 x 0.67 x 1.5 m).

Experimental design

The study was conducted using Complete Randomized Design with four replications. Significant differences among treatment means were analyzed using Least Significance Difference Test.

Experimental set-up

The experimental fish were stocked in 16 spawning hapas arranged in four rows in the pond (Figure 1.).

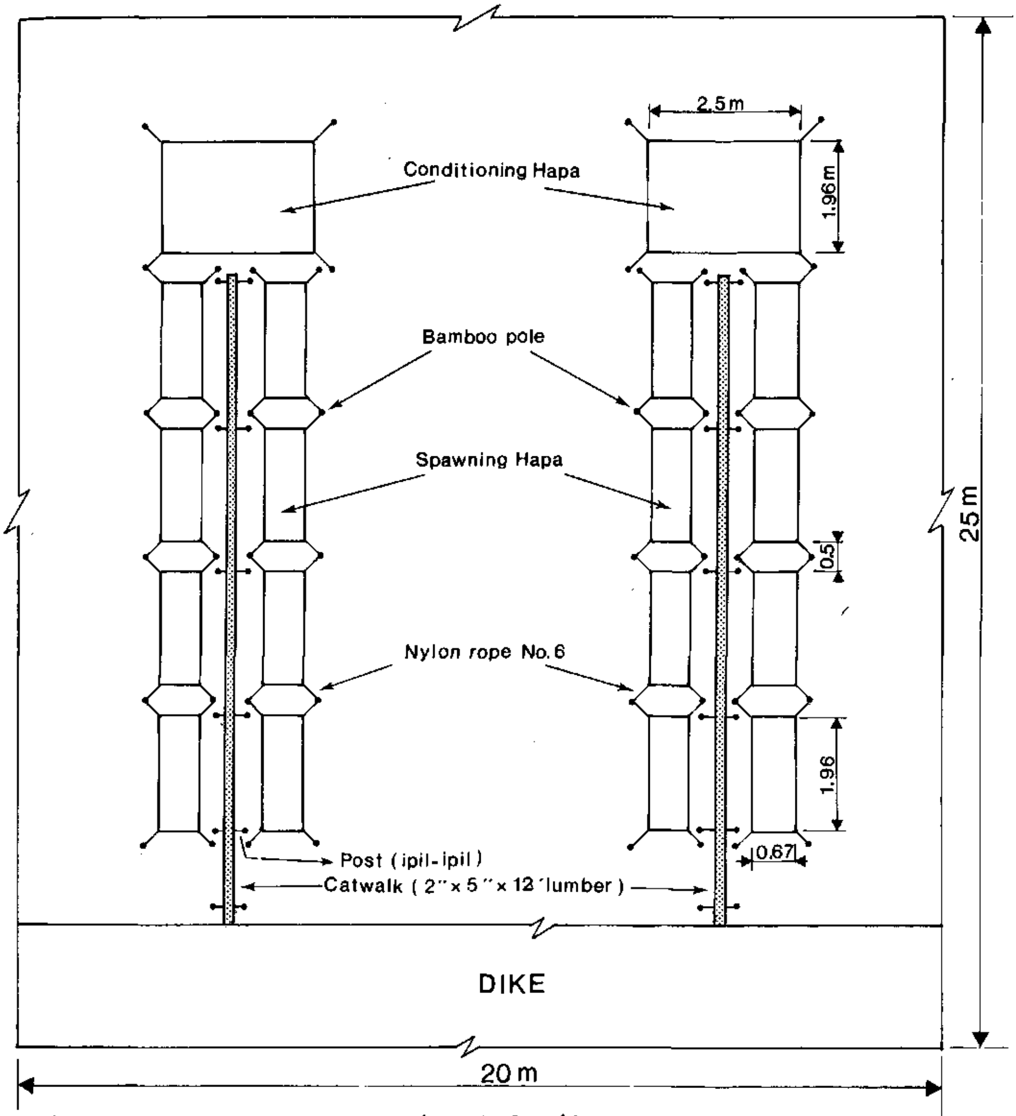

Figure 1. Layout of experimental site.

Each hapa was kept in place by using four bamboo poles and nylon rope No. 6. In order to facilitate harvest of eggs and fry, broodstock exchange, and feeding, a catwalk of lumber and ipil-ipil (Leucaena leucocephala) was constructed between the rows of spawning hapas.

Acquisition and care of broodstock

140 Breeders (80-125 g, 3-4 months old) were acquired from Freshwater Aquaculture Center (FAC), Central Luzon State University, Munoz, Nueva Ecija.

Males and females were stocked separately in conditioning hapas for at least two weeks before they were used as experimental fish. The fish were fed a FAC formulated feed containing 25% crude protein at a rate of 20% body weight per day. Feeding was done once in the morning and once in the afternoon.

Stocking

Fish were stocked at a density of 4 per spawning hapa with a sex ratio of 3 females to 1 male. The average initial broodstock weights were 121 g and 212 g for female and male, respectively. In order to facilitate distinction between sexes, blue plastic tags were used for females and white ones for males. Tagging was done by inserting telephone wire insulated by a nylon thread number 2 into the dorsal musculature, after anesthesia. Stocking was done early in the morning or late in the afternoon.

Feeds and feeding schedule

After stocking experimental fish were fed twice a day the FAC formulated feed at a total rate of 10% of the total biomass. The amount was adjusted every 21 days.
The FAC formulated feed consisted of 13% Peruvian fish meal and 87% broiler starter mash which was repulverized and mixed using a Sogo's Impact Universal Pulverizer and Feed Mixer. An electric Pelleting Machine was used for pelleting the feed.

Management and maintenance of hapas

The spawning hapas were checked every day for possible damage and for dead fish to prevent the outbreak of diseases. The nets were scrubbed after harvest to ensure adequate flow of water and prevent fouling for the succeeding breeding period. Conditioning hapas were cleaned and scrubbed every 10 days. Water depth inside the hapas was maintained at 70 cm, the upper portion of the hapas being 45-60 cm above the water line to prevent escape of fish. Benthic algae in the pond were also removed after each harvest.

Sampling schedule and procedure

Harvest of eggs and fry was done at a 21-days interval. Broodstocks were removed from the hapas at each harvest and weighed to the nearest gram. Eggs from incubating females were collected as well as fry and released eggs from each hapa. Eggs and fry collected were preserved in 5% formalin for counting at a later date. Males and females that were not exchanged were restocked into their respective hapas. Replaced broodstocks were segregated by sex and held in conditioning hapas for at least 21 days before reuse. Male and female replacement was randomly selected from the conditioning hapas, weighed and stocked in the spawning hapas.

Results

Male and female exchange (Treatment IV) gave the highest number of eggs and fry, followed by female exchange (Treatment II). Statistical analysis showed that Treatment IV was significantly different (P >0.01) from the other treatments. (Tables 1 and 2)

Table 3 shows that the average egg and fry number per gram female body weight were 1.88, 2.10, 1.79 and 2.69 after five harvests (105 days) for Treatment I, II, III, and IV, respectively.

It was observed that Treatment IV gave the highest number of eggs and fry per gram female body weight, followed by Treatment II. No increase was observed in Treatment III. Similar observations were obtained by Lovshin & Ibrahim (1987), who found also that male and female broodstock exchange gave higher number of eggs and fry from spawning hapas.

The average egg and fry number per gram female body weight per day were 0.09, 0.10, 0.08, and 0.13 for Treatment I, II, III, and IV, respectively. This observation confirmed the findings of Hughes & Behrends (1983) who collected an average range of 0.03 to 0.16 egg and fry per gram female per day from 3.3 m^2 hapas, stocked with 5 to 10 brooders per m^2 at 1:3 or 1:2 male to female ratio and harvested every 10 to 18 days. On the other hand Lovshin & Ibrahim (1987) found that the average egg and fry number per gram female body weight per day were 0.15, 0.15 and 0.18 for no broodstock exchange, female exchange, and male and female exchange, respectively.

The average number of eggs and fry per gram female body weight after 84 days was 1.89, 2.03, 1.67, and 2.84 for Treatment I, II, III, and IV, respectively. The expected increase was realized from Treatment II and IV. No increase was observed in Treatment III. This proved that male and female broodstock exchange gave a higher number of eggs and fry.

On the other hand, the average number of fry per gram female per day after 105 days was 0.08, 0.09, 0.06 and 0.11 for Treatment I, II, III and IV, respectively. Since Guerrero & Garcia (1983) found an average of about 0.03 fry per gram female per day in 20 m^2 hapas stocked with 144 brooders at 1:3 male to female ratio our findings are in accordance with Lee (1979) who stated that removing eggs from incubating females increases the seed produced per female per day. Guerrero (1986) further stated that spent breeders can rapidly retake spawning if they are separated by sex.

The average number of eggs per gram female throughout the study was 0.48, 0.16, 0.53 and 0.49 for Treatment I, II, III and IV, respectively while after 84 days, the average number of eggs per gram female were respectively 0.60, 0.05, 0.33 and 0.61. The expected increase in egg production was realized in Treatment III, and IV after 105 days. No increase was observed in Treatment II. After 84 days, the expected increase was only realized in Treatment IV. Hence, increase in egg production was realized also in broodstock exchange.

Table 1. Mean production of eggs and fry per hapa throughout the study (105 days duration).

Treatment	Replication 1	2	3	4	Mean*
No exchange	980.60	669.00	793.80	724.20	791.90 b
Female exchange	812.000	720.10	800.80	983.60	829.12 b
Male exchange	798.00	489.00	829.80	875.00	747.95 b
Male and	1279.20	1043.20	1207.20	1049.60	1144.80 a
Mean	967.45	730.32	907.90	908.10	878.44

* Means with the same letter superscript are not significantly different at 5% level.

Table 2. Mean production of eggs and fry per hapa over four harvest days.

Treatment	Replication 1	2	3	4	Mean*
No exchange	1131.75	634.25	742.00	798.00	826.50 b
Female exchange	950.75	683.25	751.75	913.25	824.75 b
Male exchange	643.25	424.25	890.25	913.00	717.68 b
Male and female exchange	1474.25	1178.00	1150.75	1037.75	1219.18 a
Mean	1050.00	729.94	883.68	924.50	879.03

* Means with the same letter superscript are not significantly different at 5% level.

Table 3. Influences of female (F), Male (M), male and female (M + F) and No. (No) broodstock exchange on *Oreochromis niloticus* egg and fry yields from spawning hapas.

Harvest date	Treat-ment	A	B	C	D	E	F	G	H	I	J	K	L	M
28-Oct-87	No	253.75	360.3	0.00	653.50	653.50	1.81	0.09	1.81	0.00				0.09
	F	222.25	351.9	217.00	629.75	846.75	2.41	0.11	1.79	0.62				0.09
	M	228.00	374.1	492.00	377.00	869.00	2.32	0.11	1.01	1.32				0.05
	M+F	243.60	399.0	0.00	847.25	847.25	2.12	0.10	2.12	0.00				0.10
19-Nov-87	No	298.60	406.2	202.75	525.00	727.75	1.80	0.09	1.29	0.50				0.06
	F	262.00	363.9	67.25	702.00	769.25	2.11	1.00	1.93	0.18				0.09
	M	268.10	417.6	228.75	435.25	664.00	1.60	0.08	1.04	0.55				0.05
	M+F	279.60	422.7	397.25	758.00	1155.25	2.73	0.13	1.79	0.94				0.09
04-Jan-88	No	344.90	429.0	155.75	665.50	821.25	1.91	0.09	1.55	1.09				0.07
	F	307.75	401.1	0.00	934.00	934.00	2.32	0.11	2.33	0.00				0.11
	M	256.00	532.9	64.00	580.00	644.00	1.48	0.07	1.34	0.15				0.06
	M+F	286.75	401.1	231.00	1260.00	1491.00	3.71	0.17	3.14	0.58				0.15
27-Jan-88	No	382.60	456.6	357.25	624.25	981.50	2.16	0.10	1.38	0.79				0.07
	F	329.00	448.8	0.00	1017.25	226.00	2.26	0.11	2.27	0.00				0.11
	M	228.40	459.9	0.00	979.75	979.75	2.13	0.10	2.13	0.00				0.10
	M+F	287.40	491.1	175.00	1098.75	1273.75	2.59	0.12	2.24	0.36				0.11
Average	No	321.85	417.7	143.15	548.75	791.90	1.88	0.09	1.55	0.48	1.89	1.49	0.60	0.08
	F	281.88	394.2	56.85	772.30	829.15	2.10	0.10	1.96	0.16	2.03	2.01	0.05	0.09
	M	262.58	514.6	202.75	541.10	747.85	1.79	0.08	1.27	0.53	1.67	1.34	0.33	0.06
	M+F	269.30	424.8	205.60	939.20	1144.80	2.69	0.13	2.21	0.49	2.84	2.24	0.61	0.11

A - Average total male weight/hapa (g)
B - Average total female weight/hapa (g)
C - Average egg number/hapa
D - Average fry number/hapa
E - Average egg and fry number/hapa
F - Average egg and fry/g female
G - Average egg and fry/g female/day
H - Average fry/gram female
I - Average egg/gram female
J - average egg and fry/gram female (2-5 harvest)
K - Average fry/gram female (2-5 harvest)
L - Average egg/gram female (2-5 harvest)
M - Average fry/gram female per day

In this study, the expected increase in egg and fry number per gram female was not realized in male exchange of broodstock after five harvests. Similar results were obtained over a 84 days experimental period.

The expected increase of fry per gram female after 105 days was realized in female exchange and male and female exchange. Similar results were obtained after 84 days. However, the expected increase of eggs per gram female was realized only in male exchange. Therefore, it was noted that male exchange gave higher number of eggs than the other replacement treatments over five harvests.

The average gain male weight in grams per day throughout the experimental period was 0.67, 0.57, 0.33 and 0.24 from Treatments I, II, III, and IV, respectively. On the other hand, the average gain female weight in grams per day for the same period was 0.19, 0.13, 0.14 and 0.08 from Treatments I, II, III, and IV, respectively. Less gain weight of broodstocks in the replacement especially male and female replacements was attributed to their higher rate of spawning performance.

The qualitative relationship of egg and fry yield and broodstock exchange for five harvest dates is shown in Figure 2. It was noted in the first spawning period that the broodstock replacement treatments gave almost the same average number of egg and fry. At this time, no exchange of broodstocks was administered. Broodstock replacement was made from the second spawning period up to the fifth harvest. It was further observed that starting from the second harvest, Treatment II and Treatment IV gave higher average number of eggs and fry. The same pattern was observed in the fourth and fifth harvest. The spawning peak of Treatment IV was observed in the fourth harvest while that of Treatment II was noted in the fifth harvest.

The highest range of egg and fry was observed in the second harvest particularly Treatment II, followed by Treatment IV of the same harvest date. By harvest date, the spawning peak was observed in the fifth harvest.

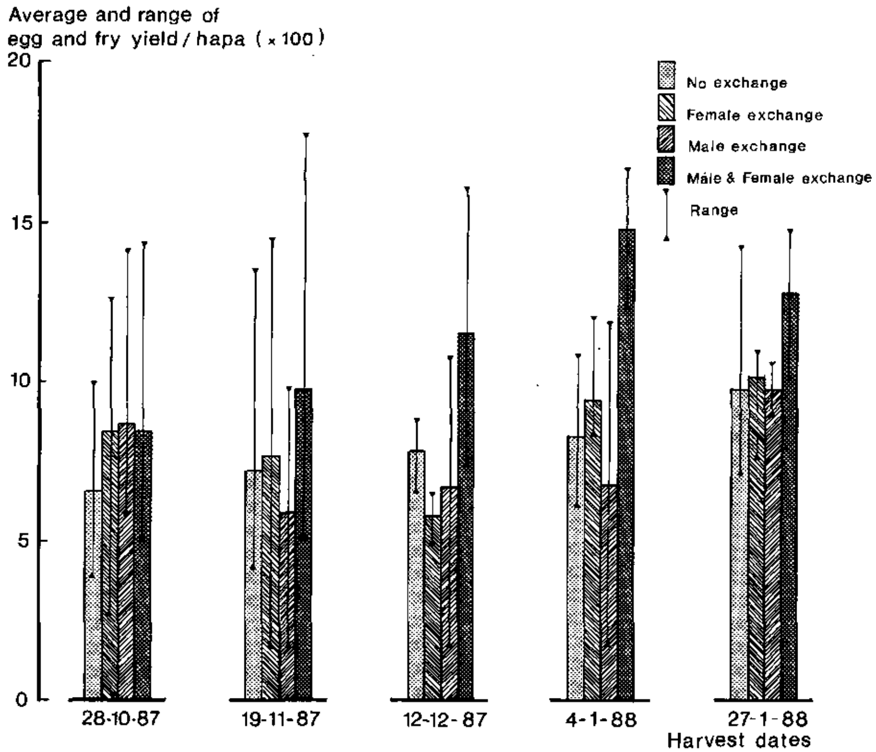

Figure 2. Yields of eggs and fry of O.niloticus as influenced by broodstock exchange techniques for 5 harvest dates.

Conclusions and recommendations

This study on the evaluation of the influence of broodstock exchange on O. niloticus egg and fry production in spawning hapas revealed that male and female broodstock exchange gave the highest number of eggs and fry produced throughout the period of study. Based on the average fry yield per gram female body weight, male and female exchange, and female exchange of broodstocks gave higher fry production than no exchange. Increase of fry from male exchange was not realized, whereas increase in egg yield was attained in male exchange and male and female exchange. No increase was noted in female exchange.

From the positive results obtained from this study, it is recommended that further studies be conducted on broodstock exchange techniques using double-walled hapas and that collection of eggs and fry be done in a shorter interval (7 days and 14 days) and that the economic and financial feasibility for broodstock exchange techniques of seed production be considered.

References

Anonymous, 1982. Laguna lake becoming less productive. Phil. Farmers Journal 24(3): 9.

Balarin, J.D. & R.D.Haller, 1982. The intensive culture of Tilapia in tanks, raceways, and cages. In: J.F. Muir and R.J. Roberts (Ed.). Recent advances in Aquaculture. Boulder Colorado, USA: Westview Press. pp. 266-355.

Bautista, A.M., 1986. Tilapia hatchery and nursery systems: Operation and management. Paper presented during the First National Symposium and Workshop on Tilapia Farming, November 24-26, 1986. PCARRD, Los Banos, Laguna.

Behrends, L.L., 1983. Evaluation of hatchery techniques for intraspecific and interspecific seed production in four species of Tilapia. Doctoral Thesis, Auburn University, Alabama, USA. pp. 71.

Berrios-Hernandez, J.M., 1979. Evaluation management and stocking techniques for maximum production of Tilapia nilotica (Steindachner) fry and fingerlings in plastic pools, Master's Thesis, Auburn University, Alabama, USA. pp. 62.

Coche, A.G., 1982. Cage culture of tilapias, p. 205-246. In: The Biology and Culture of Tilapias. ICLARM Conference Proceedings 7, 432 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Guerrero, R.D. III., 1977. Production of tilapia fry in floating net enclosures. FAO-Aquaculture Bull. 8(3-4):4.

Guerrero, R.D. III., 1982. An overview of tilapia culture in the country. Phil. Farmers Journal 24(3): 31.

Guerrero, R.D., III., 1986. A round table discussion. In: T.J.Lam. Control of Reproduction in Fish: A round table discussion. IDRC manuscript report. April 1986. 153 p.

Guerrero, R.D., III. & A.M. Garcia, 1983. Studies on fry production of Sarotherodon niloticus in lake based hatchery. In: L. Fishelson & Z. Yaron (Compilers). Proceedings of the International Symposium on Tilapia in Aquaculture, Nazareth, Israel. pp. 388-393.

Hughes, D.E. & L.L. Behrends, 1983. Mass production of *Tilapia nilotica* seed in suspended net enclosures. In: L. Fishelson & Z. Yaron (Compilers). Proceedings of the International Symposium on Tilapia in Aquaculture, Nazareth, Israel. pp. 399-401.

Lee, J.C., 1979. Reproduction and hybridization of three Cichlid fishes, *Tilapia aurea* (Steindachner), *T. hornorum* (Trewavas) and *T. nilotica* (Linnaeus) in Aquaria and plastic pools. Doctoral Thesis, Auburn University, Alabama, USA. pp. 84.

Lovshin, H.L. & H.H. Ibrahim, 1987. Effects of broodstock exchange on *Tilapia nilotica* egg and fry production in net enclosures. Auburn University, Alabama, USA. 10 p.

Maclean, J., 1984. Tilapia - the aquatic chicken. ICLARM Newsletter. 7(1): 17.

PCARRD, 1985. The Philippines recommends for tilapia. PCARRD Technical Bulletin Series No. 15-A: 24-26.

Santiago, A.C., 1983. Aquaculture in the Philippines: Lakes and reservoirs. Asian Aquaculture. 5(9): 3.

Snow, J.R., J.M. Berrios-Hernandez & H.Y. Ye, 1983. A modular system for producing tilapia seed using simple facilities. In: L. Fishelson & Z. Yaron (Compilers). Proceedings of the International Symposium on Tilapia in Aquaculture, Nazareth, Israel. pp. 402-413.

Production of Nile tilapia (Oreochromis niloticus L.) in floating cages in the Kampar river

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Summary

In order to assess the feasibility of fish culture in floating cages an experiment using Nile tilapia was conducted from September to December in the Kampar river, Riau Province, Indonesia.

Three floating cages were constructed, measuring 2.0 m length, 1.0 m width and 0.6 m depth, each cage being divided into 2 sections. Each section was stocked with 10 Nile tilapia (6.0-6.5 g, 6.9-7.4 cm). Fish in three sections received a supplemental feed composed of 50% rice bran, 25% fish meal, 15% soy bean meal and 10% green pea meal, whereas fish in the other sections did not receive any feed.

During the experiment water depth varied between 1.2-4.5 m, stream velocity between 1.5-4.4 m/sec, temperature between 25-29.5°C, water visibility between 35-100 cm, and pH between 7.0-7.5. The river bottom consisted of sandy clay. Phytoplankton densities varied from 200 to 600 organisms per liter, the main genera being Pediastrum, Micrasterias, Diatome, Synedra, Navicula, Ulothrix, Moegeotia, Bothryococcus and Brachionus.

Supplemental feeding significantly increased fish growth, the final weight after 3 months averaging 45.5 g, whereas the controls attained only 22.8 g. The mortality with and without supplemental feeding was 6.7% respectively 16.7%.

Introduction

Riau Province has four large rivers, many lakes and swamp areas totalling 296.504 ha (Anonimous, 1984). Aquaculture in the area slowly developed, although freshwater pond culture and brackishwater prawn culture in the coastal areas are progressing. Aquaculture in floating net cages has never been researched as a possible means to utilize these vast aquatic resources.

Aware of the above mentioned situation, an experiment to culture Nile tilapia was executed. Nile tilapia was choosen because of its ease of culture, rapid growth, and ready acceptance of man-made supplemental feed. In Indonesia, culture of Nile tilapia in floating cages has been conducted in Lido Lake, Bogor, in order to study relations between density, growth, production and mortality of the fish (Sumarno, 1981). The present authors have also evaluated the effect of supplemental feeding on the growth of Nile Tilapia in rainfed earthen ponds (Dahril & Ahmad, 1984). However, no floating cage culture experiments have been conducted in rivers and lakes of Riau Province. Hence, the objective of this study is to determine the effect of pelleted supplemental feeding on the production of Nile tilapia reared in floating cages in the

Kampar river, Riau.

Materials and method

Nile tilapia used in this study were bought from a commercial fish trader in Simpang Tiga, Pekanbaru. The fish averaged 6.3 g in weight and 7.2 cm in length. Before the experiment started, the fish were adapted to the cages for seven days.

The supplemental feed was pelleted and contained 50% rice-bran, 25% fishmeal, 15% soy-bean meal, and 10% green pea (*Phaseolus radiatus*) meal. The feed was given twice (07.00 AM and 17.00 PM) at a total ration of 5% of the body weight.

The bamboo-made floating cages measured 2.0 m in length, 1.0 m in width, and 0.6 m in depth. Three floating cages, each divided into two sections, were used in this experiment and each section (1.0 m x 1.0 m x 0.6 m) was stocked with 10 fishes.

Three sections, choosed randomly, were treated with supplemental feed and the other three sections did not receive supplemental feeding. The experiment was executed from September to December 1984 (rainy season) in the Kampar river of Kampung Pinang, Riau. The fish were observed twice a week. Weight and length of five fishes per section, taken randomly, were measured every two weeks.

River depth, stream velocity, temperature, water color and transparency, pH, condition of the river bottom and phytoplankton density and composition were also observed.

Results and discussion

Growth of the fish during the experiment is shown in Table 1 and in Figure 1 and 2. Nile tilapia receiving supplemental feed grew better than those without supplemental feed (45.49 g resp. 22.77 g; 13.35 cm resp. 12.96 cm), the differences being significant at the 5% level (t-test).

Table 2 indicates that the incremental weigth as well as the daily growth rate varied each time of observation.

Table 1. The influence of supplemental feed on the growth of Nile tilapia.

Observation period (week)	Supplemental feed		No Supplemental feed	
	weight (g)	length (g)	weight (g)	length (g)
0	6.30	7.20	6.30	7.20
2	6.24	7.83	6.44	7.42
4	9.97	8.46	7.03	7.74
6	12.97	9.18	8.47	8.11
8	17.94	10.56	12.09	9.09
10	28.79	13.18	19.24	13.02
12	45.49	13.35	22.77	12.96

Table 2. The influence of supplemental feed on incremental weight and daily growth rate of Nile tilapia.

Observation period (week)	Supplemental feed		No supplemental feed	
	incremental weight (g)	daily growth rate (%)	incremental weight (g)	daily growth rate (%)
2	-0.06	-	0.14	0.16
4	3.73	4.27	0.59	0.65
6	3.00	2.15	1.44	1.46
8	4.97	2.74	3.62	3.05
10	10.85	2.88	7.15	2.82
12	16.70	8.29	3.53	2.62

The differences between treatments during the first 2 weeks may be due to sampling errors, but the general trend that supplemental feeding resulted in superior growth is obvious. Growth rates obtained in this experiment are higher than reported by Jankaru & Djajadiredja (1980), who observed a daily growth rate of only 3.4%. Silitonga (1982) reported a daily growth rate of Nile tilapia cultured in cages in swampy waters receiving pelleted supplemental feed of 6.1%. Dahril & Ahmad (1984) found a daily growth rate in rain-fed earthen ponds of 4.1%. Pullin & Almazan (1983) reported a weight increase of Nile tilapia of only 0.2 g after 49 days receiving _Azolla_ sp. as food, and Silitonga (1982) fed Nile tilapia with _Hydrilla_ sp. and found a weight increment of only 4.0 g after 90 days. Hence, daily growth rate of Nile tilapia depends on age, environmental condition, feed, etc.

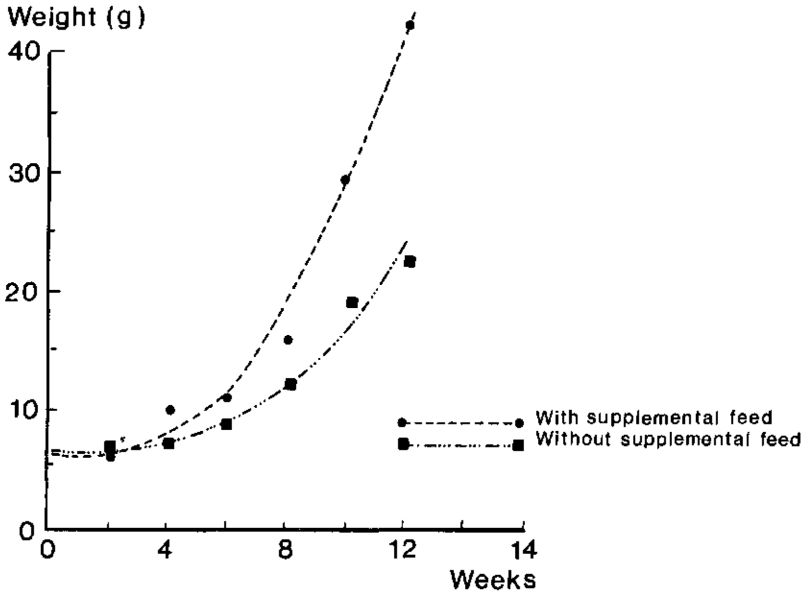

Figure 1. Weight development of Nile tilapia with and without supplemental feed.

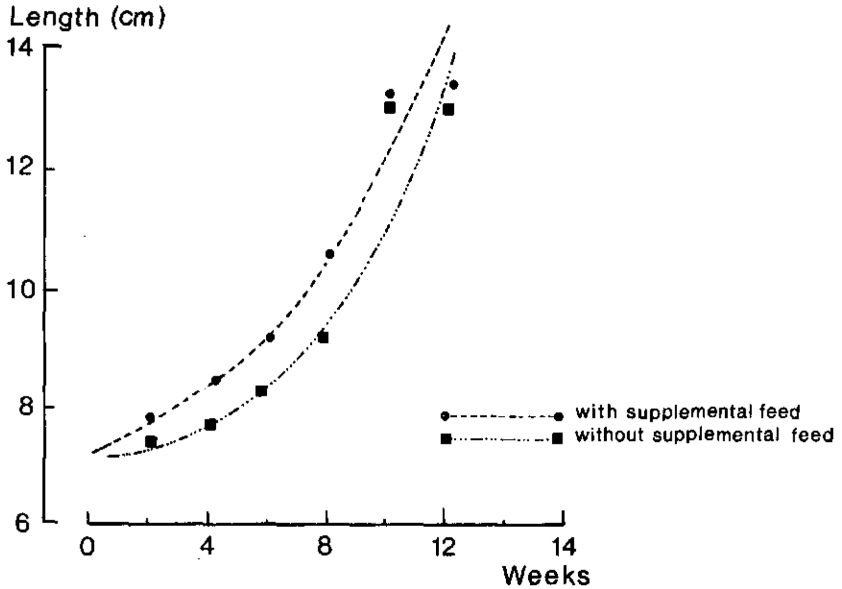

Figure 2. Length development of Nile tilapia with and without supplemental feed.

The mortality of Nile tilapia reared in floating cages in the Kampar river is shown in Table 3. It is obvious that additional feed not only affects the growth, but also the mortality of the fish. In the present experiment, dead fish were mostly found in the early part of the rearing period, which may indicate that at first fish were not well adopted to the cage or river environment.

However, environmental conditions of the experiment were rather favourable, because the depth of the river was 1.2 m-4.5 m, with a stream velocity of 1.5 m/sec to 4.4 m/sec. The temperature was around 25-30^{0}C, and the transparency was 35 cm - 100 cm depending on the rain or run-off poured into the river. The water colour was milky. The river bottom is composed of sandy clay, and the pH of the water ranged from 7.0 to 7.5.

Table 3. The influence of supplemental feed on the mortality of Nile tilapia.

Replication	Supplemental feed		No supplemental feed	
	number of fish	percentage	number of fish	percentage
I	0	0	1	10
II	1	10	3	30
III	1	10	1	10
Total	2	-	5	-
Average	-	6.7	-	16.7

Dominant plankton species observed in the cages were *Pediatrum* sp., *Micrasterias* sp., *Diatome* sp., *Synedra* sp., *Navicula* sp., *Ulothrix* sp., *Moegeotia* sp., *Botryococcus* sp., and *Brachionus* sp., whereas plankton densities varied from 200-600 organisms per liter water.

Hence, the environment can be regarded as adequate for cage culture of Nile tilapia as judged from obtained growth rates and prevailing water parameters.

Moreover, reproduction of experimental fish was observed, sothat it can be concluded that both reproduction and cultivation of Nile tilapia are biologically feasible in the waters of the Kampar River.

References

Anonymous, 1984. Survai Keadaan Umum Perairan Umum Daerah Tingkat I Propinsi Riau. Dinas Perikanan Propinsi Dati I Riau, Pekanbaru.

Dahril, T. & M. Ahmad, 1984. Pengaruh Pemberian Makanan Tambahan (Pellet) Terhadap Pertumbuhan Ikan Nila (*Tilapia nilotica*) di Kolam Tadah Hujan. Terubuk X(28): 19-32.

Jangkaru, Z. & R. Djajadiredja, 1980. Polikultur Ikan Mas dan Nila Dalam Kantong Jaring Terapung. LPPD, Bogor, 12 pp.

Pullin, R.S.V. & G. Almazan, 1983. Azolla as fish food. ICLARM Newsletter 6(1): 6-7.

Silitonga, P., 1982. Pengaruh Pemberian Makanan Tambahan Terhadap Pertumbuhan Ikan Nila (*Tilapia nilotica* L.). Thesis Faculty of Fisheries, University of Riau, Pekanbaru. 40 p. (Unpublished).

Sumarno, T.D., 1981. Pengaruh Padat Penebaran Terhadap Pertumbuhan, Mortalitas dan Produksi Ikan Nila (*Tilapia nilotica* L.) pada Kantong Jaring Terapung di Danau Lido, Cigombang, Kab. Bogor. Thesis Bogor Agricultural University, 43 p. (Unpublished).

Ecological principles of the rice-cum-ish farming system

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Summary

Rice-cum-fish farming in Malaysia is practised primarily in the rice growing area of North Krian, Perak.

Essentially the system is a captural one, wild fish being trapped and subsequently grown in the rice fields. A sump pond, dug at the lowest corner of the rice field, provides shelter during periods of adverse conditions. At present, the double cropping system and concomitently the greater use of pesticides have declined fish yield substantially. In order to ameliorate this situation studies were conducted to develop new menagerial techniques to complement the present system. These studies focussed on fish yields, fish population structure, water quality, and on primary and secondary production.

Mainly fish species possessing on accessory respiratory organ and capable of withstanding fluctuations in temperature, water level, pH, turbidity and dissolved oxygen are found in the rice fields, the most abundant and economically important indigenous species being Trichogaster pectoralis, a herbivore, Clarias macrocephalus, an omnivore, and Channa striatus, a carnivore.

Water in rice fields proved essentially acidic with higher oxygen levels than the sump ponds. Liming improved hardness and alkalinity but nitrate and orthophosphate levels are low and consequently chlorophyll-a concentrations also remained low during the study. Rice plants, phytoplankton and aquatic macrophytes (mainly Salvinia molesta, Bacopa monnieri, Mimulus orbicularis, Hydrilla verticillata, Limnocharis flava, and Azolla pinnata may compete with each other for the nutrients being present at low levels. The copepod, Mesocyclops thermocyclopoides, was the most abundant zooplankton species, followed by rotifers and cladocerans. This zooplankton seems not to be fully utilized by the fish probably because it is protected from predation by the abundance of various shelter places in the rice field. Pesticide application negatively affected zooplankton production, but post application recovery was quite rapid.

The results of the study are discussed in view of new menagerial and cultural techniques to be formulated.

Introduction

Rice-cum-fish farming, long considered an ideal method of land use, has been practised in Asia for several centuries (Coche, 1967). The farming system is thought to originate from India about 1,500 years ago and has attained its highest development in Southeast Asia (Tamura, 1961), especially in

Indonesia (Khoo & Tan, 1980; Koesoemadinata & Costa-Pierce, 1988) where different methods such as concurrent (minapadi), the rotational (palawija), and the in between rice growing (panyelang), are used. Countries such as The Philippines and Thailand also practised rice-cum-fish farming using Nile tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*), *Puntius* sp. and native species such as sepat siam (*Trichogaster pectoralis*) and catfish (*Clarias* sp.) (Sevilleja, 1988; Fedoruk & Leelapatra, 1985).

In Malaysia, where more than 50% of the total animal protein consumed originates from fish (Chua, 1986), the importance of rice-cum-fish farming has long been recognized (Soong, 1955; Tan et al., 1973). Fish harvests provide supplementary income, especially to tenant farmers who formed almost 60% of the rice farmers in the peninsular Malaysia (Tan et al., 1973).

Current methods of rice-cum-fish farming

In Malaysia, rice-cum-fish farming is practised in the Krian Irrigation Area of Northwest Perak, about 60 km south of Penang. The area, which covers 25,000 ha of ricefields, is the oldest irrigation scheme in the country (Tan et al., 1973). In the early 1970's, double cropping of rice was introduced using water from the Bukit Merah Reservoir and the Krian River (Tan et al., 1973). The area is well known for ricefield fish, such as the popular sepat siam, catfish (*Clarias macrocephalus*), and snakehead (*Channa striatus*). The area still has a high freshwater fish production even though yields have declined following the introduction of double cropping of rice.

Rice-cum-fish farming in Malaysia is essentially a captural system, wild fish being trapped and subsequently grown, and harvested at the end of the rice season (Tan et al., 1973; Ali, 1988a). No efforts to improve the farming of fish such as construction of perimeter trenches or repair of dikes to retain fish are carried out (Khoo & Tan, 1980). A sump pond, dug at the lowest section of the fields, provides shelter for fish during the periods of low water level and high water temperature and also acts as harvesting basin (Tan et al., 1973). Manuring to enhance plankton production, stocking or restocking, and feeding of fish are not done (Ali, 1988a) and the water fertility depends on fertilization.

With the introduction of double cropping of rice, various workers have reported a decline in fish yields (Tan, 1973; Tan et al., 1973). Intensive cultivation of rice using high yielding varieties, greater use of pesticides and herbicides, and shorter growing seasons, resulted in low fish harvests (Moulton, 1973; Tan et al., 1973). Because the captural system of rice-cum-fish farming depends on natural productivity, it is imperative that research on the ricefield ecosystem be carried out to improve the present culture system in order to increase fish yields. This paper summarily reviews the ecological studies conducted in the ricefields of Titi Serong, North Krian, Perak from September 1985 to January 1987.

Materials and methods

Three ricefields varying from 0.81 ha to 1.42 ha surface area were used in the study. Each field has a sump pond ranging in size from 6.5 m to 8.0 m diameter and 1.8 m to 2.0 m deep. Field preparations, described by Ali (1988a), starts with spraying the weeds with a paraquat-based herbicide, followed by manually cutting and raking the dead weeds.
Ploughing was not done because the extremely soft and boggy soil precludes the use of heavy machinery. The rice fields were fertilized twice with Nitrogen - Phosphorous - Potasium (NPK) and urea fertilizers at a rate of 112 kg/ha and 56 kg/ha, respectively, two weeks and six weeks after rice planting. A carbofuran pesticide was applied together with the fertilizers at a rate of 5.6 kg/ha.

The study was conducted for two rice growing seasons. Samples for analysis of chlorophyll a, and of water quality parameters such as alkalinity, hardness, soluble orthophosphate, and nitrate were collected fortnightly from the ricefields and the sump ponds, at 15 cm below the water surface, with 1 - liter polyethylene bottles. Samples were stored in a cooler packed with crushed ice and analyzed within six hours in the laboratory using standard methods, whereas, dissolved oxygen (D.O.), water temperature and pH were measured *in situ* using a yellow Spring Instrument Oxygen Meter (Model 57) and a Hanna pH meter (Model 8314) (Ali & Achmad, 1988; Boyd, 1979). Zooplankton samples were randomly collected fortnightly from both habitats by filtering 40 liters of water through a conical plankton net (80 u mesh). Samples were preserved in a 5 % formalin solution and later counted and identified using a compound microscope and a Sedgewick-Rafter counting chamber (Ali, 1989a).

The aquatic weed populations were also sampled fortnightly from March to December 1986 in two ricefields by assessing the population of 2 randomly taken quadrats of 1.0 m2 each in both ricefields (Ali, 1988b).

At the end of the rice growing season the sump ponds were drained and all fish harvested, separated into various species, weighed and measured (Ali, 1989b). The yield obtained from a fourth sump pond was also included in the population analysis. Three fish harvests were obtained during the study period.

Results and discussion

Water quality and productivity.

Irrigated ricefields are essentially temporary freshwater marshes with fallow periods in between periods of aquatic conditions (Fernando *et al.*, 1979). Shallow water in the fields results in water temperature fluctuations especially in the early part of the season when the fields are exposed to direct insolation (Ali & Achmad, 1988). The average temperature in the fields and sump ponds were 31.4°C and 25.7°C, respectively. The highest temperature recorded during the study at 1200 h was 40.1°C and fish were observed coming to the surface for air and congregating in the shaded sump ponds thus illustrating the importance of a sump pond in the rice-cum-fish farming system (Ali & Achmad, 1988). Water temperature declined, however, as the rice crops began to shade the water (Ali & Achmad, 1988). Dissolved oxygen (D.O.) is much lower in the shaded sump ponds where less photosynthesis and water turbulence occurs compared to the more open fields (Ali & Achmad, 1988). In the ricefields, D.O. ($\bar{x}$ = 5.53 mg/l) fluctuated between 3.0 mg/l to 4.0 mg/l in the morning and reached saturation in the afternoon due to photosynthesis by aquatic plants, whereas in the sump ponds the D.O. ($\bar{x}$ = 1.73 mg/l) ranged between 0.5 to 1.0 mg/l in the morning and seldomly exceeded 3.0 mg/l in the late afternoon. However, D.O. is not an important factor in rice-cum-fish farming because most ricefield fish possess accessory respiratory organs (Mohsin & Ambak, 1983).

The pH values indicated that the ricefields are slightly acidic ($\bar{x}$ = 6.33) probably due to the presence of humus left over from weeding and harvesting (Ali & Achmad, 1987), as well as reflecting the marshy origin of the ecosystem (Fernando et al., 1979). Liming does not play a big role in the rice crop fertilization (Moody, 1981) and is not as extensively practised as in fish ponds where the addition of lime increases alkalinity, thereby, increasing the availability of carbon dioxide for photosynthesis and providing a buffer system against drastic diel pH changes (Boyd, 1979). Liming also releases phosphorous from the mud thus increasing its availability to phytoplankton (Boyd, 1979). The total hardness in the ricefields fluctuated within the minimum level (20 mg/l) for good phytoplankton growth (Boyd, 1979). Lime application in December 1985, before the start of the season, resulted in increased total alkalinity (pre-liming = 21.6 mg/l; post-liming = 47.0 and 83.02 mg/l), hardness (pre-liming = 28.5 mg/l; post-liming = 47.0 mg/l and 83.02 mg/l) and pH (pre-liming = 5.67; post-liming = 6.28 and 6.58) for the next two consecutive seasons. Total hardness in the ricefields remained above total alkalinity indicating that calcium and magnesium are associated more with sulfate, silicate and nitrate rather than with bicarbonate and carbonate (Ali & Achmad, 1988), which provide carbon dioxide for photosynthesis by phytoplankton (Arce & Boyd, 1975). Moody (1981) stated that in the ricefield ecosystem, nitrogen is the most important element utilized by both rice crops and weeds especially in the early stages of growth (Blackman & Templeman, 1938, cited in Moody, 1981). The nitrate-N content during the study (Figure 1A) was fairly low considering the amount of both NPK and urea applied to the fields (twice at a combined rate of 168 kg/ha/application). This may indicate an intense competition for nitrogen between rice crop and aquatic macrophytes leaving less nitrate-N available for phytoplankton (Ali & Achmad, 1988). However, nitrate may not be a critical factor because studies have shown that eliminating nitrogen from pond fertilization did not significantly affect phytoplankton production (Sowles, 1977; Boyd, 1979).

Soluble orthophosphate concentration is at about the same level as reported by Zeller (1952), 0,07 mg/l - 0.09 mg/l, for fertilized fish ponds (Figure 1.). Liming released some of the phosphate absorbed to the mud (Boyd, 1979) and fertilization resulted in a higher concentration of soluble orthophosphate in the water column. This released orthophosphate is the main source of phosphorus for phytoplankton (Chiou & Boyd, 1974). Phytoplankton production in the ricefields as indicated by the concentration of chlorophyll a (Figure 1.), increased with greater orthophosphate availability (Ali, 1988 b). However, the overall chlorophyll a concentration is still fairly low, in spite of almost continuous fertilization, suggesting that shading and competition for nutrients between rice crop, weeds and phytoplankton are the limiting factors for phytoplankton growth (Ali & Achmad, 1988).

Aquatic weeds

In the ricefields, aquatic weeds compete with each other and with the rice crop for nutrients (Moody, 1981). In the rice-cum-fish farming weeds, also provide sanctuaries for zooplankton, protecting them from fish predation (Ali, 1989a). A relationship between increased weed biomass and greater zooplankton density was observed during the study (Ali, 1988b). The major weed species sampled are *Bacopa monnieri*, *Salvinia molesta*, *Hydrilla verticillata*, and *Limnocharis flava* (Ali, 1988 b). These aquatic macrophytes, especially the submerged species, provided a diversity of habitats and sanctuaries for zooplankton thus protecting them against predators (Lemly & Dimmick, 1982; Straskraba, 1965).

The diversity of aquatic weed populations in North Krian is probably due to the methods used in the field preparation. Cutting, chopping and raking the weeds following application of herbicides enables fragments of the surviving weeds to spread and repopulate the ricefields at a much faster rate than when the ricefields are ploughed with the tractors (Ali, 1988 b; Moody & Drost, 1983).

Zooplankton populations

Taxonomically, zooplankton is dominated by cladocerans (60.5 %), followed by rotifers (34.2 %) and copepods (5.3 %) (Ali, 1989a). The dominant cladocerans are : *Moina micrura*, *Simocephalus latirostris*, *Diaphanosoma sarsi*, and *Macrothrix spinosa*, whereas the dominant rotifers sampled are important fish-food species such as *Platyias patulus*, *Filinia longiseta*, *Brachionus quadridentata*, and *Lecane luna*. For copepods, one species dominated, *Mesocyclops thermocyclopoides*, which is also an important food source for fish larvae (Heckman, 1978).

Density (individuals/l) is dominated by copepods with rotifers and cladocerans forming a distant second and third group (Figure 1.). The observed density, ranging from 70 to 891 ind./l, is lower than the density of 700 ind./l (excluding copepods and rotifers) obtained in the ricefields of Tanjung Karang, Malaysia (Lim et al., 1984).

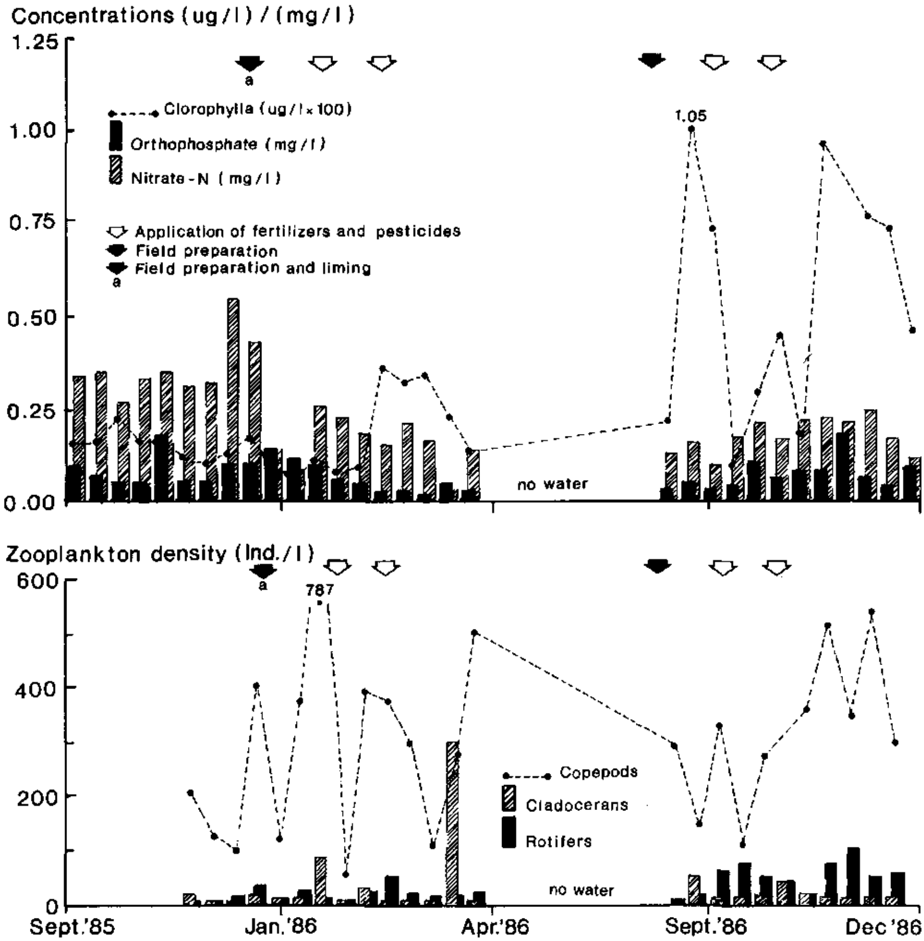

Figure 1. Concentrations of chlorophyll a, orthophosphate, and nitrate-N (upper panel), and density of major zooplankton groups (lower panel) in the rice fields of North Krian. Results of biweekly samplings from September, 1986 to December, 1986. (After Ali, 1988b and 1989a).

The zooplankton density fluctuated with the application of pesticides and herbicides (Figure 1.) and with aquatic macrophyte abundance (Ali, 1988b). The fluctuations are further modified by predator-prey relationships between the dominant populations of copepods, cladocerans and rotifers. Following herbicide application, zooplankton population recovered quickly to reach a maximum density of 891 ind./l in the first season and 394 ind./l in the second season. The density also declined rapidly whenever fertilizer-pesticide was applied to the fields during the growing season, however, post-application recovery was fairly rapid suggesting the absence of prolonged acute toxic effects, which could be due to the floating mat of aquatic weeds such as Salvinia molesta and Azolla pinnata preventing pesticide granules from entering the water (Lim et al., 1984). Carbofuran also converts rapidly to the less toxic phenol form in flooded ricefields (Siddaramappa et al., 1978).

Vertebrate predators such as fish hunt primarily by sight and are size selective preferring larger prey items such as copepods (Brooks & Dodson, 1965; Lane, 1979). This type of predation should result in increased abundance of herbivorous copepods (Lynch, 1979) and smaller-sized rotifers and cladocerans (Spencer & King, 1984; Arcifa et al, 1986). However, the dominant zooplankton species observed is the large-sized Mesocyclops thermocyclopoides indicating ineffective predation by fish on copepods, probably due to the many shelter places provided by the diverse aquatic vegetations, as previously mentioned. This dominant copepod predated on rotifers and cladocerans resulting in a decreased abundance of the latter in the ricefields (Ali, 1989a).

Fish yields

The fish species harvested are climbing perch (Anabas testudineus), panchax (Aplocheilus panchax), snakehead (Channa striatus), catfish (Clarias macrocephalus), featherback (Notopterus notopterus), sepat siam (Trichogaster pectoralis), and three spot goramy (Trichogaster trichopterus). All are air-breathers and can tolerate the extreme chemical and physical changes of the ricefields (Mohsin & Ambak, 1983; Khoo & Tan, 1980) resulting in their dominance in ricefields (Fernando et al., 1979; Heckman, 1979; Lim et al., 1984). In monocropped ricefields, such as in Northeastern Thailand where human disturbances and activities are less and the growing season in longer, a more diverse fish population is observed (Heckman, 1979).

Mean total yields obtained during the study increased from 88.3 kg/ha, and 128.0 kg/ha in the first and the second harvest, to 174.6 kg/ha in the third harvest which is probably the maximum for the captural system of rice-cum-fish farming. The percentage composition by weight of the major species indicated the dominance (by weight) of sepat siam (Table 1), however, a reduction in its dominance is apparent when compared to the yields obtained in the early 1970s (Ali, 1988c; Tan, 1873). The species, introduced from Thailand in the early 1900's, adapted extremely well to the ricefields of North

Krian (Soong, 1948) and has apparently replaced the three-spot goramy as a herbivorous prey species.

Table 1. The percentage composition (by weight) of the major fish species harvested for three consecutive growing seasons (modified from Ali, 1988c).

Species	Harvests I	II	III
T. pectoralis	46.0	53.3	66.2
C. macrochephalus	10.9	11.1	9.6
C. striatus	34.0	32.8	19.6
Others	9.1	2.8	4.6

The three commercial species are sold to the middlemen who set the minimum marketable size (sepat siam ≥ 14.0 cm; Catfish ≥ 20.0 cm; snakehead ≥ 25.0 cm) for each species. Economically, the sepat siam has become less dominant compared to the other two species (Table 2).

Table 2. Average income obtained from the three harvests (Modified from Ali, 1988c).

Species	Harvest I	Harvest II	Harvest III
	M$/ha	M$/ha	M$/ha
C. striatus	35.49	48.62	38.35
C. macrochephalus	24.70	34.06	43.16
T. pectoralis	6.34	5.39	22.61
Total	66.53	88.53	104.12

Although the yields have stabilised and are comparable to yields obtained by Tan et al. (1973), the quality of the fish harvested in the present study is lower. The yields obtained in this study consisted of fish of all sizes. Size distribution analysis for the three economically important fish (sepat siam, catfish, snakehead) indicated that marketable sizes are reached only in the 1+ age group indicating the importance of food availability and a longer growing season for this captural type of rice-cum-fish farming system.

A correlation between reduced body condition and increased abundance was detected for the sepat siam (R = -0.96), catfish (R=-0.77), and snakehead (R=-0.61) (Ali, 1989b). The sepat siam, being a herbivore, is most seriously affected by the low availability of food caused by the short growing season and the low productivity of the ricefields (Ali, 1988 d). The omnivorous catfish and carnivorous snakehead are less affected as long as small-sized fish are available for predation.

The future of rice-fish farming in Malaysia

Currently, there is no official policy on rice-cum-fish farming even though the government recognizes the importance of freshwater fish as a protein source (Ong, 1983). As such, research in this area is lacking except for the one being done by Tan et al. (1973). However, rice-cum-fish farming is still important to the economy of the rural farmers where fish harvests contribute as much as 6.78 % and 8.98 % to the total income of the owner and tenant farmers, respectively (Ali, 1988a). Although this contribution seems low, the profit obtained is essentially a net profit since almost no management inputs and costs are involved (Ali, 1988a).

The future of rice-cum-fish farming in Malaysia is not very good unless the farmers improve and modify the present system in order to continue to profit from fish harvests.

Ricefields must be prepared to retain fish during the growing season by constructing higher dikes around the fields. Perimeter trenches which provide shelter and feeding area (Kangmin, 1988) should also be built to complement the sump ponds.

To counteract low productivity and low zooplankton production, organic fertilizers should be used (Kangmin, 1988). Competition for nutrients among rice crops, aquatic weeds, and phytoplankton can be reduced by clearing the weeds especially during the early part of the growing season when higher zooplankton productivity is needed for the fish larvae. Noxious weeds such as Salvinia molesta must be controlled early in the season to prevent formation of a complete mat on the surface, thus, blocking the sunlight needed by the phytoplankton. Other submerged and emerged weeds such as Hydrilla verticillata, Ceratophyllum demersum, and Bacopa monieri must also be cleared in order to reduce hiding places for zooplanton, which reduce effective predation by fish fingerlings, fry and larvae.

To counteract the effects of short growing seasons, stocking with larger fish fry or fingerlings is needed. Supplemental feeding with cheap food sources can also improve yields. However, this will involve extra costs and may not be readily accepted by farmers. Native species should be used whenever and where ever possible because they are adapted to the local environment and are biologically superior to introduced species. As in the case of North Krian, the available fish species, due to their different biological and ecological requirements, are already suitable for this culture and are highly preferred on the market.

A more prudent and sensible use of herbicides and pesticides is important to maintain continuous productivity of the rice-cum-fish farming system. The use of less toxic and less persistent herbicides such as carbamates and organophosphates (Arce & Cagauan, 1988) is needed to ensure good fish yields. Carbofuran pesticides have been shown to be less toxic to ricefield fauna and are being used increasingly in other ASEAN countries practicing rice-cum-fish farming (Arce & Cagauan, 1988; Fedoruk & Leelapatra, 1985; Koesoemadinata & Costa-Pierce, 1988). However, Ali (1988d) observed reduced fecundity of sepat siam in the North Krian area and attribued this to the chronic effects of herbicides and pesticides applied to the ricefields. Thus, investigations on the long term effects on the ricefield fauna exposed to these pesticides are needed.

In conclusion, rice-cum-fish farming is locality specific and related to the socio-economic and cultural practices of the area (Ruddle, 1982). Therefore, research activities must be conducted to tackle problems specific to that particular area. Any changes or adaptions to the prevailing farming system must complement rather than replace the system that has evolved through the years (Ruddle, 1982).

References

Ali, A.B., 1988a. Rice-fish farming development in Malaysia: Past. present, and future. Paper presented at the International Rice-Fish Farming System Workshop, 21-25 March 1988, Ubon, Thailand.

Ali, A.B., 1988c. The impact of aquatic weeds on primary and secondary productivity in the captural method of rice-fish farming system. In: R. Suwanketnikom et al. (eds.), Proceed. 1, The Second Trop. Weed Conf., Kasetsart Univ. & Weed Sci. Soc. Thailand, Phuket, Thailand, 115-127.

Ali. A.B., 1988c. Yields obtained from the Krian Methods of rice fields fish culture monitored for three consecutive growing seasons. In: M. Mohinder Singh (ed.), Agricultural and Biological Research Priorities in Asia, International Foundation for Science & Malaysian Scientific Association, Kuala Lumpur, Malaysia, 21-27.

Ali, A.B., 1988d. Some ecological aspects of snakeskin goramy, Trichogaster pectoralis (Regan), populations harvested from ricefields-fish culture system. Indo-Malayan Zool., 5:00-00.

Ali, A.B., 1989a. Seasonal dynamics of microcrustaceans and rotifer communities in some Malaysians rice fields used for rice-fish farming. Hydrobiologia :00-00 (in press).

Ali, A.B., 1989b. Some ecological aspects of fish populations in tropical rice fields. Hydrobiologia :00-00 (in press).

Ali, A.B. and Achmad, M., 1988. Water quality in ricefields and sump ponds and its relationship to phytoplanton growth in rice fields fish culture system. Trop. Ecol., 29:63-70.

Arce, R.G. & Boyd, C.E., 1075. Effects of agricultural limestone on water chemistry, phytoplankton productivity and fish production in soft water ponds. Trans. Amer. Fish. Soc., 104:308-312.

Arce, R.G. & Cagauan, A.G., 1988. Overview of pesticides use in rice-fish farming in Southeast Asia. Paper presented at the International Rice-Fish Farming System

Workshop, 21-25 March 1988, Ubon, Thailand.

Arcifa, M.S., Nortcote, T.G. & Froehlich, O., 1986. Fish zooplankton interaction and their effects on water quality of a tropical Brazilian reservoir. Hydrobiologia, 139: 49-58.

Boyd, C.E.. 1979. Water quality in warmwater fish ponds. Ag. Exp. Stat., Auburn University, Auburn, AL, USA 359 pp.

Brooks, J.L. & Dodson, S.I., 1965. Predation, body size, and composition of plankton. Science, 150:28-35.

Choche, A.G., 1967. Fish culture in ricefields. A worldwide synthesis. Hydrobiologia, 30: 7-44.

Chiou, C. & Boyd. C.E., 1974. The utilization of phosphorous from muds by the phytoplankter, Scenedesmus dimorphus, and the significance of these findings to the practice of pond fertilization. Hydrobiologia, 45:345-355.

Chua, T.E., 1986. An overview of the fisheries and aquaculture industries in Asia. In: J.L. Mclean, L.B. Dizon & L.V. Hosillos (eds.) The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines, 1-8.

Fedoruk, A. & Leelapatra, W., 1985. Ricefields fisheries in Thailand. Dept. Fish., Bangkok, Thailand, 66 pp.

Fernando, C.H., Furtado, J.I. & Lim, R.P., 1979. The aquatic fauna of the world's ricefields. Wallaceana Suppl. 2, Dept. Zool. Univ. Malaya, Kuala Lumpur, Malaysia, 105 pp.

Heckman, C.W., 1979. Ricefields ecology in Northeastern Thailand. Vol.34, Dr. W. Junk Bv Publishers, The Hague, 227 pp.

Kangmin, L., 1988. Rice-fish culture in China: A review. Aquaculture, 71 : 173 - 186.

Khoo, K.H. & Tan, E.S.P., 1980. Review of rice-fish culture in Southeast Asia. In: R.S.V. Pullin & Z.H. Shehadeh (eds.) Integrated Agriculture-Aquaculture Farming System, ICLARM Manage. Conf. Proc. 4, Manila, Philippines 1-14.

Koesoemadinata, S., & Costa-Pierce, B.A. 1988. Development of rice-fish farming in Indonesia : Past, present, and future. Paper presented at the International Rice-Fish Farming System Workshop, 21 - 25 March 1988, Ubon, Thailand.

Lane, P.A., 1979. Vertebrate and invertebrate predation intensity on freshwater zooplankton communities. Nature, 280 :391-393.

Lemly, A.D. & Dimmick, J.F., 1982. Structure and dynamics of zooplankton communities in littoral zone of some North Carolina lakes. Hydrobiologia, 88:299-307.

Lim, R.P., Abdullah, M.F. & Fernando, C.H. 1984. Ecological studies of Cladocera in the ricefields of Tanjung Karang, Malaysia, subjected to pesticides treatment. Hydrobiologia, 113:99-103.

Lynch, M., 1978. Predation, competition, and zooplankton community structure: An experimental study. Limnol. Oceanogr. 24 : 253-272.

Mohsin, A.K.M. & Ambak, M.A., 1983. Freshwater fishes of Peninsular Malaysia. Univ. Pertanian Malaysia, Serdang, Malaysia, 284 pp.

Moody, K., 1981. Weed-fertilizer interaction in rice. IRRI Res. Pap. Ser. No 68, Manila, Philippines, 35 pp.
Moody, K. & Drost, D.C., 1983. The role of cropping systems on weeds in rice. In: International Rice Research Institute, Weeds Control in Ricefields, Los Banos, Philippines, 73-88.
Moulton, T.P., 1973. The effects of various insecticides (especially Thiodan and BCH) on fish in paddy fields in West Malaysia. Malay. Agric. J., 49:224-253.
Ong, K.S. 1983. Agriculture development in Malaysia in the 80's. Fish. Leafl. No. 18, Fish. Div., Min. Agric., 30 pp.
Ruddle, K., 1982. Traditional integrated farming systems and rural development: The example of ricefields fisheries in Southeast Asia. Agric. Admin., 10:1-11.
Sevilleja, R.C., 1988. Rice-fish farming development in the Philippines: past, present, and future. Paper presented at the International Rice-Fish Farming System Workshop, 21-25 March 1988, Ubon, Thailand.
Siddaramappa, R., Tirol, A.C., Sieber, J.N., Heinrichs, E.A. & Watanabe, I., 1978. The degradation of carbofuran in paddy water and flooded soil of untreated and treated ricefields. J. Environ. Sci. Health B13:369-380.
Sowles, J.W., 1977. The effects of ammonium nitrate on primary production in fish ponds. M.S. thesis, Auburn Univ. Auburn, AL, USA, 30 pp.
Soong, M.K., 1948. Fishes of the Malayan padi fields. I. Sepat siam (Trichogaster pectoralis Regan). Malay. Nat. J. 3:87-89.
Soong, M.K., 1955. Fish culture in paddy fields in the Federation of Malaya. FAO Inter. Rice Comm. 4th Sess., Tokyo, Japan, 1954 (mimeo.). Indo-Pac. Fish Counc. 6 th Sess., IPFC/CSS/CP 26. 5pp.
Spencer, C.N. & King, D.L., 1984. Role of fish in regulation of plant and animal communities in eutrophic ponds. Can. J.Fish. Aqua. Sci., 41: 1851-1855.
Straskraba, M., 1965. Contribution to the productivity of the littoral region of pools and ponds. I : Quantitative study of the littoral zooplankton of the rich vegetation of the back-water Labicko. Hydrobiologia, 26: 421-443.
Tamura, T., 1961. Carp cultivation in Japan. In: G. Borgstrom (ed.) Fish as food. Acad. Press, NY, USA, 103-120.
Tan, S.P., 1973. The significance of sump-ponds in harvesting of "ikan sepat siam", Trichogasterpectoralis (Regan) in the paddy-fields of Northern Krian, Preak, Malay. Agric. J., 48: 69-72.
Tan, C.E., Chong, B.J., Sier, H.K. & Moulton, T., 1973. A report on paddy and paddy-fish production in Krian, Perak. Min. Agric. Fish.,Bull. No. 128, Kuala Lumpur, Malaysia, 57 pp.
Zeller, H.D., 1952. Nitrogen and phosphorous concentrations in fertilized and unfertilized farm ponds in Central Missouri. Trans. Amer. Fish. Soc., 82: 281-288.

The effect of urea and triple superphosphate fertilizers on standing crop and chlorophyll content of klekap

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Summary

A completely randomized design with 4 levels of urea (10, 15, 20 and 25 g/m^2) and 3 levels of TSP (5, 10 and 15 g/m^2) was used to determine the optimum fertilization rate for the growth of the blue-green algae dominated klekap, the main natural food for milkfish (*Chanos chanos*). The experiment was conducted in 36 wooden tanks, 1 m^2 each, over a period of 8 weeks.

The standing crop of klekap increased with increasing levels of urea, whereas increasing TSP-levels did not significantly increase the standing crop. The combination of 20 g urea with 15 g TSP resulted in the highest standing crop e.g. 5.62×10^8 cells/m^2, whereas the lowest e.g. 3.61×10^8 cells/m^2 was found for the combination of 10 g urea with 5g TSP.

Similar results were observed for the chlorophyll-a content, the highest (18.18 g/m^2) and the lowest content (11.59 g/m^2) coinciding with the highest respectively the lowest standing crop.

Both standing crop and chlorophyll-a content were affected by time, the highest values being obtained in the third week.

Introduction

"Klekap" is an Indonesian term denoting the biological complex of mainly blue-green algae, diatoms and bacteria which form a mat on the bottom of nursery ponds or floating patches along the margins of ponds (Rabanal, 1977). It is the most favoured food of milkfish and prawn because of its nutritive value (Tand & Hwang, 1966).

Despite the popular use of klekap as natural food for milkfish in brackishwater ponds, very little is known about it. Klekap growth depends on various factors, one of these being the available nutrients specificly needed by certain primary producers.

Nitrogen and phosphorus play a significant role as nutrients for the aquatic primary producers, and, therefore, standing crop and chlorophyll content of klekap depend on the availability of those two nutrients in the aquatic ecosystem, assuming that other nutrients are at their minimum required levels.

This study aims to determine the optimum amount of urea and TSP application for standing crop and chlorophyll content of klekap.

Materials and methods

Treatments and experimental design

The following four levels of urea and three levels of TSP were used in this experiment:

Urea (N)			TSP (P)		
N_1	=	10 g/tank	P_1	=	5 g/tank
N_2	=	15 g/tank	P_2	=	10 g/tank
N_3	=	20 g/tank	P_3	=	15 g/tank
N_4	=	25 g/tank			

The treatments were randomly assigned to each experimental culture tank. This factorial experiment was carried out in completely randomized design. Triplication of treatments was carried out to ensure the accuracy.

Experimental units and their preparation

The study was conducted in 36 one square meter polyvinyl-lined wooden tanks. Tank bottoms were covered with a layer of 5 cm of soil taken from brackishwater ponds. The soil was saturated with brackishwater (salinity = 22 ± 2 ppt) by maintaining a water level of 15 cm above the soil.

Fertilizers were applied evenly over the water surface and bottom soil at the beginning of the experimental period. The day after fertilization an inocculation of 50 ml of klekap was supplied to the culture media resulting in an initial density of 14 x 10^3 cell units/m^2.

Sampling and analysis of klekap

Klekap samples were collected every 7 days starting on the seventh day after inocculation. Klekap samples were collected from the soil surface at five points (1 from each corner and 1 from the center of the culture tank), using a collector made of polyvinyl pipe of 5 cm diameter. Algae components were identified according to Allen & Ellen (1935), Davis (1935), Crosby & Wood (1959; 1961; 1963), Geitler (1932), Yamaji (1966) and counted using a Modified Lackey Drop Microtransect Counting Method (APHA, 1976).

Standing crop of klekap on a cell units/m^2 basis was calculated by the following formula:

$$N = \frac{T}{a} \times \frac{C}{F} \times \frac{V}{v} \times \frac{10\ 000}{A}$$

Where:
- N = standing crop (cell units/m^2)
- T = area of the cover slip (mm^2)
- a = area of a field (mm^2)
- C = number of organisms counted (cell units)
- F = number of fields counted
- V = volume of klekap samples (ml)

v = volume of sample under the cover slip (ml)
A = sampling area = p x n
p = area of a sampling point (cm^2)
n = number of sampling points

Chlorophyll-a was analysed spectrophotometrically as described by Strickland & Parsons (1972). Subsamples of klekap were filtered through a 47 mm of 0.45 micron HA-WP Millipore filter. Filtered klekap was extracted immediately with 90% acetone. Absorbance of the supernatant was measured with a Varian VMS 90 UV/VIS Spectrophotometer.

Chlorophyll-a concentration was calculated using the equation of Jeffrey & Humphrey (1975) and the modified APHA method as follows:

$$\text{Chlorophyll-a} = Ca \times \frac{V}{v} \times \frac{10\,000}{A}$$

Where:

- Ca = concentration of chlorophyll-a of subsample extract (mg)
- V = volume of klekap sample (ml)
- v = volume of extracted sample (ml)
- A = sampling area (cm^2) = p x n
  p = area of a sampling point (cm^2)
  n = number of sampling points

Results

Standing crop and species composition

Standing crop of klekap was very significantly affected by nitrogen ($P < 0.01$), whereas phosphorus had no effect. The highest standing crop of 5.62 x 10^8 cell units/m^2 resulted from a treatment of 20 g urea + 15 g TSP and the lowest, 3.61 x 10^8 cell units/m^2, from a treatment of 10 g urea + 5 g TSP (Table 1). The standing crop of klekap increased with increasing levels of urea (Figure 1). On the other hand, increasing the TSP levels insignificantly increased the standing crop.

Standing crop of klekap was also affected by culture period. The density of klekap increased from the first week to the third week, then decreased from the fourth week to the end of the experimental period. The highest density was 11.64 x 10^8 cell units/m^2 in the third week, while the lowest was 2.25 x 10^8 cell units/m^2 in the first week (Table 2).

Table 1. Standing crop of klekap under different nitrogen-phosphorus combinations.

Legend	Treatment Urea (g)	TSP (g)	Standing crop (x 10^8 cell units/m^2)	Log.density	Tukey test
N1P1	10	5	3.61	8.558	A
N1P2	10	10	3.80	8.580	AB
N1P3	10	15	3.80	8.580	AB
N2P3	15	15	3.88	8.589	AB
N2P2	15	10	3.91	8.592	AB
N2P1	15	5	4.02	8.604	ABC
N4P3	25	15	4.22	8.625	ABCD
N3P1	20	5	4.56	8.659	BCDE
N3P2	20	10	4.82	8.683	CDEF
N4P1	25	5	5.02	8.701	DEF
N4P1	25	10	5.25	8.720	EF
N3P3	20	15	5.62	8.750	F

Table 2. Standing crop of klekap in different culture periods.

Culture period (days)	Standing crop (x10^8 cell units/m^2)	Log.density	Tukey test
7	2.25	8.353	A
56	2.42	8.383	AB
49	3.04	8.483	BC
42	3.27	8.515	C
14	4.72	8.674	D
35	5.41	8.733	D
28	7.71	8.887	E
21	11.64	9.066	F

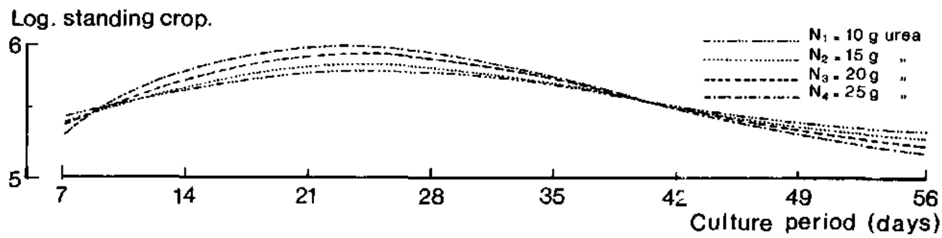

Figure 1. Standing crop of klekap under different levels of urea.

A positive correlation can be observed between the urea level and the culture period on the standing crop. The combined effect is shown in Figure 1 and in the multiple regression equation:

$$Y = 5.4176 + 0.0132\ T - 0.00001\ T^2 - 0.0476\ N + 0.0070\ TN - 0.00024\ T^2N + 0.00000243\ T^3N$$
$$(R = 0.86)$$

Where: N = urea level
T = culture period

Klekap components consist of diatoms, blue-green algae and Chlorophycea. The most dominant component were the blue-green algae, which composed 73.03 - 79.55% of the population. Oscillatoria amounted to 17.48% - 40.63%, Chroococcus to 38.51% - 55.41%, Lyngbya to 0.04% - 1.04%, and Spirulina to less than 0.25% of the blue-green algae component.

Diatoms composed 0.53% - 5.06% of the population, and consisted of Skeletonema (0.41-5.03%), Nitzschia (0.01-0.55%), Navicula (0.01-0.42%), Pleurosigma (0.00-0.43%), Gyrosigma (0.00-0.05%), Coscinodiscus (0.0-0.09%), Pinnularia (0.01-0.02%), Amphora (0.00-0.02%), and Thalassiotrix (0.02%). The later only appeared in the treatment of 20 g urea + 5 g TSP. Protococcus, the only genus of the Chlorophyceae found in this experiment, composed 16.35% - 26.43% of the population.

Chlorophyll-a content

Chlorophyll-a content of klekap was very significantly affected by urea ($P < 0.01$). On the other hand TSP insignificantly affected the chlorophyll-a content. The highest chlorophyll-a content was 14.54 g/m^2 and resulted from a treatment of 20 g urea + 15 g TSP and the lowest, 9.27 g/m^2, from a treatment of 10 g urea + 5 g TSP (Table 3). Chlorophyll-a content of klekap increased concomitantly with increasing urea levels.

Culture period also affected the chlorophyll-a content (Table 4). The combined effect of urea level and culture period on chlorophyll-a content is shown in Figure 2 and in the multiple regression equation:

$$Y = 7.8791 - 1.0676\ N + 0.1774\ TN - 0.0058\ T2N + 0.0001\ T3N$$
$$(R = 0.76)$$

Where: N = urea level
T = culture period

Table 3. Chlorophyll-a content of klekap under different nitrogen-phosphorus combinations.

Legend	Treatment Urea (g)	TSP (g)	Chlorophyll-a concentration (g/m^2)	Tukeytest
N_1P_1	10	5	9.27	A
N_1P_3	10	15	10.25	AB
N_2P_3	15	15	10.46	AB
N_1P_2	15	10	10.49	AB
N_2P_2	15	10	10.92	AB
N_2P_1	15	5	11.26	AB
N_4P_3	25	15	11.92	AB
N_3P_2	20	10	12.32	AB
N_3P_1	20	5	12.50	AB
N_4P_1	25	5	12.77	AB
N_4P_2	25	10	14.07	AB
N_3P_3	20	15	14.54	B

Table 4. Chlorophyll-a concentration of klekap in different culture periods.

Culture period (days)	Chlorophyll-a concentration (g/m^2)	Tukey test
56	7.10	A
7	7.24	A
42	7.92	AB
49	8.92	ABC
14	11.29	BC
35	12.03	C
28	16.14	D
21	23.20	E

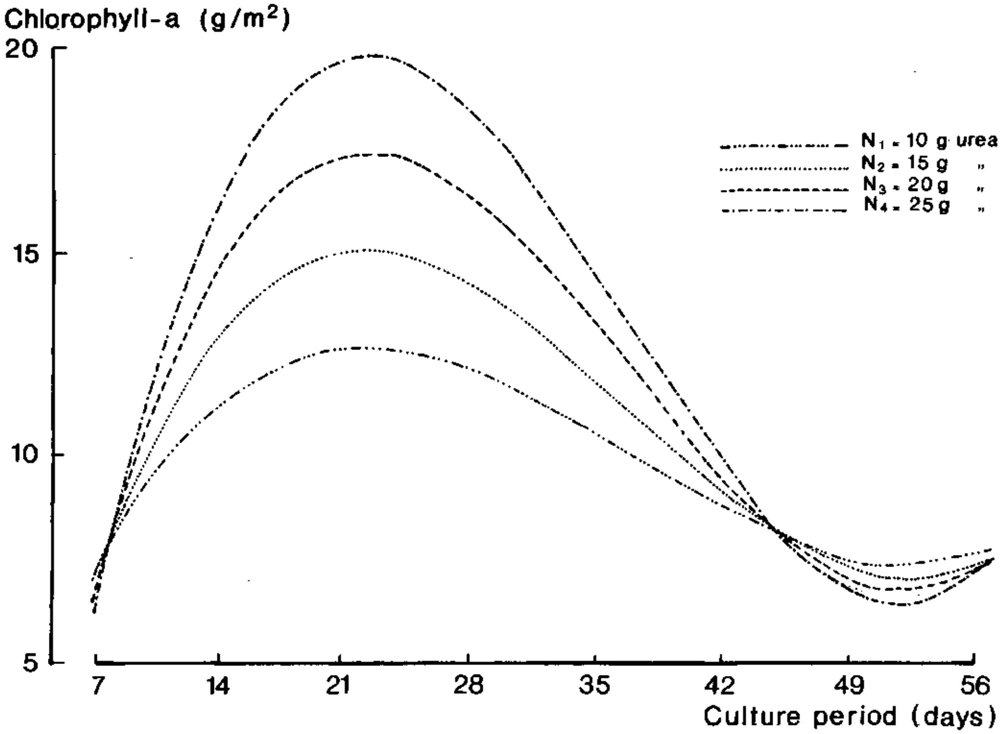

Figure 2. Chlorophyll-a content of klekap under different levels of urea.

Discussion

The results of this experiment show that urea increased the standing crop, and is supposed to play a role as nitrogen source for klekap. Similar results were observed by Carpenter et al. (1972) and McCarthy et al. (1977) whereas McCarthy (1972) observed that more than 28% of the total nitrogen uptake by natural phytoplankton was in the form of urea.

The extent to which klekap responds to urea application may depend on the relative composition of the klekap. The big share of the blue-green algae(in this study 73.13 - 79.55%) may be due to superior uptake of carbon as compared to the other components (Keating, 1978, quoted by Trimbee & Prepas, 1987), whereas also excretory products of blue-green algae are thought to suppress the growth of other algae. Moreover, Oscillatoria can survive at extremely low nitrogen levels because of its ability to fix atmospheric nitrogen (Carpenter & McCarthy, 1975; Capenter & Price, 1977).

These results are similar to the previous experiments by Malone et al. (1975) and Henry et al. (1984), who found that chlorophyll-a content of phytoplankton increased concomitantly with increasing levels of nitrogen. They also found that the rate of cell division increased as a linear function of the available nitrogen per cell and the nitrogen:carbon ratio.

TSP did not increase the standing crop nor the chlorophyll content, which may be due to unavailability of this nutrient to klekap because of soil adsorption and/or uptake by bacteria. Boyd et al. (1981) observed a higher phosphorus fixation by sediments of fish ponds enriched with granular forms of phosphorus fertilizers. Rhee (1972) found a highly effective competition of bacteria against algae in uptake of inorganic phosphates.

The chlorophyll-a content of klekap increased concomitantly with increasing the standing crop. Henry et al. (1984) observed a positive correlation between chlorophyll content and cell concentrations of phytoplankton. Therefore, the chlorophyll content can be used as an useful and simple standing crop estimator.

Both standing crop and chlorophyll-a content increased from the first week to the third week of the culture period and then decreased from the fourth to the end of the experiment. This indicates the relation between the concentration of available nutrients and the growth processes of klekap.

The concentration of orthophosphate and nitrate in this experiment may be too low to support the growth of the klekap (Table 5). Hepher (1952, quoted by Boyd & Musig, 1981) stated that the available concentration of soluble orthophosphate decreased with 90% within 1-2 weeks due to bacterial uptake and/or sediment adsorption.

Nitrogen and phosphorus are the most limiting nutrients for the primary producers of the aquatic ecosystem. Limited nitrogen caused a decreased photosynthesis and chlorophyll content of Chaetoceros (Tett et al., 1975). The growth of phytoplankton decreased at concentrations of phosphate <15 ug-P.1^{-1} and of nitrogen <1.12 ug-N.1^{-1} (Schelske et al., 1974). Decreasing nutrient levels resulted in decreased chlorophyll content of Skeletonema (Tett et al., 1975).

Eventhough the standing crop (cell units/m^2) of Chroococcus is almost equal to that of the blue-green algae, their cell size is much smaller, than that of the blue-green algae. Therefore, expressing the standing crop in cell units is not very satisfactorily.

An interesting result of this experiment was the presence of Skeletonema and Spirulina. However, their standing crop was much lower that that of Oscillatoria, but they play an important role in aquaculture. Both Skeletonema and Spirulina are important natural food for fish and prawn fry because of their high nutritive value. The low standing crop of these two may be due to the lack of required nutrients.

Table 5. Water quality parameters during the experimental period.

Parameters	Time of day	Status/concentration
Water temperature (^oC)	06.00-07.00	25.04 - 27.48
	12.00-14.00	31.80 - 35.44
Salinity (ppt)	16.00-17.00	20.00 - 25.00
Alkalinity ($CaCO_3$ eq.)	06.00-07.00	93.30 - 360.00
Carbon dioxide (ppm)	06.00-07.00	0.12 - 2.22
Dissolved oxygen (ppm)	06.00-07.00	0.34 - 3.17
Silicate (ppm SiO_3)	09.00-10.00	0.00 - 5.52
pH	08.00-09.00	7.39 - 8.57

Legend	Treatment Urea (g)	TSP (g)	PO_4-P (ppm) Initial	Final	NO_3-N (ppm) Initial	Final
N_1P_1	10	5	0.0486	0.0003	0.6579	0.0040
N_1P_2	10	10	0.0775	0.0005	0.6487	0.0056
N_1P_3	10	15	0.1230	0.0496	0.3508	0.0033
N_2P_1	15	5	0.0708	0.0016	0.7682	0.0033
N_2P_2	15	10	0.0816	0.0000	0.8189	0.0037
N_2P_3	15	15	0.1199	0.0400	0.8192	0.0019
N_3P_1	20	5	0.0894	0.0005	0.8115	0.0010
N_3P_2	20	10	0.0971	0.0000	0.8311	0.0040
N_3P_3	20	15	0.1245	0.0000	0.8133	0.0023
N_4P_1	25	5	0.1080	0.0000	0.8311	0.0035
N_4P_2	25	10	0.1622	0.0000	0.7500	0.0038
N_4P_3	25	15	0.2400	0.0016	0.8183	0.0031

References

Allen, W.E. & E. Ellen, 1935. Plankton diatom of the Java Sea. Annales du Jardin Botanique de Boitenzorg, 2(XL/V), Leiden. 225 p.

APHA., 1976. Standard methods for estimation of water and waste water. APHA-AWWA-WPFC Publ., Am.Public Health Association, Washington. 1193 pp.

Boyd, C.E. & Y. Musig, 1981. Orthophosphate uptake by phytoplankton and sediment. Aquaculture, 22: 165-173.

Boyd, C.E., Y. Musig & L. Tucker, 1981. Effects of three phosphorus fertilizers on phosphorus concentrations and phytoplankton production. Aquaculture, 22: 175-180.

Carpenter, E.J., C.C. Remsen & S.W. Watson, 1972. Utilization of urea by some marine phytoplankters. Limnol.Oceanogr., 17(2): 265-269.

Carpenter, E.J. & McCarthy, 1975. Nitrogen fixation and uptake of combined nitrogen nutrients by Oscillatoria (Trichodesmium) thiebautii in the Western Sargossa Sea. Limnol.Oceanogr., 20, 389-401.

Carpenter, E.J. & C.C. Price. IV., 1977. Nitrogen fixation, distribution and production of Oscillatoria (Trichodesmium) spp. in the western Sargossa and Caribbean seas. Limnol.

Oceanogr., 22(1): 60-72.
Davis, C.C., 1955. The marine and freshwater plankton. Michigan University Press. 562 pp.
Geitler, L., 1932. Cyanophyceae. Akademische Verlagsgesellschaft mbH., Leipzig, Germany. 1195 pp.
Grosby, L.H. & E.J.F Wood, 1959. Studies on Australian and New Zealand diatoms. II. Normally epontic and benthic genera. Trans.Royal Soc.New Zealand, 86(1): 1-58.
Grosby, L.H. & E.J.F. Wood, 1961. Studies on Australian and New Zealand diatoms. IV. Description of further sedentary species. Trans. Royal Soc. New Zealand, 88(4): 669-698.
Grosby, L.H. & E.J.F. Wood, 1963. Studies on Australian and New Zealand diatoms. VI. Tropical and subtropical species. Trans. Royal Soc. New Zealand, 2(15): 189-218.
Henry, R., J.G. Tundisi & P.R. Curi, 1984. Effects of phosphorus and nitrogen enrichment on the phytoplankton in a tropical reservoir (Lobo Reservoir, Brazil), Hydrobiologia, 118: 177-185.
Jeffrey, S.W. & G.F. Humphrey, 1975. New spectrophotometric equations for determining chlorophyll a, b, c_1 and c_2 in higher plants, algae, and natural phytoplankton. Biochem. Physiol. Planzen (BPP), 167: 191-194.
Malone, F.C., C. Garside, K.C. Haines & A.O.Roels, 1975. Nitrate uptake and growth of Chaetoceros sp. in large outdoor continuous culture. Limnol. Oceanogr., 20(1): 9-19.
McCarthy, J.J., 1972. The uptake of urea by natural populations of marine phytoplankton. Limnol. Oceanogr.,17(5):738-748.
McCarhty, J.J., W.R. Taylor & J.L. Taft, 1977. Nitrogenous nutrition of the plankton in the Chesapeak Bay. I. Nutrient availability and phytoplankton preferences. Limnol. Oceanogr., 22(6): 996-1001.
Rabanal, H.R., 1977. The culture of lab-lab, the natural food of the milkfish, Chanos chanos (Forsskal) fry and fingerlings under cultivation. Reading on aquaculture practices. SEAFDEC Aquaculture Department, Iloilo, Philippines. p. 148-157.
Rhee, G-Yul, 1972. Competition between an algae and an aquatic bacterium for phosphate. Limnol. Oceanogr., 17(4): 505-514.
Schelske, C.L., E.D. Rothman, E.F. Stoermer & M.A. Santiago, 1974. Responses of phosphorus limited Lake Michigan phytoplankton a factorial enrichments with nitrogen and phosphorus. Limnol. Oceanogr., 19(3): 409-419.
Strickland, J.D.H. & T.R. Parsons, 1972. A practical handbook of sea water analysis. Bull. Fish. Res. Bd Can., 167: 1-311.
Tang, Y.A. & T.L. Hwang, 1966. Evaluation of the relative suitability of various groups of algae as food of milkfish produced in brackishwater ponds. In T.V.R. Pillay (Ed.). Proceedings FAO World Symposium on warm water pond fish culture. FAO Fish. Rep., 44(3): 365-372.
Tett, P., J.C. Cottrell, D.O. Trew & B.J.B. Wood, 1975. Phosphorus quota and the chlorophyll:carbon ratio, in marine phytoplankton. Limnol. Ocveanogr., 20(4): 587-603.
Trimbee, A.A. & E.E. Prepas, 1987. Evaluation of total phosphorus as a predictor of the relative biomass of blue-green algae with emphasis of Alberta Lakes. Can. J. Fish. Aquat. Sci., 44: 1337-1342.
Yamaji, I., 1966. Illustrations of the marine plankton of Japan. Hoikusha. Osaka, Japan. 369 pp.

Nutrition and culture of the giant gourami (*Osphronemus goramy*, Lacepede) in floating net cages

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Summary

The first part of this study focussed on the determination of the digestibility of feeds and feed ingredients by the popular Asian food fish, the giant gourami (*Osphronemus goramy* L.), whereas the second part assessed the aquaculture potential of the species using floating net cages as husbandry system.

Digestibility of yam leaves (*Colocasium antiquorum*) was compared with that of pelleted reference and test feeds by using lignin and chromium-oxide as markers. The apparent digestibility of dry matter, protein, fat and cellulose of yam leaves was 55.29%, 72.04%, 30.53% and 52.46% respectively. The apparent digestibility of dry matter, protein, fat, ash, carbohydrate and gross energy of the reference pelleted feed amounted to 68.61%, 82.95%, 89.08%, 41.29%, 63.58% and 74.43% respectively.

This study revealed also that all feed ingredients (fish meal, soybean meal, copra cake, maize and rice bran) were well digested except the rice bran. These experiments resulted in a number of adequate diets for the giant gourami.

Using both types of feed 2 trials were carried out to determine the growth response of the fish in floating net cages.

In the first trial fish of 8.4 g individual weight at a density of 15 per m^2 were fed for 12 weeks at a daily ration of 10% of the fresh body weight per day. In triplicate 4 different feeds were used, e.g. I- yam leaves, II- pellet with 10% crude protein, III- pellet with 20% crude protein and IV- pellet with 40% crude protein.

Weight gain obtained was 5.7 g, 18.1 g, 33.1 g and 44.7 g respectively. The feed conversion ratio for feed II, III and IV was 7.33, 5.22 and 4.94 respectively, whereas PER-values amounted to 1.35, 0.99 and 0.49 respectively. The daily specific growth rate obtained for the feeds I, II, III and IV was 0.61%, 1.4%, 1.9% and 2.2% respectively. Survival rate did not differ significantly between the feeds used, but the highest survival (99.3%) was recorded for the 40% protein diet.

In the second trial fish of 13.8 to 14.9 g individual weight were fed for 18 weeks at a daily ration of 10% body weight per day at the same fish density. In triplicate 3 different pelleted diets were used e.g. 1-25% crude protein, 2-35% crude protein and 3-45% crude protein.

The weight gain obtained with the diets 1, 2 and 3 were 100.6 g, 166.6 g and 182.3 g, whereas the feed conversion ratios and the PER-values were 5.53, 4.39 and 4.58 respectively 0.721, 0.651 and 0.481.

Introduction

The giant gourami (*Osphronemus goramy*, Lacepede), the largest freshwater Anabantid is a popular food fish in Asia. It is a slowly growing fish requiring 2-3 years to attain marketable size and yielding only some 200 $kg.ha^{-1}.year^{-1}$ (Bardach et al., 1972; Hora & Pillay, 1962; Sterba, 1973).

Literature relating to the nutrition and culture of this species is scanty. Ong (1968) reported that this fish attained a weight gain of 0.30 to 0.45 kg per annum. Hora & Pillay (1962) reported that it attained a length of only 15 cm in the first year, 25 cm and 30 cm in the second and third year respectively. Ardiniwata (1981) also reported its slow growth in ponds in Indonesia attaining 100 g (17-22 cm) in 18 months, 300 g in 2 years and 700-850 g in 3 years. The poor growth of this fish is probably due to the types of feed prevailing in the ponds using the traditional extensive culture system where yield is limited by the natural productivity and capacity of the water body.

The adult fish is essentially herbivorous, feeding on soft vegetation like *Ipomaea aquatica*, *Hydrilla* sp. and yam leaves (*Colocasia antiquorum*), though it tends to be omnivorous at times, feeding on shrimps, insects and small fish (Jhingran, 1975).

The larvae feed on micro-organisms such as infusoria and rotifers, while the fry prefers insect larvae, crustaceans and macro-zooplankton. Thus the nutritional requirements of this fish are little understood. Law et al. (1983) reported that this species could not adequately digest plant material suggesting that for intensive culture systems a well balanced pellet feed is required for successful culture of this species. Tan (1983) reported that juvenile fish showed the highest weight gain at a dietary level of 40% protein.

In order to understand the basic dietary requirements of this fish two studies were conducted in relation to the digestibility of yam leaves and pelleted feeds and in relation to the culture of this fish in floating net cages to test their growth response on these feeds. The culture trials were conducted from November 1982 to January 1983 and from mid-December 1984 to early May 1985. The information obtained from these studies could contribute towards a better understanding of the nutrition of this species and a more suitable feed formulation. The results from these studies were briefly reported earlier by Ang et al. (1988), this paper giving a more detailed documentation of this study.

Materials and methods

Yam leaves (*Colocasia antiquorum*)

Young yam leaves were collected from a nearby fish pond. They were cleaned and the mid ribs of the leaves were removed before feeding to the fish.

Reference diet and test diets

The 37% protein "MARDI" feed was chosen as the reference diet its composition being given in Table 1. The test diet consisted of 30% of the test ingredient and 70% of the reference diet (Cho & Slinger, 1979). Five test ingredients were used in this study: fish meal, soya bean, maize, rice bran and copra cake. In each diet 1% of chromium-oxide (Cr_2O_3) was incorporated as an internal marker for determination of the digestibility.

Table 1. Composition of the reference diet.

Ingredients	Percentage
Fish meal	55.75
Soya bean meal	27.00
Copra cake	7.00
Maize	3.00
Rice bran	1.00
Tapioca	2.00
Vitamin mix +	0.60
Mineral mix +	3.65

+ As recommended in National Research Council (1977).

Experimental tanks and fish

Six funnel-shaped tanks, 1.3 m in diameter and 0.7 m in height were used in this study (Law, 1984). Each tank was stocked with 10 giant gourami (mean TL 18.70 ± 0.9 cm and 95.30 ± 16.3 g mean weight). Each tank was provided with aeration and water flow rate amounted to 25 $l.hr^{-1}$. A filter was fitted to each tank with a filtering rate of 15 $l.hr^{-1}$.

Water temperature (24.0-27.5°C), dissolved oxygen (7.4-8.0 mg/l), pH (6.5-7.5) and ammonium-nitrogen (1.0-1.5 mg/l) were monitored routinely and all values were within acceptable limits for fish growth.

Feeding and collection of faeces

The fish were fed at a total ration of 5% body weight per day three times daily at 08.30, 13.45 and 20.30 hour. One hour after each feeding, uneaten feed was removed and about 10 litres of water in each tank was drained to flush out any uneaten feed that had sunk to the bottom of the tank. The settled faeces were slowly drained from the bottom of the collection tube at 08.15, 13.30 and 20.15 hours daily. The collected faeces were centrifuged at 2000 rpm for 10 minutes with a Heraeus centrifuge. The precipitate was dried in an oven at 45°C and grounded, after which a proximate analysis was carried out.

Proximate analyses

Analyses of lignin, cellulose, ash and acid digestible fibre contents in the yam leaves and in the corresponding fish faeces followed the methods of Forage Fiber Analysis (Goering & Soest, 1970), while for crude protein and crude fat, the methods of A.O.A.C. (Association of Official Analytical chemists) were followed. In the reference diet, the test diets and the corresponding faeces, crude protein, fat, ash, and moisture were analysed following the methods of A.O.A.C. Carbohydrate, in percentage, was calculated by difference: 100%-% crude protein-%crude fat-%ash. The gross energy content was determined with a Parr adiabatic oxygen bomb calorimeter. The chromium-oxide content was estimated using the method of Kimura & Miller (1957).

Digestibility

The apparent digestibility of dry matter and nutrients in yam leaves and diets was estimated according to Schneider & Flatt (1975). The digestion coefficients of nutrients of the ingredients were estimated according to Cho & Slinger (1979).

Growth study in cages

During the first trial, fish of 6.41-6.91 cm and 7.37-9.49 g were stocked in 12 floating net cages (1.5 m x 2.0 m x 1.0 m) at a stocking density of 15 fish.m^{-2} The fish were fed four diets: I: Colocasia leaves; II: a pellet with 10% protein; III: a pellet with 20% protein and IV: a pellet with 40% protein. Each treatment had 3 replicates. The basic ingredients for Diet II, III and IV were soya bean meal and tapioca flour, vitamins and minerals being added. The fish were fed at 08.00 hours and 16.00 hours at a total ration of 10% body weight daily. The amount of feed was adjusted after sampling 20 fish randomly every fortnight for length and weight. pH, dissolved oxygen, temperature and alkalinity and other water quality parameters were monitored (Table 9).

During the second trial fish of 13.9-14.9 g and 7.2-7.7 cm were stocked in 9 floating net cages of similar dimensions as in the first trial. Each cage was stocked with 35 fish. Three pelleted diets: 1: a pellet with 25% protein, 2: a pellet with 35% protein and 3: a pellet with 45% protein, were tested in triplication. Sampling for length and weight was initially done every fortnight and subsequently at monthly intervals. Feeding time and feed ration were the same as in the first trial. All weight and length data were subjected to ANOVA and Duncan's Multiple range test. Condition factor (K) was determined by the formula $K = 100W/L_3$, where L is the standard length in cm and W is the weight in g (Bennet, 1962).

Specific Growth Rate (SGR) as daily percentage increase in body weight was calculated using the formula (Swift, 1955): $SGR = (\ln W_2 - \ln W_1) \times 100/T_2 - T_1$, where W_2 is the weight at T_2 and W_1 is the weight at time T_1.

The feed utilization by the fish has been calculated by determination of the food conversion ratio (FCR = Feed intake/weight gain) and the PER (Protein Efficiency Ratio = Live weight gain/Dry weight of protein consumed).

Results and discussion

Digestibility studies

Yam leaves (Colocasia antiquorum)

The proximate analyses of both yam leaves (without the mid-rib stem) and faeces collected, and the apparent digestibility of nutrients of the leaves by giant gourami are given in Table 2.

Table 2. Proximate chemical analysis of <u>Colocasia</u> <u>antiquorum</u> and the apparent digestibility by giant gourami. *

	<u>C.antiquorum</u>	Faeces collected	Apparent digestibility (%)
Lignin	3.46 ± 0.61	7.74 ± 0.85	-
Protein	32.61 ± 0.52	20.39 ± 0.58	72.05
Lipid	6.46 ± 0.24	10.04 ± 0.36	30.53
Ash	0.41 ± 0.10	5.70 ± 0.68	ND +
Cellulose	13.83 ± 1.01	13.35 ± 1.13	52.46
Acid digestible fiber	39.64 ± 1.20	38.06 ± 0.85	57.08
Dry matter	-	-	55.29

* on a dry matter basis
\+ not digestible

Reference diet and test diets

Table 3 shows the proximate analysis of the reference diet, the test diets and the corresponding faeces obtained. The digestibility values of dry matter and nutrients of the diets are presented in Table 4. Similarly, a summary of the apparent digestion coefficients of protein, ash, fat, carbohydrate and gross energy of the test ingredients used in formulating the reference diet is presented in Table 5.

Table 3. Proximate analyses of the reference and test diets and the corresponding faeces in giant gouramy.

Diets	Reference diet		Reference diet + fish meal		Reference diet + Soya bean		Reference diet + Maize		Reference diet + Rice bran		Reference diet + copra cake	
Nutrients	feed	faeces	feed	faeces	feed	faeces	feed	faeces	feed	faeces	feed	faeces
Proteins (%)	37.59	20.33	44.93	15.18	42.67	20.68	30.53	19.66	31.78	14.62	38.93	18.56
	0.80	0.09	0.57	0.36	1.41	0.17	0.55	0.33	0.43	0.12	0.11	0.24
Ash (%)	15.40	28.68	21.00	39.90	14.16	26.13	12.47	28.04	14.38	24.25	15.91	33.61
	0.27	0.31	1.39	0.30	1.33	0.28	1.15	1.18	0.19	0.17	0.23	0.57
Fat (%)	4.09	1.42	4.05	0.90	3.08	1.50	3.33	1.29	7.37	2.11	2.24	1.64
	0.48	0.26	0.13	0.06	0.38	0.14	0.10	0.27	0.07	10.35	0.42	0.03
Carbohydrate (%)	42.92	49.58	30.03	43.40	40.10	51.69	53.77	51.02	46.48	59.02	42.92	46.19
Gross Energy (%)	4126.87	3347.69	4090.23	2813.41	4314.88	3750.00	4175.91	3483.97	4294.12	3249.26	4264.23	3049.54
	35.62	63.80	31.45	38.51	87.02	74.75	20.11	28.37	24.41	66.25	41.91	50.59
Cr2O3 (%)	0.80	2.55	0.82	3.63	0.84	3.32	0.82	3.53	0.84	2.35	0.79	2.93
	0.03	0.01	0.02	0.28	0.06	0.12	0.03	0.15	0.06	0.03	0.02	0.01

Table 4. Apparent digestibility of dry matter and nutrients in the test diets.

Diets / Nutrients	Reference Diet	Ref.Diet + fish meal	Ref.Diet + soya bean	Ref.Diet + maize	Ref.Diet + rice bran	Ref.Diet + copra cake
Protein(%)	82.95	92.03	87.79	85.06	83.46	87.14
Ash (%)	41.29	56.97	53.50	47.99	39.36	43.01
Fat (%)	89.08	94.95	87.72	91.07	89.71	80.32
Carbohydrate (%)	63.58	67.27	67.51	78.07	54.36	70.97
Gross energy (%)	74.43	84.42	78.10	80.71	72.80	80.71
Dry matter (%)	68.61 ±1.00	77.27 ±1.57	74.77 ±1.71	76.86 ±1.05	64.05 ±2.17	73.01 ±0.70

Fish meal was the best digestible ingredient in the feed, the digestion coefficients for dry matter, protein, ash, fat and gross energy being close to 100%, except for carbohydrate which was only 75.87%. The data revealed that the second best digestible ingredient was maize, the dry matter, protein, ash, fat, carbohydrate and gross energy digestion coefficients being 96.10%, 90.00%, 63.663%, 95.72%, 100% and 95.38% respectively. These values were higher (except for protein and ash) than those for soya bean (Table 5). In fact, maize was the only ingredient which had a carbohydrate digestion coefficient of 100%.

Table 5. Apparent digestion coefficients of dry matter and nutrients of the tested ingredients.

Diets / Nutrients	Fish meal	Soya bean	Maize	Rice bran	Copra cake
Protein (%)	100.00	99.07	90.00	84.66	96.93
Ash (%)	93.94	81.97	63.63	34.85	47.01
Fat (%)	100.00	84.54	95.72	91.19	59.88
Carbohydrate(%)	75.87	76.67	100.00	32.83	88.20
Gross energy(%)	100.00	88.67	95.38	69.01	95.37
Dry matter (%)	97.48	89.13	96.10	53.41	83.28

Soya bean meal had lower digestion coefficients for dry matter (89.13%), fat (84.54%), carbohydrate (76.67%) and gross energy (88.67%) than maize, but the protein and ash digestion coefficients were higher than that of maize. In fact, the digestion coefficients of protein and ash in soya bean were higher than in all other ingredients except fish meal.

The protein, carbohydrate and gross energy digestion coefficients for copra cake were high and amounted to 96.93%, 88.20% and 95.37%, respectively. However, the digestion coefficient for ash and fat were rather low: 47.01% and 59.88% respectively. The digestion coefficients of the nutrients in rice bran were very low, especially for ash, carbohydrate and gross energy (34.85%, 32.83% and 69.01% respectively) indicating that it was poorly digested by the fish.

The results of these digestibility studies using yam leaves indicated that these leaves were poorly digested by the fish, the apparent digestibility of dry matter, protein, fat and cellulose being 55.29%, 72.04%, 30.53% and 52.46% respectively. The slow growth rate of the giant gourami fed with vegetables or leaves material is, therefore, probably due to the poor digestibility of these feeds in the fish (Ong, 1968; Law et al., 1983).

The results indicated that the fish could digest the reference diet quite well, the apparent digestibility of the dry matter, protein, ash, fat, carbohydrate and gross energy being 68.61%, 82.95%, 41.29%, 89.08%, 63.58% and 74.43% respectively.

This study revealed that fish meal was the best digestible ingredient of the reference diet with digestion coefficients for dry matter, protein, ash, fat, carbohydrate and gross energy of 97.48%, 100%, 93.54%, 100%, 75.87% and 100% respectively. All these values are close to 100% except the one for carbohydrate. This indicates that the fish could fully utilize the nutrients of fish meal in the pellet feed. Due to inadequate supply and high prices of fish meal, aquaculturists have been trying to replace fish meal in their feed formulation by locally available and cheap ingredients (IDRC, 1973; Viola et al., 1982). For example, Viola et al. (1982) have successfully replaced fish meal by soya bean meal for the intensive culture of carp. In this study, the results indicate that the digestion coefficients for dry matter, protein, ash, fat, carbohydrate and gross energy in soya bean were comparable to those for fish meal. Since soya bean meal contains about 42.4% of protein (National Research Council, 1977), fish meal may be partially or completely replaced by soya bean meal in feed formulation for the giant gourami.

The dry matter apparent digestion coefficient for maize was 96.10% which was higher than that for soya bean, copra cake and rice bran (89.13%, 83.28% and 53.41% respectively). However, the digestion coefficient for protein in maize was lower than that for soya bean and copra cake. The protein digestion coefficients for maize, soya bean and copra cake were 90.00%, 99.07% and 96.93% respectively. The protein digestion coefficient of maize by giant gourami was much higher than that reported for common carp (Cyprinus carpio), 66% (National Research Council, 1977), 'ikan jelawat' (Leptobarbus hoevenii), 41.85% (Law, 1984) and grass carp (Ctenopharyngodon idella), 50.61% (Law, 1986). The carbohydrate and gross energy digestion coefficients in maize were rather high; 100% and 95.38% respectively. In fact, maize was the only test ingredient which had a 100% digestion coefficient for carbohydrate. Therefore, maize meal may be an excellent source of carbohydrate and gross energy for giant gourami. This finding was similar to that obtained by Law et al. (1983) for grass carp. In addition, the carbohydrate content in maize was about 72.9% which was much higher than the carbohydrate content in all other ingredients used in formulating the pellet feed. However, the protein and fat content in maize are low; 9.6%

and 3.9% respectively (National Research Council, 1977). As a consequence maize can not be used as a source of protein and fat supplement in the feed formulation for giant gourami.

Surprisingly the digestion coefficients of dry matter, protein, carbohydrate and gross energy of copra cake were high; 83.28%, 96.93%, 88.20% and 95.37% respectively. The protein, carbohydrate and gross energy digestion coefficients of copra cake by giant gourami were higher than by 'ikan jelawat' (Law, 1984) and grass carp (Law, 1986). However, the ash and fat digestion coefficients of copra cake were low in this fish, 47.01% and 59.88% respectively. Copra cake is an abundantly present agricultural by-product in Malaysia and much cheaper than soya bean meal and maize in South-east Asia. It contains 22.8% protein, 62.9% carbohydrate and 4589 cal/g gross energy (National Research Council, 1977). Hence, copra cake could be the second alternative to soya bean in replacing fish meal as a source of protein supplier in the feed formulation for the giant gourami. In fact, Tan (1983) found that the feed conversion for a 40% protein pellet used in feeding the giant gourami exceeded 4.94 and thus indicated that the diet needed to be improved. Copra cake is definitely the best and cheapest source of energy supplement in feed formulation for the giant gourami; better than maize (3871 cal/g) and soya bean (4355 cal/g).

The digestion coefficients of protein, ash, carbohydrate and gross energy were low in rice bran compared to other test ingredients. However, the fat digestion coefficient of rice bran was rather high, 91.19%. The fat content in rice bran was 13.9% which was the highest among all the test ingredients (National Research Council, 1977). Rice bran is also another agricultural by-product which is abundant and cheap in Malaysia. Hence, it could be incorporated in the feed as a fat supplier for the giant gourami. Besides, rice bran could also act as a binder in the pelleting process.

Growth studies in cages

The average size of the fish at the start of the experiment was 6.58 ± 0.56 cm and 8.4 ± 0.77 g in the first trial. After 12 weeks the increase in length for the fish receiving Diet I, II, III and IV was 0.8 cm, 2.4 cm, 3.7 cm and 4.3 cm respectively, whereas the average weight increase in the corresponding period was 5.7 g, 18.1 g, 33.1 g and 44.7 g respectively. In the second trial the average size of the fish at the start of the experiment was 7.21 - 7.75 cm and 13.84 - 14.99 g. After 18 weeks the increase in length for the fish for treatment 1, 2 and 3 were 6.7 cm, 7.9 cm, and 9.9 cm respectively, whereas the average weight increase in the corresponding period was 100.6 g, 166.6 g and 182.3 g respectively. These average gains in length and weight were significantly different ($P < 0.05$). Data on growth rate, feed utilization and condition factors are summarized in Tables 6, 7 and 8.

8,5 -> 53 g 12 weeks = 0,5 g/d
14,5 -> 196 g 18 w = 1,4 g/d
53 -> 196 6 w = 3,4 g/d (2,8%/d)

Table 6. The mean specific growth rate (S.G.R.) expressed as percentage weight gain per day in the Giant Gourami fed with the experimental diets.

Diets	*Colocasia*	10% prot.	20% prot.	25% prot.	35% prot.	40% prot.	45% prot.
S.G.R. (%)	0.61	1.40	1.90	1.83	2.12	2.20	2.30

Table 7. Feed conversion ratio (FCR) and Protein Efficiency Ratio (PER) of Giant Gourami fed with the experimental diets.

Diets	10% prot.	20% prot.	25% prot.	35% prot.	40% prot.	45% prot.
FCR	7.33	5.22	5.53	4.39	4.94	4.58
PER	1.34	1.00	0.72	0.65	0.49	0.48

Table 8. Condition factor (K) of Giant Gourami fed with the experimental diets.

Diets	*Colocasia*	10% prot.	20% prot.	25% prot.	35% prot.	40% prot.	45% prot.
(K)	3.54	3.53	3.89	3.81	5.20	4.10	3.60

Results from the weekly determination of some physical and chemical parameters in the study area suggested that the environment was quite suitable for this fish species (Table 9). In a 24 hours study, the parameters that fluctuated more significantly were dissolved oxygen, water temperature and pH (Table 10). However, these were not found to be critical. The mean pH value of 5.5 indicated that the water was acidic and much lower than a generally recommended pH of 6.5 to 8.5. The total alkalinity and conductivity were also low as compared to productive ponds which have an alkalinity between 60-120 ppm.

Table 9. Some physical and chemical characteristics of the study area.

Parameters	Maximum	Minimum	Mean
Temperature (°C)	29.0	27.0	28.2
pH	6.1	4.7	5.5
Dissolved oxygen (mg/l)	8.0	5.0	5.8
Total hardness (mg $CaCO_3$/l)	17.8	10.0	14.9
Total alkalinity (mg/l)	8.0	5.0	7.0
Orthophosphate (mg/l)	0.50	0.1	0.27
Ammonia-nitrogen (mg/l)	1.10	0.01	0.57
Nitrate-nitrogen (mg/l)	5.0	3.0	4.6
Nitrite-nitrogen (mg/l)	0.39	0.0	0.08
Conductivity (umhos)	30.0	20.0	24.7
Turbidity (cm)	49.0	20.0	36.0

Table 10. Diurnal variation of water temperature, dissolved oxygen and pH in the experimental area.

Time parameters	9am	12am	3pm	6pm	9pm	12pm	3am	6am
Temperature(°C)	28	29	30	30	29	30	29	29
Dissolved oxygen (mg/l)	5.3	7.1	10.0	9.8	8.5	7.8	6.7	6.4
pH	5.5	6.2	6.7	5.5	5.6	5.2	5.2	5.2

The results from this study showed that the giant gourami, Osphronemus goramy, Lacepede, can grow well using pelleted diets containing 35%, 40% and 45% protein. In the second trial fish fed a 35% and 45% protein diet attained a total weight of 166.6 g and 182.3 g respectively in 18 weeks in floating net-cages. This growth rate was much higher than those reported by earlier studies. Based on this study it is concluded that a diet containing 35% protein is suitable for giant gourami.

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References

Ang, K.J., A.T. Law, S.H. Cheah, K.K. Chong & G.H. Tan, 1988. The digestibility of feed ingredients and growth response by giant gourami, Osphronemus goramy (Lacepede) to various levels of dietary proteins cultured in floating net cages. In: Agricultural and Biological Research Priorities in Asia. M.Mohinder Singh (editor) Proc. IFS Symposium of Science Asia '87, Kuala Lumpur, Malaysia, 14-17 October 1987. 37-42 pp.

Ardiwinata, R.O., 1981. Pemeliharaa gurami. Penerbitan Sumur Bandung. 76 p.

Bardach, J.E., Ryther, J.H. & MClarney, W.O., 1972. Aquaculture: The farming and husbandry of freshwater and marine organisms. Wiley Interscience, NY., London, Toronto. 868 p.

Benneth, G.W., 1962. Management of artificial lakes and ponds. New York, Reinhold Publishing Corporation. 283 p.

Cho, C.Y. & Slinger, S.J., 1979. Apparent digestibility measurement in feedstuffs for rainbow trout. In: J.E. Halver & K. Tiews (Editors). Finfish nutrition and fishfeed technology. Vol. II. Heeneman GmbH, Berlin. pp. 239-247.

Goering, H.K. & Van Soest, P.J., 1970. Forage Fibre Analysis (apparatus, reagent, procedures and application). A.R.S. U.S. Dept. Agr. Handbook No.379. Superintendent of Document, U.S. Government Printing Office, Washington, D.C. 20 p.

Hora, S.L. & Pillay, T.V.R., 1962. Handbook on Fish Culture in the Indo-Pacific Region. FAO Fish. Biol. Techn. Pap., (14): 203 p.

IDRC, 1973. Aquaculture in South-east Asia. IDRC-015 e,

Ottawa, Canada. 22 p.
Jhingran, V.G., 1975. Fish and fisheries of India. Hindustan Publishing Corporation (India). 954 p.
Kimura, F.T. & Miller, V.L., 1957. Improved determination of chromic oxide in cow feed and faeces. Agric. Food Chem. 5: 216.
Law, A.T., 1984. Nutritional study of jelawat, Leptobarbus hoevenii (Bleeker), fed on pelleted feed. Aquaculture, 41: 227-233.
Law, A.T., 1986. Digestibility of low-cost ingredients in pelleted feed by grass carp (Ctenopharyngodon idella C.& V.). Aquaculture, 51: 97-103.
Law, A.T., Cheah, S.H. & Ang, K.J., 1983. An evaluation of the apparent digestibility of some locally available plants and a pelleted feed in three finfishes in Malaysia. In: Fish Nutrition in Asia. Cho, C.Y., C.B. Cowey & T. Watanabe (Editors). IDRC, Ottawa. 154 p.
National Research Council, 1977. Nutrient requirements of warmwater fishes. National Academy of Sciences, Washington, D.C. 78 p.
Ong, K.B., 1968. Fish Culture: A guide for people in Serawak and elsewhere who wish to rear fish. Borneo Literature Bureau. 80 p.
Schneider, B.H. & Flatt, W.P., 1975. The evaluation of feed through digestibility experiments. Univ. Georgia Press, Athens. 423 p.
Sterba, G., 1973. Freshwater Fishes of the World. T.F.H. Publications Inc., New Jersey. 877 p.
Swift, D.R., 1955. Seasonal variation in the growth rate, thyroid activity and food reserve of brown trout, Salmo trutta. J.Expl. Biol., 32: 751-764.
Tan, G.H., 1983. Growth response of Osphronemus goramy (Lacepede) juveniles in cages fed pellets at three levels of protein. Final Student Project, Faculty of Fisheries and Marine Sciences, Universiti Pertanian Malaysia. 47 p.
Viola, S., Mokady, S., Rappaport, U. & Arieli, Y., 1982. Partial and complete replacement of fishmeal by soybean meal in feeds for intensive culture of carp. Aquaculture, 26: 223-236.

Food consumption of seaperch, *Lates calcarifer*, in captivity

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Summary

Growth rate of seaperch (*Lates calcarifer*) will be studied in relation to fish size, water temperature, feed ration size, and feeding frequency.

Seaperch of different weight classes are held individually in conical tanks of 250 l each, which form part of a water recirculation system. Fish are fed by hand a commercially available pelleted feed containing 44% crude protein. Water temperature is maintained between narrow ranges and salinity amounts to 32 ppt. The conical tanks allow for immediate collection of uneaten feed and thereby for determination of the actual feed intake.

These studies are being carried out in the conviction that they will provide important base-line data for the enhancement of seaperch culture.

Introduction

In the Philippines, feeds and feeding constitutes some 70% of the total capital costs in aquacultural production, which illustrates the central importance of such inputs and at the same time justifies a major research effort to study the field of nutrition, feeds, and feeding. Given a nutritionally adequate food, it is necessary to examine whether environmental conditions (e.g., water temperature, oxygen, etc.) allow fish to efficiently use the food for growth to ensure a profitable yield. If yield is as central to aquaculture as growth is to fish, then the improvement of fish yield in aquaculture should benefit from the fundamental understanding of environmental control of fish growth. In tropical aquaculture where high temperatures are the outstanding characteristics, it is worth considering whether such temperatures favor efficient fish production. Since temperature increases the rate of metabolic processess in fish, the energetic costs of this elevated metabolic activity may be considered in competition with growth for a share of the energy derived from the food (Brett, 1979). These interacting factors of food (intake and ration) and temperature and their effects on fish growth should be thoroughly studied if an economically viable management is desired.

The present research project focussed on seaperch (*Lates calcarifer*) aquaculture by using the bio-energetic concept following the models of well studied species such as perch, *Perca fluviatilis* (Solomon & Brafield, 1972); sockeye salmon, *Oncorhynchus nerka* (Brett, 1979); brown trout, *Salmo trutta* (Elliott, 1972; 1975a; 1975b; 1976; 1982), and the African catfish, *Clarias gariepinus* (Hogendoorn, 1983; Machiels &

Henken, 1986). This, being a long term goal cannot be attained before basic variables will have been studied. The immediate aims of this research project are, therefore, (1) examination of feeding rates and food consumption of the seaperch in relation to body size and temperature, and (2) determination of growth rate in relation to temperature and ration size.

This study will be conducted over a 3-years period. Firstly preliminary trials on feeding rates and food consumption by individual seaperch will be carried out to determine minimum and maximum rations. Subsequently experiments studying the relations between temperature, ration (starvation, maximum, minimum) and growth will be conducted. Variables and parameters to be investigated during the experiments will concentrate on body size, body composition, composition of growth increment, temperature and metabolism (oxygen consumption).

Food consumption experiments

Experimental fish

Seaperch are obtained from routine rearing runs at the hatcheries of the Aquaculture Department, SEAFDEC. Eggs are retrieved from artificial and natural spawning of seaperch broodstock (Garcia, 1989, in press), and transported to the laboratory for incubation. Larval rearing starts with feeding rotifers over a 10-15 days period, followed by feeding brine shrimp nauplii. At approximately 45-60 days, when the fry will have reached a total length of 4.0 cm, the fry are gradually acclimated to commercially available dry feeds (B-MEG shrimp starter mash; according to SEAFDEC analyses containing 42.18% crude protein, 3.79% crude fat, 1.56% crude fiber, 38.81% NFE). The fish are then fed this food until the desired size classes are obtained. Experience at SEAFDEC shows that in comparison with other commercial pellets, seaperch readily accepts the B-MEG pellet, which can be used as a practical standard reference diet for growth experiments in sea-perch.

Feeding tanks

For the preliminary feeding trials, 3 cylindrical fiberglass tanks (62 cm in diameter and 137 cm in height; ca. 300 l capacity) are presently being used. 10 Cylindrical tanks, 500 l capacity (109 cm in diameter and 68 cm in height) are being fabricated which will allow sufficient replication of each size class. These tanks have conical bottoms that facilitate collection of uneaten food. The tanks are set on wooden frames and receive natural illumination supplemented with artificial fluorescent lighting (40 W) to ensure a 12 L:12 D photoperiod. Each tank operates on a flow-through system. Filtered sea water is supplied from a reservoir and is pumped into the tanks at approximately 200 to 400 l/h. The conical bottom of each tank is fitted with a PVC pipe connected to a discharge tube and regulated by a valve, which facilitates collection of uneaten pellets without disturbing the fish.

Pre-feeding procedure

Seaperch ranging in size from 50-200 g and acclimated to the pelleted diet are retrieved from their holding tanks. The fish are anaesthetized (2 phenoxy-ethanol), weighed and their total length is measured to the nearest 0.05 g using a Mettler top-loading digital balance. Prior to weighing, a damp towel is rolled over the fish to remove excess moisture. Fish are then allowed to recover in the above described feeding tanks. Recovery usually takes 3 days and food is offered again to the fish over a 1-2 weeks acclimation period. Food is then withheld for 72 h (Elliott, 1972) prior to the start of each feeding trial.

Determination of consumption

Fixed amounts of pellets are offered by hand to individual fish in each tank. The pellets are dropped one by one into the tank every 1-2 minutes for one hour or until the fish ceases accepting the food. Uneaten food is immediately collected, blotted and prepared for drying. The difference between the amount of pellet and the amount collected afterwards represents the total amount of food consumed by individual seaperch. The time the fish starts to accepting the food and the time it ceases feeding are recorded for calculation of satiation time. This procedure will be repeated at 4 h intervals as well as hourly over a 24 h feeding period using seaperch of varying body sizes and at different temperatures (24^{o}, 26^{o}, 28^{o}, 30^{o} and 35^{o}C).

In the final analysis, it is important to express the amount of food consumed in relation to body weight in terms of dry weight. Therefore, samples of pellets and fish, representing each weight class, will be obtained and dried at 85^{o}C to constant weight.

Although the tanks during the feeding experiments will be supplied with aeration, dissolved oxygen and ammonia-nitrogen in the tanks will be routinely monitored throughout the duration of the experimental period.

Data analysis

The use of 3 replicates representing one size class might be not sufficient to give a 95% confidence limit and therefore, more replication over time may be needed. Sufficient replication at the same time, however, will be achieved when the 10 tanks are ready. To test the consumption differences within replicates, the analysis of covariance will be used. The relationship between consumption and body size will be determined using regression analysis.

Growth experiments

After information on food consumption of seaperch will have been obtained from the preliminary feeding trials growth experiments will be started using weight ranges of 10-20 g, 40-50 g, and 100-150 g, in separate experiments. Experimental fish will be obtained similarly as described above.

A preliminary growth experiment will be conducted using seaperch in the 50 gram size class at ambient laboratory water temperatures (27^{o}-$30^{o}C$) using 3 feeding levels up from deprivation to satiation to obtain information on growth rates and to assess and/or improve the earlier methods used (Brett et al., 1969; Elliott, 1975a and b; Hogendoorn et al., 1983). Ninety fish will be subdivided into 9 groups of 10 fish each and assigned randomly to 250 l capacity cylindrical tanks. Each feeding level will be triplicated and the experiment will be run for 28 days.

These tanks will be coupled to a recirculating system equipped with 2 sedimentation tanks and 1 gravel filter tank (1.5 ton capacity each). Water will be pumped into an elevated reservoir which will supply the individual rearing tanks. Each rearing tank will be supplied with aeration.

Throughout the experiment, temperature, dissolved oxygen, and ammonia-nitrogen will be monitored daily. The water in the recirculating system may be replaced with fresh sea water whenever necessary.

Since growth is accompanied by changes in body composition, proximate analysis of seaperch will be carried out both at the start and at the end of each experiment. Standard techniques will be employed such as the Kjeldahl technique for protein-nitrogen and Soxhlet extraction for crude fat. Likewise, the composition of the food will be determined. The energy content of feed and fish will also be determined using a Parr adiabatic oxygen bomb calorimeter.

The quantitative aspects describing growth in fish are treated extensively in the literature (Brett et al., 1969; Brett, 1979; Hogendoorn, 1981; Hogendoorn et al., 1983; Weatherley, 1972; 1976) and the most appropriate ones, pending results to be obtained will be used. Specific growth rate will be related to feeding level and to changes in body composition of the fish.

Once the preliminary experiments have led to optimization of the experimental set-up, successive trials will be performed at different constant temperatures (24^{o}, 28^{o}, 32^{o}, and $35^{o}C$) to investigate the growth response of seaperch at size classes ranging from 10-150 g and fed feeding levels up from deprivation to satiation. The set-up will be similar as that described previously with modifications to allow heating or cooling of the recirculation water. Fish will be acclimated to each temperature for at least 2 weeks prior to the start of the feeding experiment.

The analysis of the data follows either that described for sokeye salmon (Brett et al., 1969) or that modelled for the African catfish (Hogendoorn et al., 1983).

References

Brett, J.R., 1979. Environmental factors and growth. In: W.S. Hoar, D.J. Randall & J.R. Brett (Eds.). Fish Physiology. Acad. Press. New York. Vol. 8, pp. 599-675.

Brett, J.R., Shelbourne, J.E. & Shoop, C.T., 1969. Growth rate and body composition of fingerling sockeye salmon, Oncorhynchus nerka, in relation to temperature and ration size. J. Fish. Res. Bd. Can., 26: 2363-2394.

Elliot, J.M., 1972. Rates of gastric evacuation in brown

trout, Salmo trutta L. Freshwat. Biol., 2: 1-18.
Elliot, J.M., 1975a. Weight of food and time to satiate brown trout, Salmo trutta L. Freshwat. Biol., 5: 51-64.
Elliot, J.M., 1975b. Number of meals in a day rate, maximum weight of food consumed in a day and maximum rate of feeding for brown trout, Salmo trutta L. Freshwat. Biol., 5: 287-303.
Elliot, J.M., 1976. Body composition of brown trout (Salmo trutta L.) in relation to temperature and ration size. J. Anim. Ecol., 45: 273-289.
Elliot, J.M., 1982. The effects of temperature and ration size on the growth and energetics of salmonids in captivity. Comp. Biochem. Physiol., 73B: 81-91.
Garcia, L.M.B., 1989. Dose-dependent spawning response of mature female sea bass, Lates calcarifer (Bloch), to pelleted luteinizing hormone-releasing hormone (LHRHa). Aquaculture, in press.
Hogendoorn, H., 1983. Growth and production of the African catfish, Clarias lazera (C.& V.). III. Bioenergetic relations of body weight and feeding level. Aquaculture, 35: 1-17.
Hogendoorn, H., Jansen, J.A.J., Koops, W.J., Machiels, M.A.M., Van Ewijk, P.H. & Van Hees, S.P., 1983. Growth and production of the African catfish, Clarias lazera (C.& V.). II. Effects of body weight, temperature and feeding level in intensive tank culture. Aquaculture, 34: 265-285.
Machiels, M.A.M. & Henken, A.M., 1986. A dynamic simulation model for growth of the African catfish, Clarias gariepinus (Burchell 1822). I. Effect of feeding level on growth and energy metabolism. Aquaculture, 56: 29-52.
Solomon, D.J. & Brafield, A.E., 1972. The energetics of feeding, metabolism and growth of perch (Perca fluviatilis L.). J. Anim. Ecol. 41: 699-718.
Weatherley, A.H., 1972. Growth and ecology of fish populations. Academic Press, London. 293 pp.
Weatherley, A.H., 1976. Factors affecting maximization of fish growth. J. Fish. Res. Bd. Can. 33: 1046-1058.

Culture of *Clarias batrachus* (Linn.) in Indian swamps: Effects of varying nutritional and biochemical parameters and influence of vitamin A supplementation

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Summary

Environmental conditions play an important role in the nutritional status of fish cultured in captivity. The effect of the culture environment on growth and related physiological and biochemical processes of the stenohaline airbreathing catfish, *Clarias batrachus*, cultured in swamps has been scarcely studied. Carbaryl, a carbamate insecticide is a major contaminant, entering inland water bodies with agricultural runoffs. Osmoregulation of *C. batrachus* has been studied using sublethal carbaryl doses in a continuous flow set-up. Results show an impaired mineral balance in fish under such conditions. Impact of diets on the detoxification processes in the liver of *C. batrachus* have been investigated. The mixed function oxidase (MFO) system of *C. batrachus* is found to play a minor role compared to channel catfish. Carbaryl induces ethylmorphine N-demethylase in fish liver and forms glucuronide conjugates in the liver of fish. Fortification of a diet with vitamin A upto 2500 IU/kg of diet is effective in counteracting the toxicity of carbaryl. Required dietary level of vitamin A for *C. batrachus* is found to be much lower compared to other catfish species.

Introduction

The last few years there has been a continued commercial interest to increase the output of fresh water fish farming, which asks for a better understanding of the influence of the environment on the biochemical and physiological processes in fish. The increased attempts to culture the popular catfish, *Clarias batrachus*, in Indian swamps necessitates to study the impact of environmental factors on nutritional and biochemical parameters.

The impact of xenobiotics, especially those of pesticides on fish culture is only one aspect of the much wider problem of chemical contamination in general. Pesticides, entering the food chain via fish through pollution of agricultural runoff waters, create a hazard to consumers because of residual persistance.

Organochlorine insecticides impair cellular transport, permeability (Kinter & Prichard, 1977), and tissue respiration (Kaundinya & Rammurthi, 1978) in fresh water fish. Through mortality studies LC_{50} values of different pesticides have been established in different fish species.

The mixed function oxidase (MFO) system involved in detoxification of foreign compounds in mammals have also been found in fish (Stegeman & Chevion, 1980). Induction of the MFO system in fish by organochlorine pesticides was demonstrated by Ahokas et al (1977), and by organo-phosphorous pesticides by Banerjee et al (1979).

Toxicity of pesticides in terrestrial and aquatic organisms depends on several endogenous and exogenous factors. The nutritional status of animals is an example of an exogenous factor that has been shown to influence the toxicity of pesticides (Campbell & Hayes, 1976). The airbreathing fish C. batrachus can counteract the toxic action of lindane (an organochlorine pesticide) when a high protein diet is given (Das, 1981). Apart from protein supplementation, dietary vitamin A and vitamin C exhibit also protective effects on pesticide intoxications (Tiwari et al, 1982 Sugawara & Sugawara, 1978).

Carbaryl, a carbamate insecticide is being increasingly used in agriculture nowadays. Carbaryl gives neurotoxic effects in mammals and fish. Reports on the effects on biochemical and physiological processes of fish are fragmentary (Edmiston et al, 1985; Kaundinya & Rammurthi, 1978). No reports are yet available on the biotransformation of carbaryl in fish tissues.

The present study aimed to understand the impact of carbaryl toxicity on the culture of the stenohaline airbreathing catfish, C. batrachus. This fish is cultivated in captivity in swamps and in ponds, where chances of carbaryl contamination are high. The changes in the osmoregulatory processes, and the induction of detoxifying enzymes in C. batrachus at sublethal doses of carbaryl were studied. Supplementation of the diet with vitamin A was tested to study the potential of this vitamin to counteract carbaryl toxicity in fish.

Materials and methods

Maintenance of fish

Fish of an average body weight of 30 g (approximately 15-18 cm) were collected from a local fish farm stock. The fish were exposed to 2 ppm of $KMnO_4$ for 40 sec to remove ectoparasites, fungi etc, and then were allowed to acclimatize in a large cement tank containing dechlorinated water for one week. During this period the fish were fed twice daily a standard diet (Halver 1982) at a total rate of 5 % of their body weigth. The same diet was used in all experiments except in the vitamin A supplementation studies. Feeding of fish was stopped 48 hrs before sacrificing them in order to obtain better subcellullar fractions as described by Fouts (1971). In the vitamin A supplementation study 8 groups of fish were made, each group containing 10 fishes. Two groups comprised one set and a total of 4 sets were kept for 8 weeks on 4 pelleted diets varying only in vitamin A content. The diet included fish meal (30%), soyabean meal (15%), rapeseed meal (20%), wheat flour (10%), a standard vitamin mixture (2%), a standard mineral mixture (1%), fish oil (10%), and gelatin (12%). Vitamin A supplementation was 500 (diet A), 2,500 (diet B), 10,000 (diet C), and 20,000 IU/kg diet (diet D). Vitamin A was supplemented as retinyl palmitate. Body weight of fish was recorded weekly and food intake carefully monitored.

Toxicity studies

The toxicity tests to calculate 96 hrs LC_{50} values were conducted using a static system. For all long term studies set-ups were made for continuous flow as specified by the American Public Health Association, APHA (1976). Carbaryl was dissolved in acetone (analitical grade) to prepare a stock solution of 100 mg/ml. Desired carbaryl concentrations were obtained logarithmtically. The maximum amount of acetone used to prepare test solutions never exceeded 0.2 ml/l. Acetone was added as a control in an amount equal to the largest aliquot of stock solution used in the tests. Studies of physico-chemical parameters of water and determination of LC_{50} values for carbaryl were done according to APHA (1976). LC_{50} values were measured after exposing the fish for 96 hours to different concentrations of carbaryl. For all other experiments except in the vitamin A supplementation studies, a sublethal dose (10 ppm) of carbaryl was used to which the fishes were exposed for 4 weeks. In the vitamin A supplementation studies, the experimental groups were fed for 8 weeks with the diets A, B, C and D, containing different vitamin A levels, after which the fish were injected with a dose of 50 mg/kg body weight carbaryl on 4 consecutive days. The controls were injected with an equivalent amount of acetone. For the next 72 hrs the fish were kept on starvation as reported earlier (Anderson et al, 1985). Experiments were done at temperatures between 25-27° C, under a 12 hours light and 12 hours dark illumination regime.

Chemicals

All chemicals used were of analytical grade and were products of either Sigma Chemical Company (USA), or E. Merk (West Germany) or British Drug House (BDH) India Ltd. Carbaryl (1-napthyl-N-methyl carbamate) was a gift from Union Carbide Ltd.

Tissue preparation for enzymatic studies

Fish were killed after the experimental period and different tissues were taken and cleaned of cartilage, when necessary, washed, blotted and weighed. The tissues were immediately placed in ice cold 0.25 M sucrose solution containing 1 mM EDTA and 0.1 M Tris HCL buffer (pH 7.4) with 0.1 % (w/v) sodium deoxycholate and homogenized with a teflon pestle. Membrane- bound enzymes, mitochondrial enzymes and microsomal enzymes were isolated following procedures as described by Das et al (1980) and Chakraborty et al (1981).

Enzyme assays

Mitochondrial Na^{+} -K^{+} -ATPase and Ca^{++} -Mg^{++} -ATPase were assayed by procedures as described by Chakraborty & Banerjee (1979) with modifications and standardized for fish.

The protein in all enzyme assays was estimated by the method of Lowry et all (1951) using bovine serum albumin as standard.

Succinic dehydrogenase (SDH) activity was assayed by the method of Earl & Korner (1965) after standardization for *C. batrachus*.

Cytochrome P_{450} content of the liver was measured by the method of Omura & Sato (1964) as described by Guengerich (1982) with some modifications to avoid interference of hemoglobin and methemoglobin. NADPH Cytochrome C reductase activity was measured by the method of Phillips & Langdon (1962). 7-Ethoxy coumarin-O-deethylase activity was measured by the method of Greenlee & Poland (1978). Ethylmorphine N-demethylase activity was determined by the colorimetric method of HCHO measurement (Werringloer, 1978). UDP glucuronyl transferase activity was measured by the p-nitrophenol glucuronidation method as described by Fowler et al (1982). Glutathione-S- transferase activity was determined by the method of Habig et al (1974).

All the enzyme assays were carried out at 25°C except the UDP-glucuronyl transferrase and glutathione-S-transferase (30° C). These assay temperatures were determined to be optimal for individual studies.

Results

During the experimental period (4-8 weeks), there were no appreciable changes in the food intake of the test groups of fish. The LC_{50} value of carbaryl at 96 hrs for *C. batrachus* of an average of 30 g body weight was found to be 35 ppm using the probit-log dose method.

Carbaryl has been found to inhibit markedly the gill, intestine, and brain Na^{++} -K^{+}-ATPase after 4 weeks of exposure, but it has no effect on Mg^{++} -ATPase of these tissues. The mitochondrial succinic dehydrogenase activity of the gill appreciably increases under such toxic condition. Ca^{++} -Mg^{++} -ATPase of the gill, the liver, and the skeletal muscle shows significantly lower activity in case of carbaryl exposure.

Table 1. Effects of a sublethal dose (10 ppm) of carbaryl on the biotransformation enzyme activities in liver microsomal fractions of *C.batrachus* exposed for 4 weeks.

	Control	Carbaryl treated
LBW	0.87 ± 0.095	0.91 ± 0.144
Micromosal protein content[a]	9.37 ±0.70	9.45 ± 0.78
Cytochrome $P_4 50$ [b]	0.122± 0.054	0.21 ± 0.026.*
Tissue gluthione content[c]	0.254± 0.049	0.134± 0.038**
NADPH-cytochrome C reductase[d]	10.330± 1.45	16.40 ± 2.04**
7-Ethoxycoumarin O-deethylase[d]	0.12 ± 0.074	0.14 ± 0.0
Ethylmorphine N-demethylase[d]	0.20 ± 0.059	2.02 ± 0.38***
UDP-glucuronyl transferase[d]	0.18 ± 0.054	0.33 ± 0.115*
Glutathione-S-transferase[e]	6.99 ± 1.08	1.27 ± 0.60***

LBW = liver weight / body weight x 100; a = mg/g of wet tissue; b = nmole /mg microsomal protein; c = nmole / 100 g of wet tissue; d = nmole / mg microsomal protein / min; e = nmole/mg cytosol protein / min.

* <0.05, ** P<0.005, and *** P<0.001 over the control values.

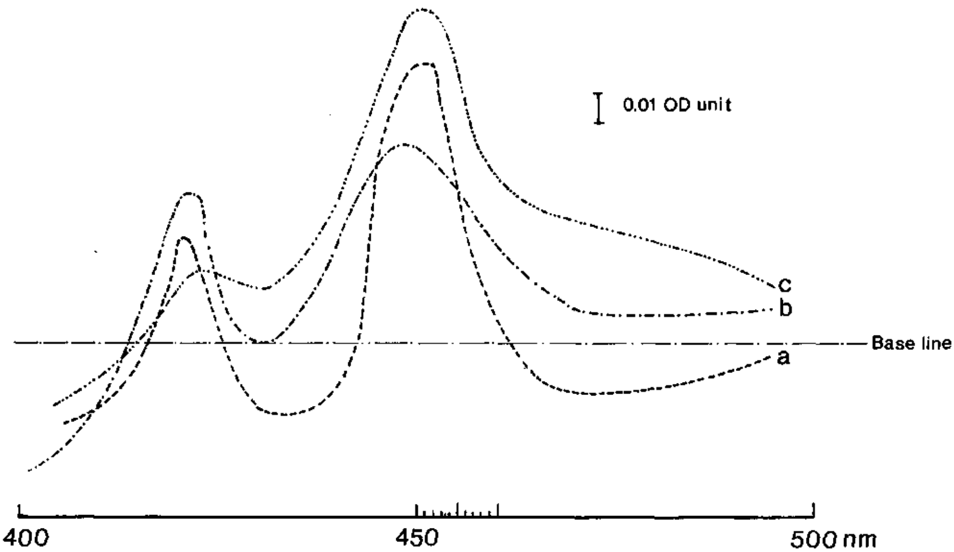

Figure 1. Cytochrome P_{450} from the liver measured (a) immediately after homogenisation, (b) after 72 hrs in absence, and (c) in presence of carbaryl.

All enzymes except 7-ethoxy-coumarin-O-deethylase show significant induction in case of carbaryl toxication. This induction is marked in the case of ethylmorphine-N-demethylase. Cytochrome P_{450} increased by 72 % when expressed as nmole per mg of protein. While UDP glucuronyl transferase is increased by 1.8, glutathione transferase shows appreciable reduction in its activity. NADPH cytochrome C reductase activity was measured as nmole cytochrome C reduced/mg protein/min. Other enzyme activities are expressed as nmole of product formed or liberated/mg protein/min. (Table 1). Cytochrome P_{450} spectra are given in Figure 1.

Changes in the body weight and LBW (Liver weight/body weight x 100) values of fish fed diets containing different levels of vitamin A in presence and in absence of carbaryl for 8 weeks are presented in Table 2. At vitamin A concentrations of more than 10,000 IU/kg of diet, growth of fish decreased.

Table 3 shows the effect of carbaryl (50 mg/kg of body weight) on the hepatic MFO system of C. batraches fed diets containing different levels of vitamin A for 8 weeks.

The microsomal protein content of the liver does not increase significantly upto a vitamin A level of 10,000 I.U./kg. Carbaryl was found to increase the NADPH cytochrome C reductase and ethylmorphine-N-demethylase activities significantly under all dietary regimes. Diet D was found to increase the NADPH-cytochrome C reductase and the ethylmorphine-N-demethylase activities markedly compared to the other diets.

Table 2. Changes in body weight and LBW (Liver weight/Body weight x 100) values of C. batrachus fed diets containing different levels of vitamin A in presence or in absence of carbaryl for 8 weeks.

Group	Diet	Vitamin A concentration (IU/kg of diet)	Carbaryl (mg/kg body weight)	Final body weight (gm)	% Increase	LBW
1	A	500	0	37.5±1.88****	35.8	0.97±0.063
2	A		50	36.5±2.5 ****	32.2	0.96±0.076
3	B	2,500	0	38.5±2.97****	39.8	1.03±0.167
4	B		50	38.1±2.47****	38.0	0.99±0.124
5	C	10,000	0	36.6±2.1 ****	32.6	0.93±0.239
6	C		50	34.6±3.3 ***	25.4	0.85±0.183
7	D	20,000	0	33.1 ± 2.86**	19.9	0.73±0.219*
8	D		50	32.4 ± 2.86*	17.4	0.65±0.16-6**

1) Initial body weight of fish = 27.6 ± 1.26 (g)
* $P<0.05$; ** $P<0.01$; *** $P<0.005$ and **** $P<0.001$

Table 3. Effect of carbaryl (50 mg/kg of body weight on the hepatic MFO activities of C. batrachus fed diets containing different levels of vitamin A for 8 weeks.

Group	Diet	Vitamin A concentration (IU/kg of diet)	Carbaryl (mg/kg) body weight	Micromosal protein content(1)	NADPH-cytochrome C reductase(2)	Ethylmorphine N-demethylase(3)
1	A	500	0	9.33±0.86	10.9±1.31	0.188±0.033
2	A		50	9.71±0.74	17.2±3.07**	1.05±0.21***
3	B	2,500	0	9.93±0.71	12.5±2.25	0.21±0.026
4	B		50	9.92±0.99	18.9±3.307***	2.46±0.19
5	C	10,000	0	10.42±1.42	14.8±2.86	0.37±0.15*
6	C		50	10.56±1.04	17.4±2.52***	4.21±0.36***
7	D	25,000	0	11.16±0.80*	15.2±2.84*	0.364±0.056***
8	D		50	11.35±1.5*	22.6±4.74***	3.85±0.157***

(1) mg/g of wet tissue
(2) nmole cytochrome c reduced/mg protein/min
(3) nmole HCHO formed/mg protein/min
* $P<0.05$; ** $P<0.01$ and *** $P<0.001$

Discussion

The manifestation of a toxic condition varies with different pollutants in various species of fish, depending on the formulation of the pollutants, on the way of exposure as well as on the method of bio-assay (Chan et all, 1982). Clarias proved a little more resistant to carbaryl toxicity compared to another air breathing fish, Heteropneustes sp.

Serum Na^+ concentration in Clarias did not chance after 4 weeks of exposure to carbaryl although membrane bound Na^+-K^+-ATPase activity was inhibited, suggesting a disruption of the Na^+ -K^+ pump. A similar observation was made by Leadem et al, (1974) in rainbow trout.

The substrate utilization optima for mitochondrial succinic dehydrogenase were different for gill, liver and brain tissue of Clarias. Environmental and nutritional factors influence the quantity of this enzyme in fish tissue (Johnston & Maitland, 1980). The increased activity of this enzyme in the liver may be explained by more energy production in the form of ATP in the presence of carbaryl, which may be utilized for mitochondrial oxidative phosphorylation by Mg^{++} -ATPase under such conditions.

The activity of Ca^{++} -Mg^{++} -ATPase may vary with environmental stress in fish (Johnston, 1975). The dependence of the enzyme activity on the external Ca^{++} and Mg^{++} have been established in our study in different tissues of Clarias, whereas this was studied earlier in marine fish gills only (Shephard, 1981). In vivo inhibition of this enzyme by a sublethal dose of carbaryl was more prominent in muscle and gills. It was observed earlier that due to the neurotoxic effects of carbaryl impairment of enzyme metabolism and cellular calcium distribution takes place (Carmines et al, 1979). Inhibition of Ca^{++} dependent transport under such conditions as observed in this study may explain this phenomenon.

The impact of pesticides on drug metabolizing enzymes have not been systematically studied in fish. The studies presented here clearly demonstrate that Clarias possesses functional components of the MFO system and can mediate conjugation reactions, at sublethal doses of carbaryl.

The basal cytochrome P_{450} level of Clarias is low compared to that of channel catfish (Lipsky & Klauning, 1978) and of salmonid fish (Ahokas, 1979). Carbaryl induces the enzymes of the MFO system and also the cytochrome P_{450} level in Clarias. Microsomal oxidation of carbamates proceeds in mammals through N-methyl hydroxylation and N-demethylation (Nakatsugwa & Morelli, 1976). In Clarias the induction of ethyl morphine-N-demethylase has also been found to be very predominant in case of carbaryl contamination. UDP-glucuronyl transferase activity increases in Clarias under such conditions indicating glucuronide conjugation of the insecticide. It is not very clear if carbaryl also undergoes glutathione conjugation.

Warm water tropical fish have not received much attention in studies on dietary requirements of vitamin A. Catfish have very little requirements for essential fatty acids responsible for transport of fat soluble vitamins compared to cold water fish (Watanabe, 1982). Supplementation of 500-2,500 IU of retinyl palmitate as vitamin A per kg diet was found to be adequate for growth of Clarias (Table 2). A higher level of vitamin A in the diet inhibits growth. However, supplementation of the diet with more vitamin A (25,000 IU) increases the microsomal protein content and further induces microsomal-N-demethylase and NADPH-cytochrome C reductase activities. The increase in liver microsomal protein may be associated with increasing enzymatic hydrolysis of the retinyl ester and with the liberation of a retinol binding protein complex.

References

Ahokas, J.T. Pelkonen, O. & Karki, N.T., 1977. Characterisation of benzo (a) pyrene hydroxylase of trout liver. Cancer Research. 37, 3737 - 3743.

Ahokas J.T., 1979. In: Pesticides and xenobiotic metabolism in aquatic organisms. (eds: Khan, Lech & Menn) ACS Symposium, 99, 280-296.

American Public Health Association (APHA). Standard Methods for the examination of water and waste water. 1976.

Anderson, T., Koivusaari, U. & Forlin, L., 1985. Comp.Biochem. Physiol. 82 C, 221-225.

Banerjee, S.K. Mukhophayay, P.K. &Dehadrai, P.V., 1979. In: Animals as monitors of environmental pollutants, National Academy of Science (USA) 378.

Campbell, T.C. & Hayes, J.R., 1976. The effect of quantity and quality of dietary protein on drug metabolism. Fed. Proc. 35, 2470-2474.

Carmines, E.L., Carehman, R.A. & Borzellica, J.F., 1979. Kepone Cellular sites of actions. Toxicol & Appl. Pharmacol. 49, 543-550.

Chakraborty, S. Banerjee, S.K., 1979. Malathion exposed seeds of V. sinensis. Internat. J.Env. studies. 14, 217 222.

Chakraborty, S. Banerjee, S.K. & Chatterjee, G.C., 1981. The effect of Malathion on animo acid incorporation into plasma membrane proteins. Agri. Biol. Chem. 45(2), 385 -391.

Chan, P.K., O'Hara, G.P. & Hayes, A.W., 1982. In: Principles and methods of toxicology. (ed : Hayes, A.W.), Raven Press, New York, 1-55.

Das, K.K., Ghosh Dastidar, S. Chakraborty, S. & Banerjee, S.K., 1980. Toxicity of mercury: A Comparative stydy in airbreathing and non airbreathing fish. Hydrobiologia, 68, 225-229.

Das, K.K., 1981. Biochemical & Nutritional Studies of airbreathing fishes under different ecological conditions. Thesis for Ph.D. Calcuta University (Biochemestry).

Earl, D.C.N. 7 Korner, A., 1965. The isolation and properties of cardiac ribosomes and polysomes. Biochem. J. 94, 721-734.

Eddy, F.B., 1982. Osmotic and ionic regulation in captive fish with particular reference to salmonids. Comp. Biochem. Physiol. 73b, 125-141.

Edmiston, C.E. Jr., Goheen, M., Maloney, G.W. & Mills, W.L., 1985. Environ. Research, 36, 338.

Fouts, J.R., 1971. Liver smooth endoplasmic reticulum "microsomal" drug metabol. enzymes system. Methods. Pharmacol. 1(9), 287-302.

Fowler, B.A., Lucier, G.W. & Hayes, A.W., 1982. In: Principles and methods of Toxicology (ed: Hayes, A.W.) Raven Press, New York, 635-658.
Greenlee, W.F. and Poland, A., 1978. An improved assay of 7-ethoxycoumarin O-deethylase activity. J. Pharma. Exp. Thrp. 205(3), 596-605.
Guengerich, F.P., 1982. In : Principles and methods of Toxicology (ed: A.W. Hayes). Raven Press, New York, 609-634.
Habig, W.H., Pabst, M.J. &Jakoby, W.B., 1974. Glutathione-S-Transfearse: The first enzymatic step in mercapturic acid formation. J. Biol chem. 249, 7130-7139.
Halver, J.E., 1982. The vitamins required for cultivated salmonids. Comp. Biochem. Physiol. 73B, 43-50.
Johnston, I.A., 1975. Adaptations in Mg++ activated myofibriller ATPase activity induced by temperature acclimatization. FEBS Letters. 50.
Johnston, I.A. & Maitland, B., 1980. Temperature acclimation in crucian carp : A morphometric analysis of muscle fibre ultrastructure. J. Fish Biol. 17, 113-125.
Kaundinya, P.R. & Rammurthi, R., 1978. Tissue respiration in T.mossambica exposed to lethal conc. of Sumithion & Sevin. Indian J. Env. Health. 20, 426-428.
Kinter, W.B. & Pritchard, J.B., 1977. In : Handbook of Physiology (Eds: Lee, Falk, Murphy & Geiger). Ann. Physiol. Soc., Bethesda, Md. USA. 563-576.
Leadem, T.P., Cambell, R.D. & Johnston, D.W., 1974. Osmoregulatory responses to DDT and varying salinities in Salmo gairdneri. Comp. Biochem. Physiol. 49A, 197-205.
Lipsky, M.M. & Klauning, J.E., 1978. Comparison of acute response to PCB in Liver of rat and channel catfish. J. Toxicol. Environ. Health. 4, 107-121.
Lowry, O.H., Rosebrough, N.J., Farr, A.L. & Randhall, R.J., 1951. Protein measurement with the Folin Phenol reagent. J. Biol. Chem. 193, 265-275.
Nakatsugawa, T. & Morelli, M.A., 1976. In : Insecticide Biochemistry & Physiology. (Ed: Wilkinson, C.F.), Plenum Press, New York, 61 - 114.
Omura, T. & Sato, R., 1964. The carbon monoxide binding pigment of liver mocrosome : Evidence for its hemoprotein nature. J. Biol. Chem. 239, 2370 - 2378.
Phillips, A.H. & Langdon, R.G., 1962. Hepatic triphosphopyridine nucleotide-cyt. C. Reductase. J. Biol. Chem. 237, 2652-2660.
Shepard, K.L., 1981. The activity and characteristic of the Ca^{++} ATPase of fish gills in relation to environmental Ca^{++} conc. J. Exp. Biol. 90, 115-121.
Stegeman. J.J. & Chevion, M., 1980. Sex differences in cytochrome P-450 and mixed function oxygenases activities in gonadally matured trout. Biochem. Pharmacol, 29, 538-558.
Sugawara, C. & Sugawara, N., 1978. The effect of Cd on vitamin A metabolism. Toxicol. Appl. Pharmacol. 46, 19-27.
Tiwari, R.K., Bandyopadhyay, S.K. & Chatterjee, G.C., 1982. Protective effect of L-ascorbic acid in lindane intoxicated rats. Acta Vitaminol. Enzymol 4, (3), 215-220.
Watanabe, T., 1982. Lipid Nutrition in Fish. Comp. Biochem. Physiol. 73b 3-15.
Werringloer, J., 1978. In:Methods in Enzymology. (eds. Fleisher & Packer), Academic Press, New York, 52, 297-302.

Use of growth promoting substances in enhancing yield of estuary grouper (Epinephelus salmoides Maxwell) in floating cages

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Summary

17-α-methyltestosterone respectively nitrovin (1, 5-bis, 5-nitro-2-furyl, 4 pentadien-3-1-amidinohydrazone-HCl) was incorporated in the diets of estuary grouper for 150 days. At the optimal dosages of 9 mg 17α-methyltestosterone réspectively 1 g Payzone nitrovin per kg of food, fish weight increased by 43.4% respectively 62.8%. The condition factors and the feed conversion ratios were also improved with the diets containing these growth promoting substances.

Introduction

A feasibility study of optimizing yield and lowering production costs by manipulating known biological factors affecting grouper (Epinephelus salmoides) growth has been carried out (Chua & Teng, 1978; 1980; 1982). The use of tyres as artificial hiding areas was demonstrated to be an improved method to increase the stocking density and thereby the net yield of the fish (Teng & Chua, 1979). It was calculated that the net yield of estuary grouper after six months would be 23.8 kg/m^3 if trash fish was used as food and the stocking density was 60 $fish/m^3$ (Teng & Chua, 1978). But the fish yield could be increased several folds if the fish were provided with artificial hides (Teng & Chua, 1979) and supplied with steroid supplemented diets. Such high yields would entice local grouper farmers to apply modern farming technology for greater economic gains.

Whilst a lot of work is being done and has been reported on the use of hormones and growth promoting substances in trout, salmon, carp, tilapia, eel and in domestic land animals (Maynard & Loosli, 1982; McDonald et al., 1973; Plisetskay & Murat, 1979; Lone et al., 1982; McBride et al., 1982; Parova et al., 1982; Degani, 1985; MacIntosh et al., 1985; Arul, 1986), very little is known about these substances in the grouper. This paper gives a preliminary study of certain effects of 17α-methyltestosterone and nitrovin on the growth of groupers. Payzone(R) (a trade name), which is a feed additive containing about 2.2% of a growth promoting compound known as nitrovin was chosen because of its wide application as an effective growth promoter in poultry and pig husbandry.

Materials and methods

Grouper acclimatized to feed voluntarily on formulated pellets were chosen for the experiments. Fish of approximately the same size were stocked at the same density (60 fish/m^3) in net cages, each measuring 1.20 m x 1.20 m x 1.65 m with a mesh size of 12.5 mm (Table 1). Six net cages were used in the experiments to study the effect of 17α-methyltestosterone (purchased from Halewood Chemicals Ltd., England) while others were used for the effect of Payzone nitrovin* (purchased from Cyanamid Ltd., Hong Kong).

The ingredient composition and the chemical composition as well as the moisture content of the formulated pellets are shown in Tables 2 and 3, respectively.

In preparing the moist pellets a mixture of vitamins and minerals was thoroughly mixed with the dry components of the pellet by means of an electric mixer. Minced trash fish comprising mainly anchovies (Engraulis mystax), sciaenids (Pseudosciaena acuta) and small carangids (Selaroides leptolepsis) were then added and the resulting moist paste was further minced to ensure thorough mixing. The size of the pellets ranged from 6 mm to 25 mm in diameter.

Dosages of 17α-methyltestosterone varying from 0.0 to 12.0 mg/kg of food and of Payzone$^{(R)}$ varying from 0.0 to 1.0 mg/kg of food (Table 1) were incorporated in the formulated pellets. The appropriate amount of 17α-methyltestosterone was dissolved in 20 ml of 95% ethanol which was then mixed evenly with the vitamin and the mineral solution of the formulated pellets. As Payzone$^{(R)}$ dissolves well in water, it was added directly to the vitamin and the mineral solution of the formulated pellets.

The experimental fish were fed till satiation once every two days around 6-7 p.m. following the method already described (Chua & Teng, 1980). To each net cage, a fine meshed lift net was placed at one corner of the net cage and the food was given to the fish at this corner. The difference of the initial amount of food and the remaining excess food was taken as the amount of food eaten by the fish.

The experimental fish were measured for total length (to the nearest 0.1 cm) and body weight (to the nearest 0.1 g) once in 30 days for a period of 150 days. The experiments using 17α-methyltestosterone and Payzone$^{(R)}$ were carried out simultaneously.

During the study, water samples inside and outside the net cages were collected every fortnight for determination of water temperature, pH, salinity and dissolved oxygen content. Winkler's method (Strickland & Parson, 1972) was used for measuring dissolved oxygen content in the water while the method for each of the other stated parameters was carried out as given in Teng et al. (1978).

*In this paper the name Payzone$^{(R)}$ is used interchangeably with Payzone nitrovin.

Table 1. Effect of 17α-methyltestosterone and nitrovin on the growth of estuary grouper: dosages, initial stocking density, number of fish stocked per cage and initial size of fish used.

Cage no.	Dosage	Stocking density (fish/m3)	No.of fish stocked per cage	Size of fish Total length(cm) Mean	S.D.*	Body weight(g) Mean	S.D.*
(A) 17α-methyltestosterone (mg/kg of food)							
1(control)	0.0	60	128	15.1	1.3	48.7	12.5
2	1.0	60	128	15.2	1.3	49.2	12.6
3	3.0	60	128	15.0	1.2	48.2	12.2
4	6.0	60	128	15.3	1.4	49.6	13.1
5	9.0	60	128	15.2	1.3	48.9	12.7
6	12.1	60	128	15.1	1.5	48.1	13.6
(B) Payzone(R)(g/kg of food)							
7(control)	0.0	60	128	15.4	1.4	50.1	12.9
8	0.25	60	128	15.5	1.3	51.2	11.8
9	0.50	60	128	15.3	1.6	52.1	14.4
10	0.75	60	128	15.6	1.2	53.2	11.5
11	1.00	60	128	15.5	1.2	50.8	11.8

* S.D.= Standard deviation.

Table 2. Composition of the formulated pellet feed.

Ingredients	Composition (%)
Semi-sun-dried trash fish (30-40% moisture)	45.0
Fish meal	30.0
Wheat flour	23.7
Vitamin mix (Supravitaminol, CEVA, B.P.57, France)	1.0
Mineral mix*	0.3
Total	100.0

* mg/100 g food: Ca $(H_2PO_4)_2H_2O$, 40; calcium lactate, 100; ferric citrate, 10; $MgSO_4.7H_2O$, 40; K_2HPO_4, 70; $NaH_2PO_4.H_2O$, 25; $AlCl_3.6H_2O$, 2; $ZnCl_2$, 8; $CuSO_4,5H_2O$, 3; $MnSO_4.4H_2O$, 2; Kl, 2; (Cowey et al., 1973).

Table 3. Chemical composition and moisture content of the trash fish and the formulated pellets used in feeding experiments. Each value is the mean ± standard deviation of five replicates.

	Chemical composition (% dry weight)					Moisture content
	Crude protein	Crude fat	Carbo-hydrate	Crude fiber	Ash	%
(A)						
<u>Engraulis</u>	81.56	9.20	1.16	-	8.08	79.58
<u>mystax</u>	± 1.28	± 0.84	± 0.19		± 0.65	± 0.59
<u>Pseudosciaena</u>	85.87	6.17	1.72	-	7.24	80.24
<u>acuta</u>	± 0.97	± 0.89	± 0.43		± 0.63	± 1.01
<u>Selaroides</u>	83.23	6.88	4.30	-	5.59	77.47
<u>leptolepis</u>	± 0.70	± 0.35	± 0.61		± 0.92	± 0.97
Average	83.22	7.42	2.39	-	6.97	79.10
(B)						
Formulated	50.61	6.34	20.63	4.31	18.11	34.62
pellets	± 0.51	± 0.71	± 0.41	±0.41	± 0.54	± 0.52

<u>Results</u>

Increase in biomass

The test groupers when fed on diets containing 17α-methyltestosterone and Payzone$^{(R)}$ showed marked increase in body weight over that of the control fish (Figures 1 and 2). Body weight generally increased with an increasing dosage of 17α-methyltestosterone in the food (Figure 1a), but the highest increase of 43.4% was observed in the fish fed with a diet containing 9 mg of the hormone per kilogram of food (Figure 1b). At inclusion levels above 9 mg/kg the growth promoting effect seems to level off or to decrease. Similarly there were increasing percentages of weight increase in the fish with increasing levels of Payzone$^{(R)}$ up to an inclusion level of 1 g/kg (Figure 2b), were a weight increase of 62.8% was recorded.

Condition factors

The condition factors of fish expressed as the ratio of the mean weight to the cube of the mean length before and after the experiments are shown in Table 4. The condition factors were found to increase correspondingly with the level of the growth promoters used in the fish diet. The condition factors of the fish feeding on diets containing either 17α-methyltestosterone or Payzone$^{(R)}$ at the levels tested were significantly higher than those of corresponding control groups (Duncan's multiple Range Test, $P < 0.05$). The condition factor for the control fish was 16.35 and it reached a value of 17.71 when the diet was supplemented with 9 mg of 17α-methyltestosterone. Fish fed with Payzone$^{(R)}$ (1 g/kg) had a condition factor of 18.19 as apposed to 16.14 for control fish. Over the culture period of 150 days the variations in the condition factor within the groups of fish receiving diets containing either the 17α-methyltestosterone at dosages between 1.0-2.0 mg/kg of food or Payzone(R) between 0.25-1.0 g/kg of food were not statistically significant (P > 0.05).

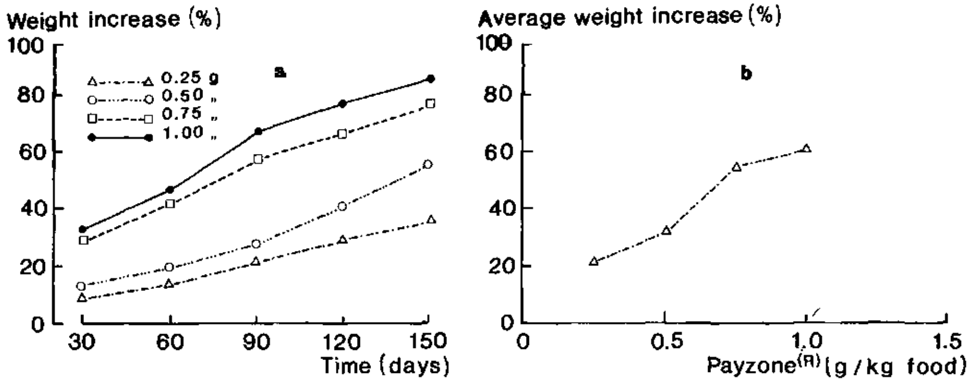

Figure 1. (a) Effect of different concentrations of 17α-methyltestosterone (mg/kg food) on the relative weight increase (over control) in grouper. (b) Relative average weight increase of grouper at varying doses of 17α-methyltestosterone.

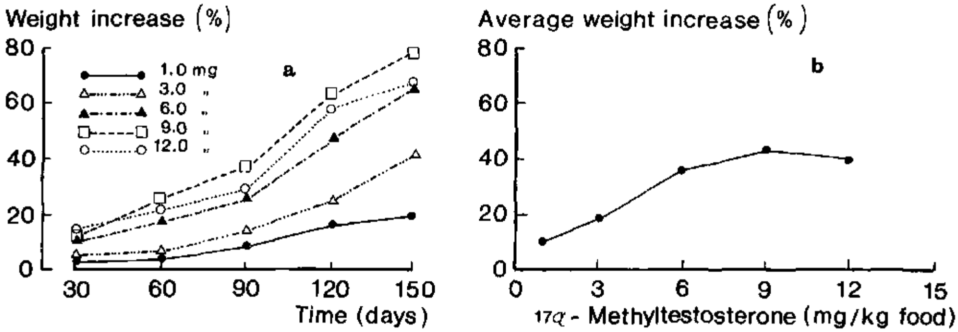

Figure 2. (a) Effect of different concentrations of Payzone-(R) (g/kh food) on the relative weight increase (over control) in grouper. (b) Relative average weight increase of grouper at varying doses of Payzone(R).

Table 4. Effect of growth promoters on the condition factor in estuary grouper.

Dosage	Condition factor*		
	Mean	Initial	Final
(A) 17α-methyltestosterone (mg/kg of food)			
0.0 (control)	15.45	14.14	16.35
1.0	15.63	14.01	17.08
3.0	15.85	14.28	17.23
6.0	15.94	13.85	17.47
9.0	16.14	13.92	17.71
12.0	15.74	13.97	17.09
(B) Payzone(R) (g/kg of food)			
0.0 (control)	15.05	13.72	16.14
0.25	15.69	13.75	17.39
0.50	16.36	14.55	17.88
0.75	16.19	14.01	17.94
1.00	16.21	13.64	18.19

* Mean for 5 monthly measurements.

Food conversion ratio

The food conversion efficiencies of the fish fed on diets containing the growth promoters were consistently higher than those of the corresponding control fish (Figures 3a and 4a). Within the groups of fish receiving different dosages of Payzone(R) the efficiencies of food conversion increased correspondingly with the increasing dosages of the growth promoter (Figure 4a). In the groups of fish receiving 17α-methyltestosterone the food conversion efficiency increased up to a level of 9 mg/kg of food. Values of 1.63 (Figure 3b) and 1.54 (Figure 4b) at the optimal dosages of 9 mg of 17α-methyltestosterone respectively 1 g Payzone(R) per kilogram of food, represented an increased efficiency of respectively 62.3% and 61.1% over the control groups.

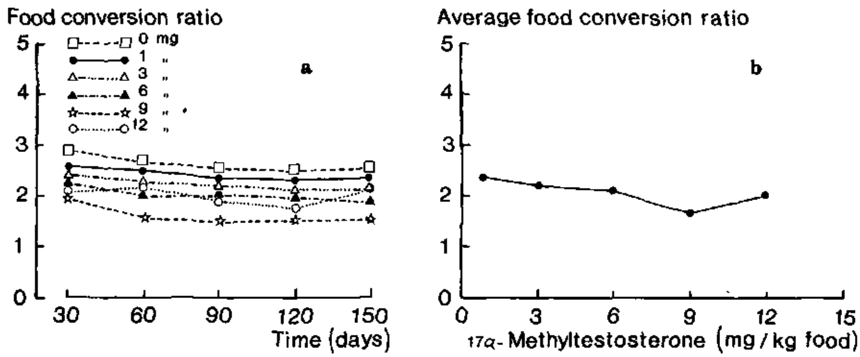

Figure 3. (a) Effect of different concentrations of 17α-methyltestosterone on the feed conversion ratio in grouper. (b) The average feed conversion ratio in grouper at varying doses of 17α-methyltestosterone.

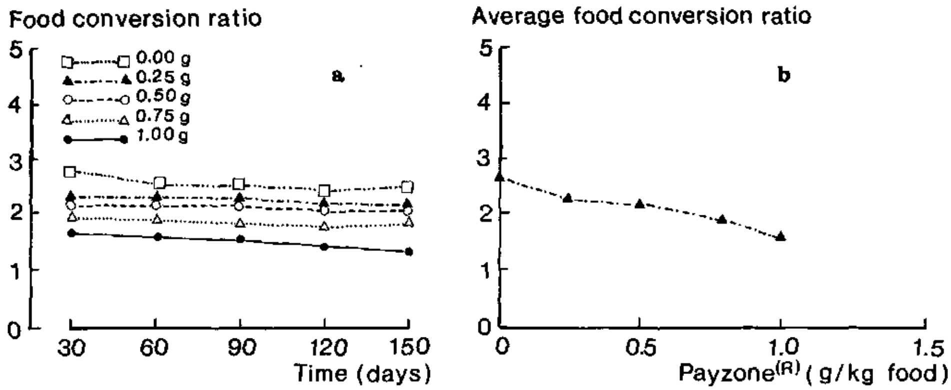

Figure 4. (a) Effect of different concentrations of Payzone-(R) on the feed conversion ratio in grouper. (b) The average feed conversion ratio in grouper at varying doses of Payzone(R).

Effects on the protein, fat and moisture content of grouper

Although the protein content of the fish muscle did not appear to be affected by the chemicals under study, the fat content was considerably increased while that of moisture was decreased. Fat content appeared to increase correspondingly with increasing levels of either 17α-methyltestosterone or Payzone(R) in the fish feeds (Table 5). During the experiment most fish were observed to be robust showing substantial increase in weight (some grew to 800 g) but there was no noticeable abnormality in their body structure. Their gonads were still in the initial stage of development. Survival was relatively good among the fish receiving the diets incorporated with the growth promoters when compared to that of the control fish (Table 6).

Table 5. Effect of growth promoters on the proximate composition of the muscle of estuary grouper at the end of the experiment (150 days). Each value is the mean ± standard deviation of 3 fish sampled.

Dosage	Chemical composition (% dry weight) Protein	Fat	Moisture content %
Control	87.94 ± 0.56	4.36 ± 0.24	78.46 ± 0.43
17α-methyltestosterone (mg/kg of food)			
1.0	87.48 ± 0.58	5.14 ± 0.36	77.38 ± 0.37
3.0	87.79 ± 0.46	6.04 ± 0.51	76.93 ± 0.41
6.0	87.86 ± 0.43	6.87 ± 0.49	75.42 ± 0.52
9.0	87.92 ± 0.48	7.32 ± 0.61	74.98 ± 0.38
12.0	87.89 ± 0.57	7.08 ± 0.42	75.14 ± 0.43
Payzone(R) (g/kg food)			
0.25	87.57 ± 0.34	5.34 ± 0.58	77.21 ± 0.47
0.50	87.73 ± 0.31	6.49 ± 0.51	76.12 ± 0.38
0.75	87.86 ± 0.38	7.62 ± 0.41	75.08 ± 0.56
1.00	87.81 ± 0.49	8.24 ± 0.39	74.62 ± 0.36

Table 6. Effect of 17α-methyltestosterone and Payzone(R) on the growth of estuary grouper. Survival rate at the end of the experiment. No. of fish per cage: 60.

Dosage	Survival rate (%)
(A) 17α-methyltestosterone (mg/kg of food)	
0.0 (control)	96.9
1.0	98.4
3.0	99.2
6.0	99.2
9.0	100.0
12.0	97.7
(B) Payzone(R) (g/kg of food)	
0.0 (control)	96.1
0.25	97.7
0.50	98.4
0.75	99.2
1.00	99.2

Environmental effects

Table 7 shows the changes of water temperature, salinity, dissolved oxygen content and pH of the water inside and outside the net cages. The fluctuations of these physical and chemical parameters were small and insignificant.

Table 7. Effect of 17α-methyltestosterone and Payzone(R) on the growth of estuary grouper cultured in floating cages: changes in water temperature, salinity, dissolved oxygen content and pH inside and outside the net-cages used in the experiment. Each value is the mean and range (in brackets) of 11 measurements taken fortnightly from 9 November 1987 to 26 March 1988.

Treatment	Water temperature (°C)	Salinity (ppt)	Dissolved oxygen (ml/l)	pH
A. in cages with fish treated with 17α-methyltestosterone				
0.0 mg/kg food	29.6	30.41	4.16	8.1
	(27.8-30.6)	(28.14-32.1)	(3.76-5.81)	(7.8-8.3)
1.0 mg/kg food	30.1	29.87	3.96	8.2
	(29.1-31.4)	(27.34-31.46)	(3.46-5.31)	(8.0-8.4)
3.0 mg/kg food	29.4	29.46	4.08	8.1
	(28.1-30.5)	(27.15-30.96)	(3.51-5.48)	7.9-8.2)
6.0 mg/kg food	29.7	30.28	4.32	8.0
	(28.3-30.7)	(28.12-31.47)	4.06-5.32)	(7.8-8.2)
9.0 mg/kg food	29.8	29.74	3.89	8.1
	(28.6-30.8)	(27.63-30.87)	(3.47-5.12)	(8.0-8.4)
12.0 mg/kg food	30.0	29.81	3.76	8.1
	(29.8-31.7)	(28.16-30.89)	(3.37-5.27)	(8.0-8.3)
B. in cages with fish treated with Payzone(R)				
0.0 g/kg food	29.7	30.12	4.14	8.0
	(28.6-30.8)	(28.34-31.46)	(3.81-5.09)	(7.8-8.3)
0.25g/kg food	29.6	29.82	4.37	8.1
	(28.3-30.3)	(28.63-31.21)	(3.76-5.34)	(8.0-8.4)
0.50 g/kg food	29.4	29.34	4.11	8.0
	(28.1-30.7)	(28.11-31.32)	(3.87-5.28)	(7.9-8.2)
0.75 g/kg food	30.1	29.12	4.08	8.2
	(29.7-31.6)	(27.89-30.94)	(3.47-5.40)	(8.0-8.4)
1.00 m/kg food	29.3	30.14	3.94	8.1
	(28.3-30.7)	(28.16-31.28)	(3.81-5.32)	(8.0-8.3)
C. outside the cages	29.6	29.46	4.67	8.1
	(28.3-31.5)	(27.86-32.04)	(3.81-5.67)	(8.0-8.4)

Discussion

The present study on Payzone(R) effects on grouper is the first of its kind in Malaysia. Payzone(R) has been widely used as a dietary supplement in feeds of poultry and pigs for growth promotion and now this use has been extrapolated to fish. The recommended dosage for Payzone(R) in pigs and poultry is 0.45 g per kg of food (Anonymous, 1974).

The addition of either 17α-methyltestosterone or Payzone(R) to the fish feeds considerably enhances the weight increment and improves the food conversion ratio and condition factor of the grouper. These findings are in agreement with other reports on anabolic hormones and particularly 17α-methyltestosterone on fish (Cowey et al.,1973; Fagerlund & McBride, 1975; McBride & Fagerlund, 1973, 1976; Yamazaki, 1976; Higgs et al., 1977; Yu et al., 1979; Degani, 1985; Arul, 1986).

Many concentrations of hormones used in feeds have been reported (Ghittino, 1970; Bulkey, 1972; Coweyet al., 1973; McBride & Fagerlund, 1976; Matty & Cheema, 1978; and Yu et al., 1979), from 0.6 mg to 10 g/kg of food. For the grouper 9 ppm was optimal.

17α-methyltestosterone when compared to estradiol and testosterone is said to be the most promising growth stimulant in coho salmon (Yu et al., 1979). In this study, Payzone(R) appears to be a much more effective growth promoter for the grouper.

The fat content in the muscle of the grouper increased when they were fed either 17α-methyltestosterone or Payzone(R) supplemented diet. Our result is different to that of Yu et al. (1979) and Degani (1985). Yu et al. (1979) reported that their experimental fish fed 17α-methyltestosterone had less fat deposition whereas the lipid content was highest in those fish receiving a testosterone supplemented diet. Their results further indicated that steroid hormones did not induce any changes in the fatty acid composition of the fish. Experiments to investigate the fatty acid composition of the grouper are required. Nevertheless the increase in fat content in the grouper is not undesirable as fat improves the flavor of cooked fish and this renders the fish very acceptable to the consumers.

Higher dosage and prolonged application of androgenic steroids may induce changes in gonadal development, external body structures and courtship behaviour of fish (Guerrero, 1974; 1976; Takahashi, 1975; Yamazaki, 1976; Billard et al., 1982). Such effects were not found in this study. A few of the test fish did grow to a bigger size. However, their gonads were still in the initial stages of development. It is possible that the dosage of steroid used in this study was too low to induce gonadal responses.

The amount of 1 g Payzone(R) in one kilogram of diet in the present study may seem high when compared to the recommended dosage of 0.45 g/kg food for domestic animals. However, the fish did not show any adverse morphological structures or suffer any toxicity effects during the 150-days trial period. It has been recorded that as much as 20,000 ppm of Payzone nitrovin fed to rats did not evoke any toxicity effects (Anonymous, 1974). Furthermore, Payzone nitrovin is excreted completely within 2-4 days at dosages between 30-380 ppm fed to rats and chickens and no significant accumulation of the chemical in the tissues was found. Results from these experiments further confirm that Payzone(R) or 17α-methyltestosterone supplementation in fish diets could be beneficial in fish husbandry: fish being raised to desired size in a shorter period of time and with higher feed efficiency. Coupled with the information that Payzone(R) is not an antibiotic and that it leaves no detectable residues in the tissues, the use of

Payzone(R) and that of 17α-methyltestosterone offers a considerable promise in the commercial production of groupers.

Acknowledgements

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References

Anonymous, 1974. Aureo - S(R) Payzone(R) feed premix use in pigs. Cynamid, U.S.A. Report FHT-A69-2M-71T2, 26 pp.

Arul, V., 1986. Effect of ethylestrenol on growth and food utilization in Channa striatus. Proc.Indian Acad.Sci.Anim.-Sci., 95(1): 51-57.

Billard, R., Richard, M. & Rombants, R., 1982. Inhibition of spermatogenesis and vitellogenesis in rainbow trout by hormonal additives in the diet. Prog.Fish Cult., 44(1): 15-18.

Bulkey, R.V., 1972. Diethyl stilbesterol in catfish feed. Trans.Am.Fish Soc., 101: 537-539.

Cowey, C.B., Pope, J.A., Andron, J.W. & Blair, A., 1973. Studies on the nutrition of marine flatfish. The effect of oral administration of diethylstilbesterol and cycloheptadiene on the growth of Pleuronectes platessa. Mar.Biol., 19: 1-6.

Chua, T.E. & Teng, S.K., 1978. Relative growth and production of the estuary grouper, Epinephelus salmoides Maxwell reared in floating net-cages. Mar.Biol., 54: 363-374.

Chua, T.E. & Teng, S.K., 1980. Economic production of estuary grouper (Epinephelus salmoides Maxwell) reared in floating net-cages. Aquaculture, 20: 187-228.

Chua, T.E. & Teng, S.K., 1982. Effects of food ration on growth, condition factor, food conversion effciency, and net-yield of estuary grouper, Epinephelus salmoides Maxwell, cultured in floating net-cages. Aquaculture, 27: 273-283.

Degani, G., 1985. The influence of 17α-methyltestosterone on body composition of eels (Anguilla anguilla (L)). Aquaculture, 50(1-2): 23-30.

Fagerlund, U.H.M. & McBride, J.R., 1975. Growth increments and some flesh and gonad characteristics of juvenile coho salmon receiving diet supplemented with 17α-methyltestosterone. J.Fish.Biol., 7: 305-314.

Ghittino, P., 1970. Riposte delle trote d'allevaments al stilboestrols e metltiuracile. Riv.ital Pisicisolt. Ittiopatol., 5: 9-11.

Guerrero, R.D., 1974. The use of synthetic androgens for the production of monosex male Tilapia aurea (Steindachner). Ph.D. dissertation, Auburn University, Auburn, Alabama, U.S.A., 112 pp.

Guerrero, R.D., 1976. Tilapia mossambica and T.zilli treated with ethyltestosterone for sex reversal. Philip.J.Biol., 5:

187-192.
Higgs, D.A., Fagerlund, U.H.M., McBride, J.R., Dye, H.M. & Donaldson, E.M., 1977. Influence of bovine growth hormone 17α-methyltestosterone and L-thyroxine on growth of yearling coho salmon (Oncorhynchus kisutch). Can.J.Zool., 55: 1048-1056.
Lone, K.P., Ince, B.W. & Matty, A.J., 1982. Changes in the blood chemistry of rainbow trout, Salmo gairdneri Rich. in relation to dietary protein level and an anabolic steroid hormone, ethylestrenol. J.Fish Biol., 20(5): 597-606.
MacIntosh, D.J., Varghese, T.J. & Satyanarayana, R.G.P., 1985. Hormonal sex reversal of wild-spawned tilapia in India. J.Fish Biol., 26(2): 87-94.
Matty, A.J. & Cheema, I.R., 1978. The effect of some steroid hormones on the growth and protein metabolism of rainbow trout. Aquaculture, 14: 163-178.
Maynard, L.A. & Loosli, J.K., 1982. Animal nutrition. 5th ed., McGraw Hill Publishing Co Ltd., New York, 533 pp.
McBride, J.R. & Fagerlund, U.H.M., 1973. The use of 17α-methyltestosterone for promoting weight increases in juvenile Pacific salmon. J.Fish Res.Board.Can., 30: 1099-1104.
McBride, J.R. & Fagerlund, U.H.M., 1976. Sex steroids as growth promoters in the cultivation of juvenile coho salmon (Oncorhynchus kisutch). In: J.W. Avoult, Jr.(Ed.),Proc.of the 7th Annual World Mariculture Society, San Diego, California, pp. 145-161.
McBride, J.R., Higgs, D.A., Fagerlund, U.H.M. & Buckley, J.T., 1982. Thyroid and steroid hormones: potential for control of growth and smoltification of salmonids. Aquaculture, 28(1-2): 201-209.
McDonald, P., Edwards, R.A. & Greenhalgh, J.F., 1973. Animal nutrition. 2nd ed/. Oliver & Boyd, Edinburgh, 479 pp.
Parova, J., Par, O. & Tejnora, J., 1982. Testing of the non-antibiotic stimulation nitrovin in feed mixture for the market carp production. Zivocisna Vyroba, 27(11): 801-810.
Plisetskay, E.M. & Murat, J.C., 1979. Endocrine mediations in the control of nutritional metabolism in fishes. Fish nutrition proceedings collection, CNERNA, Paris, France, pp. 323-336.
Strickland, D.J.H. & Parsons, T.R., 1972. A practical handbook of seawater analysis. Fish.Res.Board Can.Bull., 167, 2nd edition, 310 pp.
Takahashi, H., 1975. Masculinization of the gonad of juvenile guppy, Poecilia reticulata induced by 11-ketotestosterone. Bull.Fac.Fish Hokkaido Univ., 26: 11-12.
Teng, S.K. & Chua, T.E., 1978. Effect of stocking density on the growth of estuary grouper, Epinephelus salmoides Maxwell, culture in floating net-cages. Aquaculture, 15: 273-287.
Teng, S.K. & Chua, T.E., 1979. Use of artificial hides to increase the stocking density and production of estuary grouper, Epinephelus salmoides Maxwell, reared in floating net-cages. Aquaculture, 16: 219-232.
Teng, S.K., Chua, T.E. & Lim, P.E., 1978. Preliminary observation on the dietary protein requirement of estuary grouper, Epinephelus salmoides Maxwell, cultured in floating net-cages. Aquaculture, 15: 257-271.
Yamazaki, I., 1976. Application of hormones in fish culture. J.Fish.Res.Board Can., 33: 948-958.

Yu, T.C., Sinnhuber & Hendricks, J.D., 1979. Effect of steroid hormones on the growth of juvenile coho salmon (<u>Oncorhynchus kisutch</u>). Aquaculture, 16: 351-359.

Tilapia (*Oreochromis* sp.) and carp (*Cyprinus carpio*) production in cage systems in West Java, Indonesia

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Summary

Semi-intensive aquaculture production systems ("hapa" hatchery nets, nurseries, floating net cages) for the culture of tilapia hybrids (*Oreochromis* sp.) and common carp (*Cyprinus carpio*) were tested in the Saguling Reservoir, West Java, Indonesia.

Experiments using tilapia and common carp nursery systems were compared with and without light attractors, and in "good" and "poor" water quality conditions at a stocking of 0.5 kg/m^3 of 3.9-11.6 g fingerlings. Tilapia grew 1.6-2.2 g/day with a net production of 5.0-11.8 kg/m^3 and a feed conversion ratio of 3.1-3.7 in 80-90 days. Growth of tilapia was not significantly affected by poor water quality conditions, neither by presence or absence of light attractors. Common carp grew only 0.2-0.5 g/day and net production was significantly reduced in poor water quality, from 1.8 kg/m^3 at a feed conversion ratio of 7.2 to 1.1 kg/m^3 at a feed conversion ratio of 9.3. Light attractors gave no significant differences in common carp growth or net production.

Polyculture of 40% common carp with 60% tilapia at a stocking rate of 1.0 kg/m^3 produced 3.8 kg/m^3 at a feed conversion ratio of 1.2. In polyculture total fish production and fish growth rate were significantly higher than in monoculture of common carp and yielded 2.7 kg/m^3 in 90 days at a feed conversion ratio of 1.7.

Introduction

To supply electricity to the growing urban population of West Java two large dams were constructed, which by 1988 created two new reservoirs. Saguling (5,660 ha) and Cirata (6,200 ha), on the Citarum River. Dam construction flooded rich rice growing valleys and directly displaced an estimated 9,309 families and affected the jobs of 12,316 families who owned land or worked in the flooded area (IOE, 1979; 1980).

Since 1979 the Institute of Ecology (IOE) of Padjadjaran University (Bandung, Indonesia) has comprehensively studied the socio-cultural and natural environment of the reservoir areas being contracted by the Indonesian State Electric Company (PLN) (Soemarwoto et al., 1988). IOE Environmental Impact and Assessment reports recommended PLN to investigate the development of floating net cage aquaculture (FNCA) as an innovative means of large scale resettlement of displaced families from the reservoir regions (IOE, 1979; 1980).

In 1986 PLN contracted the IOE, who, in turn, associated with the International Center for Living Aquatic Resources Management (ICLARM) (Costa-Pierce & Soemarwoto, 1987) to implement a project to resettle 3,000 families in fisheries and aquaculture activities in the Saguling and Cirata reservoirs by 1989.

It was known before the project began that no such attempt to resettle such large numbers of people by using a planned development of aquaculture and fisheries had ever been tried anywhere.

Reservoir floating net cage aquaculture

By October 1988 the Saguling Reservoir had 1,235 commercial FNCA units, and the new downstream Cirata Reservoir (filled February 1988) had 100 units. Total fish production in 1987 reached 1,439 tonnes, and stood at 2,044 tonnes by the end of October 1988. Over 2,000 persons are currently employed in the grow-out sector of the FNCA industry in Saguling, and approximately 700 members are active in a Saguling fish farmers association. While FNCA grow-out operations, essentially water-based "feedlots", are successful, their development has greatly accelerated demand for seed fish from hatcheries and nursery systems in the region. Indeed FNCA for common carp in the Saguling reservoir is so successful that it has acquired a private research "life of its own". Therefore the focus of the IOE/ICLARM project in 1988 shifted from initial work with the FNCA grow-out systems to development and research in hatcheries and nursery systems (Costa-Pierce et al., 1988).

"Seed fish" used in FNCA units are 50-100 g average weight common carp. Demand for seed fish to stock FNCA units has created a local mini-boom in rice-fish culture, and has accelerated the financial demise of some overcapitalized and poorly managed running water systems (West Java Fisheries Agency, pers.comm.). Effendi (1988) has forecasted that total fish production from FNCA in the two reservoirs will reach 12,000 tonnes by 1993. Currently each 122.5 m3 FNCA unit requires 300 kg of seed fish for stocking each crop, and produces 1-1.5 ton during this period of 90 days. Assuming fish production at 2 ton/unit/year an estimated seed fish demand of 1,800 tonnes is forecasted by 1993. A demand of this magnitude will have far-reaching impact on aquaculture production networks in West Java, especially on the development of hatchery and rice-fish culture, and will require prompt planning by Indonesian fisheries officials at local, provincial and national levels.

Table 1. Operation and management of small scale tilapia hatchery/nursery systems.

Unit	No.	Size(m)	Mesh	Stocking/Management
Broodstock	1	3x3x2	1 inch	2 pairs held for each mating pair; sex ratio 1:1; fed 3%/day; 24% protein; each pair rotates as mating pair every 24 days.
Mating	4	3x3x1	3 mm	0.5 kg/m^3; sex ratio 3:1; fed 3%/day; 24% protein; fry removed daily; net pulled each week and all fry removed.
Nursery I	4	3x3x1	3 mm	fry fed 24% protein feed to satiation 5x/day; held 2 weeks, harvest at 5 g and up; moved to nursery II.
Nursery II	2	2.4x4x1.2	6 mm	fry from 2 nursery I nets put together; fed 20%/day, 5x/day; held 2 weeks, harvest 20 g and up, to be stocked in cages.

Experiments with small scale tilapia hatcheries using a tilapia hybrid (Oreochromis sp.; likely O. mossambicus X O. niloticus) were conducted in 1988. It was decided to focus on tilapia for a number of reasons: (1) tilapia hatcheries are easily made "floating", thereby increasing the potential for creating new businesses that use the reservoir water surface, (2) pond-based technology for rearing common carp is well developed in West Java (Jhingran & Pullin, 1985), and a research program of longer duration is needed to develop a successful "floating" common carp hatchery technology, (3) the reservoir region has few appropriate sites for traditional land-based common carp hatcheries, (4) markets for tilapia are developing quickly and good prices are currently being offered by buyers who come directly to the reservoir (although the volumes that can be regularly sold are still unknown!).

A modular tilapia production unit was set up in the northern part of the Saguling reservoir in May 1988 consisting of: (1) 4, 9 m^2 "hapa" hatchery nets, (2) 4, 9 m^2 "hapa" Nursery I nets, and (3) 2, 9.6 m^2 Nursery II nets. Sizes of the individual net units and their management are detailed in Table 1. Operation of the hatchery essentially follows a Philippine hatchery system detailed in Guerrero, 1987, with some modifications. Broodstock tilapia were chosen from stocks kept in a 49 m^2 cage at a low density and receiving a commercial feed (Comfeed, Cirebon, Indonesia; 24% protein) at 3% of their body weight/day.

Broodstock were selected on the basis of their morphological or "outward" appearances, with the goal to eliminate undesirable "mossambicus-type" traits. Broodstock tilapia were selected with: (1) light red or pink color with no black spots, (2) small head with no large mossambicus-type lips, (3) "plate-shaped" body, (4) prominent greyish vertical stripes on the body, (5) healthy condition with full, undamaged fins and a robust appearance. Broodstock were stocked (Broussard et al., 1983) at 0.5 kg/m^3, at a female:male ratio of 3:1/g with females and males ranging from 300-500 g , 100-300 g respectively. Females were chosen larger than males because Guerrero and Guerrero (1985) reported higher fry production when fewer and smaller males were stocked. Broodstocks rotated between hatchery nets and a 49 m^2 broodstock holding net cage every 21 days.

Fry production in the 4 hatchery nets ranged from 7-15 fry/m^2/day in June-July 1988. Further refinements of the system have recently been made according to the recommendations of Dela Cruz (pers.comm.). An "insert" net of 1x1x1m whose sides are 1" mesh with a 1 mm mesh bottom was placed inside each 3x3x1.5 m hatchery net. Preliminary results indicate that this improvement has increased total fry production. "Insert" nets greatly facilitate removal of broodstock when they are rotated into and out of the mating hapas every 21 days and thereby decrease stress due to netting.

Experiments with reservoir cage nursery systems

Two experiments to test the possibility of producing seed fish to stock FNCA by using "floating" nurseries were conducted. The first experiment tested the effect of different water quality on tilapia and common carp fingerlings and was performed over an 89 days period from January 1 to April 4, 1988 at two locations in the Saguling reservoir. Reservoir water levels fell throughout this period, from a monthly average elevation of 630.3 m (above sea level) in January to 629.6 m at the end of March. A second experiment tested the effect of a light attractor on growth, production and survival of tilapia and common carp fingerlings. The attractor experiment was performed over an 80 days period from March 2 to May 27, 1988 in Awilarangan village in the southern part of the

Saguling reservoir. Water levels rose throughout this period from 629.6 m to 632.3 m.

Effect of water quality on common carp and tilapia fingerlings

Locations were chosen with "poor" or "good" water quality for cage aquaculture production. Water quality was defined according to preliminary guidelines being developed (Table 2). On the basis of water quality monitoring a site at Awilarangan village exhibited "good" water quality, or, during samplings conducted during a previous three months period, the score obtained using Table 2 was always greater than a score of 15. A second site in Cipondoh village had "poor" water quality, or had experienced a score less than 15 during the previous monitoring period. These two sites were chosen to test whether water quality would have a large effect on fish growth, feed conversion ratio (FCR), and production for both species. It was anticipated that the experiment could provide further data sothat sites suitable for cage aquaculture production could be selected using water quality criteria.

Duplicate 2.4x4.0x1.2 m hapa nets of 6 mm mesh were stocked at a rate of 0.5 kg/m^3 with common carp fingerlings of 3.9-4.7 g and tilapia fingerlings of 5.5-8.2 g average weight. The growing period was 89 days at both sites. Fish were fed a finely ground commercial feed (Comfeed) at 20% of their body weight/day and sampled every 2 weeks to determine growth rate. At the time of fish sampling fish feeding rate was adjusted 2.5% lower. Weight development during the experimental period is given in Figure 1.

Yield data are presented in Table 3, and final fish weight distribution of both species shown in Figure 2. Tilapia fingerlings exhibited significantly ($P < 0.05$) superior growth rates, survival and net production, with lower FCR's, in both good and poor water quality when compared to common carp. In poor water quality tilapia had lower survival rates,lower average monthly production and lower specific growth rates, and higher FCR's, but differences observed were not significant.

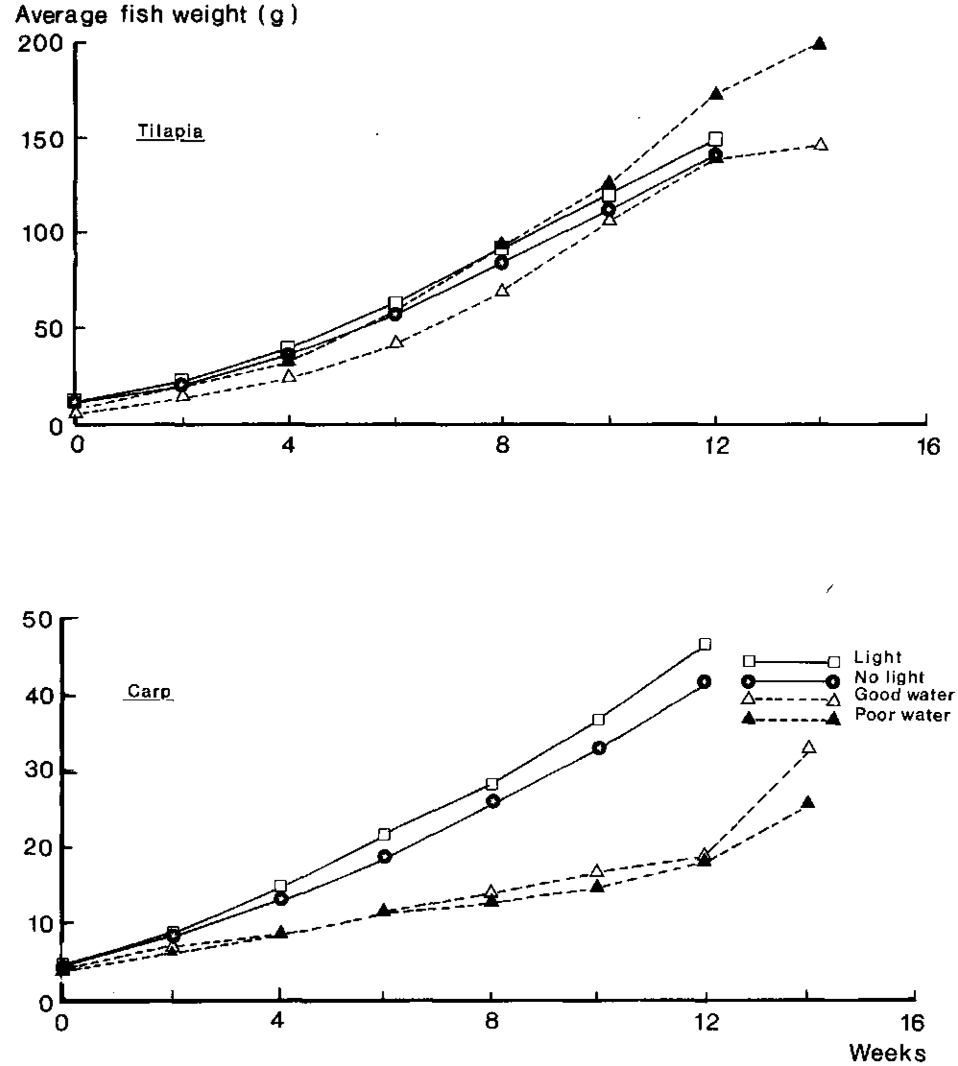

Figure 1. Growth of tilapia (upper panel) and carp (lower panel) in nursery hapas.

Table 2. Score used for evaluating water quality suitable for cage aquaculture development.

Parameter (time of measurement)	Range	Ranking (points)
DO (0500-0700) (mg/l)	< or = 1.0	0
	1.1-2.0	1
	2.1-3.0	2
	3.1-4.0	3
	4.1-5.0	4
	5.1-6.0	5
	>or = 6.1	6
CO_2 (0550-0700) (mg/l)	>or = 60	0
	50-59	1
	40-49	2
	30-39	3
	20-29	4
	10-19	5
	<or = 9	6
pH (1400-1700) (units)	<or = 4.0 & >or = 11.00	
	4.1-4.5 & 10.5-10.9	1
	4.6-5.0 & 10.0-10.4	2
	5.1-5.5 & 9.5-9.9	3
	5.6-6.0 & 9.0-9.4	4
	6.1-6.5 & 8.5-8.9	5
	6.6-8.4	6
NH_3 (1400-1700) (ug/l)	>or = 700	0
	500-699	1
	400-499	2
	300-399	3
	200-299	4
	100-199	5
	<or = 99	6
H_2S (0500-0700) (ug/l)	>or = 701	0
	601-700	1
	501-600	2
	401-500	3
	301-400	4
	101-300	5
	<or = 100	6

Ranking: (1) 25-30 points would be optimal water quality conditions for fish culture; (2) 15-24 points would be good water quality conditions; (3) 10-14 points would be poor water quality conditions, leading to poor, if any, fish growth; (4) 0-9 points would be conditions toxic or dangerous for fish growth and survival.

Effects of water quality were more apparent on common carp fingerlings. Significantly lower ($P < 0.05$) growth rates and a higher average FCR were obtained in poor water quality for common carp fingerlings (Table 3). Only 22% of the common carp fingerlings reached a size above 50 g in poor water quality compared to 56% in good water quality (Figure 2). Interestingly at harvest 63% of red tilapia were 200 g or more in poor water quality and only 44% in good water quality (Figure 2). This latter result may have been due to lower survival rates and concomitently higher growth rates, due to lower carrying capacity and less crowding in the tilapia hapas under poor water quality conditions (Table 3).

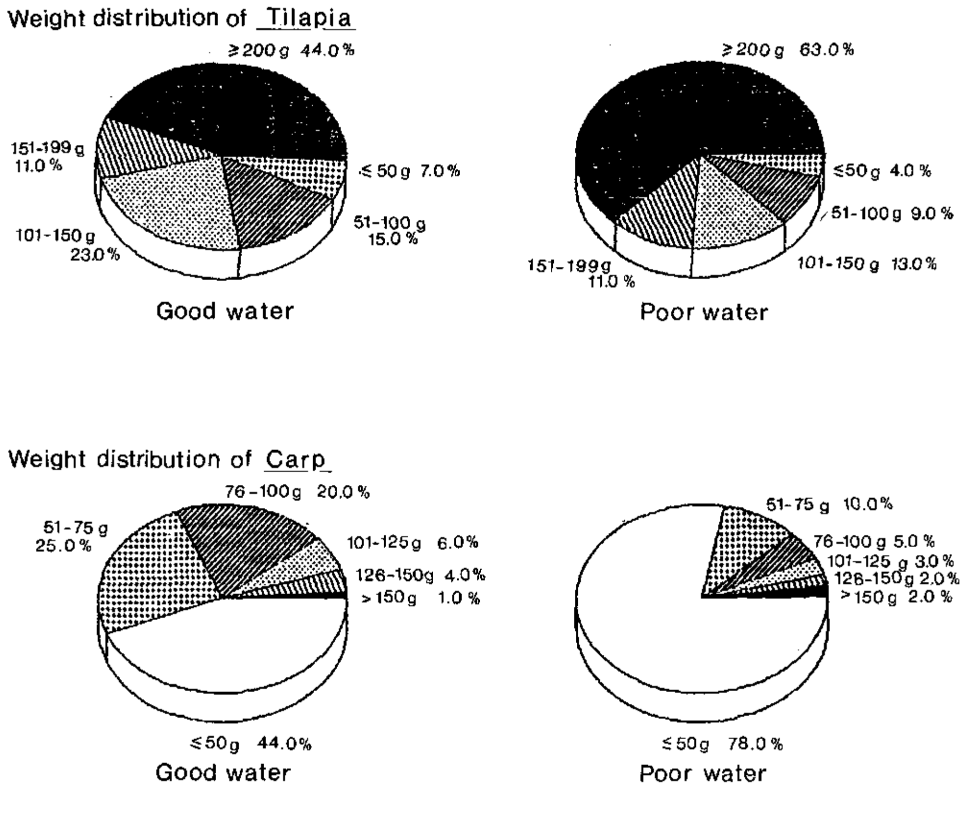

Figure 2. Weight distribution of tilapia and carp at harvest.

Table 3. Hapas nurseries in the Saguling reservoir, West Java, Indonesia.

Treat-ment	Fish species	Stocking means Wt.	No.	Biomas	Harvest means Wt.	Biomass	% Survival	Culture period	Linear G.R.	M.P.	M.S.G.	Net product.	FCR
Good WQ	Tilapia	5.5	91	0.5	146.4	12.3	92	89	1.6	4	873	11.8	3.1
	Carp	3.9	135	0.5	34.1	2.3	56	89	0.3	0.6	231	1.8	7.2
Poor WQ	Tilapia	8.2	61	0.5	200.3	10.2	83	89	2.2	3.3	805	9.7	3.4
	Carp	4.7	106	0.5	25.5	1.6	61	89	0.2	0.4	128	1.1	9.3
No at-	Tilapia	11.5	42	0.5	141.3	5.6	95	80	1.6	1.9	417	5.1	3.6
tractor	Carp	5.5	87	0.5	41.6	3.1	85	80	0.4	1	218	2.6	4.4
Attrac-	Tilapia	11.6	41	0.5	149.2	5.5	90	80	1.7	1.9	440	5	3.7
tor	Carp	5.2	92	0.5	46.4	3.6	84	80	0.5	1.2	288	3.1	4.4

Notes: M.P. = Average monthly production (biomass final-biomass initial) recalculated on a 30-days basis.

M.S.G.= Average monthly specific growth rate as % average fish stocking weight (g) for 30 days.

FCR = Kg dry feed used/kg wet fish harvested.

Methods used for rearing common carp fingerlings to stocking size in hapa nurseries for further on-growing in FNCA obviously need additional refinement and research. Common carp growth and production obtained was much lower than those reported for the current alternative rice-fish nursery system. Dela Cruz (1986) reported that common carp fingerlings stocked into ricefields in Sumatra, Indonesia at 5-7 g average weight reached 97.5-288.0 g in just 90 days. Growth rates for common carp fingerlings ranged from 1.0-3.1 g/day with 62-63% survival rates stocked into rice fields at densities between 3,000-7,000/ha. Results obtained in this experiment for growth and production of tilapia are, however, comparable to those obtained in hapa nets in the eutrophic Laguna de Bay, Philippines (Bautista, 1987) for Nile tilapia nursery systems at comparable low stocking densities. It is likely that feeding rates could be substantially reduced and stocking densities increased in the tilapia nursery systems. While some evidence was obtained that poor water quality did have effects on FRC and survival rate of tilapia fingerlings (more replicates might have produced more clear significant differences), current data would not discourage new farmers from developing tilapia aquaculture in areas of the reservoir with similar water quality as used in this experiment.

Effect of light attractors on common carp and tilapia fingerlings

It was hypothesized that a simple light attractor could possibly attract sufficient amounts of flying insects and/or zooplankton to increase fish growth and survival by providing additional "live food" for fingerlings of tilapia and common carp.

Four hapa nets (2.4x4.0x1.2 m) were stocked with tilapia and common carp fingerlings at a rate of 0.5 kg/m^3. Two of these nets were fitted with a simple "Petromax" kerosene lamp suspended from a wooden frame in the center of each net, approximately 50 cm above the water surface. Two equal sized nets with no attractors served as controls. All nets received an equal amount of finely ground commercial feed (Comfeed) at 20% of the live fish biomass/day fed in 3 times (morning, noon, sunset). Kerosene lamps were lit every evening at 20.00 h and run throughout the night until daylight (06.00 h). Fish were sampled every two weeks throughout an 80 days experimental period. At the time of sampling feeding rates were adjusted downwards by 2.5 % of the recalculated wet fish biomass present in the nets.

Use of a kerosene light attractor had no significant effect ($P > 0.05$) on any growth or production figure obtained for tilapia and common carp (Table 3; Figure 1). Average FCR's were also not improved by the use of the attractor.

Common carp growth rates were, however, significantly higher during the attractor experiment than during the water quality experiment. Tilapia did not experience such a dramatic difference (Figure 1). One preliminary explanation for this may be that reservoir water levels could differentially affect growth of the fish species. Further study is required in this area.

Polyculture of common carp and tilapia in cages

In previous field observations it was noted that tilapia were quite effective in cleaning cage net walls, and when cultured with common carp, tilapia "trained" the carp to be more aggressive when feed was offered. The potential of polyculture of common carp and tilapia in FNCA was investigated over a 90 days period from October 10, 1987 to January 17, 1988. Duplicate 7x7x2.5 m floating net cages were stocked with a polyculture of red tilapia at a rate of 0.6 kg/m^3 and common carp at 0.4 kg/m^3. Duplicate control cages were stocked with a monoculture of common carp at 1.0 kg/m^3 stocking density.

Total growth rate and net fish production was siginificantly higher for the polyculture than the common carp monoculture (Table 4; Figure 3).

Table 4. Polyculture of Nile tilapia and common carp in floating net cages.

		Stocking means			Harvest means								
Treatment	Fish species	Wt. (g)	No. (per m3)	Biomass (kg/m3)	Wt. (g)	Biomass (kg/m3)	% Survival	period (d)	Culture G.R. (g/d)	Linear M.P. (30d)	M.S.G. (%/30d)	product. (kg/m3)	Net FCR
Monoculture	Carp	83.3	12.0	1.0	308.5 (259.0)	3.7 (3.2)	99.0 (99)	90.0 (90)	2.5	0.9	90.0	2.7	1.7
Polyculture	Carp	179.5	2.0	0.4	376.0	0.7	94.0	90.0	2.2	0.1	37.0	0.3	1.2
	Tilapia	44.7	14.0	0.6	314.8	4.1	93.0	90.0	3.0	1.2	201.0	3.5	

Notes: M.P. = Average monthly production (biomass final-biomass initial) recalculated on a 30-days basis.
M.S.G. = Average monthly specific growth rate as % average fish stocking weight '(g) for 30 days.
FCR = Kg dry feed used/kg wet fish harvested.

Notes: M.P. = Average monthly production (biomass final-biomass initial) recalculated on a 30-days basis.
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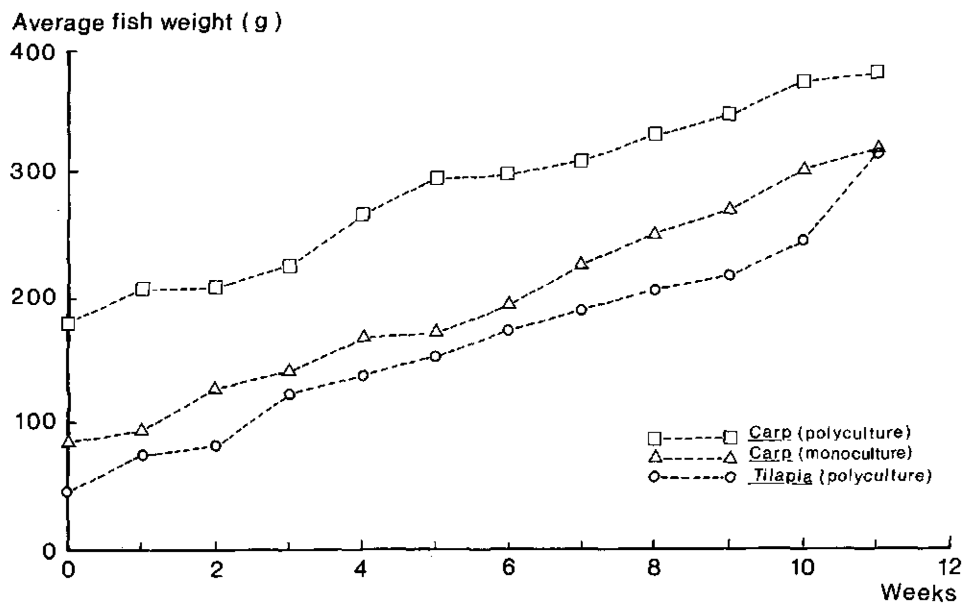

Figure 3. Growth of tilapia and carp in polyculture and of carp in monoculture in floating net cages.

In addition the average FCR was significantly lower in polyculture. Growth rate for common carp was insignificantly

(P >0.05) lower in monoculture than in polyculture. Differences in growth rate of common carp may have been obscured by the fact that common carp fingerlings stocked in polyculture were stocked at a larger size than those in monoculture; smaller fingerlings in monoculture may have had a faster growth rate than the larger fingerlings stocked in polyculture.

Dela Cruz (1979) reported that a similar polyculture (35% O. niloticus: 65% C. carpio) in 144 m3 cages was conducted in Taiwan over 110 days culture periods, but at a much higher stocking rate (1.7 kg/m3 for tilapia and 3.2 kg/m3 for common carp) and feeding higher protein feeds than reported here. The reported monthly specific growth rate (MSG in %/30 days) for Nile tilapia in Taiwan was 280 and final average weight was 338 g. These figures are comparable to those reported here (Table 4). However, Dela Cruz (1979) reported that common carp grew at a remarkable 16.8 g/day (MSG of 339). In the present polyculture, common carp, of nearly the same stocking size as reported in Taiwan (179.5 g versus 150.0 g) grew only 2.2 g/day. The reasons for these great differences may be in the quality and quantity of feeds given in Taiwan.

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References

Bautista, A.M., 1987. Tilapia hatchery and nursery systems: operation and management. In: R.D. Guerrero, D.L. Guzman & C.M. Lantican (editors). Proceedings of the First National Symposium and Workshop on Tilapia Farming. PCARRD and SEAFDEC, Los Banos, Laguna, Philippines. PCARRD Book Series, 48: 8-13.

Broussard, M.C. Jr., Reyes, R. & Raguindin, 1983. Evaluation of hatchery management schemes for large scale production of Oreochromis niloticus fingerlings in Central Luzon, Philippines. In: L. Fishelson & Z. Yaron (compilers). Proceedings of the International Symposium on Tilapia in Aquaculture. Tel Aviv University, Israel, pp. 414-424.

Costa-Pierce, B.A. & Soemarwoto, O., 1987. Proliferation of Asian reservoirs: the need for integrated management. NAGA, The ICLARM Quarterly 10: 9-10.

Costa-Pierce, B.A., Wiraatmadja, G., Effendi, P. & Zainal, S., 1988. Integrated aquaculture systems in the Saguling reservoir, West Java, Indonesia. In: S.S. De Silva (editor). Reservoir Fisheries Management and Development in Asia: Proceedings of a Workshop held in Kathmandu, Nepal, 23-28 November 1987. IDRC, Ottawa, Canada, pp. 224-233.

Dela Cruz, C.R., 1979. Observations on freshwater aquaculture and extension in Malaysia, Thailand, Japan and Taiwan. ICLARM

Newsletter 2: 6-8.
Dela Cruz, C.R., 1986. Final Report. Small scale fisheries development project. Rice-fish culture sub-project. USAID/ARD Project No. 497-0286. USAID, Jakarta, Indonesia, 226 pp.
Effendi, P., 1988. Program pengembangan perikanan di Cirata selama Pelita V 1989-1993. (Fisheries development program in Cirata for the 5th National Plan 1989-1993). Dinas Perikanan Propinsi DT I Jawa Barat UPTD Saguling-Cirata, Bandung, Indonesia, 36 pp.
Guerrero III, R.D., 1987. Tilapia farming in the Philippines. National Book Store, Metro Manila, The Philippines, 84 pp.
Guerrero III, R.D. & Guerrero, L.A., 1985. Effect of breeder size on fry production of Nile tilapia in concrete pools. Trans.Nat.Acad.Sci.Tech. (Phils.) 7: 63-66.
IOE (Institute of Ecology), 1979. Environmental impact analysis of the Saguling dam. Report to Perusahaan Umum Listrik Negara (PLN), Jakarta. IOE, Padjadjaran University, Bandung, Indonesia, 157 p.
IOE, 1980. Environmental impact analysis of the Saguling dam. Mitigation of impact. Final report to PLN, Jakarta. IOE, Padjadjaran University, Bandung, Indonesia, 163 p.
Jhingran, V.G. & Pullin, R.S.V., 1985. A hatchery manual for the common, Chinese and Indian major carps. ICLARM Studies and Reviews 11, Asian Development Bank and ICLARM, Manila, Philippines, 91 p.
Soemarwoto, O. et al., 1988. Pemukiman kembali penduduk Saguling dan Cirata melalui pengembangan perikanan. (Resettlement of the Saguling and Cirata population through the development of fisheries). Laporan Perkembangan, Seminar Pemukiman Kembali Penduduk Saguling dan Cirata Melalui Pengembangan Perikanan, Bandung, 12-13 Februari 1988. Institute of Ecology, Universitas Padjadjaran, Bandung, Indonesia, 93 pp.

Fingerling production trials in rice fields in North Sumatra, Indonesia

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Summary

Between 1983-1986, the Government of Indonesia (Directorate General of Fisheries) and the United States Agency for International Development initiated a rice-cum-fish culture project in Simalungun, North Sumatra with plans to cover other neighbouring provinces later. As part of the project, the techniques of producing common carp fingerlings in rice fields were documented in order to transfer such techniques to the target areas.

On-station and on-farm trials on fingerling production were conducted in concurrent rice-cum-fish farming systems and in fields without rice plants. Fry of 1-3 cm were reared for about one month at stocking rates of 5 fry/m^2 (concurrent system), and 5 or 10 fry/m^2 (no rice plants). Inputs (insecticides, feeding) and water management were the other treatments used.

Weekly application of the insecticide Sumithion 50 EC at low dosage minimized aquatic insect predation and increased survival to a profitable level. In the concurrent rice-cum-fish system, fingerling survival in on-station trials improved to 60-65%, and 52-58%, during the first and the second harvest in one rice crop, respectively.

In on-farm trials the highest mean survival of 59-67% was obtained from the smallest plot size (500-700 m^2). The survival of fingerlings in the two larger plot sizes were significantly lower during the second harvest.

In fields without rice plants, mean survival of fingerlings without insecticide application was 54%; with insecticide application this increased to 73% and 69% at stocking rates of 5 and 10 fry/m^2, respectively. In another trial, fish survival, using two feeds containing 30 % and 15% crude protein (CP), did not show a significant difference with mean values of 75% and 76%, respectively. Although the mean standing crop in the 30% CP feed was 36% higher than in the 15% CP, the later was found more profitable than the former, because the price of fingerlings is based on length and not on weight in North Sumatra.

Attempts to improve production by confining the fry in a small area during the first 10 days after stocking to have better access to feed did not produce significant results.

Introduction

Indonesia has the largest area devoted to rice-cum-fish farming in Southeast Asia, in 1984 totalling 114,000 ha (ICLARM, 1987). Although rice-cum-fish farming is found nation-wide, it is most commonly practiced on the island of Java. Despite the widespread occurence and history, rice-cum-fish farming is poorly documented and remains little understood (Ruddle, 1982).

Sumatra is one of the Indonesian islands which has great potential for rice-cum-fish farming. Sofar the number of farmers engaged in this venture is still limited. Between 1983 to 1986, the Directorate General of Fisheries (DGF) of the Government of Indonesia (GOI) and the United States Agency for International Development (USAID) jointly implemented a rice-cum-fish farming project in Sumatra to promote the industry and increase the farmers' income. The initial target area was Simalungun District, North Sumatra Province.

Simalungun is North Sumatra's rice "bowl" and has the largest potential for fish cultivation in rice fields within the province. The district's rice fields total 45,000 ha (total for the North Sumatra is 59,776 ha) of which 93% are already irrigated and 2,920 ha are proposed for irrigation. The other fisheries resources are 596 ha of ponds, 425 ha irrigation canals; 86 ha small impoundments/reservoirs; 110 ha swamps; 2,149 ha rivers; 8,250 ha lakes (part of lake Toba). Furthermore about 275 sites are identified for running water culture systems (Sinaga, 1983).

Fish culture in rice fields in Simalungun

The two main rice-cum-fish farming systems in Simalungun are summarily described below.

Mina padi (concurrent rice-fish). Prior to 1981, common carp (Cyprinus carpio) fingerlings were generally stocked together with rice and raised for consumption. Few farmers raised fry to fingerlings using the concurrent rice-fish (RF) system. Between March 1980 and August 1982, the Simalungun Fisheries Service initiated the production of fingerlings in farmers' rice fields using the concurrent RF system with a culture period of 28-30 days. The survival rates obtained were generally low and below profitable levels (North Sumatra Fisheries Service, 1982).

In 1983, some farmers produced fingerlings (3-5, 5-8, and 8-12 cm) from fry stage (1-3 cm), using the concurrent RF system. Stocking rates varied between 3 to 30 fry/m². In general, inorganic and organic fertilizers were the main inputs, and sometimes additional feeds were given. Feeds consisted of rice bran, ground corn, cassava, chicken starter feed and cooked or dried rice. Feeding rates varied widely and frequency was very irregular as well. With this RF system farmers usually obtained 2-3 fingerling crops per rice crop with culture periods of 22-24 days.

The palawija ikan and penyelang systems (rotational systems). These systems are more widely practiced than the mina-padi. The palawija ikan system is the production of either one crop of consumable sized fish or 3-4 crops of fingerlings between two rice crops in 2.5-3 months periods. When producing consumable fish, common carp are stocked immediately after rice harvest in rice fields with a water depth of 30-40 cm or deeper. Stocking size and rate ranged from 25-50 g to 75-100 g, and from 1,000 to 2,500 fish/ha. Average production was about 500 kg/ha. A few skilled farmers claimed to harvest 800-900 kg/ha using feeding rates depending on initial size at stocking. An example of feed reported was whole corn grain soaked in water overnight.

In the penyelang system fingerlings are raised in rice fields starting from the initial preparation up to the time of transplanting the rice plants. The usual duration of this culture is 18-20 days. As in mina-padi stocking rates in penyelang systems vary widely (3 to 30 fry/m^2) and mortality rates are usually unknown.

The role of rice fields in the aquaculture systems

The significance of rice fields as a fish production system is depicted in Figure 1. The government and private hatcheries mainly produce common carp fry (1-3 cm). The fry are sold to farmers who raise them to fingerlings, post fingerlings, and grow-out sizes mostly in rice fields. The practice of pure fish culture in rice fields within the rice planting season was stopped by the local government since a rice planting policy to control brown planthopper was implemented in 1983.

This resulted in a tremendous shortage of fish seed with sizes appropriate for stocking in grow-out systems. While the production of fry from the hatcheries was 38 million in 1982, fingerlings in the size classes 3-5 and 5-8 cm were almost non-existent. Under this situation, improvement of seed production techniques in rice fields became imperative.

Within the limits of available resources, dela Cruz (1986) conducted production trials to improve and document the indigenous fingerling production practices in North Sumatra in order (1) to make them transferable to the surrounding areas; (2) to test some locally available feeds to give farmers a choice; and (3) to establish yields and survival rates to help farmers program and operate their seed production activities.

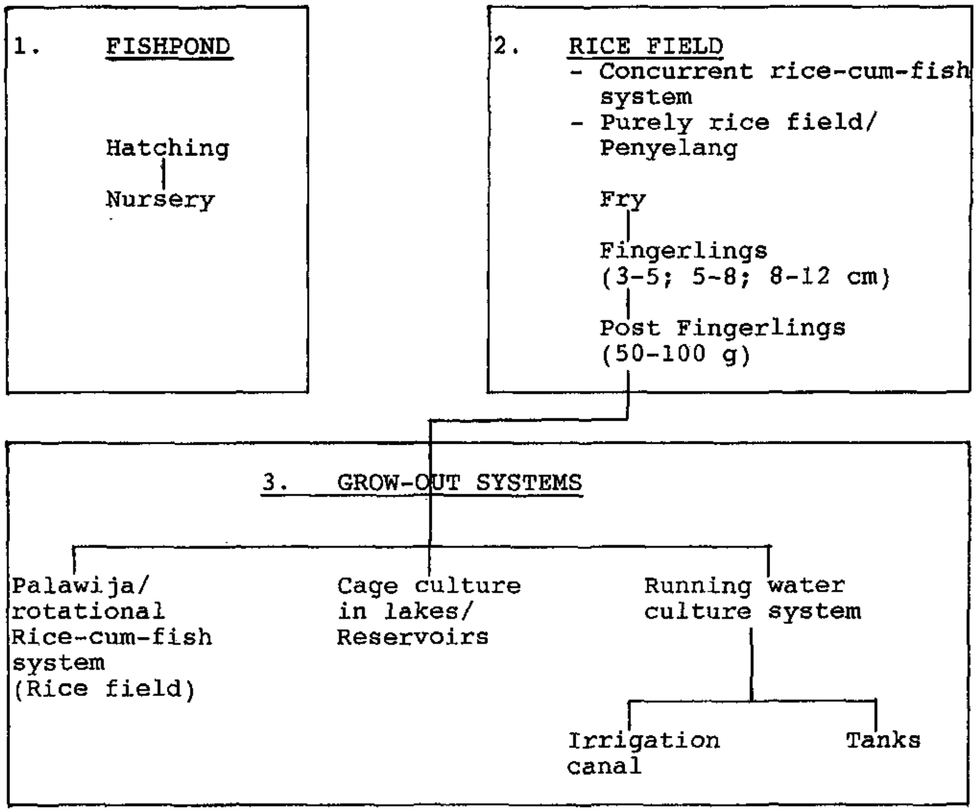

Figure 1. Role of rice fields in the aquaculture systems of North Sumatra.

Methodology

The methodology deviated from formal research procedures. An improved and documented rice-cum-fish farming system had to be developed and demonstrated in farmers' fields within two years. Thus, the procedures and inputs had to be modified whenever necessary.

Fingerling production was executed in rice fields with a concurrent RF system and in rice fields with no rice plants. The former was conducted both on-station (DGF's central fish hatchery, Kerasaan, Simalungun) and on-farm with farmers cooperating, whereas the later was done on-station only.

Rearing of fry to fingerlings was done using various treatments such as different trench designs, different water flow in paddy fields, different sizes of production units, different stocking rates, different feeds and other management inputs. The initial trials produced unexpectedly low and puzzling results in which treatment effects were even negated. These negative results became useful as they pointed the way to an overruling factor namely the predation by aquatic insects, snakes and birds.

Application of the insecticide Sumithion 50 EC produced positive results in minimizing aquatic insect predation (Figure 2). Since then, the regular use of Sumition 50 EC as a technique component was adopted in following trials in both concurrent RF systems and in fields with no rice plants. The design of these trials is given in Table 1. The inputs and the methods are as follows.

Land preparation consisted of plowing, harrowing, and levelling. Trenches of 50 cm wide and 30-40 cm deep were dug in the plots (400-500 m^2). Fine-meshed wire screens were placed at the water inlet and outlet to prevent entry of unwanted fish species and escape of fish stock. Sumithion 50 EC was sprayed one day prior to the stocking of fry. Thereafter, weekly sprayings were applied at concentrations of 0.10-0.15 mg/l active ingredient (a.i.). This concentration was increased to 0.20-0.30 mg/l a.i. during the second fish crop in the concurrent RF system. The culture period of every fish crop was 30 days. Some differences in trial procedures are described below.

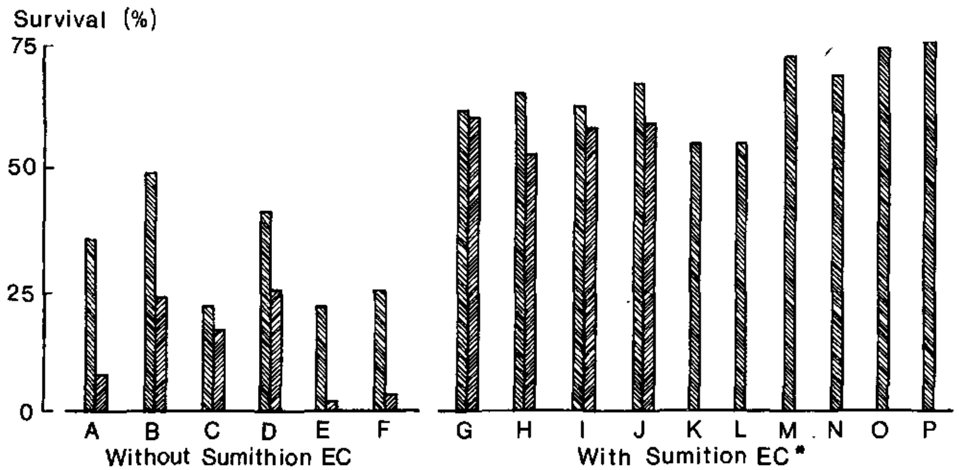

Figure 2. Effect of Sumithion EC application on carp fingerling survival in rice-cum-fish culture.
A-D: Trials with various designs of central and peripheral trenches and catch basins; Feed: rice bran.
E-H: Trials with or without water flow-through; Feed: rice bran mixed with chicken starter mash (RBCM).
I : Trial with water flow-through and no feeding.
J : Trial in farmer's field. Feed: RBCM.
K-P: Trials with 5 or 10 fry/m^2; Feed: 10-30% RBCM of fish biomass (K, L, M, N), 30% crude protein pellets (O), 15% crude protein-RBCM (P).
Trials A-J in concurrent rice-fish systems (2 bars indicate 2 fish crops per rice crop).
Trials K-P in rice fields without rice plants *
except K and L, where no Sumithion EC was applied.

Concurrent rice-fish system

Center trenches, or combinations of peripheral with either center or diagonal trenches were used. In farmers' fields of 1500-2000 m^2 area parallel inner trenches were constructed 15-20 m apart. During land preparation, a pre-emergent herbicide was applied in 3-4 cm water depth two days before rice planting. The water was drained one day after application. Application of mixed trisuperphosphate (TSP) and urea (400 kg/ha) with Curaterr 3G (34 kg/ha) followed prior to planting the IR 46 rice seedlings.

Carp fry (1-3 cm or 0.05-0.10 g) were stocked 20 days after rice planting to enable the plants to develop tillers. Water depth was maintained at 5-10 cm. Flow-through of water happened daily from 8.00 A.M. to 1.00 P.M.

Immediately after the first fingerling crop, fry for the second production cycle were stocked. Water depth was increased gradually to 15-20 cm during the second fish crop. The feed and feeding method was the same in both crops.

Table 1. The fingerling production trials, treatments, stocking rates and feeds.

Trial	Treatment	Stocking rates, fry/m^2	Remarks
Concurent Rice-Fish System			Feed: mixed rice brand and starter mash at 1:1 ratio (RBCM)
1) Effect of water flow and feeding	Flow through + feeding	5	given once daily at 10-152 of fish
	no flow + feeding	5	biomass adjusted
	flow through + no feed	5	every 10 days
2) Effect of area of production	500- 700 m2	4-5	trial in 12 farmer's field
	900-1100 m2	4-5	same inputs and procedure
	1500-2000 m2	4-5	as on-station trial
Fingerling production in rice field (no rice plants)			
1) Effect of insecticide	with Sumithion 50 EC	5 and 10	trials with and without insec ticide done in sequence due to limited plots; fed with RBCM at 10% of fish biomass during first fish crop; then increased to 30% in subsequent crops.
	without Sumithion 50 EC	5 and 10	

			Feed adjusted every 10 days.
2) Profitability of high protein feed	15% crude protein (CP) 30% crude protein	10	feeds: RBCM, 15% CP given at 30% of fish biomass adjusted every 10 days; and formulated feed 30% CP; given at 50% sliding down to 12.5% adjusted every 2 days
3) Improving survival by confining fry in small area	fry stocked in whole plot area fry stocked in 10% of plot area	10 10	confining fry for 10 days done by fencing off 10% of the area; commer cial feed (16% CP) given at 50-12.5% adjusted every 5 days.

Fingerling production in rice fields without rice plants

Only two plots without rice plants were used repeatedly following the same culture procedures to obtain 2-4 replications over time. Water depth was maintained at 30-40 cm in all the trials. The first application of organic or inorganic fertilizer and lime was done 3-4 days before fish stocking. Chicken manure was applied every two weeks at 800-950 kg/ha in those trials where no insecticide application was done.

For the trials treated with insecticide, land was prepared once for every three fish crops. After every harvest aquatic weeds were removed from the plots and dikes and screens were repaired. Each plot received a single gift of 70 kg/ha TSP and 70 kg/ha urea. Lime was applied as soil conditioner at 90-95 kg/ha. Feeds and feeding rates are given in Table 1.

Results and discussion

Concurrent rice-fish (RF)system

Effect of water flow and feeding. Fish survival significantly improved in the first and second fish crops as shown in Table 2. This was attributed to the spraying of Sumithion 50 EC which decreased the predation by aquatic insects. Although some adult aquatic insects were not killed by the insecticide, the weekly spraying seemed to affect their predatory behaviour. It was observed that adult aquatic insects such as the great diving beetle, the water bug, and the water scorpion got out of the water just after spraying. Birds and snakes were not affected and were numerous as usual.

There were no significant differences in fish survival between the 3 treatments (flow-through + feeding, no flow-through + feeding, and flow-through + no feeding). It appeared that water flow through in the plots during daytime (8.00 A.M to 1.00 P.M.) had no advantage over no flow-through of water. The later practice is recommended in order to save water and probably nutrients.

There was a significant difference between the sizes of fish in the treatments. The size distribution (Table 2) indicates that the largest size of fingerlings was obtained in the flow-through + feeding treatment and the smallest in the flow-through + no feeding treatment. The data suggest that the natural food carried by the inflowing water was not sufficient to sustain good growth and that feeding should be applied to ensure food availability.

As far as the fish component in the RF culture is concerned, flow-through and no flow of water may be practiced depending on water availability. Flow-through conveys natural fish food from outside and also minimizes water temperature fluctuation especially when rice is newly transplanted and on extremely hot days. However, good water screens should be provided to minimize fish losses. When comtinuous flow of water is not possible, maintenance of a proper water level will render the production unaffected.

Effect of production unit size. The highest mean survival from the two fish crops was obtained in the smallest area group (Table 3). The difference in survival among the area groups did not show during the first but during the second culture cycle. More consistent yields were obtained in the 500-700 m² group. Variation can be attributed to predation by snakes/birds and to differences in skill of the farmers. The results suggest that greater success can be obtained by using small production units. As the area becomes larger, the chance of success tends to decrease.

Table 2. Effect of water flow and feeding in fingerling production in rice-fish culture with spraying of Sumithion 50 EC. Figures are means of three replicates.

Harvest (1985)	Treatment	Total no.of fish	size class composition(%) 3-5	5-8	8-12	Survival (%)
First harvest (Jan.5-8)	Flow-through + feeding	1409	45.2	53.4	1.4	61.6
	No flow-through + feeding	1476	52.9	46.3	0.8	64.9
	Flow-through + no feeding	1486	71.6	28.1	0.3	62.4
Second harvest (Feb. 12-16)	Flow-through + feeding	1389	85.9	13.8	0.3	60.6
	No flow-through + feeding	1179	88.3	11.5	0.2	52.4
	Flow-through + no feeding	1381	92.1	6.9	1.0	57.9

Table 3. Fingerling survival from rice-fish (RF) systems in farmers fields (Aug - Sept. 1984). Figures are means of four farmers. Coefficient of variation in parenthesis.

Area group (m^2)	Survival (%) First harvest	Second harvest
500 - 700	67.0 (4.4)	58.7 (28.0)
900 -1100	47.9 (30.4)	38.9 (69.8)
1500 -2000	53.6 (23.0)	15.7 (79.3)

Rice fields without rice plants

Trials with and without insecticide. The mean survival rate from the trials with weekly spraying of Sumithion 50 EC was 31% higher than that from the unsprayed trials (Table 4 and 5). However, the mean survival rates between the two stocking densities, did not show a significant difference. The mean standing crops in Table 5 indicate that the stocking density of 10 fry/m^2 increased the yields only by 14% compared to the stocking density of 5 fry/m^2. Comparing the size composition (Table 6), it is apparent that the lower stocking rate resulted in larger fingerlings than the higher stocking rate.

Table 4. Carp fingerling production in rice fields without rice plants and without the application of insecticide.

Stocking density (fry/m2)	Month (1984)	Total no.of fish	size class composition (no.) 3-5 cm	5-8 cm	8-12 cm	Survival (%)
5	June-July	1072	530	540	2	50.5
	Aug -Sept	1208	723	480	5	57.0
	Mean	1140	627	510	3	53.8
10	June-July	2294	2110	182	2	52.0
	Aug -Sept	2484	2276	206	2	56.8
	Mean	2389	2193	194	2	54.4

The two sets of trials are not strictly comparable because of some differences in inputs and in duration of the trials. However, there are strong indications that improvement in survival can be attributed to the regular applications of Sumithion 50 EC. This supports the reported practices in fry nurseries, whereby some organophosphate insecticides (Dipterex, Fumadol, Diazinon, and Sumithion or Agrothion) are being used to reduce cladocerans, copepods and other aquatic insects in order to promote the abundance of rotifers which are the prefered food of fry (Badrudin 1984; Kusumowidjojo 1984; and Bhutta 1984).

Simple profitability analysis on raising fingerlings in rice fields indicated that the stocking density of 10 fry/m^2 is more profitable (by about 54%) than the 5 fry/ha stocking density although the latter has larger-sized fish. The stocking density to be adopted by farmers would depend on market demand. 10 fry/m^2 is more profitable if the price of fish is based on length. If based on weight or if the allowable time to grow fingerlings is limited, a lower stocking density than 10 fry/m^2 is advisable.

Table 5. Yields of fry to fingerling culture in rice fields (without rice plants) and sprayed regularly with Sumithion 50 EC.

Month (1984-1985)	5 fry/m²			10 fry/m²		
	Standing crop		Survival (%)	Standing crop		Survival (%)
	g/plot	kg/ha		g/plot	kg/ha	
Oct-Nov	9721	222	74.8	9246	218	68.2
Nov-Dec	8850	209	79.5	13013	298	88.0
Dec-Jan	7398	169	74.6	6368	150	51.4
Jan-Feb	9225	218	61.3	9610	220	66.0
Mean		205	72.4		222	68.4

Table 6. Mean weight (g) per size group in fry to fingerling culture in rice fields without rice plants and sprayed regularly with Sumithion 50 EC.

Stocking density (Fry/m²)	Month (1984-1985)	Size group (cm)					
		3-5		5-8		8-12	
		Weight (g)	% of total	Weight (g)	% of total	Weight (g)	% of total
	Oct-Nov	3.6	54.4	6.7	40.2	25.7	5.4
	Nov-Dec	3.0	32.6	6.3	67.4		
	Dec-Jan	2.4	37.4	5.8	62.6		
5	Jan-Feb	3.2	49.9	10.9	49.6	25.0	0.5
	Mean	3.0	43.6	7.4	55.0	25.3	
	Oct-Nov	2.5	90.0	8.7	9.5	29.9	0.5
	Nov-Dec	3.0	89.3	6.9	10.7		
10	Dec-Jan	2.3	82.6	5.7	17.4		
	Jan-Feb	2.5	84.3	7.7	15.6	35.0	0.1
	Mean	2.6	86.6	7.3	13.3	32.4	

Profitability of high protein feed. The mean survival of fingerlings was high both for feeding a 15% and 30% crude protein diet (Table 7). The mean values of survival and the size composition by length for the two feeds did not show significant differences. The final biomass for the 30% CP treatment was 36% higher than that of the 15% CP treatment. Since the price of fingerlings is based on length rather than on weight, the advantage of an increased biomass is negated. This implies that the use of low protein feeds such as the rice bran/chicken starter mash is more economical and profitable than high protein feeds.

Table 7. Mean weight (g) of fingerlings in each size group and standing crop at a stocking density of 10 fry/m².

Kind of feed	Month (1985)	Size group (cm) 3-5 (g)	5-8 (g)	8-12 (g)	Standing crop g/plot	kg/ha	Surv. %
30 % CP feed	Mar-Apr	2.1	11.1	32.2	11316	267	72.8
	Apr-May	2.9	8.7	50.0	9881	206	69.7
	May-Jun	2.3	10.5	25.0	9502	217	82.0
	Mean	2.4	10.1	35.7	10223	230	74.6
15 % CP feed	Apr-May	1.6	6.6		6252	127	75.6
	May-Jun	2.4	9.8	30.0	8872	210	75.8
	Mean	2.0	0.2	30.0	7562	169	75.7

Improving survival by confining fish in small areas. There was no significant difference between the treatments with and without a fence in terms of survival rates (Table 8). It was observed that confining the fry in a small area made them more vulnerable to predation by snakes and birds. Therefore a system should be devised to prevent predators from entering.

Table 8. Fingerling production in rice fields without rice plants at a stocking density of 10 fry/m² and 30-days culture period.

Treatment	Replication	Total no. of fish	Size class composition % 3-5 (cm)	5-8 (cm)	8-12 (cm)	Survival %
With fence	1	2882	95.4	4.6	0.0	63.8
	2	2924	96.6	2.9	0.5	62.9
	3	3345	97.3	2.7	0.0	73.2
	Mean	3050	96.4	3.4	0.2	66.6
Without fence	1	2791	97.1	2.9	0.0	60.8
	2	3354	97.3	2.4	0.3	77.3
	3	2953	95.7	4.1	0.2	57.9
	Mean	3033	96.6	3.2	0.2	65.3

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References

Badrudin., 1984. Carp hatchery and nursery technology in Lampung, Jambi and South Sumatra Provinces, Indonesia. p. 18. In: R.C. May, R.S.V. Pullin, & V.G. Jhingran (eds.). Summary report of the Asian Regional Workshop on carp Hatchery and Nursery Technology. ICLARM Conf. Proc. 11.

Bhutta, M.S., 1984. Status of carp hatcheries in Pakistan, p. 21. In: R.C. May, R.S.V. Pullin & V.G. Jhingran (eds.). Summary report of the Asian Regional Workshop on Carp Hatchery and Nursery Technology. ICLARM Conf. Proc. 11.

Cruz, C.R. dela, 1986. Small-scale fisheries development project: Rice-fish culture sub-project. Final report for the DGF, Indonesia and USAID. 226 pp.

ICLARM., 1987. Technical assistance to the International Center for Living Aquatic Resources Management for research on rice-fish farming system. Report for ADB.

Kusumowidjojo, W.H., 1984. Developments in carp hatchery and nursery techniques in Indonesia, p. 17. In: R.C. May, R.S.V. Pullin, & V.G. Jhingran (eds.). Summary report of the Asian Regional Workshop on carp Hatchery and Nursery Technology. ICLARM Conf. Proc. 11.

North Sumatra Fisheries Service., 1982. The 1980/81 and 1981-/82 mina-padi project in North Sumatra. Report. North Sumatra Province, Indonesia.

Ruddle, K., 1982. Traditional integrated farming system and rural development: The example rice field fisheries in Southeast Asia. Agricultural Administration 10 (1982): 1-11.

Sinaga, P., 1983. Concept for the development of fishery in Simalungun District. District Fisheries Service, Simalungun. North Sumatra. Paper.

The growth of "ikan lemak", (<u>Leptobarbus hoeveni</u> Blkr) receiving a pelleted supplemental feed and human excreta in floating cages

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Summary

A potential method for aquaculture development in Riau Province is the culture of fish in floating cages. A study on the growth of ikan lemak (<u>Leptobarbus hoeveni</u>) receiving supplemental feed and human wastes in floating cages was conducted from August 1985 to February 1986 in the Kampar River in Riau Province, Indonesia.

Fish were cultured in two floating cages measuring 4.5m x 4.0 m x 0.6 m, each cage being divided into 6 sections. Above four of the sections, small latrines were constructed to be used by the people who cared for the cages. <u>L. hoeveni</u> averaging 15.7 cm in length and 36.3 g in weight were stocked in each section of the cage at 10 fish/m^2.

The 3 treatments evaluated were (a) supplemental pelleted feed at a ration of 3% of the fresh body weight per day, (b) supplemental feeding with human wastes, and (c) no nutrient input as a control.

The best growth was found with human wastes, length respectively weight increasing with 6.3 cm and 89.6 g. Growth of fish, receiving pelleted feed, was significantly lower (4.4 cm resp. 49.2 g). Lowest growth was observed in the control (3.1 cm resp. 34.1 g), however there was no significant difference between the control and the application of pelleted feed.

Introduction

Riau Province has four big rivers covering 44,600 ha in addition to 43,420 ha of lakes and dams, and 180,810 ha of swampy land (Anonymous, 1982). Most of the people live in the riverine area, and some of them stay on floating houses on the river. Household waste and human excreta are discharged into the river, which might be a source of contamination and pollution.

Productivity of local pond fish culture approximates some 700 kg/ha/year (Anonymous, 1984), whereas the potential yield of inland waters is about 48 kg/ha/year (Fauzi, 1982). However, apart from pond fish culture and fishing, no other commercial culture methods have been developed in the inland waters up to now.

Aware of the above facts, an experiment to develope floating cage culture of <u>L. hoeveni</u> was conducted using human excreta and pellets as inputs in order to find a way to utilize human or household waste to increase the productivity of the water and at the same time to decrease the degree of contamination of the river, which also serves as a water resource for daily consumption for the rural population.

L. hoeveni is a cyprinid species living in the brackish part of the rivers. The fish originates from Sumatra and Kalimantan (Oetomo, 1958). Culture of the species has been tried in the Batanghari river, Jambi (Ondara & Kasim, 1968), and the prospects seem bright. However, fry supply still depends on the availability in nature as it is collected in the river. Using floating cages of 8m x 4m x 1.5m, the production of L. hoeveni in Batanghari river amounted to 27 kg/m^2/year (Zain, 1983). No study, however, has been conducted to use human excreta and household waste or pelleted supplemental feed for L. hoeveni cultured in the floating cages in Riau Province. Therefore, the present study is the first experiment in the province to evaluate the growth of L. hoeveni reared in floating cages and receiving human excreta or a pelleted diet.

Materials and methods

360 L. hoeveni were reared in 12 sections of two bamboo-made floating cages measuring 4.5m x 4m x0.6 m. Each cage was divided into 6 sections of 1.5m x 2m x 0.6 m. Above four sections chosen randomly small laterines were constructed. These laterines were used by a family of eight persons, who cared for the cages, every two persons being a source of human excreta as fish food for each section.

Fish in four other sections were fed with a pelleted supplemental feed at a ration of 5% of their body weight per day, whereas the remaining four sections did not receive any feeding. L. hoeveni averaging 15.7 cm in length and 36.3 g in weight were stocked at a density of 10 fish/m^2. Water quality parameters such as pH, DO, transparency, temperature, etc. were measured at the beginning of each month during the experiment. The composition of the pelleted diet was 12.5% protein, 5.6% fat, 42.6 carbohydrate, the remainder being water, fibre and ash. As pellet ingredients 35% of a concentrate feed and 65% of rice bran were used.

The pelleted feed was given twice a day at 7.30 AM and 4.30 PM, but no special time was fixed for supplying human excreta. Fish were reared for four months. The experiment was executed from August 1985 to February 1986 in the Kampar river at Kampung Pinang village (about 18 km from the University campus in Pekanbaru).

The growth of the fish was measured in weight and in length. The fish condition was analyzed by using the formula:

$K = \frac{10^5 W}{L^3}$, where K is condition factor, W is weight in g, and L is length in cm.

Statistical analysis was carried out using the F-test and the Newmann-Keuls test for determination of significant differences between treatments.

Results and discussion

Growth and condition

The gains in weight and length over the four months period are given in Table 1, which shows that the increase in length as well as in weight is higher for human excreta as compared to pelleted supplemental feed and no supplemental feeding.

The growth response of the fish receiving human excreta proved significantly higher than the other 2 treatments. However, no significant differences existed between pelleted supplemental feed and no supplemental feeding. Hence, the best growth of L. hoeveni was found using human excreta. Length increased by 6.3 cm and weight by 89.6 g. Fish receiving the pelleted supplemental feed grew 4.4 cm and 49.2 g. The lowest growth was observed in the treatment receiving no supplemental inputs, where fish length increased by only 3.1 cm and weight by 34.1 g.

Table 1. Mean incremental weight and length of L.hoeveni at the different treatments.

Replication	Supplemental feed		Human excreta		No supplemental feeding	
	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)	length (cm)
1	65.8	5.8	88.2	6.3	46.2	3.7
2	53.3	4.8	76.2	6.1	23.3	2.1
3	42.5	3.7	81.6	5.9	31.5	3.2
4	35.3	3.1	112.5	6.8	35.3	3.3
Total	196.9	17.4	358.5	25.1	136.3	12.3
Mean	49.2	4.4	89.6	6.3	34.1	3.1

Mean condition factor for the human excreta treatment was 1.18, whereas the treatments pelleted supplemental feed and no supplemental feeding had the same condition factor of 1.05. These differences most probably are due to both the nutritional composition of the feeds and the quantity of the feeds given daily.

The results of the present experiment are somewhat different from other studies (Asmawi, 1984; Rosyadi, 1986; Zain, 1983).

Table 2 indicates that the differences in growth were much due to the size of the fish stocked, the location and the duration of the experiment, and the feed given to the fish. In this experiment the ration of pelleted supplemental feed given per section per day averaged 105 g as compared to some 600 g of human excreta.

Table 2. Growth of ikan lemak (Leptobarbus hoeveni) reared in floating cages in various locations.

Table 2. Growth of ikan lemak (Leptobarbus hoeveni) reared in floating cages in various locations.

Location	Density (fish/m2)	Kind of feed	Rearing period (month)	Initial weight (g)	Final weight (g)	Weight increment (g)	Monthly weight increment (g)	References
Lake, Jambi	55	household waste	12	35.5	199	163.5	13.6	Zain, 1983
Lake, Jambi	16	pellet* (3%/BW/day)	12	36	1579	1513	128.6	Zain, 1983
Kalimantan	50	pellet (15%BW/day)	6	20	400	380	51	Asmawi, 1984
Swamp, Riau	80	pellet (15%BW/day)	3	1.1	4.6	3.5	1.2	Rosyadi, 1986
Swamp, Riau	80	Hydrilla	3	1.2	2.3	1.1	0.4	Rosyadi, 1986
River, Riau	10	human excreta	4	36.3	125.9	89.6	22.4	Present experiment
River, Riau	10	pellet (5%BW/day)	4	36.3	85.5	49.2	12.3	Present experiment
River, Riau	10	no supplemental feeding	4	36.3	70.3	34.1	8.5	Present experiment

* BW = Body weight.

Mortality

The mortality of the fish for each treatment during the experiment is shown in Table 3. In general the mortality was rather low as compared to other experiments (Asmawi, 1984; Rosyadi, 1986 and Zain, 1983). The fish obviously rather well adopted to the natural food, since the treatment without supplemental inputs showed lowest mortality.

Table 3. Mortality of L. hoeveni at each treatment (in percent).

Replication	Supplemental feeding	Human excreta	No supplemental feeding
1	3.3	6.7	3.3
2	6.7	3.3	3.3
3	0.0	6.7	6.7
4	10.0	3.3	0.0
Average	5.0	5.0	3.3

Water quality

The water quality parameters measured are shown in Table 4. Environmental changes as judged from the water quality changes were minimal, except for transparency, stream velocity and water depth due to rain fall.

In view of the data on growth and survival of the fish receiving no nutrient inputs, it can be concluded that the water quality in the Kampar river is suitable for L.hoeveni.

Table 4. Water quality parameters of Kampar River during the experiment.

Parameter	Oct.24, '85	Nov.24, '85	Dec.24, '85	Jan.24, '86	Feb.24, '86
Stream velocity	1.1	1.2	2.0	1.8	2.2
Temperature(°C)	26.1	26.7	25.8	26.6	25.9
Transparency (cm)	45.2	32.6	13.1	15.7	11.9
pH	6.0	6.0	6.0	6.0	6.0
Water depth(m)	2.4	3.1	6.2	4.7	6.4

Conclusions

Pelleted feed and human excreta affect the growth of L. hoeveni reared in floating cage. Statistical analysis showed a significant difference in growth between human excreta and a pelleted supplemental feed. No difference was detected between pelleted supplemental feed and no supplemental feeding.

Although, it is shown that human excreta can increase the production of L. hoeveni reared in floating cages, research on the impact of human excreta on the health of fish and on the health of the consumer is needed.

In view of the differences found between human excreta and pelleted supplemental feed further research in the field of diet composition is required in order to enhance cage culture of L. hoeveni.

References

Anonymous, 1982. Buku Tahunan Statistik Perikanan Tingkat Propinsi 1981. Dinas Perikanan Propinsi Dati I Riau, Pekanbaru, Riau.

Anonymous, 1984. Survai Keadaan Umum Daerah Tingkat I Propinsi Riau. Dinas Perikanan Propinsi Dati I Riau, Pekanbaru, 30 pp.

Asmawi, S., 1984. Pemeliharaan Ikan Dalam Keramba. Gramedia, Jakarta. 82 pp.

Fauzi, 1982. Jenis-jenis Ikan Liar yang Perlu didomestikasi Untuk Pengembangan Aquaculture. TERUBUK IV(12): 2-18.

Oetomo, K.S., 1958. Ikan Jelawat di Kalimantan Timur. Dinas Perikanan Daerah Swatantra Tingkat I Kalimantan, Timur, Samarinda. 26 pp.

Ondara, S. & A. Kasim, 1968. Survey Benih Kelemak (Leptobarbus

hoeveni) di Jambi. LPPD, Laporan No. 35. Bogor. 13 pp.
Rosyadi, 1986. Pengaruh Pemberian Makanan Tambahan Terhadap Pertumbuhan Ikan Lemak (*Leptobarbus hoeveni* Blk.) dan Ikan Pawas (*Osteochilus hasselti* CV.) secara Monokultur dan Polikultur Dalam Keramba di Kolam Percobaan Kulim. Faculty of Fisheries, Thesis University of Riau, Pekanbaru. 86 pp.
Zain, Z., 1983. Pemeliharaan Ikan Kelemak (*Leptobarbus hoeveni* Blk.) Dalam Sangkar Terapung di Danau Mudung, Kecamatan Danau Teluk, Propinsi Dati I Jambi. Laporan Praktek Umum, Faculty of Fisheries, University of Riau, Pekanbaru. 51 pp.

Effect of 'Veluwe' ducks on Oreochromis niloticus recruitment under extensive fish culture conditions

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Summary

An experiment was conducted to test whether 'veluwe' ducks could control tilapia recruitment in a polyculture system comprising Oreochromis niloticus, Cyprinus carpio and Aristichthys nobilis at a 4:3:2 ratio with a total stocking density of 18,000 fish/ha. Ponds were fertilized with duck litter. The ponds were divided into 2 parts by means of net material. In one part of each pond ducks were released from 9.30 h. till 15.00 h. (treatment I), while the other part remained undisturbed (treatment II). At the end of the 154-days culture period, there was no significant difference ($P > 0.05$) between the treatments in terms of total biomass and number of tilapia recruits. The survival of tilapia recruits increased mainly due to the removal by the ducks of insects and amphibians, which prey upon small fish.

Introduction

The production of Oreochromis niloticus (Nile tilapia), a popular freshwater fish in Sri Lanka, decreases substantially due to problems encountered with recruitment. Sex reversal techniques or interbreeding to produce only male offspring are not generally performed as yet.

Fish fingerlings larger than 10 cm are recommended for stocking in duck-cum-fish integrated systems, because of predation of smaller fingerlings by ducks (Woynarovich, 1979; Jhingran & Sharma, 1980). Consequently, ducks may have the potential to control the recruitment of tilapia. In addition ducks might disturb the breeding sites of tilapia as Cyprinus carpio (common carp) does by agitating the substratum. The objective of this study was to evaluate the ability of ,veluwe' ducks to control the recruitment of Nile tilapia.

Materials and methods

The experiment was conducted in two ponds with mud bottoms and cement walls of 80 m² each. Each pond was partitioned into two equal areas of 40 m² with net material, in order to prevent the movement of fish from one area to another and to avoid ducks from entering. A duck house consisting of 4 units, 7 m² each, was situated at the end of the 2 ponds. Ducks from 1 unit could enter 1 part of each pond. The other part of the

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pond was fertilized daily at 15.15 h. with the litter of the other unit containing an equal amount of ducks. The ducks of the 2 units were alternately released. Ducks were released inside the 2 partitioned parts at a rate of 3,000 ducks/ha (12 per pond), daily from 9.30 h till to 15.00 h.

Two weeks prior to stocking both ponds were fertilized with limed duck litter at a rate of 10,000 kg/ha (dry matter basis). The 4 parts were stocked with Nile tilapia (1:1 male-female ratio), bighead carp (Aristichthys nobilis) and common carp (Cyprinus carpio) at 18,000 fish/ha in a 4:2:3 ratio. Water quality parameters and plankton numbers were determined between 4.30 and 5.30 a.m. using the methods as reported by Edirisinghe (1988).

Fish were harvested after 154 days. At stocking and at harvesting individual weights of all fish were taken to the nearest 0.1 g. At stocking Nile tilapia (25-50 g) were visually sexed, while bighead carp and common carp (50-100 g) were introduced without considering the sex. At harvest the total biomass of tilapia recruits of different size classes was taken. A completely randomized block design was used for statistical analysis.

Results

Physico-chemical parameters of pond water were within the suitable range for fish culture. The mean values and standard errors are given in Table 1. Observed low dissolved oxygen (DO) concentration in the morning did not lead to fish kills.

Table 1. Physico-chemical parameters of pond water (mean ± se).

Parameter	Unit	With Ducks	Without Ducks
Temperature (air)	°C	25.6 ± 0.2	25.6 ± 0.2
Temperature (water)	°C	27.3 ± 0.2	27.3 ± 0.2
Conductivity x 10^{-5}	uhos/cm	316.0 ± 3.1	307.0 ± 3.2
DO	mg/l	5.07± 0.13	4.09± 0.2
pH *		7.12± 0.03	7.04± 0.04
Secchi disc visibility	cm	9.8 ± 0.2	10.5 ± 0.3
Total alkalinity	mg/l	101.3 ± 2.5	92.9 ± 2.6
Total nitrogen	mg/l	0.29± 0.01	0.28± 0.01
Total phosphates	mg/l	0.20± 0.00	0.20± 0.00

* Geometric mean

Table 2 gives the details of total particle concentration (debris + phytoplankton + zooplankton), phytoplankton and zooplankton.

Table 2. Plankton density (No. per litre) in different ponds.

Type	With ducks	Without ducks
Total particles x 10^5	37.11 ± 1.80	33.44 ± 1.6
Phytoplankton x 10^5	22.61 ± 0.91	19.04 ± 0.61
Zooplankton x 10^5	4.38 ± 0.33	3.33 ± 0.27

Mean increase in weight of stocked fish, their standard errors and ranges are given in table 3. Table 4 gives the average weight of tilapia recruits of different size classes and their total weight.

Table 3. Mean increase in weight and weight range of fish at the end of the experiment.

Fish species	With ducks		Without ducks	
	Mean ± s.e. (g)	Range (g)	Mean ± s.e. (g)	Range (g)
Bighead carp	56.3 ± 23.7	22.1-105.4	60.9 ± 21.3	29.9-128.4
Common carp	73.1 ± 25.4	38.2-142.5	65.4 ± 20.8	30.5-119.0
Male tilapia	70.0 ± 20.2	39.1-101.4	74.5 ± 17.5	40.7-108.1
Female tilapia	51.8 ± 16.8	30.1- 86.8	56.3 ± 21.8	35.3-138.0
Total tilapia recruits	6143.9 ± 79.48		6038.8 ±101.08	

Weight gain of tilapia, bighead carp, common carp and tilapia recruits did not show significant differences ($P > 0.05$) for the different treatments. However the total weight and number of tilapia recruits was higher in the treatment with 'veluwe' ducks.

Table 4. Weight of tilapia recruits per treatment for different size classes.

Class	No per sample	With ducks		Without ducks	
		Total wt. ± se (g)	Av. wt. (g)	Total wt. ± se (g)	Av. wt. (g)
Extra large	25	-	-	990.2±178.3	47.9
Large	25	1518.3±155.8	31.6	1996.0±323.5	30.7
Medium	50	2249.9±269.1	14.4	1958.7±909.0	21.3
Small	50	2375.7±346.1	7.1	1100.0±737.4	88.3
Total		6143.9± 79.5		6074.9±101.1	

Discussion

Physico-chemical regimes in the two treatments did not show significant differences. Alkalinity, pH and DO values tended to be lower in the parts of the ponds where ducks were not given an access. This might be attributed to lesser agitation of the water in those parts. Furthermore, there was a bloom of Cyanophyceae in one of those replicated parts, during the last week of the culture period. Results indicate that 'veluwe' ducks cannot effectively control tilapia recruitment, since total weigth of tilapia recruits did not show a significant difference ($P > 0.05$) between the treatments. 'Veluwe' ducks stay on water for less than 40% of the total time when they have free access to land and water (Edirinsinghe & Rajaguru, 1985). In this experiment, ducks were kept on water daily from 9.30 h to 15.00 h, which affected their laying behaviour.

Production rates of the treatments with and without ducks are shown in table 5. About 50% of the yield was made up by tilapia recruits.

Table 5. Production rates of the different fish species in the two treatments.

Fish species	With ducks kg/ha/day	Without ducks kg/ha/day
Bighead carp	1.462	1.582
Common carp	2.848	2.548
Tilapia	6.327	6.795
Tilapia recruits	9.974	9.862
Total	20.611	20.787

In Vietnam, fish yield is increased by 400% (Delmendo, 1980), and in Thailand the cost of fish production is reduced (Edwards & Kaepaitoon, 1983) when integrated with ducks. The observed low production rates in this experiment indicate that tilapia recruits have affected the production of all the species. This implicates that tilapia recruits can succesfully compete with other fish species. Edirisinghe (1988) has reported that a production rate of around 21 kg/ha/day was achieved when male tilapia were used in the same polyculture system.

There is no significant difference between the treatments with respect to increase in weight of the three species ($P > 0.05$). This indicates that the presence of ducks in the pond had no direct effect on the production of fish in this polyculture system.

It is evident that stocking of unsexed tilapia is not suitable for pond fish culture. In order to popularize extensive pond fish culture, acceptable methods of producing only male tilapia fingerling should be investigated.

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References

Delmendo, M.N., 1980. A review of intregated livestock-fowl-fish farming systems. In: R.S.V. Pullin & Z.H. Shehadeh (eds.), Integrated agriculture-aquaculture farming systems, ICLARM conference proceedings 4, Manila, Philippines. 59-71.

Edirisinghe, U., 1988. Ducks-fish integration under extensive fish culture, without the use of a fish feed. In: S. Radhakrishna, M.M. Singh & C.R. John (eds.), Proceedings of the second Asian Conference on Technology for Rural Development, Kuala Lumpur. Malaysia, 4-7 Dec. 1985. World Scientific Publishing Co. Pte. Ltd., Singapore. 392-406.

Edirisinghe, U. & Rajagura, A.S.B., 1985. An investigation on the time spent in water by two species of ducks. Proc. Sri Lanka Ass. for the Advancement of Science, 41(1), 48.

Edwards, P. & Kaewapaiton, K., 1983. Integrated fish farming in Thailand. International Centre for Living Aquatic Resources Management News letter, 5(3): 3-4.

Jhingran, V.G. & Sharma, B.K., 1980. Integrated livestock-fish farming in India. In: R.S.V. Pullin & Z.H. Shehadeh (eds.), Integrated agriculture-aquaculture farming systems, ICLARM conference proceedings 4, Manila, Philippines. 135-142.

Woynarovich, E., 1979. The feasibility of combaining animal husbandry with fish farming, with special reference to duck and pig production. In: T.V.R. Pillay & Wm.A. Dill (eds.), Advances in aquaculture. Fishing News Books Ltd., Farnham, Surrey, England. 203-208.

Use of Derris root powder for management of freshwater ponds

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Summary

Use of toxicants is essential for controlling fish predators and competitors in freshwater ponds. In the Philippines, insecticides and teaseed cake are commonly applied for fish pond management. Because of the environmental hazards and import constraints for these materials, there is a need for safer and more practical alternatives.

Roots of *Derris* sp., indigenous plants in the Philippines, contain rotenone which is toxic to fish. Application of coarse and fine *Derris* root powders at 10 and 20 ppm proved effective in killing *Oreochromis niloticus* fingerlings within 1.7 hr in bioassay tests using plastic bags with freshwater. Coarse root powder at 10 ppm applied in an earthen pond killed five species of freshwater fish within 1 hr.

The use of *Derris* root powder as a source of fish toxicant for freshwater pond management is feasible under Philippine conditions because of the availability, practicality and safe features of the material. Production of *Derris* sp. and its utilization are encouraged.

Introduction

The control of fish predators and competitors in ponds is an essential part of management. In the Philippines, the commonly applied fish toxicants for brackishwater pond management are insecticides and saponin from teaseed cake. While materials like teaseed cake are safer to apply because of their biodegradability and selectivity, their supply could be limited in certain countries like the Philippines because of import constraints.

There are indigenous sources of botanical fish toxicants in Southeast Asia. Among these are plants of the genus *Derris* (Family Papilionacea) that contain rotenone, a chemical that has insecticidal and piscicidal properties, in their roots (Duke, 1983). Dried *Derris* root powder contains 4 % rotenone (Tumanda, 1980).

The use of rotenone in commercial formulations as a toxicant for eradication of wild and stunted fish populations in freshwater bodies is widely practiced in the United States (Gilderhus *et al.*, 1986). In the Phillipines, *Derris* roots (tubli) are used by some fishermen for clandestine fishing in open waters. Tumanda (1980) reported that application of *Derris* root powder in brackishwater ponds at 10 ppm proved effective for controlling 14 species of fish. Prawns (*Penaeus monodon* and *P. indicus*) were tolerant to concentrations of upto 30 ppm of the material.

For freshwater management, the use of insecticides is still prevalent in the Philippines for lack of a practical alternative. The use of ammonia is effective and practical (Guerrero et al. 1986), but the chemical, not being a selective toxicant, is inimical to both fish and crustaceans. No published information on the use of Derris root powder for management of freshwater ponds is available in the literature.

Materials and methods

Dry roots of Derris sp. were obtained from the Province of Albay in the Bicol Region of the Philippines. The material was processed into two forms, coarse and fine powder, following the methods of Tee (1976). The roots were chopped into 2-3 cm sizes, oven dried at 60°C and ground in a laboratory pulverizer. Coarse powder was produced using seive no.15 while seive no. 40 was used for the fine powder.

Three concentrations (5, 10 and 20 ppm) of each form were evaluated using Oreochromis niloticus fingerlings, 2 g in average weigth, as test fish. Plastic bags, each with 10 l of tap water and five fingerlings, were used. Each concentration of powder form was replicated twice. The time in minutes required for the death of the fish after addition of the material was recorded. Water temperature was measured.

The concentration that showed promise for field application was tested in the field using a 200 m^2 earthen pond on a commercial fishfarm. After most of the harvestable - sized fish were seined, water was drained to a depth of approximately 0.1 m by means of an axial flow pump.

Coarse root powder at 10 ppm was then applied in the pond by first mixing the material with water in a basin at a proportion of 100 g powder in 50 l of water. After thorough mixing, the solution was spread evenly over the pond surface. A total of 200 g of root powder (200 m x 0.1 m x 10 g) was required for treatment of the pond.

The time in minutes for the appearance of moribund fish after application of the material was recorded. Dead fish were collected, counted and weighed. Pond water temperature was measured.

Results and discussion

Results of the bioassay (Table 1) showed that only 10 and 20 ppm of both Derris powder forms were effective in causing total kills of the test fish in less than 2 hrs at 28°C. No fish were killed at 5 ppm with either powder form beyond 12 hrs.

Fish exposed to the fine root powder at 10 and 20 ppm died faster than those treated with coarse powder at the same concentration. The concentration of 10 ppm of either root powder form was found promising for pond application.

In the pond test, distressed fish were observed 5 to 60 minutes after application of the material at 29°C. O.niloticus fingerlings were the first to be affected followed by Channa striata adults, Trichogaster pectoralis juveniles, Poecilia reticulata adults and a Clarias batrachus adult (Table 2). The results indicated a varying response of the fish to the material depending on species. O.niloticus appeared to be the most vulnerable of the five species.

Table 1. Effect of two forms of *Derris* root powder at three concentrations on *O.niloticus* fingerlings in plastic bags.

Material	Concentration (ppm)	Time lapse for total kill (min)
	5	720 >*
Fine	10	37
	20	35
Coarse	5	720 >*
	10	104
	20	71

* No death beyond 12 h.

Table 2. Effect of *Derris* root powder (coarse) at 10 ppm on freshwater fish in an earthen pond.

Species killed	Number	Total weight (g)	Time lapse (min)
O.niloticus fingerlings	30	80	5
C.striata adults	2	430	20
T.pectoralis juveniles	3	70	30
P.reticulata adults	6	5	45
C.batrachus adult	1	400	60

Although rotenone is not readily soluble in water (Tee, 1976), it is apparently active in aqueous solutions as prepared by Tumanda (1980) for brackishwater ponds and in this study. The faster effect of fine root powder compared to the other form can be explained by the greater surface area of the fine particles.

Rotenone inhibits the respiratory process in the gills of fish (Rach & Gingerish, 1986). Its activity is enhanced by temperature. This accounts for the faster response of fish to the test material in the ponds compared to that in the plastic bags.

Our result corroborate those of Tumanda (1980) on the use of *Derris* root powder at 10 ppm for control of fish predators and competitors in ponds. His findings also showed that salinity has no effect on the activity of rotenone.

Our study supports the feasibility of using *Derris* root powder for freshwater pond management. Because of its local availability, practicality and safer features compared to chemical insecticides, propagation of Derris sp. should be encouraged and its utilization as fish toxicant promoted.

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References

Duke, J.A., 1983. Handbook of Legumes of world economic importance. Plenum Press, New York. 345 p.

Gilderhus, P.A., J.L. Allen & V.K. Dawson, 1986. Persistence of rotenone in ponds at different temperature. North American Journal of Fisheries Management 6: 129-130.

Guerrero, R.D., L.A. Guerrero & M.E. Alamar, 1986. Use of ammonia as fish toxicant for management of freshwater ponds. Transactions of the National Academy of Science. 8: 151-155

Rach, J.J. & W.H. Gingerich, 1986. Distribution and accumulations of rotenone in tissues of warmwater fishes. Transaction of the American Fisheries Society. 115: 214-219.

Tee, B., 1976. Analysis of rotenone content and toxicity of the powdered roots of the common species of Derris in the Province of Cebu. M.S.thesis, University of San Carlos, Cebu City. Philippines. 51 p.

Tumanda, M., 1980. Effects of rotenone containing Derris root extract on the mortality of some predator fishes of pond culture prawns under different water temperature - salinity combination. M.S.thesis, University of San Carlos, Cebu City, Philippines. 89 p.

Evaluation of some indigenous ingredients as dietary protein sources for catfish (Clarias batrachus, Linnaeus) fry

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Summary

This study aimed to evaluate the suitability of linseed meal, frog waste meal and poultry by-product meal, as partial or complete substitutes for dietary fish meal protein for fry of Asian catfish, Clarias batrachus. All experimental diets contained about 35% protein e.g. 28% from the protein sources to be tested and 7% originating from rice bran, wheat bran and wheat flower. The latter cereal by-products were primarily used as dietary carbohydrate sources.

The following 6 diets were formulated and fed to the fry over a 7 weeks period: diet 1- 28% protein from fish meal (control), diet 2- 14% linseed protein plus 14% fish meal protein, diet 3-14% frog waste meal protein plus 14% fish meal protein, diet 4 - 28% waste meal protein, diet 5- 14% poultry by-product meal protein plus 14% fish meal protein, diet 6- 28% poultry by-product meal protein.

Based on criteria such as feed acceptability, growth, feed conversion and protein utilization, diet 6 showed the best performance and proved to be the cheapest one. The results from diet 2 and 5 did not significantly differ from those obtained with the control diet. The poorest performance was observed with diet 4 followed by diet 3. However, in terms of feed costs and economic return diet 4 still performed better than the control diet and proved comparable to diet 2 and 5.

Introduction

Although Bangladesh has excellent fish culture potential because of its abundant water resources, aquaculture in this country has not made much progress. Lack of technological know-how and unavailability of suitable feeds are the major draw-backs to increase fish production by intensive aquaculture methods. Therefore, studies to formulate suitable feeds for commercially important fish species would constitute an important area of research for the development of aquaculture in the country.

Traditionally, fish meal has been the major source of protein in commercial fish feeds elsewhere in the world. However, the use of fish meal for fish feed is not feasible in Bangladesh because it is not widely available and in any case prohibitively expensive (Hasan, 1986). Therefore, it is necessary to use alternative protein sources for fish feeds to boost the aquaculture industry.

In Bangladesh, a large number of indigenous raw materials such as slaughter house waste, poultry by-product meal, frog waste meal, various oil cakes and cereal by-products are widely available. Many of these ingredients are rich in protein both in quality and quantity. With exception of a few (i.e. oil cakes and cereal by-products), these ingredienst are, however, not being utilized in the country for any production purpose.

Of the many native fish species suitable for aquaculture, the catfish (Clarias batrachus) commonly known as "magur" is one of the most preferred farmed fish in Bangladesh, because of its fast growth rate, high acceptability among consumers, good market value, wide tolerance to temperature and pH, and its disease resistance.

There is a paucity of information on the suitability of indigenous ingredients as dietary protein source for the feeds of catfish fry. However, many of these ingredients have been used successfully as dietary protein source for other fish species, i.e. slaughter house waste meal (Aquaculture Development Coordination Programme (ADCP), 1983), blood meal (Fowler & Banks, 1976; National Research Council (NRC), 1983), poultry by-product meal (Higgs et al., 1978; Alexis et al., 1986; Hurculano, 1987), frog waste meal (Rahman et al., 1982), linseed (Hasan, 1986), groundnut meal (Jackson et al., 1982; Hasan, 1986), sesame meal (Hasan, 1986) and mustard meal (Capper et al., 1982; Hasan, 1986).

The present investigation was designed to evaluate some selected dietary ingredients (linseed, frog waste meal and poultry by-product meal) as alternative protein sources for partial or complete substitution of the fish meal protein in a diet for catfish fry.

Materials and methods

Experimental system and animals

A static indoor rearing system was used to conduct the experiment. 30 Litre capacity rectangular glass aquaria containing 20 litres of water were used as experimental tanks. A stone aerator connected to a compressed air supply was used to maintain an adequate level of dissolved oxygen in each test tank. All tanks were kept on a 1 m high cement platform to facilitate better observation and accessibility.

20 Days old uniformely sized (mean weight 438 mg; SE ± 7.1) Clarias batrachus fry obtained through induced reproduction were used for the present investigation. The fry were supplied by the Department of Aquaculture and Management, Bangladesh Agricultural University, Mymensingh. Prior to the start of the experiment, the fry were acclimated to the laboratory condition for 5 days and fed an artificial diet containing fish meal, rice bran, wheat bran and wheat flour (protein content 40%).

Diet formulation and preparation

Six iso-nitrogenous diets were formulated to evaluate linseed meal, frog waste meal and poultry by-product meal as dietary protein source for catfish fry. In addition to the above protein sources, rice bran, wheat bran and wheat flour were used in all diets as dietary carbohydrate sources. The control diet was prepared with fish meal as the sole source of protein.

Fish meal (grade A) was obtained from Bangladesh Fisheries Development Corporation, Dhaka. Poultry by-product meal was prepared by drying the raw intestines of chickens in sunlight and in a thermostatic oven (W.C. Heraus GmbH, Hanau) at 35-45°C. All parts of the body of Rana tigrina except its hind leg were used for the production of frog waste meal. Raw frog waste was then processed similar to that of poultry by-product meal. Linseed oil cake, rice bran, wheat bran and wheat flour were purchased from the local market.

All dietary ingredients were analysed for proximate composition (Table 1) prior to the formulation of diets. Amino acid contents for fish meal, poultry by-product meal, rice bran and wheat flour were obtained from NRC (1983). Amino acid contents of linseed meal and wheat bran were obtained from Hasan (1986) and of frog waste meal from Rahman et al.(1982). All the diets were formulated to contain 35% protein (Cruz & Laudencia, 1976; NRC, 1983; Chuapoehuk, 1987), 10-12% lipids (NRC, 1983), 5-10% crude fibre (Jauncey & Ross, 1982) and 25-35% digestible carbohydrates. Diets were also formulated to be as iso-caloric as possible. Efforts were made to balance all the essential amino acids. The computation for feed formulation was carried out with a microcomputer (Amstrad PCW 8256) using a spreadsheet (Cracker II-New Star Software Ltd.).

The dietary protein sources tested individually or in combination provided 80% of the protein of the diet and the remaining 20% protein was contributed by rice bran, wheat bran and wheat flour. Both frog waste meal and poultry by-product meal were tested at two inclusion levels (40 and 80% of total protein i.e. 50 and 100% replacement of fish meal protein). Linseed meal was tested at one inclusion level only (40% of total protein). The composition of the experimental diets is presented in Table 2. The proximate analyses and the calculated levels of amino acids of the experimental diets are presented in Table 3 and 4 respectively. Amino acid requirements for channel catfish (Ictalurus punctatus) in a 24% protein diet are given in Table 4 for comparison.

Proximate composition of all diets did not vary considerably with exception of diet 1 (control diet) which contained a higher amount of ash (17.80%). However, this amount of ash is unlikely to have affected the performance of catfish fry.

The diets were prepared by mixing the dry ingredients (ground to pass 0.5 mm seive), followed by the addition of oil and water until a stiff dough was obtained. The moist diet was than extruded through a mincer with a 2.0 mm die. The resulting pellets were then sundried at about 35-45°C. The pellets were ground by hand mortar and seived to obtain particle sizes ranging between 0.5 and 1.0 mm.

Table 1. Proximate composition of dietary ingredients (% dry matter).

Ingredients	Components					
	dry matter	crude protein	crude lipids	crude fibre	ash	nitrogen free extract (NFE)
Fish meal	90.00	57.10	15.30	-	26.67	0.93
Linseed meal	87.14	37.88	11.89	9.00	8.95	32.28
Frog waste meal (FWM)	91.20	68.75	16.48	-	14.85	-
Poultry by-product meal (PBM)	87.22	68.12	25.68	-	6.19	-
Rice bran	91.00	9.02	8.72	30.09	18.33	33.84
Wheat bran	92.65	16.62	3.25	11.33	8.82	59.98
Wheat flour	93.20	12.48	1.32	2.14	2.11	81.95

Table 2. Formulation (% dry weight) and costs per kg of the experimental diets.

Ingredients	Diet number					
	1	2	3	4	5	6
Fish meal	49.00	26.00	24.50	-	24.50	-
Linseed meal	-	38.00	-	-	-	-
Frog-waste meal (FWM)	-	-	20.00	40.00	-	-
Poultry by-product meal (PBM)	-	-	-	-	20.00	40.00
Rice bran	10.00	8.00	10.50	12.00	11.00	12.00
Wheat bran	29.00	18.00	32.00	34.00	33.00	35.00
Wheat flour	10.00	8.00	10.00	11.00	10.00	11.00
Soyabean oil	0.50	0.50	1.50	0.50	0.50	0.50
Cod liver oil	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin premix*	0.50	0.50	0.50	0.50	0.50	0.50
Mineral premix**	0.50	0.50	0.50	0.50	0.50	0.50
Costs/kg diet***	15.15	12.80	12.90	10.17	12.39	9.79

* After Hasan (1986)

** g/100 g mix: $MgSO_4 . 7H_2O$, 127.5 g; KCl, 50.0 g; NaCl, 60.0 g; $CaHPO_4 . 2H_2O$, 727.8 g; $FeSO_4 . 7H_2O$, 25.0 g; $ZnSO_4 . 7H_2O$, 5.5 g; $CuSO_4 . 5H_2O$, 0.785 g; $MnSO_4 . 4H_2O$, 2.54 g; $CuSO_4 . 4H_2O$, 0.478 g; $Ca(10_3)_2 . 6H_2O$, 0.295 g; $CrCI_3 . 6H_2O$, 0.128 g.

*** In Bangladesh Taka (= US $ 0.03).

Table 3. Proximate analysis of the experimental diets (% dry matter).

Nutrient content	Diet number					
	1	2	3	4	5	6
Crude protein	34.10	35.79	36.30	35.66	36.15	35.45
Crude lipids	10.95	9.76	11.00	10.21	10.80	12.12
Crude fibre*	6.51	8.44	7.00	7.70	7.26	7.82
Ash	17.80	13.40	13.40	10.20	11.80	8.40
NFE**	29.43	32.58	31.18	33.47	31.94	34.06
Gross energy (kcal/g)	4.08	4.19	4.28	4.26	4.28	4.45
Metabolizable energy (ME) (kcal/g)	3.49	3.58	3.66	3.64	3.66	3.82
PE ratio***	97.61	100.01	99.24	97.92	98.76	92.91

* Calculated as crude fibre derived from test protein source and other dietary ingredients.

** Calculated as NFE derived from test protein source and other dietary ingredients.

*** Protein to energy ratio in mg protein/kcal of ME.

Table 4. Calculated levels of amino acids in diets and amino acid requirements for channel catfish (*Ictalurus punctatus*) in a 24% protein diet (% dry matter basis) (adapted from Jauncey & Ross, 1982).

Amino acid	Diet number						Require-ments for channel catfish
	1	2	3	4	5	6	
Arginine	2.52	2.48	2.41	2.30	2.30	2.10	1.03
Histidine	0.85	0.73	0.76	0.67	0.68	0.52	0.37
Isoleucine	1.81	1.45	2.03	2.25	1.57	1.35	0.62
Leucine	2.84	2.31	2.82	2.81	2.55	2.30	0.84
Lysine	2.70	1.94	2.61	2.52	2.07	1.49	1.05
Methionine	0.98	0.67	1.18	1.38	0.76	0.55	0.56
Phenyla-lanine	1.55	1.40	1.40	1.26	1.43	1.33	1.20
Threonine	1.61	1.32	2.10	2.59	1.38	1.17	0.53
Tryptopha	0.48	0.47	0.55	0.62	0.40	0.33	0.12
Valine	1.97	1.64	2.01	2.06	1.80	1.65	0.71

Analytical methods

Feed ingredients, experimental diets and fish samples were analysed for their proximate composition by the methods given in Association of Official Analytical Chemists (AOAC) (1970). The gross energy contents of the diets were estimated after Brody (1945, cited by Jauncey, 1982). The metabolizable energy contents (ME) of the diet was calculated using for protein 4.5 kcal/g as reported for trout (Smith, 1971), for lipids 8.51 kcal/kg (Austreng, 1978), and for carbohydrates 3.49 kcal/g as reported for carp by Chiou & Ogino (1975).

Water parameters were monitored in each test tank throughout the experimental period. The temperature and pH were measured daily and dissolved oxygen was measured at weekly intervals. Temperature in °C was measured using a nitrogen filled mercury thermometer, pH by using a Corning pH meter (Model-5) and dissolved oxygen by the azide modification of Winklers method (American Public Health Association et al., 1980). Water quality parameters were more or less similar between different test tanks throughout the experimental period. The ranges of the water quality parameters during the experimental period were for temperature 25.0-30.5°C; for pH 6.0-7.7; for dissolved oxygen 4.0-7.1 mg/l.

Experimental procedure

Catfish fry were randomly distributed at a density of twenty fish per tank and duplicate tanks were used for each experimental diet. All fish were fed thrice daily at four hourly intervals between 09.00 and 17.00 hours at a fixed ration of 5% body weight per day. The feeds were slowly administered into the tanks and the feeding behaviour and acceptability of the diets were observed. The experiment lasted for 7 weeks. The total biomass of the fish from each tank were weighed at weekly intervals and the feeding rates were adjusted accordingly. To maintain good water quality, water was changed in each tank at weekly intervals. On termination of the experiment the fish were weighed individually and mean weight for each tank was calculated.

Analysis of experimental data

Specific growth rate (ln final body weight - ln initial body weight/time) x 100, feed conversion ratio (dry food fed/live weight gain) and protein efficiency ratio (live weight gain/-protein intake) were calculated. Comparison of treatment means was carried out using one-way analysis of variance (Annova), followed by testing for pairwise differences using Duncan's new multiple range test (Steel & Torrie, 1960). For comparison of mortalities between treatment values, percentage mortality was subjected to arcsin transformation (Zar, 1974) and the resulting data were subjected to analysis of variance as above.

Economic evaluation

An economic analysis was performed to estimate the costs of feed to raise a unit biomass of fish. Costs of feed was used as single economic criterion on the assumption that all other operating costs for commercial fish production will remain the same for all diets. The approximate costs of each diet tested was first calculated on the basis of Mymensingh wholesale market prices (1987) of all the dietary ingredients used. The costs of different dietary ingredients (in Taka/kg) were as follows: - fish meal - 15.00; linseed meal - 5.00; frog waste meal - 6.00; poultry by-product meal - 5.00; rice bran - 3.00; wheat bran - 4.00; wheat flour - 6.50; soyabean oil - 25.00; cod liver oil - 20.00/100 ml; mineral mix - 35.00/100 g and vitamin mix- 35.00/100 g. An additional 7.5% on top of the total costs of the raw materials has been included for manufacturing costs, marketing expenses and operation margins (ADCP, 1983).

Results

The fish became accustomed to the experimental diets within two to three days after the start of feeding. However, the acceptability of all diets was not equal. The control diet (diet 1) and the diet containing linseed meal (diet 2) were generally quite acceptable, but diets with frog waste meal (diets 3 and 4) showed poor acceptability. Diets containing poultry by-product meal (diets 5 and 6) were initially less acceptable, but after 7-10 days fishes were found to feed actively on both these diets.

Fish mortality occured due to cannibalism as well as to natural mortality. Mortality ranged from 15.0 to 27.5% (Table 5) and were not significantly different ($P > 0.05$; Annova) between treatment groups. The growth responses of catfish fry are presented in Table 5 and shown graphically in Fig.1. There were no statistically significant differences in the initial weights of the fish stocked in the various treatments but the performances differed significantly (P <0.01; Annova) in terms of mean final weight, weight gain and specific growth rate.

Table 5. Mortality, growth, feed utilization, costs per kg weight gain and carcass composition of <u>Clarias batrachus</u> fry.

Mean values	Diet number 1	2	3	4	5	6	±SE*
Initial body weight (mg)	440	452	451	435	411	440	19.14
Final body weight (mg)	1668b**	1715[b]	1370[bc]	1125[c]	1613[b]	2148[a]	107.68
Weight gain(mg)	1228[b]	1263[b]	919[bc]	690[c]	1202[b]	1708[a]	99.13
% mortality	17.5	22.5	27.5	25.0	15.0	20.0	4.25
Specific growth rate (%)	2.72[b]	2.72[b]	2.26[c]	1.94[c]	2.79[b]	3.23[a]	0.12
SGR as % control	100.00	100.00	83.46	71.80	102.63	119.17	
Feed conversion ratio	1.64[ab]	1.62[ab]	1.96[bc]	2.16[c]	1.68[ab]	1.30[a]	0.13
Protein efficiency ratio	1.62[ab]	1.57[bc]	1.27[bc]	1.18[c]	1.49[bc]	1.97[a]	0.11
Cost of diet/kg weight gain (Taka)	24.85	20.74	25.28	21.97	20.82	12.73	
Carcass composition (% wet weight)							
Moisture	76.80	77.80	78.00	76.30	76.40	76.40	
Crude protein	14.08	14.30	14.49	14.12	14.67	14.53	
Lipid	3.92	3.30	2.11	2.48	2.73	2.60	
Ash	5.20	4.60	5.40	6.60	6.20	6.40	

* Standard error of treatment mean, calculated from residual mean square in the analysis of variance.

** Figures in the same row with same superscripts are not significantly different (P >0.05; Dunkan's test).

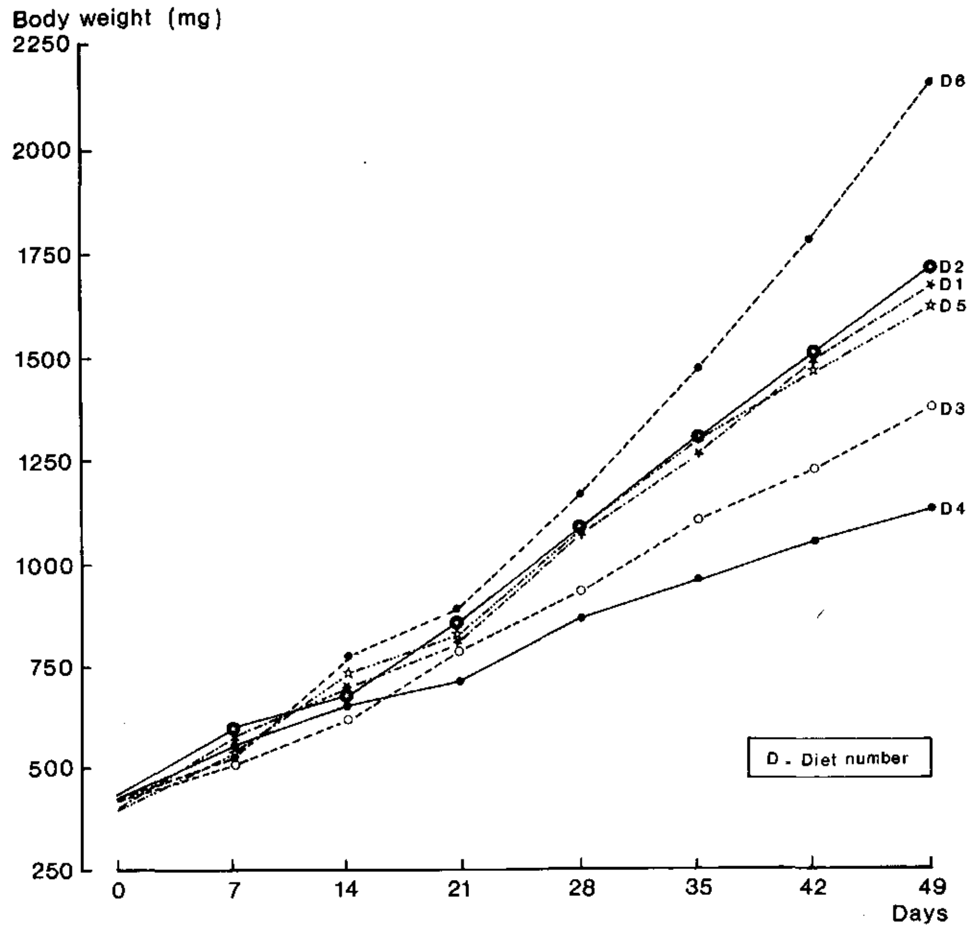

Figure 1. Growth responses of catfish fry at different dietary treatments.

The figure shows that in the first two weeks growth was more or less similar but from the third week onwards a variation in the growth response appeared and a clear trend was established up from the fourth week. The best growth response (SGR 3.23%) was recorded for diet 6 (80% protein from PBM) followed by diet 5 (40% protein from PBM) and diets 1 (control) and 2 (40% protein from linseed meal). However, the growth response for diets 5 (SGR 2.79%) and 2 (SGR 2.72%) were not significantly (P >0.05; Duncan's test) different from the control (SGR 2.72%). The poorest growth was observed at diet 4 (80% FWM protein) followed by diet 3 (40% FWM protein).

Feed conversion ratios (FCRs) for the various test diets are presented in Table 5. Diet 6 gave the lowest FCR (1.30), although this was not significantly different (P >0.05) from diet 2 (FCR 1.62), diet 1 (FCR 1.64) and diet 5 (FCR 1.68). Diet 4 (80% FWM) showed the poorest FCR (2.16).

The level of protein utilization for the different dietary protein sources fed to the catfish fry were evaluated in terms of protein efficiency ratio (PER). The highest PER value

(1.97) was obtained for diet 6 and the lowest value (1.18) was observed for diet 4 (Table 5).

The carcass compositions of the experimental fish at the end of feeding trial are shown in Table 5. The moisture (76.4-77.8%) and crude protein (14.08-14.67%) contents of the carcasses were more or less similar between different treatment groups. However, there exists some variation in lipid (2.11-3.9%) and ash (4.6-6.6%) content but these do not indicate any clear trend.

The estimated total costs per kg of feed and the costs of feed to produce a kg weight of catfish fry are showen in Table 3 and 5 respectively. The cost analysis shows both in terms of costs of the diet and costs of the feed per kg weight gain, the control diet to be the most expensive and diet 6 the cheapest one. Though in terms of growth, feed conversion and protein utilization the poorest performance was observed for diet 4. However, diet 4 performed better than the control diet and proved comparable to diets 2 and 5 in terms of feed costs and economic return.

Discussion

The results of the present investigation indicate that poultry by-product meal at a higher inclusion level (80% of protein) is a very good dietary protein source for catfish fry. The reason for this better performance even in comparison with a fish meal based control diet is nor clearly understood. The high acceptability of this diet may be one of the contributing factors for the excellent growth response and feed utilization. However, the differences in feed acceptability do not sufficiently explain the large differences in growth and feed utilization. The poultry by-product meal is remarkably rich in vitamin choline (Gohl, 1981) and therefore, it may be another contributing factor for its excellent performance as fish feed. The finding of the present investigation supports the observation reported by Alexis et al., (1985), who recorded a better performance of rainbow trout if the fish meal contained in their diets was partially substituted by poultry by-product meal. Similarly poultry by-product meal has also been succesfully used as a partial or complete replacement of fish meal in the feeds of rainbow trout (Tiews et al., 1976; Alexis et al., 1986), coho salmon (Higgs et al., 1978) and tambaqui, Colosoma macropomum (Hurculano, 1987).

Growth, feed conversion and protein utilization values of catfish fry fed diet 2 (40% linseed meal protein) were not significantly different from those of fish receiving the control diet. The efficiency of linseed meal as dietary protein source for common carp fry has been demonstrated by Hasan (1986). The author noted that amongst several ingredients (mustard, sesame, copra, leucaena and groundnut meals) tested as partial substitution for fish meal protein, linseed and groundnut meal resulted in comparable growth and feed utilization values as the fish meal based control diet.

The poor performance of catfish fry at diets containing frog waste meal may be attributed to poor acceptability of the diets. The calculated amino acid content in both the diets were either similar or higher compared to the amino acid contents of other diets and above the amino acid requirement levels for channel catfish. The above finding is in contrast with the results reported for Oreochromis niloticus (Rahman, 1983) and for Heteropneustes fossilis (Rahman et al., 1982). In both cases frog waste meal as a protein source gave superior growth in comparison with fish meal. However, in both studies the ingredients were not individually evaluated as a source of protein and feeds were formulated by varying the ingredient composition as well as the protein content. Therefore, the better growth responses in those studies might have been due to the higher protein content in the diet rather than the effect of frog meal as a protein source. Therefore, further investigation is needed to reach a definite conclusion.

The fish meal based control diet was found to be the most expensive and diet 6 (80% PBM) to be the cheapest one, both in terms of costs of feed and the economic return. Therefore, the study demonstrated that the use of poultry by-product meal as complete substitution of fish meal provides a significant economic advantage in the production of catfish fry.

The economic analysis also points out that the costs of cod liver oil and mineral and vitamin premixes account for about 30-50% of the total raw material costs. Therefore, the costs of these diets may be substantially reduced by using a cheaper source of lipids and by reducing the inclusion level of mineral and vitamin premixes. FAO Regional Lead Centre for Aquaculture in India recommended the use of 0.3% table salt, 0.1% trace minerals and 0.1% vitamin mixture for test diets of major carp fry, fingerling and brood fish (ADCP, 1983).

Dietary lipids act as a source of energy as well as a source of essential fatty acids of both the linolenic (W3) and linoleic (W6) series. Fish oil is a rich source of W3 fatty acids while most of the oil seeds are generally rich in W6 fatty acids. However, among oil seed, linseed is a particularly good source of W3 fatty acids (McDonald et al., 1981; Alexis et al., 1985). Therefore, replacing cod liver by the cheaper linseed oil will reduce the feed costs, apart from fulfilling the requirements for energy and essential fatty acids.

Although poultry by-product meal was found to be an excellent source of protein for catfish fry in terms of growth response, utilization and economic return, further experimentation may be conducted to study its long term growth pattern and eventual histological changes before a definite recommendation can be made.

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References

Alexis, M.N.,Papaparaskeva-Papoutsoglou, E. & Theochari, V., 1985. Formulation of practical diets for rainbow trout (Salmo gairdneri) made by partial or complete substitution of fish meal by poultry by-products and certain plant by-products. Aquaculture, 50: 61-73.

Alexis, M.N., Theochari, V. & Papaparaskeva-Papoutsoglou, E., 1986. Effect of diet composition and protein level on growth, body composition, haemotological characteristics and cost of production of rainbow trout (Salmo gairdneri). Aquaculture, 58: 75-85.

American Public Health Association, American Water Works Association & Water Pollution Control Federation, 1980. Standard Methods for the Examination of Water and Waste-water. 15th edition. American Public Health Association, Washington, DC. 1134 pp.

Aquaculture Development and Coordination Programme, 1983. Fish Feeds and Feeding in Developing Countries, ADCP/REP/83/18. UNDP/FAO, 97 pp.

Association of Official Analytical Chemists, 1970. Official Methods of Analysis of the Association of Official Analytical Chemists. AOAC, Washington, DC. 1015 pp.

Austreng, E., 1978. Digestibility determination in fish using chromicoxide marking and analysis of contents from different segments of the gastrointestinal tract. Aquaculture, 13: 265-272.

Capper, B.S., Wood, J.F. & Jackson, A.J., 1982. The feeding value for carp of two types of mustard seed cake from Nepal. Aquaculture, 29: 373-377.

Chiou, J.Y. & Ogino, C., 1975. Digestibility of starch in carp. Bulletin of Japanese Society for ScientificFisheries, 41: 465-466.

Chuapoehuk, W., 1987. Protein requirements of walking catfish, Clarias batrachus (Linnaeus), fry. Aquaculture, 215-219.

Cruz, E.M. & Laudencia, I.L., 1976. Preliminary study on the protein requirement of Clarias batrachus. Fisheries Research Journal of Philippines, 1: 43-45.

Fowler, L.G. & Banks, J.L., 1976. Animal and vegetable substitutes for fish meal in the Abernathy diet, 1973. Progressive Fish-Culturist, 38: 123-126.

Gohl, B., 1981. Tropical Feeds, Food and Agricultural Organisation of the United Nations, Rome. 528 pp.

Hasan, M.R., 1986. Husbandry factors affecting survival and growth of carp (Cyprinus carpio L.) fry and an evaluation of dietary ingredients available in Bangladesh for the formulation of a carp fry diet. Ph.D.thesis, Institute of Aquaculture, University of Stirling, Scotland. 415 pp.

Herculano, L., 1987. The use of four different diets in experimental cultures of tambaqui, Colossoma macropomum Cuvier 1818. In: J.A.J. Verreth, M. Carillo, S. Zanuy & E.A. Huisman (editors), Aquaculture Research in Latin America. Pudoc, Wageningen, pp. 128-132.

Higgs, D.A., Markert, J.R., Macquarrie, D.W., McBride, J.R., Dosanjh, B.S., Nichols, C. & Hoskins, G., 1978. Development of practical dry diets for coho salmon, Oncorhynchus kisutch, using poultry by-product meal, feather meal, soybean meal and rapeseed meal as major protein sources. In: J.E. Halver & K. Tiews (editors), Finfish Nutrition and Fish Feed Technology, Vol. II., H.Heenemann GmbH & Co, Berlin, 1979. pp. 191-218.

Jackson, A.J., Capper, B.S. & Matty, A.J., 1982. Evaluation of some plant proteins in complete diets for the tilapia Sarotherodon mossambicus. Aquaculture, 27: 97-100.

Jauncey, K., 1982. The effects of varying dietary protein level on the growth, food conversion, protein utilization and body composition of juvenile tilapias (Sarotherodon mossambicus). Aquaculture, 27: 43-54.

Jauncey, K. & Ross, B., 1982. A Guide to Tilapia Feeds and Feeding. Institute of Aquaculture, University of Stirling, Scotland. 111 pp.

McDonald, P., Edwards, R.A. & Greenhalgh, J.F.D., 1981. Animal Nutrition. Longman, London, New York. 479 pp.

National Research Council, 1983. Nutrient Requirement of Warmwater Fishes and Shellfishes. National Academy of Sciences, Washington, DC. 102 pp.

Rahman, M.A., Gheyasuddin, S. & Chakraborty, S.C., 1982. Formulation of quality fish feeds from indigenous raw materials and its effect on the growth of catfish (Heteropneustes fossilis). Bangladesh Journal of Fisheries, 2-5: 65-72.

Rahman, S.M.A., 1983. Studies on intensive culture of Sarotherodon nilotica (Linnaeus) in floating ponds and effects of frog meal supplement on the growth of the same. M.Sc.thesis, Department of Fisheries Biology & Limnology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 89 pp.

Smith, R.R., 1971. A method for measuring digestibility and metabolizable energy of fish feeds. Progressive Fish-Culturist, 33: 132-134.

Steel, R.G.D., 1960. Principles and Products of Statistics. McGraw-Hill Book Company Inc., New York, Toronto & London. 480 pp.

Tiews, K., Gropp, J. & Koops, H., 1976. On the development of optimal rainbow trout pellet feeds. Arch.Fisch Wiss., 27: 1-29.

Zar, J.H., 1974. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ. 620 pp.

Aquacultural research as a tool in international assistance

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Summary

Be it that the global production ratio fish to meat approximates 0.6, the role of fish in many developing countries is more important than this ratio suggests. Since it is more and more realized that capture fishery resources are not unlimited, emphasis has been given to enhancement of aquaculture in order to close the increasing gap between demand for and supply of fish.

Total international assistance to the aquacultural sector amounted to some 370 million US $ over the period 1978-1984. Such an investment is only justified as "a means to an end" e.g. as a means to ultimately contribute to the autonomous growth of the industry.

Against this background the role of aquacultural research is discussed. It is argued that aquacultural research should not only be production oriented, e.g. related to fish, to fish husbandry systems and to fish farming systems, but that research also should be resource oriented and take into account the market (purchasing power and consumer behaviour), the socio-economic feasibility respectively rentability, as well as the adequacy of target groups as future producers. The major challenge to the researcher lays in contributing to the development of those aquacultural operations, which are socially absorbable, economically feasible, and which have a high scope for multiplication in the target area.

Introduction

Total international assistance to fisheries over the period 1978-1984 amounted to US $ 2,566,434,000 of which 14% (US $ 368,000,000) was provided to the aquaculture sector (UNDP/NMDC/FAO, 1987). Over the same period landings from capture fisheries in developing countries increased with some 1.0 million tons per year, whereas the increase in aquacultural production in these countries attained some 0.4 million tons per year (Table 1.).

Table 1. International assistence to the fisheries sector (1978-1984).

	Capture fisheries	Aquaculture
Expenditure (x US $ million)	2,200	368
Production increase (x million tons/annum)	± 1.0	± 0.4

Sources: UNDP/MNDC/FAO, 1987
FAO Yearbooks of Fishery Statistics

Against the background of this financial effort it is stated that international assistance must be regarded as a means to ultimately realize the autonomous existence or growth of the activity concerned. This should also apply to aquacultural research, the more so since "research and development" takes a major share of the global budget allocated to international aquaculture assistance.

In view of this, the following aspects will be touched at in this contribution:

- the role of fish *,
- the role of aquaculture, and
- the role of aquacultural research in international assistance.

<u>The role of fish in developing countries</u>

Products of animal origin - including fish - are of major importance as human food commodities due to their relatively high amount of essential amino-acids. Moreover, a health claim is often attributed to fish consumption in view of fish having high amounts of poly-unsaturated fatty acids compared to husbandry animals.

The share of fish in the total world food production of animal origin is some 12%, the production ratio fish to meat being 0.6 ** (Table 2.). However in many developing countries fish plays a much more important role than these figures suggest, fish protein contributing 25% respectively 31% to the total animal protein consumption in Africa and the planned economies of Asia respectively the Far East, these regions being inhabited by roughly half of the world population.

* the term "fish" includes finfish, shellfish and crustaceans.

** From a consumption point of view this ratio can be set at about 0.45, since somewhat over 20 million tons of fish are processed for fish meal/oil.

Table 2. World production of feed commodities from animal origin (1986).

Milk	521 million tons
Eggs	32 million tons
Meat	155 million tons
Fish	85 million tons

Especially in low-income countries the consumption ratio fish to meat is much higher than 0.6, stressing the fact that fish represents a relatively cheap commodity. Be this the case, per capita fish consumption in these countries is also related to the average per capita income, which stresses the importance of purchasing power as a governing factor in fish consumption (see for more details: Huisman, 1986).

The role of aquaculture in developing countries

In Table 3 the relative contribution of aquaculture to the total fish consumption is given for the different world regions, which indicates that both Asia and - be it to a lesser extent - Europe can be considered as "aquaculture developed" regions, whereas aquaculture in Africa is almost neglegible. Moreover, Table 4 indicates that a major part of the "aquaculture developed" countries do have a domestic fish supply (mainly from capture fisheries) which exceeds domestic fish consumption or, in other words: countries with a high per capita aquaculture production are often net-exporters of fish products (be it fishery or aquacultural products).

Table 3. Relative contribution of the aquaculture production to the fish consumption per region (1985).

Region	Fish consumption (in kg per caput per annum)	Aquaculture production (in kg per caput per annum)	Relative contribution of aquaculture (%)
Asia & Oceania	15.8	2.25	14.2
Latin America	9.8	0.21	2.1
Africa	10.5	0.03	0.3
North America	16.6	0.75	4.5
Europe	18.0	1.57	8.7

Source: Huisman and Machiels, 1986.

Table 4. The world's major aquaculture developed countries.

Country	Fish consumption	Fish catch	Aquaculture production
	(in kg per caput per annum)		
Taiwan	-	-	9.29
Japan	84.6	89.3	4.71
Denmark	48.2	395.2	3.34
Philippines	31.4	31.6	3.10
Israel	17.1	6.7	3.02
Bulgaria	5.5	14.2	2.58
Hungary	3.6	3.1	2.47
Norway	51.5	589.6	1.95
Romania	6.1	7.8	1.86
Hong Kong	49.5	38.2	1.57
Yugoslavia	3.1	2.6	1.31
USSR	25.5	35.7	1.28
India	3.1	3.6	1.24
Indonesia	11.6	12.4	1.24
Sri Lanka	14.1	12.6	1.16

Source: FAO, 1984
Huisman and Machiels, 1986.

Obviously, aquaculture does not serve always, nor exclusively, the objectives of domestic food security, but may have a number - or a mixture - of other objectives as well, like trade and foreign currency objectives, employment objectives and/or objectives to increase the income of rural communities. The following examples may illustrate this;

* The Indonesian shrimp exports accounted for some US $ 280 million in 1986 and government policy aims at enhancing shrimp cultivation for export: a foreign currency objective (Affandi, 1987).
* In Bangladesh shrimp forms the second important export commodity and half of it is cultivated: also a foreign currency objective.
* In Nigeria annual capture fishery landings decreased over the period 1980-1986 with about 60% (± 325,000 tons). This short-fall due to over-fishing and habitat modifications could be compensated by increased imports up to a maximum of ± 250,000 tons. However, these massive importations have ceased - and thereby fish consumption dropped - after the recently implemented monetary restructurization. In view of these developments last year a "Nation-wide Aquaculture Development Programme" has been initiated with the ambitious objective to ultimately restore fish consumption at former levels: a mixture of a food security and a foreign currency savings objective.
* In Ecuador some 100,000 new jobs were created over the past 2 decades in the fast growing shrimp culture in-

dustry: a mixture of an employment and a foreign currency objective.

Whatever the objectives may be, aquaculture development invariably needs either domestic or foreign demand for the food and/or cash crops to be produced.
Based on what has been mentioned before it can be argued that successful aquaculture development asks for a market with purchasing power (income-dependent fish consumption), but it also asks for the commodity fish being already available and accepted, since aquaculture developed countries often are also well developed in capture fisheries (Table 4.). This prerequisite concerning fish availability leads to the theory that fisheries may pave the way for aquaculture via product acceptation and trade respectively market infrastructural facilities.

As has been mentioned in the introduction (inter)national assistance to aquaculture development should ultimately realize a self-sustained and autonomous growth of the industry. In view of such an objective FAO (1984) suggests that assistance to enhance or develop an aquaculture sector should continue till a threshold production level of some 50 to 100 g production per caput per annum has been reached. If such an objective is not aimed at, the question may be asked whether aquaculture directed assistance must not be regarded as an indirect and ineffective form of food aid.

The role of aquacultural research in international assistance

It must realized that execution of aquacultural research should be the outcome of a previous decision making process. First of all on policy-level the question should be answered whether or not more fish is required and for what reason (food security, export, or otherwise). In case this question is answered positively, the strategy to obtain more fish must be decided on: by capture fisheries versus by aquaculture versus by importations. Only if aquaculture is regarded the strategic viable option aquacultural action-research - be it fundamental or applied - should be executed.
In the framework of international assistance the research challenge will often lie in the question "in which form and under what circumstances can aquaculture be implemented in such a way that both economic rentability of the production and demand and purchasing power for the product lead ultimately to an autonomous development of the industry?"
In view of this question a few aspects of aquacultural research will be touched at with emphasis on the role of aquaculture in rural areas.

Fish related research

There is a tremendous need for more knowledge concerning aquaculture species, be it established or promissing candidate species.

- Roughly some 250 different species are in a more or less controlled way cultivated by man (FAO, 1983). However, by far the majority does not reproduce in captivity and only a few can be dependably reproduced on demand throughout the year.
- The knowledge about quantitative and qualitative nutritional requirements of these species is restricted to a small number of established cultured species and this concerns mainly cool and cold water carnivorous ones.
- Research in fish health is often very limited in developing countries. The International Foundation for Science (IFS) at present has financed 196 scientists in its aquacultural programme (IFS, 1988) of whom only 13 in the fish health sector. This is already a large improvement because 2 years before this sector was only represented by 3 out of 150 grantees (Huisman, 1987).

Farming/husbandry system related research

Aquaculture - be it extensive or intensive - is carried out in many different husbandry systems (still water ponds, flow-through ponds, cages, hatcheries, enclosures) and can be encountered in different farming systems (subsistence, industrial, monoculture, polyculture, integrated culture). The choice of the system depends on the knowledge available about the species of concern, the physical-geographical characteristics of the site, the availability and "payability" of inputs, like fertilizer, feeds, capital, labour, energy and expertise.The importance of such a choice can be illustrated as follows. Total energy costs per kg product in an intensive milkfish/prawn culture can be 1,200 times as much as the energy costs of an extensive carp/tilapia polyculture, whereas the farm-gate prices of these products differ "only" by a factor 10 (Pitcher & Hart, 1982). Such differences in required inputs are important to consider in formulating aquacultural development objectives and implementation strategies.

In the framework of introduction of aquaculture in certain target areas the multiplicability of the system to be introduced must be taken into account and this asks for thorough physico-geographical surveys with respect to hydrology and soil characteristics to ensure the feasibility of a snowball-effect.

Market related research

In fact market studies should preceed any aquaculture enhancement or development action, but in reality such studies are mostly limited to declare that there is a need for fish argued on the basis of decreasing catches and/or quantitative or qualitative shortfalls in fish.

In Africa some 90% of all donor funds over the period 1972-1985 (US $ 135 million) was spent for small-scale aquaculture development with the subsistence farmer as target group and improvement of the family diet as main objective (CIFA, 1983; Euroconsult, 1985; Huisman, 1986). However, it should not be forgotten that the cost price of 1 kg cultivated tilapia or catfish almost equals an unskilled labourer's daily wage. For aquaculture development especially in rural areas, there is a major need to identify (future) target consumer groups and to assess their purchasing power, consumer behaviour and preferences.

In most cases cultivated fish will reach the consumer through more or less the same channels as captured fish. However, the market supply of the fishermen has a much wider species variability than that of the aquaculturist. From this it follows logically that a high research effort is put in "species directed husbandry technology". For instance all 196 grantees financed by the IFS-aquaculture programme sofar study over a 100 different species, and in fact many of them devote themselves to "aquaculture candidate identification research". Such a broad diversification can not only be argued from a consumer's preference point of view, but also from a number of other reasons, e.g. avoiding risks of introduction of exotic species, suitability of the species for research purposes, over-exploitation of the natural stock, enlargement of the aquaculture data-base, etc.etc. However, apart from these pro's, there are also con's as follows.

Aquaculture candidate identification asks for answers to species-specific - but often disciplinary identical - questions (e.g. easy reproduction, efficient feed conversion, handling- and disease resistence), and thereby leads to more or less similar research projects. At the same time such a broad species diversification also leads to an exponential growth of research requirements which will be difficult to meet in view of limited resources. It is, therefore, argued that the aquaculture industry would be more efficiently enhanced by limiting species diversification somewhat more in favour of disciplinary specialization.

Economy related research

Economic rentability of the production process has already been advocated as a prerequisite for continuity and autonomous development of aquaculture. In case of luxurious species, like prawns and seabass, such a prerequisite is often met. However, if aquaculture is ment to play a role in a food security strategy for rural areas, the situation is often different. The low purchasing power in many rural areas and concomitantly the low fish prices are often prohibitive to make large investments in rural aquaculture.

In the document of UNDP/NMDC/FAO, (1987) aquaculture development in the Central African Republic is often used as a positive example.However, the cost component of the expatriate experts, involved since 1973, amounts to some US $ 3 per kg cultivated product (Euroconsult, 1985).

In Nepal public funds to operate the aquaculture stations and hatcheries are of such a magnitude that in fact they form a governmental subsidy of US $ 0.55 per kg cultivated fish, the retail price of this fish ranging from US $ 1.0 to US $ 1.5 per kg.

In the Fisheries Research Institute of Malaysia almost half of the total staff work on aquaculture, whereas aquaculture production is only some 10% of the fisheries production (UNDP/NMDC/FAO, 1987).

Such types of "investments" are not necessarily unjustified, but - the more so - they point to the need to ultimately obtain autonomous development of the industry, and at the same time they point to the long term character of such a development.

In this context a remark must be made about the often advertised small-scale approach. Construction costs of small ponds is relatively very expensive (Figure 1.) and certainly does not always justify the optimism about the economic rentability of the small-scale approach. The choice of species, of husbandry- and of farming system seems of more importance to realize economic feasibility in aquaculture operations.

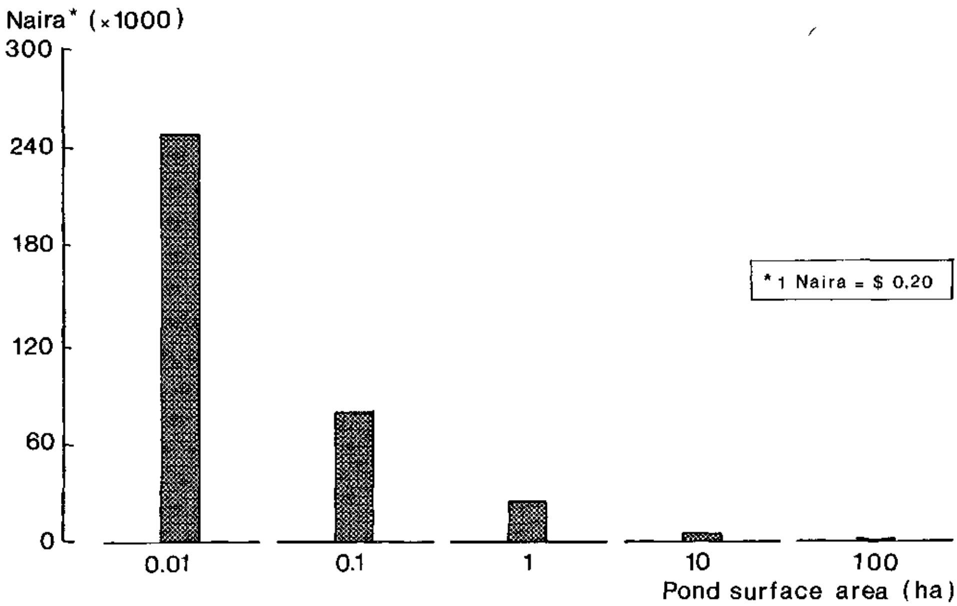

Figure 1. Costs of pond construction per ha relative to pond surface area (Nigeria, 1987).

Producer related research

A main question in aquaculture development is "who is going to culture the fish?". Concerning this a few remarks will be made based on African experiences. Rural development in Africa is mostly directed to the subsistence farmer, who has a rather extensive land-use with relatively low inputs, a low yield per unit of surface area and a rather high diversification in crops, cultivated in a seasonal cycle. In the (semi) humid areas these farmers become fishermen in the dry season, not only because then the fish is easily captured but also because agricultural labour demand is generally low in the dry season.

Since aquaculture in Africa is to quite an extent a novelty (Table 3), a subsistence farmer, who often has an attitude of risk avoidance will not easily trust such a novelty introduction with inherent risks both in production and marketing.

Under such circumstances an aquaculture development strategy should

- include a safety net for the producer, like garanteed selling prices, credit schemes and marketing assistance.
- introduce those types of aquaculture, which can be linked to - and do not compete with - present and accepted agricultural pratices.
- be of long term character and not only have the objectives of biological and technological success but should also include a certain production volume and the economic rentability as objectives to be attained.

Concluding remarks

Based on what has been mentioned sofar it is stressed that both research in aquaculture (species and system related) and research about aquaculture are badly needed to answer the question "in which form and under what set of circumstances can aquaculture be introduced and developed successfully in rural areas?".

Such research inherently has to reconsider the often cited project objectives like family nutrition and diet improvement as well as the direct target groups of subsistence farmers, although both these objectives and target groups can be of great importance in governmental policy concerning aquaculture development.

As has been mentioned, fisheries paves the way for aquaculture. Therefore integration of certain aquacultural operations, like reproduction centers, with existing and accepted forms of fisheries, resulting in so-called "culture based fisheries" could be a better socio-economically absorbable approach in rural areas than aquacultural operations in senso stricto.

In summary, aquacultural research as a tool in international assistance should be fashioned to the needs to develop and implement such forms of aquaculture, which are socially absorbable, economically feasible, linked to - and not competing with - present activities of the target groups and have a high scope for multiplication in the target area, to ensure ultimately autonomous growth of the industry.

References

Affandi, A., 1987. Agriculture development for rural welfare. Ministry of Agriculture, Jakarta, Indonesia. 32 pp.

CIFA, 1983. Aquaculture development. 5th Session of Committee for Inland Fisheries of Africa (CIFA), Cairo, Egypt, 15-20 January 1985. Paper No. CIFA/83/5. 23 pp.
Euroconsult, 1985. The effectiveness of aquaculture projects in Africa. Euroconsult, Arnhem, The Netherlands. 90 pp.
FAO, 1983. Aquis: aquaculture information system, user's manual. ADCP/REP/83/19, FAO, Rome. 76 pp.
FAO, 1984. A study of methodologies for fore-casting aquaculture development. FAO Fish.Techn.Paper No.249. FAO, Rome. 47 pp.
FAO, 1987. The state of food and agriculture, 1986. FAO, Rome. 191 pp.
Huisman, E.A., 1986. Current status and role of aquaculture with special reference to the Africa Region. In: E.A.Huisman (Ed.), Aquaculture Research in the Africa Region. PUDOC, Wageningen, The Netherlands. p. 175-188.
Huisman, E.A., 1987. Aquaculture development and the role of the International Foundation for Science (IFS). In: Colloque Aquaculture et Developpement, Cahiers d'Ethologie Appliqué d'Université de Liège, Belgium. pp. 11-26.
Huisman, E.A. & Machiels, M.A.M., 1986. Fish production for food in the tropics. In: T.G.Taylor & N.K.Jenkins (Eds.), Proceedings of the XIII Int.Congress of Nutrition, Brighton, U.K. John Libbey & Company Ltd., London. pp. 892-896.
IFS, 1988. Directory of grantees, 1974-1987. International Foundation for Science (IFS), Stockholm, Sweden. 110 pp.
Pitcher, T.J. & Hart, P.J.B., 1982. Fisheries ecology. Croom Helm Ltd., London. 414 pp.
UNDP/NMDC/FAO, 1987. Thematic evaluation of aquaculture. United Nations Development Programme, Norwegian Ministry of Development Cooperation and FAO, Rome. 85 pp.

Food and feeding biology of a Malaysian freshwater catfish, *Mystus nemurus* C.& V. with reference to physico-chemical parameters of its natural habitat, Chenderoh reservoir

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Summary

Recently, interest has been increased noticeably for pond culture of *Mystus nemurus* C.& V., which initiated this baseline study of its food and feeding biology, including the water chemistry of the Chenderoh reservoir, a natural habitat of the species in Malaysia.

The Chenderoh reservoir is weakly stratified and oligotrophic with a marked chemocline of dissolved oxygen in the bottom layer of the profundal zone. Temperature, dissolved oxygen, conductivity, pH, total alkalinity and transparency show an insignificant seasonal variation at different sampling stations, their range varying from respectively 27.1 to 30.7°C, 0.5 to 8.0 mg/l, 44 to 55 umhos/cm, 5.7 to 6.9, 14 to 36 mg/l $CaCO_3$ and 0.83-0.93 m. It is suggested that these values represent optimal ranges for both development and growth of this popular freshwater catfish.

Results, furthermore, indicate that the onset of larval exogenous feeding starts with plankton, whereas young of the year mainly predate on crustaceans and insects. Adults predominantly predate on teleosts, followed by crustaceans and insects, aquatic vegetation and detritus being found incidentally.

Introduction

Considerable reduction in capture fishery landings exerts an absolute thrust to increase aquacultural output in Malaysia. This pressing need involves selection of promising and suitable freshwater aquaculture candidates and thorough biological study of such candidates to furnish basic information necessary for their intensive or semi-intensive culture.

During recent times, interest has been growing rapidly for the culture of the indigenous bagrid catfish, *M. nemurus* C.& V., which is found in abundance in certain lakes and reservoirs. Cage culture of the species is increasing in Chenderoh reservoir. Therefore, the present study which includes its food and feeding biology and ecological requirements in its natural habitat was undertaken to extract baseline information necessary for culture and diet formulation.

Materials and methods

Gut content analysis

A total of 267 specimens of M. nemurus was obtained at nearby landing sites of the reservoir (Figure 1) from the fishermen who caught them by hook and line and gill netting. Methods commonly employed for gut contents analysis, frequency of occurence, numerical, and volumetric analysis were adopted (Hynes, 1950; Hyslop, 1980; Lagler, 1956; Windel & Bowen, 1978). The combination of the three methods entails a reasonable appraisal of the kind of food eaten, the number of individuals of each kind of food eaten, and the frequency with which each category of food is eaten.

Physico-chemical parameters

Water samples were collected monthly at three sampling sites in the reservoir during one year (Figure 1). Temperature and dissolved oxygen were determined using an oxygen meter (Yellow Spring Instrument, Model 57), pH was determined using a portable pH-meter (Schott Geräte 817), transparency by Secchi disk, conductivity by a conductivity-salinity meter (Yellow Spring Instrument), and total alkalinity by the titration method. Most of the samplings were done 'in situ' between 09.00 and 12.00 hours.

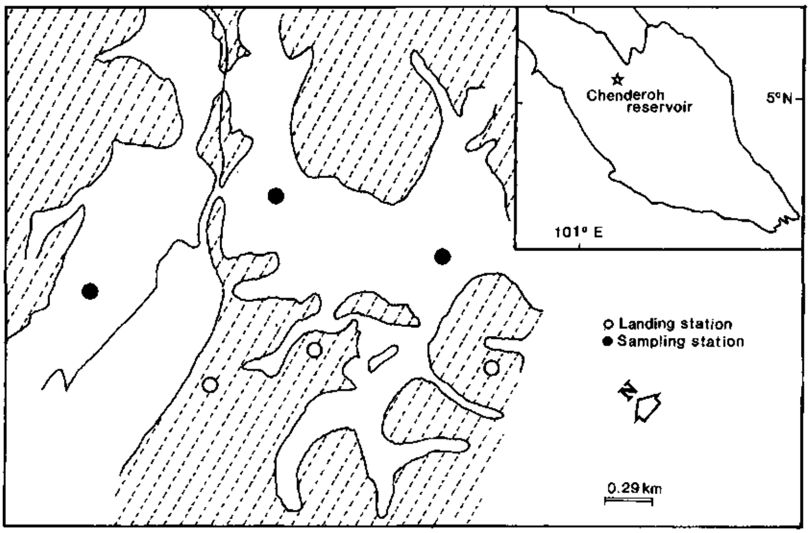

Figure 1. Target area in Chenderoh reservoir showing sampling stations.

Results

Food and feeding biology

Like in other species, functional morphology of the various organs in M. nemurus was closely associated with food intake and digestion. The body was slender and compressed laterally with a flattened ventral side. The edges of the jaws ended in undeveloped, blunt, and cartilaginous lips. The mouth was of the crushing type with strong and wide upper and lower jaw intended for preliminary crumbling of the hard armature of vertebrates. Two pairs of mandibular and maxillary barbels helped, perhaps, in searching for food according to its selectivity. Dentition was villiform and the buccopharyngeal cavity was much enlarged. Gill rakers were few, strong, stubby, and blunt at the end point which indicated an easy exit of algal material. The stomach was sac-shaped, large and had a huge distensibility of two to three times the normal size. Internal musculature of it was hardy which, probably, functioned as macerating or grinding organ.

The results of the gut content analysis showed that teleostomi predominated as major trophic category, followed by arthropods, gastropods, aquatic vegetation, detritals, and offal (Table 1). Aquatic vegetation, detritals and offal, found sporadically, might have been taken accidentally during voracious feeding on animals. Fish scales found in the offal, were abundant in every specimen, up to 27% according to the numerical method. A scale-eating habit, though characteristically found in some species (Sazina, 1984), proved not exclusively and dominant, scales probably being the left over portion of fish which were digested rapidly.

M. nemurus exhibited nocturnal feeding and in day time it used to remain almost sluggish in hideouts. Mizuno et al. (1982) also reported its active predation at night, probably facilitated by barbels and taste buds since feeding by sight is not involved (Khanna, 1968).

The study of the ontogeny of feeding specificity showed that M. nemurus changed principally from consuming crustacea and insects in young fish to teleostomi in the adult ones (Figure 2).

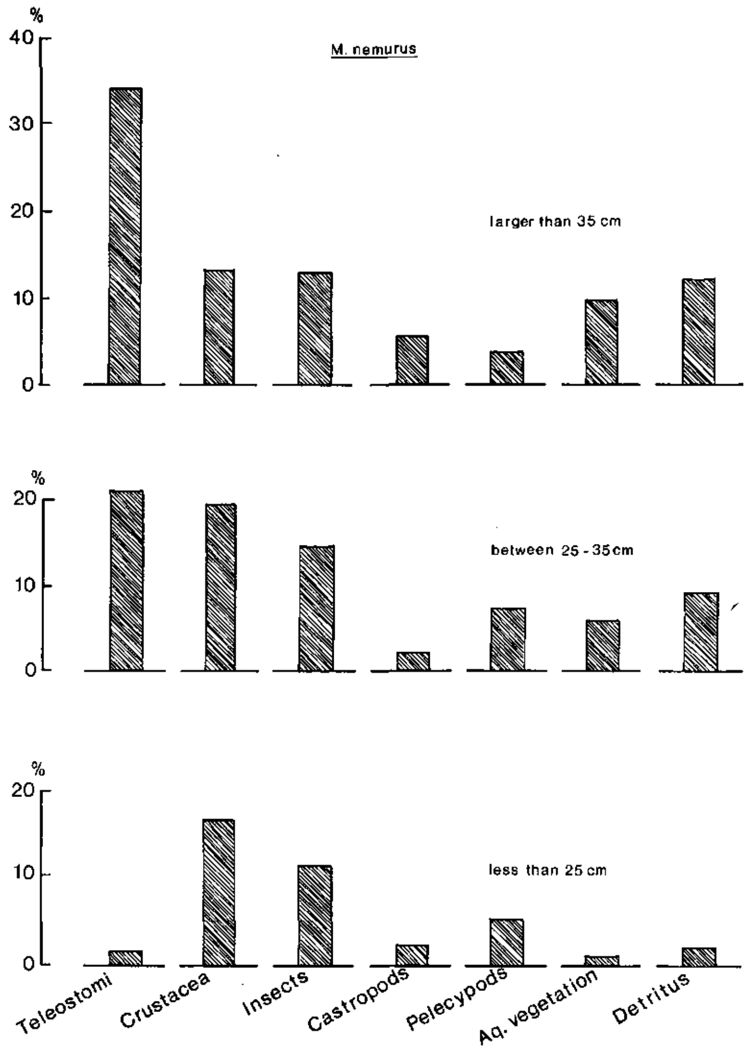

Figure 2. Relative composition of food items in different size groups of M. nemurus.

Table 1. Food and feeding habit analysis of *M.nemurus*.

Food items	Stage of of develop-ment	Numerical method	Percentage frequency of occurence	Volumetric method
Teleostomi				
Oxyeleotris marmoratus	fingerling	63	9.81	76.20
Osteochilus hasselti	mature	4	1.50	45.00
Channa micropeltes	post-larval	33	4.90	5.60
Ompok bimaculatus	juvenile	3	0.75	5.00
Trichogaster trichopterus	adult	3	0.75	6.00
Puntius bulu	maturing	3	1.12	60.00
P.schwanenfeldi	mature	50	9.00	131.00
Fish scale		500	26.41	12.00
Unidentified fish		15	3.77	38.40
Insects				
Beetles (Ceoloptera)		20	5.66	6.80
Dragonfly (Odonata)	larval	30	6.42	8.60
Damselfly (Odonata)	larval		13.21	8.00
Mayfly (Ephemeroptera)	larval	5	1.13	3.20
Hemiptera	larval	5	1.00	3.50
Diptera	larval	40	4.53	2.00
Unidentified aquatic insect	larval	30	7.16	9.00
Crustacea				
Macrobrachium lanchesteri	adult and juvenile	302	50.42	75.00
Mollusc				
Gastropods	unidentified	50	9.43	7.80
Pelecypods	unidentified	60	14.72	8.00
Aquatic vegetation			24.53	15.00
Detritus			15.09	35.00
Offal			3.00	6.00

Physico-chemical parameters

The vertical temperature profile in Chenderoh reservoir, natural habitat of M. nemurus, showed an amplitude from 27.5°C at the bottom to 30.7°C at the surface (Figure 3). Such a weak thermal stratification is virtually common in the tropics which is very unstable and only of a diurnal basis (Ruttner, 1931; Lewis, 1973; Fernando, 1984). At night the temperature profile is reversed which is also of temporary nature. Chenderoh reservoir, as such, can be categorized as a polymictic reservoir.

Lower Secchi depths were recorded during the monsoon and higher ones during the dry season (Figure 3) which, however, was not remarkably defined.

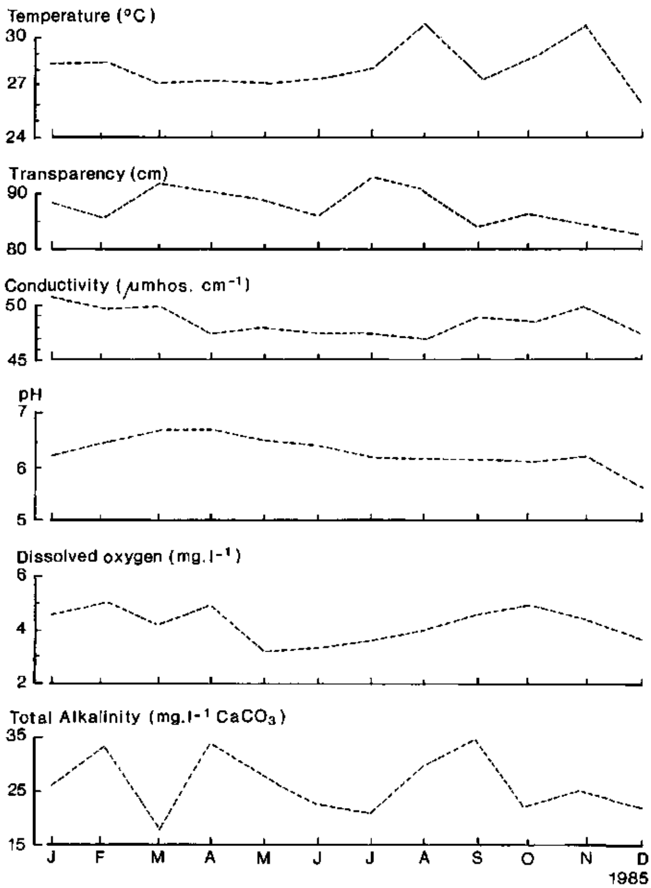

Figure 3. Seasonal variation of water quality parameters. Values are means of the three sampling stations indicated in Figure 1.

Dissolved oxygen (DO) was not strongly fluctuating (Figure 3). The profundal zone was characterized by a marked chemocline of dissolved oxygen which was reported for other reservoirs in Malaysia as well (Lai & Chua, 1976; Arumugam & Furtado, 1980). M. nemurus obviously survives in low dissolved oxygen concentrations.

pH in Chenderoh reservoir was slightly acidic, virtually common to this region (Fernando, 1984). Seasonal variation was small (Figure 3). Fairly uniform values were recorded in the vertical water column. pH proved independent of rainfall.

The water of Chenderoh reservoir is soft because of its relatively low specific conductivity which varied insignificantly with depth and a seasonal variation was hardly present (Figure 3).

Total alkalinity was recorded lowest in March (14 $mg.l^{-1}$ $Ca.CO_3$) and highest in September (36 $mg.l^{-1}$ $CaCO_3$), usually increasing with monsoonal rain (Figure 3). This was, perhaps, due to accumulation of carbonate or bi-carbonate compounds from the watershed during the wet season. Generally total alkalinity in Chenderoh reservoir was lower than those reported by Lai & Chua (1976), Ambak (1984) and Fatimah et al. (1984), which indicated its soft water characteristics.

The insignificant variation of most of the variables mentioned previously largely attributed to the uniform climatic conditions throughout the year in Malyasia.

Discussion

Feeding was extremely voracious in M. nemurus and, as such, a variety of substances were encountered in the gut. Such omnivorous feeding behaviour is documented for many of the catfish species (David, 1963; Thomas, 1966; Sastrawibawa, 1979). The species can be regarded as a promissing aqauculture candidate since it can effectively utilize the bottom organisms and has a diverse feeding regime because of its euryphagous character.

Various physico-chemical parameters in Chenderoh reservoir are common to this region and seem to be conducive to the growth and development of M. nemurus. The most vital parameter, the dissolved oxygen, whose impact on fish life has been broadly discussed by Duodoroff & Shumway (1970), was found within an optimal range (2.9-5.5 $mg.l^{-1}$) for M. nemurus. pH was found slightly acidic, however, a moderate alkalinity acts as an effective buffer system to prevent huge fluctuations of the pH equilibrium in the reservoir.

Acknowledgements

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References

Ambak, M.A., 1984. Fish communities of Paya Bungor with notes on its development, management and recreational use. Ph.D-dissertation, Universiti Pertanian Malaysia, Serdang,

Malyasia, pp. 317.
Arumugam, P.T. & Furtado, J.I., 1980. Physico-chemistry, destratification and nutrient budget of a lowland eutrophicated Malaysian reservoir and its limnological implications. Hydrobiologia, 70: 11-24.
David, A., 1968. Fishery and biology of the Schilbeid catfish, Pangasius pangasius (Ham.) and its utility and propagation in culture ponds. Ind. J. Fish., Section A. 10(2): 521-600.
Duodoroff, P. & Shumway, D.L., 1970. Dissolved oxygen requirements of freshwater fishes. FAO Fish. Tech. Pap. 86. pp. 291.
Fatimah, M.Y., Mohsin, A.K.M. & Mustafa Kamal, A.S., 1984. Physico-chemical parameters of a swamp lake in Malaysia. Malays. App. Biol. 13(1): 115-120.
Fernando, C.H., 1984. Reservoir and lakes in South-East Asia (Oriental region). In: F.B. Taub (editor), Ecosystems of the world 23, Lakes and Reservoirs. Elsevier Science Publishers BV, Amsterdam, The Netherlands. p. 411-442.
Hynes, H,B.N., 1950. The food of freshwater sticklebacks (Gasterosteus aculeatus and Pygosteus pungitus), with a review of methods used in studies of the food of fishes. J. Anim. Ecol. 19: 36-58.
Hyslop, E.J., 1980. Stomach content analysis - a review of their methods and their application. J. Fish Biol. 17: 422-429.
Khanna, S.S., 1968. A study of the bucco-phyryngeal region in some fishes. Ind. J. Zool., 3: 1-48.
Lagler, K.F., 1956. Freshwater Fishery Biology (2nd edition). WMC Brown Company Publishers, Dabuque, Iowa, USA. 421 pp.
Lai, H.C. & Chua, T.C., 1976. Limnological features of Muda and Pedu reservoir with an observation on their suitability for fish culture. Malays. Agric. J. 50(4): 480-501.
Lewis, W.M., 1973. The thermal regime of Lake Lanao (Philippines) and its theoretical implications. Limnol. Oceangr. 18: 200-217.
Mizuno, N., Lim, R.P., Shiraishi, Y., Nagai, M. & Furtado, J.T., 1982. Food habits in Tasek Bera. In: The ecology of a freshwater swamp, J.T. Furtado & S. Mori (editors), Dr.W. Junk Publishers, The Hague, The Netherlands. pp. 346.
Ruttner, F., 1931. Hydrographische und hydrochemische beobachtungen auf Java, Sumatra und Bali. Arch. Hydrobiol. Suppl. 8: 197-454.
Sastrawibawa, S., 1979. Some biological aspects of M. nemurus in Juanda reservoir, West Java. Seameo Regional Centre for Tropical Biology, Bogor, Indonesia. pp. 26.
Sazina, T., 1984. Scale-eating in Characoid and other fishes. In: Evolutionary ecology of neotropical freshwater fishes. Proc. 1st Int. Symp. on systematics and evolutionary ecology of neotropical freshwater fishes, Illinois, USA (1982). T.M. Zarel (editor). 9(2): 83-85. Dr.W.Junk Publishers, The Hague, The Netherlands.
Thomas, J.D., 1966. On the biology of the catfish Clarias senegalensis in a man-made lake in the Ghjanian Savana with particular reference to its feeding habits. J. Zool. 143: 476-514.
Windel, J.T. & Bowen, S.H., 1978. Methods for study of fish diets based on analysis of stomach contents. In: Fish

production in freshwaters. TPB Handbook No. 3, T. Bagenal (editor). Blackwell Scientific Publication: 219-227.

Potential of finfish production in Malaysia

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Summary

Recurrent short falls in landings from capture fisheries emphasize the need to enhance aquaculture production in Malaysia. Greatest constraints, however, are the lack in trained and well-skilled manpower as well as the lack in adequate techniques, both factors being vital for aquaculture development.

Rational aquaculture development asks for a multi- and interdisciplinary approach taking into account biological, physical and socio-economical aspects.

Production systems and management techniques are intricably proportionate to each other and may vary pending type of operation, site characteristics, and other factors.

The present paper deals with both the potential and the various constraints of finfish aquaculture under Malaysian circumstances.

Introduction

Dwindling catch from marine stocks and increasing local consumption force Malaysia to develope aquaculture. The greatest constraints, however, are, the lack of trained manpower and of improved production techniques (Ong, 1983, Pillay, 1983). Management techniques and production systems are highly correlated in mass propagation and production of finfish. However, both vary in extend of operation from one locality to another and even within the locality depending on various biological and physico-chemical parameters. Finfish aquaculture, therefore, calls for cohesive management techniques to achieve its ambitious goal.

Irrelated parameters linked with finfish aquaculture

Aquaculture, no doubt is a high risk bio-industry at any stage of its operation. Sometimes, it is far more an art than a science (Jhingran & Pullin, 1985)

All fish culture management techniques have a common goal, i.e. increased productivity by utilizing carrying capacity to or near the maximum sustainable yield (MSY). This calls for a number of interconnected parameters to be fully understood. Figure 1 exemplifies the way in which an aquaculture production system can be (is) linked to other fields of research e.g. to other production systems.

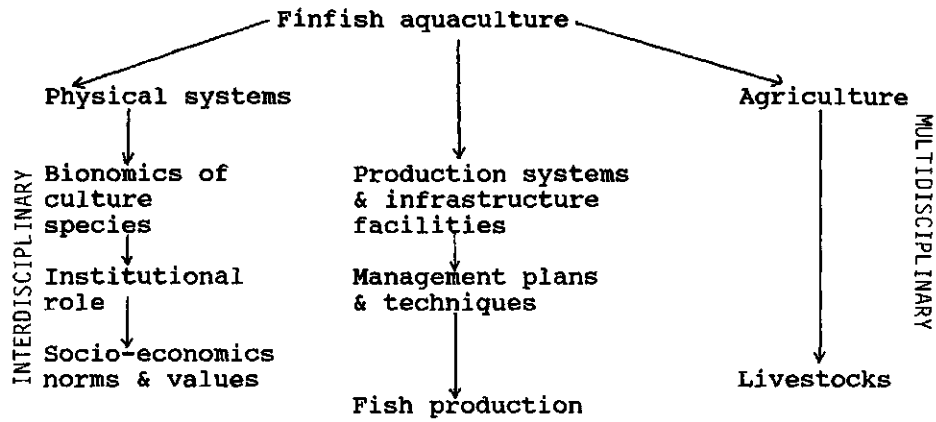

Figure 1. Interdisciplinary and multidisciplinary relations of finfish aquaculture systems.

Management techniques can be broadly classified into four major categories as shown in Figure 2. Hatchery management ususally involves induced spawning, seed production, larval and post-larval rearing, and nutrition of cultured species. Open water management is limited in its application while closed water aquaculture and culture in closed enclosures have great potential. The former involves site selection, stocking rate, adequate tools and equipments, production targets, selection of cultured species, type of husbandry, and level of integration of species etc. which have been comprehensively elaborated by Kovari (1983) and Huisman (1986).

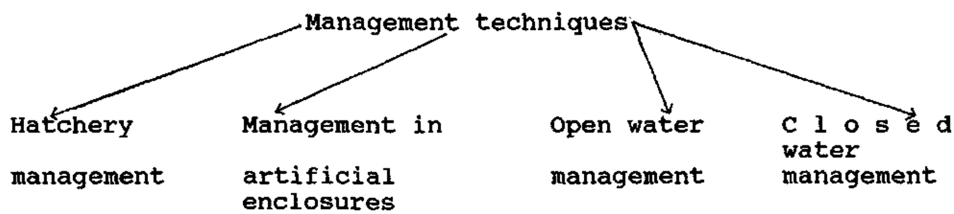

Figure 2. Management techniques in different production systems.

Malaysian perspectives and constraints

At present Malaysian aquaculture is in a period of transition from mainly a subsistence into mainly a commercial industry. This is in contrast to other ASEAN member nations, be it that in a number of them crustacean culture on commercial scale has developed spectacularly during recent years.

Malaysia has a total freshwater area of more than 524,669 ha which consists of rivers, lakes, reservoirs, paddy fields, disused mining pools, and other impounded waters (Low, 1976). Equatorial climate throughout the year favours an uninterrupted biological growth which is an additional advantage in the culture of many of the popular fish species.

Most of the finfish culture systems - grow-out farms in both the private and the public sector - in Malaysia are semi-intensive . The number of commercial finfish farms are few, most probably due to the unattractiveness of freshwater fish as foodfish, lack of patronage and entrepeneurship, and high costs of production. Extensive systems where fish thrive on natural productivity are existent. Management techniques in private and public farms are highly variable. Mono- and polyculture of commercial finfishes have been established while integrated farming is drawing increased attention in view of its low cost management techniques and its suitability for marginal income holders.

Apart from aquaculture development, Malaysian fish production can be enhanced by a rational management of the vast aquatic resources available, e.g. lakes and reservoirs. Stocking and restocking of indigenous and exotic finfish is sporadically executed by the Department of Fisheries. Other options as limitations of the fishing effort (number of boats and licences), catch quota, establishment of closed seasons, and creation of artificial spawning grounds are to be considered. Plans have been made to re-use old tyres as artificial reefs in highly productive estuarine habitats to increase shelter and spawning places for finfish and other aquatic life. The use of cage culture has been advocated as an econimically feasible option to utilize otherwise un-used aquatic resources (Lai & Chua, 1976).

Apart from these perspectives, Malaysia also faces a number of constraints which may hemper to quickly reaping the benefits of its aquatic production potential. Water pollution through agricultural pesticides, industrial and agricultural waste effluents, oil spillage, etc. are main constraints. The large surfaces of sulphate acid soils in the mangrove areas limit the availability of suitable sites for aquaculture development. Last but not least the lack of trained manpower as well as the lack of up to date expertise ask for an integrated approach to improve aquaculture and fisheries oriented research, education and extension.

References

Huisman, E.A., 1985. Current status and role of aquaculture with special reference to the African region. In: Aquaculture Research in the African region. E.A. Huisman (editor): Pudoc, Wageningen, The Netherlands. p. 11-23.

Jhingran, V.G. & Pullin, R.S.VV., 1985. A hatchery manual for the common Chinese and Indian major carps. ICLARM studies and reviews 11, pp. 191.

Kovari, J., 1984. Consideration in the selection of sites for aquaculture. In: Inland aquaculture engineering - lectures

A goat-fish integrated farming system in the Philippines: effects of stocking densities and goat manure loading rates on the yield of *Oreochromis niloticus*

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Summary

Results of a survey revealed that the supply of dietary animal protein in the Philippines is inadequate. Raising goats and developing fish pond management for small-scale farmer families could contribute to minimizing the protein malnutrition. The major constraint for small-scale farmers involved in aquaculture is the shortage and high costs of pond fertilizers and commercial feeds.

The waste of small ruminants like goats has not yet been adequately assessed for their potential use in the integrated agriculture-aquaculture farming system. This study aims to assess the potential use of goat manure as fertilizer and feed in fish ponds stocked with *Oreochromis niloticus*.

Introduction

The new Philippine government seeks to encourage increased and efficient production of basic food commodities and to ensure adequate and continuous supply of basic foods at reasonable prices. In region I of the Philippines, the average farm size per family is only 1.25 hectares. This limited size asks for optimal land utilization in order to produce more food and to obtain self-sufficiency.

Aquaculture provides employment in the region, 21.2% of the total number of employed persons being engaged in fish pond culture. A serious problem for the small-scale farmers is the shortage and high costs of fertilizer and commercial feeds (NEDA, 1985).

Based on these facts, there is a dire need to evolve a development strategy that will benefit the small farmers. One possible solution is an integrated farming system approach.

Integrated farming systems offer several potential advantages e.i., increased productivity, greater income, improved cash flow, fuller employment, a better diet for the farmer and his family and the spread of both biological and economical risks since two subsystems are involved as opposed to one in a single commodity farming system (Edwards, 1986).

The integration of goats with tilapia production might be a way to establish a sustainable farming system that aims to maximize productivity and to minimize operational costs. There is a great potential for this kind of intergration because the regional demand for milk and meat is high. The importance of goat in many developing countries is now being recognized but this is not yet reflected in any widespread integration with fish culture as cited by Little & Muir (1987).

Goat is the number one delicacy of Ilocanos. PCARRD (1982) revealed that 99% of the goat population in the Philippines is in the hands of small farmers. In addition, the government has thought of an effective approach to improve the quality of life of the people both in urban communities and in the rural areas through the socalled 'livelyhood project'. The livelyhood project is a centre piece program of the government which seeks to boost the livelyhood opportunities nation-wide, wherein goat raising has become one of the priorities. The small size of goats, their early maturity, inquisitive feeding habits and low capital investment must be exploited to enhance the development of intensive goat production including the utilization of its wastes for fish culture.

At present there is also an expansion of the tilapia industry. Tilapia is an ideal fish for fish pond culture, because it matures in just four months time and breeds the whole year round at two-to-three month intervals. It also thrives in almost all kinds of water conditions, in nearly all sizes of ditches, rivers, lakes, and ponds, and is inexpensive to maintain as it feeds on a variety of feedstuffs. The low initial capital investment renders tilapia culture suitable for small-scale producers. The intensification of the tilapia industry, however, in the long run will depend on the availability of economical feeds. Therefore, the use of goat manure could be exploited to improve productivity of small-scale farmers at reduced costs. This study was initiated to determine the optimum goat manure loading rates and stocking densities of Oreochromis niloticus per unit area of fish pond, and to design a goat-fish integrated farming system that would provide the highest economic return, giving manure as the only nutrient input. This paper presents the preliminary results from two 120-days fish culture periods in a 240-days goat rearing cycle.

Methodology

This study was conducted in 12 fish ponds of 200 m² each. The goat houses having a floor area of 0.75 m x1.5 m/goat were built over one side of each fish-pond.

The factorial experimental design consisted of three rates of goat manure loading (0 (control), 200 and 300 goats/ha) and two fish stocking densities (10,000 and 20,000 fish/ha). The goat manure was the only source of fertilizer for the ponds.

Plate 1. Goat houses constructed over the fish ponds.

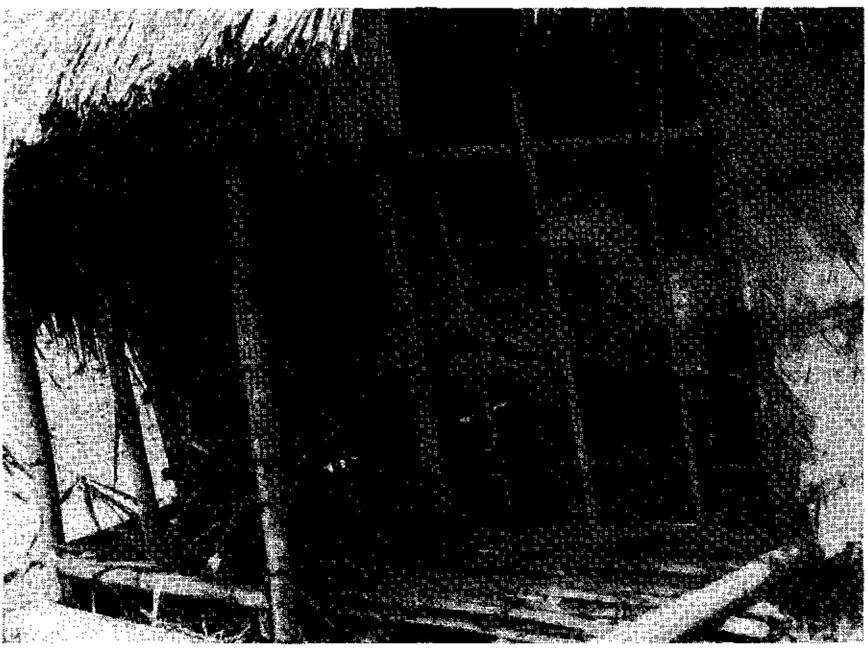

Plate 2. Confined goats fed with soilage.

Newly weaned native goats with an average weight of 8-9 kg each were randomly distributed in the experimental lots. The confined goats were fed with mixed soilage (grasses and legumes) three times a day, at about 6.30 in the morning, between

11.00 and 12.00 at noon and between 4.00-5.00 in the afternoon.

Every morning goat manure was collected on galvanized iron sheets under the goat houses, weighed and discharged to the ponds. Urine and washings from the houses were directly added to the ponds. The water depth was kept at 0.75 meter.

Plate 3. Recording the yield of tilapia harvested from ponds fertilized with goat manure.

The growth of fish was monitored monthly. Fish were harvested at the end of each culture period by draining the ponds and growth data and yields were recorded.

Results and discussion

First 120-days culture period.

The growth rate of tilapia during the first 120 days-culture period as affected by goat manure loading rates and fish stocking densities is shown in Table 1 and in Figures 1 and 2. The treatment combination of 300 goats and 10,000 fish/ha registered the highest increase in length and weight (13.05 cm and 78.05 g), followed by the treatment combination 200 goats and 10,000/ha (12.85 cm and 71.15 g), whereas the lowest increase was recorded by the ponds receiving no goat manure and stocked with 20,000 fish/ha (8.90 cm and 45.95 g).

The results imply that growth rate of tilapia increased with increasing goat stocking rates and decreased at increasing fish densities.

As shown in Figure 2 computed yields increased with increasing goat stocking rates and fish stocking densities (300 goats- 20,000 tilapia /ha) to a maximum of 1,170 kg /ha.

Table 1. Growth and yield of tilapia as affected by different goat manure loading rates and fish stocking densities (first 120-days test period, October 1987 - February 1988).*

Treatment: goat/ha tilapia/ha	0 10,000	0 20,000	200 10,000	200 20,000	300 10,000	300 20,000
Mean initial size (cm)	4.95	4.70	4.85	5.00	4.95	5.10
Mean initial weight (g)	3.40	3.30	3.35	3.45	3.25	3.30
Mean final size (cm)	14.60cde	13.60f	17.70ab	14.65cd	18.00a	15.50c
Mean final weight (g)	63.75c	49.24f	81.35ab	53.45a	84.80a	58.25d
Mean size gain (cm)	9.65de	8.90def	12.85ab	9.65d	13.05a	11.40c
Mean weight gain (g)	60.35c	45.95ef	71.15b	50.00e	78.05a	54.95d
Yield in 120 days (kg/ha)	637.50f	965.00c	813.50de	1069.00b	848.00d	1170.00a

* Means followed by the same letter are not significantly different at 0.01 level of significance (DMRT).

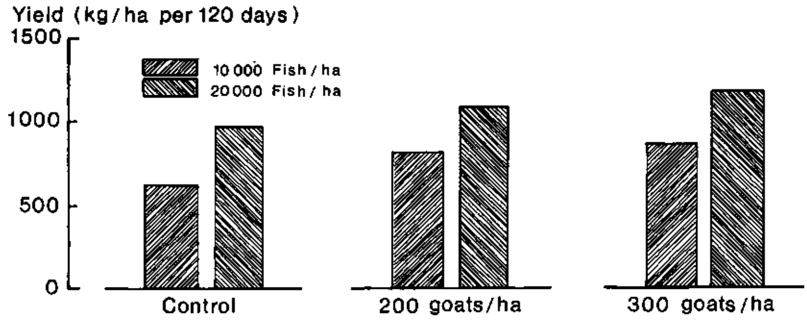

Figure 1. Average individual weight gain of tilapia over the first 120-days period in ponds receiving different goat manure loadings.

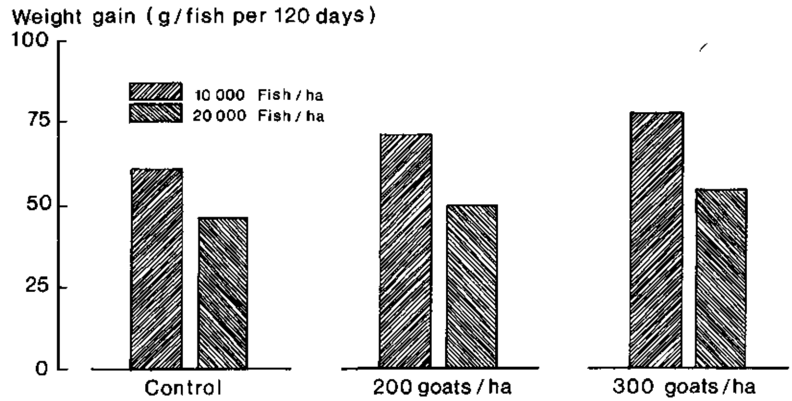

Figure 2. Calculated net yields of tilapia over the first 120-days period in ponds receiving different goat manure loadings.

Second 120-days culture period

Table 2 and Figures 3 and 4 present the growth rates and the yields of <u>Oreochromis</u> <u>niloticus</u>. in the second test period, using the same goats of the first 120-days experiment, then weighing approximately 18 kg (Table 3).

Table 2. Growth rate of tilapia as affected by different goat manure loading rates and fish stocking densities (second 120-days test period, March 1988-June 1988).*

Treatment: goat/ha	0	0	200	200	300	300
tilapia/ha	10,000	20,000	10,000	20,000	10,000	20,000
Mean initial size (cm)	4.85	4.78	3.42	4.85	4.82	4.80
Mean initial weight (g)	3.46	3.45	3.40	3.42	3.40	3.42
Mean final size (cm)	15.20cde	14.45ef	18.15ab	15.68cd	19.00a	16.63bc
Mean final weight (g)	66.05c	50.45f	84.05ab	62.20de	87.55a	65.28cd
Mean size gain (cm)	10.12de	9.60ef	13.30ab	10.55cd	13.80a	11.35cd
Mean weight gain (g)	62.65c	46.00f	80.83b	58.70e	83.70a	61.73cd
Yield in 120 days (kg/ha)	660.50f	1009.00c	840.50de	1244.00b	875.50d	1305.50a

* See footnote Table 1.

Table 3. Individual mean weights (kg) of goats during the two 120-days test periods.

A. First 120-days test period (October 1987-Februari 1988).

Goat-tilapia/ha	Initial	Month 2	3	4
200-10,000	8.2	11,2	14.5	16.0
200-20,000	9.0	11.4	14.4	16.4
300-10,000	8.4	11.0	14.6	16.6
300-20,000	8.5	11.6	14.6	16.3

B. Second 120-days test period (February 1988 - June 1988)

Goat-tilapia/ha	Initial	Month 2	3	4
200-10,000	18,1	21.4	24.8	27.8
200-20,000	18.5	20.6	23.9	27.3
300-10,000	18.2	20.4	24.5	27.7
300-20,000	18.0	20.9	24.8	27.6

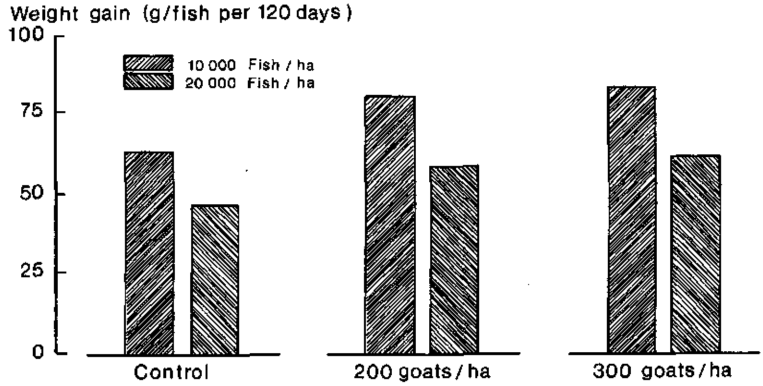

Figure 3. Average individual weight gain of tilapia over the second 120-days period in ponds receiving different goat manure loadings.

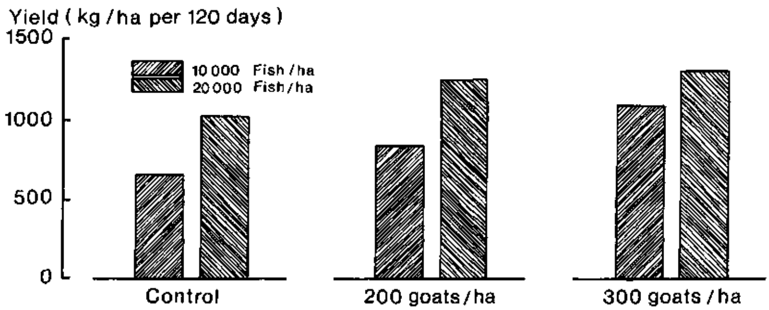

Figure 4. Calculated net yields of tilapia over the second 120-days period in ponds receiving different goat manure loadings.

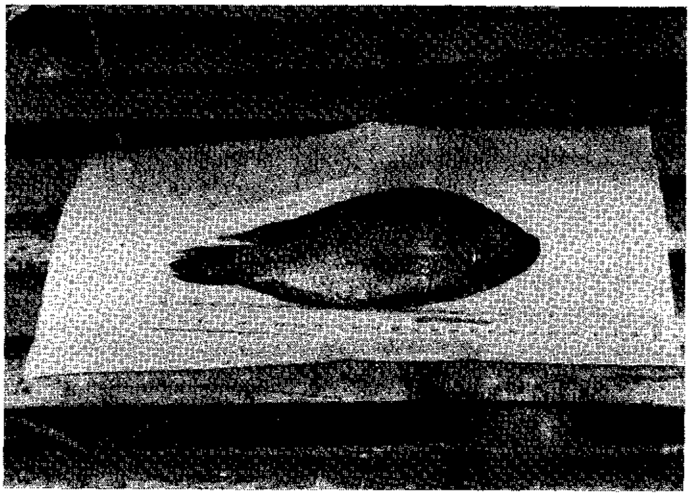

Plate 4. Measuring the size of tilapia.

It can be noted that growth rates and net yields are higher due to increased goat manure delivery. The results of the second trial followed the same trend as in the first 120-days culture period. The highest individual mean increase in length and weight (13.80 cm and 83.70 g) was recorded in the 300 goats-10,000 tilapia combination, followed by the 200 goats-10,000 tilapia combination (13.30 cm and 80.83 g). The lowest increase in length and weight was recorded in ponds without goat manure and stocked with 20,000 fish/ha (9.60 cm and 46.00 g).

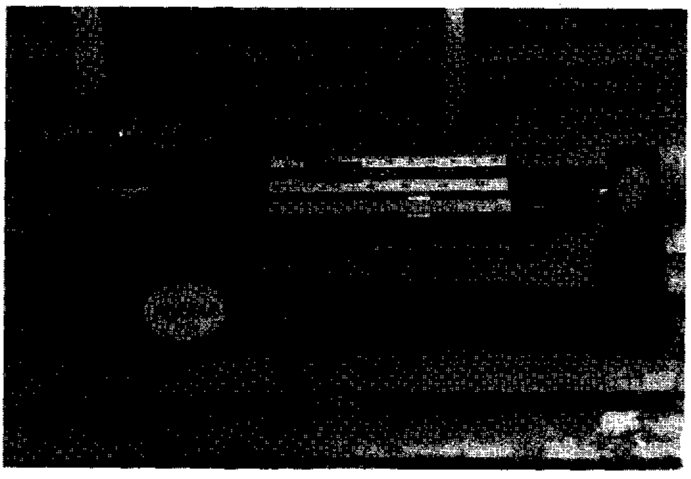

Plate 5. Recording the individual weight of tilapia.

In both trials growth of tilapia increased with increasing goat manure loading rates. This indicates that the application of goat manure is an efficient way of increasing the fish biomass.

Table 4 summarizes the costs and returns from the different goat-fish combinations per hectare over a period of 240 days. The analysis shows that the highest net return of ₱ 129,872 was obtained with the 300 goats-20,000 tilapia combination followed by 300 goats-10,000 tilapia/ha (₱ 108,952.5). However, with the present trend of marketing found in some local markets, where large fishes are offered at significantly higher prices than small size fishes, the 300 goats - 10,000 tilapia/ha combination will be more profitable.

New trials are proposed to test the compatibility and profitability of increasing the population of goats i.e. up to 600 head/ha with fish stocking densities of 10,000 and 20,000 fish/ha.

Table 4. Costs and returns per hectare from two 120-days culture periods of tilapia in a 240-days goat rearing cycle inregion I, The Philippines 1987-1988 (US$ 1.00 = ₱ 21.23

ITEMS	Goats-tilapia combinations					
	0-10,000	0-20,000	200-10,000	200-20,000	300-10,000	300-20,000
A. Returns						
Sale of fish at / 35/kg	45,430	69,090	57,890	80,955	60,323	86,643
Sale of goats at ₱ 650/head	-	-	130,000	130,000	195,000	195,000
TOTAL	45,430	69,090	187,890	210,955	255,323	281,643
B. Costs						
Fingerlings at ₱ 0.27 each	5,400	10,800	5,400	10,800	5,400	10,800
Goats at ₱ 400/head	-	-	80,000	80,000	120,000	120,000
Fodder	-	-	6,480	6,480	9,720	9,720
Mineral supplements	-	-	500	500	750	750
Land rental	1,500	1,500	1,500	1,500	1,500	1,500
Labor	1,500	1,500	6,000	6,000	9,000	9,000
TOTAL	8,400	13,800	99,880	105,280	146,370	151,770
Net Profit (A-B)	37,030	55,290	88,010	105,675	108,953	129,873

References

Edwards, P., 1986. Duck/Fish integrated farming systems. In: Farrel, D.J. & Stapleton. Duck production science and world practice. Farrel University of New England p. 268.

Little, D. & Muir, J., 1987. A guide to integrated warm water aquaculture. Institute of Aquaculture, University of Stir-

ling. FK 94 LA, Scotland p. 56.
NEDA, 1985. The Philippine yearbook. Pasig, Metro Manila. p. 357-358.
PCARRD, 1982. Philippine recommends for goat production. Los Banos, Laguna, Philippines. p.1.

Polyculture of grouper (Epinephelus tauvina) and tilapia (Oreochromis mossambicus) in brackishwater ponds

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Summary

The study was conducted in twenty-one 171 m^2 brackishwater ponds at the Bicol University College of Fisheries, with the aim to determine the optimum stocking combination of tilapia and grouper in polyculture. Seven treatments were replicated three times in a completely randomized design. Of the seven treatments, three were monoculture of tilapia (Treatment I- 20,000 tilapia/ha, Treatment II- 25,000 tilapia/ha, Treatment III- 30,000 tilapia/ha), one monoculture of grouper (Treatment IV- 1,000 grouper/ha), and three polyculture of tilapia and grouper (treatment V- 20,000 tilapia + 1,000 grouper/ha, Treatment VI- 25,000 tilapia + 1,000 grouper/ha, Treatment VII - 30,000 tilapia + 1,000 grouper/ha).

Polyculture produced better results for both species. In the monoculture of tilapia, 83-89% of the population were composed of young recruits (less than 20 g), whereas in polyculture, young tilapia comprised only 3-15% of the population. Grouper reduced young tilapia by 72 to 76%, thus resulting in higher recovery of the original tilapia stock and in significanctly higher ($P < 0.05$) production of marketable tilapia in polyculture. Similarly, grouper sustained significantly higher ($P < 0.05$) recovery, growth, and production in polyculture. A grouper : tilapia ratio of 1:20 proved to be most effective.

Introduction

Oreochromis mossambicus and other species of tilapia are widely cultured in the Philippines. Intensifying its culture however is limited due to its prolific reproduction which results in an overpopulation of undersized fish (Guerrero, 1982). Introduction of piscivorous fish in tilapia ponds will not only maintain a desired fish population but will also increase the total fish production.

Few studies have been conducted on the use of a predator for the biological control of tilapia in ponds. Cruz & Magisa (1980) evaluated the efficiency of snakehead (Ophiocephalus striatus) to control tilapia recruits in freshwater ponds. They showed that tilapia recruits were totally controlled at a stocking combination of 300 snakehead/ha plus 10,000/ha Tilapia nilotica. Fortes (1980) established a 1:10 tarpon (Megalops cyprinoides) - tilapia (O. mossambicus) ratio in brackishwater ponds. He further suggested an interval of three weeks between the stocking of the tilapia and the tarpon to prevent predation on the original tilapia stock. Recent studies on polyculture of grouper and O. mossambicus (Manzano, 1985) revealed that grouper could be easily reared in brackish water ponds. It attained a survival rate of 82 - 92% with water salinities ranging from 3 - 27 ppt. Hence, the practice of many fish pond operators to add about 10 sacks/ha of salt in order to maintain the desired salinity (Elizalde & Marcial, 1983) may not actually be required. Results showed that the presence of grouper in tilapia ponds reduced numerically the tilapia population by 327 - 456% thus increasing the growth of the remaining tilapia and resulting in a marketable size at harvest. Similarly, the presence of tilapia increased growth and production of grouper.

This study therefore aimed to determined the optimum stocking combination of tilapia and grouper in a polyculture system.

Methods

Experimental ponds

Twenty-one 171 m^2 brackishwater ponds were used in this study. Each pond was provided with a 10 cm diameter PVC standpipe which served as water inlet/outlet. Every pond was supplied with tidal water through a main water supply canal, in which way a water depth of 60 cm was maintained in the experimental ponds.

The ponds were repaired, drained, dried and leveled. Nylon screen with a mesh size of 0.5 mm was installed in the opening of each standpipe. Agricultural lime (300 kg/ha), tobacco dust (1500 kg/ha), and urea (50 kg/ha) were spread on the pond bottom. Shelters consisting of 6 stumps per pond were placed in the pond and the water level was gradually raised to about 60 cm prior to stocking.

Experimental design

Seven treatments were replicated three times in a completely randomized design. The treatments were as follows:

Treatment	Stocking rate per hectare	
	Tilapia *	Grouper
I	20,000	-
II	25,000	-
III	30,000	-
IV	-	1,000
V	20,000	1,000
VI	25,000	1,000
VII	30,000	1,000

* 1 : 3 male to female ratio

Stocking

O. mossambicus weighing 8.5 - 22 g were stocked on March 3, 1986. Grouper fingerlings weighing 2.9 - 5.9 g were added after 53 days in order to give the tilapia enough time to breed.

Management techniques

Within the 223 days culture period, inorganic NPK fertilizer (16-20-0) was applied every three weeks (Ikotun, 1981) upto a total of 10 applications. Salinity, pH, dissolved oxygen and temperature of the water were monitored three times a week between 7.00 to 8.00 in the morning. Rainfall readings were taken every day (Table 1 and 2).

Water renewal was done whenever possible, especially before fertilizer application and after heavy rainfall.

Table 1. Ranges of the physico-chemical parameters measured between 7.00 and 8.00 a.m. during the study period.

Treatments	Parameters			
	Temp.(°C) (mg/1)	Salinity(ppt)	pH	D.O.
I	26 - 39	7.5-34	7.9-9.3	2.2-5.4
II	26 - 39	7.5-34	7.0-9.3	2.0-5.6
III	26 - 39	7.5-34	6.9-9.5	2.8-6.0
IV	26 - 39	7.5-34	6.5-9.8	3.2-6.6
V	26 - 39	7.5-34	6.2-9.1	2.2-5.4
VI	26 - 39	7.5-34	7.0-9.1	3.0-6.4
VII	26 - 39	7.5-34	6.2-9.1	1.8-4.4

Table 2. Monthly averages and ranges of daily rainfall measured during the period of study.

Month	Average (mm)	Range (mm)
March	5.08	0-40.6
April	2.54	0-15.2
May	3.81	0-30.5
June	3.52	0-25.4
July	4.76	0-63.5
August	6.69	0-45.7
September	1.87	0-18.5
October	10.79	0-36.8

Table 3. Mean weights, recovery and production of grouper, adult tilapia* and tilapia recruits** in monoculture and polyculture at different stocking combination***.

		Adult Tilapia			Tilapia recruits		Grouper			Total production
Treatment	Replicate	Mean wt (g)	Prod. kg/ha	Recovery (%)	Mean wt (g)	Prod. kg/ha	Mean wt (g)	Prod. kg/ha	Recovery (%)	kg/ha
I	1	57	433	38	3	380	-	-	-	813
	2	55	508	45	12	406	-	-	-	914
	3	53	534	50	3	522	-	-	-	1056
	mean	55	491b	44	6	436a	-	-	-	928ab
II	1	42	544	50	6	347	-	-	-	891
	2	59	932	64	4	425	-	-	-	1357
	3	57	923	36	4	375	-	-	-	898
	mean	53	666ab	50	5	382a	-	-	-	1048a
III	1	47	736	53	4	513	-	-	-	1248
	2	42	722	57	3	812	-	-	-	1534
	3	46	722	52	3	219	-	-	-	942
	mean	45	757a	54	4	515a	-	-	-	1241a
IV	1	-	-	-	-	-	162	76	47	76
	2	-	-	-	-	-	114	47	41	47
	3	-	-	-	-	-	108	88	82	88
	mean	-	-	-	-	-	128	70b	57b	70c
V	1	65	636	61	11	6	233	205	88	1013
	2	47	632	60	9	2	204	203	94	836
	3	40	743	88	7	6	181	137	100	886
	mean	45	726a	70	9	4b	206	182a	88a	912ab
VI	1	50	636	51	11	27	187	164	88	827
	2	47	760	64	8	13	169	158	94	932
	3	40	722	72	8	12	170	169	100	903
	mean	45	706a	62	9	18b	175	164a	164a	887b
VII	1	43	772	60	7	15	175	143	82	930
	2	36	921	86	6	19	277	146	53	1085
	3	57	637	37	6	19	183	129	71	785
	mean	45	777a	61	6	18b	212	139a	69ab	934a

* 20 grams and above

** less than 20 grams

*** Means in columns with at least one common letter subscript are not significantly different (P >0.05).

Harvesting

Grouper and tilapia were harvested together on October 12-16, 1986. The harvests were assorted according to species and size, and subsequently weighed and counted. Representative samples were taken from each pond to determine length-weigth relationships (Bennet, 1970). The intraspecific competition of tilapia and the predation of grouper on tilapia were computed according to the competition indices of Reich, 1975 and Yashouv, 1986 respectively.

Maximum size of tilapia to be swallowed by grouper was determined by force-feeding various sizes of grouper with tilapia that could pass through their maximum mouth opening. The weight, the total length and the body depth of these tilapia were measured. For grouper, the maximum mouth opening and total length were determined.

Results and discussion

Efficiency of grouper in controlling the tilapia population.

Tilapia were classified into two groups. Those below 20 g weight (or 11 cm total length) were considered to be young recruits (Fortes, 1982). Fish from the adult or original stock were bigger than 20 grams.

In tilapia monoculture, 83-89% of the population consist of young recruits. This is significantly higher ($P < 0.05$) than in polyculture in which the young tilapia recruits comprised only 3-15% of the total population (Table 4). The decrease in number of young tilapia in polyculture was due to grouper predation. Grouper could swallow tilapia with a body depth equal to its mouth opening, the latter being 16-20% of its total length. Body depth of tilapia is 29-37% of its total length.

Higher recovery of the original stock was obtained in polyculture although no significant difference ($P > 0.05$) existed between treatments. The lower recovery of tilapia in monoculture could be attributed to over-population, resulting in a greater intraspecific competition for food (Tables 4 and 5).

Table 4. Tilapia population in monoculture and polyculture at different stocking combinations*.

Treat- ment	Repli- cate	Adult Tilapia		Young Tilapia	
		Number	% Population	Number	% Population
I	1	129	5.67	2145	94.33
	2	156	20.66	599	79.34
	3	173	6.30	2575	93.34
	mean	153	10.88b	1772	89.12a
II	1	220	18.66	959	81.34
	2	272	14.27	1634	85.73
	3	275	16.04	1440	83.96
	mean	256	16.32b	1344	87.68a
III	1	270	9.73	2506	90.27
	2	293	7.37	3684	92.63
	3	275	19.17	1130	80.63
	mean	256	12.09b	2440	87.91a
V	1	212	95.50	10	4.50
	2	208	98.58	3	1.42
	3	304	95.90	13	4.10
	mean	241	96.66a	9	3.34b
VI	1	219	84.23	41	15.77
	2	274	90.13	30	9.87
	3	306	92.73	24	7.27
	mean	266	89.03a	32	10.97b
VII	1	308	89.02	38	10.98
	2	439	89.78	50	10.22
	3	192	76.50	59	23.50
	mean	313	85.10a	49	14.90b

* Means in columns with at least one common letter subscript are not significantly different ($P > 0.05$)

Table 5. Intraspecific competition indices for tilapia at different stocking densities in monoculture.

Treat- ment	Stocking density (no./ha)	Average production of 20,000 tilapia (kg/ha)	Intraspecific Competition Index
I	20,000	927.0	-
II	25,000	838.8	0.10

Effect of grouper on the production of marketable tilapia.

Higher production of adult tilapia was obtained from polyculture (Table 3). Comparison of treatments with the same stocking density of tilapia such as treatments VII and III (30,000/ha), treatments V and I (20,000/ha) and treatments VI and II (25,000/ha) showed that the presence of grouper had a direct effect on the number of marketable tilapia (Tables 3 and 4). Tilapia in polyculture tended to have a higher condition factor than those in monoculture (Table 6) which can be explained by reduced feed availabilty due to over-population in the monocultures.

Table 6. Condition factors of tilapia at different stocking densities cultured in monoculture and in polyculture.

Treat-ment	Stocking density (no./ha)	Repli-cate	Average length (cm)	Average weight (g)	Condition Factor
I	20.000	1	11.72	33.68	2.09
	(mono-	2	12.71	36.61	1.88
	culture)	3	15.71	57.58	1.70
		mean	13.15	43.29	1.89
II	25.000	1	13.22	42.03	1.82
	(mono-	2	12.95	44.22	2.04
	culture)	3	14.75	46.25	1.44
		mean	13.64	44.17	1.77
III	30.000	1	12.87	45.07	2.11
	(mono-	2	14.11	42.10	1.74
	culture)	3	13.41	45.45	1.62
		mean	13.64	44.21	1.82
V	20.000	1	13.80	52.13	1.98
	(poly-	2	14.11	53.60	1.84
	culture)	3	13.53	46.67	1.88
		mean	13.87	50.80	1.90
VI	25.000	1	12.38	38.56	2.03
	(poly-	2	14.20	54.00	1.88
	culture)	3	11.19	32.10	2.29
		mean	12.59	41.52	2.07
VII	30.000	1	12.17	35.79	1.99
	(poly-	2	13.27	42.35	1.11
	culture)	3	12.54	41.71	2.11
		mean	12.66	39.95	1.97

Effect of tilapia on the recovery and production of grouper

The results of recovery and production of grouper were signficantly higher in polyculture compared to the monoculture. Highest recovery of grouper was obtained in treatment VI, 94.21 % (Table 3). Similarly, the growth of grouper amd its condition index was higher in polyculture (Tables 7 and 9). Since tilapia serve as food for grouper, negative results were obtained when the competition index of Yashouv was applied for measuring the effect of tilapia to grouper (Table

8).

Table 7. Growth rate of tilapia and grouper in monoculture and polyculture at different stocking combinations*.

Treatment	Replicate	Tilapia		Grouper	
		Average weight gain (g)	Growth rate (g/day)	Average weight gain (g)	Growth rate (g/day)
I	1	41.11	0.185		
	2	38.37	0.173		
	3	36.99	0.167		
	mean	38.82	0.175		
II	1	30.46	0.151		
	2	46.03	0.207		
	3	46.02	0.207		
	mean	41.84	0.188		
III	1	38.88	0.171		
	2	20.05	0.091		
	3	26.68	0.119		
	mean	28.80	0.127		
IV	1			158.40	0.937
	2			108.10	0.640
	3			104.90	0.621
	mean			123.80b	0.732
V	1	51.06	0.230	227.40	1.346
	2	38.82	0.175	198.20	1.173
	3	28.27	0.127	177.87	1.052
	mean	39.39	0.177	201.06a	1.190
VI	1	32.88	0.148	180.77	1.070
	2	31.64	0.143	165.85	0.981
	3	25.36	0.114	167.04	0.988
	mean	29.94	0.135	171.22ab	1.013
VII	1	27.86	0.125	172.10	1.018
	2	20.88	0.094	272.79	1.614
	3	42.97	0.194	100.40	1.064
	mean	30.57	0.138	208.43a	1.233

* Means in a column having at least one common letter subscript are not significantly different ($P > 0.05$).

Table 8. Competition indices used for the predation of grouper on tilapia at different stocking densities.

Specifications	Average production(kg/ha)		Competition Index
	Monoculture	Polyculture	
A. Competiton of tilapia to grouper			
1) 1000 grouper with 20,000 tilapia/ha	927.7	730.7	0.21
2) 1000 grouper with 25,000 tilapia/ha	1048.5	723.5	0.31
3) 1000 grouper with 30,000 tilapia/ha	1241.5	794.5	0.36
B. Competition of grouper to tilapia			
1) 20,000 tilapia with 1,000 grouper/ha	70.4	181.7	-1.58
2) 25,000 tilapia with 1,000 grouper/ha	70.4	163.5	-1.32
3) 30,000 tilapia with 1,000 grouper/ha	70.4	139.2	-0.98

Table 9. Condition factors of grouper at different stocking densities cultured in monoculture and in polyculture.

Treatment with specifications		Replicate	Average Weight (g)	Average Length (cm)	Condition Factor
IV	1,000 grouper/ha	1	81.0	18.8	1.22
		2	108.3	20.4	1.27
		3	56.7	16.0	1.38
		mean	82.0	18.4	1.29
V	1,000 grouper/ha	1	220.0	25.2	1.38
	plus 20,000	2	178.8	24.6	1.21
	tilapia/ha	3	173.0	22.3	1.28
		mean	180.6	24.0	1.29
VI	1,000 grouper/ha	1	208.3	24.3	1.45
	plus 25,000	2	174.3	22.5	1.53
	tilapia/ha	3	175.0	23.0	1.44
		mean	185.9	23.3	1.47
VII	1,000 grouper/ha	1	177.7	23.2	1.43
	plus 30,000	2	235.0	25.5	1.42
	tilapia/ha	3	122.3	21.5	1.23
		mean	178.33	23.6	1.36

Conclusions and recommendations

The experiment proved that grouper can be used to control tilapia populations. Predation on the original stock of tilapia can be avoided by initial stocking of tilapia which are bigger than grouper. When tilapia recruits serve as the main food source for grouper, stocking tilapia prior to grouper in order to give them enough time to breed will minimize predation on the original stock. Moreover there will be enough food for grouper.

Within the range of stocking combinations used in this study, treatment V (20,000 tilapia plus 1000 grouper/ha) proved the best combination.

References

Bennet, G.W., 1970. Management of Lakes and Ponds. 2nd Ed. New York, Van Nostrand Reinhold Company. 375 p.

Cruz, E.M. de la, & R.C. Magisa, 1980. The effect of three stocking densities of snakehead on the control of tilapia reproduction. Research Highlights from PCARRD Network. 1981.p 77.

Elizalde, L.P. & B. Marcial, 1983. A fresh venture, Lapu-Lapu in Ponds. Fisheries Today Vol. V, No.1, p. 34-39.

Fortes, R.D., 1982. Tarpon as fish to control tilapia young. PCARRD Monitor. Vol. X, No. 2, p. 4-5.

Guerrero, R.D., 1982a. The Biology and Culture of Tilapia.

ICLARM Conf. Proc. no. 7, 432 p.
Ikotun, S.J., 1981. Frequency of inorganic fertilizer application and its effects on milkfish (Chanos chanos) production in brackish water ponds. Master Thesis. UPVCF, Iloilo City, Philippines, 86 pp.
Manzano, V., 1985. Polyculture systems using groupers (Epinephelus tauvina) and tilapia (T. mossambica) in brackishwater ponds (Phase I). R and D Journal. Vol 1, no. 2, p 43-50.
Reich, K., 1975. Multispecies fish culture (polyculture) in Israel, Bamidgeh, 27: 85-99.
Yashouv, T., 1978. Mixed fish culture: an ecological approach to increase pond productivity. FAO World Symposium on Warm Water Pond Fish Culture. 13 pp.

The feeding and metabolism of carbohydrates in warm water fish

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Summary

According to some investigators warm water fish have no requirement for dietary carbohydrates. However, from recent studies it would appear that carbohydrates can have value both as an energy source and as metabolic intermediates and hence may promote growth. As in tropical and sub-tropical regions of the world carbohydrates are cheaper and more readily available than protein sources it is important to maximize their economical value by the optimum feeding of these nutrients. This must be accomplished without compromising growth and conversion efficiencies. As fish are regarded as being "diabetic" then diets must be formulated with this in mind. The present paper reviews recent research and discusses the role and efficiency of utilization of some carbohydrates in the diets of warm water fish and their relation to protein utilization and to flesh production.

Introduction

For many years it has been realized that as fish are reared on a high protein diet compared with domestic animals considerable economic saving could be achieved if carbohydrates could maximally replace proteins as an energy source for growing cultured fish (Furuichi, 1983; Anderson et al., 1984).

Studies on the utilization of carbohydrates by fish have, until quite recent years, been carried out largely on salmonids and opinions, both regarding the optimum level of dietary carbohydrates and the molecular chain length for maximum growth, have been divided (Philips et al., 1948; McLaren et al., 1946; Buhler & Halver, 1961; Akiyama et al., 1982). It is reported that the growth rate of chinook salmon decreases with feeding of carbohydrates of increasing molecular weight. However, α-starch appears to be a superior carbohydrate source for chum salmon to dextrin, maltose or glucose based on growth and feed efficiency data.

Utilization of carbohydrates

The utilization of carbohydrates by warm water fish has not gone neglected and a number of important studies have been made (Shimeno et al., 1978; Furuichi & Yone, 1982; Furuichi et al., 1986). These, and other reports, have indicated different growth responses depending on species, feeding frequency and carbohydrate chain length. The utilization of different carbohydrates in warm water fish (and in cold water species) depends initially on their digestibility in the fish. Digestibility of carbohydrates in fish was first determined in rainbow trout where absorption after 36 hours varied from 99%

for glucose to 38% for raw corn starch (Philips & Brockway, 1959). Singh & Nose (1967) further demonstrated that the digestibility of these carbohydrates varied when fed at differing levels. The complex carbohydrates were far inferior to other sugars especially at high feeding levels. For example, potato starch had a digestibility of 69% when fed at a 30% level in the diet but a digestibility of only 26% when fed at a 60% level in the diet.

It was somewhat surprising when Chiou & Ogino in 1975 found that the digestibility of carbohydrates by carp remained constant between 85-90% regardless of the level of carbohydrate in the diet as long as it did not exceed a 50% inclusion. This, as Cowey & Sargent (1979) have pointed out, is surprising because there is good evidence to suggest that carp do not metabolize carbohydrates more rapidly than any other species of fish. Shimeno et al. (1978) demonstrated that another warm water fish, the yellowtail, (Seriola quinqueradiata) like the salmonids digested carbohydrate according to its level of inclusion in the diet. At a 10% level α-potato starch had a digestibility of 57% but at a 40% inclusion in the diet a digestibility of only 39% was found. These workers also confirmed the results of Chiou & Ogino (1975) on carp where diets up to a 50% inclusion level of α-starch, resulted in digestibility remaining at around 88%.

Furuichi & Yone (1980) compared the effects of dietary dextrin levels on growth and feed efficiency as well as dextrin absorption rates in warm water fish. They examined carp, red sea bream, and yellowtail fed on diets containing up to 40% dextrin for 40 days. Growth retardation and low feed efficiency were noticed in carp fed on 40% dextrin diet, red sea bream on 30% dextrin and yellowtail on 20% dextrin. However, these workers found that high intestinal absorption of protein and dextrin were maintained in all species regardless of dietary dextrin levels. The same workers (Furuichi & Yone, 1981) carried out a more intensive study on the availability of carbohydrates in the nutrition of carp and red sea bream. They investigated growth and feed efficiency, changes in rates of absorption and in blood sugar levels after administration of carbohydrates. The growth and feed efficiency of carp were highest when fed with an α-starch diet followed by dextrin and glucose. However, red sea bream did not show any differences in growth but showed a higher feed efficiency for α-starch than for dextrin or glucose. Absorption within 2 hours of administration was highest for glucose followed by dextrin and α-starch. But absorption after this period followed the reverse order. The authors suggested that the low availability of glucose and dextrin in the nutrition of warm water fish is caused by their rapid absorption, e.g. before the enzymatic system related to carbohydrate metabolism is completed which is induced by the secretion of insulin.

Murai, Akiyama & Nose (1983) fed fingerling carp α-starch, dextrin, maltose, or glucose containing diets at differing daily frequencies. At twice daily feeding the starch diet resulted in the best weight gain and feed efficiency. When the feeding frequency was increased from 2 to 4 or 6 times daily the weight gain improved together with increased food consumption in all dietary treatments. All dietary groups achieved more than 500% weight gain in 6 weeks when fed 6 times daily (the authors recommended 4 times a day for optimum growth). The utilization of carbohydrates with different chain lengths by carp is thus affected by frequency of daily feeding. Although frequency of feeding had no effect on carcass constituents glucose chain length did show significant effects on liver glycogen levels, moisture and fat.

Furuichi, Taira & Yone (1986) followed up their work on carp and red sea bream by investigating the availabilities of α-starch and glucose in the nutrition of the more carnivorous fish, the yellowtail. They fed diets containing α-starch or glucose at a level of 10% or 20% for 30 days. The 10% α-potato starch and 10% glucose fed fish showed no difference in growth or feed efficiency. The growth of the 20% α-potato starch fed fish was similar to that of the 10% α-potato starch. However, the 20% glucose group showed extremely low growth. This was in spite of the fact that plasma glucose values were higher in the glucose fed fish. Thus, like in carp and red sea bream availability of glucose in the yellowtail is lower than that of α-potato starch. Anderson et al. (1984) incorporated glucose, sucrose, dextrin and maize starch into experimental rations at three levels (10%, 25% and 40%) and fed them to juvenile tilapia (Oreochromis niloticus). Growth improved at increasing levels of all these carbohydrates. At the 40% level net protein retention was highest on the dextrin diet and lowest on the glucose diet. As the level of carbohydrate in the diet was increased and thus the protein/energy ratio decreased, protein retention increased for all diets. The presence of non-protein energy clearly improved the efficiency with which dietary protein was converted into fish protein. Thus, in tilapia inclusion of up to 40% carbohydrates in diets (30% gross energy) does not retard growth and their use in this fish could be an effective means of reducing feed costs.

Physiology

Most warm water fish can only utilize glucose in their diets up to about 10-20% (even tilapia utilizes glucose less efficiently than sucrose or dextrin). Why are more complex carbohydrates utilized more efficiently? The reason is unclear. It has been suggested that in the rat a surge of blood sugar upon consumption of sucrose (or glucose) may stimulate activity of lipogenic enzymes and cause more lipogenesis than upon consumption of starch. This may be the case for fish too. A more plausible explanation may be due to glucose "saturation". As a monosaccharide, glucose requires no digestion and is rapidly assimilated across the gut, whilst starch and dextrin must undergo hydrolysis before assimilation. Hence glucose appears at gut absorption sites more rapidly than disaccharide or polysaccharide hydrolysis products and the rate of appearance of glucose is more related to its concentration in the diet. The significance of this is that glucose is known to inhibit the transport of amino acids at absorption sites on the mammal gut membrane (Alvarado & Robinson, 1979) and the same effect has been found in fish, (Hokazono et al., 1979). It is possible that imhibition of amino acid transport accounts for the inferior protein retention of warm water fish fed on diets containing glucose levels above 25%.

Also fish are unable to metabolize glucose rapidly possibly due to low liver hexokinase values. The role played by insulin in maintaining physiological equilibrium is not well understood. Insulin is probably more concerned with maintaining amino acid homeostasis in fish than with maintaining blood sugar levels.

Most experimental work involving starch diets has utilized α-starch, that is, gelatinized starch and not β-starch or raw starch. Some years ago Chiou & Ogino (1975) demonstrated that the digestibility of β-starch was lower than α-starch. More recently Furuichi et al. (1987) have compared the nutritive value of α- and β-starch in carp and red sea bream. They found both species differences and inclusion level effects.

Fibre

Utilization of fibre and its relation to dietary carbohydrate is of great interest to the practical fish culturist. Fibre refers to all indigestible plant matter such as celluloses, lignins and other complex carbohydrates in animal diets. The natural diet of carnivorous fish generally contains little dietary fibre but that of omnivorous and herbivorous fish do. Although Dupree & Sneed (1966) reported growth improvement in channel catfish (Ictalurus punctatus) when fed purified diets containing 21% cellulose flour, Leary & Lovell (1975) found growth depression using practical diets with 8% or more of cellulose. Cellulase activity has been demonstrated in the digestive tracts of several species of fish. This is a microfloral activity which can be an important consideration in aquaculture. However, unless a microflora is present in carp, or any other fish, they are unable to degrade cellulose or hemicellulose (Bergot, 1981).

In trout dietary fibre levels are recommended to be less that 10% of the diet (Hilton et al., 1983) but trout can compensate for up to a 30% inclusion of cellulose in the diet by increasing total feed intake (Bromley & Adkins, 1984). Little work has been carried out on warm water fish but Anderson et al. (1984) increased the amount of α-cellulose in the diets of tilapia from 0% to 40%. They found that growth, feed conversion efficiency, net protein retention and carcass fat all reduced as the inclusion of cellulose in the diets increased. Growth on diets of 25% α-cellulose and above was lower than the controls. Thus, like in trout, fibre levels above 10% are not desirable in tilapia diets. In a very recent paper Shiau et al. (1988) examined the effects of different dietary fibres (cellulose, agar, guar gum, carrageenan and carboxymethylcellulose) on dextrin utilization in tilapia. Inclusion of all fibres resulted in lower growth. Some fibres such as guar and pectin affect intestinal absorption of monosaccharides directly by increasing the viscosity of the intestinal contents (O'Dea et al., 1981). Also improved utilization of dextrin in red sea bream by supplementing carboxymethylcellulose in the diet has been reported (Morita et al., 1982). Clearly much remains to be investigated regarding the role of fibre in fish nutrition.

Chitin

Another complex carbohydrate is chitin. Although chitinase has been found in the gastro-intestinal tract of several fish few studies on the possible utilization of chitin by warm water fish have been made. Kono et al. (1987) include chitin in the diets of red sea bream, Japanese eel and yellowtail. The growth rate and feed efficiencies of these fish fed with a 10% supplementation of chitin were superior to those of the control suggesting that chitin is digested and utilized. However, Lindsay et al. (1984) observed poor growth when chitin was included in rainbow trout diets.

The utilization of carbohydrates, simple or complex depends largely on hydrolysis, prior to absorption, by amylases. These enzymes are present in the gut fluid and many body tissues of fish. Amylase in the serum increases in carp as the carbohydrate content of the diet increases (Hayama & Ikeda, 1972) and also in the liver as dextrin is increased in the diet (Uodike & Matty, unpublished). Intestinal amylase also adaptively responds to anti-amylase inhibitors that are present in raw wheat (Natarajan et al., 1988).

Practical diets

Finally, it must be mentioned that although many facets of carbohydrate utilization have been studied in the laboratory few studies have been made with practical diets containing high levels of carbohydrate materials which can be included in production diets. Ufodike & Matty (1983) fed differing levels (15, 30, 45%) of cassava or rice to mirror carp for 10 weeks. Fish grew best on a 45% rice diet but 45% cassava also gave good growth. Digestibility of both feedstuffs were high. Viola et al. (1988) further evaluated tapioca (cassava) in carp and tilapia kept in earthen ponds. At inclusion levels of 20% and 30% growth performance of carp and tilapia was equal to fish fed commercial diets. The utilization of practical carbohydrate sources by eels has also been studied. Eels digest a considerable amount of carbohydrate. Hagihara et al. (1967) reported that eels digested 78-98% of potato α-starch when incorporated into diets at levels of 20-60%. Degani et al. (1986) found that feed conversion, protein retention and energy retention were higher for eels fed wheat meal than other carbohydrates. This is unexpected as wheat meal is composed of raw starch grains and requires further investigation although Degani & Viola (1987) were able to show that the growth of eels fed 40% protein and 38% wheat meal was greater than that of eels fed 50% protein and 20% wheat meal or 30% protein and 56% wheat meal.

Conclusions

Carbohydrate utilization in warm water fish depends on species, molecular chain length and structure, level of inclusion in the diet and frequency of feeding. Probably other factors such as loading density (Srivasttava & Sahai, 1987) also influence carbohydrate utilization. Although fish will grow when fed solely protein/lipid diets carbohydrates can provide a cheaper source of energy. Starches and dextrins are as valuable as simple sugars in production diets; glucose is of little use. It should be possible to include carbohydrates (starches) into practical diets, thereby sparing the use of energy from dietary protein so that the protein in the feed is used nearly exclusively for fish flesh production. Complex carbohydrates (celluloses and chitin), although not a major energy source can usefully be included in practical diets up to about 10%. Further research is required on the possible use of cheap high carbohydrate sources of plants as part of compounded fish diets.

References

Akiyama, T., Murai, T. & Nose, T., 1982. Carbohydrate utilization by chum salmon fry. Bull. Natl. Res. Inst. Aquaculture, 3: 75-80.

Alvarado, F. & Robinson, J.W.L., 1979. A kinetic study of the interactions between amino acids and monosaccharides at the intestinal brush border membrane. J. Physiol., 295: 457-475.

Anderson, J., Jackson, A.J., Matty, A.J. & Capper, B.S., 1984. Effects of dietary carbohydrate and fibre on the tilapia Oreochromis niloticus (Linn.). Aquaculture, 37: 303-314.

Bergot, F., 1981. Etude de l'utilisation digestiye d'une cellulose purifiée chez la truite arc-en-ciel (Salmo gairdneri) et la carpe commune (Cyprinus carpio). Reprod. Nutr. Develop., 21: 83-93.

Bromley, P.J. & Adkins, T.C., 1984. The influence of cellulose filler on feeding, growth and uttilization of protein and energy in rainbow trout, Salmo gairdneri Richardson, J. Fish Biol., 24: 235-244.

Buhler, D.R. & Halver, J.D., 1961. Nutrition of salmonid fishes. IX. Carbohydrate requirements of chinook salmon. J. Nutr. 74: 307-318.

Chiou, J.Y. & Ogino, C., 1975. Digestibility of starch in carp. Nippon, Suisan Gakkaishi, 41: 465-466.

Cowey, C.B. & Sargent, J.R., 1979. Nutrition. In: W.S. Hoar, D.J. Randall & J.R. Brett (Editors), Fish Physiology, Vol. VIII. Academic Press, New York, NY. pp. 1-69.

Degani, G. & Viola, S., 1987. The protein sparing effect of carbohydrates in the diets of eels (Anguilla anguilla). Aquaculture, 64: 283-291.

Degani, G., Viola, S. & Levanon, D., 1986. Effects of dietary carbohydrate source on growth and body composition of the European eel (Anguilla anguilla L.). Aquaculture, 52: 97-104.

Dupree, H.K. & Sneed, K.E., 1966. Response of channel catfish fingerlings to different levels of major nutrients in purified diets. U.S. Bur. Sport Fish. & Wildlife, Tech. Papers 9: 3-21.

Furuichi, M., 1983. Studies on the utilization of carbohydrates by fishes. Report of the Fishery Research Laboratory, Kyushu University, No. 6, 1-59.

Furuichi, M. & Yone, Y., 1980. Effect of dietary dextrin levels on the growth and feed efficiency, the chemical composition of liver and dorsal muscle, and the absorption of dietary protein and dextrin in fishes. Bull. Japan. Soc. Sci. Fish., 46: 225-229.

Furuichi, M. & Yone, Y., 1981. Change of blood sugar and plasma insulin levels of fishes in glucose tolerance test.

Bull. Japan. Soc. Sci. Fish., 47: 761-764.
Furuichi, M. & Yone, Y., 1982. Availability of carbohydrate in nutrition of carp and red sea bream. Bull. Japan. Soc. Sci. Fish., 48: 945-948.
Furuichi, M., Taira, H. & Yone, Y., 1986. Availability of carbohydrate in nutrition of yellowtail. Bull. Japan. Soc. Sci. Fish., 52: 99-102.
Furuichi, M., Ito, G. & Yone, Y., 1987. Effect of β-starch on growth feed efficiency and chemical components of liver and blood of carp and red sea bream. Bull. Japan. Soc. Sci. Fish., 53: 1473-1442.
Hagihara, S., Ishikawa, T. & Shoji, Y., 1967. Potato starch in commercial eel feed. Annu. Meet. Japan. Soc. Sci. Fish. pp. 8-13.
Hayama, K. & Ikeda, S., 1972. Studies on the metabolic changes in fish caused by diet variation. 1. Effect of dietary composition on the metabolic changes of carp. Bull. Japan. Soc. Sci. Fish., 38: 639-643.
Hilton, J.W., Atkinson, J.L. & Slinger, S.J., 1983. Effect of increased dietary fibre on the growth of rainbow trout (Salmo gairdneri). Can. J. Fish. Aquat. Sci. 40: 81-85.
Hokazono, S., Tanaka, Y., Katayama, T., Chichester, C.O. & Simpson, F.L., 1979. Intestinal transport of L-lysine in rainbow trout, Salmo gairdneri. Bull. Japan. Soc. Sci. Fish., 45: 845-848.
Kono, M., Matsui, T. & Shimizu, C., 1987. Effect of chitin, chitosan and cellulose as diet supplements on the growth of cultured fish. Bull. Japan. Soc. Sci. Fish., 53: 125-130.
Leary, D.F. & Lovell, R.T., 1975. Value of fibre in production type diets for channel catfish. Trans. Am. Fish. Soc., 104: 328-332.
Lindsay, G.J.H., Walton, M.J., Adron, J.W., Fletcher, T.C., Cho, C.Y. & Cowey, C.B., 1984. The growth of rainbow trout (Salmo gairdneri) given diets containing chitin and its relationship to chitinolytic enzymes and chitin digestibility. Aquaculture, 37: 315-334.
McLaren, B.A., Herman, E.F. & Elvehjem, C.A., 1946. NMutrition of rainbow trout; studies with purified rations. Arch. Biochem. Biophys., 10: 433-441.
Morita, K., Furuichi, M. & Yone, Y., 1982. Effect of carbomethylcellulose supplemented to dextrin containing diets on the growth and feed efficiency of red sea bream. Bull. Japan. Soc. Sci. Fish., 48: 1617-1620.
Murai, T., Akiyama, T. & Nose, T., 1983. Effects of glucose chain length of various carbohydrates and frequency of feeding on their utilization by fingerling carp. Bull. Japan. Soc. Sci. Fish., 49: 1607-1611.
Natarajan, M., Ross, B. & Ross, L.G., 1988. Amylase activity in carp fed raw wheat and heat treated wheat. Aquacl. Int. Congress Abst. p. 62.
O'Dea, K., Snow, P. & Nestel, P., 1981. Rate of starch hydrolysis in vitro as a predictor of metabolic responses to complex carbohydrate in vivo. Am. J. Clin. Nutr. 34: 1991-1993.
Phillips, A.M. & Brockway, D.R., 1959. Dietary calories and the production of trout in hatcheries. Progressive Fish Culturist, 3-16.
Phillips, A.M., Tunison, A.V. & Brockway, D.R., 1948. The utilization of carbohydrate by trout. Fish. Res. Bull. 11: 44

p.
Shiau, S.Y., Kwok, C.C., Chen, C.J., Honmg, H.T. & Hseih, H.B., 1988. Effects of different dietary fibre on the utilization of dextrin in Tilapia. Aquacl. Int. Congress Abst. p. 66.
Shimeno, S., 1974. Studies on carbohydrate metabolism in fish. A.A. Balkema, Rotterdam. 123 pp.
Shimeno, A., Hosokawa, H. & Takeda, M., 1978. The importance of carbohydrate in the diet of carnivorous fish, FAO/EIFAC/-Symp. E/5, pp. 1-32.
Singh, R.P. & Nose, T., 1967. Digestibility of carbohydrates in young rainbow trout. Bull. Freshwater Res. Lab., 17: 21-25.
Strivastava, A.K. & Sahai, I., 1987. Effects of loading density on carbohydrate metabolism and hematology in the Indian freshwater catfish, Heteropneustes fossilis. Aquaculture, 66: 275-286.
Ufodike, E.B.C. & Matty, A.J., 1983. Growth responses and nutrient digestibility in mirror carp (Cyprinus carpio) fed different levels of cassava and rice. Aquaculture, 31: 41-50.
Viola, S., Arieli, Y. & Zohar, G., 1988. Unusual feedstuffs (tapioca and lupin) as ingredients for carp and tilapia feeds in intensive culture. Bamidgeh, 40: 29-34.

The mass culture of a cladoceran, Daphnia carinata (King), for use as food in aquaculture

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Summary

Daphnia carinata King was reared in low initial stocking densities in a medium containing anaerobically fermented poultry litter (basic diet) and filtered algal biomass (supplemented diet) as sources of food under controlled conditions of light and temperature. No deficiency was noticed in the reproductive potential of the species for over 64 days. A pH value around 7-8 and low levels of ammonia in the culture medium appeared to be important for successful cultivation of D. carinata.

Harvesting of the daphnia by "alternate cropping", compared favourably to "selective cropping" and yielded a total biomass of 418.76 g/wk/m³. The carbohydrate, protein and lipid content in this species was recorded to be respectively 57.62%, 36.10% and 24%. Indoor rearing of this natural food organism is suggested for small scale nursing of fish larvae.

Introduction

Laboratory rearing of fresh water Cladocera of the family Daphniidae has evolved from Banta's medium (Banta, 1921) to the defined, synthetic medium of Conklin & Provasoli (1977). The laboratory culture based on physiological, ecological, genetical and modern taxonomic studies has much significance. The study of mass culture of members of Daphniidae and the assessment of its potential application as live food in fresh water aquaculture is still far from complete.

A significant proportion of filter feeding crustaceans in aquatic systems are herbivorous and among them Cladocera are noteworthy. Cladocera are live food sources of prime importance in aquaculture research due to their abundance, ease of handling as well as sorting from other plankters, wide range of potential sizes and parthenogenetic reproduction. The filter feeding habit together with the parthenogenetic reproduction under suitable conditions make the cultivation of species of Daphnia in the laboratory a simple procedure.

Although available literature on culture of Cladocera can be categorised into synthetic culture (Murachi & Tmai, 1954; Taub & Dollar, 1964; 1968; Murphy, 1970; D'Agostino & Provasoli, 1970; Conklin & Provasoli, 1977; 1978) and mass culture (Bhamot & Vaas, 1976; Rees & Oldfather, 1980 and De Pauw et al., 1981), data on the production of biomass are very scarce. Moreover, little work is done so far in open systems for the large scale culture of daphnids. Recently, Murugan (1983a,b) attempted with limited success to cultivate Daphnia carinata, on cowdung extract and powdered ground nut cake. The present study aims at harvesting a significant biomass of D. carinata by developing a microbial medium from anaerobically fermented poultry litter (AFPL) and filtered algal biomass.

Experimental organism

The local species found to be suitable for mass culture is D. carinata (Figure 1), because it is ovoviviparous and reproduces parthenogenetically throughout the year under favourable conditions so that a single clone of genetically identical individuals can be produced, thereby considerably reducing variability between animals (Birch, 1960). This species belongs to the active swimming plankton. As a filter feeder, it mainly consumes organic particles. Its role in the food web is forming a link between primary producers and saprophytic bacteria on one side and the final consumers like fish on the other (Muller, 1980). Further, Daphnia species have been extensively used in population studies (Slobodkin, 1966).

A considerable amount of information has been gathered regarding the biology of D. carinata. Under laboratory conditions this species has 5 preadult and 8 adult instars at a temperature range of 29 to 31°C. Over a mean life span of 24 days 142.4 eggs are produced (Navaneethakrishnan & Michael, 1971). Venkataramam (1981) reported that the same species underwent 3 preadult and 15 adult instars producing 57.8 eggs over a total mean life span of 26 days. The average maximum length attained by an individual in both studies is 3.8 and 2.1 mm respectively. The neonates measure about 1.3 respectively 0.77 mm as has been reported by the above cited workers. In the present study a mean length of 0.72 mm is found and each female produces seven broods with a total average of 80.3 eggs during its life span of 16 days, whereas the average maximum length of an individual is 2.6 mm.

Figure 1. Parthenogenetic female of D. carinata.

Nutritional status

Most fish larvae require small live organisms as food at the onset of exogenous feeding. The movement of live food is an important factor for those fish species which prefer only moving preys. The movement of food will be very difficult to imitate in artificial feeds. Many authors, therefore, have rium fishes (Alikunhi, 1952; Alikunhi et al., 1955; Cooper & Granlight, 1963; Free, 1966) and for feeding fry and fingerlings in fish farms (Barthelmes, 1969; Huet, 1970; Ivleva, 1973).

In nature all fry start as plankton feeders consuming first phytoplankton and later zooplankton or directly zooplankton. The size of the food particle is of prime importance in feeding different stages of fish larvae. The selection of feed particles depends upon the initial size of the fry. Since the initial length of carp fry amounted to some mm's, daphnids ranging between 0.5 mm and 2.6 mm in size are considered the most suitable feed materials. Furthermore, natural food can deform during the course of intake, which enables the fry to ingest bigger particles than they could normally swallow (Thorpe & Wankowski, 1979).

Daphnids contain substantial quantities of carbohydrates, proteins and lipids. In nature variations exist among different species of Cladocera which may be due to differences in age and feeding habits. The values for protein reported varied from 41 to 85% (Blazka, 1966), from 22.3 to 39.3 (Farkas, 1958) and from 69.4 to 74.1 (Vijverberg & Frank, 1976) in various species of Cladocera.

Reports on free amino acid contents of cladocerans are fragmentary. Seventeen free amino acids have been identified in Ceriodaphnia sp. and Daphnia pulex (Dabrowski & Rusiechi, 1983). It has been reported that the availability of sufficient free amino acids is essential for survival and growth of fish larvae in which the gastro-intestinal tract is not fully developed.

The water content of a feed particle is a significant factor. As live food contains 85-95% water in comparison to 5-10% in dry feeds, fry and fingerlings feeding on natural food have no need for additional efforts to meet the water requirements. Moreover, the supply of artifical feed inevitably leads to water pollution (Van der Wind, 1979).

Materials and methods

Preparation of AFPL and microbial media

A small scale anaerobic system was designed consisting of sets of plastic vessels, each filled with a litre of tap water well mixed with 100 gram of dried powdered poultry litter, and covered. The vessels were opened after 10, 20 and 30 days of incubation. The dried slurry designated as AFPL was used for preparation of the organic feeding media for Daphnia.

The organically enriched microbial media were prepared separately in earthern containers, each filled with tap water and powdered slurry of known incubation time at equal proportions. The containers were closed and kept undisturbed for a couple of days. Due to hydrolytic decomposition the water became foul indicating the development of microbes. This water was filtered through a nylon gauze (Fabric number 26) and was used as the basic feed.

Establishment of the feed dosage of AFPL

A number of trial experiments was carried out separately to ascertain the suitable medium and proper dosage of AFPL. Culture flasks were prepared with a) 800 ml of tap water, b) 100 ml of filtered algal biomass as supplemental feed, c) 100 ml of microbial media of known incubation time as basic feed. Ten individuals with a size > 1.2 mm were introduced into each flask from the Daphnia population maintained in the laboratory. The medium was completely replaced in each jar once in 3 days. The flasks were kept in the laboratory to receiving imitated natural illumination in a 12:12 dark and light cycle. Oxygen was supplied through aeration with an air stone for each flask. Survival was monitored daily for 12 days. The suitable medium was identified by maximum number of survivors. From repeated trials, the slurry obtained from an incubation of 10 days (10 days AFPL) proved most suitable for maximum survival.

The suitable dosage was established by using respectively 0.5, 1.0 and 2.0 g/l of 10 days AFPL for preparation of the microbial media and by determining the number of neonates released.

Experiments for mass culture of D. carinata

Mass culture of D. carinata was established in a concrete tank (65 l) filled with 44 l of tap water, 4 l of organically enriched microbial water (basic diet) and 2 l of filtered algal biomass (supplemental diet). The medium was inoculated with 10 D. carinata (8 ovigerous and 2 non-ovigerous) individuals/l. Basic and supplemental diets were provided daily maintaining a 50 l volume of the medium by siphoning out the excess culture medium. Aeration was provided and a 12 hr natural photoperiod which varied from 2000 to 13000 Lux was maintained. The culture tank was monitored daily and maintained healthily by removing regularly the bottom debris which included unconsumed diet, faeces, moults etc. The temperature of the culture medium varied between 28°C and 30°C.

Sampling protocol

The population was assessed quantitatively by taking a random sample of 1 l water from the culture tank. The mean population density was expressed as number of animals per litre. The same samples were also used for measuring the size of the individuals in the population. The arithmetic mean size was expressed in mm. The percentage of ovigerous and non-ovigerous females was also recorded.

Biomass harvest by alternate cropping

Biomass was estimated, usually once a week, by partial drainage of the culture water. Through alternate cropping animals < 1.0 mm and > 1.0 mm were harvested using a standard nylon screen of 1 mm mesh. The harvested animals were placed on a preweighed aluminium foil and the water drops were removed by careful application of Whatman filter paper. The animals were dried in an oven at 60°C for 6 hrs and weighed.

Analysis of the chemical composition

Knowledge of the chemical composition of D. carinata is essential for the understanding of its food value. Therefore, the relative amounts of carbohydrates (Lowry et al., 1951), proteins (Dubois et al., 1956) and lipids (Raymont et al., 1964) were estimated in the two size groups of the species studied.

Results and discussion

The aim of the study is to use the most inexpensive and easily accessible materials for culture of D. carinata by using fermented slurry of poultry manure. Poultry manure containing uric acid and ammonia salts cannot be used directly as food for the organisms. The difficulties encountered in using unprocessed animal wastes as a food base are many. Processing raw wastes modifies the basic characteristics of the material which may improve the food value. Therefore, anaerobical fermentation of poultry litter is undertaken.

The survival experiments clearly indicate a high percent survival (90%) in 10 days AFPL as against 20% survival in 20 and 30 days AFPL. The regression coefficient for the relationship between number of rearing days and the reproductive potential estimated by the number of neonates released is presented in Figure 2 in which the regression equations are $y = (71.21)x - 169.09$; $y = (15.90)x - 19.18$ and $y = (28.38)x - 44.90$ for 10. 20 and 30 days AFPL respectively (x represents number of days of observation; y denotes cumulative number of neonates). The regression line is most steep for 10 days AFPL.

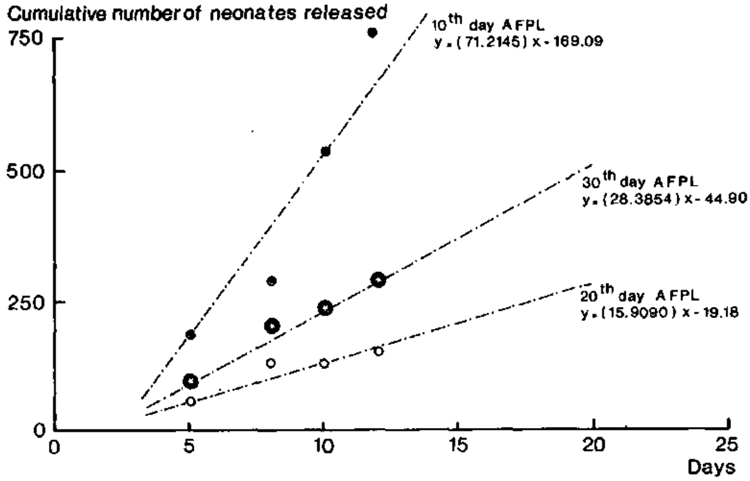

Figure 2. Regression lines between cumulative number of neonates released and number of days of observation.

The mean number of neonates released in different doses of 10 days AFPL are represented in Table 1. The mean number of neonates recorded in 1 g/l is 52.42 per day which is 2.19 and 2.63 times higher than the neonates observed in 0.5 and 2 g/l.

Table 1. Release of neonates of D. carinata as a function of the dosage of AFPL.

Dosage of 10 days AFPL (g/l)	Days of observation 1	4	8	12
	Neonates (cumulative)			
0.5	8	66	251	287
1.0	13	145	403	629
2.0	0	61	204	239

In order to test its significance, the data in Table 1 have been computed for analysis of variance (Table 2). It reveals that the F value with 1 and 22 df of 35.712 for 1 g of ADPL/l is highly significant at 1% level.

Table 2. ANOVA showing degrees of freedom (df), sum of squares (SS), mean of squares (MS) and F values for 0.5, 1.0 and 2 g/l of 10 days AFPL.

Dosage of 10 day AFPL(g/l)	Summary of variance	df	SS	MS	F
0.5	regression	1	1.6033	1.6033	
	residual	22	2.6391	0.1200	13.3608
1.0	regression	1	3.3355	3.3355	
	residual	22	2.0542	0.0934	35.7120
2.0	regression	1	1.0740	1.0740	
	residual	22	3.9807	0.1812	5.9272

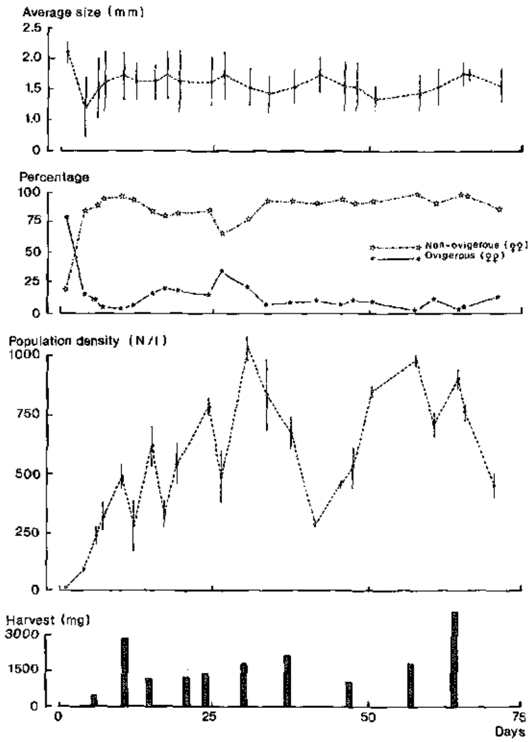

Figure 3. Size, composition of females population density and biomass harvested of D. carinata cultured on 10 days AFPL.

The experimental results of the mass culture of D. carinata are graphically represented in Figure 3 which depicts the population density and biomass (wet weight) obtained over a period of 9 weeks. From this it becomes evident that D. carinata can be grown upto an unlimited number of generations without any decrease in its reproductive potential.

During the whole culture period, low ammonia levels of about 117 um/l, conductivity levels between 612 and 1350 millimhos, and pH values between 7 and 8 were recorded. Optimal pH for mass culture of D. magna was reported to be around 7.0 (Rees & Oldfather, 1980) as is the case for a wide variety of aquatic species under cultivation (Ackefors & Rosen, 1979). Present experimental set-up acts as self regulating both for pH and ammonia levels. The oxygen level was always higher than 5 ppm/l. The qualitative analysis of the basic diet revealed the abundance of micro-organisms. Earlier reports suggest that bacteria play a major role in freshwater food chains serving as a food source for zooplankton (Gliwicz & Hillbricht-Ilkowska, 1972; Weglenska, 1971; Coveney et al., 1978) and other crustaceans (Provasoli et al., 1959). Gophen et al. (1977) and Lampert (1874) also reported that small daphnids prefer feeding on bacteria over algae. Taub & Dollar (1968) reported that D. pulex failed to grow in cultures fed exclusively algal food. Similarly D. longispina did not survive with bacteria as sole food source (Tezuka, 1971).

Results of the present study have proved that a combination of microbial water and algal biomass forms an excellent feed for D. carinata. Similar findings are reported by Smyly & Collins (1975) in Ceriodaphnia quadrangula.

The alternate harvest was attempted for the first time as against selective harvest (De Pauw et al., 1981) to obtain maximum biomass. The alternate harvest has many advantages since it avoids intraspecific competition in the culture tank, supplies suitable sized food organisms (< 1.0 mm) as first feed for fish larvae, the available free amino acids present in smaller daphnids being essential for the growth and survival of fry (Dabrowski & Rusiechi, 1983). The biomass production in alternate cropping is shown in Table 3. In 64 days the total biomass harvested amounted to 17.48 g, giving a total yield of 418.76 g/wk/m^3.

Table 3. Biomass production in alternate harvest of D.carinata.

Growth period until harvest (days)	Wet weight harvested (g)	Dry weight (g)	Yield ($g/wk/m^3$)
6	0.424	0.036	9.8933
5	2.840	0.218	79.5200
4	1.130	0.098	39.5500
6	1.173	0.137	27.3700
3	1.314	0.096	61.3200
6	1.750	0.136	40.8333
7	2.104	0.160	42.0800
10	1.027	0.070	14.3780
10	1.770	0.135	24.7800
7	3.952	0.314	79.0400
64	17.484	1.400	418.7646

De Pauw et al. (1981) have reported yields for D. magna fed on rice bran between 300 and 600 $g/wk/m^3$ (non selective harvest) and 500 and 900 $g/wk/m^3$ (selective harvest). However, the initial population density in their work is 50 times higher than in the present work. If corrected for this difference, yields in the present work are between 495 and 3976 $g/wk/m^3$, and far greater than obtained by De Pauw et al. (1981). Yields, reported earlier by Murugan (1983a, b) for cow dung extract and for a combination of cow dung extract and powdered ground nut cake were 113.76 and 190.48 $g/wk/m^3$. No comparison can be made with the study of Bhanot & Vaas (1976) which deals with numerical estimation of the population of D. carinata using fresh poultry manure as a nutrient source. Bogatova & Askero (1958) have reported that the initial stocking density has a profound effect on the maturation of the culture and recommended a more dense inoculation only when cultures are to be utilized for a short period. For consistent harvest over a longer duration, the best results may be obtained from cultures with a low initial density (Pechen, 1967).

A comparative study of yields of Daphnia fed with other waste products reveals that the highest yields are obtained with the combination of organically enriched microbial medium and algal biomass (Table 4). The low yields in other waste products such as cow dung, horse manure, swine manure and extract of cow dung may be attributed to the organic content being completely degraded.

Table 4. Production in different cultures of *Daphnia*.

Species	Nutrient	Yield* (g/wk/m3)	Source
D.magna	horse manure	350	Ivleva, 1973
D.magna	swine manure	35-250	De Pauw et al., 1981
D.magna	pure algae	100-700	De Pauw et al., 1981
D.magna	rice bran	300-600 (NSH) 500-900 (SH)	De Pauw et al., 1981
D.carinata	cow dung extract	113 (SH)	Murugan, 1983a
D.carinata	cow dung extract plus powdered ground nut cake	190 (SH)	Murugan, 1983b
D.carinata	microbial medium plus algal biomass	495-3976(AH)	present work

* NSH : Nonselective Harvest
SH : Selective Harvest
AH : Alternate Harvest

The mean relative composition in carbohydrates, proteins and lipids is expressed in percentages of ash-free dry weight in Table 5. Results are variable and difficult to interpret. It is inferred that these variations are due to differences in the methods used and/or in the physical state of the organisms or to trophic differences of the ecosystems (Vijverberg & Frank, 1976).

Table 5. The relative amounts of carbohydrates, proteins and lipids of different species of daphnids.

Authors	Species	% of ash-free dry matter		
		Carbo-hydrate	Protein	Lipid
Farkas, 1958	*D.magna*	43.2	22.3	34.6
Blazka, 1966	*D.pulicaria*	7.3	78.1	14.6
	D.magna	17.9	68.0	13.1
	D.longispina	12.2	75.6	12.2
	D.obtusa	23.9	67.5	8.6
	Ceriodaphnia reticulata	53.0	41.0	6.0
	Simocephalus sp	2.2	54.4	12.4
Mittelholzer, 1970	*Daphnia* sp.	22.2	13.0	65.0
Present study	*D.carinata*			
	< 1.53 mm	47.92	36.10	15.97
	> 1.53 mm	57.62	18.37	24.00

At present, there is no commercial exploitation of Daphnia in India. Although the methods described in this study may not be regarded as an ideal open culture, relative large and consistent harvests of Daphnia can be obtained by using a rather uncomplicated set-up. Further research may confirm the economical feasibility and acceptability of this system resulting in large scale Daphnia farming for freshwater fish hatcheries.

The results of the present study justify further identification of promissing Cladoceran species to be used as life food in freshwater aquaculture.

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References

Ackefors, H. & Rosen, C.G., 1979. Farming aquatic animals. Ambio, 8: 132-143.

Alikunhi, K.H., 1952. On the food of young carp fry. J. Zool. Soc. India, 4: 77-84.

Alikunhi, K.H., Chandhuri, H. & Paachandean, V., 1955. On the mortality of carp fry in nursery ponds and the role of plankton in their survival and growth. Indian J. Fish., 2: 257-313.

Banta, A.M., 1921. A convenient culture medium for daphnids. Science, 53: 557.

Barthelmes, D., 1969. Möglichkeiten einer industriemassigen Naturmahrungsproduktion in Kombination mit der industriemassigen Karpfenproduktion. Z. Fischerei NF, 17(1-4): 117-125.

Bhanot, K. & Vaas, K.K., 1976. Mass rearing of Daphnia carinata King in the field. J. Inland Fish. Soc.India,8:145 148.

Birch, L.C., 1960. The genetic factor in population ecology. Am. Nat., 94: 5-24.

Blazka, 1966. The ratio of crude protein, glycogen and fat in the individual step of the production chain. In: J.Hrbacek (editor), Hydrobiological studies I. Academic Publishing House of the Czechoslovak, Academy of Science, Prague. pp. 395-409.

Bogatova, I.B. & Askero, M.K., 1958. Experiment in commercial cultivation of Daphniidae. Rybnoye Khozyaystvo, 12: 21-26.

Conklin, D.E. & Provasoli, L., 1977. Nutritional requirement of the water flea Moina macrocopa. Biol. Bull., 152: 337-350.

Conklin, D.E. & Provasoli, L., 1978. Biphasic particulate media for the culture of filter feeders. Biol. Bull., 154: 47-54.

Conveney, M.F., Cornberg, G., Enel, M., Larsson, K. & Olofesson, L., 1978. Phytoplankton, zooplankton and bacteria standing crop and reproduction relationship in eutrophic lake. Oikos, 29: 5-21.

Cooper, E.L. & Granlight, J.R., 1963. Differential survival of rainbow trout fed living organisms and hatchery diets. Prog. Fish. Cult., 25(4): 193-197.

Dabrowski, K. & Rusiecki, M., 1983. Contents of total and free amino-acids in zooplanktonic food of fish larvae. Aquaculture, 30: 31-42.

D'Agostino, A.S. & Provasoli, L., 1970. Dixenic culture of D. magna Straus. Biol. Bull., 139: 485-494.

De Pauw, N., Laureys, P. & Morales, J., 1981. Mass cultivation of Daphnia magna Straus on rice bran. Aquaculture, 25: 141-152.

Dubois, M., Giles, K.A., Hamilton, J.K., Roberts, P.A. & Bonnet, J., 1956. Colorimetric method of sugars and related substances. Anal. Chem., 28: 350-356.

Farkas, T., 1958. Comparative studies on the chemical composition of lower and higher crustaceans. Annal. Biol. Tihany, 25: 179-186.

Free, N., 1966. Grow your own live fish food. Aquarium, 35(1): 36-39.

Gliwicz & Hillbricht-Ilkowska, 1972. Efficiency of the utilization of nannoplankton primary production by communities of filter feeding animals measured in situ. Verh. Int. Ver. Limnol., 18: 197-203.

Gophen, M., 1977. Feeding of Daphnia on Chlamydomonas and Chlorobium. Nature, 265: 271-272.

Gophen, M., Carari, B.Z. & Berman, T., 1974. Zooplankton feeding on a differentially labelled algae and bacteria. Nature, 247: 393-394.

Huet, M., 1970. Traite de Pisciculture. Editions ch. de Wyngaert. Bruxelles, 718 pp.

Ivleva, I.V., 1973. Mass cultivation of invertebrates, biology and methods. Translated from Russian, Israel Program for Scientific Translations, Jerusalem, 193 pp.

Lampert, W., 1974. A method for determining food selection by zooplankton. Limnol. Oceanogr., 19: 995-998.

Lowry, O.H., Rosenborough, J.J., Farr, A.L. & Randall, R.J., 1951. Protein measurement with folin phenol reagent. J. Biol. Chem., 193: 265-275.

Mittelholzer, E., 1970. Population dynamik und Produktion des zooplanktons. Hydrologie, 32: 106-139.

Muller, H.G., 1980. Experiences with test systems using Daphnia magna. Ecctoxicology and Environmental safety, 4: 21-25.

Murugan, N., 1983a. Aquaculture of Daphnia. In: Proceedings of the First Biennial Conference on Warmwater Aquaculture Crustacea, Feb. Hawaii.

Murugan, N., 1983b. Live animal food for rearing carp fingerlings in Aquaculture. In: Proceedings of the Conference on biology and biotechnology in developing countries, Nov., Singapore.

Murachi, S. & Imai, T., 1954. Studies on the culture of waterfleas, Moina macrocopa Straus, in artificial medium. Tohoku. J. Agr. Res., 5: 27-36.

Murphy, J.S., 1970. A general method for the monaxenic cultivation of the Daphnidae. Biol. Bull., 139: 321-332.

Navaneethakrishnan, P. & Michael, R.G., 1971. Egg production and growth in Daphnia carinata King. Proc. Ind. Acad. Sci., 73: 117-123.

Pechen, G.A., 1967. Mass culture of Cladocera. Fisheries

Research Board of Canada, Translation Series No. 871.
Provasoli, L., Shiraishi, K. & Lance, J.R., 1959. Nutritional idiosyncrasies of Artemia and Tigriopus in monoxenic culture. Ann. N.Y. Acad. Sci., 77: 200-261.
Raymont, J.E.G., Austin, J. & Linford, E., 1964. Biochemical studies in marine zooplankton. I. The biochemical composition of Neomysis integer. J. Cons. Int. Explor. Mer., 28: 354-363.
Rees, T. & Oldfather, M., 1980. Small scale mass culture of Daphnia magna Straus. Proc. World Maricul. Soc., 11: 202-210.
Slobodkin, L.B., 1966. Growth and Regulation of Animal Populations. Holt, Rinehart and Winston, New Yoek.
Smyly, W.J.P. & Collins, G., 1975. The influence of microbial food sources and aeration on the growth of Cerodaphnia quadrangula (O.F.Muller) (Crustacea: Cladocera) under experimental conditions. Freshwat. Biol., 5: 251-256.
Taub, F.B. & Dollar, A.M., 1964. Chlorella-Daphnia food chain study: The design of a compatible chemically defined medium. Limnol. Oceanog. 9: 61-74.
Taub, F.B. & Dollar, A.M., 1968. The nutritional inadequacy of Chlorella and Chlamydomonas as food for Daphnia pulex. Limnol. Oceanog., 13: 607-617.
Tezuka, Y., 1971. Feeding of Daphnia on plankton bacteria. Jap.J. Ecol., 21: 127--134.
Thorpe, J.E. & Wankowski, J.W.J., 1979. Feed presentation and food particle size for juvenile atlantic salmon, Salmo salar L. In: Halver, J.E. & Tiews, K. (editors), Finfish nutrition and fishfeed technology I. Heenemann GmbH & CO, Berlin, p. 501-513.
Van der Wind, J.J., 1979. Feed and feedings in fry and fingerlings culture. In: E.A. Huisman & H. Hogendoorn (editors). EIFAC workshop on mass rearing of fry and fingerlings of freshwater fishes. EIFAC technical paper No. 35, suppl. 1., p. 59-70.
Venkataraman, K., 1981. Field and laboratory studies on Daphnia carinata King (Cladocera: Daphniidae) from a seasonal tropical pond. Hydrobiologia, 78: 221-225.
Vijverberg, J. & Frank,. H., 1976. The chemical composition and energy contents of copepods and cladocerans in relation to their size. Freshwat. Biol., 6: 333-345.
Weglenska, T., 1971. The influence of various concentrations of natural food on the development fecundity and production of planktonic crustaceans filterators. Ekol. Pol., 30: 427-473.

Recent developments in carp culture technology in India with special reference to the State of Andhra Pradesh

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Summary

In India, carp are the most widely cultured species in the freshwater sector. However, the techniques adopted by farmers remained rather an art till a few years ago. Only recently, the technology of carp culture known as composite culture was developed on a scientific basis, involving rearing of 3-6 species together for efficient utilization of food and space. Experimental studies have shown the possibility of producing over 10,000 kg/ha/yr with the six species combination. Since about a decade, this type of carp culture has been taken up on a commercial scale by a number of farmers in a southern state of India, Andhra Pradesh, where over 50,000 ha of artificially constructed ponds are reported to be used. Though the farmers have adopted the basic principles of composite carp culture technology, large deviations from some of the recommended practices like species cultured, number of species used, fertilization rate, feeding strategy, etc. are noticed. Productions ranging rom 2,000-10,000 kg/ha/yr are obtained with three species of Indian major carps. However, with the adoption of intensive management practices, farmers are now facing a number of problems, particularly bacterial and parasitic diseases. This paper discusses the techniques adopted by the farmers of Andhra Pradesh and highlights the priority areas of research to further develope carp culture.

Introduction

Indian carp culture is believed to be as old as Chinese carp culture. Since immemorial times, carp were cultured traditionally in stagnant waters in some north-eastern states of the country, particularly in West Bengal. After indepence, significant importance was attached to the development of fisheries and research institutes were established to investigate the resource potential and to develop appropriate technologies. The sustained research efforts of these institutes for almost three decades has led to understanding the basic principles of traditional carp culture and to development of appropriate technologies for adoption throughout the country. This paper examines progress made, problems encountered and prospects envisaged for carp culture in India.

Existing technology

Traditionally, Indian carp, namely, catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and calbasu

(Labeo calbasu) were stocked in certain ratios and cultured together. This system of polyculture enables utilization of all available food in the pond ecosystem due to the differing species-specific food habits, thereby resulting in optimum production. However, of late, calbasu is not included anymore in the system, since there is overlap in food habits between mrigal and this species. Though catla is a zooplankton feeder, there exists no competition between catla and rohu, because of the latter's feeding on periphyton. It has been observed that catla, rohu and mrigal stocked in a 4:3:3 ratio result in the best production. With the introduction of Chinese carp, namely, common carp (Cyprinus carpio var. Communis), silver carp (Hypophtalmichthys molitrix) and grass carp (Ctenopharyngodon idella), polyculture involving three Indian major carp and three Chinese carp has been developed. Grass carp largely feeds on macro-vegetation and does not compete for food with other carp, while silver carp, a voracious feeder of phytoplankton and common carp which feeds on detritus compete to some extent for food with the Indian major carp. Nonetheless, productions of over 10,000 kg/ha/yr of fish have been achieved through polyculture of the six species (Chauduri et al., 1974). The economic viability and commercial feasibility of this six species combination is discussed later in the article.

In general, the system of polyculture in ponds involves (1) removal of unwanted weeds and fishes, (2) liming of the pond to optimize pH, (3) fertilization with organic manure like cowdung (20,000 kg/ha/yr) and poultry manure (10,000 kg/ha/yr) in separate doses at monthly intervals and inorganic N and P fertilizers at 180-200 kg/ha/yr respectively 250-300 kg/ha/yr, (4) stocking of three to six species of carp at 3,000-10,000 individuals/ha, (5) regular feeding of fish with a mixture (1:1) of rice bran and oil cake at 2-3% body weight and feeding of grass carp with aquatic and terrestrial weeds in the absence of weeds in the cultured pond, and (6) harvesting of fish usually at the end of a one year growing period (Jhingran, 1986). Depending on the type of culture, productions ranging from 400-10,000 kg/ha/yr are obtained. The national average production is estimated to be around 600 kg/ha/yr (Srivastava, 1986). Under intensive culture practices, a three species culture of Indian carp alone is known to yield 4,000 kg/ha/yr, while a six species culture has given record productions of over 10,000 kg/ha/yr.

Recent developments

By and large, throughout the country, the system of polyculture remains the same, except for the species chosen for culture, which varies largely according to the local availability of seed fish. The level of technology varies considerably from region to region, depending on the economic capability of the farmers and the availability of technical guidance for their culture operations. Due to large variations in applied technology, production also varies widely, being in most cases less than 1,000 kg/ha/yr.

Carp culture on a commercial basis was first taken up in a southern state of India, Andhra Pradesh, where nowadays over 50,000 ha of new constructed ponds for carp culture are present. Though basic principles of polyculture remain the same, considerable modifications in the adoption of technology has been made in order to obtain optimum production and better economic returns. The development taken place in this region has become an eye opener for policy makers at regional and national level, since it has given a new look to the commercial viability of carp culture. In fact, the practices adapted here have acted as real examples of carp culture technology for most parts of the country. This technology will be briefly discussed.

Most of the carp culture activities are concentrated around the Kolleru lake, which covers an area of 674 km², with a depth ranging from 3-13 ft. A few ponds constructed in the early years of the last decade on the borders of this lake initiated the expansion of a booming carp culture industry (Rao, 1987). Paddy is the major crop cultivated in this area which is known as the 'rice bowl' of India. However, frequent floods, increasing scarcity and costs of labour and poor returns from the paddy crop led the farmers to look for a crop which could overcome these problems. The success achieved in the few ponds constructed in the peripheral zone of the lake led other farmers to venture into this business. The success story spread at such a rate that on average about 5,000-10,000 ha of paddy area is converted into fish ponds every year. It is feared that paddy may no longer remain the major crop of the region, if aquaculture development remains at this rate. This rapid expansion proves beyond doubt that the technology applied is economically viable.

Pond construction

Most ponds constructed thus far derive water either from Kolleru lake or from irrigation canals connected to reservoirs. Though initially a "complete excavation method" was followed for the construction of ponds of 1-2 m depth, in recent years the "trench method" has become more popular. Using the latter method, trenches measuring 5-20 m in width and 0.5-0.7 m in depth are dug on all the four sides of the pond and the excavated earth is used for the construction of the dam. This method has the advantages, that costs of construction are nearly 60-70% less, and that at the time of harvest, when the pond is fully drained, fish take shelter in this trench and can be kept alive till they are harvested. The size of the ponds generally ranges from 0.4 to 10 ha, with an average size of 1.0 ha.

Stocking practices

In all farms, only Indian major carp are cultured, together with a few grass carp (50-100/ha) to control marginal vegetation. Though a six species culture yields high productions, farmers use only three species of Indian major carp because of greater economic returns. Silver carp, may contribute more than its stocking percentage in terms of production, but its poor keeping quality, lower market demand and its competition with catla for food, resulting in lower growth of the latter, have led the farmers to exclude this species from the polyculture system. Also common carp is excluded because of its pond breeding habit and its competition for food and space with mrigal. Though grass carp commands good market prices, this species is stocked at very low density since farmers encounter difficulties in providing the required quantities of weeds. Moreover, grass carp has also been observed to feed voraciously on artificial feeds provided for other fish, resulting in poor growth of the other species of carp. Therefore, grass carp is stocked at very low density, mainly in cases where an aquatic weed problem is faced.

In most of the farms, 8-10 months old stunted fingerlings of 100-200 g in size are stocked. Usually, seed procured in advance is kept in ponds at a density of 40,000-50,000/ha for 8-10 months during which period they do not grow due to the high density. Carp are known to grow rapidly during the second year and this trait is well utilized by the farmers to their advantage.

Though under the standardized culture practice, the stocking ratio of catla, rohu and mrigal is recommended to be 4:3:3 for optimum production, most farmers use these species in the ratio of 2:7:1. Further, instead of the optimum stocking density of 4000 per ha, usually a stocking density of 1,500-2,000/ha is adopted, although some farmers are now changing to increased stocking rates.

Pond fertilization

Poultry manure is the most commonly used organic manure. The dosage of manure applied varies widely. In intensively cultured ponds, upto 20 tons/ha/yr is used. Along with poultry manure, urea and superphosphate are also used at 200-500 kg/ha/yr. Fertilizers are applied at fortnightly or monthly intervals. Inorganic fertilizers are mixed with organic manures and then applied to the pond.

Feeding

Feeding is widely employed in all farms. De-oiled rice bran mixed with either groundnut cake, mustard cake, sunflower cake or soya cake at a 4:1 ratio is used as against the recommended practice of a 1:1 rice bran/oil cake mixture. The reason for this change are the increased costs of the cakes. Many farmers use solely rice bran at the initial stage and only towards the end of the grow-out period oil cake is used upto 20%, to enhance fish growth. Feeding rate generally ranges from 2-10% of the fish biomass per day. During the winter months when feed conversion efficiency is low, low feeding rates are applied.

An improved technique of feeding has been developed by the farmers. Unlike the common practice of throwing feed into the pond, feed is kept in perforated bags tied to bamboo poles. Per ha 10-20 fertilizer bags of 20"x30" in size with two rows of perforations at the bottom are tied individually to bamboo poles fixed at different places in the pond. Upto 12 kg of feed can be kept in each bag. Fish browse on the feed through the perforations and within two hours most of the feed kept in the bags is utilized. Feed bags are removed, washed thoroughly and dried before reuse. When the perforations become too big, bags are replaced. This method results in a minimum wastage of feed. If the feed is not consumed within 2-3 hrs after feeding, farmers suspect diseases and will immediately examine their fish. When the fish have to be treated for disease, drugs are usually mixed with the feed and fed for a specified period.

Harvesting

Harvesting of fish is done after 9-12 months of culture. Most of the fish grown in this area is taken to the Calcutta market and the harvesting dates are adjusted to festival/auspicious days when demand for fish is high. Fish weighing over 1-2 kg fetch good prices while smaller fish fetch 30-40% less. Hence, farmers resort to harvesting fish of over one kg. Among the three carp, rohu commands the highest price. Depending on the intensity of management practices adopted, catla attains a weight of 3-5 kg, rohu 2-3 kg and mrigal 1-3 kg, with an average survival of 80-95%, the total fish production ranging between 1,500 and 9,000 kg/ha/yr.

During this year, the Indian Branch of the Asian Fisheries Society honoured a farmer for obtaining a record net fish yield of 8,926 kg/ha/yr, with three species of Indian major carp. In brief, the management practice adopted by this farmer consisted of (a) stocking catla, rohu and mrigal weighing 150-250 g at a total density of 3,750/ha at a ratio of 13% catla, 78% rohu and 9% mrigal in a pond measuring 1.2 ha with a water depth of 2 m, (b) fertilizing the pond periodically with biogass slurry (@ 16.5 tonnes/ha/yr), poultry manure (@ 12.5 tonnes/ha/yr), urea (@ 200 kg/ha/yr) and superphosphate (@ 300 kg/ha/yr), and (c) daily feeding of fish with de-oiled rice bran and groundnut oil cake at about 2% body weight per day. At the end of a 15-months culture period, catla attained an average weight of 5 kg with 91.7% survival, while rohu and mrigal attained 3.0 kg each with 98.6% and 100% survival respectively.

Depending on the management practices adopted, production costs are believed to range between Rs.4 and 12/kg. Though the market price fluctuates widely from Rs.15-60/kg, a price of Rs.20/kg is generally obtained.

Disease problems

Until recently, diseases of carp were not a major problem and as a result this field did not receive considerable importance in research. However, with the adoption of intensive culture practices, occurence of diseases has become also common in carp ponds and there are no suitable curative measures for many of these diseases. Moreover, in many instances the causative organisms are yet to be identified. Commonly occuring parasitic, fungal and bacterial diseases and the treatment measures adopted at present are summarized in Table 1. Most of the treatment measures have been developed by the farmers themselves on a trial and error basis. However, indiscriminate use of pesticides and antibiotics is increasing at an alarming rate. In most cases, the farmers, fearing the loss of fish due to diseases, use antibiotics 4-6 times a year, as a preventive measure. On an average, it is reported that each farmer spends upto Rs. 1,000/ha/yr on medication

(Rao, 1988). Excessive use of organic manure, improper drying of ponds and poor water exchange are responsible for the outbreak of these diseases. Since all the farms derive water from and discharge water to the common canal, the spread of diseases from one farm to another has become unavoidable. It is feared that if the disease problem increases further, the existence of the industry might be threatened.
(Rao, 1988).

Table 1. Common diseases encountered in carp culture ponds (Rao, 1988).

Causative organism	Fish species	Treatment	Periode of occurrence
Parasitic diseases			
Myxobolus	catla	NaCl at 50 kg/ha applied in 2-3 instalments at 3-4 days interval. CaO at 100 kg/ha. Tetracycline and Chlortetracycline at 5 g/100 kg of fish	October to February
Epistylis Zoothamnium	catla and rohu	20-50 kg/ha NaCl applied in 2-3 instalments at 4 days interval	November to February
Dactylogyrus Gyrodactylus	catla and rohu	Malathion at 0.2 ppm applied 2-3 times at 4 days interval	April to June
Argulus	rohu	Malathion at 0.5-0.25 ppm or	throughout the year
Lernaea	catla	Dichlorovos at 0.05-0.1 ppm, applied in 2-4 instalments at 4-7 days interval	with increased infection in summer months
Fungal diseases			
Saprolegnia Branchiomyces	catla and rohu	$CuSO_4$ at 0.2-0.5 ppm in 2-3 instalments at 3-4 days interval	throughout the year
Bacterial diseases			
Ulcerative syndrome	catla, rohu and mrigal	Nitrofurans 7-10 g/100 kg of fish or Sulphadiazine + Trimethoprim at 5 g/100 kg and Chlortetracycline 7 g/100 kg of fish for 7 days	November to May
Columnaris disease	rohu and	Oxytetracycline or Chlortetracycline	November to May

	mrigal	or Nitrofurans at 7-10 g/100 kg of fish for 10 days	
Unidentified bacterial diseases	rohu	Nitrofurans at 10 g/100 kg of fish and Sulphamethozole + Trimethoprim at 5-7 g/100 kg of fish along with Chlortetracycline 7-10 g/100 kg of fish	November to May

New areas for investigation

Throughout the years carp culture used to be carried out only on a low profile in the existing stagnant seasonal and perennial water bodies. With the adoption of carp culture on a commercial basis, farmers start raising many questions pertaining to increase their returns. However, no satisfactory answers can be given (yet). Some areas asking for urgent attention can be enumerated as follows.

- Identification of suitable species with high market demand, which can be cultured together with carp.
- Optimization of manure load to obtain the best yield.
- Determination of the optimum water depth and water exchange rate in order to increase growth rate and yield.
- Assessment of the quantity of nutrients to be fed at different stages of growth to reduce input costs.
- Development of prophylactic and curative measures for various diseases.
- Investigations on the keeping quality of fish and assessing the possibilities of preparing fish-based "ready to eat" products.

Conclusions

India possesses over 1,600,000 hectares of freshwater area, of which only 600,000 hectares are reported to be under culture. With the successful large scale demonstration of carp culture technology on a commercial basis in Andhra Pradesh, the area under carp culture is expected to increase rapidly. The present high rate of economic returns from culture is likely to drive paddy growers of other areas into fish culture, apart from the utilization of existing water resources. However, unfortunately, at present, the entire fish production of Andhra Pradesh is marketed only in Calcutta. There is fear of a market collaps in the near future, if the present rate of expansion is continued to depend only on the Calcutta market and the industry is likely to face price problems. Hence, there is a need to find other major marketing areas for carp, within the state as well as elsewhere.

The availability of quality seed is another major problem presently encountered. Efforts are now underway to increase the number of carp hatcheries to meet this demand. It is encouraging to note that a number of private entrepreneurs has already entered into the seed production business. Considerable progress has also been made in the breeding of carp by advancing their maturation. Further, a new and effective compound called "ovaprim" has been experimentally used with great success in replacing pituitary material for breeding of carp. This investigation is likely to have a positive impact on the seed production industry.

The shift in culture practice from six to three species indicates that the economic return is the primary factor to be considered in developing a technology rather than the higher yield. Though the farmers of Andhra Pradesh have adopted the basic principles and practices of composite carp culture, there is a large deviation from the standard practices recommended.

Previously, scientific knowledge was mostly obtained from results of short term experiments conducted in small water bodies. However, the experience of the Andhra Pradesh farmers in large water bodies indicates that the existing package of practices needs to be re-examined and modified to enhance large scale commercial culture of carp.

References

Chaudhuri, H., Chakraborty, R.D., Rao, N.G.S., Janakiram, K., Chatterjee, D.K. & Jena, S., 1974. Record of fish production with intensive culture of Indian and exotic carps. Current Science, 43: 303-304.

Jhingran, V.G., 1986. Aquaculture of Indian major carps. In: R. Billard & J. Marcel (editors). Aquaculture of cyprinids. Institut National de la Recherche Agronomique, Paris. pp. 335-346.

Rao, K.G., 1987. Freshwater carp culture in Andhra Pradesh. Asian Fisheries Society, Indian Branch Newsletter, 1: 1-4.

Rao, K., 1988. Current fish disease problems in farmers' ponds of Andhra Pradesh. Asian Fisheries Society. Indian Branch Newsletter, 2: 3-6.

Srivastava, U.K., 1986. Rural aquaculture in India. In: Research for third world development: Canada's contribution through the International Development Research Centre, 1970-1985. IDRC 246c. Ottawa, Canada. pp. 125-132.

Influence of silkworm Pupa based diets on growth, organoleptic quality and biochemical composition of Catla-Rohu hybrid

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Summary

An experiment was conducted to study the feasibility of replacing fish meal, either partially or completely, with non-defatted silkworm pupa in the diet of catla-rohu hybrid, this hybrid being more promising than rohu in composite carp culture. In two diets, fish meal was completely replaced with silkworm pupa, incorporated at 35% (pellet A) and 25% (pellet B) respectively, while in another two diets silkworm pupa was incorporated at 20% (pellet C) and 15% (pellet D) respectively, in addition to fish meal present at 10%. A fish meal based standard diet was used as the reference diet (pellet E). The other components of the diets were groundnut oil cake, rice bran and tapioca flour. All the diets were enriched with 1% vitamin and mineral mixture, and were nearly isonitrogenous and isocaloric.

The growth experiment was conducted over a period of 112 days in 10 cement basins of 25 m^2 each. Each diet was tried in duplicate. Each basin was stocked with 20 uniformly sized catla-rohu hybrid fry. Fish were fed with the test diets at 5% body weight daily in the morning. Fish growth was assessed at fortnightly intervals.

Fish fed on pellet D showed consistently better growth throughout the rearing period, attaining 37.19% higher weight than the fish fed on the reference diet. The final weights attained with pellet A (86.98 g) and pellet E (86.18 g) were almost equal, while they were a little lower with pellet B (84.67 g) and C (84.80 g). The average specific growth rate was also higher with pellet D for both weight (3.64) and length (1.17). The feed conversion rate was better with pellet B (2.07) and C (2.12), as compared to the reference diet (2.39) and pellet A (2.42) and D (2.48). The water stability of all diets was found to be satisfactory even at the end of six hours.

The body composition showed an increase in fat and ash in all treatments compared to that of the fish fed the reference diet.

However, protein content was higher in the fish fed on reference diet. Among the experimental diets, protein content was lower where fish meal had been completely replaced. The organoleptic evaluation of fish grown on these diets was carried out by a group of trained panelists for various criteria like colour, odour, texture and flavour in raw fish, fish cooked in 1.5% salt solution and fish fried using spices in Indian style. Though statistically no difference could be observed between different treatments, it could be noticed that incorporation of pupa at 35% resulted in lowering the overall quality of flesh.

Introduction

In India, traditional carp culture is undergoing major transformation, with emphasis on regular feeding of fish with balanced diets. At the same time, attention is paid to find suitable alternate sources of protein, especially native sources, to replace fish meal, in order to cut down costs of production. One such local source is silkworm pupa the availability of which has phenomenally increased with the rapid expansion of the sericulture industry in the country. Non-defatted silkworm pupa is rich in protein and fat, but costs only half of that of fish meal. The present investigation was undertaken to study the effect of replacing fish meal with non-defatted silkworm pupa either partially or completely in the diet of catla-rohu hybrid. This hybrid, a cross between male catla (*Catla catla*) and female rohu (*Labeo rohita*), with the latter's food habit, grows faster than rohu and is widely recommended for use in composite carp culture (Keshavanath et al., 1980).

Materials and methods

Diet formulation

Incorporation of pupa was studied at four different levels *viz.*, 35% (diet A); 25% (diet B); 20% (diet C) and 15% (diet D). A fish meal based diet served as control (diet E). Diets A and B were devoid of fish meal, while C and D were supplemented with 10% fish meal. Other ingredients used in diet formulation, namely, groundnut cake, tapioca flour and rice bran were adjusted to obtain (near) isonitrogenous and isocaloric test diets (Table 1). The finely ground ingredients were sieved and dry pellets were prepared following the procedure described by Jayaram & Shetty (1981).

Table 1. Ingredient composition and proximate analysis of the experimental diets.

Ingredient	Diet A	Diet B	Diet C	Diet D	Diet E
Non-defatted silkworm pupa	35	25	20	15	-
Fish meal	-	-	10	10	20
Groundnut cake	15	24	24	24	29
Rice bran	39	40	35	40	40
Tapioca flour	10	10	10	10	10
Vitamin and mineral mix*	1	1	1	1	1
Proximate analysis(%)					
Dry matter	94.91 ±0.06	95.64 ±0.17	95.23 ±0.21	95.40 ±0.14	94.73 ±0.27
Crude protein	27.42 ±0.11	26.66 ±0.49	27.14 ±0.23	27.18 ±0.21	27.29 ±0.18
Crude fat	9.66 ±0.06	8.50 ±0.35	8.23 ±0.34	7.49 ±0.37	6.29 ±0.05
Crude fibre	11.14 ±0.12	11.93 ±0.21	13.25 ±0.19	11.31 ±0.12	14.26 ±0.09
Ash	15.98 ±0.32	15.71 ±0.08	15.23 ±0.26	16.35 ±0.11	14.92 ±0.17
Nitrogen free extract	30.71	32.84	31.38	33.07	31.97
Caloric content (kcal/g)	3.47	3.41	3.35	3.36	3.21

* Nuvimin forte - supplied by Sarabhai Chemicals Ltd., India.

Experimental design

Each treatment was duplicated in cement cisterns of 25 m2 (5x5x1 m) with no soil bed. Twenty uniformly sized fry (average weight 2 g) of catla-rohu hybrid were stocked per cistern. Fish were fed once daily in the morning at 5% body weight and sampled once a fortnight to assess growth and to adjust the feed quantity. After every sampling, water in the cisterns was replenished partially. Water temperature ranged from 27 to 32°C during the experimental period, which lasted 112 days.

Analysis of feed and fish

Ingredients, compounded diets and fish samples were analysed for moisture, protein, fat, fibre and ash, following AOAC (1975) methods, while nitrogen free extract (NFE) was calculated by the difference method. Water stability of the diets was determined employing the wet durability test of Hastings (1964).

Digestibility studies

Digestibility of protein and fat in the test diets containing 1% chromic oxide as an indicator was determined using fish acclimated for 10 days and kept in glass aquaria (70x35x35 cm). Faecal samples collected over a 15 days experimental period were pooled and analysed for both nutrients.

Organoleptic evaluation

On termination of the experiment, fish from each treatment were evaluated for colour, texture, odour and flavour in raw as well as cooked form (in 1.5% salt solution) by a group of 15 trained panelists. Samples fried in Indian style using spices were also evaluated by the panelists who graded the product for odour, texture and flavour. The method of Kramer & Twigg (1970) was used to find differences in individual attributes, while that of Udupa & Jayaram (1979) was employed for overall quality.

Statistical analysis

Multiple range test of Duncan (1955) was used for statistical analysis of the data.

Results and discussion

Proximate analysis of diets

Silkworm pupa contained 41% protein and 17% fat, while fish meal had 55% protein and 7.6% fat. In the formulated diets, protein content ranged from 26.66% to 27.42%, the lowest being in diet B (Table 1). Due to the high fat content of pupa, large variation occured in fat content of the diets, which progressively decreased from diet A to D (9.66%-7.49%) corresponding to the decrease in pupa content; fat content was considerably low in diet E (6.29%). Energy level was lower in diet E (3.21 kcal/g) largely due to its low fat content. Other diets had almost equal levels of energy (3.35-3.47 kcal/g). All the experimental diets containing silkworm pupa showed higher levels of ash. The relatively high fibre content of the diets, particularly diet C(13.25%) and E (14.26%), had no adverse effect on growth. Indian major carp are known to grow satisfactorily on feed containing fibre upto 16% (Anil, 1981; Bhatet al., 1986; Nandeesha et al., 1988a).

Water stability

The stability of the diets was satisfactory even at the end of 6 hrs (Table 2). Stability decreased progressively in all the diets with time and diet D showed the lowest dry matter content (79.94%) at the end of 6 hrs. Diet A and E showed higher stability throughout the period as compared to the other diets, which could be attributed to their higher fat content. Gelatinization of starch and presence of fat (Boonyaratpalin & Lovell, 1977; Jayaram & Shetty, 1981; Nandeesha et al., 1988b) are known to be responsible for maintaining the integrity of diets in water. Diets with better stability are preferred for feeding carp since they are slow feeders.

Table 2. Stability of formulated diets *

Diet	Time			
	1 hr	2 hr	4 hr	6 hr
A	91.21[a]	89.61[b]	86.13[e]	82.42[b]
B	91.66[b]	88.92[ab]	83.97[b]	80.66[ab]
C	91.89[c]	88.11[a]	84.92[c]	81.69[b]
D	92.26[d]	90.91[c]	82.72[a]	79.94[a]
E	93.36[e]	91.33[c]	85.97[d]	81.23[ab]
SEM**	0.06	0.35	0.18	0.68

* Figures in the same column having the same superscript are not significantly different ($p < 0.05$).

** Standard error of means.

Growth studies

The growth of fish in terms of weight and length is graphically represented in Figure 1 and 2. There was no significant difference in growth between the replicates. Diet D containing 15% silkworm pupa and 10% fish meal gave superior growth throughout the experimental period and the final weight was 37.19% higher than obtained by the control diet. Weight of fish from treatment D was significantly superior to all other treatments ($p < 0.05$). Weights attained with other diets were not significantly different and ranged from 84.67 g to 86.98 g. Gain in length almost followed the pattern of weight, the length attained with diet D (20.98 cm) being the highest whereas it varied from 18.78-19.19 cm in other treatments. The overall average specific growth rate for both weight (3.64%) and length (1.17%) was also higher with diet D, but feed conversion efficiency was slightly lower compared to the other diets (Table 3).

Table 3. Growth, feed utilization and survival of catla-rohu hybrid fed on different diets.

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E
Final average weight (g)	86.98	84.67	84.80	118.23	86.18
Net weight gain (g)	84.98	82.67	82.80	116.23	84.18
Average specific growth rate in weight (%)	3.37	3.34	3.35	3.64	3.36
Final average length (cm)	19.19	18.87	19.08	20.98	18.78
Net length gain (cm)	13.53	13.21	13.42	15.32	13.12
Average specific growth rate in length (%)	1.09	1.08	1.09	1.17	1.07
Daily weight gain(g/fish/day)	0.76	0.74	0.74	1.04	0.75
Daily feed intake(g/fish/day)	1.84	1.53	1.57	2.58	1.79
Feed conversion	2.42	2.07	2.12	2.48	2.39
Overall survival (%)	72.50	75.00	67.50	77.50	85.00

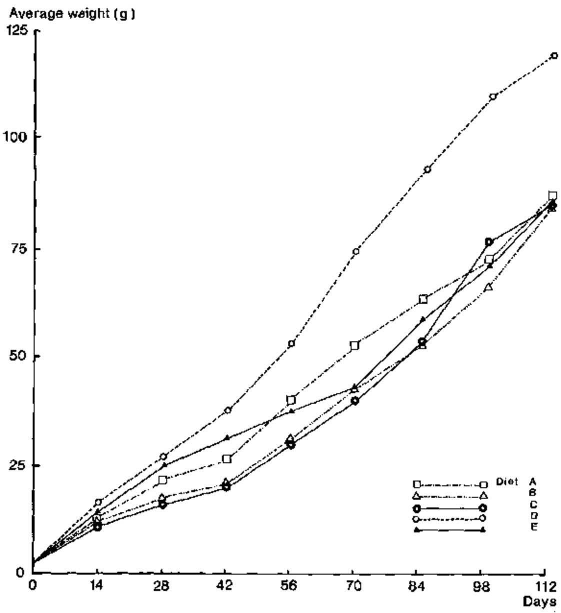

Figure 1. Growth responses (in weight) of catla-rohu hybrid fed experimental diets.

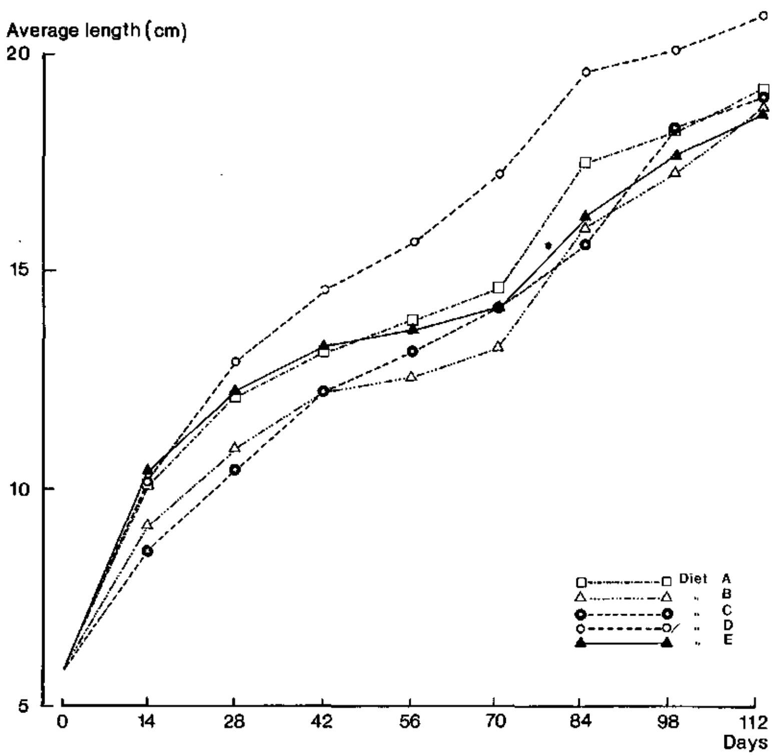

Figure 2. Growth responses (in length) of catla-rohu hybrid fed experimental diets.

Silkworm pupa is known to give superior growth of catla and common carp (Jayaram & Shetty, 1980c; Nandeesha et al., 1988b) when completely replacing fish meal in diets. It is reported that silkworm pupa contains some attractants and appetite stimulants (Ina, 1976; Tsushima & Ina, 1978) which enhance acceptability and thereby growth. Among the different levels of pupa tried, the best growth of fish was observed at a 15% inclusion in combination with 10% fish meal. Food intake was also higher in treatment D (Table 3) which indicates its better acceptability. Hora & Pillay (1962) reported on the extensive use of silkworm pupa in carp diets in China and Japan. However, in the case of chum salmon fry, silkworm pupa failed to improve growth but feed efficiency was found to be satisfactory (Akiyama et al., 1984). Chang et al., (1983) found better acceptability of pupa by grass carp with a feed conversion ratio of 1.1. The synergistic effect of fish meal (10%) and pupa (15%) cannot be easily explained; it appears that apart from better acceptability, the balanced nutrient profile of the combination resulted in faster growth. Jayaram & Shetty (1980c) observed poor growth of rohu when fed a diet containing 30% silkworm pupa but good growth of catla and common carp. The catla-rohu hybrid having food habits more like rohu appears to respond poorly to higher level of pupa incorporation.

Digestibility of feeds

The digestibility studies indicated a better digestibility of protein (88.84%) from diet D and of fat (91.64%) from diet E as compared to other diets (Table 4).

Table 4. Digestibility coefficient (%) of formulated diets*.

Parameter	SEM**	Diet				
		A	B	C	D	E
Protein	0.43	87.43^{ab}	88.66^{b}	87.11^{a}	88.84^{b}	86.91^{a}
Fat	0.35	90.71^{ab}	90.11^{a}	91.43^{b}	89.74^{a}	91.64^{b}

* Figures in the same row having the same superscript are not significant different ($p < 0.05$).
** Standard error of means.

In contrast to this, the digestibility of fat and protein from respectively diet D and E was found to be poor. In the other three test diets, digestibility of protein varied from 87.11-88.66% and that of fat from 90.11-91.43%. These values are in close proximity with the findings of Jayaram & Shetty (1980b) who reported protein and fat digestibility of 91.89% respectively 91.38% in rohu given a 30% silkworm pupa based diet. Goldfish and rainbow trout were also found to digest upto 80 respectively 85% of the protein from silkworm pupa (Hastings, 1969). In contrast to these high values, Kim (1974) observed low apparent digestibility for pupa protein (63.9%) in common carp. Since growth is considerably influenced by the digestibility of nutrients the present experiment suggests that the catla-rohu hybrid is able to adequately digest the nutrients from silkworm pupa based diets.

Fish composition

Moisture content was lowest in fish raised on diet D, while it was highest in fish growth on diet B (Tabel 5). Increasing body weight is known to decrease the moisture content (Papout

Table 5. Composition of fish fed on experimental diets.*

Parameter	Diet					
	A	B	C	D	E	SEM**
Moisture	80.36^{a}	81.88^{b}	80.71^{a}	80.03^{a}	80.31^{a}	0.24
Crude protein	15.65^{b}	15.26^{a}	16.06^{c}	16.01^{c}	17.02^{d}	0.02
Crude fat	2.10^{e}	1.97^{d}	1.90^{c}	1.88^{b}	1.75^{a}	0.02
Ash	1.17^{c}	1.02^{a}	1.14^{c}	1.08^{b}	0.99^{a}	0.01

* Figures in the same row having same superscript are not significant different ($p < 0.05$).
** Standard error of means.

In the present study, no reciprocal relationship between moisture and fat or protein could be observed as reported earlier (Grayton & Beamish, 1977; Watanabe, 1977). Fish protein content was significantly lower for diet A and B, in which fish meal was completely replaced by silkworm pupa. In contrast to this, fish fed the control diet showed higher protein deposition, followed by diet C and D. However, fat deposition was lowest in the control diet and it progressively increased from diet D to A. There was a direct relationship between fat level in the diet and in the fish in all treatments. Jayaram & Shetty (1980a) and Viola & Amidan (1980) also reported increased fat deposition with the use of fatty diets. Dupree (1969) reported a decline in protein deposition with increasing fat levels beyond the optimum level in channel catfish. Since diet D gave the best growth and also resulted in optimum protein deposition, it appears that optimum fat requirement for this hybrid is in the range of 6-7%. The ash content was significantly lower in control fish, while it was highest in fish raised on 35% pupa. The pupa based diets had higher ash content as compared to control. The biochemical data obtained in the study show that the diets tested had a major influence on flesh compositon.

Organoleptic evaluation

There were no significant quality differences in panel scores between the fish fed the respective diets. However, the flesh quality of fish fed diet A containing 35% pupa was poor as indicated by the low overall mean panel scores in both raw as well as in cooked form (Table 6). Partial substitution of fish meal or reduced level of pupa (25%) resulted in better acceptability. At 35% pupa incorporation odour, texture and flavour of cooked flesh were poor as compared to that of other diets. However, at a reduced level of pupa incorporation (15%) meat quality was found to be better. Further, when the fish were fried in Indian style with spices, the 15% pupa diet scored better than the rest (Diet D).

Table 6. Mean panel scores of raw (R), cooked (C) and fried (F) fish.

Diet	Colour and gloss of	Colour of flesh		Odour of flesh		Texture of flesh		Flavour	Overall quality		
	R	R	C	R	C	R	C	C	R	C	F
A	2.91	3.15	2.92	3.00	2.69	3.62	2.62	2.69	3.17	2.73	2.83
B	3.38	2.92	3.08	2.77	2.77	3.77	3.00	2.77	3.21	2.94	2.90
C	3.23	2.77	2.77	3.00	2.85	3.77	2.77	3.08	3.25	2.85	3.14
D	3.23	3.08	3.15	2.92	3.00	3.62	2.69	2.92	3.21	2.96	3.22
E	3.31	3.00	3.08	2.85	2.92	3.62	2.85	2.92	3.19	2.94	3.10

One of the problems associated with the use of non-defatted silkworm pupa in fish diets is the off-odour problem. It is reported that fish in Japan are purged before marketed when pupa based diets are used (Spinelli, 1979). Nandeesha et al. (1988b) also recorded poor flesh quality of fish when pupa was incorporated at 30% level in the diet. In order to overcome the acceptability problem, it is advisable to use pupa at a reduced level.

The present study clearly demonstrates that pupa when used at a 15% level in combination with fish meal (10%) results in superior growth of fish. Since pupa costs much less than fish meal and is available in large quantities, it can be profitably utilized in the formulation of low-cost, nutritionally balanced diets.

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References

Akiyama,. T., Murai, T., Hirasawa, Y. & Nose, T., 1984. Supplementation of various meals to fishmeal diet for chum salmon fry. Aquaculture, 37: 217-222.

Anil, K., 1981. Studies on the growth performance of cultivable carps fed on four formulated feeds. University of Agricultural Sciences, Bangalore, India, M.Sc. Thesis, 169 pp.

Association of Official Analytical Chemists (AOAC), 1975. Official Methods of Analysis, Washington, DC, USA, 1094 pp.

Bhat, K.G., Shetty, H.P.C. & Nandeesha, M.C., 1986. Formulation and evaluation of pelleted fish feed based on soyabean meal and squilla meal. In: J.L. Maclean, L.B. Dizon & L.V. Hosillos (editors). Proceedings of the First Asian Fisheries Forum, 26-31 May 1986. Asian Fisheries Society, Manila, Philippines, pp. 539-542.

Boonyaratpalin, M. & Lovell, R.T., 1977. Diet preparation for aquarium fishes. Aquaculture, 12: 53-62.

Chang, W.Y.B., Diana, J.S. & Chuapoehutz, W., 1983. Workshop report to agency for International development, 19-29 April 1983. Strengthening of South-east Asian Aquaculture Institutions, 30 p. Mimeo.

Crayton, B.D. & Beamish, F.W.H., 1977. Effects of feeding frequency on food intake, growth and body composition of rainbow trout (Salmo gairdneri). Aquaculture, 11: 159-172.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1-42.

Dupree, H.K., 1969. Influence of corn oil and beef tallow on growth of channel catfish. Technical paper. Bureau of US Sport Fisheries and Wildlife, 27: 1-13.

Hastings, W.H., 1964. Fish feed processing research. Feedstuffs, 36-43.

Hastings, W.H., 1969. Nutritional Score. In: O.W. Neuhaus & J.E. Halver (editors). Fish in Research. Academic Press, New York, pp. 263-292.

Hora, S.L. & Pillay, T.V.R., 1962. Handbook on fish culture in the Indo-Pacific Fisheries region. FAO Fisheries Biology Technical Paper, No. 14, pp. 203.

Ina, K., 1976. Fish behaviour. Kagaku To Seibutsu, 14: 648-653.
Jayaram, M.G. & Shetty, H.P.C., 1980a. Influence of different diets on the proximate body composition of Catla catla, Labeo rohita and Cyprinus carpio. Mysore Journal of Agricultural Sciences, 14: 381-384.
Jayaram, M.G. & Shetty, H.P.C., 1980b. Digestibility of two pelleted diets by Cyprinus carpio and Labeo rohita. Mysore Journal of Agricultural Sciences, 14: 578-584.
Jayaram, M.G. & Shetty, H.P.C., 1980c. Studies on the growth rates of catla, rohu and common carp fed on different formulated feeds. Mysore Journal of Agricultural Sciences, 14: 598-606.
Jayaram, M.G. & Shetty, H.P.C., 1981. Formulation, processing and water stability of two new pelleted feeds. Aquaculture, 23: 355-359.
Keshavanath, P., Varghese, T.J. & Konda Reddy, P., 1980. Preliminary studies on the growth of catla-rohu and rohu-catla hybrids. Mysore Journal of Agricultural Sciences, 14: 401-407.
Kim, Y.K., 1974. Determination of true digestibility of dietary proteins in carp with chromic oxide containing diets. Bulletin of Japanese Society of Scientific Fisheries, 40: 651-653.
Kramer, A. & Twigg, B.A., 1970. Quality control for the food industry, Vol. I. AVI Publishing Company, Westport, 566 pp.
Nandeesha, M.C., Srikanth, G.K., Basavaraja, N., Kehavanath, P., Varghese, T.J., Bano, K., Ray, A.K. & Kale, R.D., 1988a. Influence of earthworm meal on the growth and flesh quality of common carp. Biological Wastes, 26: (in press).
Nandeesha, M.C., Srikanth, G.K., Varghese, T.J., Keshavanath, P. & Shetty, H.P.C., 1988b. Growth performance of an Indian major carp, Catla catla (Ham.) on fish meal free diets. Paper presented at the Third Workshop on Fish Nutrition, AIT, Bangkok, 6-10 June 1988.
Papoutsoglou, S.E. & Papaparaskeva-Papoutsoglou, E.G., 1978. Comparative studies on body composition of rainbow trout (Salmo gairdneri R.) in relation to type of diet and growth rate. Aquaculture, 13: 235-243.
Spinelli, J., 1979. Influence of feed on finfish quality. In: J.E. Halver & K. Tiews (editors). Finfish Nutrition and Technology, Vol. II., Heenemann, Berlin, pp. 346-352.
Tsushima, J. & Ina, K., 1978. Survey of feeding stimulants for carp, Cyprinus carpio. Journal of Agricultural Chemistry Society of Japan, 52: 225-229.
Udupa, K.S. & Jayaram, M.G., 1979. A note on the statistical analysis of panel test data of food products by sensory evaluation. Current Research, 18: 106-107.
Viola, S. & Amidan, G., 1980. Observations on the accumulation of fat in carp and Sarotherodon (Tilapia) fed oil-coated pellets. Bamidgeh, 32: 33-40.
Watanabe, T., 1977. Sparing action of lipids on dietary protein in fish-low protein diet with high caloric content. Technocrat, 10(8): 34-39.

The effect of soil composition on the growth of the natural food "Klekap"

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Summary

Plants are the major natural food items in tidal pond ("tambak") culture. In "tambaks" the benthic food consists of macro- and micro-organisms called "klekap" (or lab-lab in the Philippines), which forms the principle food for milkfish (Chanos chanos) and penaeid shrimps.

In order to optimize growth of "klekap" the role of factors which can be manipulated, such as nutrient content, water level and soil texture, should be studied. This study indicates that the best growth of "klekap", dominated by Cyanophyceae, is obtained on soils with at least 30% of clay; on soils with a lower clay content "klekap" growth is limited.

Also, the important role of nitrogen for "klekap" growth is stressed.

Introduction

The natural food of plant origin in tambaks (tidal ponds) can be classified into plankton, necton, and benthos. Benthos consists of macro- and micro- plant and animal organisms called klekap (Rabanal et al., 1951). Klekap is the main food of milkfish and penaeids in tidal ponds (Poernomo, 1979). This study observed the growth and the type of klekap in relation to different clay contents of the substrate.

Materials and methods

The study was conducted in the Marine Science Laboratory at Ancol, Jakarta. The pond soil was taken at a depth of 20 cm under the surface at nine spots in a pond measuring 15 x 25 meter in Karangantu Banten, West Java. After mixing these samples the soil was fractionated using sieves to obtain three separated fractions: a) one with a particle size between 125-1250 micron called sand, b) one with a particle size between 3.7-125 micron called dust, and c) one with a particle size below 3.7 micron called clay.

To obtain 7 experimental substrates the fractions were mixed in different proportions with and without original pond soil (Table 1).

Table 1. Composition (%) of clay, dust, sand and original pond soil of the experimental substrates.

Substrate	Clay	Dust	Sand	Original pond soil*
A	50	20	30	0
AT	37.50	15	22.50	25
B	30	20	50	0
BT	22.50	15	37.50	25
C	10	20	70	0
CT	7.50	15	52.50	25
T	0	0	0	100

* Composition: clay 52%, dust 17%, sand 31%.

Klekap samples were obtained from five randomly selected sites of 1 m^2 each from the pond in Karangantu Banten. The samples were combined and mixed in the laboratory to form a homogeneous stock for inoculation.

Glass aquaria (90x75x50 cm) were filled with a layer of 5 cm of experimental substrate and a water level of 30 cm was maintained above the substrate. Klekap was inoculated in 9 randomly selected sites in each aquaria by means of an inoculation of 10 ml of the klekap stock suspended in 10 ml of pond water. Each aquarium was fertilized with 2.5 g of urea and 2.5 g of TSP, except substrate T. The experiment was carried out in triplicate. Samples of soil, water, and klekap were taken at 5 spots per aquarium 2, 6 and 10 days after inoculation by using a PVC pipe with a diameter of 2.5 inches. Substrate samples were mixed and analysed for N-NO_3, P-P_2O_5 and SiO_2. The 5 klekap subsamples from each replicate were mixed and abundance (cell units/cm^2), dry weight (mg/g wet klekap) and energy content (cal/g wet klekap) of klekap were measured. To identify the type of klekap the relative abundance of Cyanophyceae, Chlorophyceae, and Bacillariophyceae was microscopically determined.

Regression analysis was applied to determine the relations between klekap abundance and N-NO_3, P-P_2O_5, Si-SiO_2, energy content and dry weight.

Results and discussion

Klekap abundance and composition are shown in Table 2. In all treatments klekap consisted of a mixture of Cyanophyceae, Chlorophyceae and Bacillariophyceae. Cyanophyceae were dominant in all treatments, followed by Bacillariophyceae and Chlorophyceae.

Total klekap abundance (cells/cm2) ranged from 40,877 on substrate C to 92,026 on substrate AT (Table 2). Cell abundance was not significantly different ($P > 0.05$) between substrates A and B, but both A and B were significantly different ($P \leq 0.05$) from substrate C. Substrates AT, BT and CT followed the same pattern as substrates A, B and C. Low cell abundance on substrates C and CT indicate poorer klekap production on soils containing less than 30% clay. It was also observed that klekap detachment from the substrate occured after one hour on substrate C, whereas this took on average 10 hours for the other substrates.

Table 2. The composition of klekap in relation to different substrates.

Sub-strate	Total klekap abundance	Cyanophyceae total (%)	Chlorophyceae total (%)	Bacillario phyceae total (%)
		cell units/cm^2		
A	63117	31803 (50.39)	5961 (9.44)	25353(40.17)
AT	92026	46284 (50.29)	6947 (7.55)	38795(42.17)
B	61648	30801 (49.96)	5200 (8.43)	25647(41.60)
BT	83215	43618 (52.42)	2872 (3.45)	12242(44.13)
C	40877	21973 (53.75)	- -	19547(47.82)
CT	60964	33829 (55.49)	827 (1.36)	26338(43.20)
T	52126	26204 (50.27)	2393 (4.46)	23525(45.13)

Klekap energy content for the seven treatments is shown in Figure 1. The energy contents on substrates A and B were not significantly different ($P > 0.05$). Energy content on substrate C was significantly lower ($P < 0.05$) than that on substrates A and B. Klekap energy content on substrates AT, BT and CT was higher than that on substrates A, B and C, but followed the same pattern as on substrates A, B and C. Results indicate that klekap growth is retarded on soils with a clay content less than 30%. Consistently better klekap production was observed on substrates containing 25% original pond soil which may indicate some nutrient loss during the fractionation process.

The relations between klekap abundance and energy content and between dry weight and energy content are shown in Table 3 and 4, respectively.

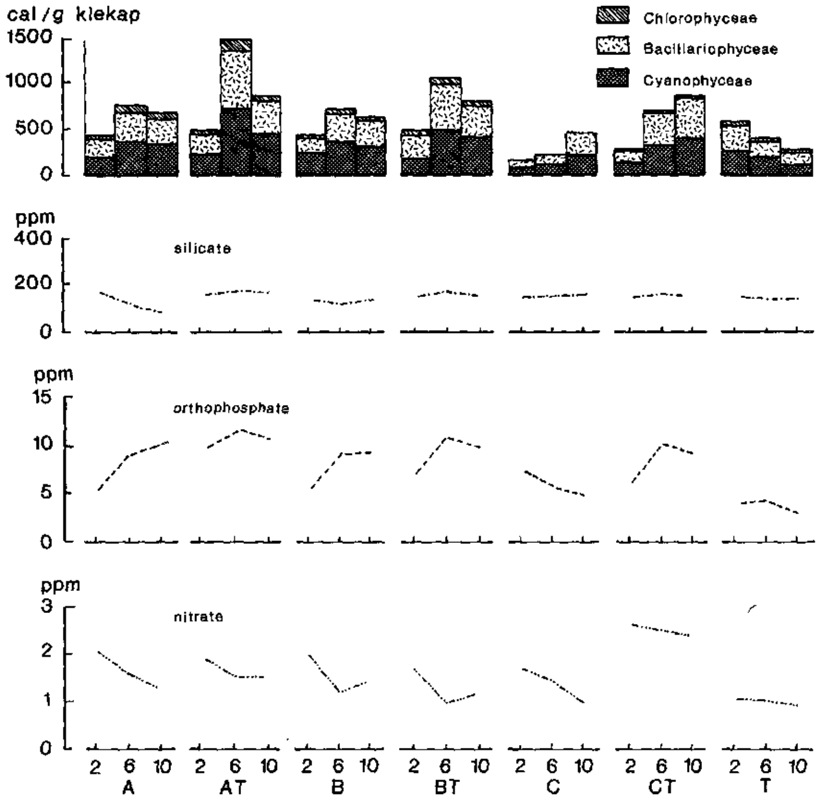

Figure 1. Composition and energy content of dry klekap (upper panel) and nutrient concentrations (lower panels) in the experimental substrates (A-T), 2, 6 and 10 days after inoculation.

Table 3. The regression equations between the abundance of klekap (Y) and the energy content (X).

Substrate	Linear	R
A	Y = - 86.15 + 0.10 X	0.82
AT	Y = - 1864.50 + 0.28 X	0.95
B	Y = 5445.24 + 2.17 X	0.30
BT	Y = 6891.91 + 2.86 X	0.64
C	Y = - 88.09 + 0.08 X	0.90
CT	Y = 4.34 + 0.09 X	0.99
T	Y = 87.99 + 0.06 X	0.92

Table 4. The regression equations between the dry weight (Y) of klekap and the energy content (X).

Substrate	Logaritmic			R
A	Y = 1164.47	+	209.65 ln X	0.72
AT	Y = 2046.75	+	494.12 ln X	0.86
B	Y = 1061.49	+	176.46 ln X	0.77
BT	Y = 1782.25	+	380.26 ln X	0.84
C	Y = 0.04	+	1.79^{-5} ln X	0.29
CT	Y = 2173.32	+	496.08 ln X	0.68
T	Y = 1684.36	+	406.42 ln X	0.73

Substrate nutrient concentrations as measured during the study are shown in Table 5. Concentrations of NO_3-N decreased for all substrates during the course of the study, while concentrations of PO_4-P increased for most substrates. The concurrent decrease in substrate NO_3-N and increase in klekap concentration was attributed to uptake of N by klekap. Reduction in PO_4-P was attributed to soil absorption of inorganic phosphorus.

Table 5. Average concentrations of N-NO_3 (ppm), P-PO_4 (ppm) and Si-total (ppm) 2, 6 and 10 days after inoculation.

Nutrient	Day	Substrate						
		A	AT	B	BT	C	CT	T
N-NO3 (ppm)	2	2.10	1.90	2.06	1.73	1.73	3.80	1.10
	6	1.60	1.43	1.30	0.93	1.53	2.83	1.03
	10	1.33	1.43	1.60	1.23	0.97	1.93	0.90
P-PO4 (ppm)	2	4.26	9.36	4.49	6.06	7.28	6.68	3.18
	6	8.31	11.23	9.18	10.07	5.55	9.79	3.91
	10	9.66	10.63	9.95	9.52	5.06	8.89	2.90
Si total (ppm)	2	175.04	158.27	155.51	161.06	172.73	172.94	174.41
	6	120.42	188.65	144.49	179.54	174.94	176.98	173.47
	10	107.44	187.53	153.70	175.16	176.28	172.46	173.19

Substrate N:P ratios are reported in Table 6. Research by Porcella & Bishop (1975) indicates that N is a limiting factor when N:P ratios are less than 15:1, and P is a limiting factor when N:P ratios are greater than 15:1. In this study, N:P ratios were substantially less than 15:1 for all substrates at all sampling periods, indicating that N was the most limiting factor for klekap growth for all substrates. Computation of regression coefficients for energy content versus nutrient.

Table 6. N:P ratios in the experimental substrates.

Days after inoculation	A	AT	B	BT	C	CT	T
2	0.40	0.20	0.46	0.29	0.24	0.57	0.11
6	0.19	0.12	0.14	0.09	0.28	0.28	0.35
10	0.14	0.13	0.16	0.13	0.19	0.22	0.31

Table 7. The regression coefficients between the energy content and the available nutrients ($N-NO_3$, $P-P_2O_5$, $Si-SiO_2$ (ppm)).

Substrate	Regression $Y=a_o + a_1X_N + a_2X_P + a_3X_{Si}$	R^{2**}
A	$Y_{Kl}{}^{*} = 713.93 - 45.81X_N + 23.11X_P - 1.40X_{Si}$	0.72
AT	$Y_{Kl} = 369.75 - 731.79X_N + 265.48X_P - 5.41X_{Si}$	0.69
B	$Y_{Kl} = 2398.23 - 6.32X_N + 22.95X_P - 13.02X_{Si}$	0.91
BT	$Y_{Kl} = 1610.56 - 407.88X_N + 89.93X_P - 5.79X_{Si}$	0.91
C	$Y_{Kl} = -3485.35 - 364.46X_N + 15.07X_P - 23.86X_{Si}$	0.83
CT	$Y_{Kl} = - 902.72 - 195.26X_N + 70.08X_P - 8.64X_{Si}$	0.92
T	$Y_{Kl} = -2789.92 - 632.34X_N + 862.32X_P - 0.04X_{Si}$	0.86

* Y_{Kl} = energy content of klekap.
** R at 0.05 level = 0.87

Conclusions and recommendations

Results indicate that site analysis for new tambak areas should include soil texture analysis to determine soil clay content. It is recommended that soils with less than 30% clay should not be used for the construction of tambaks that will require klekap production as the primary food source.

Results additionally indicate that nitrogen is the primary limiting nutrient or the production of klekap in brackishwater ponds. Therefore tambak management programs utilizing klekap as the primary food source, should include nitrogen fertilization schedules.

References

Poernomo, A., 1979. Budidaya udang ditambak. Dalam udang. Aprilani Soegiarto, Victor Toro, Kinarti A, Soegiarto, Projeck Penelitian potensi Sumber Daya Ekonomi LONLIPI, Jakarta. p. 77-173.

Porcella, D.B. & A.B. Bishop, 1975. Comprehensive management of phosphorus water pollution. Ann Arbor Sci. Publ. Inc. ASA., 129 pp.

Rabanal, R., H. Montalban & D.K. Villaluz, 1951. The preparation and management of Bangos fishpond nursery in the Philippines. The Philippines J. Fisheries: 1(1): 4-189.

The effect of various levels of protein, fat, carbohydrates and energy on growth, survival and body composition of Chanos chanos fingerlings

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Summary

Optimum protein, fat, carbohydrates and energy requirements of milkfish fingerlings were determined using growth, survival and body composition as parameters to assess the effectiveness of the diets. Chanos chanos fingerlings weighing 0.5 to 8.0 g were fed semi-purified dry diets consisting of casein and gelatin (4:1), corn oil and cod liver oil (1:1), dextrin, vitamin and mineral mixes, celufil and carboxymethyl cellulose. Treatments consisted of 27 combinations using three levels of protein (15, 30, 45%), fat (0, 6, 12%) and carbohydrates (10, 20, 30%) with two replicates each.

Each replicate consisted of 20 milkfish which were reared for 8 weeks in a flow-through fibreglass tank (40 l volume) using filtered seawater. Temperature and salinity ranged from 26 to 31°C and 30 to 32 ppt, respectively. Feeding rate of dry pellets was 10% of total biomass.

The results indicate that fingerlings require a protein level of 30-40% depending on their size, a fat level of 10% and a carbohydrate level of 25%. Weight gain did not improve if energy levels exceeded 3500 kcal/kg diet.

Based on response surface analysis a summary of possible optimum combinations of protein (%)-, fat (%)-, carbohydrate (%)- and energy levels (kcal/kg) in the diets are: for survival rate, 30/12/10/2540; for weight gain, 30/6/20/2680; for protein deposition 40/6 to 10/20 to 30/2960 to 3740; for fat deposition 40/6/10 to 30/2560 to 3360; for ash deposition 40/6/20 to 30/2460 to 3740.

Of the treatments, the following 5 diet combinations gave mortality rates less than 50%: 15/0/30/1800, 30/12/10/2680, 45/0/10/2220, 45/0/30/2800 and 45/12/20/3780.

Introduction

Rice and fish are staple foods in the Philippines as well as in other parts of Southeast Asia, where calorie/protein malnutrition is a serious problem. Milkfish, (Chanos chanos) is well-liked by the masses and, therefore, it could be a good source of protein and calories. In traditional culture, milkfish yield is rather low and limited to the carrying capacity of the culture ponds (Lim et al., 1979). To increase production through intensive culture, a diet to supplement the natural food in the ponds is needed. However, practical diet formulation is hampered by the lack of knowledge about the nutritional requirements of milkfish. The present study was carried out to determine optimum protein, fat, carbohydrate and energy levels for milkfish fingerlings using growth, survival, and body composition as parameters for determining the effectivity of the diets. The response surface analysis was explored graphically using a "freehand" technique to search for optimal diets with respect to dietary levels of protein, fat and carbohydrates.

Methodology

Chanos chanos fingerlings (0.5 to 0.8 g) were fed dry semi-purified diets consisting of casein and gelatin in a 4:1 ratio as protein sources, cod liver oil and corn oil (1:1) as fat sources, and dextrin as a carbohydrate source. Celufil made up for the difference in dextrin while vitamins and minerals were added. Carboxymethyl-cellulose (CMC) was used as binder (Table 1). Diets were prepared as described in National Academy of Sciences NAS/NRC (1973).

Table 1. Percentage Composition and P/E ratio's of the experimental diets.

Table 1. Percentage composition and P/E ratio's of the experiment diets.

Diet no.	P-F-C	Casein: Gelatin	Protein as analyzed in %	Fat as analyzed in %	Protein/Energy ratio (P/E in mg P/kcal)
1, 2, 3	15-0-10/20/30		15.9, 15.5, 15.9	0.2, 0.1, 0.3	150, 107, 83
4, 5, 6	15-6-10/20/30	12.67:	15.1, 16.3, 16.6	5.9, 5.7, 5.5	97, 77, 64
7, 8, 9	15-12-10/20/30	3.17	17.4, 16.6, 16.1	11.4, 11.6, 10.2	72, 60, 52
10, 11, 12	30-0-10/20/30		29.8, 29.8, 30.6	0.4, 0.2, 0.5	188, 150, 125
13, 14, 15	30-6-10/20/30	25.35:	31.4, 36.3, 29.6	5.1, 5.1, 4.5	140, 118, 102
16, 17, 18	30-12-10/20/30	6.40	32.5, 30.9, 31.4	10.7, 10.7, 10.4	112, 97, 86
19, 20, 21	45-0-10/20/30		45.9, 45.5, 45.1	0.6, 0.4, 0.3	205, 173, 150
22, 23, 24	45-6-10/20/30	37.60:	45.4, 43.7, 44.8	4.7, 4.3, 4.4	164, 143, 127
25, 26, 27	45-12-10/20/30	9.60	45.7, 46.3, 44.4	9.5, 9.1, 8.2	137, 122, 110

Vitamin mix (mg/kg/diet)
Vit. A, 10.99 mg; Vit. D_2, 0.025 mg; Vit. E, 67.06 mg; Vit. K_3, 10.0 mg; Choline Chloride, 581.52 mg; Niacin, 99.92 mg; Riboflavin, 19.98 mg; Pyridoxine HCl, 19.98 mg; Thiamine HCl, 19.98 mg; D-Calcium Pantothenate, 49.96 mg; Biotin, 10.0 mg; Folacin, 15.0 mg; Vit. B_{12}, 12.0 mg; Ascorbic Acid, 100.00 mg; Inositol, 100.0 mg; Celufil, 12,303.585 mg.

Mineral mix (mg/kg/diet)
$CaHPO_4$, 16.37; $CaCO_3$, 14.8; KH_2PO_4, 10.0; KCl, 10; NaCl, 6.0; $MnSO_4H_2O$, 0.35; $FeSO_4.7H_2O$, 0.50; $MgSO_4.7H_2O$, 6.137; $K1O_3$, 0.01; $CuSO_4.5H_2O$, 0.03; $ZnSO_4.7H_2O$, 0.347; $CoCl_2.6H2O$, 0.0031;

Diets were pelleted using a meat grinder and oven-dried (60°C) until moisture content was 10% or below. Diets were stored in a refrigerator at 4°C.

Fingerlings were taken from a pond, acclimated to laboratory conditions and seawater, fed a pelleted dry diet for two weeks, and anesthetized with 2-phenoxy ethanol (0.25 ppt) prior to weighing and stocking. Two replicates of 20 milkfish each were reared for eight weeks in 40 liters of filtered sea water in flow-through rectangular tanks (61 cm x 35 cm x 24 cm). Temperature and salinity were measured twice daily and ranged from 26 to 31°C and 30 to 32 ppt, respectively. Feeding rate was 10% of total biomass. Fish were fed thrice daily.

Fish were pooled per treatment for proximate analyses at the end of the study. Proximate composition of the diets were obtained by methods previously reported (Pascual et al., 1983). Energy levels and protein to energy (P/E) ratios were calculated using kilocaloric values of 4/g protein, 9/g fat, and 4/g carbohydrates (CHO).

Total weights of fish stocked per tank were obtained at the start and at the end of the study. Daily mortalities were recorded.

A 3x3 factorial incomplete block design was followed. The treatments consisted of 27 combinations with three levels (%) of protein (15, 30, 45), fat (0, 6, 12), and carbohydrates (10, 20, 30) with two replicates for each of the 27 treatments. The milkfish were blocked by size such that fibreglass tanks were arranged in three incomplete blocks consisting of nine tanks per block. Analysis of variance was used to show statistical differences among treatment means. Honest significant difference (HSD) to determine differences between treatment means and response surface analysis were used to estimate some possible optimal diets.

Results

Percentage survival of the milkfish fingerlings showed that none of the diets could be singled out as a diet providing good survival. However, of the 27 treatments, 6 diets gave survival rates of more than 50% throughout the experimental period (Table 2 and 3).

Table 2. Diet combinations that gave survival rates of more than 50%.

% Survival	Protein	Fat	CHO	kcal/kg Diet	P/E ratio
53	15	0	30	1800	83
55	30	0	30	2400	125
60	30	12	10	2680	112
55	45	0	10	2220	205
58	45	0	30	2680	150
60	45	12	20	3680	122

Table 3. Analysis of variance of the arcsin transformed percentage survival rates of milkfish fingerlings after a period of 56 days.

Source of variation	df	Sum of squares	Mean square	F
Replicates	1	325.69016	325.60016	5.81*
Blocks within replicates	4	5,513.05370	1,378.26343	24.59**
A (protein)	2	766.45750	383.22875	6.84**
B (fat)	2	269.48409	134.74204	2.40
C (carbohydrate)	2	1,303.14914	651.57457	11.62**
A x B	4	1,192.21117	298.05279	5.32**
A x C	4	222.48304	55.62076	0.99
B x C	4	632.22878	158.05720	2.82**
AxBxC unconfounded	4	346.97976	86.74494	1.55
partially confounded	4	206.46332	51.61583	0.92
Experimental error	22	1,233.12862	56.05130	
Total	53	12,001.32928		

* Significant (P <0.05)
** Highly significant (P <0.01)

Response surface analysis for weight gains showed that a well defined maximum appeared at 30% protein, 6% fat, and 20% CHO. As the level of CHO increased to 30%, a higher protein level seemed to be required to obtain optimum weight gain.

Body composition is shown in Table 4.

Table 4. Percentage mean weight gain, survival, crude protein, crude fat and crude ash of milkfish fingerlings fed various diets.

Diet No.	P-F-C	Mean weight gain[1] %	Survival %	Crude protein[2] %	Crude fat[2] %	Crude ash[2] %
1	15-0-10	43.01	20	71.79	5.63	14.78
2	15-0-20	8.87	38	70.09	4.81	16.43
3	15-0-30	52.64	53	67.40	12.52	13.76
4	15-6-10	30.34	25	68.18	6.91	18.37
5	15-6-20	14.65	18	69.41	7.50	18.85
6	15-6-30	2.96	23	70.00	5.30	19.76
7	15-12-10	-19.52	5	66.38	-	-
8	15-12-20	-21.69	25	67.46	4.62	23.83
9	15-12-30	12.19	28	69.68	6.41	19.97
10	30-0-10	43.12	28	67.97	7.00	17.26
11	30-0-20	36.42	45	66.44	10.60	14.51
12	30-0-30	56.13	55	66.97	9.50	13.65
13	30-6-10	38.80	45	66.65	11.72	15.33
14	30-6-20	149.92	33	62.40	15.38	13.37
15	30-6-30	28.81	25	61.56	12.64	12.23
16	30-12-10	18.46	60	65.78	12.72	15.44
17	30-12-20	3.27	18	60.78	18.70	-
18	30-12-30	4.04	10	64.03	16.88	-
19	45-0-10	32.36	53	68.25	9.03	14.76
20	45-0-20	51.68	38	67.34	9.69	14.59
21	45-0-30	61.44	60	67.84	9.52	13.48
22	45-6-10	68.06	15	61.62	13.10	14.45
23	45-6-20	63.53	25	60.56	13.97	12.72
24	45-6-30	79.33	48	60.72	13.79	12.99
25	45-12-10	43.19	18	67.43	9.64	15.13
26	45-12-20	24.58	58	65.13	11.24	15.73
27	45-12-30	28.04	28	64.53	14.64	14.64
	Std.error of the mean	±24.15	±0	±0.451	±0.628	±0.558
	HSD (.05)			2.58	3.58	3.18

[1] Analyses of variance indicated insignificant differences.

[2] Analyses of variance indicated highly significant differences.

Note: In a column of any two means whose difference is larger than the HSD (Honest Significant Difference) values are declared significantly different.

The response surfaces for percentual protein and fat deposition showed that protein and fat deposition occured at all levels of CHO. The minimum levels for protein deposition are 30-45% protein, whereas the maximum level for fat deposition amounts to some 6% fat.

On the basis of response surface analysis, a summary of possible optimal combinations of diets is presented in Table 5.

Table 5. Some possible optimal combinations of diets.

Response variable	Protein	Fat	CHO	kcal/kg diet	P/E ratio
Survival rate	30	12	10	2680	112
Weight gain	30	6	20	2540	118
Protein deposition	40	6-10	20-30	2960-3740	135-107
Fat deposition	40	6	10-30	2960-3360	156-119
Ash deposition	40	6	20-30	2460-3740	163-107

Discussion

Survival up to eight weeks is possible even without dietary fat. According to Gorriceta (1982) milkfish of marketable size are able to desaturate and elongate fatty acids. One of the best natural foods "lab-lab" contains only 0.92% fat, yet it supports growth and provides for good survival. Milkfish avail over amylases and can digest raw starches (Chiu & Benitez, 1981). Likewise, proteases are present (Benitez & Tiro, 1982), but lipases occur in less amounts in marketable size milkfish.

Although digestive enzymes in milkfish fingerlings has not been defined, data suggest that milkfish can survive and grow with little or no dietary fat. Survival of more than 50% was obtained if fish fed diets 15-0-30, 30-0-30, 45-0-10 and 45-0-30, whereas these fish had mean weight gains of 52.6, 56.1, 32.4 and 61.4% respectively, which were among the higher ones obtained.

Total energy levels did not seem to affect survival. Mortality rates were less than 50% as long as caloric levels ranged between 1800 and 3680. Weight gains did not improve at caloric levels beyond 3500 kcal. Likewise, protein and fat deposition were optimal within this range. A protein energy ratio of 112 to 118 mg could be needed for weight gain and survival.

The low survival and relatively poor growth using some combinations could have been due to several factors, one of which may be the type of fat used. Corn oil contains much more w6 than w3 and very little C22 and C24 w3 fatty acids that are needed by marine fish for maximum growth (Yone, 1975). The same author reports poor growth and some toxic effects when high levels of w6 fatty acids were fed to seabream, whereas the NAS/NRC H440 diet mixture (NAS/NRC, 1973) from which the diets were patterned work well for salmonids and some catfish species (Halver, personal communication).

A ratio of 1:1 cod liver oil and corn oil was used in this study and total lipid was 6 and 12%. Since in previous experiments, where only corn oil was used, very poor growth and survival were obtained, a combination of corn oil and cod liver oil was used in this study. The fatty acid profiles of the diets were not analyzed, but published literature on the fatty acid profiles of corn oil and cod liver oil show that the latter has more w3 while corn oil has more w6 fatty acids. When total fat was 12%, diets with 30 to 45% protein gave poor growth, but average gains of 68.06, 63.5 and 79.3% were obtained at 6% dietary fat and 45% dietary protein.

Alava (1985), who worked with various sources of oils (cod liver oil, corn oil, beef tallow, pork lard, sesame oil, and coconut oil) showed that cod liver oil was the best source while corn oil gave the poorest growth, survival, and liver histology. Furthermore in a study using various levels of cod liver oil, diets containing 7 to 10% gave the highest percentage weight gain and survival, whereas cellular and structural changes occured in milkfish fingerlings fed diets containing less than 7% or more than 10% cod liver oil (Alava & dela Cruz, 1983.).

Benitez & Gorriceta (1985) suggest that chain elongation and desaturation takes place in the liver where significant quantities of 20:2w6, 20:3w6, 20:5w3, 22:4w6, and 22:5w3 were found despite the absence of these fatty acids in the natural food of the milkfish.

Furthermore, they showed that w6 fatty acids are also needed by the milkfish since they were found in milkfish livers and not in the depot fat. Tilapia zillii has been found to require w6 fatty acids in their diets (Kanazawa et al., 1980). Bautista & Cruz (1983) reported that milkfish fingerlings fed linolenic and/or linoleic acid showed good growth and survival, a combination of 1% linolenic acid with 6% lauric acid giving better growth than linoleic acid.

Diet combinations resulting in survival rates of more than 50% in this study show that milkfish are able to utilize protein and catbohydrates for the production of fatty acids, even in the absence of dietary fat.

Lim & Alava (1983) used 42% crude protein, 9% fat, and 33% carbohydrate for milkfish fry and obtained good results. Lim et al. (1979) found an optimum protein level of 40% while Coloso et al. (1988) reported the level to be around 45%. All these studies used milkfish much smaller than in this study.

Another factor causing low survival and/or poor growth using some diet combinations could be a vitamin deficiency in the diet. Vitamin C used was not the stable form. Furthermore, the diet processing, hot water (80°C) being added to the CMC-vitamin mixture followed by oven drying at 60°C for 6 hours, could have caused destruction of some heat-labile vitamins. In another study with practical diets for milkfish, an increase of the vitamin levels from 4 to 6% in the diet improved weight gain and survival in fish fed 40% protein, 25% CHO, and 10% fat (Pascual, 1983).

In a study by Lim et al. (1979) mean weight gains of milkfish fry initially weighing 40 mg, fed 10% body weight per day, were directly related to the levels of protein up to 40%. Lim's diet contained 6% fat (1:1 ratio cod liver oil to corn oil) and 31% CHO, whereas digestible energy was calculated to be 3340 kcal/kg.

Crude protein contents of 70% and above for body composition were observed in fish fed diets with 15% protein, the crude fat contents being much lower than in fish fed 30 to 45% protein. An increase in fat deposition was observed as protein levels in the diet were increased to 30 and 45%. Zeitler et al. (1984) found the protein content of carp (Cyprinus carpio) to decrease with decreasing amounts of protein in the diet while fat deposits increased.

The P/E ratio of 127 mg protein/kcal is similar to that obtained by Winfree & Stickney (1981) with Tilapia aureus. They showed that a diet containing 56% protein, 4600 kcal/kg diet, and 123 mg protein/kcal produced the highest gain in fry (2.5 g) while larger fish grew most rapidly when fed a 34% protein 3200 kcal diet with a P/E ratio of 108. Cho et al. (1985) have indicated that it is not valid to assume that protein and complex carbohydrates have similar metabolizable energy values for fish, thus values presently reported will have to be confirmed and metabolizable energy studies in milkfish are urgently required.

Response surface analysis is a relatively fast method of determining optimal dietary nutrient combinations and could possibly hasten the study of nutrient requirements, be it that results can be difficult to interpret. Studies of diets containing 30-40% protein, 6% fat from a source containing various levels of w3 and w6 fatty acids, 20% CHO and optimal vitamin levels will be needed. The energy values presented are also tentative until metabolizable and digestible energies have been determined. Although results are tentative, a diet containing 30-40% protein, 6-10% fat, 20-30% CHO, a protein/energy ratio of 118-114, and 2500-3500 kcal/kg is recommended for milkfish fingerlings, and this formulation can be reconsidered as soon as more nutritional data become available.

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References

Alava, V.R., 1985. Dietary fat sources in dry diets for Chanos chanos (Forsskal) fingerlings. Abstracts Second International Conference on Warmwater Aquaculture Finfish, February 5 to 8, 1985. Abstract No. 1.

Alava, V.R. & de la Cruz, M.C., 1983. Quantitative dietary fat requirements of Chanos chanos fingerlings in a controlled environment. Abstracts Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October, 4 to 8, 1983. p. 32.

Bautista, M.N. & de la Cruz, M.C., 1983. Effects of dietary linoleic and linolenic acids on growth, survival, fatty acid composition and liver histology of milkfish fingerlings. Abstracts Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4 to 8, 1983. p. 55.

Benitez, L.V. & Gorriceta, I.R., 1985. Lipid composition of milkfish grown in ponds by traditional aquaculture. In: Cho, C.Y., Cowey, C.B. & Watanabe, T., Finfish Nutrition in Asia: Approaches ro research and development. Ottawa, Ont. IDRC. p. 145.

Benitez, L.V. & Tiro, L.B., 1982. Studies on the digestive protease of the milkfish Chanos chanos. Mar.Biol. 71: 309-

315.
Chiu, Y.N. & Benitez, L.V., 1981. Studies on the carbohydrates in the digestive tract of the milkfish Chanos chanos. Marine Biology of 61. p. 247.
Cho, C.Y., Cowey, C.B. & Watanabe, T., 1985. Finfish Nutrition in Asia: Methodological approaches to research and development. Ottawa, Ont. IDRC. p. 11.
Coloso, R.M., Benitez, L.V. & Tiro, L.B., 1988. The effect of dietary protein energy levels on growth and metabolism of milkfish (Chanos chanos Forsskal). Comp. Biochem. Physiol., v. 89A, No. 1, p. 11-17.
Gorriceta, I.R., 1982. Studies on the digestive lipases and lipid composition of milkfish, Chanos chanos Forsskal. MSc-Thesis, Univ. of the Philippines, 56 pp.
Kanazawa, A., Teshima, S. & Sakamoto, M., 1980. Requirements of Tilapia zillii to essential fatty acids. Bull. Jap. Soc. of Scient. Fish., 46(11): 1353-1356.
Lim, C. & Alava, V.R., 1983. Artificial diets for Chanos chanos (Forsskal) fry. Abstract Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4 to 8, 1983. p. 57.
Lim, Chorn, Sukhawongs, Somchart & Pascual, F.P., 1979. A preliminary study on the protein requirements of Chanos chanos (Forsskal) fry in a controlled environment. Aquaculture, 17: 195-201.
Mead, J.F. & Kayama, M., 1967. Lipid metabolism in fish. In: Stansky, M.E. (ed.). Fish oils. The AVI Publ. Co., Westport, CT, USA, 289-299.
NAS/NRC, 1973. Nutrient requirement of domestic animals no. 11. Nutrient requirements of trout, salmon and catfish. Subcommittee on Fis Nutrition, Committee on Animal Nutritional Agricultural Board, Nat. Res. Council of Nat. Acad. Sci., p. 50.
Pascual-Piedad, F., 1983. Biological evaluation of some practical diets developed for milkfish fingerlings. Abstracts Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4 to 8, 1983. p. 59.
Sinnhuber, R.D., 1969. The role of fats. In: Newhaus, O. & Halver, J.E. (editors). Fish in Research. Academic Press, New York, N.Y., USA. 245-259.
Takeuchi, T. & Watanabe, T., 1976. Nutritive value of w3 highly unsaturated fatty acids in pollack liver oil for rainbow trout. Bull. Jap. Soc. Scient. Fish, 42: 907-916.
Takeuchi, T. & Watanabe, T., 1977. Effect of eicosapentaenoic and docosahexaenoic acid in pollack liver oil on growth and fatty acid composition of rainbow trout. Bull. Jap. Soc. Scient. Fish., 43: 947-953.
Winfree, Robert A. & Stickney, Robert R., 1981. Effects of dietary protein and energy on growth, feed conversion efficiency and body composition of Tilapia aureus. J. Nutri., 111: 1001-1012.
Yone, Yasuro, 1976. Nutritional studies of the red sea bream. Proceedings of the First International Conference on Aquaculture Nutrition. College of Marine Studies, Univ. of Delaware, New York, Delaware, USA. p. 39.
Zeitler, M.H., Kirchgeasner, M. & Schwarz, F.J., 1984. Effects of different protein and energy supplies on carcass composition of carp (Cyprinus carpio L.). Aquaculture, 36: 37-48.

The effects of petroleum crude oil on the growth of common carp (*Cyprinus carpio* L.)

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Summary

The effect of petroleum crude oil from Minas on common carp (*Cyprinus carpio*) has been studied under laboratory conditions. The LC_{50} for 96 hours was 216 ppm. Common carp were treated for 24 hours with 3 different oil concentrations, e.g. 54, 108 and 162 ppm and subsequently grown for 6 weeks.

Although analysis of variance on growth rates did not reveal any significant difference amongst the treatments, all 3 treatments retarded growth significantly in comparison with the control.

Introduction

World wide exploration, exploitation, and transportation of crude oils entail potential pollution hazards.

In Riau Province, there are a number of petroleum mining fields, one of them being located in Minas in close vicinity to some fish ponds that are used by local fish farmers to raise different fish species. Since waste disposal from the mining fields partially may enter the fish ponds, Siagian (1986) conducted experiments to assess the toxicity of crude oils for common carp. He found a LC_{50} value of 215.332 ppm for an exposure time of 96 hours.

Apart from lethal toxic effects, crude oils may also affect fish growth. The present study was carried out to assess such effects of crude oil on the growth of common carp.

Materials and methods

One month old common carp of 2-5 cm in size (200-400 mg) collected from fish farmers in Rumbai were acclimatized in glass aquaria (75 x 30 x 30 cm) to laboratory conditions. To assess the effects of crude oil from the Minas mining field fish were kept for 24 hours in crude oil concentrations equivalent to 25, 50 and 75% of the LC^{96}_{50}-value (54, 108, and 162 ppm). Subsequently fish were reared for 6 weeks at a density of 10 fish per aquarium and fed a pelleted feed at a daily rate of 5% of the body weight.

Water in the aquaria was exchanged every week and water quality parameters such as water temperature, pH, CO_2 and O_2 were measured. Experiments were carried out using a completely randomized block design with four treatments (including a control treatment) and three replications (Sudjana, 1982).

Relative growth, using the formula $(Wt-W0)/W0 \cdot 100\%$, was determined, as well as growth rate (g) using the exponential growth formula $Wt = W0.e^{gt}$, both growth parameters being calculated per week (t in weeks). Data were analyzed ANOVA (F-test) followed by least significant difference testing between treatments.

Results

In Table 1 the average values of the water quality parameters measured are given. Growth data obtained during the experimental period are presented in Table 2 and graphically illustrated in Figure 1.

Table 1. Average values of water quality parameters during the experiment.

Treatment	Temperature (°C)	CO_2 (ppm)	O_2 (ppm)	pH
Control	27.2	1.5	6	6.5
54 ppm	26.8	1.7	6	6.7
108 ppm	27.5	1.8	6	6.5
162 ppm	27.5	1.8	6	6.7

Table 2. Relative growth and growth rate of common carp treated with different crude oil concentrations for 24 hours.

	Relative growth (%)				Growth rate ($x10^{-4}$)			
Replicate	Control	54 ppm	108 ppm	162 ppm	Control	54 ppm	108 ppm	162 ppm
1	16.04	9.95	9.12	8.51	1392	982	1019	877
2	12.18	10.54	10.47	10.65	1445	1010	1019	1052
3	14.56	10.09	10.83	8.59	1403	1041	920	983
Average	14.26	10.19	10.12	9.25	1413	1011	986	971

Statistical analysis of the relative growth and the growth rate data revealed that control carp grow significantly faster ($P < 0.01$) than carp exposed to different crude oil concentrations, but there was no significant difference in growth of carp between the 3 experimental treatments used.

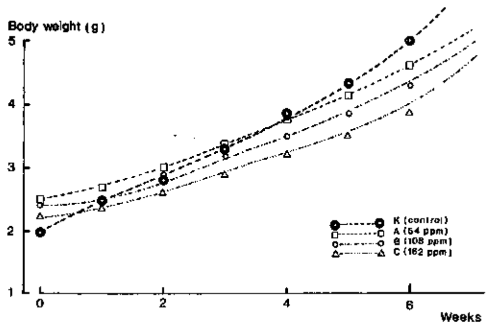

Figure 1. Growth curves of common carp exposed to different concentrations of crude oil for 24 hours.
Growth equations:

Control	:	Ln WK = 0.7585 + 0.1413 t
54 ppm	:	Ln WA = 0.9115 + 0.1020 t
108 ppm	:	Ln WB = 0.7682 + 0.0990 t
162 ppm	:	Ln WC = 0.8802 + 0.0969 t

Discussion

The results of this study clearly indicate that growth rate of carp is considerably reduced (30-40%) after 24 hours exposure to relatively low crude oil concentrations. This is in agreement with the results of Takusa (1977) who observed a 50% decrease in growth at a crude oil concentration of 100 ppm. Allyn (1972) points out that crude oil contamination affects the appetite of aquatic organisms, whereas Djalal et al. (1972) state that crude oil may affect behaviour as well as may destruct the nervous system and the gastro-intestinal tract.

The above mentioned authors used dissolved fractions of crude oil, whereas in the present study crude oil as such was used. Nevertheless, also in this study loss of appetite was observed in fish exposed to crude oil. This may be associated with the fact that crude oil from the Minas mining fields floats on the water surface. As a result gills may be affected and thereby respiration hampered.

The absence of significant differences between the different treatments is not fully understood, but may be explained by assuming that crude oil in concentrations as used in this experiment primarily affects fish through physically damaging the gills and, thereby, hampering respiration which results in loss of appetite and/or in a lower feed conversion efficiency.

References

Allyn, B. & Bakon, 1972. Environmental management science and politics. Morton Gorden & Marsha Gorden. Development Sciences Inc., 548 pp.

Djalal, T.S., S.D. Harminani & A. Handari, 1973. Penelitian histologis intestinum Tilapia mossambica yang mati dilingkungan crude oils Ledok dan Kawengan dalam Lab. Seminar Biologi III., Jakarta. 25 pp.

Siagian, M., 1986. Uji toksisitas minyak mentah (crude oils)

Minas terhadap ikan mas. Dep. Pendidikan dan Kebudayaan. Univ. Riau, Puslit. Pekanbaru. 27 pp.
Sudjana, 1982. Desin dan analisa experiment. "Tarsito". Bandung. 283 pp.
Takuda, H., 1977. Fundamental studies on the influence of oil pollution upon marine organisms. Bull. of Jav. Scientific Fisheries, 43.5: 587-593.

Cheap sources of alternate feed for the farming of snakehead fish (Teleostei:Channidae) in Sri Lanka

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Summary

Five species of snakehead fish (Channa spp.) are found in Sri Lanka and three of these grow to a suitable size for farming purposes. However, based on consumer acceptance, availability of fry and fingerlings from natural sources for stocking, and growth potential only C. striatus is suitable for farming in Sri Lanka. Although snakeheads sell at higher prices than other freshwater fish, their production will be rather expensive. Being carnivorous, they need feeds from animal origin. Trash fish and forage fish are used for snakehead production in some countries, but in view of the present price setting this is not economically feasible in Sri Lanka.
Therefore, aquatic oligochaetes, caridina shrimps, earthworms, chicken offals and land snails were tested as alternate feeds for different sizes of 2 snakehead species e.g. C. punctatus (Bloch) and C. striatus. The results indicate that aquatic oligochaetes such as Aelosoma spp. and Allonais spp., which can easily be collected from freshwater habitats, are suitable for fry; chicken offalls are suitable for fingerlings and juveniles, whereas earthworms such as Eudrilus sp. and Pheretima sp. and land snails, like Achatina fulica, can be used for all sizes up from fry. Suitable mixtures of these animal feeds are suggested for different sizes of C.striatus and such feeds will considerably reduce the costs of snakehead production.

Introduction

Snakeheads are very tasty and very popular food fishes in most southern and south-eastern Asian countries. They are believed to contain some recuperative and strength-giving substances, and are therefore especially given to elderly people and convalescents (Ling, 1977). Until recently, snakeheads were available only from capture fisheries, although some attempts had been made to grow them in tanks and cages using trash fish. Being large carnivores, snakeheads are at the top of the food pyramid and have to be fed with (expensive) feeds of animal origin. Therefore, their production is expensive in comparison with herbivorous and omnivorous species. However, because their higher market price offsets the high production costs, farming methods have been developed recently in several Asian countries in which suitable feeds such as trash fish could be obtained readily and relatively cheaply. Snakehead farming began around 1955 in Thailand (Ling, 1977) and spread to other countries including Hong Kong, India, Kampuchea, Taiwan and Vietnam. The popular species for farming is Channa striatus (Bloch), but two other species, C. maculatus (Lacépède) and C. micropeltes (Cuvier & Valenciennes) are also farmed. Attempts to farm C. marulius (Hamilton) and C. punctatus (Bloch) have been made as well.

In Sri Lanka, there are five snakehead species of which three grow to a relatively large size. The maximum sizes recorded for these species in Sri Lanka are as follows. C. marulius 81 cm, 4.9 kg; C. punctatus 26 cm, 225 g; and C. striatus 55 cm, 1.5 kg (K.H.G.M. de Silva, unpublished data). C. striatus is very popular and priced highest among all the freshwater fish species. C. gachua (Hamilton) and the endemic C. orientalis Bloch & Schneider are small, maximum size recorded in Sri Lanka being 16 cm, 55 g and 11 cm, 18 g, respectively (K.H.G.M. de Silva, unpublished data), and are seldomly consumed.

In most snakehead farming practices, the major feed, if not the only one, is trash fish. In Sri Lanka, trash fish is scarcely obtainable, and even those species which may be used as forage fish (e.g. tilapia, carplets) are either costly or not readily available. Therefore, if snakehead farming is to become an economically viable venture in Sri Lanka, alternate cheap sources of feed have to be found. The present paper examines the suitability of some of such readily available feeds for snakehead farming.

Materials and methods

Fry and fingerlings of C. punctatus and C. striatus were collected from irrigation reservoirs, in which they are commonly found in the littoral region. However, C. marulius was seldomly found and could not be used for experimentation. In preliminary experiments, easily available and inexpensive feeds were tested for their acceptance by various sizes of C. striatus and C. punctatus. Depending on the observations of these experiments feeds were selected for detailed experimentation. In all experiments a randomized design was adopted for assigning tanks to different treatments. All specimens used in any single experiment were obtained from the same brood to minimize effects of genetic variation.

Fry culture

Plankton, aquatic tubicid oligochaetes (Aelosoma spp. and Allonais spp.), and ground fish muscle were tested on fry of both species. Nine groups of five C. striatus fry, standard length 15-20 mm, were taken randomly from a stock acclimatized to laboratory conditions for at least one week. Each group was kept in 10 l of water in a circular glass tank, 35 cm diameter and 15 cm height. Tanks were assigned to three groups, three tanks per group. The first group contained pond water with an initial plankton density of 1.2 ml in 10 l of water, this being ten times the highest plankton density observed in plankton cultures fertilized with cattle manure and superphosphate. Zooplankton was dominated by copepods, cladocerans, and different nauplii stages. Pond water was renewed twice weekly and the plankton density was brought to the original level. The other six tanks contained pond water filtered through a phytoplankton net (55 µm mesh size). About 1 g (wet weight) of tubicid oligochaetes respectively freshly ground fish muscle was given to the fish in each tank of the second respectively the third group every morning and afternoon. Water was renewed every day. Fry were weighed weekly and the experiment was terminated after four weeks. A similar experiment was carried out using C. punctatus fry of the same standard length range.

Fingerling culture (small fingerlings)

Three feeds, namely, freshwater shrimp, tubicid oligochaetes, and minced fish, were tested on small fingerlings for eight weeks. These fingerlings as well as latter stages used in subsequent experiments were reared in the laboratory from the fry stage.

15 fingerlings of C. striatus standard length 50-60 mm, were kept individually in plastic tanks (21 cm resp. 27 cm top resp. bottom diameter, 26 cm height), in 10 l of water. A continuous water flow was maintained of about 5 l per hour per tank. Fingerlings were assigned to 3 groups of 5 each. Each individual of the first group was initially offered 50 weighed freshwater shrimp of the species Caridina fernandoi Arud. & Costa of 10-15 mm length (the wet weight of shrimps being roughly equal to the initial body weight of the fingerling) and this number was increased to 100 in the second month. The number consumed was replaced daily with weighed fresh ones. Weights of fingerlings and unconsumed shrimp were measured fortnightly. Individuals of the second respectively the third group were given aquatic oligochaetes respectively minced fish at a rate of 50% body weight once daily in the evening, the unconsumed feed being removed in the morning, blotted and weighed. Under the prevailing experimental conditions, it was observed that the fish did not feed very much during the day time but they fed well during the night, although Javid (1970) reports that C. punctatus feeds mainly in the day time. Fingerlings were weighed every fortnight. Experiments were duplicated with another 15 fingerlings of the same size class.

A similar experiment was carried out using 30 fingerlings of C. punctatus of a standard length class of 40-50 mm.

Fingerling culture (large fingerlings)

Three feeds, namely, chopped fish, earthworms, and chopped chicken offals, were tested on large fingerlings of C.striatus for eight weeks.

30 fingerlings, standard length 100-120 mm, were kept in groups of 5 in 6 fibre-glass tanks (160 x 90 x 70 cm). Four of the five fingerlings in each tank were individually marked by notching either the left, the right or both pelvic fins, or the posterior end of the anal fin. This notching procedure did not seem to affect the individuals. Each tank contained about 600 l of water and a continuous water flow was maintained at a rate of about 25 l per hour per tank. Two tanks were assigned to each feed. The three feeds, chopped fish, earthworms (Eudrilus eugeniae (Kinberg) and Pheretima posthuma (Vaillant)), and chopped chicken offals were given at a rate of 50% body weight once daily in the evening, the unconsumed feed being removed in the morning, blotted and weighed. These fingerlings, as well as other stages used in the subsequent experi-

ments, were individually weighed every fortnight after 24 hours of starvation. Fish were anaesthetized in a 67 ppm solution of benzocaine (BDH Chemicals, Poole, U.K.) prior to weighing for ease of handling and to minimize physical stress and damage.

Juvenile culture

Three feeds, namely, chopped fish, chopped chicken offals, and chopped foot muscle of the land snail Achatina fulica Ferussac were tested on juveniles of C. striatus of a standard length range of 160-260 mm. Snails were kept in the freezer for at least 24 hours prior to the removal of the foot in order to reduce the amount of slime produced. Two experiments were carried out, and the experimental procedures were similar to those described for large fingerling culture, except where differences are indicated.

In the first experiment 15 juveniles were kept in groups of five in 3 fibre-glass tanks. Each group was given chopped fish, respectively boiled and chopped chicken offals, respectively boiled and chopped land snail muscle for four weeks. In the second experiment, 18 juveniles were kept in six tanks, three fish per tank, and were given either chopped fish, chopped chicken offals, or chopped snail muscle for eight weeks.

Effect of tank size on fish growth

It appeared that the growth rates of fingerlings and juveniles in the fibre-glass tanks were very low on all feeds. This was thought to be due to the small size of the experimental tanks, fish being easily disturbed. Therefore, an experiment to investigate the effect of tank size on growth rate was carried out using rectangular tanks of three sizes; (i) fibre-glass tanks with an area of about 1.5 m^2 used for earlier experiments, (ii) small cement tanks (1.75x2x 1 m), and (iii) larger cement tanks (4x2.5x1.3 m). The level of water in each tank was kept at about 40 cm and a continuous water flow sufficient to renew the tank volume in about 24 hours was maintained. Four fibre-glass tanks were stocked with one fish each. Two small cement tanks were stocked with 4 individually marked fish per tank, and 2 larger cement tanks were stocked with 10 individually marked fish each. C. striatus of a standard length range of 150-250 mm were used in the experiment and the fish were offered chopped fish at a rate of 50% body weight per day. Fish were weighed after a starvation period of 24 hours at the start and at the end of the experimental period of 60 days.

Estimation of growth rates

The growth rates (r) were estimated using the formula log (r + 1)=(log Wt-log Wo)t, where Wo, Wt, and t are the initial weight, the weight after t days, and duration of culture in days. In fry culture, mean growth rate was estimated using growth rates of individual groups. In other experiments, mean growth rates were estimated using growth rates of individual fish. The significance of the differences of mean growth rates of different treatments in each experiment was tested by

Student's t-test at 5% level. Feed conversion ratios were estimated from the weight of feed consumed and the weight gained by the fish during the period.

Results

The temperature, pH, dissolved oxygen concentration and electrical conductivity of the water in the experimental tanks varied during the experimental period between 24°C and 26°C, 7.2 and 7.8, 82% and 112% saturation (7.6 and 9.0 $mg.l^{-1}$), and 55 and 90 $\mu S.cm^{-1}$ at 25°C, respectively. These parameters were measured every day between 07.00 and 09.00 hrs.

The growth rates of various stages of the two snakehead species obtained on different feeds are given in Table 1. Biweekly growth rates are given in Table 2. Growth curves of various stages are shown in Figure 1 and 2. Fry of both species showed better growth on plankton than on either tubicid oligochaetes or ground fish in the first fortnight but the growth rates were rather similar in the second fortnight, with slightly better growth rates on oligochaetes than on either of the other two feeds. Small fingerlings also showed lower growth rates on minced fish initially but the growth rates improved later. Larger fingerlings of C. striatus showed better growth rates on earthworms than on chopped fish, and lowest growth rates on chopped chicken offals. Juveniles showed comparable growth rates on chopped fish and chopped chicken offals but lower growth rates on snail foot muscle. Sub-adults (>25 cm) were observed to consume snail foot muscle better but their growth rates were not measured.

The relatively low growth rates of large fingerlings and juveniles of C. striatus observed in the present experiments are probably due to confining the fish to small fibre-glass tanks in which they are easily disturbed, since increased growth rates were observed in larger tanks (Table 3).

Feed conversion ratios (FCR) (i.e. wet weight of feed consumed : wet weight gain) for C. striatus are shown in Table 1. Caridina shrimp and tubicid oligochaetes showed better FCRs than minced fish when used as feed for small fingerlings. For larger fingerlings, earthworms and chicken offals gave the highest and the lowest FCRs respectively. For juveniles, chopped fish gave better FCRs than chicken offals; snail muscle showed the lowest FCR.

Discussion

Fry and fingerlings of C. marulius are rarely encountered in Sri Lanka, and it is unlikely that they can be collected in sufficient quantities from natural sources for farming. In a monthly search for two years in irrigation reservoirs in the Anuradhapura area, where adults are caught regularly, fry and fingerlings of the species were encountered only on two occasions, in January and in March. Thus, despite the claims of higher growth rates of this species in comparison to C. striatus (Devaraj, 1973; Murugesan, 1978), it is not possible to farm this species in Sri Lanka until artificial spawning techniques are perfected and brood stock is available in sufficient numbers. Successful artificial spawning of the species by hypophysation using carp pituitary has already been reported by Parameswaran & Murugesan (1976). Fry and fingerlings of C. striatus, on the other hand, were common in the irrigation reservoirs and were observed throughout the year, except during prolonged dry periods in which the level of the reservoirs became very low. Occurrence of fry and fingerlings of C. punctatus was restricted to the rainy season but during this season they could be collected in great numbers.

Table 1. Growth rates and feed conversion ratios (FCR) of C. striatus and C. punctatus on different feeds.
(CO-chicken offals; COB-boiled chicken offals; EW-earthworms; FC-chopped fish; FG-ground fish; FM-minced fish;
PL-plankton; SH-freshwater shrimps; SM-snail muscle; SMB-boiled snail muscle; TO-tubicid oligochaetes.)
Significantly different (P >0.05) growth rates in different treatments in a particular month for a particular stage are indicated by the same superscript.

(CO-chicken offals; COB-boiled chicken offals; EW-earthworms; FC-chopped fish; FB-ground fish; FM-minced fish;

Stage	Feed	Initial Wt (g) (mean S.E.)	Final Wt (g) (mean S.E.)	Growth rate 1st month	(mean S.E.) 2nd month	FCR
C. striatus						
Fry	PL	0.102 0.0043	0.198 0.0082	23.9 0.78a(n=3)		
(15-20 mm)	TO	0.100 0.0064	0.175 0.0161	19.9 1.18a(n=3)		
(n=15)	FG	0.105 0.0024	0.153 0.0105	13.4 2.22a(n=3)		
Fingerling	FM	2.382 0.0613	5.002 0.2056	6.7 0.67a	19.6 0.76ab	14.8:1-15.1:1
(50-60 mm)	TO	2.223 0.0617	8.645 0.3674	23.4 0.89a	25.5 0.94a	6.8:1-7.2:1
(n=10)	SH	2.303 0.0540	10.366 0.2574	29.5 0.46a	24.9 0.47b	6.1:1-6.9:1
Fingerling	FC	19.835 1.8126	33.915 2.4883	8.3 0.70a	11.2 1.05a	12.6:1-15.1:1
(110-150 mm)	EW	14.494 1.0050	29.992 2.1075	10.6 0.44a	15.7 0.75a	10.3:1-11.8:1
(n=10)	CO	22.208 2.0170	37.555 2.7932	7.0 0.93a	12.4 0.72a	15.7:1-17.4:1
Juvenile	FC	157.6 16.33	174.4 17.37	3.7 0.26b		7.3:1-10.5:1
(200-260 mm)	COB	165.4 15.52	184.6 16.75	4.0 0.53c		8.3:1-12.5:1
(n=5)	SMB	185.8 16.46	194.2 16.60	1.6 0.57bc		12.7:1-16.1:1
Juvenile	FC	149.6 14.20	180.6 15.54	3.3 0.38b	3.7 1.32b	
(160-250 mm)	CO	179.5 11.60	202.7 8.88	1.2 1.21	3.1 0.85c	
(n=6)	SM	195.7 12.72	196.0 13.66	-0.5 0.23b	0.5 0.30bc	
C. punctatus						
Fry	PL	0.053 0.0027	0.083 0.0031	16.6 0.62b(n=3)		
(15-20 mm)	TO	0.052 0.0022	0.079 0.0066	14.5 1.61c(n=3)		
(n=15)	FG	0.049 0.0047	0.065 0.0061	4.0 3.75bc(n=3)		
Fingerling	FM	1.387 0.0457	3.169 0.1432	3.8 0.72a	26.0 1.40ab	
(40-50 mm)	TO	1.577 0.0424	5.383 0.1097	23.5 1.34a	21.1 0.80a	
(n=10)	SH	1.538 0.0543	5.133 0.1384	20.7 1.93a	22.9 1.56b	

Significantly different (P> 0.05) growth rates in different treatments in a particular month for a particular.

Table 2. Growth rates of different stages of *C. striatus* and *C. punctatus* on different feeds. (CO-chicken offals; COB-boiled chicken offals; EW-earthworms; FC-chopped fish; FG-ground fish; FM-minced fish; Pl-plankton; SH-freshwater shrimps; SM-snail muscle; SMB-boiled snail muscle; TO-tubicid oligochaetes).

Stage	Feed	Growth rates (mean±S.E.) 0-14 days	15-28 days	29-42 days	43-56 days
C. striatus					
Fry	PL	24.97±2.452	22.87±1.014		
(15-20 mm)	TO	14.74±3.386	25.12±4.033		
(n=3)	FG	4.71±1.497	22.23±3.625		
Finger-ling	FM	5.66±0.758	8.41±0.853	12.37±1.823	27.02±2.289
(50-60 mm)	TO	25.02±1.123	21.88±1.678	22.83±1.751	28.14±1.212
(n=10)	SH	29.15±1.543	29.92±1.978	23.66±0.928	26.21±1.091
Finger-ling	FC	5.46±0.870	11.25±1.901	9.57±1.084	12.86±1.497
(110-150 mm)	EW	5.94±0.726	15.19±1.202	16.78±1.321	14.60±1.907
(n=10)	CO	6.67±1.305	7.98±1.092	12.65±0.900	12.13±0.859
Juvenile	FC	2.71±0.436	4.64±0.125		
(200-260 mm)	COB	2.76±0.389	5.17±1.026		
(n=5)	SMB	0.89±1.021	2.37±0.177		
Juvenile	FC	3.31±0.933	3.33±0.492	5.27±1.816	3.18±0.745
(160-250 mm)	CO	-0.33±1.522	2.76±0.905	3.27±0.979	3.55±1.199
(n=6)	SM	-0.63±1.086	-1.84±1.056	0.39±1.034	1.13±0.632
C. punctatus					
Fry	PL	9.66±0.997	23.52±2.259		
(15-20 mm)	TO	3.51±0.759	25.54±2.781		
(n=3)	FG	-3.68±1.371	11.80±6.160		
Finger-ling	FM	2.67±0.734	4.84±1.163	21.75±1.161	30.21±2.247
(40-50 mm)	TO	22.64±2.380	24.33±1.882	17.60±2.016	24.58±1.150
(n=10)	SH	20.07±1.938	21.34±3.280	23.36±2.383	22.51±1.191

Although both *C .punctatus* and *C. striatus* appear to take about two years to become sexually mature in Sri Lanka, during this period *C. punctatus* grows only to about 12 cm whereas *C. striatus* grows to about 30 cm. This indicates that even in nature the growth rate of C. punctatus is much lower than that of C. striatus. In India it takes two years for C. striatus to grow to about 35 cm, whereas C. punctatus grows to about 17 cm; and C. marulius to 53 cm over the same period (Devaraj, 1973).

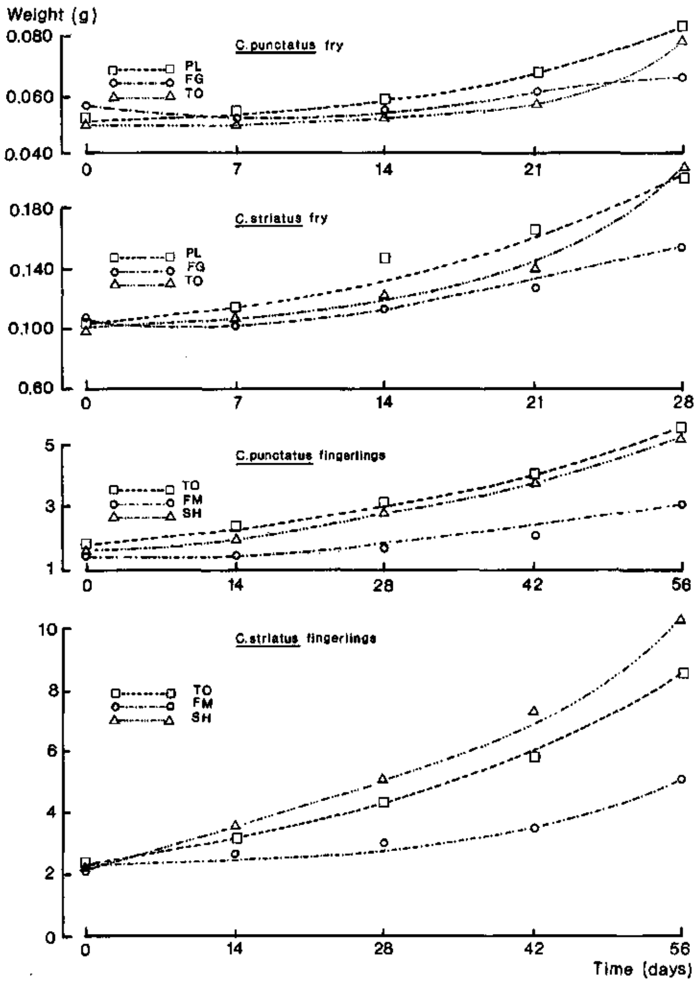

Figure 1. Growth curves of fry of C. punctatus and C. striatus fed ground fish (FG), plankton (PL), or aquatic tubicid oliogochaetes (TO), and of fingerlings fed minced fish (FM), fresh water caridina shrimp (SH) or tubicid oliogochaetes (TO).

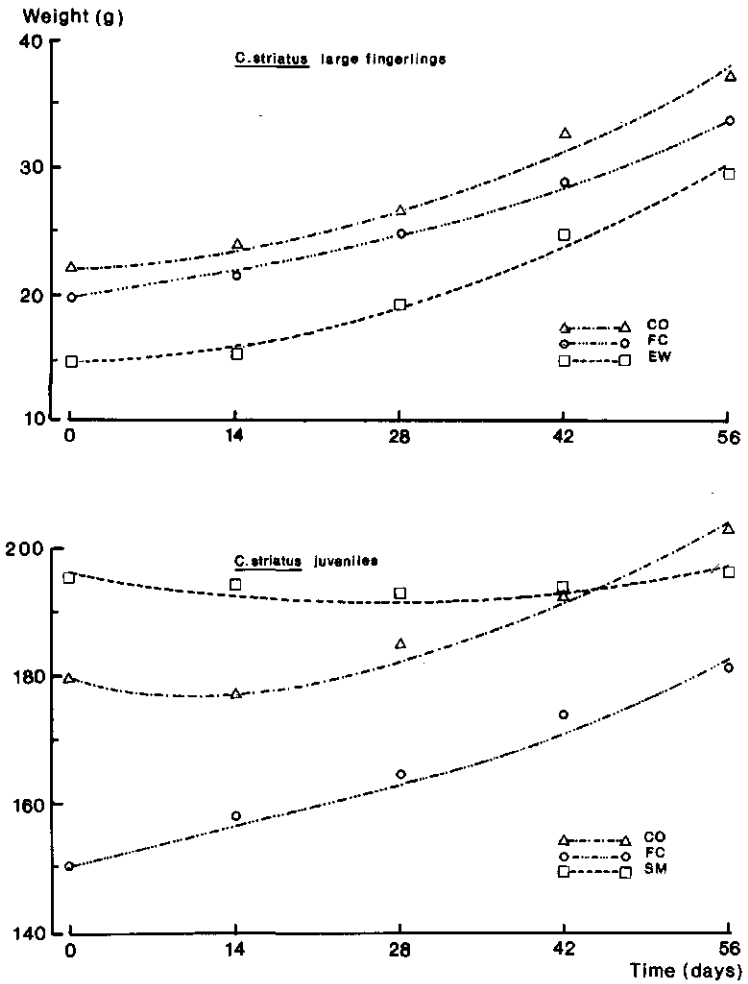

Figure 2. Growth curves of large fingerlings of C. striatus fed chopped chicken offals (CO), earthworms (EW), or chopped fish (FC), and of juveniles fed chopped chicken offals (CO), chopped fish (FC), or chopped land snail muscle (SM).

Table 3. Growth rates of C. striatus (standard length range 150-250 mm) on chopped fry in tanks of different sizes, determined over an experimental period of 2 months.

Tank size (m^2)	No. of Fish (n)	Initial Wt. (mean±S.E.)	Final Wt. (mean±S.E.)	Growth rate
1.5	4 (1 per tank)	103.67±12.767	110.65±13.155	1.12±0.196
3.5	8 (4 per tank)	70.16±08.311	151.06±19.116	12.68±2.470
10.0	20 (10 per tank)	102.86±15.860	228.47±14.824	16.15±1.335

The consumer preference for the three species is in the order of C. striatus, C. marulius, and C. punctatus. Although C. marulius grows to a larger size than C. striatus, it has a rather oily taste and, therefore is not in such a demand as C. striatus. The demand for C. punctatus is very low because of its smaller size. In case of a surplus, all three species are salted and dried. The demand for the dried fish is in the same order as for fresh fish.

Therefore, availability of seed from natural sources, growth rates, and consumer preferences indicate that at present only C. striatus is suitable for commercial farming in Sri Lanka.

Large fingerlings of C. striatus are difficult to collect as they are found scattered in deeper parts of the irrigation reservoirs. However, the orange coloured fry are gregarious and remain together in the shallow littoral zone, where the nests were built by the adults, until they are about 5-6 cm, by which stage they turn brown. Soon after this stage - as fingerlings -they start to scatter and move into the deeper parts of the reservoirs. Therefore, the best stage for collection is just before the fry lose their orange colour, and the farmer must be prepared to culture snakehead from the fry stage onwards.

The present experiments show that fry can be raised on plankton, which may be collected from tanks and ponds fertilized with cattle manure or otherwise, or on tubicid oligochaetes, which are abundant in the slow flowing streams, especially if the latter contain biological refuse.

Use of trash fish to feed snakehead is uneconomical in Sri Lanka where trash fish is seldom available. Low grade fish such as small tilapia cost at least Rs 10-20 per kg and the retail price of C. striatus at present is only about Rs 50-70 per kg in city markets limiting the farm gate price to about Rs 30-50 per kg. Feed conversion ratios (FCR) of 7.3 to 10.5 were obtained in the present study using chopped fish as feed (Table 1). FCRs of 6 to 10 were reported from Hong Kong and 10.4 to 12.8 from Indonesia when trash fish was used as feed for C. maculatus and C. micropeltes respectively (Wee, 1983). Therefore, in order to farm snakehead economically successful, trash fish should not cost more than 5-7% of its farm gate price, in Sri Lanka. Even mixing of trash fish with low cost ingredients such as wheat flour, as practised in Taiwan in a ratio of 8:1 (Chen, 1976), or rice bran, as practised in Thailand in ratios of 9:1 to 14:1 (Wee, 1983) would still cause a net loss.

The present experiments show that alternate cheaper feeds such as caridina shrimps, earthworms and chicken offals could be used profitably. The land snail Achatina fulica is acceptable to larger snakehead (>25 cm in length) but not to smaller ones, the non-acceptance being probably due to the presence of excessive slime. In Vietnam, cooked or uncooked flesh of snails and mussels is used as feed for snakehead (Pantulu, 1976). Caridina shrimp are very common in most water bodies and could be collected from these or cultured in fish ponds on decaying leaves. Earthworms and land snails can be cultured easily and cheaply. Earthworm species of moderate size such as Pheretima posthuma (length~30 mm), Eudrilus eugeniae (length~140 mm), and Megascolex species are present in Sri Lanka. Animal offals such as chicken offals could easily be obtained from livestock farms. If snakehead culture is integrated with vegetable and livestock farming, cattle manure for culture of earthworms, and vegetable refuse for culture of snails, will be directly available. Pandian (1967) observed that a day of intensive feeding by C. striatus is frequently followed by a day of less feeding. A similar observation has been made by Wee (1982) on C. micropeltes. Such habits could be used in farming practices to reduce wastage of feed.

The costs of snakehead culture could further be reduced by growing snakehead in polyculture with tilapia. In a preliminary polyculture experiment with 30 pairs of breeding Oreochromis mossambicus (Peters) 10 snakehead (standard length 215-280 mm) showed a growth rate of 8.68±1.399 growing from 261.89±23.268 g to 337.07±28.271 g in 30 days, in contrast to specific growth rate of 4.25±0.599 of 10 control snakehead (standard length 205-275 mm) which grew from 260.7±24.88 g to 294.6±27.41 g within the same period, when fed chopped fish (K.H.G.M. de Silva & S.B. Weerasekera, unpublished data).

From the growth rates and FCRs at various growth stages of C. striatus observed in the present study (Table 1) and by others (Wee, 1983), the feed requirements could be estimated, as given in Table 4. At the end of a 9-month culture period, each fish would have grown to about 800 g. With a stocking density of 3,000 fingerlings and allowing for a mortality of 10%, a harvest of 2,150 kg could be expected from a 0.1 ha pond.

Table 4. Estimated feed requirements for a 0.1 ha pond stocked with 3,000 fingerlings of C. striatus, assuming the stocking size, culture period, and average size at harvest to be 25 g, 9 months, and 800 g, respectively.

Month of culture	Assumed mean weight (g)	Amount of feed required (kg)	Suggested feed mixture		
			earth-worms	offals	land-snails
1	42	1000	700	300	0
2	80	1200	700	500	0
3	130	1500	700	600	200
4	195	2000	900	700	400
5	270	2200	900	700	600
6	360	2700	900	900	900
7	470	3300	1000	1100	1200
8	595	3800	900	1200	1700
9	730	4100	800	1200	2100

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References

Chen, T.P., 1976. Aquaculture practices in Taiwan. Fishing News Books Ltd., Farnham, U.K. 161 pp.

Devaraj, M., 1973. Experiments on the culture of the large snakehead, Ophiocephalus marulius (Hamilton). Indian J. Fish. 20(1): 138-147.

Javid, M.Y., 1970. Diurnal periodicity in the feeding activity of some freshwater fishes of West Pakistan. I. Studies on Channa punctatus and Mystus vittatus. Pakistan J. Zool., 2(1): 101-111.

Ling, S.W., 1977. Aquaculture in South East Asia - A historical overview. Washington University Press, Seattle. 198 pp.

Murugesan, V.K., 1978. The growth potential of the murrels, Channa marulius (Hamilton) and Channa striatus (Bloch). J. Inland Fish. Soc. India, 10: 169-170.

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

Pantulu, V.R., 1976. Floating cage culture of fish in the lower Mekong basin. In: FAO Technical conference on

Aquaculture, Kyoto, Japan, 26 May-2 June 1976. FIR:-AQ/CONF/76/E10.
Parameswaran, S. & Murugesan, V.K., 1976. Observations on the hypophysation of murrels (Ophiocephalidae). Hydrobiologia, 50(1):81-82.
Wee, K.L., 1982. Snakeheads - Their biology and culture. In: Recent advances in aquaculture. Muir, J.F. & Roberts, R.J. (editors), Croom Helm, London. 179-213.
Wee, K.L., 1983. Studies on intensive snakehead (Channa spp.) culture with special reference to their nutrition. Ph.D. Thesis. University of Stirling, U.K. 273 pp.

On the applicability of a mixed feeding schedule for common carp, Cyprinus carpio Var. Communis

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Summary

Based on the daily variation observed in the digestibility of protein and dry matter, De Silva (1985) postulated that fish do not require the same level of protein every day and recommended the alternate use of high and low protein diets to reduce feed costs. A trial was conducted in cement tanks to study the applicability of this theory in common carp, Cyprinus carpio, using the two feeding schedules which gave the best response in tilapia, Oreochromis niloticus. Two diets, respectively containing a low protein (16.39%) and a high protein (30.96%) level were employed. There were four treatments viz., feeding the low protein diet daily (A); feeding the high protein diet daily (B); feeding one day the low protein diet, followed by three days feeding the high protein diet (1A/3B); feeding the low protein diet for two days, followed by three days feeding the high protein diet (2A/3B). Each treatment was triplicated in tanks of 25 m^2 surface with no soil bed. Fifteen carp fry (1.88 g) were stocked in each tank and fed once daily at 5% body weight for a period of 126 days.

Throughout the rearing period, growth was similar for fish fed on diet B and 1A/3B. Fish fed diet A and 2A/3B attained almost equal weights, but these were significantly lower than those of the other two. Feed conversion ratio was found to be better in the treatment 1A/3B, which also resulted in higher protein and fat deposition. Based on total protein input, 15% protein can be saved without affecting growth, by adopting the 1A/3B feeding schedule as compared to daily feeding of fish with the high protein diet.

Introduction

Feed input is the single largest operational cost in a majority of aquacultural practices. Fish nutrition investigations are mainly directed towards reducing feed costs through substitution of the expansive dietary components, principally protein, with cheaper sources. However, the siginificant findings of De Silva & Perera (1983, 1984), on the existence of a rhythmic digestibility of protein in cichlids have opened new ways of reducing feed costs. De Silva (1985) conclusively proved the existence of daily variations in dry matter and protein digestibility and opinioned that feeding fish everyday with the same level of protein is not economical. His investigations in Nile tilapia, Oreochromis niloticus with seven different feeding schedules involving low and high protein diets indicated that feeding a low protein diet for one to two days, followed by three days feeding with a high protein diet resulted in good growth as compared to that of continuous feeding with a high protein diet. Based on this, the present experiment was designed to study the applicability of a mixed feeding schedule for common carp, Cyprinus carpio.

Materials and Methods

The experiment was conducted in outdoor cement tanks of 25 m^2 surface each (5x5x1 m) without a soil bed, over a period of 126 days. Each treatment was triplicated. Common carp fry (mean weight 1.88 g) stocked at a density of 15/tank were fed once daily at 5% body weight. Fortnightly sampling of fish was carried out to assess the increase in weight and to correct the quantity of feed.

Two diets containing low (16.39%) and high (30.96%) protein levels were employed (Table 2). Four treatments were tried viz., feeding the low protein diet daily (A); feeding the high protein diet daily (B); feeding one day the low protein diet, followed by three days feeding the high protein diet (1A/3B); feeding the low protein diet for two days, followed by three days feeding the high protein diet (2A/3B).

Feed and fish samples were analysed for proximate composition following AOAC (1975) methods. Water was analysed for various physico-chemical parameters viz. temperature, pH, dissolved oxygen, dissolved organic matter and free carbon dioxide following APHA (1985) procedures. Plankton samples were collected from each tank at monthly intervals using a plankton net of 60 u mesh size, by towing 20 meters of water surface.

Dry weight of plankton was determined and expressed in mg/100 l.

Results

Water temperature ranged from 28 to 31.5°C during the experimental period. Dry weight (mg/100 l) of plankton varied from 2.32-2.86, 2.30-2.98, 2.24-3.04 and 2.28-2.53 in the treatments A, B, 1A/3B and 2A/3B respectively. The pH of water was alkaline and fluctuated between 7.6 and 8.2 in treatment A, 7.6 and 8.0 in treatment B, 7.6 and 8.4 in treatment 1A/3B and 7.8 and 8.0 in treatment 2A/3B. Dissolved oxygen (ppm) content of the water varied from 4.53-6.27 (A), 4.96-6.40 (B), 4.8-6.13 (1A/3B and 5.1-6.0 (2A/3B). Free carbon dioxide values were low and fluctuated from 0.8-1.6 in the four treatments, while dissolved oxygen matter (ppm) ranged from 5.2-6.7 in A, 3.7-5.2 in B, 4.3-7.1 in 1A/3B and 3.6-5.8 in 2A/3B. The values for total alkalinity (ppm) were 22.0-33.0 (A), 18.33-25.67 (B), 20.6-48.0 (1A/3B) and 11.0-66.0 (2A/3B).

Table 1. Relative composition (%) of ingredients in the experimental diets.

Ingredients	Diet A	Diet B
Fish meal	10	30
Groundnut cake	15	25
Rice bran	49	39
Tapioca flour	25	5
Vitamin and mineral mix	1	1

Table 2. Proximate analysis of the experimental diets (%).

Diet	A	B
Dry matter	91.84	92.21
	±0.06	±0.09
Crude protein	16.39	30.96
	±0.11	±0.16
Crude fat	6.41	6.70
	±0.19	±0.06
Crude fibre	14.77	12.99
	±0.70	±0.12
Ash	14.53	13.68
	±0.08	±0.23
NFE	38.74	27.88
Energy content (kcal/g)	2.99	3.27

The ingredient composition and the proximate analysis of the diets are presented in Table 1 and 2. These diets differed from those employed by De Silva (1985) because both diets had rather similar levels of fat (6.41% and 6.71%) and energy (2.99 and 3.27 kcal), whereas the diets used by De Silva (1985) had 9.8 % fat in the low protein (18.2%) diet and 14.1% fat in the high protein (30.4%) diet with almost the same levels of energy in both.

Due to poor survival of fish in one tank of each treatment growth varied significantly between replicates. Therefore data on growth from replicate tanks are presented separately in Table 3. The growth pattern in terms of length and weight is depicted in Figure 1 and 2.

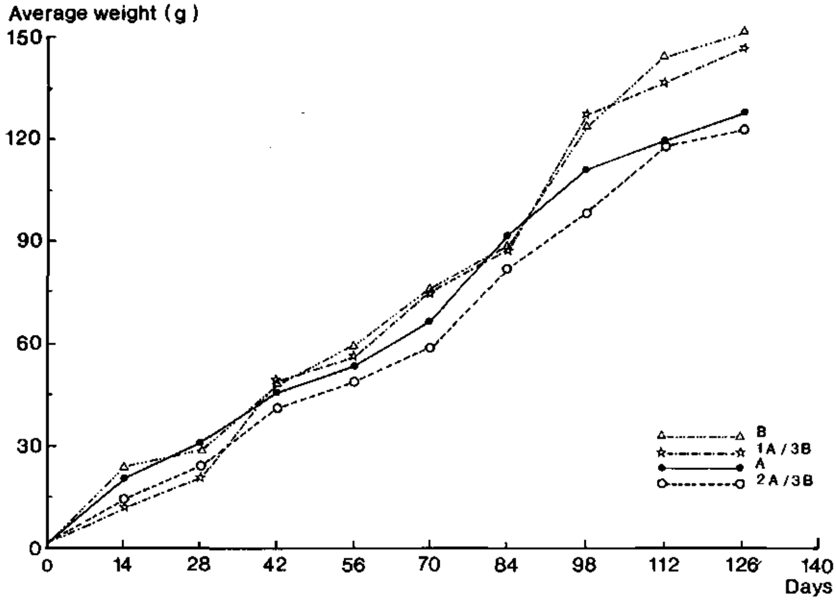

Figure 1. Growth responses (in weight) of common carp fed different experimental dietary schedules.

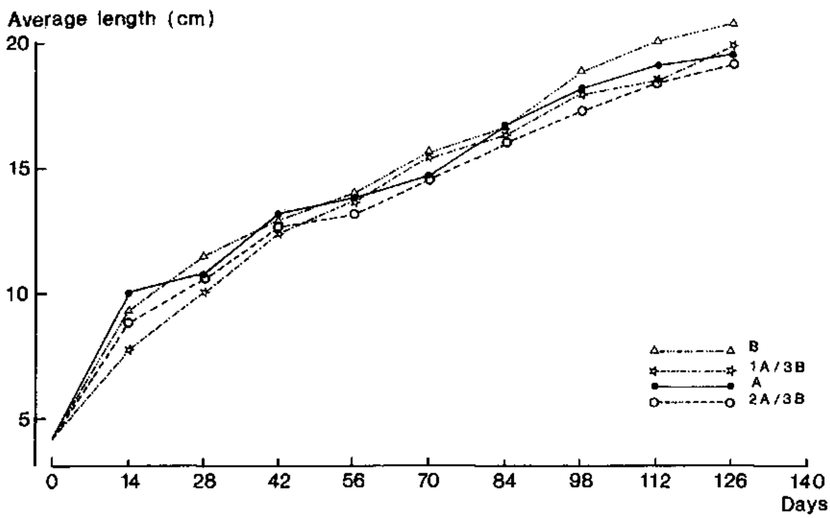

Figure 2. Growth responses (in length) of common carp fed different experimental dietary schedules.

These figures show that growth patterns of fish from treatment B and 1A/3B were almost similar, be it that the growth in treatment 1A/3B was poor till the 28th day as compared to other treatments. But from then on growth improved satisfactorily, the fish attaining even a better weight than the rest by the 98th day. However, after this period, growth in treatment B surpassed that of 1A/3B and a higher weight was obtained on termination of the experiment. But, there was no significant difference between the final weights from these two treatments. In addition, better survival in treatment 1A/3B resulted in marginally higher wet weight of fish than obtained in treatment B.

Table 3. Growth and survival of fish in the different treatments.

	A	B	1A/3B	2A/3B	A	B	1A/3B	2A/3B
Mean final weight (g)	127.00 ±14.04	150.19 ±18.01	145.30 ±13.06	121.01 ±16.31	166.36 ±23.85	215.43 ±6.90	185.00 ±13.82	155.83 ±16.92
Net in weight (g)	125.12	148.31	143.42	119.13	166.48	213.55	183.12	153.95
Specific growth rate (% body weight per day)	3.34	3.48	3.45	3.31	3.56	3.76	3.64	3.51
Mean final length(cm)	19.63 ±2.71	20.72 ±1.88	19.77 ±1.69	19.23 ±2.01	21.47 ±2.19	24.10 ±1.87	23.74 ±2.42	20.56 ±1.19
Net gain in length (cm)	15.36	16.45	15.50	14.96	17.20	19.83	19.47	16.29
Specific growth rate (% body length per day)	1.21	1.25	1.22	1.19	1.28	1.37	1.36	1.25
FCR1	2.96	2.75	2.73	2.79	2.82	2.02	2.67	2.71
PPV2	41.49	21.93	34.03	49.46	-	-	-	-
PER3	2.06	1.17	1.34	1.43	2.16	1.60	1.37	1.52
Survival(%)	90.00	83.33	86.67	93.33	73.33	46.67	53.33	73.3

1 Dry weight of food given/gain in wet weight of fish.
2 (Final carcass protein - Initial carcass protein) 100/Total dry weight of protein fed.

3 Gain in wet weight of fish/dry weight of protein fed.

The growth of fish attained in treatment A and 2A/3B differed significantly from the others ($p < 0.05$) though there was no significant difference between the two of them. Interestingly, weight of fish from treatment A was slightly higher than that of 2A/3B. Survival of fish had a major influence on weight gain, the gain being higher in tanks where poor survival was recorded. The specific growth rate (SGR) for both lenght and weight and the protein efficiency ratio (PER) were comparable between treatment B and 1A/3B. But, feed conversion was better in 1A/3B (2.73), followed by treatment B (2.75), 2A/3B (2.79) and A (2.96).

Flesh composition showed a decline in moisture and ash and an increase in protein and fat in all the treatments as compared to the initial values. Moisture content was lowest and protein deposition highest in fish from treatment 2A/3B. However, treatment 1A/3B resulted in the highest fat deposition as well as in a higher protein deposition than treatment A and B. Although fat deposition in treatment B was comparable to 1A/3B, protein deposition was lower (Table 4).

Table 4. Proxmate analysis (%) of fish.

	Initial	A	B	1A/3B	2A/3B	SEM*
Moisture	84.01d	79.29c	78.72b	77.71a	77.21a	0.1012
Crude protein	12.65a	15.69b	15.99c	17.04d	17.65e	0.0874
Crude fat	1.09a	3.84b	4.05b	4.16b	3.84b	0.2113
Ash	2.03c	1.14a	1.20ab	1.06a	1.29b	0.0426

Figures in the same row with the same superscript are not statistically significant ($p < 0.05$).
* Standard error of means.

Discussion

Common carp, *Cyprinus carpio* is reported to grow adequately under field conditions with a 30% protein diet (Varghese et al., 1976). Since growth attained in treatment 1A/3B was equal to that of fish fed continuously with a 30% protein diet (treatment B), it appears that this species does not require the same protein input every day. Existence of a rhythm in protein digestibility has been reported in *Etroplus suratensis* (De Silva & Perera, 1983) and *Oreochromis niloticus* (De Silva & Perera, 1984). Though there is no such information available at the moment in the case of common carp, the results of the present investigation indicate the possible existence of such a rhythm. In fact, De Silva & Perera (1983; 1984) were also unable to trace a well defined rhythm in the cichlids and De Silva (1985) adopted randomly determined feeding schedules to confirm its existence. His studies showed that feeding Nile tilapia with a 2A/3B or a 1A/3B schedule results in higher growth and better returns. Due to lack of tank facilities, other feeding schedules which might prove better results could not be tried. Alternate administration of high/low protein diets influences the growth performance of fish independently of the mean dietary protein input, which is believed to be due to a rhythm in certain basic metabolic activities (De Silva, 1985).

Based on the economics of production, treatment 1A/3B proved to be more economical than the rest. Application of this treatment saves 9.31% of the costs of feed inputs in terms of value and 15.39% in terms of protein in comparison with a contineous feeding of diet B. In addition, protein and fat deposition was higher in treatment 1A/3B than obtained with diet B. Thus, the results of the present study indicate the possibility of using mixed feeding schedules in carp. Intensified research in this area is worthwhile since it may contribute to a considerable reduction of feed input costs.

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References

Association of Official Analytical Chemists (AOAC), 1975. Official Methods of Analysis. Washington, D.C., USA, 1094 pp.

American Public Health Association (APHA), 1985. Standard Methods for the examination of water and waste water. 16th ed., APHA, Washington, D.C., USA, 1268 pp.

De Silva, S.S., 1985. Performance of Oreochromis niloticus (L.) fry maintained on mixed feeding schedule of differing protein content. Aquaculture and Fisheries Management, 16: 331-340.

De Silva, S.S. & Perera, W.M.K., 1983. Digestibility of an aquatic macrophyte by the cichlid Etroplus suratensis (Bloch) with observations on the relative merits of three indigenous components as markers and daily changes in protein digestibility. Journal of Fish Biology, 23: 675-684.

De Silva, S.S. & Perera, W.M.K., 1984. Digestibility in Sarotherodon niloticus fry: effects of protein level and salinity with further observations on variability in daily digestibility. Aquaculture, 38: 203-206.

Varghese, T.J., Devaraj, K.V., Shantharam, B. & Shetty, H.P.-C., 1976. Growth response of the common carp, Cyprinus carpio var. Communis to protein-rich pelleted feed. Paper presented at the Symposium on the Development and Utilization of Inland Fishery Resources, 27-29 Oct., Colombo, Sri Lanka, pp. 1-9.

Food intake and food conversion efficiency of the snakehead *Ociocephalus striatus* Bloch in a peaty swamp in Sri Lanka

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Summary

The Muthurajawela swamp is an unutilized area of about 3000 ha and extends for about 12 km to the north of Colombo along the coastal margin of the island. The water is characterized by a low pH, low levels of dissolved oxygen and low values of primary productivity. The soil is peaty, acidic and slightly saline. Attempts to cultivate paddy have failed due to the acidic condition of the water. This study investigates the feasibility of cultivating the popular food fish, *Ociocephalus striatus* in this vast unutilized swampy area.

The present study was carried out for 40 days using the water of the swamp, which had a pH of 4.8 ± 0.2. A control was also carried out simultaneously using pond water with a pH of 7.0 ± 0.1. Total length of the experimental fish ranged from 15.1 to 16.2 cm. They were fed *ad libitum* with live forage fish, *Puntius vittatus*, which are abundant in the swamp.

The relationship between the mean daily food intake (Y) and the body weight (X) in swamp water was found to be $Y = 0.0442 X^{0.7540}$ and in pond water $Y = 0.0348 X^{0.9027}$. The food conversion efficiencies ranged from 0.2173 to 0.2331 in swamp water and differed significantly from those in pond water (0.2123 to 0.2174). These data indicate, that food is more efficiently utilized for growth by *O. striatus* at low pH levels in swamp water than at neutral pH levels in control pond water.

Introduction

The snakehead, *Ophiocephalus striatus* Bloch which inhabits the irrigation reservoirs, streams, ponds, swamps, marshes and paddy fields in the low-country (Mendis & Fernando, 1962; Indrasena, 1965) is the most popular freshwater food fish found in Sri Lanka. Although it is the most commonly cultured species of snakehead in many South-east Asian countries (Ling, 1977), the demand for it in Sri Lanka is still entirely met by capture fisheries from the wild.

For a successful culture of the species, knowledge on food intake, digestion, absorption and conversion efficiency is a prerequisite (Wee, 1982). Many factors influencing food intake and conversion efficiency of *O. striatus* are reported. These include temperature (Vivekanandan & Pandian, 1977), dissolved oxygen content (Vivekanandan, 1977a), feeding frequency (Sampath & Pandian, 1984), crowding (Sampath & Pandian, 1980), activity patterns (Vivekanandan, 1977b), nutritional status (Pandian, 1967a) and size of the fish (Pandian, 1967b). However, there is paucity of information about the effect of pH on food intake and conversion efficiency of this species. Present investigations were, therefore, carried out as part of a study dealing with aquaculture of O. striatus in low pH waters of Muthurajawela swamp, an unutilized area of land in the western province of Sri Lanka.

Occupying about 3300 ha, this swamp extends for about 12 km along the coastal margin of the island to the north of Colombo. Soil of this swamp is peaty and slightly saline. The water is slightly acidic with low amounts of dissolved oxygen and low primary productivity (Costa & Keembiahetty, 1987). In the recent past, many attempts have been made to cultivate paddy and other crops in this formally arable land but these ventures have failed due to derelict ecological conditions of the swamp. Recent investigations have shown that Oreochromis mossambicus could be succesfully cultured in this swampy area by increasing the primary productivity of the water (Costa & Keembiahetty, 1987). However, since O. striatus is preferred over O. mossambicus by the community, present investigations were carried out as an initial step to determine the feasibility of aquaculture of this popular food fish in this swamp.

Materials and methods

Experiments were carried out for a period of 40 days in glass aquaria measuring 90x30x30 cm using Ophiocephalus striatus collected from Muthurajawela swamp. Experimental fish stocked at a density of 4 individuals per aquarium were fed ad libitum with weighed individuals of live forage fish Puntius vittatus collected from the swamp.

Ambient temperature during the study period was 29±1°C. The pH of the swamp water used in the experiment ranged from 4.6 to 5.0.

Approximately half of the water volume in each aquarium was replenished once in every two days and the weight of the test individuals was determined on every fifth day. Food conversion efficiency was calculated using the equation described by Lagler et al. (1977).

$$\text{Food conversion efficiency} = \frac{\text{Increase of body weight}}{\text{Weight of the food consumed}}$$

Experiments were repeated using normal pond water with a pH ranging from 6.9 to 7.1.

Results

Initial total length and weight of the test individuals and the food conversion efficiencies measured are summarized in Table 1. Growth pattern of test groups are shown in Figure 1, and growth equations in Table 3.

Table 1. Initial total length and weight of O. striatus and the food conversion efficiencies obtained.

	Normal pond water	Swamp water
No. of individuals	16	16
Total length (cm):		
range	15.40-16.10	15.20-17.20
mean ± s.d.	15.84± 0.36	15.96± 0.71
Body weight (g):		
range	23.50-30.10	23.98-34.85
mean ± s.d.	28.11± 2.42	29.45± 4.54
Food conversion efficiency:		
range	0.2123-0.2174	0.2173-0.2331
mean s.d.	0.2151±0.0016	0.2263±0.0048

Results of the analysis of variance are given in Table 2. Initial length and body weight of the two groups of test individuals were not significantly different from each other (P >0.05). However, food conversion efficiencies of the fish reared in swamp water were found to be significantly higher than those of the fish reared in normal pond water (P <0.01).

Table 2. Summary of the analysis of variance for initial total lenght and weight and for food conversion efficiencies obtained.

Source	S.S.	D.f.	M.S.	F.	P.
		Total length			
Between	0.005	1	0.005	0.041	> 0.05
Residual	3.675	30	0.122		
Total	3.681	31			
		Body weight			
Between	0.905	1	0.905	0.147	> 0.05
Residual	184.510	30	6.150		
Total	185.415	31			
		Food conversion efficiency			
Between	0.001	1	0.001	79.783	0.01
Residual	0.0004	30	0.00001		
Total	0.0014	31			

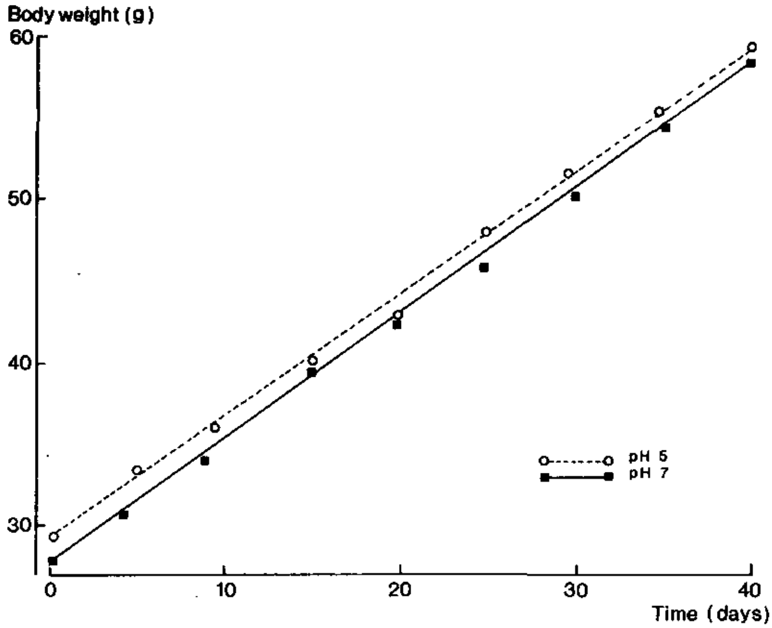

Figure 1. Average growth response of test individuals during the study period.

Table 3. Growth equations for test individuals reared in swamp water and normal pond water (W = weight in g, t = time period in days).

Individuals reared in	Regression equation	n	Correlation coefficient	P
Swamp water	$W = 0.7283t + 29.33$	9	0.99	<0.01
Normal pond water	$W = 0.7716t + 27.51$	9	0.98	<0.01

Statistical analysis showed that the rate of increase in body weight of the test individuals reared in swamp water was not significantly different from that of the individuals reared in normal pond water ($P > 0.05$).

The relationship between the daily food intake (Y in g) and the mean body weight (X in g) could be described as $Y = 0.0442\ X^{0.7540}$ respectively $Y = 0.0348\ X^{0.9027}$ for fish reared in swamp respectively normal pond water, the weight exponents being significantly different from each other ($P < 0.05$).

Discussion

The snakehead O. striatus has been observed to survive at pH values ranging from 3.1 to 9.1 (Verma, 1979). This species, therefore, was considered to have a high potential for aquaculture in environments such as Muthurajawela swamp where water is characterized by a low pH.

Higher food conversion values observed for test individuals reared in swamp water indicate that when grown in this slightly acidic environment, food material ingested by O. striatus is converted more efficiently into body tissues than when grown in normal pond water. However, since the increase in body weight of the test individuals reared in swamp water was not significantly different from that of the individuals reared in normal pond water, it appears that the growth rate of O. striatus is not affected by pH values as used in this experiment. Geen et al. (1985) observed an influence of pH on the growth rate of Oncorhynchus tshawytscha.

In metabolic studies the exponent of the equation relating food intake to body weight is found to be very close to 0.8 (Winberg, 1956). A higher value for this exponent indicates that the food material ingested is primarily utilized for energy expenditure rather for growth (De Silva & Weerakoon, 1981). Results of the present study, therefore, suggest that when grown in normal pond water, food material ingested by O. striatus is utilized more for energy than for growth.

Concentration of dissolved compounds have been found to increase significantly with increasing acidity of the environment (Norton, 1982). Thus, the osmotic pressure of water in these acidic environments will increase resulting in a low "inflow" of water into the bodies of freshwater fish inhabiting these habitats. Therefore, these fish may require less energy for osmoregulation than those living in environments with a normal pH. This may be one of the reasons for a low energy requirement of O. striatus reared in swamp water with a low pH.

Since the food material ingested by O. striatus may be utilized more for growth than for energy this species may have a good potential for aquaculture in the low pH environment of Muthurajawela swamp. However, further growth studies carried out over longer periods and studies on population dynamics of forage fish such as P. vittatus will also be of utmost importance for a successful implementation of aquaculture programmes using O. striatus in this presently unutilized peaty swamp.

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References

Costa, H.H. & Keembiahetty, C.N., 1987. An experimental study on the culture of fry of Oreochromis mossambicus (Peters) in a peaty swamp in Sri Lanka using cowdung and poultry manure as fertilizer. Resources and Conservation, 13: 247-254.

De Silva, S.S. & Weerakoon, D.E.M., 1981. Growth, food intake and evacuation rates of grass carp, Ctenopharyngodon idella fry. Aquaculture, 25: 67-76.

Geen, G.H., Neilson, J.D. & Bradford, M., 1984. Effects of pH on the early development and otolith microstructure of chinook salmon, Oncorhynchus tshawytscha. Can. J. Zool., 63: 22-27.

Indrasena, H.H.A., 1965. Freshwater fishery resources. Bull. Fish. Res. Stn Ceylon, 18: 87-90.

Lagler, K.F., Bardach, J.E., MIller, R.R. & Passino, D.R.M., 1977. Ichthyology, John Willey and Sons, N.Y., pp. 505.

Ling, S.W., 1977. Aquaculture in Southeast Asia: A Historical Overview. University of Washington Press, Seattle, pp. 108.

Mendis, A.S. & Fernando, C.H., 1962. A Guide to the Freshwater fauna of Ceylon, Bull. Fish. Res. Stn Ceylon, 12: pp. 160.

Norton, S.A., 1982. The effects of aciddification on ground and surface waters. In: R.E. Johnson (editor), Acid Rain/Fisheries. Proceedings of the International Symposium on Acidic Precipitation and Fish Impact in Northeastern North America, Cornell University, Ithaca, NY, 1981. American Fisheries Society, Behtesda, MD. 93-102.

Pandian, T.J., 1967a. Intake and digestion, absorption and conversion of food in the fishes Megalops cyprinoides and Ophiocephalus striatus. Mar. Biol., 1: 16-32.

Pandian, T.J., 1967b. Food intake, absorption and conversion in the fish Ophiocephalus striatus. Helgolander Wiss. Meeresunters, 15: 637-647.

Sampath, K. & Pandian, T.J., 1980. Effects of density on food utilization and surfacing behaviour in the obligatory air breathing fish Channa striatus. Hydrobiologia, 68(2): 113-117.

Sampath, K. & Pandian, T.J., 1984. Interactions of feeding frequency and density on food utilization in air-breathing murrel, Channa striatus. Proc. Indian Acad. Sci. (Anim. Sci.), 93(5): 445-453.

Verma, B.R., 1979. Studies on the pH tolerance of certain freshwater teleosts. Comp. Physiol. Ecol., 4(2): 116-117.

Vivekanandan, E., 1977a. Effects of the pO_2 on swimming activity and food utilization in Ophiocephalus striatus. Hydrobiologia, 52(2,3): 165-169.

Vivekanandan, E., 1977b. Surfacing activity and food utilization in the obligatory air breathing fish Ophiocephalus striatus as a function of body weight. Hydrobiologia, 55(2): 99-112.

Vivekanandan, E. & Pandian, T.J., 1977. Surfacing activity and food utilization in a tropical air-breathing fish exposed to different temperatures. Hydrobiologia, 54(2): 145-160.

Wee, K.L., 1982. Snakeheads - their biology and culture. In: J.F. Muir & R.J. Roberts (editors), Recent Advances in Aquaculture, Croom Helm Ltd., London, pp. 179-213.

Winberg, G.G., 1956. Rate of metabolism and food requirements of fishes. Minsk-Belorusskogo Nauchnye Trudy Belorussk, Gos. Univ. Imeni. V.I. Lenina, pp. 253. (Translation Fish. Res. Board Can., No. 194).

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