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RAPPORT MANUSCRIT
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Cage Culture Research Projects
Projets de recherche sur la pisciculture en cages

Report of a workshop held in Cairo, Egypt, 23–26 October 1985
Compte rendu d'un atelier tenu au Caire, Égypte, du 23 au 26 octobre 1985

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CANADA

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CAGE CULTURE RESEARCH PROJECTS

PROJETS DE RECHERCHES SUR LA PISCICULTURE EN CAGES

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Editor Rédacteur
Howard Powles

Jointly sponsored by the International Development Research Centre and the Academy of Scientific Research and Technology of Egypt

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PREFACE

The culture of fish in cages presents several theoretical advantages over pond based systems for the small scale fish culturist. Existing water bodies can be used, simplifying water management problems; initial investment is relatively low, at least if maximum use is made of cheap locally available materials; natural water productivity can be taken advantage of, but supplemental feeds can also be used up to high levels.

Following a 1979 workshop jointly sponsored by IDRC and the Southeast Asian Fisheries Development Centre (SEAFDEC), a number of cage culture research projects have been pursued. By 1984, it appeared that results of these projects justified another workshop to review progress. This workshop could not hope to present a definitive review of all cage culture projects; but it provides a good overview of cage culture systems usable in a wide range of ecological and socioeconomic milieux.

The Workshop was jointly sponsored and organised by IDRC and the Academy of Scientific Research and Technology of Egypt, whose Institute of Oceanography and Fisheries has been conducting cage culture research since 1978.

Objectives of the Workshop were :

- to summarise and compare results from cage culture research projects in a variety of milieux;
- to identify priority research areas in cage culture systems and possible approaches to these;
- to discuss specific aspects of cage culture systems (for example feed, economics);
- to provide an opportunity for aquaculture researchers to discuss current problems in the field.

The following persons contributed to the Workshop organisation and production of this report, and are gratefully acknowledged : Dr. Fawzy Kishk, IDRC Regional Director for the Middle East and North Africa; Sohair El Shabassy; Rose Marie Erambert; Marie F. Ndiaye; Ndioro Ndour

Howard Powles
Editor

P R E F A C E

La pisciculture en cages offre plusieurs avantages théoriques, en comparaison avec les systèmes de pisciculture en étang. Les plans d'eau existants peuvent être utilisés, et ainsi les problèmes de gestion de l'eau sont minimisés; les coûts d'investissement sont relativement faibles, au moins si on utilise au maximum les matériaux de construction disponibles localement à peu de frais; la productivité naturelle des plans d'eau contribue à la croissance des poissons, mais on peut également utiliser des aliments supplémentaires pour permettre une augmentation de la densité des poissons dans les cages.

Le CRDI et le Southeast Asian Fisheries Development Centre (SEAFDEC) ont organisé conjointement un atelier sur la pisciculture en cages en 1979. Depuis la tenue de cet atelier, plusieurs projets de recherche sur la culture en cages se poursuivent. En 1984, on a considéré que la tenue d'un nouvel atelier était justifié, pour résumer les progrès des divers projets. Evidemment, cet atelier ne pourrait pas présenter une revue définitive de tous les projets en cours. Mais il fournit une bonne vue d'ensemble des systèmes de culture en cages utilisables dans divers milieux écologiques et socioéconomiques.

L'Atelier a été organisé et parrainé conjointement par le CRDI et l'Academy of Scientifc Research and Technology de l'Egypte. Des recherches sur la culture en cages se poursuivent depuis 1978 sous la direction de l'Institute of Oceanography and Fisheries de l'ASRT.

Les objectifs de l'Atelier étaient :

- de résumer et de comparer les résultats de projets de recherche en pisciculture en cages entrepris dans divers milieux;
- d'identifier les thèmes de recherche prioritaires pour la culture en cages;
- de discuter des composants des systèmes de culture en cages (par exemple, les aliments; les aspects économiques);
- de permettre aux chercheurs en aquaculture de discuter des problèmes d'actualité de leur domaine.

Les personnes suivantes ont contribué à l'organisation de l'Atelier et à la production de ce Rapport, et sont vivement remerciées: Dr. Fawzy Kishk, Directeur Régional pour le Moyen Orient et l'Afrique du Nord du CRDI; Sohair el Shabassy; Rose Marie Erambert; Marie F. Ndiaye; Ndioro Ndour.

Howard Powles
Rédacteur

Address by Prof. Dr. Mohammed Kamel
President, Academy of Scientific Research and Technology
Cairo, Egypt

Distinguished guests, Ladies and Gentlemen :

It gives me great pleasure and honour to welcome you to the Symposium of Cage Fish Culture convened in Cairo through collaborative effort between the Academy of Scientific Research and Technology and IDRC (International Development Research Centre of Canada). This symposium fits within the national and international interests or responsibilities of the Academy which is the national central body responsible for the development of Science & Technology in Egypt according to its establishing Presidential Decree in 1971.

It is the existing body at the highest level of Egyptian Government which has the understanding and comptence to shoulder the responsibility of integrating Research and Development Planning at the national level.

Its main functions are to :

- Enhance the contribution of Egyptian Scientific capabilities to Development.
- Bridge the existing gap between scientists on the one hand and industry, agriculture and other sectors of the economy on the other.

Within the structure of the Academy, we have the Specialized Research Councils which carry out the Academy's functions in sectoral planning and coordinating scientific research at the national level. They are concerned with all the scientific, technological, economic and social activities which are related to the council's field of interest. For this reason, each council constitutes an integrated team of members selected from scientists and technologists in the various disciplines from various ministries, research institutions, universities and users. At present about 1000 members, belonging to the specialised councils and their affiliated 50 commissions and 24 committees are involved.

Among those councils, the Food and Agriculture Research Council has been, for more than 10 years, concerned with the problems related to agriculture, animal and fisheries development. Within this context, it has implemented a number of projects through contractual basis with the different organisations including universities, ministries and research institutions. As regards fisheries, interest has been directed to both natural and fish culture areas.

Egypt is now considering aquaculture as one of the main approaches for development of the fisheries and it is expected that by the year 2000, about 50% of our fish needs will be furnished from fish farms. As examples of our fisheries research projects that began in 1974 may be mentioned :

- Developing 80 acres of EL-Abbassa Lake into a pilot fish farm.
- Fish-raising in rice fields.
- Improving the efficiency of shore fishing practices in the northern lakes.
- Developing fish production from Lake Qarûn.

Within the present five-year research plan the following projects are considered of priority :

1. Evaluation of stocks in natural waters especially the Gulf of Suez and Lake Nasser.
2. Fish feeds.
3. Evaluation of fishing methods adopted in main fishing areas.

Close cooperation between the Academy and the Ministry of Agriculture exists. Together with the private sector, the Ministry of Agriculture are the main users of the research results. The Ministry and the Academy mutually fund and execute, when necessary, some activities. At present, a bilateral program is directed to statistical evaluation of fish production from different water masses.

The Academy also plays a key role in building up the capability of fisheries expertise in the Country. The Institute of Oceanography and Fisheries is affiliated, as some other technical institutes, to the President of the Academy. This institute is the main research body in Egypt and its activity dates back for over 60 years. It has been responsible for the introduction of new technologies for development of fish production such as new gears or new techniques. The cage culture, as the theme of your symposium, is an example of the institute's role within this context.

On the other hand, your symposium fits within the interest of the Academy within the context of its bilateral regional and continental cooperative responsibility. A number of fisheries specialists have been seconded to some Arabian and African countries. The Academy with the Ministry of Agriculture and Ministry of Foreign Affairs as well as the Food & Agriculture Organization convened the fifth meeting of the Committee of Inland Fisheries of Africa which was held in Cairo, January 1983. This meeting as well as the present and future ones symbolize the interest of the Academy in the process of development especially in areas of paramount importance and directed to the problems of the Continent especially food.

Moreover, our cooperation with the IDRC cannot be overlooked. Cage culture is one of the examples. Other institutions are also involved in this support. I am very thankful for IDRC for its convening your symposium in Cairo. This meeting symbolizes also the Continent's interest in the new technologies directed to alleviating the problem of food in the Continent. Due to drought and decline in food production, great effort should be directed to this problem according to properly planned and prioritised programmes. I am looking forward to the IDRC for supporting cooperative programmes, executed in a number of countries and directed to problems of common interest. We are grateful for the concerned efforts Dr. Kishk is making in this respect.

Lastly, I wish your symposium success in its goals and for our guests nice stay in Cairo and a safe journey home.

Needless to mention in conclusion that the Academy is interested to cooperate with African Countries on bilateral, regional or subregional activities.

CAGE CULTURE OF FISH IN EGYPT

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INTRODUCTION

The present production of fish in Egypt is not sufficient to satisfy the demands of the increasing population. About 100,000 tonnes of frozen fish; almost 50% of the annual consumption, are imported annually. Increasing fish production is one of the main objectives of the Government and this goal is fully supported within the framework of the national food security programme.

Egypt has vast areas of aquatic resources, freshwater, marine and brackish water, roughly estimated to be 2,500,000 hectares. Intensification of fishery production in such natural water bodies can be undertaken in a variety of ways including the application of various management measures in order to utilize the natural production potential. The decline of fish availability from the natural sources during the past two decades, and the high fish prices have supported the development of fish culture in Egypt.

The oldest records of cage culture come from Kampuchea where the fishmen used to keep _Clarias_ spp. and other commercial fishes in bamboo until ready to transport to markets. The fish were fed kitchen scraps and were found to grow readily (Pantulu, 1979 and Beveridge 1984). This traditional method has spread to different countries of Southeast Asia, Europe and the United States. Coche (1979) gave a review of fish cageculture and its application in Africa.

In Egypt, the intensifying of fish production in lakes and natural water bodies is feasible through the adoption of intensive systems of fish culture. In this respect, cage culture has been suggested as a new culture technology and a project was outlined and supported by IDRC of Canada to carry out a systematic research to develop cage culture technology under local conditions. This paper reviews the result of some cage culture experiment carried out within the framework of the project.

Because cage culture is an entirely new practice in Egypt, research activities were directed toward obtaining knowledge on the production possibilities of several fish species in different aquatic systems. For each fish species the studied parameters included :

environmental conditions, stocking density, size of fish at stocking, survival, supplementary feed (especially level of crude protein in the diet), size of cage and production. Data were collected on the fixed costs (cage construction etc.) and also the culture operation cost. The experimental cages were of 1 and 4 m^3 in order to have several replicates of each treatment. The results of these studies are presented in the project reports (Ishak et al 1982, 1985; and Badawi, 1984).

Tilapias

Experiments on cage culture of tilapias were carried out at the Serow Fish Culture Research Station. The cages were placed in a pond of one ha, and the inlet and the outlet of the pond was regulated to maintain a moderate flow of water of 1.5 m depth.

Two species of Tilapias were examined, Oreochromis niloticus and Oreochromis galileus. Each fish species was examined by three different stocking densities; 100, 200 and 300 fish/m^3. For each stocking density four cages were used, two of 1 m^3 and the other two of 4 m^3. O.niloticus were of an average weight of 14.2 g/fish and O.galileus were of an average weight of 19.3 g/fish. The fish were fed with supplementary food of 20% protein. The food was offered twice daily six days a week, at a rate of 5% of the body weight. Control cages of the lowest stocking density were maintained without supplementary feed. The rearing period was 180 days.

The results of the experiments showed that O. niloticus is more sensitive to handling than O. galileus. An acclimation period of at least 10 days is essential to reduce the mortality rate after stocking in cages was higher for O. niloticus than that for O. galileus reared under the same conditions. For both species supplementary feeds were found to be essential. The best stocking rate was 200 fish/m^3, that gave a maximum production rate of 32 and 17.4 kg/m^3 and also a higher final average size of 178.7 kg/m^3 and 108.1 g/fish for O. niloticus and O. galileus respectively.

Experiments on rearing of O. niloticus in cages placed in running water systems (the River Nile) and in standing waters were carried out at the Barrage Fish Research Station. (Table 1)

The fish were of an average weight of 25 g and the cages were one m^3. Used oil drums served as the floating element in running water system. The fish were fed twice daily, six days a week on pelleted feed of 25% protein, at a level of 5% of the body weight. The rearing period was 150 days.

In running water system, the best production of O. niloticus was attained at a stocking density 50 and 100 fish/m^3. The loss of feed by the strong flow and the low fertility of the water are among the main causes for the relatively low production. In another running system irrigation canal, Ibrahimia canal, Beni-Suef Governorate, the growth rate fo O. niloticus stocked at a density of 100 fish/m^3 (Avg wt 30 g/fish) was 1.4 g/fish/day. Therefore, the natural fertility of a given body of water is an important factor to be considered for increased production of O. niloticus.

On the other hand, production of O. niloticus in cages placed in stagnant ponds is significantly lower than in running water due to the accumulation of organic matter and low water quality.(Table 1)

The sex of the reared O. niloticus is an important item to consider in cage culture. The results of the experiments showed that males attained larger sizes than females stocked at the same size and density. Males showed better growth rate, better production/m^3 and better condition factor than females . (Table 2)

The common carp Cyprinus carpio L.

The experiments were carried out at the Serow Fish Culture Research Station. The experimental conditions were the same as previously described for tilapias.

C. carpio were of two sizes, 27.3 g/fish and 95.7 g/fish. The stocking densities were 80, 160 and 240 fish/m^3 for the small fish and 30, 60 and 90 fish/m^3 for the large fish. The rearing period was 180 days.

The results on cage culture of the common carp showed that the size of fish at stocking is a limiting factor for production/m^3. When the fish were stocked at an initial average size of 27 g/fish, maximum production rate (20 kg/m^3) was found in a 4 m^3 cage at a stocking density of 160 fish/m^3 while when the stocking size was 95 g/fish maximum production rate was 32.5 kg/m^3 at a stocking density of 60 fish/m^3. It was evident that the production rates for the larger size carp (95 g) were almost double that of the smaller size carp. The lowest feed conversion coefficient (2.74), highest average weight of fish of 584 g after six months was obtained using 95 g average size fingerling at a stocking rate of 60 fish/m^3.

Biculture of Nile Tilapia and the Common Carp in cage

This work was carried out at the Serow Research Station. The main objectives were to determine the feasibility of raising the common carp C. carpio and the Nile tilapia and determine the growth rate and production of the two species in relation to stocking densities.

Six cages were used, each of 1 m^3. They were placed in a one ha pond where the water was regulated to maintain a reasonable flow of water. The experimental fish were stocked into two groups : Group A (Table 3) was stocked with 80 fish/m^3; (40 O. niloticus and 40 C. carpio). O. niloticus were of an average weight of 51.6 g and average total length of 15.1 cm and C. carpio were of an average weight of 104.2 g and average total length of 19.8 cm. The initial weight for both species at stocking was 6.3 kg/m^3. Group B (Table 4) was stocked with 100 fish/m^3 (80 O. niloticus of an average weight of 51.6 g and total length 15.1 cm; and 20 C. carpio of 100.3g average weight and 18.7 cm average total length). The initial weight at stocking for both species was 6.1 kg/m^3.

The fish were given a mixture of 1:1 of pelleted feed (25% crude protein) and a commercially available feed (19% crude protein). The fish were fed daily at a rate of 5% of the experiment was 90 days starting July 1st 1984.

The results showed that the biculture of the two species is feasible and the survival rate for both species is high (Table 3 and 4). The fish of Group B (80 O. niloticus and 20 C. carpio) had a better growth and production/m^3 than the fish of Group A (40 O. niloticus and 40 C. carpio). O. niloticus of Group B increased from an average weight of 51.6 g to 160/ fish, thus representing an average of 1.2 g gain/fish/day while the same species in Group A increased from an average weight of 51.6 g to 129.6 g/ fish a significantly lower rate of gain/fish/day of 0.87G.

Similarly, C. carpio of Group B had a better growth than those of Group A, attaining a final average weight of 369.9 and 250.8 g/fish respectively. The gain/fish/day for fish of Group B was almost twice that of Group A; being 3 and 1.6 g respectively.

The production for both species was better for Group B than that for Group A; being 19.9 kg and 15.2 kg/m^3 respectively in a period of three months. It is evident that ratio of stocking of 2:1 tilapia to carp (Group B) is more profitable under the Egyptian market condition where tilapia are more expensive than carp.

The utilization of supplementary feed by Group B was higher than that for Group A, the feed conversion coefficient being 2.96 and 4.06 respectively. It is know that O. niloticus is an aggressive fish and therefore they first utilize the supplementary feeds and the leftover is not wasted but efficiently utilized by carp.

Nile Catfish Clarias lazera

This species seems to be a suitable candidate for cage culture development especially in Upper Egypt where market conditions are good. The preliminary results carried out at the Barrage Research Station indicated that the growth rate of the fish was about 3.5 g/fish/day when stock at a density of 200 fish/m^3 and fed a pelleted feed of 25% crude protein (Table 5). Further experiments are planned to determine the nutritional requirements of this species under cage culture conditions.

Seabass Dicentrarchus labrax

Fingerlings of the seabass Dicentrarchus labrax were reared in cages (12 m^3) placed in Lake Quarun, at a water salinity of 30.1% for a period of three months. The fish were of an average weight of 10 g. They were fed fresh trash fish collected from the lake. The preliminary data is promising (Table 6).

The fingerlings stocked at a rate of 200 fish/m^3 attained an average weight of 325 g/fish. This stocking density gave the lowest feed conversion coefficient (2.7), the highest rate of survival 80.5% and a net production of 50.3 kg/m^3. Further experiments are designed to use dry pelleted balanced diets.

PROSPECTS OF CAGE CULTURE

Experimental work on fish cage culture started in Egypt 1979 at the Serow Fish Culture Research Station, Institute of Oceanography and Fisheries. Since that time, research activities have been spread to experiment cage culture in natural water bodies, the River Nile and irrigation canals and lakes; and in ponds.

The potential of cage culture of fish is great due to suitability of the prevailing environmental conditions (the growing period extends for almost nine months a year), the availability of fish seed that suits the different aquatic systems and the increasing market demand for fresh fishes. The only limiting factor for cage culture development is the increased demand for supplementary feeds. However, this point is being solved through the production of balanced pelleted fish feeds from agricultural by products and the utilization of uncoventional ingredients (Ishak and Hassanen 1984). However, it is possible to utilize the productive lakes and other water bodies for cage culture of the planktonic and plant feeding fish species.

A wide variety of locally available fish species, that are suitable for cage culture, could be utilized in the development of such technology in the country. Among these, are the freshwater fish species, tilapias especially (Oreochromis niloticus and Oreochromis aureus); the common carp (Cyprinus carpio), the chinese carps, grass carp Ctenopharyngodon idellus, silver carp Hypothalmichtys molitrix, bighead carp Aristichys nobiliis); the Nile Catfish (Clarias lazera); the Nile perch (Lates niloticus). For brackfish and marine waters, the fish species include the highly priced fish, the seabass (Dicentrarchus labrax); the gilthead bream (Chrysophyrs auratus), the rabbit fish (Siganus siganus) and the grouper (Epinephelus spp.).

However, for the development of an efficient cage culture technology for any of the above-mentioned fish species, biotechnical research data as well as an economic feasibility analysis should be carried out. Problems associated with such development, namely the shortage of fingerling supply for some species, the availability of the balanced fish feeds for a particular species, and poaching should be considered.

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Table 1 : Cage Fish Production in Different Waters (O. niloticus)

Location	Running water		Standing water	
Cage Group	A	E	F	G
Stocking density (Fish/m^3	50	100	100	100
No.of cages	6	8	3	3
Av. stock. wt. (kg)	24.6	24.6	24.6	24.6
T. stock. wt. (kg)	1.23	1.23	2.46	1.23
Total No.stocked	300	400	300	150
Total No.cropping	90	370	205	128
Mortality (%)	70	5	31.7	20
Av. wt. cropping (g)	50.8	155.5	82.9	92.5
Tot. production (kg)	4.572	59.09	16.995	11.84
Prod./m^3 (kg)	0.782	7.586	5.665	3.947
Net prod./m^3 (kg)	0.468	6.165	3.205	2.717
Food conversion	---	2.2	3.8	3.6
Growth rt. (g/fish/day)	0.17	0.873	0.390	0.453
Quantity of food (kg)	---	13.54	12.18	9.78

Table 2: Growth, production, food conversion ratio and mortality, for mono-sex _O. niloticus_ reared in separate cages. (Capacity of cage of one m^3).

Item	Male	Female
Initial Avg. Wt/fish (g)	52.0	55.9
Final Avg. Wt/fish (g)	169.5	132.7
Gain in Weight (%)	225.96	137.4
Initial Avg. length (cm)	15.2	14.4
Final Avg. length (cm)	20.3	19.5
Gain in length (%)	33.6	35.4
No. of fish/cage	120	120
No. of loss (average)	6.3	12.7
% Survival	94.7	89.4
Initial Wt of fish/cage (Kg)	6.2	6.7
Total crop/cage (Kg)	19.4	14.3
Gain in weight/cage (Kg)	13.2	7.6
Production rate (Kg/m^3)	13.2	7.6
Total feed (Kg)	41.2	36.2
Feed conversion coefficient	3.1	4.8
Avg. gain/fish/day (g)	1.3	0.85

Each figure represents an average of three cages. Rearing period 90 days.

Table 3 : Growth, production, food conversion ratio and mortality for *O. niloticus* and *C. carpio* reared in one cage at stocking ratic at 1:2 by weight/m^3 respectively. (Capacity of cage one m^3).

Group A

Item	*O. niloticus*	*C. carpio*	Total/cage
Initial avg. wt/fish (g)	51.6	104.2	
Final avg. wt/fish (g)	129.8	250.8	
Gain in weight (%)	151.6	140.7	
Initial avg. length (cm)	15.1	19.8	
Final avg. length (cm)	19.2	23.0	
Gain in length (%)	27.2	16.3	
No. of fish/cage	40	40	
No. of loss	2	1.3	
% survival	95	96.7	
Initial wt of fish/cage (kg)	2.1	4.2	6.3
Total crop/cage (kg)	5.3	9.9	15.2
Gain in weight/cage (kg)	3.2	5.7	8.9
Production rate (kg/m^3)	3.2	5.7	8.9
Total feed (kg)	36.1		
Feed conversion coefficient	4.08		
Avg. gain/fish/day (g)	0.87	1.6	

Each figure represents an average of three cages.

Table 4 : Growth, production, food conversion ratio and mortality for O. niloticus and C carpio reared in one cage at stocking ratio of 2:1 by weight/m^3 respectively (capacity of cage one m^3).

Group B

Item	O. niloticus	C. carpio	Total/cage
Initial avg. wt/fish (g)	51.6	100.3	
Final avg. wt/fish (g)	160.6	369.9	
Gain in weight (%)	211.2	268.8	
Initial avg. length (cm)	15.1	18.7	
Final avg. length (cm)	20.1	26.4	
Gain in length (%)	33.1	41.2	
No. of fish/cage	80	20	
No. of loss	1	0.7	
% survival	98.8	96.5	
Initial wt of fish/cage (kg)	4.1	2.0	6.1
Total crop/cage (kg)	12.7	7.2	19.9
Gain in weight/cage (kg)	8.6	5.2	13.8
Production rate (kg/m^3)	8.6	5.2	13.8
Total feed (kg)	40.8		
Feed conversion coefficient	2.96		
Avg. gain/fish/day (g)	1.2	3.00	

Each figure represents an average of three cages.

Table 5: Growth rate, feed conversion, and survival rate at termination of 9 weeks period for Nile catfish, Clarias lazera fed different levels of protein* (Stocking density 200 fish/m^3).

Item	CP % in the diet			
	20	25	30	40
Initial Avg. Wt/fish (g)	97.50	97.43	97.34	97.45
Final Avg. Wt/fish (g)	324.30	322.24	316.46	308.51
Gain in Weight (%)	232.62	230.74	225.11	216.58
Initial Avg. length (cm)	18.4	18.70	18.30	18.6
Final Avg. length (cm)	30.20	29.90	30.10	30.0
Gain in length (%)	64.13	59.89	64.48	61.29
No. of fish/cage	40	40	40	40
No. of loss	—	—	—	—
% Survival	100	100	100	100
Initial wt of fish/cage (Kg)	3.90	3.90	3.9o	3.90
Total crop/cage (Kg)	12.97	12.89	12.65	12.34
Gain in weight/cage (Kg)	9.07	8.99	8.75	8.44
Production rate (Kg/m^3)	45.35	44.95	43.75	42.20
Total feed (Kg)	14.48	14.40	14.17	14.10
Fed conversion coefficient	1.60	1.60	1.62	1.67
Price/Kg/feed P.T.	19.80	22.95	29.08	32.54
Cost/Kg/fish P.T.	31.68	36.72	47.11	54.34
Av. gain/fish/day (g)	3.60	3.57	3.48	3.35

Values reported are means of two cages, each 0.2m^3 capacity.

Rearing Period, nine weeks.

Table 6 : Growth, production, food conversion ratio and percent survival for *Dicentrarchus labrax* reared in cages for a period of three months under different stocking densities.

ITEM	Stocking densities			
	Control	100 fish/m³	200 fish/m³	400 fish/m³
Initial avg. wt/fish (g)	10	10	10	10
Final avg. wt/fish (g)	58	405	325	228
Gain in weight (%)	480	3950	3650	2180
Average gain/fish/day (g)	0.5	4.4	3.5	2.4
Initial No. of fish/cage	1200	1200	2400	4800
No. of loss/cage	751	278	468	1681
% survival	37.4	76.8	80.5	64.98
Initial total wt. of fish/cage	12	12	24	48
Total production (kg/cage)	26.0	373.5	627.9	711.1
Net production (kg/cage)	14.0	361.5	603.9	663.1
Net production (kg/m³)	1.2	30.1	50.3	55.3
Total amount of food (kg)*	--	1258.8	1638	2190.6
Food conversion ratio	--	3.5	2.7	3.3

* Total amount of food was calculated as 10% of the total fish weight estimated weekly by random weight measurements.

LA PISCICULTURE EN CAGES EN EGYPTE

M. M. Ishak

Résumé français

La demande pour le poisson est beaucoup supérieure à la production nationale, ainsi quelques 100.000 t de poisson (50% de la consommation) sont importées chaque année. Un projet de recherche pour développer des techniques de pisciculture en cages adaptés aux conditions locales a été entrepris avec le soutien du CRDI, en 1978. On a étudié la culture en cages des tilapias O. niloticus et O. galilaeus dans des étangs et dans un grand canal d'irrigation. Une alimentation supplémentaire est nécessaire pour les deux espèces. la production maximale a été atteinte à un taux d'empoissonnement de 200/m^3 pour les cages dans les étangs, et à 50 - 100/m^3 dans le canal. Pour O. niloticus, la production a été de beaucoup moindre dans les cages situées dans des eaux tranquilles que dans les eaux coulantes du canal. Des essais de culture en cages de C. carpio ont montré une influence de la taille à l'empoissonnement sur la production : pour une taille à l'empoissonnement de 27 g, la production est de 20 kg/m^3, mais pour une taille à l'empoissonnement de 95 g la production est de 32.5 kg/m^3 (période d'essai = 180 jrs). Des essais de production de O. niloticus et C. caprio ensemble ont démontré une production totale, en trois mois, de 19.9 kg/m^3, en utilisant 80 O. niloticus et 20 C. carpio par m^3. Quelques essais préliminaires avec le Clarias lazera ont démontré un taux de croissance moyen de 3.5 g/j, à une densité de 200/m^3, en utilisant un aliment en granulé de 25% de protéine. On a également fait des essais d'élevage en enclos du Dicentrarchus labrax dans le lac Quarun (salinité : 30%), en utilisant du poisson non-commercialisable comme aliment - la production nette a été de 50.3 kg/m^3.

Le potentiel pour le développement de la culture en cages en Egypte est grand, étant donné la longue saison de croissance, la présence de plusieurs espèces utilisables dans les cages, et la disponibilité de grandes superficies de plans d'eau. Le manque d'aliments pourrait contraindre le développement, mais des recherches sur la formulation d'aliments en granulé à partir de sous-produits agricoles sont en cours, en vue de résoudre ce problème.

GROWTH OF CAGED OREOCHROMIS NILOTICUS REARED ON DIETS CONTAINING VARIOUS PROTEIN LEVELS

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INTRODUCTION

The increasing demand for fish, as a source of protein, in Egypt has motivated the development of aquaculture and intensification of culture methods (Ishak 1979). Investigations on cage culture of O. niloticus and some other fish species indicated the feasibility of this method of culture in Egypt (Badawi, 1984, Ishak et al. 1982, 1984).

It is well known that the success of intensive fish culture depends to a large extent on supplementary feeds (Cho et al. 1985). The basic information on the nutritional requirements and feed formulation for O. niloticus is incomplete. Therefore, information on the protein requirements of this species, which is the most expensive element of the diet, is necessary to minimize feed-cost inputs.

The objective of this investigation was to determine through feeding trials the optimum dietary protein level for O. niloticus raised in an intensive cage culture system.

MATERIALS AND METHODS

Nine cages were used in this study. The cages were placed in the Menoufy Diversion of the Nile at the site of the Barrage Research Station. The dimensions of each cage were (1 x 1 x 1.5 m) depth; made of galvanized plumbing tubes, coated with a netting material of 1 cm mesh size and oil drums as floating elements. The volume of the net cage under water was 1 m^3.

O. niloticus fingerlings were collected from the experimental cement ponds at the Barrage Research Station. The fish were randomly distributed to the experimental cages at a density of 100 fish/m^3. The fish were of an average weight of 34.27 g and an average total length of 12 cm.

Three experimental diets of different crude protein levels (26, 29, 32%) were prepared. Fish meal, meat and poultry by-product meal were the source of animal supplement protein. In order to maintain the quality of the animal supplement protein in all the feeds, these ingredients were increased at the expense of cotton seed meal, rice bran and wheat bran (Table 1). The feeds were prepared as dry pellets of 2 mm in diameter and 4 mm length using a California Laboratory Pellet Mill (Model CL).

The first 15 days of the experimental period was considered as an acclimation period where the experimental feeds were given to the fish as 3% of the body weight per day. The daily rate ratio was offered into two portions, at 9 AM and 4 PM. Each experimental diet was fed to three cages. To minimize the effect of handling, all the fish in each cage were weighted at fortnight intervals. Individual length and weights were taken at the end of the experiment.

Body composition of O. niloticus was determined at the beginning and at the end of the experiment on fifteen fish taken from each cage. The fish were deep-frozen and then ground for analysis. The following parameters were analysed according to the methods described in A.O.A. (1975); fresh weight, dry weight, ash content, protein (Kjeldahl method) and lipids (Soxclet method).

RESULTS AND DISSCUSSION

The average weight and length of the experimental fish of different groups is presented in Table 3. Weight gain did not differ significantly between fish fed diets containing 26% and 32% crude protein. However weight gain of fish fed diet containing 29% crude protein was significantly lower ($P<0.05$). This may indicate that a proper balance of protein and non-protein energy is needed to supply calories and raw materials for rapid growth and efficient feed utilization. Phillips (1972) found that the protein content of brown trout diets could be reduced without decreasing growth if the calorie content of the non-protein ingredients. This observation was supported by the results of studies on channel catfish (Page and Andrews, 1973).

The protein digestibility values for O. niloticus reared in cages is decreased with decreasing the dietary crude protein level from 29 to 20% (Wannigama et al. 1985). The low digestibility was attributed to the considerable quantities of rice huskies in the rice bran they used. However the present results agree with those reported by Jauncey and Ross (1982) who found that for S. niloticus of 6 - 30 g mean body weight, a dietary protein level of 25% produced 85% of the maximum specific growth rate obtained by fish of the same size range fed a dietary protein level of 30%.

Feed conversion did not differ significantly among the different experimental diets (Table 4). However, feed consumed varied with the protein content of the diet. When the protein content was increased, the feed consumed decreased. For the whole experimental period fish fed 26% crude protein consumed 9% more feed than in fish fed 32% crude protein diet.

The average net production per cage at harvest is shown in Table 4. There were no significant differences among the different experimental protein levels in the diet on the net production/m^3. The least cost of production was obtained using the diet containing 26% CP.

The protein efficiency ratio (PER*) improved as the amount of crude protein in the diet decreased (Table 5). These values are lower than

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$$\text{*PER} = \frac{\text{gain in weight}}{\text{protein intake}}$$

these obtained by Ogino and Saito (1970) for the common carp, and by Buhler and Halver (1961) for the salmon. But these values are higher than those found by Takeda and Yone (1971) on the Japanese seabream and Cowey et al. (1970) on their studies on the plaice (maximum PER value 1.16). Protein and energy retention also show a better yield for the fish receiving less protein (Table 5).

Data of the proximate analysis of fish are presented in Table 6. The dry matter content ranged from 25.8 to 26.30%. The highest value was found in the fish fed diet containing 26% CP, while the lowest value was recorded in the fish fed diet containing 32% CP. The crude protein content on the average ranged from 74.60 to 78.40. The highest value was found in the fish fed 29% CP. It's obvious from the carcass analysis that fat content decreased with increasing protein levels in the diets. The highest ash content was recorded in the group fed 32% CP. Carcass calorific values were clearly affected by dietary protein. The highest calorific value was found in fish fed 26% CP.

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Table 1 : Composition of experimental diets

Ingredients	CP Content %		
	26	29	32
Fish meal	5	8	11
Meat meal	2	5	8
Poultry by-product meal	5	9	13
Cotton seed meal	30	26	21
Rice bran	16	13	10
Wheat bran	35	32	30
Animal fat	3	3	3
Limestone	2	2	2
Sodium chloride	1	1	1
Vit, min, premix*	1	1	1

* Vitamine and mineral premix per Kg feed: Vit A 1000Iu; D 5000Iu; E 201 mg; K 10 mg; riboflavin 25mg; niacin 100 mg; cholinechloride 2 mg; pantothenic acid 50 mg; pyriodoxine 2 mg; B12 0.05 mg; Mn 25 mg; Zn 55 mg; Fe 0.25 g; Cu 7.8 mg; I 2.9mg.

Table 2: Proximate composition and energy values of the experimental diets.

	Crude Protein (CP) content %		
	26	29	32
Crude protein	26.01	29.00	32.10
Crude fat	7.70	8.28	8.83
Crude fiber	8.25	7.48	6.14
Ash	8.35	9.54	10.09
GE. Kcal/Kg[1]	4224	4235	4242
ME. Kcal/Kg[2]	2221	2305	2372
C/P ratio[3]	85.11	78.83	73.90

1- Gross energy ; a Ballistic Bomb Calorimeter , CBB-330-010L - Gallen_kamp; was used.

2- Metabolizable energy, calculated according to the values 3.9 Kcal/g of protein; 8/g of fat and 1.6/g of carbohydrate (Phillips et al 1985).

3- Kcal/g protein

Table 3: Average growth of reared <u>O. niloticus</u> fed with different protein level diets in running water*.

Cage Groups	Experimental Diets 26%CP		29%CP		32%CP	
Time (days)	length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)
0	12.1	33.7	11.9	35.9	12.0	33.2
15	12.5	44.9	12.9	47.0	12.2	27.2
30	13.5	48.9	13.3	45.0	13.3	44.3
45	14.2	58.5	14.0	53.1	13.6	50.1
60	14.3	60.3	14.5	61.4	14.3	60.0
75	16.2	76.0	16.0	73.0	15.0	60.8
90	17.4	1o4.2	16.3	82.3	17.7	96.7
105	17.2	103.5	18.0	112.5	18.3	117.5
120	18.6	123.8	18.5	123.2	19.1	125.2

* Values reported are average of 3 cages.

Table 4 : Growth, feed conversion, condition factor, and net production at termination of 120 days for O. niloticus fed different levels of protein (Mean of 3 cages, 100 fish/cage).

Protein %	26	29	32
Initial Avg. wt/fish(g)	33.70	35.90	33.20
Final Avg. wt/fish (g)	123.80	123.20	125.20
Gain in weight (%)	267.40	243.20	277.10
Initial Avg. length(cm)	12.10	11.90	12.00
Final Avg. length (cm)	18.60	18.50	19.10
Gain in length (%)	53.70	55.50	59.20
Condition factor (K)	1.92	1.95	1.80
Average mortality (%)	11.70	10.00	10.00
Initial wt of fish/cage(Kg)	3.37	3.59	3.32
Total crop/cage (kg)	10.90	11.10	11.30
Net production (Kg/m^3)	7.53	7.51	7.98
Feed consumed (Kg)	22.59	21.80	21.55
Feed conversion	3.00	2.90	2.70
Price/Kg feed P.T.*	21.40	26.80	31.90
Cost/Kg fish P.T.	64.20	77.70	86.10

* 100 P.T = 1 L.E.; ONE L.E. = US $ 0.74

Table 5: Effects of dietary protein and energy values on protein efficiency ratio (PER) protein retention and energy retention of *O. niloticus*.

Protein %	PER	P*	Protein** retention	Energy retension
26	1.27	34.90	40.43	66.00
29	1.19	38.96	37.80	50.58
32	1.16	42.75	35.31	48.40

$$* P = \frac{\text{dietary protein energy}}{\text{total dietary energy}} \times 100$$

** Protein retention = 63.11 - 0.65 (Garling and Wilson, 1976).

Table 6: The Analysis of body constituents* at the start and at the end of the experiment for *O. niloticus*.

Body Constituents	Initial	Final		
		26%CP	29%CP	32%CP
Dry matter	23.21	26.30	26.10	25.80
Protein	65.81	74.60	78.40	77.30
Fat	22.20	18.60	14.90	12.40
Ash	11.04	5.80	6.00	9.30
cal/g.	5076	5781	5606	5630

*Dry basis

LA CROISSANCE DU OREOCHROMIS NILOTICUS EN CAGES EN FONCTION DE LA TENEUR EN PROTEINE DE LA DIETE

MM. Ishak et G.D.I. Hassanen

Résumé français

Le succès de la culture en cages dépend de la disponibilité d'aliments supplémentaires. Le but de cette étude a été de trouver la teneur en protéine optimale pour l'élevage intensif du O. niloticus en cages.

On a stocké des fingerlings de poids moyen 34 g dans 9 cages de volume individuel 1 m^3, à une densité de 100 poissons/m^3. Trois aliments composés à 26, 29 et 32% de protéine ont été préparés en granulés de diamètre 2 mm et longueur 4 mm. L'aliment a été donné à un taux de 3% du poids des poissons par jour et on l'a offert deux fois par jour (0900 et 1600 hrs). La durée de l'expérience a été de 120 jours et chacun des trois aliments a été testé dans 3 cages.

La production nette n'a pas été différente pour les trois diètes, mais le moindre coût de production a été réalisé avec la diète de 26% de protéine. Les quotients nutritifs des 3 diètes ont été semblables. L'efficacité d'incorporation des protéines a été augmenté avec une diminution de la teneur en protéines de la diète.

CAGE CULTURE EXPERIMENTS IN KEBAN DAM RESERVOIR

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1. INTRODUCTION

As is known, cage culture has been applied in many countries in recent years for the purpose of increasing fish yield and production. Keban Dam Reservoir with seventy thousand hectares surface area is the largest lake used for fisheries in Turkey. The reservoir (Fig. 1) has fourteen leasing regions which are hired by fourteen fishermen cooperatives. Besides increase of production, the leisure time of fishermen can be utilized, and a socio-economic structure can be created around the Keban Reservoir, by encouraging or directing the fishermen to undertake cage culture. For this purpose, experiments have been carried out to determine the appropriate and economical fish varieties and cage types.

Cage culture is an important part of the activities of the "Keban Dam Reservoir Fisheries Development Project", carried out in cooperation with IDRC (International Development Research Center). In the beginning of the experiments carried out from 1980 some problems appeared with cage types and designs and with the materials used in cages. These problems are :

a) Main part of this type cage was made of wood, thus resistance to physical damage was low. Some connection points and flimsy pieces of the cage structure broke in a short time.

b) Control of the cage nets was difficult (holes and broken pieces of nets).

c) In the same way, monitoring of the fish in the cage (measuring, feeding, chemical baths, pick up of dead fish) was difficult.

A second type of cage made of iron casks and iron framework, also broke easily. After these observations we built a third type of cage, based on research in some publications. These cages eliminated all of the previous problems. Wooden planks are used as Walkway. Workers can do everything without problems. (Feeding, chemical baths, measurement, repair of nets etc.). No problems have been observed in three years in physical structure. Nevertheless, having approximately 15 meters annual differences between the highest and lowest water levels of the reservoir was a disadvantage in the activities. One reason is that it is necessary to regulate the rope attaching the cage to the shore every day according to the water levels. Another, Some water levels can be suitable and the others can be unsuitable for cages. Also, the biological structure of the lake changes according to the water levels.

The cages are also useful in other activities related to stocking the reservoir : fish holding, counting, storage, adaptation, marking and so on.

This report describes the developments realized between October 1984 and July 31 1985, summarises the present situation and also proves the necessity of going on with experiments until the fish reaches market size.

2. MATERIAL AND METHODS

Mirror carp which have completed the larval phase are used as material in the experiments. Fish were bred in Adana Hatchery establishments of DSI (State Hydraulic Works) in the breeding period (May - June) of 1984. Fry were transported to Keban and cages were stocked in October 1984.

Six cages were used in the experiments, made of metal barrels, angle iron and wood. Surface area is 10 m^2. Anchovy nets of 6 mm mesh and 3 m deep were used for the cages. In order to keep the nets streched lead weights were attached to the lead line (bottom end) of the nets at 0,5 m intervals. The cages were covered with old nets to protect them against gulls.

Cage were numbered from 1 to 6 (Table 2). The nets of number 3 cages were broken by storms and the fish were lost. One cage stocked with 100 fish fries per square meter (1000 pieces total) and empty (unstocked) cage were transferred to Içme Fishermen Cooperative area and the responsibility of them transfered to the cooperative (Figure 1).

Same quality feed was used for all cages. The feed, prepared and produced in Elazig Feed Factory, was made up as follows.

Protein proportion is 31%

The contents of the feed :

23% wheat bran

50% sun-flower oil cake

24% fish meal

3% molasses with 0,25% vitamins and 0,1% minerals.

Feeding was repeated twice a day (in the morning and in the evening). The feeding box or basket of each cage was weighed separately before feeding. Feed was given until fish stopped eating. The remaining feed was weighed again to find out how much was eaten by the fish.

Fish length and weight measurements were made in all cages on 20% of fish. Measurements were made in October 1984 (at the beginning), April 1985 and July 1985 (Table 2).

Water temperature was measured twice a day (morning and evening) and O_2, pH and NH_3 were monitored from time to time.

Plankton samples were taken both within and outside the cages to find out which organismes are used by fish.

Chemicals (Malachite green and $CuSO_4$ bath) were applied occasionally in the experiments : $CuSO_4$ 1 gr. to 2 liters water, malachite green 1 gr. to 5 l water.

Cleaning, monitoring and repairing of the nets when necessary, and setting or adjusting the cage according to the water level increases and decreases were the routine activities of the experiments.

3. EXPERIMENT PERIOD

The experiment activities started in October 1984 by transferring the fish from Adana hatchery and stocking them into the cages.

The means of air and water temperatures measured twice a day (morning and evening) were as below.

Means of Temperatures C°

		Morning		Evening	
Months		Air	Water	Air	Water
October	1984	12,1	18,8	11,8	18,8
November	1984	9,1	15	9	15
December	1984	2,1	9,4	1,6	6
January	1985	4,3	7,9	4,5	7,3
February	1985	3,4	6,9	3,2	7,3
March	1985	3	6,2	3,5	5,3
April	1985	13	12,3	11,8	12,7
May	1985	20,6	18,8	20,7	19,4
June	1985	22	22,2	24,7	22,7
July	1985	22	22,8	24,3	23,9

During the period of the experiments between October 1984 and July 1985 the minimum air temperature was 0°C (December 1984) maximum air temperature was 29°C (July 1985), maximum water temperature was 26°C (July 1985).

When the weather was windy and the water was wavy the fish were not fed, to prevent feed loss. Fish used in the experiments didn't feed when temperatures were 12-13°C or less. The same situation was observed in earlier experiments carried out between October 1983 and May 1984.

In order to prevent stress on fish, the weighing and measuring were done at the beginning when fish were put into the cages; then, at the end of the winter season when the fish started to grow and the water temperature was suitable for feeding (April); to get the final result measurements were made July 31, 1985.

Results are shown in Table 2. The first thing that strikes the eye is the numbers of fish remaining in the cages. When we add the present and dead fish of cage, we get less fish then we put at the beginning. This is accounted for by escape of fish from the broken nets and the fish predation by snakes. To make up for the losses due to broken nets and snakes we endeavoured to compensate the fish losses with the same size fish which were used to stock the Keban reservoir.

As seen in the table, the best result was obtained from cage 5 and the worst from cage 4. The final appraisal will be done at the end of the experiments.

In general, the O_2 content was 8,5 - 9ppm, but in July the O_2 measured as 7 - 7,5 ppm. The pH of the water was 8,5 - 8,6 in general, but in July pH measured as 9,5.

To examine the effect of fish on plankton, samples were taken from inside and outside of the cage and analyzed for quality and quantity. This will be continued. The results of the analyses of cage 6 in November 1984 and April 1985 are in Table 1.

No problems have risen from the structures of the cages used in experiments in 2,5 years.

4. CONCLUSION

It is impossible to say much about the growing results of the fish from experiments to date, because only part of a summer season has passed and the experiments are going on.

The experiments were useful for solving the problems of types and designs of the cages. The cages finally developed have not caused problem up to the end of the period.

Assessing acceptability to fishermen is part of the cage culture experiments. When the responsibility of two cages (one empty the other 1000 fish fry) was given to a fishermen cooperative, all the fishermen were highly interested in the cage culture. Another interesting point was

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the request of the fishermen : they wished to use the empty cage to store live fish caught from the reservoir for later sale.

The most important problem in the experiments was feed and this continue to be a problem, because the feed factory of Elazig mainly produces other kinds of feed for chicken, cows etc. They produce once a year fish feed (500 - 600 kg) only for our experiments. It is usually mixed with remainder of the other feed. Thus, we are not sure of composition of the fish feed. Also they don't agree to make different kinds of fish feed composition for experiments, so we were unable to try various feed compositions chosen for the various conditions to find the ideal ones.

Table 1 : Plankton composition (per 1cc volume) inside and outside cages, Keban reservoir.

November 1984

Out of cage		In cage	
BACILLARIOPHYCEAE		BACILLARIOPHYCEAE	
Cyclotella sp.	131	Cyclotella sp.	192
Melosira granulata	6	Melosira granulata	13
Fragilaria sp.	1	Fragilaria sp.	6
		Amphora sp.	1
DINOPHYCEAE		DINOPHYCEAE	
Ceratium hirundinella	4	Ceratium hirundinella	4
CHLOROPHYCEAE		CHLOROPHYCEAE	
Sphaerocystis sp.	3	Sphaerocystis sp.	3
ROTIFERA		ROTIFERA	
Polyarthara vulgaris	2	Polyarthara vulgaris	1
		CHRYSOPHYCEAE	
		Dinobryon sp.	1

April 1985

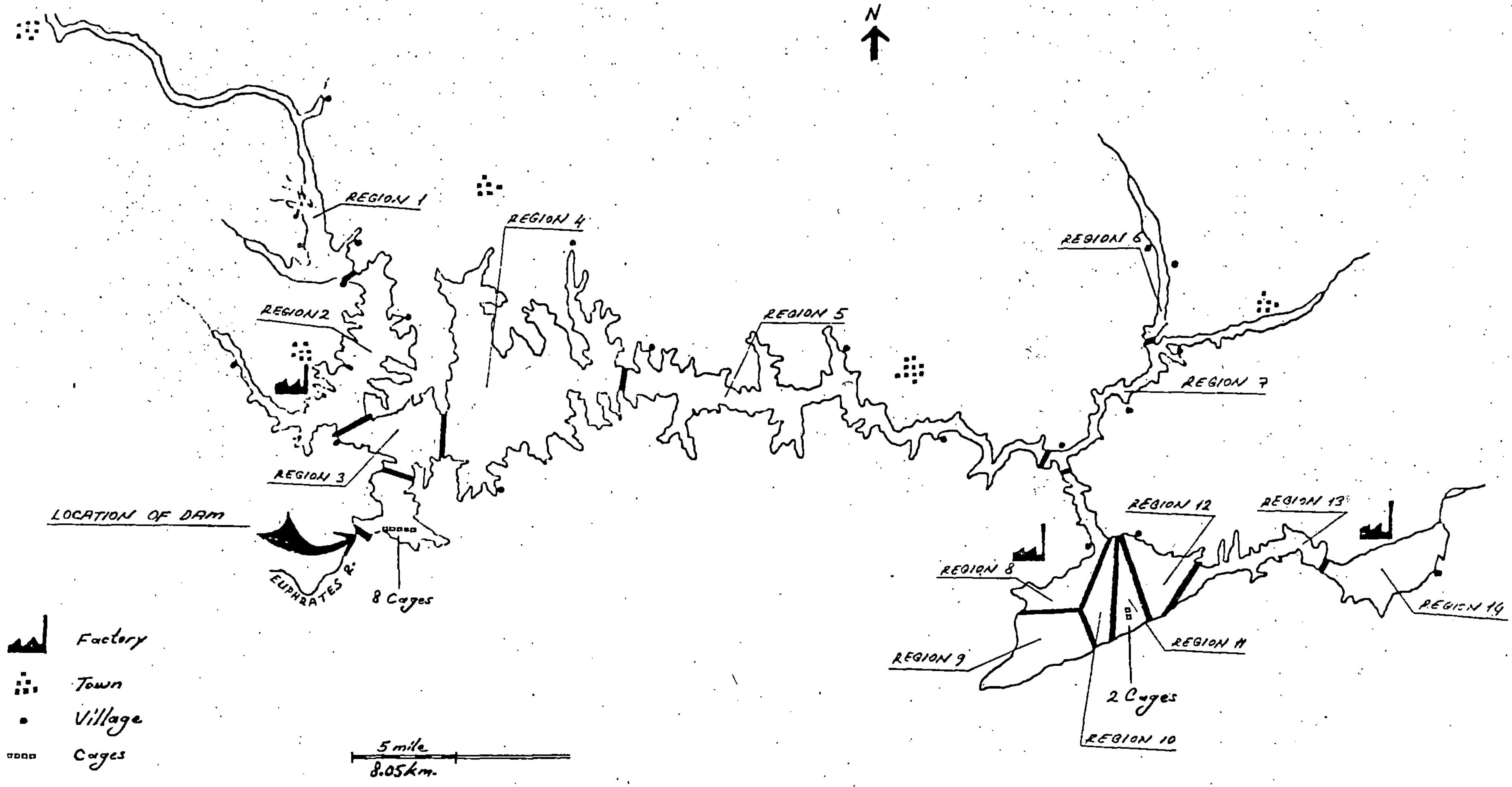
Out of cage		In cage	
BACILLARIOPHYCEAE		BACILLARIOPHYCEAE	
Synedra sp.	40	Synedra sp.	19
Cyclotella sp.	10	Cyclotella sp.	7
Cymbella sp.	2	Fragilaria sp.	2
Navicula sp.	1		
Fragilaria sp.	1		
Gomphonema vantricosum	1		

DINOPHYCEAE	
Ceratium hirundinella	5
ROTIFERA	
Synchaeta oblonga	76
Epiphanes sp.	50
Polyarthra vulgaris	6
COPEPODA	
Nauplius	3

DINOPHYCEAE	
Ceratium hirundinella	2
ROTIFERA	
Synchaeta oblonga	28
Epiphanes sp.	22
Polyarthra vulgaris	4
Ploessorea sp.	4
COPEPODA	
Nauplius	1
CYANOPHYCEAE	
Oscillatoria sp.	1
CHRYSOPHYCEAE	
Dinobryon sp.	6

Table 11 : The Results of the Measurements of Mirror Carp
October 1, 1984 and July 31, 1985.

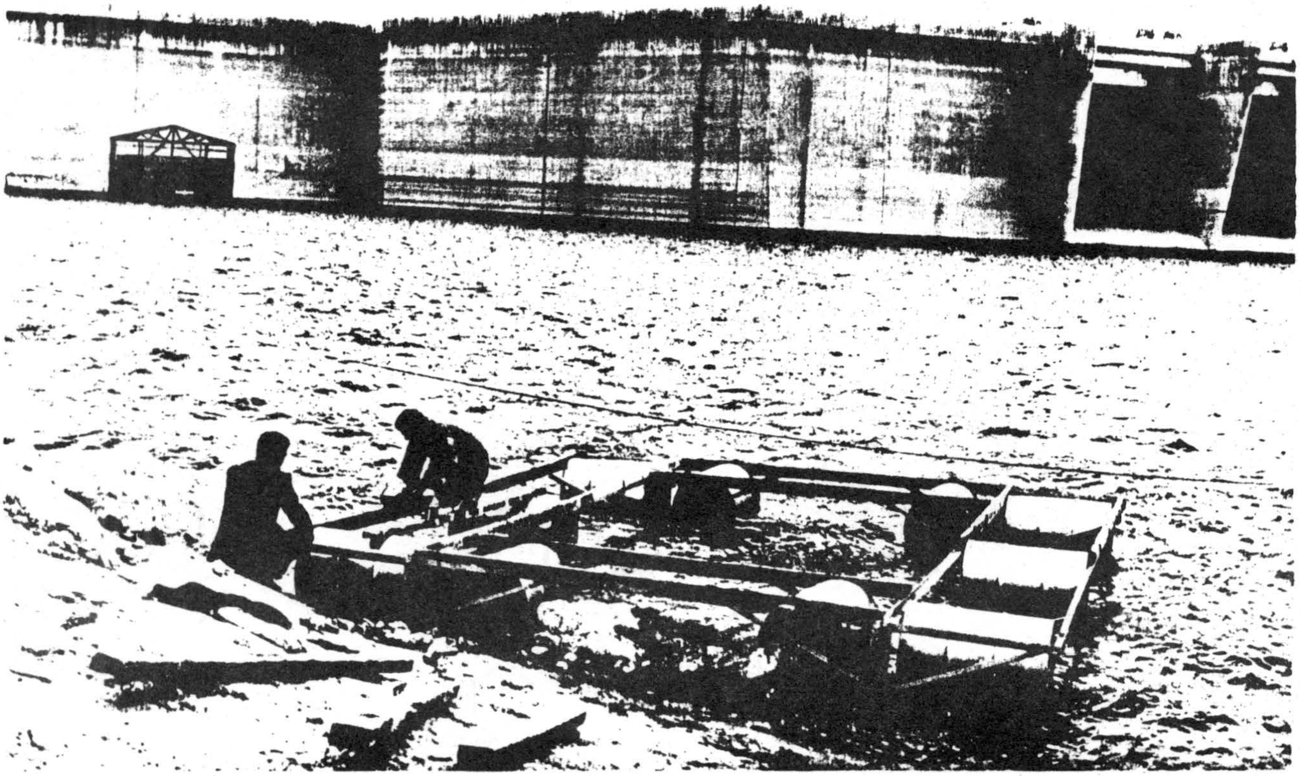
Cage No. (Area 10 m²)		Beginning October 84	April 30 1985	July 31 1985	Total Mortality (Number)	Fish Remaining (Number)	Total Feed Used (gr.)	Total weight gained (gr.)
1) Per m² 450	length cm	6,5	8,1	7,9	511	1900	29770	7410
Total 4500	weight gr	4,5	6,5	8,4				
2) Per m² 450	length cm	6,4	7,6	9,1	1140	2250	31920	9225
Total 4500	weight gr	4,3	4,9	8,4				
3) Per m² 350	length cm	5,2	5,3	7.0	226	956	17890	1816
Total 3500	weight gr	3.0	3,9	4,9				
4) Per m² 250	length cm	4,8	5.0	8,9	401	1057	18270	13529
Total 2500	weight gr	2,2	6,3	15				
5) Per m² 250	length cm	5,1	6.0	9,7	126	661	16325	11501
Total 2500	weight gr	2,6	3,4	20.0				
6) Per m² 100	length cm	–	4,8	6,7	–	930	–	–
Total 1000	weight gr	–	4,2	5.0				
Located to 1cme Cooperative Region							114 175	43481

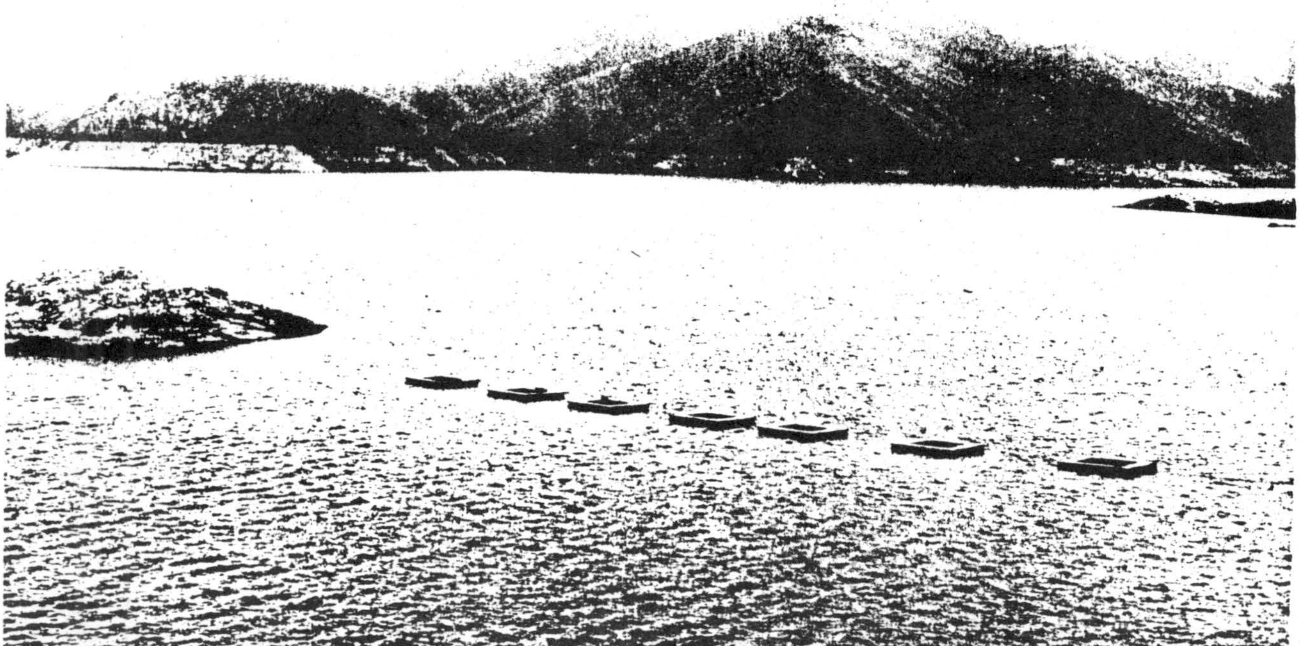


Sayfa :10

Leasing regions of the Keban Dam Reservoir to fisherman cooperatives and Cages places.

Harita : 1





ESSAIS DE CULTURE EN CAGES DANS LE RESERVOIR DE BARRAGE DE KEBAN, TURQUIE

Selcuk Erden

Résumé français

Le lac de barrage de Keban, d'une superficie de 70.000 ha, est le lac le plus grand de la Turquie. Quatorze coopératives de pêcheurs exploitent les quatorze régions du lac. Des essais de culture en cages, dont le but général est d'augmenter la production du lac, se poursuivent depuis 1980 dans le cadre du "Projet de développement des pêches du lac de barrage de Keban", entrepris en collaboration avec le CRDI. Au début, les efforts se sont concentrés sur la recherche d'une structure de cage solide qui résisterait aux tempêtes. Entre octobre 1984 et juillet 1985, des essais de production ont été faits. L'espèce utilisée est la carpe miroir (C. carpio). L'aliment utilisé, d'une teneur en protéine de 31%, est formulé à partir de son de blé (23%), tourteau de tournesol (50%), farine de poisson (24%) et mélasse (3%), avec des suppléments de vitamines et de minéraux. Les températures de l'eau ont varié entre 5.3°C (mars) et 23.9°C (juillet), et on a noté que les poissons ne s'alimentaient pas à des températures de moins de 12 - 13°C. Le poids à l'empoissonnement a été de 2.2 - 4.5 gm, et à la fin de cette expérience préliminaire les poissons ont atteint des poids de 5 - 20g. Les pertes, soit par la mortalité ou suite à des dommages aux cages, ont été importantes. Ces résultats très préliminaires seront complétés pendant les années à venir par des expériences de plus longue durée.

Le problème principal est le manque d'aliment de composition connue; l'aliment est produit par une compagnie commerciale qui n'accorde pas une grande priorité à cette activité.

Les pêcheurs ont montré un grand intérêt pour la culture en cages et ont déjà commencé des essais avec des cages et des alevins fournis par le projet.

STUDIES ON CAGE CULTURE OF *SAROTHERODON NILOTICUS* IN MAN-MADE LAKES IN SRI LANKA. EFFECT OF FIVE STOCKING DENSITIES AND FIVE DIETARY CRUDE PROTEIN LEVELS ON GROWTH

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1. INTRODUCTION

The importance of cage/pen culture as a means of culturing suitable species of fish is well recognized throughout the world and well documented (International Workshop on Pen and Cage Culture of Fish, Philippines, 1979, Coche, 1982). The advantages of cage culture are described by Galapitage (1981). This method of culture is practised extensively as commercial enterprises in the Philippines, Africa and Latin America, while at the same time, proving useful and efficient as water-based hatcheries for *S. niloticus* in the Philippines. Cage culture was initiated in Sri Lanka in 1980 with funds from the International Development Research Centre (IDRC), Canada. The main objectives of this project were to :

1.1 Study the applicability of cage culture systems in lakes and tanks and other inland waters using various types of freshwater fish;

1.2 Determine the potential economic value of technologically sound cage culture systems together with their constraints to adoption;

1.3 Cooperate with rural farmers and fishermen in the development and implementation of cage culture;

1.4 Conduct preliminary surveys on productivity of lagoons and inland tanks and test the feasibility of pen culture in selected areas;

1.5 Develop a system of extension of the suggested technology for rural farmers and fishermen.

2. INITIAL WORK ON CAGE CULTURE

The preliminary work carried out on cage culture in Sri Lanka and its economic implications is described by Galapitage (1981), and Wannigama and Weerakoon (1982). The experimental conditions and results are summarised in Table 1.

2.1 The sites :

The sites for cage culture activities under Phase I were selected on the basis of their close proximity to fisheries research stations rather than on the basis of productivity (which were later carried out). Originally, three (3) reservoirs at three sites were selected for cage culture trials with S. niloticus.

2.1.1 Udawalawe reservoir - intermediate dry zone;

2.1.2 Parakarma Samudra - North Central dry zone;

2.1.3 Muruthawela reservoir - intermediate dry zone.

2.2 Species used for the trials :

Early experimentation with Grass Carp (Ctenopharyngodon idella) and Bighead carp (Aristichthys nobilis) fingerlings (4-7 cm) proved futile, and was therefore discontinued (Wannigama and Weerakoon 1982). Subsequently, the choice of S. niloticus as the experimental species was made on the basis of the following criteria :

2.2.1 Availability of fingerlings from most of the Inland Fisheries Stations;

2.2.2 Immediate response to supplemental feed whether in mash or pelletted form;

2.2.3 Hardy nature of fingerlings (which facilitate easy handling) and resistance to disease at all sizes.

2.3 Cage design :

The cage design and construction for the trials are amply described (Wannigama and Weerakoon 1982). The frames were made of bamboo and the net cage was constructed of kuralon or nylon netting, the mesh and ply of which ranged from 1 to 2 cm and 6 to 9 respectively. The best cage design which proved to be efficient and withstood adverse weather conditions, consisted of a floating bamboo square frame with platforms as walkways, with the net cage suspended from stilts attached to the four corners of the bamboo frame.

2.4 Observations :

During the trials in Phase I, the following observations were made:

2.4.1 There was considerable wastage of feed when fed 10% by bodyweight/per fish twice daily. As such, it was decided to feed the fish at 3% by bodyweight per fish six times daily (Wannigama and Weerakoon 1982).

2.4.2 There was no significant difference in the final mean weight per fish at the stocking densities tested, viz. 100, 150 and 250 fish/m^3 (Wannigama and Weerakoon 1982). Because of this, it was natural to expect a higher final biomass (Bf) from cages stocked at the maximum stocking density which was 250 fish per m^3 for this trial.

2.4.3 The Feed Conversion Rates (FCR) were comparatively lower when the culture period for S. niloticus was confined to between 5 and 6 months (Table 1).

3. CAGE CULTURE TRIALS - PHASE II

For the purpose of this Paper, the cage culture trials, conducted in Phase II at Udawalawe, will be described in detail. On the basis of the trials conducted in Phase I, IDRC and MOF felt the need for further research trials and IDRC agreed to fund Phase II of the project which officially commenced in September 1982. Cage culture trials were conducted at two new sites, in addition to the site at Udawalawe. The two new sites were Wennappuwa tank on and West coast and Thalgaswela tank situated in a low contry tea estate belonging to the State Plantations Corporation. In Wennappuwa and Thalgaswela tanks, in addition to S. niloticus, Chinese and Indian carps are also being used for trials. The experiments are in progress.

3.1 Culture of S. niloticus in cages in Udawalawe reservoir :

3.1.1 Site : Udawalawe reservoir : this reservoir is situated in the Sabaragamuwa Province in the Intermediate dry zone of Sri Lanka (6° 20" N,/,80° 50" E). It has a catchment area of 1162 km^2 (De Silva, et al 1984). At full spill level (FSL) the reservoir has a water spread of 3,374 ha corresponding to a volume of 2.55 X $10^{12}m^3$ and a mean water depth of 78.3 m. The dead storage capacity is 1.66 X 10^{11} m^3 (Chandrasoma, et al in prep.). The full supply level is at 87.5 m.

A quantitative analysis of phytoplankton and zooplankton are given in Table 2a and 2b respectively. Seasonal variation in gross productivity at two stations were carried out by Chandrasoma, et al (in prep.). The gross primary productivity ranged from 3.5 g O_2/m^2/day (February 1985) to 10.55 g O_2/m^2/day (December 1983) and from 3.75 g O_2/m^2/day (October 1984) to 10.904 O_2/m^2/day (December 1983) at stations 1 and 2 respectively. The average net primary productivity values were 2.992 and 4.0 g O_2/m^2/day at the two stations respectively. The dissolved oxygen content and temperature measurements were carried out for a one year period.

The mean dissolved oxygen content was 8.0 ppm, the range being between 6.0 and 9.4 ppm, and the mean temperature was 30° the range being between 28°C and 31.5°C (Chandrasoma et al in prep.).

3.2 Materials and methods :

The design of the cages are described in section 2.3. The dimension of the cage frame was 3m X 3m and the effective volume of the net cage was $5m^3$. During the first trial under Phase II, 24 cages were put into operation. Three stocking densities were tested during the first trial with S. niloticus. The stocking densities were 400 fish per m^3 ($400/m^3$), 600 fish per m^3 ($600/m^3$) and 800 fish per m^3 ($800/m^3$). The fish at each stocking density were fed four diets with varying protein contents 19% (F_2), 20% (F_3), 25% (F_4) and 29% (F_5) at 3% body weight per day. The feed formulations are given in Table 3. The feed was given in pelletted form, broadcast by hand every two hours, six times daily. Each trial was conducted in three replicates. The trial period was 5 months from January to June 1983. During trial 2 of Phase II, in addition to the two stocking densities $400/m^3$ and $600/m^3$, two other stocking densities 1,000 fish per m^3 ($1{,}000/m^3$) and 1,200 fish per m^3 ($1{,}200/m^3$) were tested for S. niloticus. The fish at each stocking density were fed two diets with a protein content of 17% (F_1) and 20% (F_3), the same diet used in the earlier trial. The fish were fed six times daily at 3% by body weight per day.

The same cages used for the earlier trials were also used for the second trial with minor maintenance work. In both trials, sampling of fish was carried out every fifth week, and a random sample of 10% was measured for total length and weight. Other parameters like dissolved oxygen, temperature, and conductivity were measured once every two weeks. The trial was conducted for five months only and it had to be terminated due to unforeseen weather conditions*. The trial period was from March 1984 to September 1984.

3.3 Results :

3.3.1 Live weight gain : the percentage live weight gain (LWG) is expressed by the equation :

$$\frac{W_t - W_o \times 100}{W_o}$$

where W_o = initial weight

W_t = weight at time t.

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* Due to south-west monsoons there was high wave action in the reservoir resulting in frequent mortality at the beginning of the 5th month.

LWG values for the grow out period for each group of fish at various stocking densities and dietary crude protein levels are given in Table 4. Between $400/m^3$ and $800/m^3$, the variation in the LWG values between diets F_2 (19%), F_3 (20%), F_4 (25%) and F_5 (29%) for a particular stocking density as well as between stocking densities for a particular diet was not significant (P> 0.05). The same was true for $400/m^3$ and $600/m^3$ and diets F_1 (17%) and F_3 (20%). However, when LWG values for $400/m^3$ are compared with those for $1000/m^3$ and $1200/m^3$ there was a significant difference (P< 0.05) for diets F_1 (17%) and F_3 (20%).

3.3.2 The final mean weight : the final mean weights for each treatment at the end of the culture period (5 months) are presented in Table 5. According to Figure 1, the final mean weight decreased as the stocking density increased for a particular diet. A two way analysis of variation was carried out using the computations described by Spiegel (1975). The computed F values with final mean weights for different treatments between $400/m^3$, $600/m^3$ and 800/m3 showed that there was no significant difference (P> 0.05) in the final mean weights between different diets (F_2, F_3, F_4 and F_5) for a particular stocking density. However, the difference in the final mean weights between stocking densities for a particular diet was significant (P< 0.05). The final mean weights of fish, fed diets F_1 (17%) and F_3 (20%) at a particular stocking density (400, 600, 1000 and $1200/m^3$) were not significantly different (P> 0.05). But the difference in the final mean weights between stocking densities for a particular diet was significant. However, an analysis of variance carried out with final mean weights at $400/m^3$ and $600/m^3$ and diets F_1 (17%), F_4 (25%) and F_5 (29%) showed that there was a significant difference in the final mean weights between the diets F_1 (17%) and F_4 (25%) and between F_1 (17%) and F_5 (29%) for a particular stocking density (P< 0.05).

Figure 2 shows the growth of S. niloticus at stocking densities from $400/m^3$ to $1200/m^3$ for diet F_3 (20%). From this, it can be seen that growth of S. niloticus up to 60 days at all stocking densities was almost similar, the difference being due to the variation in the initial weights which ranged between 23.0 and 30.7 gms. A one way analysis of variance carried out for the mean weights at the end of 60 days, however, showed that there was no significant difference in the mean weights at the end of 60 days for the various stocking densities tested ($400/m^3$, $600/m^3$, $800/m^3$, $1000/m^3$ and $1200/m^3$, with diet F_3 (20%), at P = 0.01 level. This shows that under the conditions described in this paper with S.niloticus, whatever stocking density that is used between $400/m^3$ and $1200/m^3$ with an initial weight ranging between 23 g and 30 gms, growth will be similar for the first 60 days deviating thereafter with time.

Figure 3 shows the growth of S. niloticus at $400/m^3$ fed diets F_1 (17%) and F_3 (20%) after thinning out to $25/m^3$ has been carried out. From this, it is evident that there is rapid growth in 30 days after thinning, the fish gaining in weight by nearly 40% (Table 5, see values in parenthesis).

3.3.3 The final biomass : the final biomass (Bf) determined by actually weighing the total biomass at the end of the culture period, are presented in Table 5. It is seen from this, that as the stocking density increased, the Bf also increased for a particular diet. But the Bf decreased for $1200/m^3$, well below the Bf for $1000/m^3$ (Figure 4). Table 5 also present values for total weight gain per 1000 fish (GN/1000). Although the Bf increases with increasing stocking density, the GN/1000 fish tends to decrease, with increasing stocking density implying that $600/m^3$ is the maximum stocking density. The daily rate of increase in biomass (DRIB) was computed, using the equation :

$$Bf = B_i (1 + i)^n$$

where Bf = actual final biomass at harvest

B_i = initial biomass.

i = DRIB expressed as a percentage.

n = culture period.

The DRIB values for the different treatments are presented in Table 6. Figure 5 shows the variation in the DRIB values from $4000/m^3$ to $1200/m^3$ for diets F_1 (17%), F_2 (19%), F_3 (20%), F_4 (25%) and F_5 (29%). When $400/m^3$ is compared with $1000/m^3$ and $1200/m^3$, the DRIB actually decreased by half for diets F_1 (17%), F_3 (20%) at $1000/m^3$ and $1200/m^3$ and this decrease was significant ($P< 0.05$). On the other hand, for $400/m^3$, $600/m^3$ and $800/m^3$, the DRIB values were not significantly different for a particular diet (F_2, F_3, F_4 and F_5) or between diets for a particular stocking density ($400/m^3$, $600/m^3$ and $800/m^3$) at the P = 0.05 level.

3.3.4 Feed conversion rates (FCR) : the feed conversion rates (FCR) are presented in Table 5. Between $400/m^3$, $600/m^3$ and $800/m^3$ and diets F_2 (19%), F_3 (20%), F_4 (25%) and F_5 (29%), the variation in the FCR was between 2.7 and 3.2. However, at $400/m^3$ and $600/m^3$ the FCR increased significantly ($P< 0.05$) for the diet F_1 (17%). The same was observed when FCR values at $1000/m^3$ and $1200/m^3$ for diets F_1 (17%) and F_3 (20%) were compared with the same diets for the rest of the stocking densities. According to Table 5, at $400/m^3$, $600/m^3$ and $800/m^3$ the lowest FCR values were recorded for diet F_4 (25%). Futher, minimal variation in the FCR values among these stocking densities was observed for this diet F_4 (25%). This adequately proves that beyond a particular stocking density whatever the increase in the final biomass as the stocking density increased, it did not necessarily compensate for the decrease in the final mean weight per fish as in the case of $600/m^3$, $800/m^3$, as the maximum carrying capacity has been already reached beyond $1000/m^3$. Under such circumstances, the FCR values increases for higher stocking densities. This also shows that for S. niloticus, a diet containing less than 19% protein is inadequate to bring about the desired growth and feed conversion. Finally, it was pointed out in Section 3.3.2 that, after thinning out of fish in cages where the stocking density was $400/m^3$ after the fifth month (mean weight per fish 120 - 130 gms), in 30 days of culture thereafter, the mean final weights increased by nearly 40%. After 30 days of culture, the mean final weight ranged between 160 and 175 gms. This 40% increase in weight decreased the FCR value for that particular stocking density ($400/m^3$) from 3.2 to 2.5 and from 4.1 to 2.7 for diet F_3 (20%) and F_1 (17%) respectively. This is a very significant observation as the economic viability of cage culture of S. niloticus in Sri Lanka depends on feed inputs to a very large extent.

3.3.5 Condition factor (CF) and final mean length : the condition factor (CF) is defined by the formula :

$$CF = \frac{W}{L^3} \times 100$$

The CF varied between 1.9 ($400/m^3$) for diet F_4 (25%) and 2.24 ($1200/m^3$) for diet F_1 (17%) and F_3 (20%). Although the variation in the CF values is small between stocking densities for a particular diet, the variation in the mean length between stocking densities for a particular diet is more and the difference is significant when $400/m^3$ is compared with $1000/m^3$ and $1200/m^3$ ($P < 0.05$).

4. DISCUSSION

4.1 Technical considerations :

It should be mentioned at the outset that these trials on cage culture using S. niloticus was carried out to assess the economic viability on a commercial scale. As the results of these trials were to be directly extended to the fish farmers, after experimentation, it was necessary to select a cage with a size that could be practically applicable in the field. Hence, the selection of a cage with a volume of $5m^3$ for these trials. When a $5m^3$ cage volume is opted for selection, it should be realised that a large quantity of fingerlings is required for the trial. For the first trial under Phase II, a total of 72,000 fingerlings were made use of. For trial 2 under Phase II, a total of 64,000 fingerlings were required. To obtain a near uniform size fingerlings in such large quantities for trials 1 and 2, approximately about 100,000 fingerlings had to be sampled for each trial. As a result, it was practically not possible to obtain uniform sized fingerlings for the different treatments. Hence, the variation in the initial mean weight per fish for both trials. The variation being between 22.6 g and 30.7 g and between 24.7 g and 29.9 g for trials 1 and 2 respectively. Even within a group (treatment) every effort was made to keep the standard deviation at the minimum level, but even a slight deviation in the individual weights, could bring about hierachy among fish (Brown, 1946). Moreover, when large numbers are involved, a slight deviation in the initial weight between fish, becomes multiplicative and its effect manifests itself, in the final mean weight per fish, at the end of the culture period. This is a factor which cannot be controlled in trials of this magnitude. Coche (1982), has mentioned the importance of having the least variation in size for tilapia cage culture. In addition to this, these trials which were carried out in large reservoirs, were subjected to frequent unavoidable environmental factors. In an experiment conducted on a small scale, in a pond or some such water body, or in the laboratory, most of the other factors, like dissolved oxygen p^H, conductivity, temperature, etc., could be controlled, as a result of which the expected results could be obtained to a fair degree of accuracy. When field trials are considered, factors like dissolved oxygen, p^H, conductivity temperature and wave action and the effect of shade (from a watch hut situated at the trial site) cannot be controlled, and these factors have their own individual or combined effects, on the growth of fish under consideration, thereby bringing about unexpected results.

A significantaspect of the final mean weight and that of the whole biomass at the end of the 5 month period, is the change that occurs after the fish have been thinned out as pointed out in Section 3.3.2. In this particular cage, the fish which were in a crowded state at the end of 5 months, were exposed to more space at thinning and the sudden increase in weight after 30 days could be attributed to this. The increase in the FCR to 2.7 and 2.5 for diets F_1 (17%) and F_3 (20%) respectively in this case, is also most significant, as a higher mean weight per fish at harvest is achieved in 6 months rather than at a comparatively lesser mean weight per fish in 5 months at a higher conversion rate. Table 7 present results from several trials conducted under intensive cage culture (Coche, 1982). According to the data presented, very few are available for comparison with the work carried out in Sri Lanka. In most of the cases, the type of feed presented, the initial weight per fish, the size of the cages and the culture period differs from the work carried out here. The data which has a near comparison to the data presented in this paper, comes from Ivory Coast (Coche, 1977). Here, the initial weight per fish was 29 g. the stocking density 349 fish per m^3, the culture period was 142 days, and the protein content of the feed 24.7%. This can be compared with 400/m^3 data for diet F_4 (25%) in this paper. The final mean weight reported in the data in this particular case (from Coche, 1977) was 197 gms, whereas for the diet F_4 (25%) in this paper, the mean weight recorded was 127.5 gms. However, it should be noted that in the present work, the daily feeding rate was 3% by body weight as against 4 to 6% (Coche, 1977). Also the size of the cage in the present work was 5m^3 as against 1m^3 (Coche, 1977). In the present work, the maximum final biomass Bf was 413.2 kg (83.0 kg/m^3) for the 800/m^3. The minimum Bf was 174.2 kg (35.0 kg/m^3), for the 400/m^3. This was in a period of 5 months. If we take the case where the fish were thinned out at the end of 5 months (400/m^3 and diet F_3) which, when further subjected to a culture period of 30 days, resulted in an increase in the final biomass (at the end of 6 months period) amounting to approximately 333 kg (66.3 kg/m^3), then this is comparable with the data presented by Coche (1977). Although the final biomass tended to to increase with increasing stocking density from 400/m^3 to 800/m^3, for all diets, from the present data, it can be seen that, at 1000/m^3 for the diet F_3 (20%), the Bf was 382.1 kg which was about the same as for the 800/m^3 which was 387.2 kg. Further, at the 1200/m^3 for the same diet, the Bf was further reduced to 346.0 kg. This definitely shows that the Bf increases with increasing stocking density only to a certain limit and when the maximum carrying capacity is reached for that cage volume, whatever further increase in stocking density would bring about a lowering of the Bf for that cage volume (Coche, 1977). From this data, we could therefore safely conclude that with an initial biomass of approximately 12 kg to 24 kg per m^3, a maximum carrying capacity of between 66.3 kg and 83.0 kg per m^3 could be achieved for the 800/m^3 stocking density. Although the maximum Bf was obtained at 800/m^3 for diets F_2 to F_5, if the final mean weight and the gain in weight per 1000 fish (GN/1000) is considered (Table 5), the optimum stocking density lies between 400/m^3 and 600/m^3 under the conditions described in this Paper.

Campbell (1972), has reported a maximum carrying capacity of 70 kg per m^3 for a 6m^3 cage with a mesh size of 2.5 cm. This corresponds with the data presented in this paper.

4.2. Economic considerations :

4.2.1 Production of harvestable fish at higher stocking density : it was shown in Table 4, that although the Bf increases with increasing stocking density, the GN/1000 fish decreases as the stocking density increased. From this, it follows that the optimum stocking density lies between 400/m^3 and 600/m^3. According to the results, the diet F_4 (25%) was considered to be the best as it produced the

highest FCRs at all stocking densities (400/m³, 600/m³ and 800/m³). Although at 400/m³, diet F_1 (17%) and F_3 (20%) produced a FCR of 4.1 and 3.2, it was shown that, thinning of that cage after the fifth month, and a further one month of culture, the FCRs decreased from 4.1 to 2.7 and from 3.2 to 2.5 for diets F_1 and F_3 respectively.
The final mean weight per fish also increased upto between 160 and 175 gms for these two diets, followed by an increase in biomass from approximately 244 kg to 350 kg. Therefore, from an economic point of view it would be more economical to produce fish at 400/m³ using diet F_1 (17%) or F_3 (20%), also taking into consideration the price differences between these two diets and F_4 (25%) diet.

4.2.2 Production of harvestable fish at lower stocking density : according to certain unpublished data and Wannigama and Weerakoon (1983), at lower stocking densities (50/m³ to 250/m³), it is possible to produce 130 to 175 g marketable *S. niloticus* in 4 to 6 months period. Let's assume that at 50/m³, a farmer could produce harvestable fish at 175 g per fish in 4 to 6 months. Then, the total production from a 5m³ cage could amount to approximately 44 kg. From the same cage volume at 400/m³ the farmer gets 350 kg in 6 months (5+1)*, with an average fish weight of 175 g (Figure 3). To produce 350 kg at harvest, at 50/m³ the farmer would have to commission nearly 8 numbers of 5m³ cages. Therefore, it probably would be economical for the farmer to produce fish at 400/m³ rather than 50/m³, if all other factors are kept constant.

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* Thinning out done at the end of 5 months and a further one month culture thereafter.

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TABLE 1: Total final biomass at each stocking density of *S. niloticus* at end of November 1981 (5 months) on the basis of actual number of fish surviving as at end of October 1981 (Phase I)

No. stocked	Size at stocking gms	Survival rate % Nov.	Average weight of fish at end of Nov.	Total biomass at end of Nov.	Conversion ratio at end of Nov.	Dec.
600 (1 kg/m^3)	10.0	93	116.2*	64.8 (10.8 kg/m^3)	1.52	2.22
900 (2.1 kg/m^3)	14.0	93	130.0	109.3 (18.2 kg/m^3)	2.07	3.02
600 (2.1 kg/m^3)	11.5	98	148.2	88.2 (14.7 kg/m^3)	1.34	2.62
900 (1.9 kg/m^3)	13.0	94	130.0	110.5 (18.4 kg/m^3)	1.73	2.08
1500 (2.9 kg/m^3)	11.5	87	143.0	187.6 (31.2 kg/m^3)	1.83	3.1
1500 (2.5 kg/m^3)	10.0	94	153.0	216.7 (36.1 kg/m^3)	1.79	2.93

* Error in sampling

TABLE 2a: The density of phytoplankton (units/l) at difference depths in the reservoir - (Station II)

Depth	August 1984	October 1984	December 1984	February 1984
Surface	(1.82×10^{4})	(2.01×10^{4})	(8.4×10^{3})	(8.12×10^{3})
1m	(2.28×10^{4})	(2.3×10^{4})	(9.88×10^{3})	(1.42×10^{4})
2m	(2.2×10^{4})	(2.49×10^{4})	(9.62×10^{3})	(9.66×10^{3})
3m	(2.42×10^{4})	(2.22×10^{4})	(9.8×10^{3})	(9.1×10^{3})
4m	(1.99×10^{4})	(1.65×10^{4})	(6.92×10^{3})	(8.71×10^{3})
5m	(1.87×10^{4})	(1.14×10^{4})	(6.88×10^{3})	(3.46×10^{3})
Av. No. of phytoplankton/lit.	(2.1×10^{4})	(1.97×10^{4})	(8.67×10^{3})	(8.88×10^{3})

Scenedesmus sp, Pediastrum sp and Microcytis sp are the permanent occurrences, as well as dominant species in this reservoir.

TABLE 2b: The density of Zooplankton (numbers/l) at different depths in the reservoir - Station 2

Depth	August 1984	October 1984	December 1984	February 1984
Surface	450	800	128	44
1m	252	800	60	28
2m	320	1500	30	72
3m	240	880	96	106
4m	224	1400	72	58
5m	67	816	68	56
Av. density number/lit.	259	1032	75	60

The dominant species are the rotifers and cladocerans.

TABLE 3: Percentage composition of diets used for the cage culture trials with the dietary crude protein levels.

Ingredients	Diets				
	F_1	F_2	F_3	F_4	F_5
Fish meal	05	05	10	20	30
Chick mash	15	92	45	40	35
Rice bran	77	-	42	37	32
Sharkliver oil	03	03	03	03	03
Overall crude protein level	17.2	19.0	20.0	25.4	29.1

TABLE 4: Percentage live weight gain (LWG) of *S. niloticus* fed five dietary crude protein levels at 5 stocking densities. Duration of culture - 5 months

Diet	Protein level %	400 fish/m^3 % LWG	600 fish/m^3 % LWG	800 fish/m^3 % LWG	1000 fish/m^3 % LWG	1200 fish/m^3 % LWG
F_1	17.2	236	200	--	174	123
F_2	19.0	355	348	320	--	--
F_3	20.0	396	337	330	152	132
F_4	25.4	442	347	330	--	--
F_5	29.1	391	348	335	--	--

TABLE 5: Data on final biomass (B_fW), net gain per 1000 fish (GN/1000) and feed conversion rates (Fd/GN) for different dietary crude protein levels at five stocking densities of *S. niloticus*

Dt/CP	B_iW	B_fW	Surv. %	M_fW/ fish g	GN/ cage kg	GN/1000 kg	Fd/Gn
2000 fish/cage (400 cu.m)							
17%	58.80	174.20	88.20	98.8	115.40	69.35	4.10
		(281)			(222.2)	(129.9)	(2.7)
19	59.80	272.50	95.60	136.2	212.70	112.62	3.00
20	61.40	243.70	94.70	121.6	182.30	97.96	3.20
		(332.7)			(271.3)	(144.9)	(2.5)
25	47.00	255.20	92.80	127.5	208.20	114.00	2.70
29	59.80	293.80	92.90	146.9	234.00	128.22	2.80
3000 fish/cage (600 cu.m)							
17%	89.70	230.10	91.80	83.5	140.40	53.65	4.80
19	67.80	296.70	89.80	98.9	228.90	87.53	3.20
20	89.40	330.00	97.70	110.0	240.60	82.78	3.10
25	80.40	356.40	90.70	119.8	276.00	104.18	2.90
29	73.50	332.10	97.60	110.7	258.60	88.92	3.00
4000 fish/cage (800 cu.m)							
19%	118.80	337.5	67.50	125.0	218.7	95.3	3.00
20	90.00	387.20	97.10	96.7	297.20	77.19	2.80
25	96.00	413.20	94.30	103.4	317.20	85.54	2.80
29	119.20	400.60	97.50	100.1	281.40	72.91	3.20
5000 fish/cage (1000 cu.m.)							
17%	147.00	366.60	98.70	74.3	219.60	44.88	5.70
20	163.00	382.10	85.40	89.4	219.10	56.88	4.90
6000 fish/cage (1200 cu.m)							
17%	148.20	310.90	93.70	55.3	162.70	30.60	5.90
20	155.40	346.00	95.80	60.2	190.60	34.29	5.70

Values in parenthesis for FBW, GN/cage and GN/1000 were obtained after thinning out to 25 SD after the fifth month and 30 days of culture thereafter.

B_iW – Initial fish biomass B_fW – final fish biomass GN/cage – Net gain per cage GN/1000 – Net gain per 1000 fish

Fd/GN – Feed conversion ratio M_fW – Mean weight per fish at harvest.

TABLE 6: Daily rate of increase in biomass (DRIB) for *S. niloticus* at various stocking densities (SD) fed five diets of varying dietary crude protein levels.

Feed	Stocking density				
	$400/m^3$ DRIB	$600/m^3$ DRIB	$800/m^3$ DRIB	$1000/m^3$ DRIB	$1200/m^3$ DRIB
F_1 (17.2)	0.81	0.78	-	0.67	0.54
F_2 (19.0)	0.92	0.92	0.97	-	-
F_3 (20.0)	1.13	0.99	0.97	0.61	0.56
F_4 (25.4)	1.07	1.11	0.80	-	-
F_5 (29.1)	1.01	1.08	0.95	-	-

TABLE 7: Summary of stocking, growth and harvesting data for the intensive cage culture of S. niloticus including monosex male populations (Coche, 1982)

Country	Feeding details	P_m (g)	N/m	B_i (kg/m^3)	DRIB (%)	Pm_f (g)	B_f (kg/m^3)	FCR	Culture period (d)	Reference and remarks
Philippines	10% copra meal: 20% fishmeal and 70% rice bran as a mash:DFR 4% B	36	150	5.4	1.01	67	10.1	3.6	56	Guerrero 1980a :1m³ cages (mesh 2.5cm) in pond:mean results
Philippines	23% fishmeal and 77% rice bran as moist pellets (24.2% dry weight of protein) DFR 5% B	20	250	5.0	2.72	100	25.0	2.5	60	Guerrero 1979a: 1m³ cages (mesh 1.9cm) in pond
Ivory Coast	Chicken feed as dry pellets (24.7% protein) DFR 4 to 6% B	16 22 29 29	268 218 257 349	4.3 4.8 7.5 10.1	1.52 1.29 1.32 1.27	175 207 232 197	41.9 34.6 56.1 60.9	2.8 3.4 3.3 3.2	151**) 154*) 153**) 142*)))	Coche 1977: 1m³ cages(mesh 2.5cm) in the artificial Lake Kossou at 27 to 30°C: *DO 5mg/L for about 30 days: **DO 3mg/L for about 20 days and 5mg/L for 2 to 2.5 mo.
Ivory Coast	(20% protein) : DFR 6 to 4% B (22% protein) : DFR 6 to 4% B	22 23 33 32 36	71 72 185 177 182	1.6 1.7 6.1 5.6 6.6	1.81 1.78 1.97 1.64 1.68	213 236 308 278 284	13.3 17.2 49.9 42.1 50.3	2.2 2.3 2.4 2.1 1.9	118**) 131**) 108*) 124*) 122*))	Campbell 1978: *6m³ cages (mesh 2.5 to 1.4cm) : **20m³ cages (Ibidem) in artificial Lake Kossou:sex ratio, average 84% males: DO 5mg/L

Pm_i = mean weight at stocking

N/m = number of fish

B_i = mean biomass at stocking

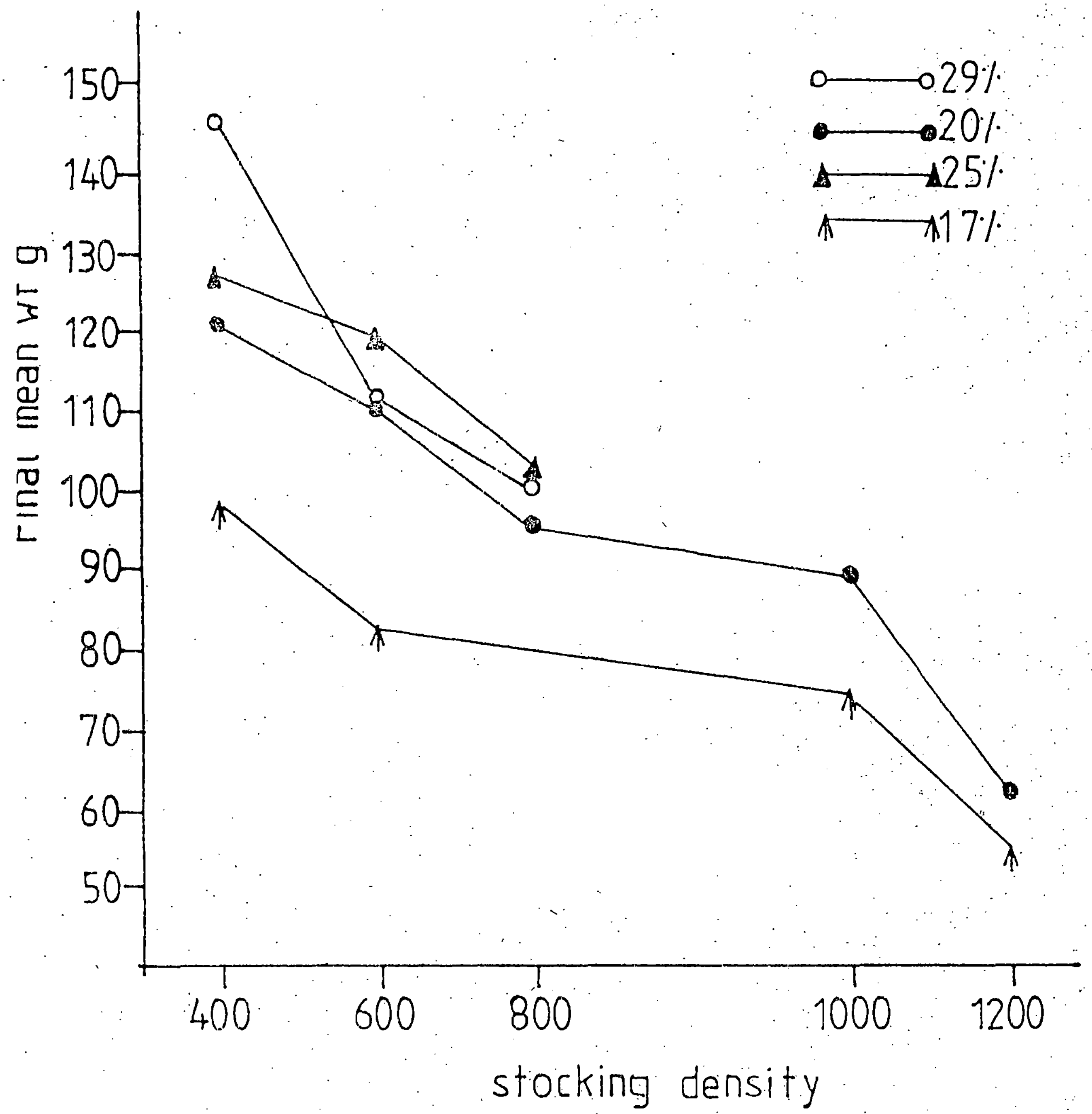
DRIB = daily rate of increase in biomass

Pm_f = mean weight at harvest

B_f = mean biomass at harvest

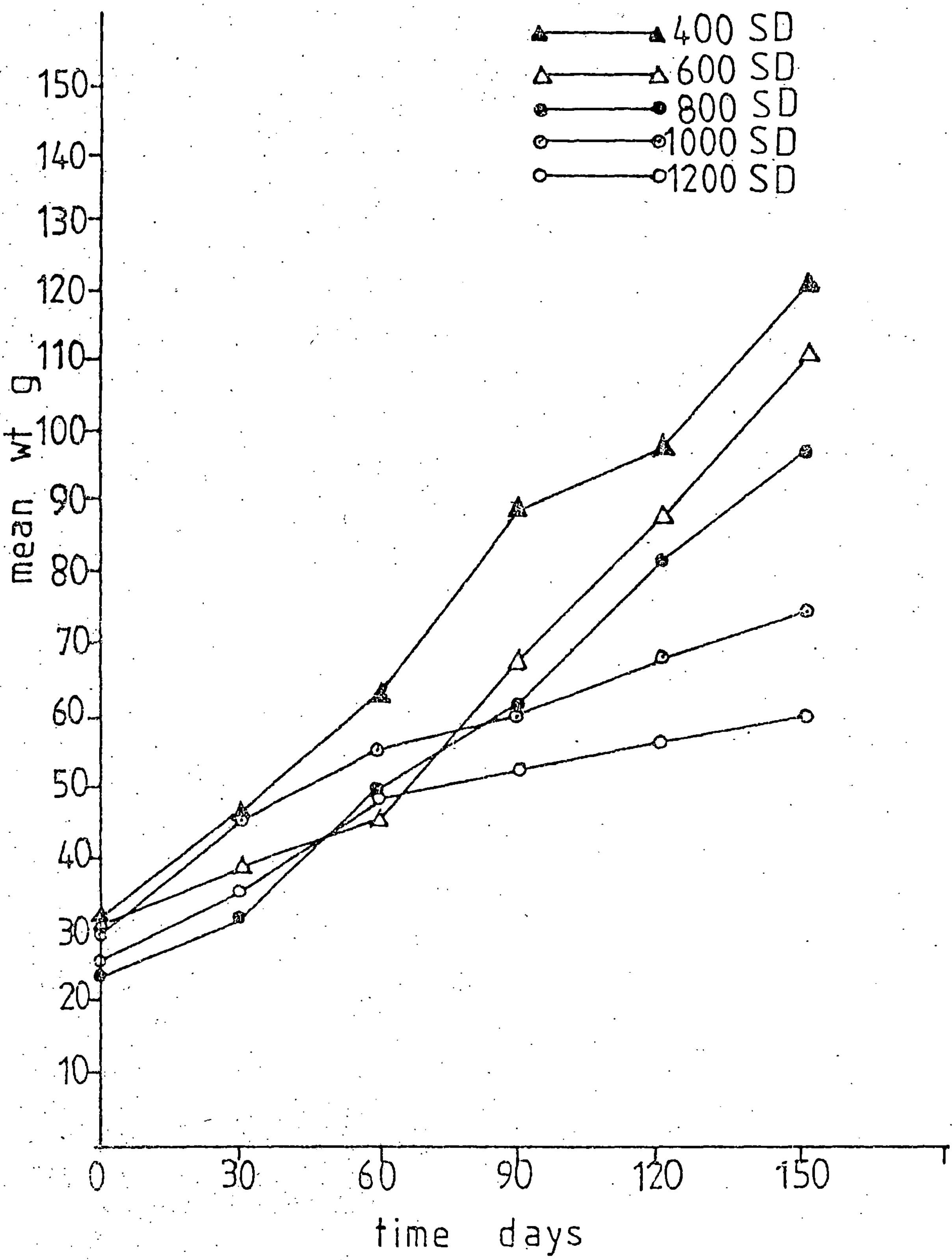
FCR = feed conversion ratio

Fig 1



Relationship between the final mean weight and stocking density at four dietary crude protein levels for S.niloticus.

Fig 2



Growth rate of S. niloticus at five stocking densities, fed diet F_3 (dietary crude protein level of 20%).

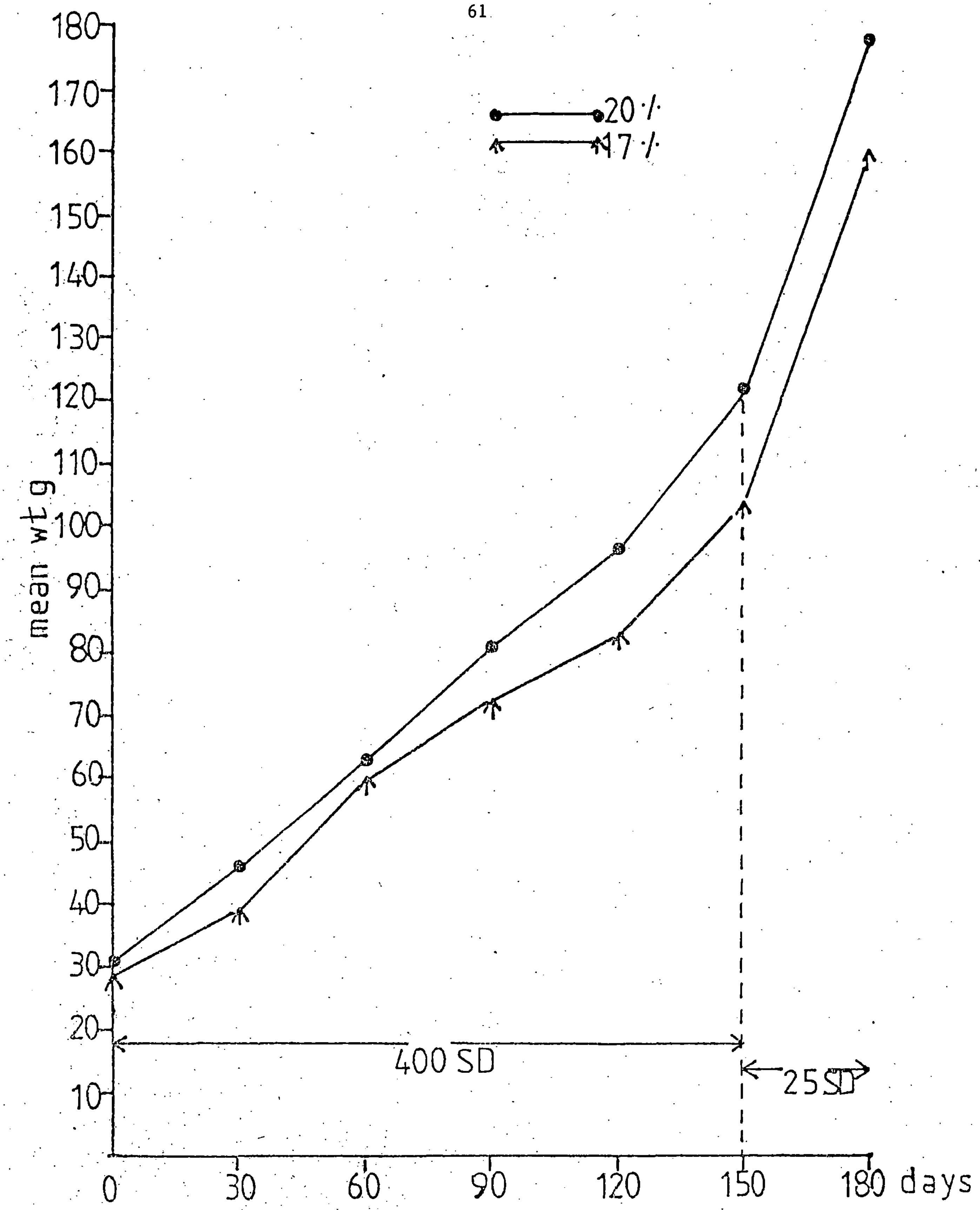


Fig 3 Growth rate of S. niloticus fed diets F_1 (17%) and F_3 (20%). First 150 days, stocking density 400 SD and 30 days thereafter 25 SD.

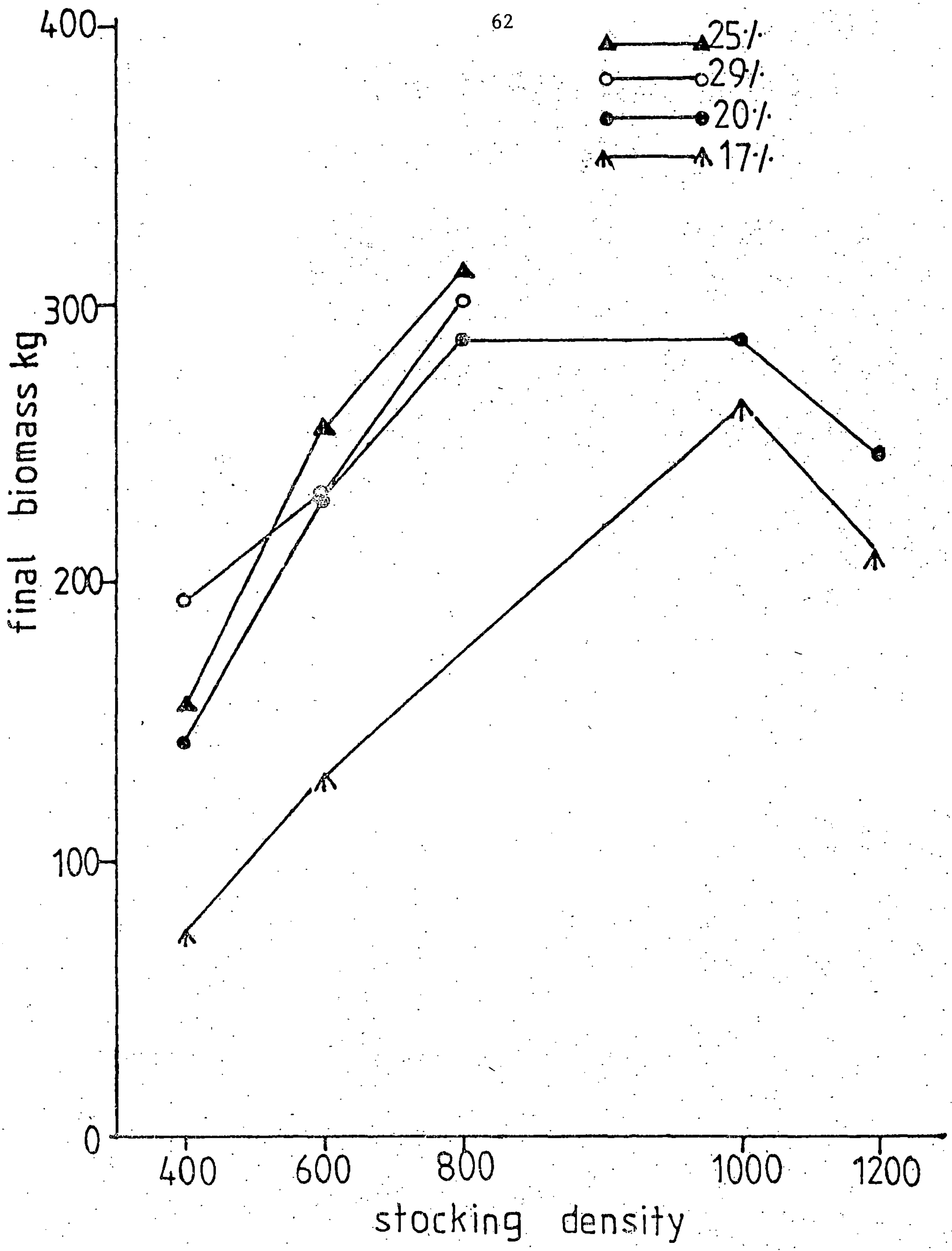


Fig 4 Variation of the final biomass (B_f) of S. niloticus with stocking density, at four dietary protein levels.

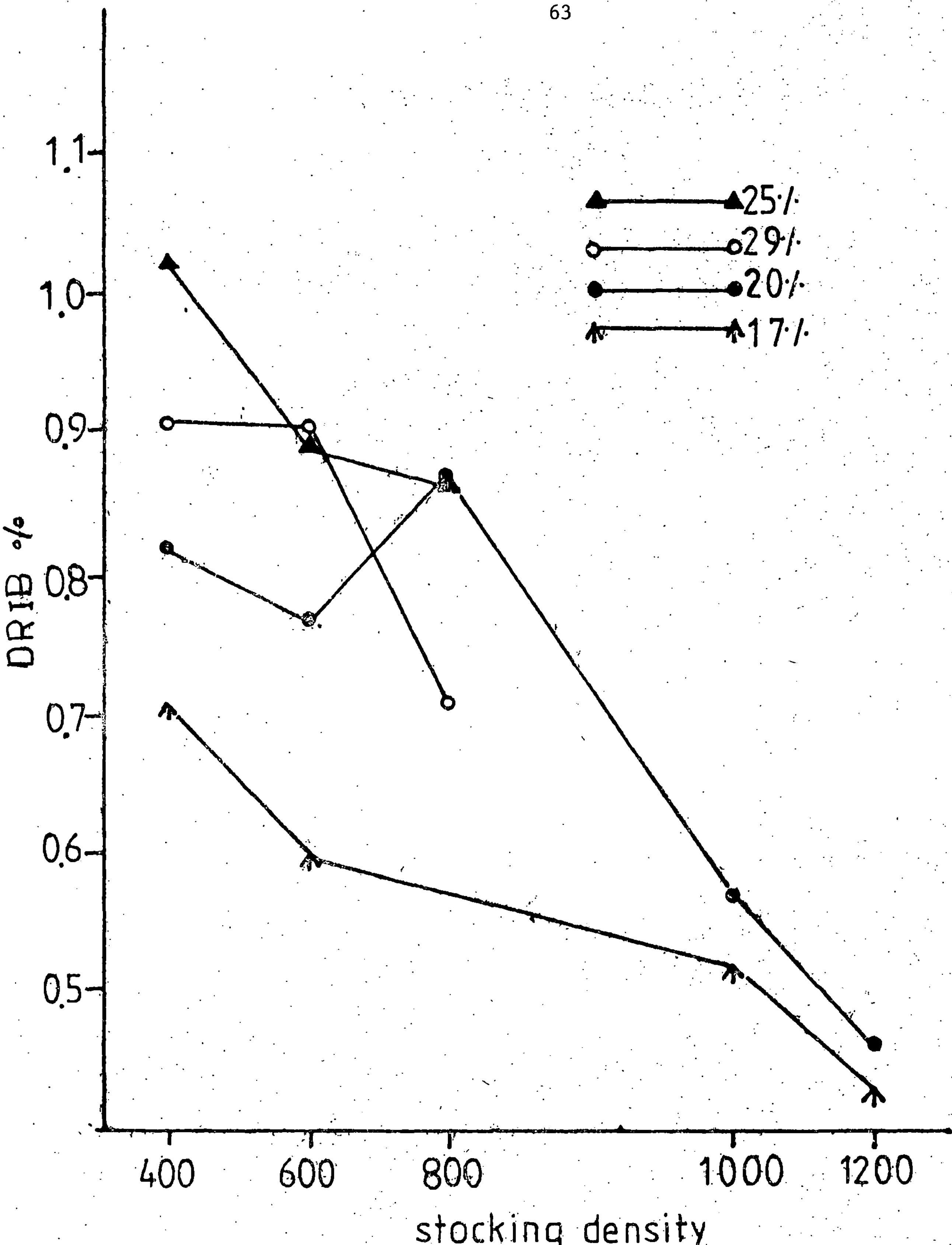


Fig. 5 Variation in the daily rate of increase in biomass of S.niloticus with stocking density, at four dietary crude protein levels.

ETUDE DE LA CULTURE EN CAGES DU SAROTHERODON NILOTICUS DANS LES LACS DE BARRAGE AU SRI LANKA : INFLUENCE SUR LA CROISSANCE DE CINQ DENSITES D'EMPOISSONNEMENT ET DE CINQ TENEURS EN PROTEINE

Gamini Muthukumarana et D.E.M. Weerakoon

Résume français

Les expériences de culture en cages ont débuté au Sri Lanka en 1980, avec un financement du CRDI. Des essais préliminaires avec la carpe herbivore *Ctenopharyngodon idella* et la carpe à grande tête *Aristichthys nobilis* ont été infructueux, et on s'est concentré par la suite sur le tilapia *S.niloticus*. Les cages sont construites en bambou, avec des filets de Kuralon ou de nylon; le volume utile est de 5 m^3. On a évalué la croissance et la production à des densités d'empoissonnement variant entre 400 et 1200/m^3, et en utilisant des aliments de teneur en protéine entre 17 et 29%. L'aliment a été distribué 6 fois par jour, et un poids d'aliment équivalent à 3% du poids total des poissons a été donné chaque jour. L'expérience a duré 5 mois, de mars à septembre 1984. Les taux de croissance en poids ont été semblables à toutes les densités d'empoissonnement (400 - 1200/m^3) jusqu'à 60 jours, mais ensuite la croissance a été plus rapide à des densités moindres; ainsi, le poids moyen final est inversement proportionnel à la densité d'empoissonnement. Le poids moyen final n'a pas de relation évidente à la teneur en protéine de la diète. Le gain de poids journalier est semblable pour toutes les diètes à des taux d'empoissonnement de 400 - 800/ m^3, mais à 1000 - 1200/m^3 les diètes plus faibles en protéines donnent une croissance journalière moindre. Le QN minimal correspond à la diète de teneur en protéine de 25%. Une réduction de la densité d'empoissonnement (400/m^3 pour 5 mois, ensuite 25/m^3 pour 1 mois) a comme résultat une augmentation du taux de croissance et une réduction du QN.

Les meilleurs résultats, en termes de production, se situent à une densité d'empoissonnement entre 400 et 600/m^3 avec une diète de teneur en protéine de 25%. Cependant, d'après des analyses préliminaires, il semble que l'efficacité économique est maximale pour une densité de 400/m^3 avec des diètes faibles en protéine (17 - 20 %). La réduction de la densité d'empoissonnement pendant le cycle de production peut améliorer la productivité des cages.

CAGE CULTURE IN THE DOMINICAN REPUBLIC

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Located in the Caribbean and sharing Hispaniola Island with Haiti, is the Dominican Republic. Being the second largest Island of this part of the world, means that potential fish production is high, but potential is not realised. Our continental shelves are not as rich as those in other countries although fish catching can be improved.

The inland production of fish is fairly new. Although at the arrival of Columbus in 1492, our natives were described as fish eaters, since then we have not developed the habit of fish use as we have done with red meat. Perhaps the buccaneers influenced our society's development : killing wild cattle, salting the meat and marketing it to travelers was more important than fishing.

In 1952 an FAO mission helped in the establishment of the Nigua fish research and demonstration farm. Since that time, because of economic, political and social reasons, aquaculture has moved very slowly. In recent years the outlook for aquaculture has improved with the raising of Macrobrachium, carps and Tilapia sp. on an economic scale.

Aquaculture is a new economic activity in this country and other enterprises are being considered such as shrimp, king crab, lobster, eels, etc.

At the Asociacion para el Desarrollo, Inc. (a non profit institution headed by community leaders) and its Centro de Investigacion y Mejoramiento de la Produccion Animal (CIMPA), aquaculture has been of interest from the view of protein production for low income people.

Cage culture is an activity recently introduced to the country, with the objective of helping decision-makers, producers and families to know of an activity that can be economical and a source of food to them.

With the support of IDRC since 1979 we have been able to start a research program in cage culture of fish. This activity has shown the importance of aquaculture, even though the main interest of commercial producers has been shrimp production, because of economic considerations.

Aquaculture in a country like ours must be well understood by the people as a source of income and proteins for them to eat. A lot of public relations have been behind this project : field days, training, television, newspaper and personal visits.

The different water sources in our country are the natural media to show the people how to produce aquatic animals. It can be done and it is one of the objectives of the joint program between IDRC, CIMPA and the Department of Agriculture of the Dominican Government.

In the near future aquaculture will be a highly appreciated activity and among it cage culture, because of the source of food it can be, for the rural people by having floating or underwater cages.

Some of the objectives established in our cage culture program are:

a) To demonstrate the importance of the activity for small rural producers around dams.

b) Produce more cheap protein to feed the people.

c) Produce better rural income.

d) Demonstrate nutritional quality of inland fish.

e) Diversify production activities around dams.

The experiments have been conducted at Tavera and Rincon dams, also at a reservoir at the Instituto Superior de Agricultura (ISA).

The experiments were done in the following way.

FIRST STAGE

Tavera Dam reservoir has a length of 8 km and an average width of 0.81 km. Altitude is 280 m, annual rainfall 1000-1100mm, average temperature 25°C. Water is used for electricity generation (80.000 kw) and agriculture.

TAVERA DAM

I. Search for optimum *Tilapia* sp. density without supplementary feed.

3 sites each with 4 cages of 3 m^3
Densities used : 50, 75, 100 and 125 per m^3

Fishes were checked during 8 months and the best results were 0.42 gr. per day at 50 fishes per m^3.

II. New design with different densities without feed.

3 sites each with 4 cages of 100m^3
Densities used 10,15,20 and 25 per m^3

At this experiment the fish were stolen at density of 25 per m^3, but experiments were completed at 10,15 per m^3.

III. Study of Tilapia nilotica density

4 cages of 3 m^3 each
Densities used : 50, 75, 100 and 125 per m^3

It was the worst of the three trial, because of high density fish did not grow well during the 6 months trial.

IV. Study of Tilapia sp. density with supplementary feed.

3 sites with 4 cages each of 3 m^3
Density used : 250, 300, 350 and 400 per m^3

Feed was given at 3% of body weight per day. Feed composition used throughout the project was as follows :

Dry tomato seeds	25%
Dry coffee pulp	25%
Chicken manure	25%
Rice bran	20%
Pre-mix (mineral)	5%
	100%

In our country there is not a fish feed commercially made.

Fish were checked during 8 months and best results were of 0.42 gr. per day at density of 350 m^3.

RINCON DAM

I. Search for optimum Tilapia sp. density without supplementary feed.

3 sites 4 cages of 3 m^3
Density used : 50, 75, 100 and 125 m^3

The study ran for six months and the growth was not good. Densities were changed to 10, 15, 20 and 25 per m^3, these new densities were studied for 4 months and significant growth was registered.

INSTITUTO SUPERIOR DE AGRICULTURA (ISA) RESERVOIR

I. Study the density of Tilapia sp. without supplementary feed at a reservoir of 5500 m^2.

8 cages of 3 m^3 were study
Densities used : 50, 75, 100 and 125 per m^3

The growth was not good and densities were changed to 5, 10, 15 and 20 fishes per m^3. These were studied during four months, and again no significant growth was noticed. This experiment was ended at that point.

Cage costs

The cost of each project changes from one country to another, because of economic changes. The following data is just a reference.

100 m³ :

- 40 lbs of net at RD$18.33 each	RD$733.52
- 36 units of bamboo at $0.80 each	28.80
- 20 lbs nylon rope at $5.50 each	110.00
- 4 workers at $6.00 each	24.00
- Other hand labor to make cage	35.00
- 4 anchors $0.90 each	3.60
- Others	6.00
	RD$940.92

1 US$ = 3RD$ - US$313.64

12 m³ :

- Nets	RD$329.94
- Bamboo	28.52
- Nylon	110.00
- Labor	18.00
- Labor for nets	20.00
- Anchor	3.60
	RD$510.06
	US$170.02

3 m³ :

- Nets	RD$164.97
- Other costs	53.05
	RD$218.02
	US$ 72.67

Nets last for 3-4 years and the bamboo wood 1-1 1/2 years.

The cage depth goes from 2.0 to 2.5 m and there is 0.5 m above the water surface.

For comparaison market prices of various fish species are :

Tilapia nilotica	1.50 - 1.75 RD$/pound
Tilapia sp.	1.25 - 1.50
Common carp	1.50 - 2.00
Black bass	2.00 - 2.50

Other sources of animal protein range fram 2.00 RD (chicken) to 3.50 RD (pork, beef) per pound.

Other information :

In order to produce our own seeds, the project has built a small hatchery to multiply Tilapia sp. and Carps.

Also another important part of the project is the planting of bamboo as a source of wood for the cages. Bamboo is difficult to find so cultivation is important. Supplies are reduced by overharvesting.

Conclusion of first stage

These studies showed that two types of culture were good economically.

a) Tilapia sp. at densities of 350 fishes per m^3 with supplemental feed of 3% body weight per day, at Tavera dam.

b) Tilapia sp. at density of 15 fishes per m^3 in cages of 100 m^3 without supplementary feed, at Tavera dam.

The results of the first stage showed us the importance of research with different densities, cages, species of fish, etc., so we initiated the new stage.

SECOND STAGE

In 1982 the second stage was initiated with similar objectives, in particular searching for the possibility of economic production.

The new research was conducted with Silver carps, a new species. The results of some research are shown in Table 1, Figures 1 and 2.

CONCLUSIONS

The cage culture experience that we have obtained, shows us the importance of aquaculture and the need to keep research in our country, to contribute to new ways of feeding our growing population and the use of our bodies of water.

So far we have moved a few steps in the decision-making process for the development of aquaculture, but further work is needed : research, training, demonstration programs. Demand for this type of source of protein should be encouraged.

More resources shall be dedicated to aquaculture, for example in cage culture (floating or bottom) but also we need to investigate corrals, pens or stocking water bodies with fishes.

The limiting factors that must be overcome for example :

1. Need for more Dominicans trained on aquaculture on short and long-term training, formal and informal courses outside or inside the country.

2. Continue research and expand to other dams, reservoirs ,irrigation channels, etc.

3. Improve facilities at the fish nursery so it can be a training center for producers, technicians and young people.

4. Produce more fingerlings of the species under investigation and other new species.

5. Start extension work with the people around the dams to project the watersheds.

6. Diversify fisheries research to other areas and methods.

We have to realize that fish production has in our country great potential, but this idea has to be passed to decision makers.

Our institution wants to express its sincere thanks to IDRC for its support and also to the Dominican Government, USAID and the Taïwan Technical Mission in this joint effort for a better society.

Grateful thanks also to Mr. Stuart Davies, IDRC Consultant, for his advice and work on the project.

Table 1 : Results of cage culture experiments

Experiment No.	Cage Size	Daily Growth (Gr)	Stock Density per m^3	Initial Weight	Final Weight (Month)	Dates
18* (A_1) CP	12 m^3	6.18	1	10.4	1040.9(6)	8-5-84
18* (A_2) CP	12 "	6.32	2	10.4	1036.9(6)	8-5-84
18* (A_3) CP	12 "	5.63	3	9.7	942.6(6)	8-5-84
19* (B_1) CP	12 "	6.61	1	8.3	931.8(5)	10-5-84
19* (B_2) CP	12 "	6.34	2	8.3	897.7(5)	10-5-84
19* (B_3) CP	12 "	5.32	3	8.3	751.3(5)	10-5-84
19* (B_4) CP	12 "	4.44	4	7.5	622.9(5)	10-5-84
19* (B_5) CP	12 "	4.52	5	5.5	635.7(5)	10-5-84
19* (B_6) CP	12 "	4.87	6	7.2	686.4(5)	10-5-84
17* (C_1) CV	12 "	1.07	1	125	258.4(5)	15-5-84
17* (C_2) CV	12 "	0.53	2	145.8	193.4(4)	15-5-84
16* (D_1) CP	12 "	5.09	1.5	27.7	631.2(4)	19-4-84
16* (D_2) CP	12 "	5.07	2.5	28.4	625 (4)	19-4-84
16* (D_3) CP	12 "	5.01	3.5	27.5	462 (4)	19-4-84
14* (M_2) CP	27 "	4.35	0.5	215.7	1679 (8)	4-1-84
14* (M_3) CP	27 "	5.05	1	265.9	1890.9(8)	4-1-84
1 (P_2) CP	100 "	8.56	1/5 m^3	12.5	2837.5(12)	12-7-83
23* (23A) TN	100 "	0.44	50	9.6	49.6(4)	13-6-84
6 (M_1) T.rendalli	27 "	0.22	3	37	79 (6)	
5 T.roja	3 "	0.32	5	11.7	60	

Al present we have 23 cages on research and we have included (T. hornorum x T.mossambica).

CP = Silver carp TN = Tilapia nilotica

* At present

Figure 1. Growth of Silver carp without supplementary feed at Tavara Dam, Dominican Republic (cage volume : 27 m³ for 1/m³; 12 m³ for others).

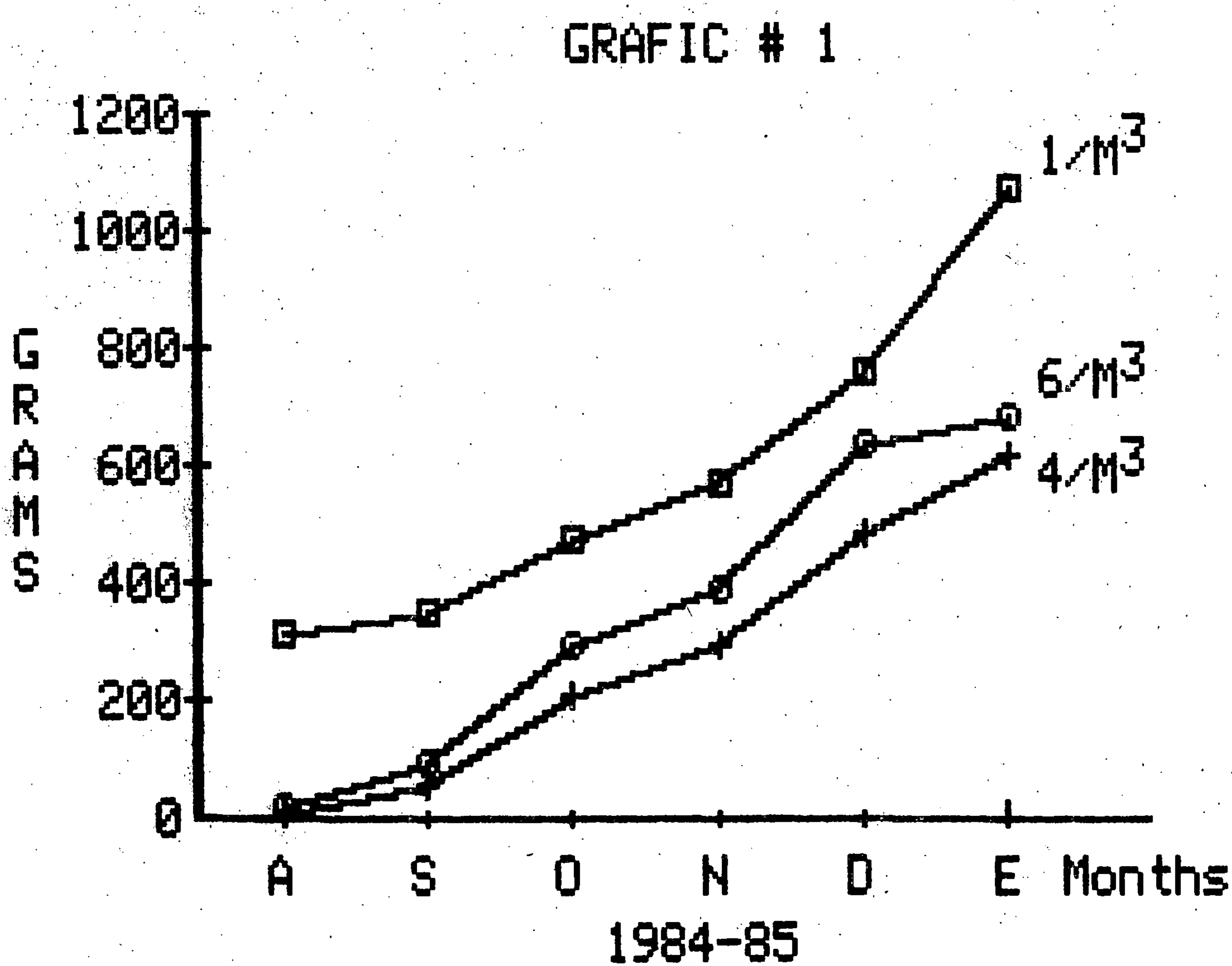
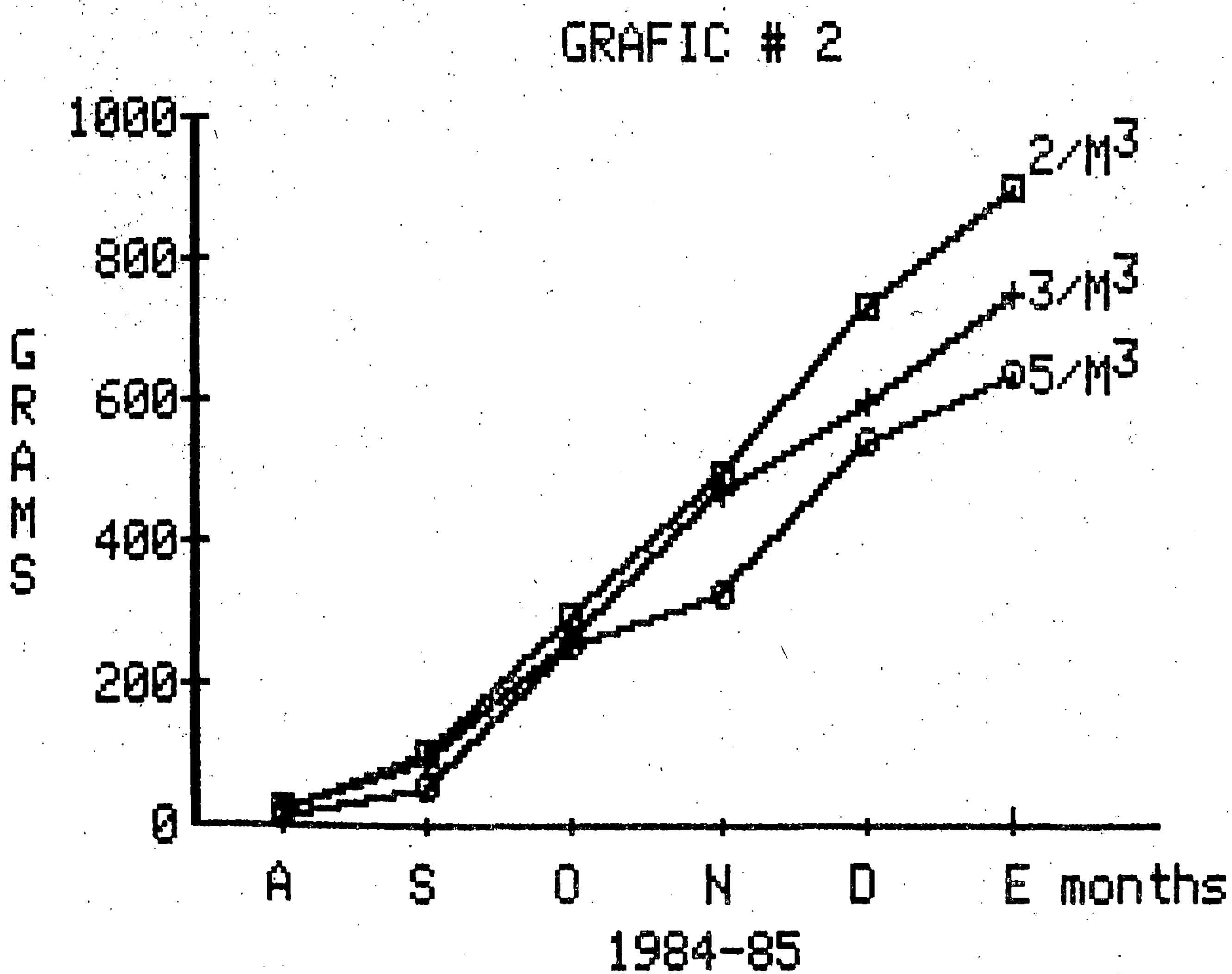


Figure 2. Growth of Silver carp without supplementary feed at Tavera Dam, Dominican Republic (cage volume : 12 m^3).



LA CULTURE EN CAGES EN REPUBLIQUE DOMINICAINE

Emilio A. Olivo

Résumé français

Un projet de recherche sur la pisciculture en cages a débuté en 1979, avec le soutien du CRDI, dans le but d'augmenter la disponibilité des protéines et les revenus des producteurs ruraux, et de diversifier les activités de production autour des lacs de barrage. Dans une première phase, on a découvert que le T. nilotica a une croissance assez bonne (0.4 g/jr) à de faibles densités d'empoissonnement (15/m^3) à un des 3 réservoirs testés, mais la croissance a été faible aux deux autres. En utilisant un aliment supplémentaire (graines de tomates, pulpe de café, fientes de poulet, son de riz; 3% du poids des poissons par jour) on a observé un taux de croissance moyen de 0.4 g/j sur 8 mois à 350 poissons/m^3. On a initié une deuxième phase en 1982 y compris des recherches avec la carpe argentée, qui a démontré un bon taux de croissance sans aliments supplémentaires à des densités d'empoissonnement faibles (1-6/m^3). Des données économiques sur les coûts de construction des cages sont fournis.

L'ELEVAGE EN CAGE EN EAU DOUCE EN COTE D'IVOIRE

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1. HISTORIQUE DE L'ELEVAGE EN CAGE EN COTE D'IVOIRE

L'élevage en cage a commencé en Côte d'Ivoire en mars 1974 sur le lac de Kossou avec des essais effectués par M. André Coche, suite à un programme de recherche lancé en janvier de la même année. Plus tard, le Centre Technique Forestier Tropical (CTFT), organisme de recherche sur la pisciculture, a fait des essais en fleuve et en lac en 1981. Dans tous ces cas, l'espèce utilisé était le Tilapia nilotica pour ses nombreuses propriétés biologiques et physiologiques (croissance rapide, haute résistance aux maladies et aux parasites, grande valeur marchande, etc...).

1.1 Série 1 : Essais faits par M. Coche dans le lac de Kossou

Ces essais ont eu lieu dans des cages de 1m^3 de volume, de maille 14 mm, une cage comprenait :

- la structure proprement dite faite de bois assemblés aux dimensions 1 x 1 x 1,10 m et recouverte sur 5 faces par du grillage plastique;

- deux flotteurs de 1 x 0,2 x 0,1 m faits de blocs de styrofoam fixés latéralement :

- un couvercle opaque
- une mangeoire faite en bois suspendue en travers de la cage.

Ainsi, 15 cages ont été utilisées durant les essais. Elles étaient toutes reliées entre elles par un cordage.

3 méthodes d'élevage ont fait l'objet d'essais :

Essai 1 : Aliment de poulet en granulé

Il contient 24,7% de protéine et composé de :

20% de farine de poisson
70% de farine basse de riz
10% de tourteau de copra

la ration journalière est de 4% de la biomasse

Essai 1.1 : Méthode standard

Elle était destinée à servir de modèle dans le future. Elle consistait à donner à la population de poissons, une alimentation en granulé acheté sur le marché. Ration : 6% de la biomasse, le Qn (quotient nutritif) était de 3.

Essai 1.2 : Méthode avec tri

L'objectif était d'uniformiser la taille des poissons marchands récoltés. 2 cages étaient utilisées et alimentées à 6% de la biomasse.

Essai 1.3 : Méthode d'alimentation réduite

Elle consistait à réduire l'indice de consommation de l'aliment tout en maintenant une bonne croissance. La ration était réduite chaque 2 mois d'élevage jusqu'à 4% de la biomasse.

Du 14 mars 1974 au 15 janvier 1975, 8 essais ont eu lieu, soit 985 jours. Les récoltes ont donné 467,9 kg soit 2450 poissons de 191 g de poids moyen (voir tableau 1).

CONCLUSION : selon le rapport, la méthode standard donnerait plus de garantie de succès. Mais cela dépend de la taille des poissons à la mise en charge. Avec des alevins de 20-30 g, la durée de l'élevage est d'environ 150 jours. Si l'on veut la réduire à 120 jours, il faut utiliser des alevins de 40 g de poids moyen. Pour maximiser la production, il a été recommandé de mettre de forte densité à l'empoissonnement (20 kg/m³). Le problème qui restait à résoudre était l'obtention d'alevins calibrés.

Série 2 : Essais effectués par le Centre Technique Forestier Tropical en rivière :

L'aliment utilisé contenait 20% de protéïne et composé comme suit :

4% de farine de poisson
18% de tourteau de coton
77% de son de riz
1% de sels minéraux.

Il était distribué sous forme de granulé à 10% de la biomasse. Les résultats sont résumés dans le tableau 2.

Série 3 : Essai effectué par le Projet de Développement de la Pisciculture

En 1980, dans l'intention de vulgariser cette activité, le projet PNUD/FAO, a procédé à des essais dans certains Cantonnements.

Les essais étaient faits dans des cages de 20m³, de dimensions 2,75 x 2,75 x 3,10 m avec des filets de mailles 14 mm. La ration alimentaire variat entre 6 et 4% de la biomasse. La distribution se faisait à la volée 2 fois/j. Ces différents essais ont eu lieu dans les Cantonnements de Bondoukou, Korhogo et Bouaké. Les résultats sont les suivants :

Essai 3.1 :

TABLEAU 3 : secteur de Bondoukou dans le lac de Kpoda

N° cage	MISE EN CHARGE				V I D A N G E				Quantité aliment distribué
	Date	Nombre	Poids total	Poids moyen	Date	Nombre	Poids total (kg)	Poids moyen (g)	
1	27/10/80	498	14,9	30	17/06/81	621	158,2	255,7	97,13
2	-	-	-	-	-	418	102,5	265	70

La cage 2 n'a pas été empoissonnée au départ. Ce sont des poissons provenant du lac qui y sont rentrés. Ils ont donc été nourris. Il a été impossible de calculer le quotient nutritif parce que les conditions de départ n'étaient pas respectées.

Essai 3.2 :

TABLEAU 4 : secteur de Korhogo sur le lac du Sologo

N° cage	MISE EN CHARGE				V I D A N G E				OBSERVATIONS
	Date	Nombre	Poids total	Poids moyen	Date	Nbre	Poids total	Poids moyen	
1	03/05/80	1400	29	20,7	26/11/80	949	118,6	125	
2	-	2400	49,8	20,7	-	980	98	100	

Les poissons ont été nourris à partir du 16/05/80 et de façon irrégulière; ce qui n'a pas permis de calculer le Qn.

Essai 3.2

TABLEAU 5 : secteur de Bouaké dans le lac de Loka (1981)

N° cage	MISE EN CHARGE				V I D A N G E				Croissance (g)	Quantité d'alevins
	Date	Nbre	Poids	Poids	Date	Nbre	Poids	Poids		
1	21/01/81	1995	60	30	09/07/81	146	33,6	230	1,18	1146
2	-	1929	57,8	30	-	760	160	210	1,06	889
3	-	2090	62,7	30	22/10/81	1721	267,9	155,6	0,46	2457

Les poissons des 2 premières cages ont été nourris avec des granulés achetés sur le marché et contenant 20 à 25% de protéine. Ceux de la dernière avec de l'aliment pulvérulent (50% farine basse de riz et 50% de tourteaux de coton) et déversé dans un cadre en bois de 1 x 2m.

2. STRUCTURE D'ELEVAGE

C'est fort de tous ces résultats d'essais que la Direction du Projet a décidé en 1980 de vulgariser l'élevage en cage. Il existe 3 types de structure utilisée par les éleveurs.

2.1 Le type lagunaire

Il comporte 2 parties. Une partie émergée et une partie immergée.

2.1.1 Partie émergée : elle est constituée d'un bâti en bois porté par 2 fûts de 200 l. Le bâti est constitué de 2 chevrons de 8 x 8cm de section, de 7m de long espacés de 30cm sur lesquels sont fixées des planches de 60 x 13 x 2,7cm de dimension. Ces planches forment la passerelle qui permet de se déplacer et d'effectuer les opérations d'alimentation et de contrôles. A 75 cm de l'extrémité des chevrons, sont fixés perpendiculairement deux autres chevrons de 6 x 6 cm de section et de 5 m de long aux extrémités desquelles sont fixés 4 blocs de polystyrène expansé de 0,5 x 0,3 x 0,2 m. Ils assurent la stabilité de l'ensemble (fig. 1 en annexe).

2.1.2 Partie immergée : elle comprend un filet de 4 x 2,3 issu de nappes de 50 m de long et de 4 m de chute. Les mailles sont de 14 mm de côté. Le filet est monté sur des rallingues (montage à 71%) de 6 mm de diamètre. Le dessus de la cage est couvert de nappes de mailles 14 mm. Le volume peut varier de 20 à 30 m^3. Lorsque le filet est accroché, on fixe à chaque extrémité inférieure un poids (blocs de pierre, de laterite, etc...) pour le tendre.

2.2 Le 2ème type de structure

Il est composé de 4 chevrons cloués entre eux pour former un carré ou un rectangle. A chaque angle est attaché un bidon de 60 à 100 l ou un fût de 200 l pour assurer la flottaison. Des clous sont fixés sur les faces internes des chevrons pour accrocher le filet. Le filet utilisé est le même que celui du premier type. Le volume peut varier de 20 à 60 m^3 (fig. 2).

2.3 Le 3ème type de structure

C'est le même type que le deuxième mais au lieu des chevrons, l'armature est faite de tuyaux en acier de 6 m de long. Elle a été recommandée par un consultant FAO en 1983 du nom de D. Campell. Les tuyaux sont rattachés 2 à 2 à l'aide de joints d'attache de façon à voir voir un complexe de 4 cages de 30 m^3 chacune. On attache un bidon à chaque angle pour assurer la flottaison (fig. 3).

Le coût d'investissement varie selon le type de structure.
Voici 2 exemples :

TABLEAU 6 : coût de construction d'un complexe de 4 cages. 3è type de structure.

Matériel	Nombre	Prix unitaire	Prix total	Amortissement	Valeur annuelle
- tuyau acier	14	12.000	168.000	10 ans	168.800
- joints d'attache	24	600	14.400	10 ans	1.400
- fûts plastiques 220 l	8	5.000	40.000	2 ans	20.000
- filet couvercle	4		7.000	2 ans	3.500
- filet 210/18	4/5		75.000	5 ans	25.040
- ralingue nylon 6 mm et cordage ancrage 12 mm fil 210/48					
- main d'oeuvre confection de la cage	4	3.000	12.000		
TOTAL..........			336.600		

Le coût total est 336.600 F CFA en 1983 l'unité de 4 cages de 30 m^3.

Pour le type lagunaire, le coût est estimé à 1.860.000 F les 12 cages; soit 620.000 F l'unité de 4 cages de 30 m^3 chacune.

En conclusion, le type en bois est plus économique que celui en acier mais de durée vie relativement brève (5 ans).

3. METHODES D'ELEVAGE

Il a été recommandé à chaque éleveur d'avoir des étangs de production d'alevins pour éviter les contretemps. Chaque éleveur dispose d'un barrage dans lequel il fait son élevage. Pour ceux qui ne peuvent pas faire d'étangs parce que le site ne s'y prête pas, ils achètent des alevins dans le centre d'alevinage le plus proche. Lorsque ces alevins arrivent sur l'exploitation, compte tenu de leur petite taille, (1 à 5 g), ils séjournent un mois environ dans des cages de prégrossissement. Les mailles de ces filets sont de 6 mm. Les alevins sont nourris à 6% de leur poids total initial jusqu'à 20 à 30 g, taille à laquelle ils ne peuvent plus passer à travers les mailles de 14 mm. A ce premier stade, la densité n'est pas déterminée compte tenu de la fragilité des bêtes.

A 20 g, les poissons sont mis dans les cages de grossissement à une densité de 100/m^3. Les poissons sont nourris pendant 6 à 7 mois jusqu'à la taille de 200 g et plus.

L'aliment utilisé est celui fabriqué pour les poissons par DOMAK (Domaine d'Abadjan Kouté) ou FACI (Fabrique d'Aliment de Côte d'Ivoire). Il est vendu en granulé de 4 mm de diamètre et distribué en fonction d'un tableau de ration que voici :

TABLEAU 7 : ration alimentaire en fonction de la taille des poissons et de la saison.

Poids moyen (g)	QUANTITE D'ALIMENT/JOUR/POISSON (g)	
	Saison chaude	Harmattan (moins de 20°C
10 - 29	1,0	0,6
30 - 59	1,5	0,9
60 - 79	1,7	1,0
80 - 99	2,3	1,2
100 -119	2,0	1,4
120 -139	2,5	1,5
140 -169	2,7	1,6
170 -209	3,0	1,8
210 -239	3,2	1,9
239 -300	3,2	1,9

Ces rations journalières sont multipliées par le nombre de poissons existant dans la cage. Le chiffre trouvé est la quantité réelle qu'il faut distribuer par jour. Ces chiffres sont arrondis au 100 g supérieur.

Le prix du kilogramme de cet aliment est de 110 F vendu à l'usine. Le quotient nutritif (Qn) est de 2.

La composition est la suivante (aliment FACI) :

Min. protéine....................28%
Min. graisse.....................7,6%
Maxi. cellulose.................. 7%
Maxi. humidité...................12%

Exemple de calcul pour suivre l'évolution de la population et servant à déterminer la production/cage/cycle, la quantité d'aliment à distribuer.

Base de calcul : Qn aliment = 2
Volume de la cage = 30 m^3
Poids moyen initial = 30 g
Durée alimentation/mois = 30,5 j
Taux de mortalité = 10%
Durée de l'élevage = 6 mois

TABLEAU 8 : évolution de la population

mois \ données	efféctif	poids moyen(g)	poids total(kg)	ration j/(kg)	ration /mois(kg)	croissance (g)
0	3000	30	90	4,5	137,2	0,75
1	2950	52	156,3	4,6	140,3	0,75
2	2900	75,8	219,8	4,9	149,4	0,84
3	2850	101,4	289	6,5	198,2	1,14
4	2800	136,2	361,4	7	213,5	1,25
5	2750	174,3	479,3	8,2	250	1,5
6	2700	220	594			

L'examen de ce tableau ressort les données suivantes :
- à la fin de l'élevage, 2700 poissons d'un poids moyen de 220 g et 594 kg de poids total/cage, seront récoltés.
- 1089 kg d'aliment seront distribués pendant le cycle.
- La ration journalière est distribuée en 2 temps. Une moitié le matin et l'autre l'après midi.

4. IMPACT SUR LA POPULATION

L'élevage en cage suscite un engoument au sein de la population. Je n'en veux pour preuve, les nombreuses demandes qui parviennent au service de la pisciculture. Mais compte tenu des échecs subits ça et là, nous avons été obligé de recommander la prudence à nos agents vis à vis des éventuels candidats. Ces échecs sont imputables à une insuffisance d'encadrement, à un mauvais suivi des paramètres d'élevage, au manque de gardien sur les installations, au manque de notions comptables pour faire face aux petites dépenses urgentes et à l'insuffisance des moyens financiers. Dorénavant, nous n'accepterons que les demandes émanant des promoteurs fortement motivés, conscients des risques de la méthode, des limites techniques du service d'encadrement.

En 1980, pour vulgariser cette technique d'élevage, le Projet PNUD/FAO a décidé de construire des cages de 20 m^3 au prix de 45.000 à 60.000F/pièce pour les pisciculteurs privés. Il est évident que les prix ont changé actuellement.

De 1980 à nos jours, il y a eu 8 éleveurs répartis sur l'étendue du territoire. Certains ont abandonné pour les raisons évoquées plus haut; d'autres continuent contre vents et marées.

TABLEAU 10 : liste des éleveurs de 1980 à 1985

N° d'ordre	ville d'implantation	année d'implantation	nombre de cage	année d'abandon	raisons
1	Alangouassou	Octobre 1980	2 de 20 m³/l'une (3 x 41,85)	1983	
2	Dabakala	Juin 1981	2 de 20 m³/l'une	1982	
3	Languebonou	1981	2 de 20 m³/l'une	1982	diminution du niveau d'eau dans le lac
4	Kossou	1982	13 cages de 60 m³/l (4 x 6 x 2,7 m)	1984	problème financier
5	Abengourou	1983	6 cages de 60 m³/l	1984	problème financier
6	Odienné	1983	12 cages de 20 m³/l	1984	manque de moyen financier. Attends un emprunt bancaire pour continuer
7	Toumodi	1983	12 cages de 30 m³/l (3 x 4 x 2,5 m)		
8	Odienné	1984	12 de 30 m³/l l'une		

4.1 Résultats chez quelques éleveurs

TABLEAU 11 : résultats chez l'éleveur N° 1

RUBRIQUES	CAGE 1	CAGE 2
Mise en charges		
Date	25/11/80	25/11/80
Nombre	2016	2035
Poids total	40,32 kg	61,05 kg
Poids moyen	20 g	30 g
Taux de survie	98,3 %	97,50 %
Echantillonnage		
Date	26/02/81	26/02/81
Poids moyen	184 g	156 g
Nombre en cage	1991	1985
Poids total estimé dans la cage	366 kg	311 kg
Ration alimentaire	4% de la biomasse	4%
Quantité d'aliment/j	14 kg	12 kg
Quantité total d'aliment distribué	466 kg	564 kg
Croissance/j	2,47 g	1,03 g
Quotient nutritif	1,36	2,25
Vidange		
Date	14/08/81	la cage a été vidée par le propriétaire en l'absence des encadreurs
Poids moyen	400 g environ	
Poids total	270 kg	

Remarques : l'aliment était en granulé et acheté dans une maison de fabrique d'aliment de bétail/

TABLEAU 12 : résultats de l'éleveur N° 3

RUBRIQUES	CAGE 1	CAGE 2
Empóissonnement		
Date	18/07/81	30/07/81
Nombre	2000	1150
Poids moyen	33,5 g	43,47 g
Poids total	67	80 kg
Echantillonnage		
Date	11/09/81	11/09/81
Nombre pris	46	39
Poids moyen	52,17 g	56,4 g
Poids total	104,34 kg	64,9 kg
Ration alimentaire	6 %	6 %
Quantité d'aliment par jour	6	6

En ce qui concerne la vidange, le 20/01/82, à la suite d'une baisse importante du niveau d'eau dans le barrage, le propriétaire a vidé les 2 cages à l'absence des encadreurs. Les chiffres mentionnés ci-dessus concernent les 2 cages. Il s'agit de 157 kg de poissons sortis de 92 g de poids moyen.

4.2 Comparaison d'essais faits

La formule de l'aliment est la suivante :

- son de blé.........................55%
- tourteaux de coton................13%
- tourteaux d'arachide..............25%
- premix P2 (vitamines)............. 2%
- farine de poisson................. 5%

TABLEAU 13 : comparaison entre les résultats obtenus par M. Campell à Kossou et par le Projet PNUD dans le lac de Loka.

L I B E L L E	KOSSOU	LOKA(projet)
Nombre de jours d'élevage	88	144
Nombre de poissons/cage	1440	2422
Nombre de poissons/m^3	72	134
Poids total à l'empoissonnement (kg)	35,17	134
Poids moyen à l'empoissonnement (g)	21,1	55,3
Nombre à la vidange	1412	1132
Mortalité (%)	1,8	53,3
Poids total à la vidange (kg)	215,68	353
Poids moyen à la vidange (g)	154,7	311,4
Production/cage (kg)	180,5	219,0
Production/m^3 (kg)	19	10,9
Croissance individuelle (g/j)	1,4	1,77
Quantité d'aliment distribuée (kg)	374,3	885,7
Qn (quotient nutritif)	2,08	4,0'

Tels sont quelques résultats que nous avons pu avoir malgré beaucoup d'efforts fournis. Les raisons sont multiples :

- inexistance ou non remplissage des documents de gestion par les exploitants.
- manque de données fiables pour établir une statistique parce que beaucoup d'éleveurs récoltent et vendent leurs poissons à l'absence de l'encadreur .

5. ASPECT ECONOMIQUE

Il y a très peu de données sur ce plan parce que nous n'avons pas encore eu de résultats avec nos éleveurs. L'exemple qui suit vous permettra de savoir ce qu'un exploitant peut attendre de son élevage. Il s'agit d'un dossier technique qui a été fait pour permettre à un éleveur d'obtenir un prêt à la banque et recommencer son élevage. Les données sont les suivantes :

- la somme de l'emprunt est de 2.600.000 F
- le remboursement se fera en 3 cycles, sur 24 mois; le 1er interviendra après 12 mois.
- l'éleveur dispose déjà de 12 cages et de 4 étangs pour produire ses alevins.
- le petit matériel existe sur l'exploitation
- les poissons commercialisables seront produits à une taille de 220 g environ, 6 mois d'élevage, avec de l'aliment granulé à 550 F rendu sur l'exploitation.
- dans les étangs, les poissons seront nourris avec de l'aliment fabriqué par le Projet de Développement de la Pisciculture à Bouaké disponible à 100 kg de l'exploitation à 42 F et à 60 F rendu chez l'éleveur.

5.1 Eléments de calcul des coûts et revenus

5.1.1 Côuts

511.1 Matériel

- remise en état des étangs : moine et buse = 4 x 10.250 F — 41.000 F
- remise en état des étangs et pontons pour les 2 premiers cycles — =540.000 F
- entretien cages et étangs cycles ultérieur/cycle — =100.000 F

511.2 Personnel

- manoeuvre + gardien/cycle.................=180.000 F

511.3 Aliment

- Aliment/cycle de 6 mois dans les cages
  - * poissons produits = 5.280 kg/cycle
  - * Qn = 1,9 aliment complet commerce (FACI ou DOMAK)
  - * quantité/6 mois :
    10.032 kg à 150 F = 1.504.800 F
- Aliment/6 mois alevinage :
  1150 kg/cycle d'aliment 3A à 60F/kg
  = 69.000 F

5.1.2 Revenu

512.1 Poissons marchands

11 cages de 2400 poissons seront utilisées, suivies : 9%.Prix de vente : 600 F/kg = 3.168.000 F.

TABLEAU 14 : récapitulatif des coûts

Désignation	1er cycle	2è cycle	3è cycle	4è cycle
Nombre de cages				
Nombre d'alevins (2400/cages)	26.400	26.400	26.400	26.400
Quantité d'aliments				
* alevins à 60 F/kg	1.150	1.150	1.150	1.150
* cages à 150 F/kg	10.032	10.032	10.032	10.032
Achat d'aliments (alevinage + cages)	1.574.000	1.574.000	1.574.000	1.574.000
Remise en état des cages et étangs	270.000	270.000	270.000	270.000
Main d'oeuvre	180.000	200.000	220.000	240.000
	2.024.000	2.044.000	1.894.000	1.914.000

Plan de financement

* Emprunt bancaire	2.600.000	80 %
* Apport personnel	660.000	20 %
* Coût total	3.260.000	100 %

TABLEAU 15 : compte d'exploitation

Désignation	1er cycle	2è cycle	3è cycle	4è cycle
- Chiffres d'affaires				
* vente poissons (5280 kg/cycle à 600 F/kg)	3.168.000	3.168.000	3.168.000	3.168.000
- Charges				
* charges d'exploitation	2.024.000	2.024.000	1.894.000	1.914.000
* frais financiers	159.000	159.000	159.000	-
Total charges	2.183.000	2.203.000	2.053.000	1.914.000
- Résultat d'exploitation				
- Trésorerie				
* ressources				
* crédit bancaire	2.600.000			
* résultat d'exploitation	925.000	965.000	1.115.000	1.254.000
Total ressources	3.585.000	965.000	1.115.000	1.254.000
- Emplois				
* investissement (renouvellement)	540.000			372.000
* remboursement de l'emprunt	867.000	867.000	867.000	
Total emplois	1.407.000	867.000	867.000	
- Disponible	2.178.000	98.000	248.000	
- Disponible cumulé	2.178.000	2.276.000	2.524.000	3.778.000

L'examen de ce tableau montre que lorsque l'éleveur aura fini de payer ses dettes, c'est à dire à la fin de la 3ème année, il aura un revenu semestriel de 1.068.000 F; car les cages sont amortissables sur 5 ans (186.000 F). Il aura donc un revenu mensuel de 178.000 F ce qui est somme toute intéressant.

6. DIFFICULTES RENCONTREES ET SOLUTIONS PRECONISEES

L'élevage en cage est une activité d'avenir mais ses problèmes sont multiples :

6.1 Indisponibilité d'alevins calibrés

L'insuffisance d'alevins calibrés constitue un problème pour le respect des dates d'empoissonnement et de vidange. Bien que la plupart des éleveurs aient en aval de leur barrage des étangs pour la production de poissons, ceux-ci restent insuffisants.

Il faudrait que chaque éleveur ait ses propres structures de production d'alevins, de production de fingerlings afin de :

- pouvoir démarrer son élevage à des tailles lui permettant d'écourter le cycle dans les cages de production,

- éviter les longs voyages de transport au bout desquels, on constate beaucoup de mortalité.

6.2 Prix de l'aliment

Nous estimons que le prix de l'aliment est élevé par rapport à la catégorie d'éleveurs que nous encadrons. En effet, l'aliment constitue près de 60% du coût de fonctionnement. Les unités de production d'aliment sont éloignées des régions abritant les cages; ce qui rend le prix de vente difficilement accessible (110 à 150 F selon les régions). Il est nécessaire de créer des centres de dépots d'aliment à l'intérieur du pays pour réduire les frais de transport.

Nous souhaiterions par ailleurs, que la direction du projet confectionne de l'aliment performant pour le vendre aux éleveurs à un prix subventionné comme cela a été déjà fait pour l'élevage en étang. Des essais doivent être effectués avec des granulés confectionnés à partir de l'aliment 3A dont la formule est la suivante :

- 70 % farine basse de riz
- 20 % tourteau de coton
- 10 % farine de poisson

6.3 Sur le plan technique

L'équipe technique en place sur l'exploitation n'est pas souvent compétante pour mener à bien l'élevage. Elle est incapable d'appliquer les techniques élémentaires de la pisciculture. Le minimun à faire, est de mettre une personne lettrée. Il faudrait que cette personne habite sur l'exploitation pour servir de gardien; qu'elle sache nager pour effectuer de temps en temps des interventions sur le ponton. Quant à l'équipe de travail, elle doit :

- savoir relever les filets en évitant les pertes de poissons,

- savoir distinguer les espèces sauvages des espèces cultivées (T. zillii et T. nilotica),

- connaître les méthodes d'inventaire (échantillonnage et calculer le poids moyen, le poids total, etc...),

- savoir calculer la ration alimentaire.

Il est impérieux d'organiser des stages de formation pratique en faveur des éleveurs chaque année. En outre, la fréquence des visites des agents d'encadrement est encore bas; ce qui n'aide pas du tout les éleveurs.

En certaines exploitations, on note l'absence complète de matériel technique (table de tri, seaux, balance, épuisettes, aliment etc...). Il est indispensable d'avoir tout cela sur place si on veut réussir dans ce qu'on entreprend.

La technologie des cages est inadaptée aux différentes interventions pendant l'élevage (pêche de contrôle, pesée, etc.). Leur conception doit permettre à deux personnes de peser et de compter les poissons. Pour cela, il faudrait une revanche suffisante pour éviter que les poissons en sautant, tombent dans le lac. Des supports d'élevation que l'on fixera au ponton à chaque angle de la cage, pourraient être utilisés lors des manipulations (fig. 5).

Mise à part le modèle lagunaire, les manipulations sur les cages sont difficiles et dangereuses pour ceux qui ne savent pas nager.

Les cages doivent être lestées pour qu'elles conservent leur volume initial.

6.4 Problèmes financiers

Jusque là, cette activité semble ne réussir qu'à une catégorie d'individus; ceux nantis financièrement (Ministres, Directeurs, Fonctionnaires, etc...). Tous ceux qui ont abandonné, l'ont fait pour des raisons financières. Ils n'arrivaient plus à joindre les 2 bouts.

CONCLUSION

L'avenir de l'élevage en cages dépendra du temps que l'on mettra pour résoudre les problèmes évoqués plus haut. En effet, les demandes sont nombreuses, les retenues d'eau ne manquent pas sur l'étendue du territoire national. Des cages peuvent être installées sur tous ces lacs pourvu que les promoteurs soient sûrs de surmonter les difficultés et rentabiliser leur exploitation. Cela dépend pas seulement des encadreurs. Il dépend aussi des exploitants qui pour avoir été séduits par les documents ou informer par des amis, se lancent dans cette activité. Il faudrait que les encadreurs s'inspirent du document intitulé "COMMENT REPONDRE A UNE DEMANDE D'ENCADREMENT D'UN ELEVAGE EN CAGES", édité par le projet de développement de la pisciculture en Côte d'Ivoire pour la mise en place des nouveaux denandeurs.

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TABLEAU 1 : RESULTAT DE LA SERI 1

PMI (g)	DENSITE N/m3	BIOMASSE INITIAL (kg)	CROISSANCE/J (g)	TAUX DE CROISSANCE/MOIS %	P.M.F. (g)	B.F. kg/m3	Q.N.	DUREE D'ELEVAGE/J
16	268	4,3	1,05	197	175	41,9	2,8	151
22	218	4,8	1,20	164	207	34,6	3,4	154
29	257	7,5	1,33	138	232	56,1	3,3	153
29	349	10,1	1,18	122	197	60,9	3,2	142
40	355	14,2	1,54	166	228	73,6	3,2	122
40	488	20,5	1,39	104	169	71,9	3,0	92
55	215	11,8	2,21	121	265	53,0	3,1	95
49	300	14,7	1,8	110	271	75,9	3,3	122

Pmi = Poids moyen initial

Pmf = Poids moyen final

Bf = Biomasse final

Qn = Quotient nutritif

TABLEAU 2 : Résultats de la serie 2

NOMBRE DE JOURS	MISE EN CHARGE			ALIMENTATION		VIDANGE			SURVIE %	PRODUCTION		
	P.M.I.	N.I.	B.I.	QUANTITE (kg)	Q.N.	P.M.F.	N.F.	B.F. (kg)		POIDS TOTAL	CROISSANCE G/J	RESULTAT kg/m3/An
128	39,69	820	32,70	240	3,56	127,47	786	100,20	96,0	67,50	0,68	38,50
128	41,87	680	28,50	177	5,18	97,87	640	62,6	94,1	37,17	0,44	21,20
128	39,69	770	30,56	233	3,15	136,2	760	105,1	98,67	98,67	0,70	56,27
133	49,68	750	37,26	218	5,81	103,7	721	74,77	96,1	37,51	0,41	20,56
127	42,77	469	20,06	-	3,87	137,56	450	61,90	95,9	41,81	0,75	24,03
133	49,30	518	25,54	146	5,75	102,47	497	50,93	95,9	25,39	0,39	13,94

PMI = Poids moyen initial

NI = Nombre initial

BI = Biomasse initial

QN = Quotient nutritif

PMF = Poids moyen final

NF = Nombre final

BF = Biomasse final

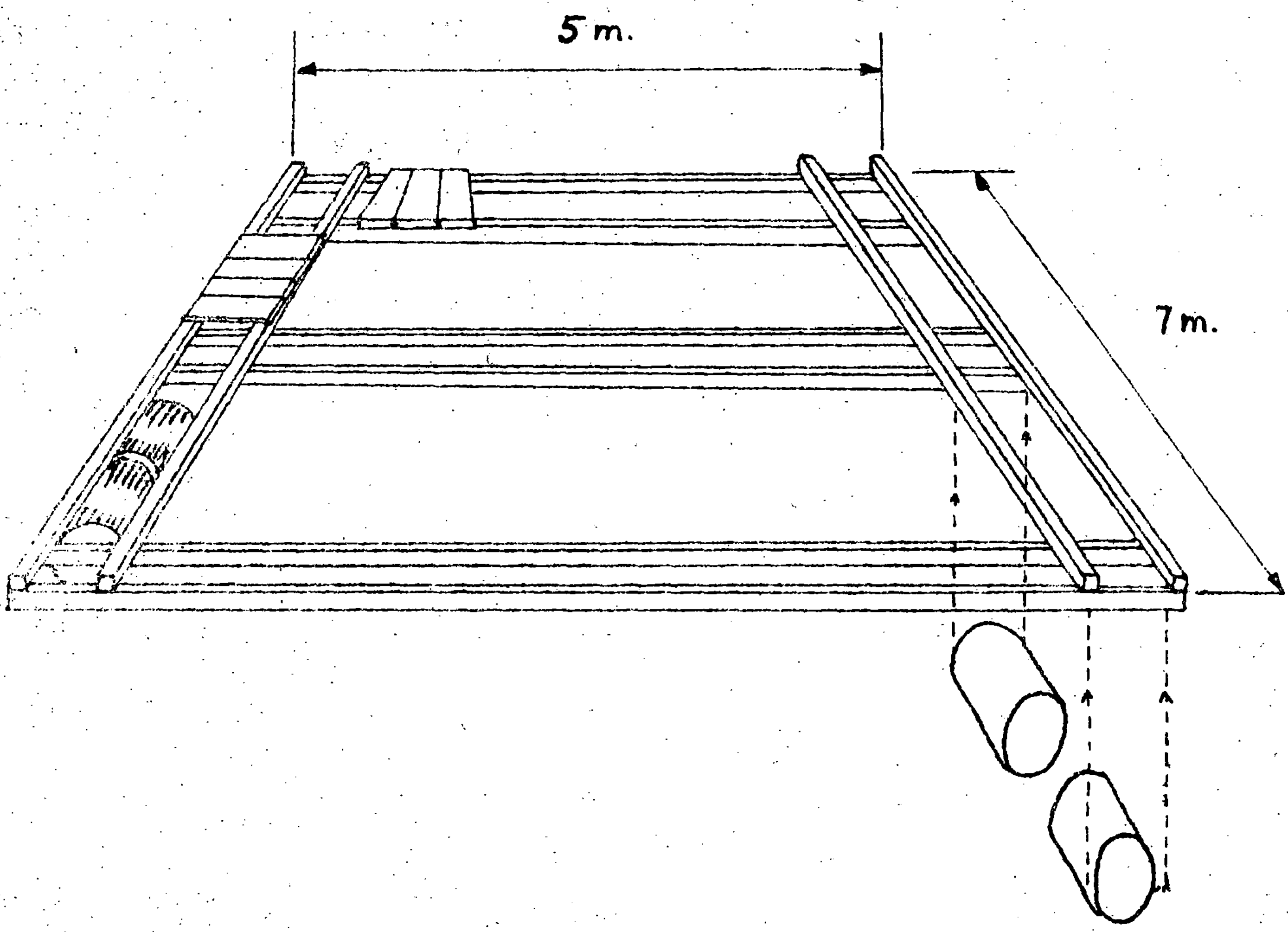

Fig. 1 : Structure de type lagunaire

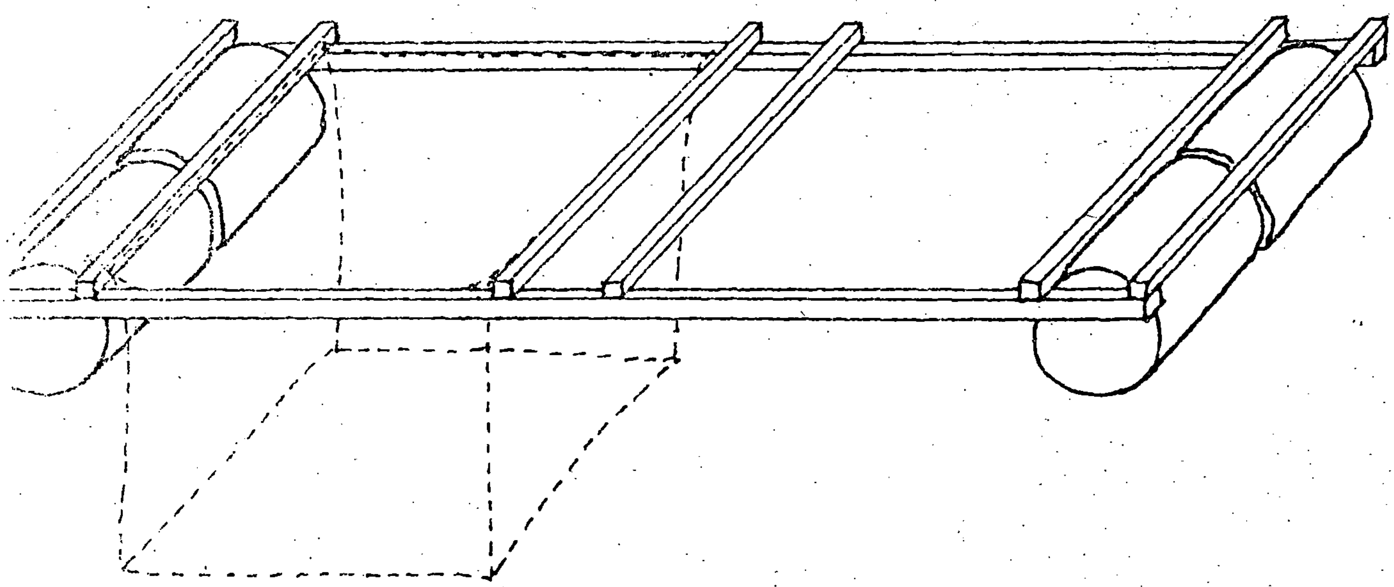

Fig. 2 . : 2ème type de structure avec un filet accroché

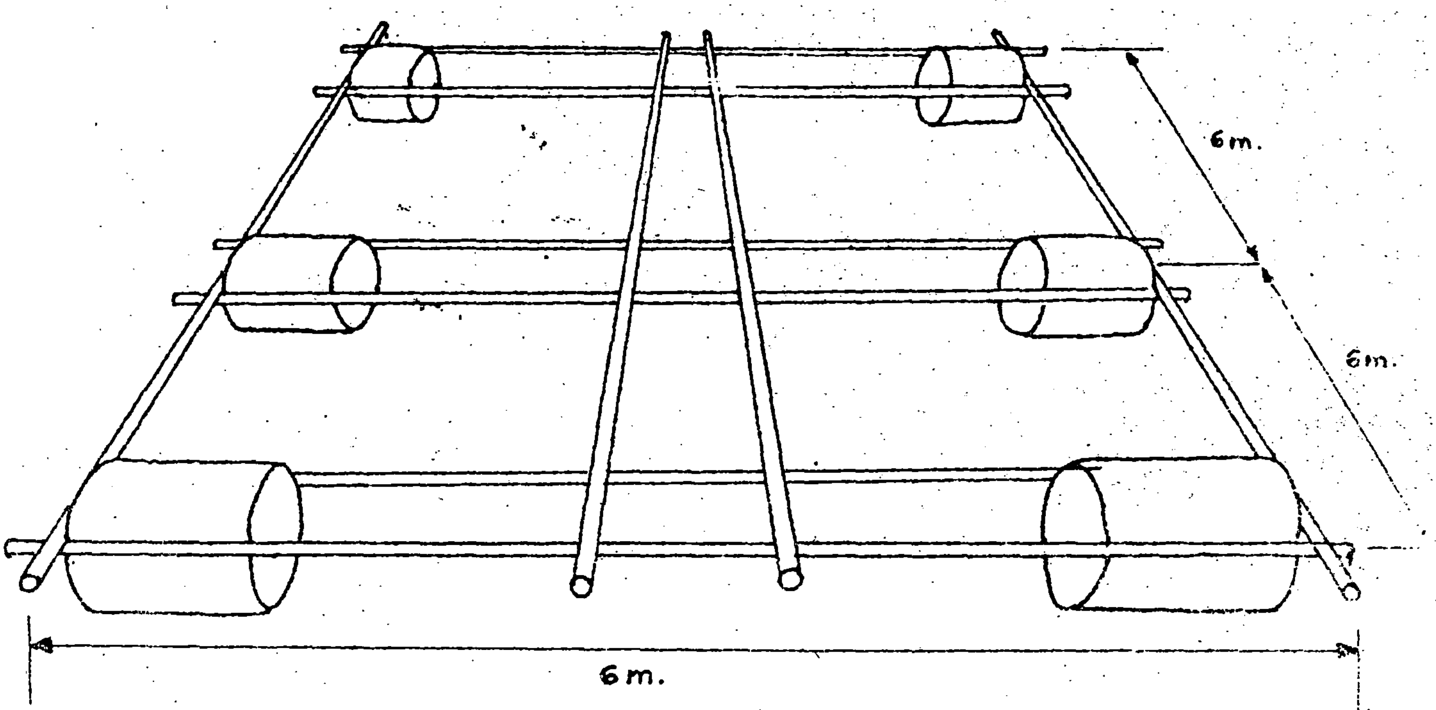

Fig. 3 : 3ème type de structure fait de tuyaux en acier

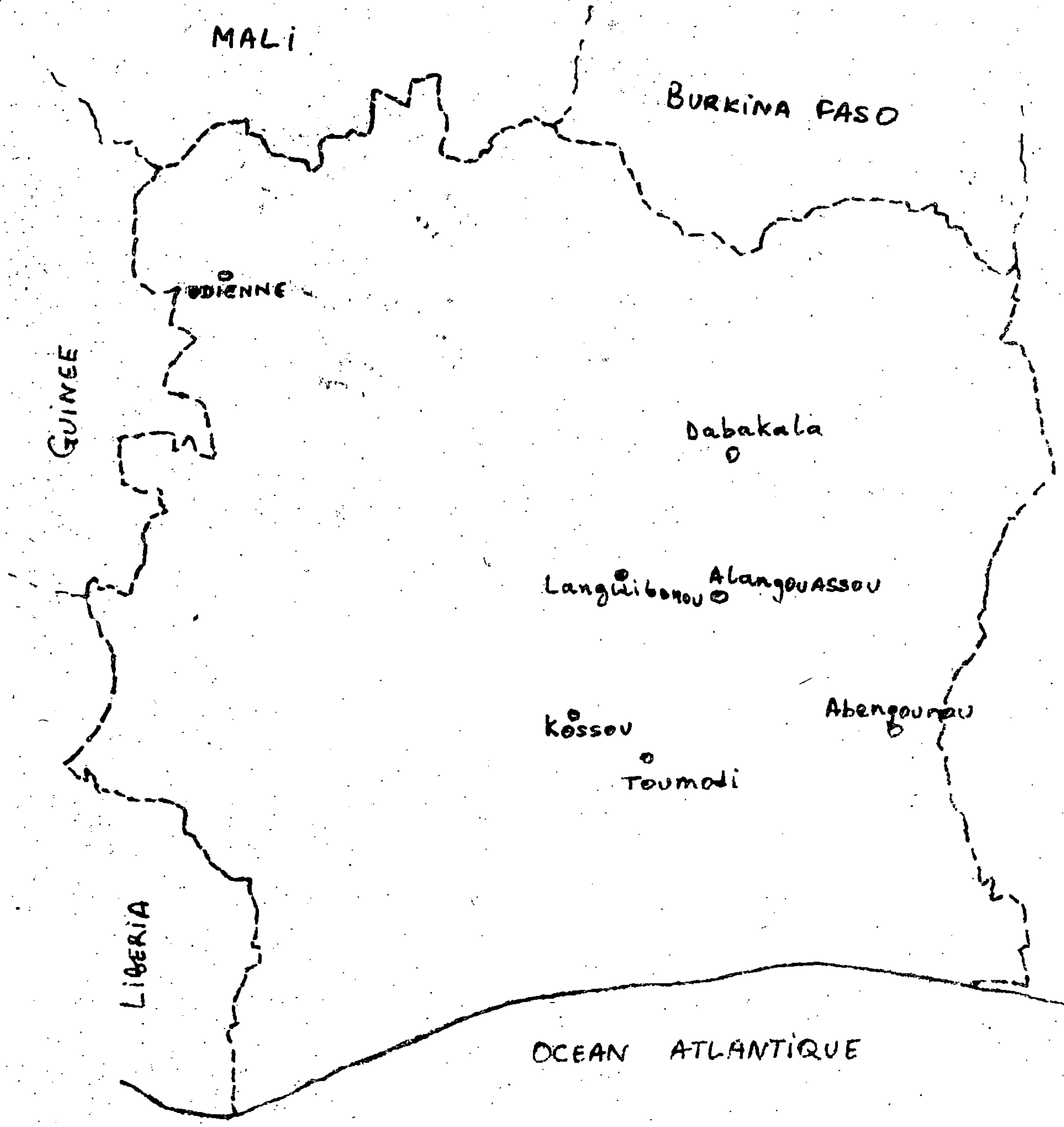

Fig. 4 : Disposition géographique des éléveurs de 1980 à 1985 en Côte D'ivoire

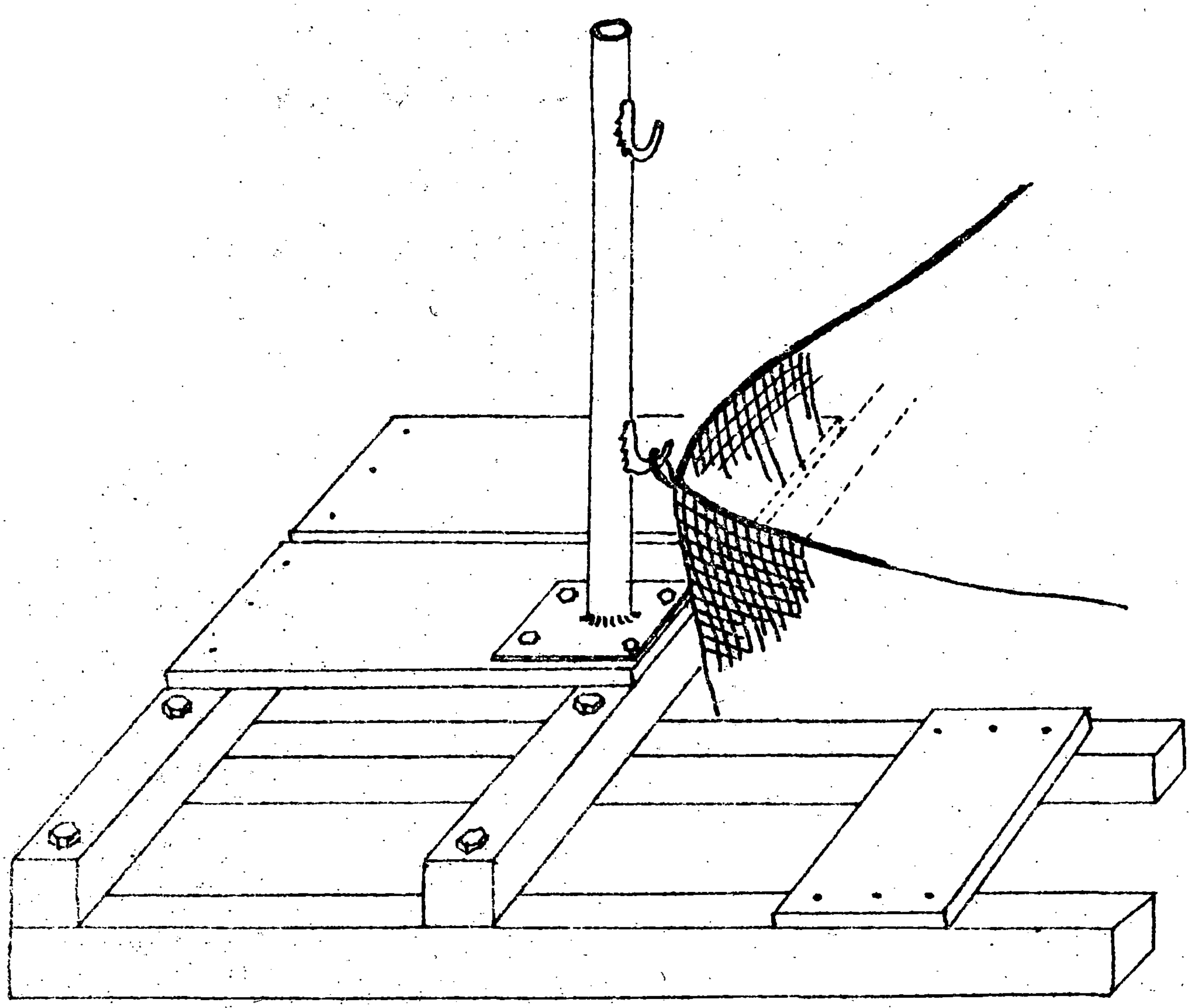

Fig. 5 : Un aspect du type de cage construit à Toumodi avec un système pour accrocher le filet lors des interventions

Summary of "Freshwater Cage Culture in Ivory Coast" by N'Draman Amoikon

Experimental cage culture in fresh waters in Ivory Coast during the 1970's and early 1980's produced promising results, leading to the decision to conduct cage culture extension work as part of the Rural Fish Culture Development Project undertaken by the Ministry of Rural Development with assistance from FAO and UNDP. Three series of experiments are summarised here : those undertaken by Coche on Lac Kossou; those of the Centre technique forestier tropical on rivers; and those of the Rural Fishculture Development Project itself.

Numerous requests have been received from entrepreneurs for assistance with setting up cage culture. However, of the 8 entrepreneurs who have begun cage culture since 1981, six abandoned operations after 1-3 years, most because of financial problems. Only economically better-off individuals have the financial resources to operate cage culture systems.

Several cage designs have been used by entrepreneurs, based on either metal pipe or wood frames and supported by empty barrels for floats. Cost estimates for cage construction are given. Compounded feeds are used by commercial culturists, made up specifically for fish by local companies. Feed costs represent some 60% of operating costs. Data on several commercial culture trials are given but difficulties were experienced in getting detailed data. An economic analysis (based on an application for a bank loan) of commercial cage culture is given, indicating that bank loan can be paid off over three 6-month culture cycles and that a monthly income of 180.000 CFA francs (about US $500) can be realised from 11 cages of $30 m^3$ each once loans are repaid.

Problems experienced with cage culture include a lack of fry of similar sizes (operators are encouraged to produce their own fry but this does not always work out), the high price of feed (simpler feeds possibly subsidised by Government could help) and the lack of technical skills (fish handling; record-keeping; calculation of amounts of feed) and equipment (sorting tables, balances) in personnel working on commercial operations.

LES EXPERIENCES DE CULTURE EN CAGES AU NIGER

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1. LA PRODUCTION DE POISSON ET SON EVOLUTION AU NIGER

1.1 Le réseau hydrographique nigérien

Le réseau hydrographique dont dépend le potentiel halieutique se présente ainsi :

- le fleuve Niger qui offre dans sa partie nigérienne (550 km) une superficie inondable de l'ordre de 63.000 ha (9.000 ha en période d'étiage).
- Le Lac Tchad (310.000 ha) dont les eaux se sont totalement retirées dans la partie nigérienne, obligeant ainsi les pêcheurs à pratiquer l'agriculture,
- la Komadougou Yobé cours d'eau semi-permanent estimé à 600 ha,
- les mares permanentes et semi-permanentes de l'intérieur du du pays estimées à 3.400 ha.
- Les affluents temporaires en provenance du Burkina Faso et du Bénin à savoir le Goroual, la Sirba et la Mékrou 3.600 ha.

La superficie totale de ce réseau était estimée à 400.000 ha il y a de cela une decennie.

A ce réseau, s'ajoutent les plans d'eau artificiels à superficies très variables (Lacs de Barrages) qui constituent des resources potentielles.

1.2 Le milieu pêcheur nigérien (Fleuve Niger)

1.2.1 Population

Les pêcheurs vivent le long du fleuve Niger seuls dans de petits campements ou dans des villages à prédominance agricole. Ils sont généralement isolés, dispersés, très peu alphabétisés et sans couverture sanitaire importante.

Cette population estimée en 1982 à 12.000 personnes ne connait actuellement aucune organisation de type coopératif, l'unité type de production étant la famille composée en moyenne de 10 personnes.

1.2.2 Engins de pêches-embarcations

Les engins de pêches les plus courants sont : les filets maillants, les palangres à hameçons multiples, les filets éperviers individuels, les nasses (grandes et petites).

Les embarcations sont généralement des pirogues en planches planquées de taille petite; il y a lieu de signaler qu'aux fins de l'exportation du poisson fumé, quelques familles disposent de grandes pirogues motorisées.

1.2.3 Revenus des pêcheurs

En 1984-1985 une enquête du Projet Développement Pêches FAO/NIGER indique que l'activité de pêche, si elle n'est pas purement abandonnée, ne procure plus de ressources suffisantes pour l'entretien des pêcheurs et de leurs familles (l'activité de la pêche représente 50,4 % des revenus, l'agriculture 36,5 %, l'élevage 6,1 % et divers 7 %).

1.3 Les périodes de pêche

La pêche sur le fleuve Niger se déroule selon le calendrier suivant :

Mois	Hydrologie	Vies des poissons	Activité de pêche
Octobre - Février (Mouvement des pêcheurs vers le Nigéria pour écouler le poisson fumé)	Hautes eaux	Migration latérale dans les plaines et croissance des jeunes poissons	Peu active
Février - Mai	Décrue	Migration de retour des poissons dans le fleuve	Début de la pêche active
Mai - Juillet	Basses eaux	Concentration et migrations longititudinales des poissons	Pêche très active
Juillet - Septembre	Crue	Reproduction	Pêche réduite

1.4 Quantification de la production de poissons au Niger

La production de poisson au Niger provient essentiellement de l'exploitation par la pêche du Fleuve Niger et très accessoirement des mares du pays.

Elle était estimée à 11.000 tonnes en 1978 conte 3.000 tonnes en 1984 (Service des statistiques, Etudes et documentation de la Direction des Pêches et de la Pisciculture).

La sècheresse persistante que subit le Niger depuis un certain nombre d'années, l'endiguement des zones d'inondation pour la réalisation des aménagements hydro-agricoles aménuisent la production halieutique.

Dans ces conditions, le développement de la pisciculture mérite d'être promu.

1.5 Destination de la production

Une partie très importante de la production au Niger est exportée vers le Nigéria à l'état fumé :

1978 : 5720 tonnes
1984 : 1972 tonnes

Cette baisse des quantités exportées est liée à la diminution de la production nationale du poisson.

1.6 Le prix du poisson

La demande se présente supérieure à l'offre. On assiste alors à une forte spéculation au détriment du consommateur bien sûr. En effet le prix du poisson varie considérablement sur le marché selon l'espèce de poisson, le régime hydrologique du fleuve, la journée (week-end) etc...

1.7 La production de l'Aquaculture

La production artificielle de poisson a été quasiment nulle au Niger jusqu'en 1983. Quelques tentatives timides ayant concerné une dizaine d'étangs ruraux ont été conduites avant 1981, date de démarrage du Projet Pilote de Développement de l'Aquaculture au Niger.

2. LES STRUCTURES D'INTERVENTION DANS LE DOMAINE DES PECHES ET DE LA PISCICULTURE AU NIGER

L'encadrement des pêcheries nigériennes était initialement assuré par l'administration des Eaux et Forêts.

Conscient du rôle appréciable que le secteur des pêches et de la pisciculture peut jouer dans la réalisation de la politique d'auto-suffisance alimentaire nationale le Gouvernement décida en Novembre 1982 (Plan quinquennal 1979-1983) de la réorganisation de l'administration.

Cette réorganisation s'est traduite par la création, sous la tutelle du Ministère de l'Hydraulique et de l'Environnement :

- d'une Direction des Forêts et de la Faune,
- d'une Direction des Pêches et de la Pisciculture à laquelle se trouve rattaché le Projet de Développement de l'Aquaculture.

3. LE PROJET DE DEVELOPPEMENT DE L'AQUACULTURE AU NIGER

3.1 Introduction

Financé par la Caisse Centrale de Coopération Economique et le Fonds d'Aide et de Coopération, le Projet Aquaculture au Niger oeuvre depuis Mars 1981 à la mise au point d'une technique d'élevage intensif du Tilapia nilotica mâle en cages flottantes dans les divers plans d'eau du pays.

Le but recherché est à la fois social par la création d'une activité de substitution pour les pêcheurs confrontés à un épuisement des ressources halieutiques du fleuve, et économique par l'approvisionnement en poissons d'un marché déficitaire.

3.2 Le système de production

Il comprend trois phases d'élevage :

- la production d'alevins de 1 g.
- la production de fingerlings de 5 et 30 g.
- la production de poissons marchands de 200 à 250 g.

Les deux premières phases se déroulent en étangs (station d'alevinage) et la dernière en cages flottantes dans le fleuve Niger.

3.3 Les résultats techniques du Projet

Les deux premières années du Projet ont permis la mise en place des infrastructures d'élevage et le démarrage de la production de poisson marchands.

C'est raisonnablement en 1984 que les premiers résultats significatifs ont été enregistrés.

3.3.1 Production d'alevins en étangs

Elle est réalisée en étangs sur la station d'alevinage de Sona comprenant 34 étangs de 350 m^2 en eau chacun.

La technique ayant donné les meilleurs résultats est la suivante :

- mise en charge des étangs : 60 mâles (150 g) et 180 femelles (100 g), soit 68 géniteurs par are d'étang.
- Alimentation avec un aliment composé farine dosé à 50 % de tourteau d'arachide et 50 % de son de blé. Cet aliment est distribué 6 jours par semaine et deux fois par jour dans des cadres flottants à raison de 10 g/géniteur/jour.
- Récolte des alevins avec une senne (maille de 6 mm). la première pêche a lieu 45 jours après la mise en place des géniteurs et les autres à un rythme régulier de 15 jours (il est important de pêcher un maximum d'alevins).
- Vidange des étangs après 120 jours puis les géniteurs mis en repos. En général, les géniteurs sont renouvelés à partir d'un poids moyen de 400 g.

La production moyenne obtenue dans ces conditions est de 56.000 alevins par étang (pm = 0,8 g) avec un QN de 4,7.

3.3.2 Production de fingerlings en étangs

- Les alevins récoltés sont mis dans des étangs à raison de 20 à 25 par m^2.
- Alimentation 6 jours par semaine et deux fois par jour, les rations étant définies en fonction de la biomasse des alevins :

  pm < 5 g = 15 % de la biomasse

  5 g < pm < 10 g = 6,6 % de la biomasse

  10 g < pm < 20 g = 5,3 % de la biomasse

  20 g < pm < 30 g = 4,6 % de la biomasse

Une pêche de contrôle opérée tous les mois permet de réajuster ces rations alimentaires. L'aliment distribué est pulvérulent et composé de 40 % tourteau d'arachide, 40 % son de riz et 20 % farine de poisson (37 % de proteine). Le sexage intervient dès que les poissons ont atteint 25 - 30 g de poids moyen.

l'élevage de 45.412 poissons donnent (Tableau 2) :

QN = 2,75

Survie = 71,7 %

Croissance = 0,3 g/jour

Rendement = 16 t/ha/an.

3.3.3 Production de fingerlings en cages

Afin d'éviter la fuite des alevins à travers les mailles du grillage, un cycle de prégrossissement jusqu'à 4 g est envisagé. Ce cycle se déroule en étangs sur la station d'alevinage de SONA :

- mise en charge avec 23.000 alevins (densité de 65 à 66 alevins par m^2).
- Alimentation 6 fois par jour avec la même composition que dans le cas de la production de fingerlings en étangs.
- Les rations sont calculées et réajustées en fonction du Tableau 3 excluant la pêche de contrôle mensuelle .
- Les étangs sont fertilisés à l'aide de déchets de contenus de panse de bovins qui subit au préalable une fermentation pendant deux mois. La dose apportée est de 60 kg de matière sèche par hectare et par jour.

Un test portant sur 46.704 alevins montre :

. QN = 2,27

. Croissance = 0,13 g/jour

. Survie =75,8 %

. Rendement =23,1 tonnes /ha/an.

A 4 g, les alevins sont comptés, pesés et mis en cages de prégrossissement ayant un volume de 5 m^3. La poche réalisée avec du grillage Nortène (comme les cages destinées à la production de poissons marchands) de maille 7 mm empêche toute fuite d'alevins de cette taille (4g).

La technique mise en oeuvre à ce niveau est la suivante :

. Mise en charge = 3000 alevins de 4 g par cage (20 à 22 kg/m^3 en fin de cycle).

. Alimentation avec le même que pour le prégrossissement, quatre fois par jour.

Cet aliment est distribué dans des mangeoires sous forme de farine.

. Les rations sont calculées d'après la table suivante :

pm ≤ 5 g = 15 % de la biomasse

5 g < pm < 10 g = 10 % de la biomasse

10 g < pm < 20 g = 8 % de la biomasse

20 g < pm < 30 g = 6 % de la biomasse

Dans ce cas, la pêche de contrôle a bien lieu.

Dans ces conditions, les résultats suivants ont été obtenus :

. QN = 3,4

. Croissance = 0,295 g/jour

. Survie =79,9 %.

3.3.4 La production de poissons marchands en cages flottantes

3.3.4.1 Technologie des cages flottantes

Il s'agit d'un système de cages flottantes qui forme deux trains parallèles arrimés à une plate-forme située en amont. L'unité de base de ce système est constituée par un ponton supportant deux cages de 16 m^3 environ.

- La structure flottante

L'armature est constituée par des chevrons sur lesquels sont fixées des planches en bois blanc qui servent de passerelles et permettent d'effectuer des manipulations autour de la cage. La flottabilité est assurée par des bidons vides plastiques de 30 l.

- La poche immergée

Cette poche est constitueé d'un grillage plastique rigide "NORTENE" choisi pour tenir compte du milieu d'élevage (eaux courantes du fleuve Niger). Deux types de maille 7 et 14 mm sont utilisés correspondant respectivement à la production de fingerlings en cages et de poissons marchands.

Les dimensions d'une poche sont de 3,50 m x 3,50 m x 1,30 m de chute soit un volume de 16 m^3 environ.

3.3.4.2 La technique d'élevage

Pour la production de poissons marchands, d'alevins ou de fingerlings, les résultats à partir desquels les modalités d'élevage au Niger ont été établis proviennent essentiellement de la Côte d'Ivoire Les conditions écologiques étant différentes de celles qui prévalent au Niger, une adaptation constante de ces techniques aux conditions spécifiques du Niger s'impose.

C'est ainsi que le Projet a voulu tester différents facteurs notamment ;

- les densités d'élevage,
- différentes formules alimentaires (en faisant varier le taux d'incorporation de la farine de poissons),
- le taux et la fréquence d'alimentation.

Les cages de 16 m^3 sont mises en charge à partir de fingerlings mâles de 30 g en raison de 2000 poissons soit une densité de 125 mâles par m^3 de cages.

L'alimentation des poissons se fait avec des granulés (Composition Tableau 4). Le calcul et réajustement des rations est mensuel et est fonction de la biomasse mais aussi des conditions du milieu (Tableau 6).

Nota

Le coût de l'aliment comprend les frais de fabrication.

L'existence de deux périodes climatiques au Niger a conduit le projet à effectuer un cycle d'élevage dans chacune de ces saisons :

a) Cycle d'élevage en saison chaude (Mars à Septembre) :

Ce test a porté sur 31.767 fingerlings mâles de 39 g de poids moyen. Les densités ont varié de 75 à 140 par m^3.

Les résultats obtenus sont les suivants :

Nombre de cages	Nombre de poissons	Densité au m^3	Nombre de jours d'élevage	Poids initial en g	Poids final en g	Croissance en g/j	QN	Survie en %
19	31 767	104	202	39	219,4	0,9	2,88	91,3

b) Cycle d'élevage en saison froide (Octobre à Février) :

En 1983, des mortalités très importantes de l'ordre de 60 à 70 % ont été enregistrées dans les cages. Ce test doit permettre d'adapter la technique aux conditions spécifiques de la saison. Il a porté sur 26 687 poissons de 31 g de poids moyen.

Les densités ont varié de 41 à 130 par m^3 et les formules alimentaire citées en 3.342 ont été distribuées.

Les résultats obtenus sur l'ensemble des cages sont résumés dans le tableau suivant :

Nombre de cages	Nombre de poissons	Densité au m^3	Nombre de jours d'élevage	Poids initial en g	Poids final en g	Croissande en g/j	QN	Survie en %
19	26 687	85	177	31,0	67,4	0,31	2,04	90,2

Ces résultats sont très satisfaisants car ils montrent qu'en modulant au plus près le taux et la fréquence d'alimentation en fonction de la température, on peut limiter les mortalités à 10 %.

D'autre part ils permettent de ne pas limiter l'élevage à la seule saison chaude.

c) Conclusions

Les élevages réalisés sur l'ensemble des douze mois de l'année ont porté sur un total de 57.455 poissons, ce qui permet de disposer de résultats représentatifs des possibilités de l'élevage en cages du Tilapia nilotica dans les conditions du Niger.

Le Projet a obtenu également des résultats très groupés sur un ensemble de 38 cages, quelles que soient la formule alimentaire et les densités appliquées.

Cette répétabilité témoignera de la maîtrise et de la fiabilité de la méthode d'élevage mise en oeuvre.

D'autre part, les résultats obtenus en fonction des formules alimentaires utilisées permettent de constater (Tableau 5) :

- que l'incorporation d'un C.M.V. dans l'aliment n'apporte aucun effet positif marquant;
- des effets contradictoires au niveau du taux d'incorporation de la farine de poisson, entre les résultats du cycle de saison chaude et du cycle saison froide.

3.3.5 Le transport des poissons

La maîtrise des techniques de transport des poissons est capitale pour la réussite des opérations de pisciculture. Au Niger, la vulgarisation des techniques d'élevage en cages flottantes suppose que connaissance maximale des normes de transport de poissons, le projet pouvant être amené à livrer à partir de la station d'alevinage, des poissons vivants (alevins ou fingerlings) sur des distances très variables.

Actuellement, deux systèmes sont expérimentés par le Projet correspondant à deux catégories de poissons :

- Alevins jusqu'à 15 g :

Le transport se fait en sacs plastiques, sous oxygène, placés dans des caisses individuelles (0,4 x 0,4 x 0,6 de hauteur).

La norme appliquée est de 1 kg de poisson pour 6 litres d'eau.

Après le transport de 20.272 alevins de 4 à 5 g, la mortalité relevée a été de 207 alevins soit 1,02 %.

- Fingerlings de 15 à 30 g :

Le transport s'effectue dans une caisse oxygènée d'une capacité de deux compartiments de 300 1 chacun.

La technique est la suivante :

. 1 kg de poisson pour 5 litres d'eau;

. Dilution de phénoxy-éthanol dans l'eau à raison de 0,1 ml/litre d'eau;

. Maintien du taux d'oxygène dissout,voisin de 7 mg par litre.

Dans ces conditions le projet a transporté 24.160 fingerlings en 1984 avec une mortalité de 1,5 % à la mise en charge.

3.3.6 Les périodes d'alevinage au Niger

Pour l'alevinage, les périodes caractérisées par une instabilité thermique ne sont pas favorables pour le *Tilapia nilotica*. En effet, des alevinages réalisés par le projet en mars-avril et octobre-novembre ont enregistré des mortalités de 25,8 et 42,2 %.

3.4 Conlusion générale : les perspectives du Projet.

Les résultats aussi bien techniques qu'économiques obtenus en première phase du Projet permettent une diffusion de l'activité d'aquaculture du moins dans la vallée du fleuve Niger.

C'est ainsi que le Projet, dans le cadre de sa poursuite, se propose les orientations suivantes :

1°) vulgarisation de la technique mise au point dans la zone fluviale. Etant donné les contraintes liées à la nature de l'élevage proposé, une prudence particulière sera volontairement observée afin d'assurer une base solide pour la promotion sûre de cette activité. A cet effet des visites de sensibilisation des stations du Projet par les pêcheurs ont été organisées. Mieux, un test de prévulgarisation qui concerne trois pêcheurs est en cours.

Les objectifs essentiels de ce test sont :

. Provoquer la réaction des pêcheurs vis à vis de l'élevage de poissons et ainsi mieux appréhender les problèmes d'approche et de communication qui pourront se poser,

. recenser les problèmes techniques et humains qui pourraient apparaître dans un cadre de vulgarisation,

. d'obtenir un compte d'exploitation réel sur un ensemble de cages de production.

. de mettre au point un modèle simplifié de gestion technique des élevages.

2°) Adaptation de la technique aux plans de l'intérieur du pays (lacs de barrages et mares).

3°) Recherche d'accompagnement à la vulgarisation : il s'agit là de poursuivre les recherches au niveau de la station de cages flottantes afin d'améliorer les acquis techniques.

4°) Pour le moment les objectifs de production étant très limités en vulgarisation, le projet envisage d'encourager les initiatives d'aquaculture privée, réduisant ainsi le déficit actuellement très important entre l'offre et la demande en poissons.

Tableau 1 - PRODUCTION D'ALEVINS - STATION DE SONA

Etang	Nombre de géniteurs		Poids moyen des géniteurs		Jours élevage	Nombre de ré-coltes	Nombre alevins récoltés	Poids alevins récoltés (kg)	Poids moyen alevins (g)	Fingerl. récoltés à la vidange (kg)	Aliments distr. (kg)	Q.N alevin	NAFS
	M	F	M	F									
A 2	53	180	268	102	119	6	63.903	47,3	0,74	8,0	238,5	4,3	20,9
B 6	55	200	263	73,5	119	6	31.600	41,0	1,30	5,5	240,0	5,2	9,3
A 10	55	180	323	158	143	7	58.740	45,8	0,78	10,4	279,5	5,0	16,0
B 10	53	180	310	158	143	7	55.030	52,9	0,96	8,8	279,5	4,5	15,0
B 15	63	200	206	100	119	6	68.539	45,7	0,67	6,3	236,0	4,5	20,2
A 16	70	200	253	102	119	6	58.094	40,3	0,69	6,2	236,0	5,1	17,1
T O T A L							335.906	273	0,81	45,2	1.509,5	4,7	16,2

$$\text{Q.N alevin} = \frac{\text{Poids d'aliment distribué}}{\text{Poids des alevins et fingerlings récoltés}}$$

$$\text{N.A.F.S.} = \frac{\text{Nombre d'alevins cumulés récoltés x 7}}{\text{Nombre de jours d'élevage x nb. de F.}} = \text{Nombre d'alevins par femelle et par semaine}$$

Tableau 2 – PRODUCTION DE FINGERLINGS EN ETANG – STATION DE SONA

Etang	Mise en charge		Vidange		Nombre jours élevage	Biomasse produite (kg)	Quantité aliments distribués (kg)	Q.N	Vitesse croissance (g/j)	Survie (%)	Rendement t/ha/an
	Nombre	Poids moyen (g)	Nombre	Poids moyen (g)							
A 2	6.000	2,9	3.719	28,4	67	88,2	209	2,37	0,38	62	13,7
B 6	7.862	2,7	4.512	26,2	76	96,9	293	3,02	0,31	57,4	13,3
B 7	6.700	1,4	4.613	26,1	72	110,7	332	2,99	0,34	68,8	15,7
A 8	7.950	2,1	5.930	24,7	68	129,9	312	2,40	0,33	74,5	19,5
B 8	8.800	2,3	6.490	16,9	67	89,5	307	3,43	0,22	73,7	13,6
B 9	8.100	2,3	7.292	19,2	65	121,4	297	2,45	0,26	90,0	19,1
MOY	7.569	2,28	5.426	22,76	69	106,1	291,7	2,75	0,30	71,7	16,0

Tableau 3 - TABLE D'ALIMENTATION POUR ALEVINS DE 0,2 G A 4 G
(STATION DE SONA)

Nombre de jours	Poids moyen initial													
	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0/1,1	1,2/1,3	1,4/1,6	1,7/1,9	2,0/2,3	2,4/2,9
1 - 7	0,030	0,045	0,060	0,075	0,090	0,105	0,120	0,135	0,137	0,163	0,195	0,234	0,215	0,260
8 -14	0,135	0,130	0,143	0,156	0,169	0,182	0,195	0,217	0,228	0,254	0,220	0,250	0,285	0,264
15-21	0,208	0,220	0,234	0,247	0,260	0,210	0,220	0,230	0,245	0,265	0,290	0,256	0,284	
22-28	0,230	0,240	0,250	0,260	0,270	0,280	0,290	0,240	0,252					
29-35	0,240	0,250	0,260	0,264	0,272	0,280								

ableau en rations journalières en gramme/jour/poisson

Tableau n° 5 - Influence de l'aliment sur les performances d'élevage

Type de l'aliment	Nombre de cages	Nombre de poissons	Densité moyenne au m³	Nombre de jours d'élevage	Poids moyen initial	Poids moyen final	Croissance moyenne	Quotient nutritif	Survie en %
Saison chaude									
(1)	7	11.218	100	211	40,7	224	0,67	3,15	89,2
(2)	3	5.973	124	189	50,3	231	0,96	3,12	92,5
(3)	6	9.859	103	197	33,3	223	0,96	2,58	94,5
(4)	3	4.717	98	205	32,9	202	0,82	2,66	92,7
Saison froide						(*)			
(1)	3	4.216	88	126	31,5	77,8	0,37	1,76	90,5
(2)	2	2.881	90	117	34,6	69,7	0,30	2,00	87,4
(3)	3	4.226	88	124	32,85	76,7	0,35	2,02	91,5
(4)	3	4.223	88	98	30,97	52,42	0,22	2,27	93,4
(5)	4	4.811	75	116	26,56	62,37	0,31	2,00	89,3
(6)	4	5.330	83	122	31,1	67,4	0,30	2,29	88,7

(*) Il s'agit ici des poids moyens au 27 mars 1985.

Tableau 6 : Alimentation des poissons à Kokomani (1984)

Taux et fréquence d'alimentation pendant la saison chaude

- Table d'alimentation

  30 < pm < 150 g = 3 % de la biomasse

  150 < pm < 200 g = 2,5 % de la biomasse

  200 < pm = 2 % de la biomasse.

- Heures d'alimentation

  9 h / 11 h 30 / 14 h / 16 h 30

Taux et fréquence d'alimentation pendant la saison froide

- Poissons de poids moyen > 150 g

24°C > t > 22°C = 70 % de la ration alimentaire journalière normale
3 alimentations par jour (9 h / 11 h 30 / 14 h)

22°C > t > 20°C = 60 % de la ration alimentaire journalière normale
2 alimentations par jour (11 h 30 / 14 h)

20°C > t = 40 % de la ration alimentaire journalière normale
2 alimentations par jour (11 h 30 / 14h)

- Poissons de poids moyen < 150 g

24°C > t > 22°C = 70 % de la ration alimentaire journalière normale
3 alimentations par jour (9 h / 11 h 30 / 14 h)

22°C > t > 20°C = 50 % de la ration alimentaire journalière normale
2 alimentations par jour (11 h 30 / 14 h)

20°C > t = 30 % de la ration alimentaire journalière normale
2 alimentations par jour (11 h 30 / 14 h)

CAGE CULTURE EXPERIMENTS IN NIGER

Idrissa Ali

English Summary

In Niger, capture fisheries are practised in the Niger River, Lake Chad (the Niger part of which is currently dry) and several smaller seasonal or permanent water bodies. Catches declined from 11000 t in 1978 to 3000 t in 1984 due to drought; exports (mainly to Nigeria) also declined from 5720 t to 1970 t in the same period. Fisheries are seasonal, with peak catches at low water in the Niger (May - July).

The Niger Aquaculture Project, funded by the Caisse Centrale de Coopération Economique and the Fonds d'Aide et de Coopération (France) has been studying development of intensive T. nilotica culture in floating cages since 1981. Production is in three phases: fry, 1 g (ponds); fingerlings 5 - 30 g (cages or ponds); market fish 200 - 250 g (cages). Following two years of setting up of systems, results began to be produced in 1984. Fry are produced in 34 ponds of 350 m^2 each at Sona using techniques discussed in the paper; annual production is 56,000 fry per pond. Fingerlings in ponds grow on average 0,3 g/d on feed of groundnut cake (40%), rice bran (40%) and fish meal (20%) and are sexed at 25 - 30 g. Fingerlings are also produced in cages within the Sona ponds, in two stages (1 - 4 g; 4 - 30 g), using the same feed 4 - 6 times per day. Growth is 0.13 g/d to 4 g, 0.3 g/d to 30 g. Male tilapias are grown to market size in "Nortene" plastic mesh cages (16 m^3 volume) in the Niger River. Production trials in the warm season (March - September) gave growth of 0,9 g/d over 202 d at a density of 100 fish/m^3, using feed whose composition is given in the paper. On an initial trial, cool season (October to February) mortalities were 60 - 70%, but these were later reduced to 10% by reducing feeding. Growth was 0,3 g/d over 177 d at a density of 85/m^3. Fry mortality is high (25 - 40%) at seasonal changeover (March - April and October - November). The Project plans to continue with extension of the methodology to fishermen, adaptation of the technique to standing waters (seasonal lakes, reservoirs) and further research.

Large Scale Cage Farming of Sarotherodon niloticus

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Results from commercial cage farming of S. niloticus in the Ivory Coast over one year are given. An efficient means of rearing large numbers of Tilapia fry and fingerlings is described. Fry production from ponds was 4083 kg of fish averaging 1.7 grams. 30.7 metric tons of fish weighing 14 grams mean weight were produced in 110 3 m^3 fingerling cages. Using 8500 m^3 of rearing cages, over 200 tons were harvested. Mortality in the fingerling cages was 12.93 % and 11.8 % in rearing cages. Using a pelleted feed with 28 % protein, food conversions were 1.75 with fish to 14 g mean weight, and 2.23 to harvest. For increasing mean population weight, minimum and maximum feed rations and corresponding growth for the fish are given. A table of size distribution is presented to facilitate intermediate sorting.

Ce document, qui a été présenté lors de l'Atelier, est publié dans la revue Aquaculture 48 : 57 - 69 (1985). On a reproduit le Résumé avec la permission des éditeurs.

Résumé

Les résultats d'un élevage commercial en cages du S. niloticus en Côte d'Ivoire, pour une période d'un an, sont décrits. Des méthodes efficaces de production en masse d'alevins et de fingerlings de Tilapia sont détaillées. La production d'alevins dans les étangs a été de 4083 kg de poisson, d'un poids moyen de 1.7 gm. On a produit 30.7 t de fingerlings d'un poids moyen de 14 gm dans 110 cages d'un volume individuel de 3 m^3, et plus de 200 t de poisson marchand dans 8500 m^3 de cages. La mortalité lors de la production de fingerlings a été de 12.93 % et lors de la production de poisson marchand, de 11.8 %. En utilisant un aliment en granulé de 28 % de protéine, on a réalisé un quotient nutritif de 1.75 pour la production de fingerlings de 14 gm, et un QN de 2.23 pour la production de poisson marchand. Les rations journalières minimales et maximales, et les taux de croissance correspondants, sont détaillés en fonction de la taille moyenne de la population d'une cage. Un tableau de la distribution des tailles est présenté dans le but de faciliter le tri des poissons à des étapes intermédiaires.

LA PISCICULTURE EN CAGE AU TOGO

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1)- INTRODUCTION

Situé dans l'hémisphère nord, la République Togolaise s'étire entre le 6è et 11è degré de lattitude sur une longueur de 600 km, et entre 0° et 1,5° de longitude Est. Elle est baignée par l'Océan Atlantique sur une largeur d'environ 50 km.

Au Togo, le poisson entre pour près de 50 % dans la consommation de protéines d'origine animale bien que sa contribution per capita soit faible (environ 9 kg/habitant/an).

La production nationale est faible par rapport aux besoins de consommation. Pour pallier le déficit, le Togo a recours aux importations de poissons et autres produits de pêche.

Cependant, le Togo dispose d'atouts en eaux continentales que l'on peut exploiter rationnellement pour réduire voire supprimer le déficit.

Le projet de pisciculture en cage initié et financé conjointement par le Centre de Recherches pour le Développement International (C.R.D.I.) et la République Togolaise veut apporter sa contribution à la résolution des problèmes d'approvisionnement en poissons dont souffre le pays et se propose de promouvoir le développement et la vulgarisation en milieu paysan de la culture en cage.

2)- Programme de recherche du projet

Le projet de pisciculture en cage se propose :

- d'assurer la production d'alevins
- d'étudier le comportement des alevins mis en cage
- de concevoir et adapter différentes sortes de cages selon les matériaux disponibles localement
- d'étudier les densités de stockage et tester les formules alimentaires à base de sous-produits locaux, etc...

3)- Les composantes du système

3.1. Zones d'implantation

Le projet initialement devait utiliser tous les plans d'eau existants qui disposent d'au moins 2 m de profondeur. Mais, pour certaines contraintes, il s'est circonscrit à trois (3) points à savoir la Lagune de Lomé, le Lac Togo et le Barrage de Notsè. Les caractéristiques générales de ces plans d'eau sont les suivantes :

Lagune de Lomé (faiblement saumâtre)

p^H = 9,5

Salinité 2,5 g/l

Conductivité 5.500 mho. cm^{-1}

Une particularité de la Lagune de Lomé est qu'elle reçoit beaucoup d'eaux usées domestiques. De ce fait elle est très productive comme l'atteste sa couleur verte permanente. Cette haute productivité est sans doute à l'origine de la bonne croissance sans nourriture observée durant les expérimentations. Ce qui n'est pas le cas du Lac Togo et du Barrage de Notsè où la croissance a été très mauvaise.

Lac Togo

p^H = 8,45

Salinité inférieure à 0,5 g/l, mais à certaines périodes, la salinité augmente jusqu'à 12,8 g/l.

Conductivité 1.800 mho. cm^{-1}

Barrage de Notsè

p^H = 7,6

Salinité nulle

Conductivité 150 mho. cm^{-1}

3.2. Les cages

Les cages sont construites avec des nappes de filet 210/48, sans noeud, de 16 mm de maille de côté. Elles ont une forme rectangulaire. On distingue :

- des cages semi-commerciales dont le volume utile est de 18 m3

  4 m x 3 m x 1,5 m soit 18 m3

  et des cages expérimentales 2 m x 2 m x 0,5 m = 3 m3

Les nappes de filet sont importées.

Les supports flottants sont en bambous, matériaux disponibles au Togo, et construits selon une architecture particulière. (voir photo)

On a également essayé le raphia mais sa durée de vie est inférieure à celle du bambou. Les cages construites avec ce matériel sont difficilement manipulables.

3.3. Espèces en culture

L'espèce cultivée est du genre Tilapia.

Les premières expériences ont porté sur *T. heudeloti* et *T. zilli*. Les résultats ont été mauvais. On a alors choisi *Tilapia nilotica* qui a donné une meilleure croissance avec ou sans nourriture.

3.4. Production d'alevins

Les alevins sont produits en étang. La station d'alevinage est à 160 km de Lomé, 195 km du Lac Togo et 90 km de Notsè. Cette situation rend les problèmes d'empoissonnement plus ardus malgré les moyens dont dispose le projet (transport sous oxygène). Compte tenu du nombre important d'alevins que nécessite le projet, le nombre d'étangs disponibles est insuffisant pour couvrir les besoins en alevins. La superficie totale des étangs est de 11 ares.

Les étangs d'alevinage devraient être construits près des lieux d'expérimentation en vue de minimiser les mortalités.

3.5. Alimentation

La pisciculture en cage étant réalisée en milieu clos qui limite les aptitudes à la recherche de nourriture des poissons, une alimentation d'appoint doit être distribuée. Au Togo, on utilise des sous-produits agricoles locaux et on a adopté suivant les 2 périodes du projet, deux types d'aliment.

- 1ère période Fév. 81 - Avril 82

Tourteau d'arachide	30 p.100
Graine de coton	20 p.100
Son de riz	25 p.100
Son de blé	15 p.100
Drèche de bière	10 p.100

La teneur en protéine est de 23 p.100

- 2ème période Avril 82 - Déc. 1984

Maïs blanc	25 p.100
Son de mil	25 p.100
Farine de poisson	15 p.100
Tourteau de coton	30 p.100
Fécule de manioc	5 p.100

La fécule de manioc sert de liant pour les différents ingrédients. La teneur en protéine de cet aliment est estimée à 34,4 p.100. Le coefficient de transformation est de 2,9 à 3,4.

L'aliment est présenté sous la forme d'une boule.

4. Expérimentation et résultats

On distinguera deux périodes dans le projet qui correspondent aux 2 phases d'expérimentations effectuées.

4.1. 1ère période - Fév.1981 - Avril 1982

Les premiers essais ont été effectués à Agbodrafo, (Lac Togo) et à la Lagune de Lomé.

Les *Tilapia heudeloti* et *T. zilli* étaient les espèces cultivées. L'empoissonnement a été réalisé à un poids moyen de 24-30 grammes.

Les alevins étaient pêchés à l'épervier dans les plans d'eau et remis dans les cages. Les mortalités étaient importantes et dues aux manipulations excessives.

Les cages étaient totalement immergées.

En général, le Tilapia heudeloti et le Tilapia zilli ont une très mauvaise croissance en cage. Ce qui a amené à changer d'espèce.

2ème période - Avril 82 - Déc. 1984

On a apporté au cours de cette période, des modifications à la configuration de la cage et les expériences ont porté sur Tilapia nilotica.

La cage comporte deux parties :

- une partie immergée et une autre émergée qui sert d'antichambre aux poissons.

Le volume utile de cage est de 18 m3.

Les empoissonnements sont réalisés avec des alevins produits en étangs et transportés vers les cages avec beaucoup de précautions.

Etude de la densité de stockage

Lagune de Lomé

Trois (3) cages expérimentales de 3 m3 furent empoissonnées avec des fingerlings de T. nilotica de 24-30 g de poids moyen au taux de 10,25 et 50/m3 et ne sont pas nourris. Après un mois, le gain de poids était dans les cages de

10/m3	0,83 g/j
25/m3	0,45 g/j
50/m3	0,98 g/j

Mais on a perdu les résultats de l'expérimentation à la suite d'un vol.

On a également entrepris la production d'alevins dans les happas. Quatre (4) cages ont été construites en toile moustiquaire et empoissonnées aux densités de 2 femelles pour 1 mâles, 3 femelles pour 1 mâle, 4 femelles pour 1 mâle et 5 femelles pour 2 mâles.

Après un mois, la cage comportant 2 femelles et 1 mâle a donné 242 alevins.

Barrage de Notsè

On a répété l'expérience à Notsè avec 4 cages expérimentales d'un volume de 3 m3. Elles étaient empoissonnées avec des fingerlings d'un poids moyen compris entre 24-30 g au taux de 10, 25, 40 et 50/m3. Les poissons n'étaient pas nourris. La croissance fut mauvaise. La productivité de ce plan d'eau est faible, ce qui explique les mauvais résultats enregistrés.

Relation taille-poids observée dans les cages semi-commerciales.

Les expériences ont été menées de Sept.1982 à Mars 1983.

Densité de stockage = 75 p/m3

Taille (en cm	Poids (g)
12	32,5
13	43
14	50
15	65
16	80
17	95
18	105
19	125
20	146
21	170
22	180
23	210

La relation est de la forme

$$W = a L^{b}$$

W = poids moyen individuel
L = longueur
a et b sont les constantes caractérisant la relation.

$$W = 0,03 \, L^{2,87}$$

Production

Pour une cage semi-commerciale, avec un taux d'empoissonnement de 75/m3, on a besoin de 1.500 alevins. Le poids moyen étant de 24 g.

Poids à l'empoissonnement

24 g x 1.500 = 36.000 g ou 36 kg

Poids à la récolte = 186,5 kg

Le ratio de croissance = 1 : 6

Poids moyen individuel = 140 g.

Prix de vente moyen = 500 F/kg

Revenu : 186,5 x 500 = 93.250 F

Investissement = 60.000 F

Bénéfice = 33.250 F

Les trois (3) zones d'expérimentation : Lomé, Agbodrafo et Notsè disposent d'un marché où l'on peut vendre à 500 F/kg et même plus. Les produits sont vendus frais.

C O N C L U S I O N

La culture en cage *T. nilotica* est possible.

Relation âge-poids dans les cages semi-commerciales

Mois d'expé-rimentation.	1	2	3	4	5	6
Taille (cm)	10	15	18	20	22	23

Analyse coût-bénéfice (Année 1983)
(cage semi-commerciale de 24 m3)
Période d'élevage - 6 mois

Article	Coût par cage	Durée de vie	Coût/6 mois
1) Filet pour cage	41.000	5 ans	4.100
2) Ficelles et corde	4.000	3 ans	666
3) Clous	15	2 ans	4
4) Bambous	15.000	1 an	7.750
5) Bateau	70.000	5 ans	7.000
6) Bassins, seau, épuisette.	4.000	2 ans	1.000
7) Médicaments	-	-	-
8) Alevins	22.500	0,5 an	22.500
9) Nourriture	-	-	24.000
Total	156.500		60.000

Prix d'alevin = 15 F.CFA
Poids d'un alevin = 24 g
Densité de stockage = 75 al/m3

Les contraintes

a)- Production insuffisante d'alevins

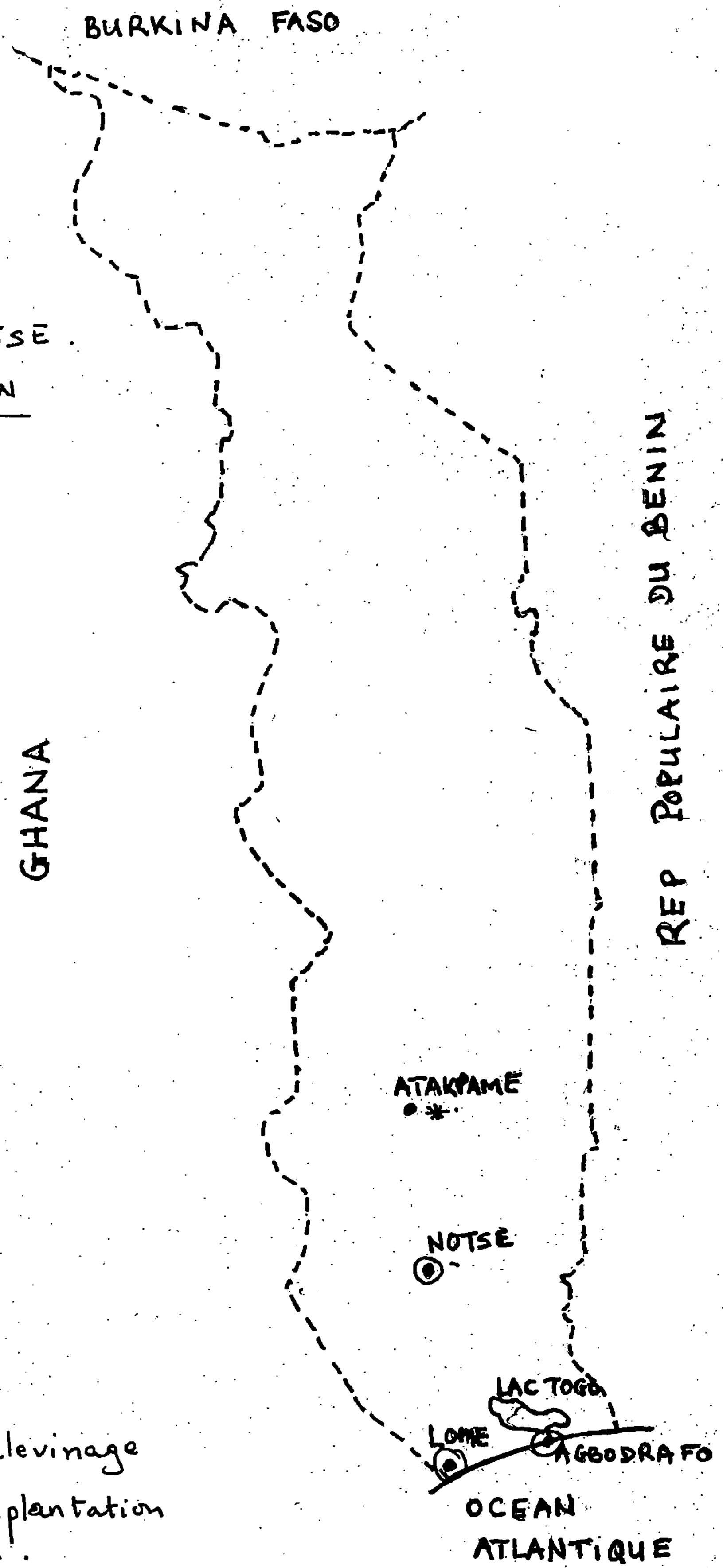
b)- Transport des alevins

c)- Mortalités à l'empoissonnement.

REMERCIEMENTS

Nous tenons à remercier très vivement MM. John Sollows et Stuart Davies, consultants, pour leurs conseils tout au long de ce projet.

REPUBLIQUE TOGOLAISE.
SITES D'IMPLANTATION
DES CAGES



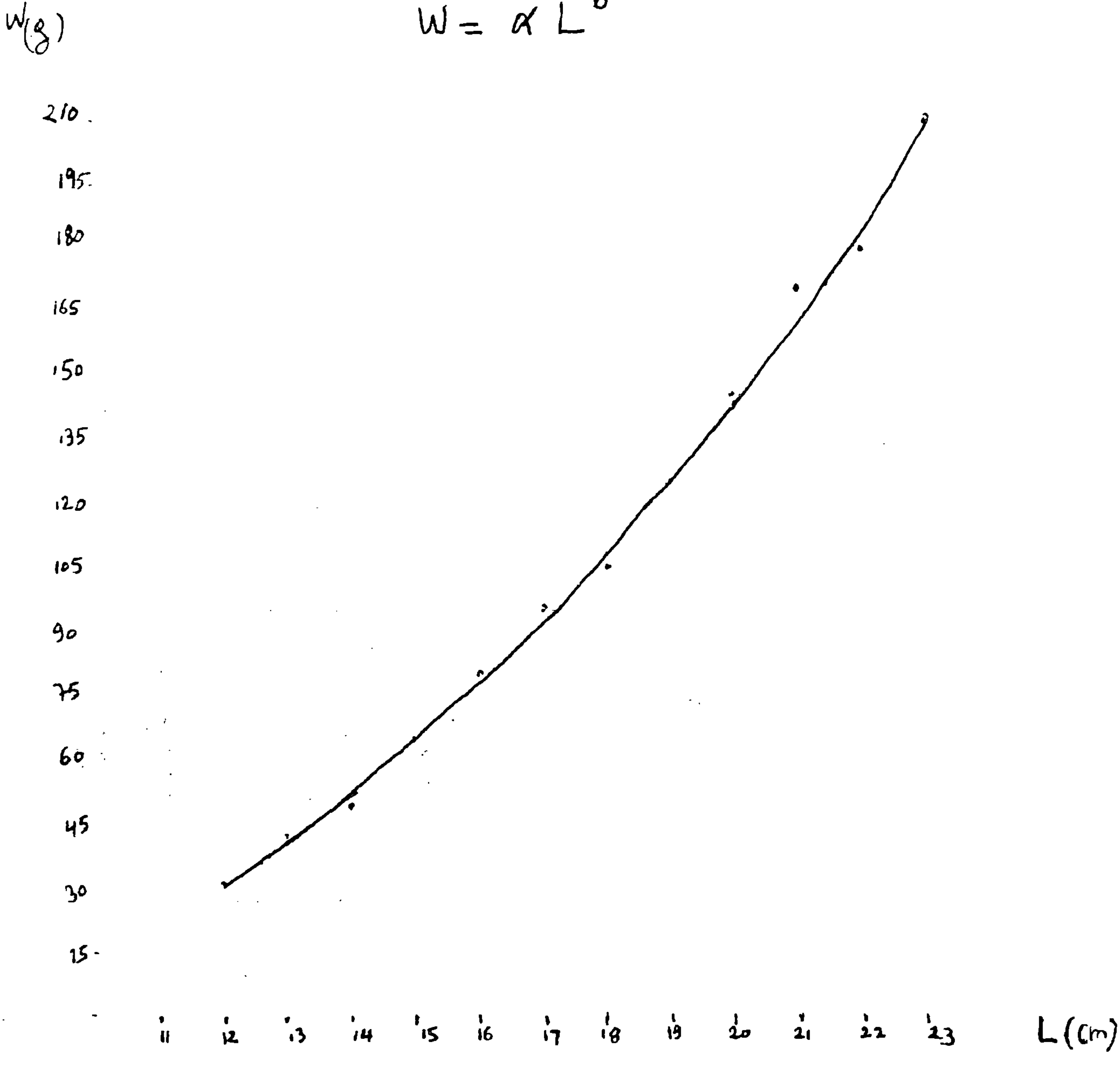
LEGENDE

* Station d'alevinage

⊙ Sites d'implantation des cages.

courbe reelle

$W = \alpha L^b$

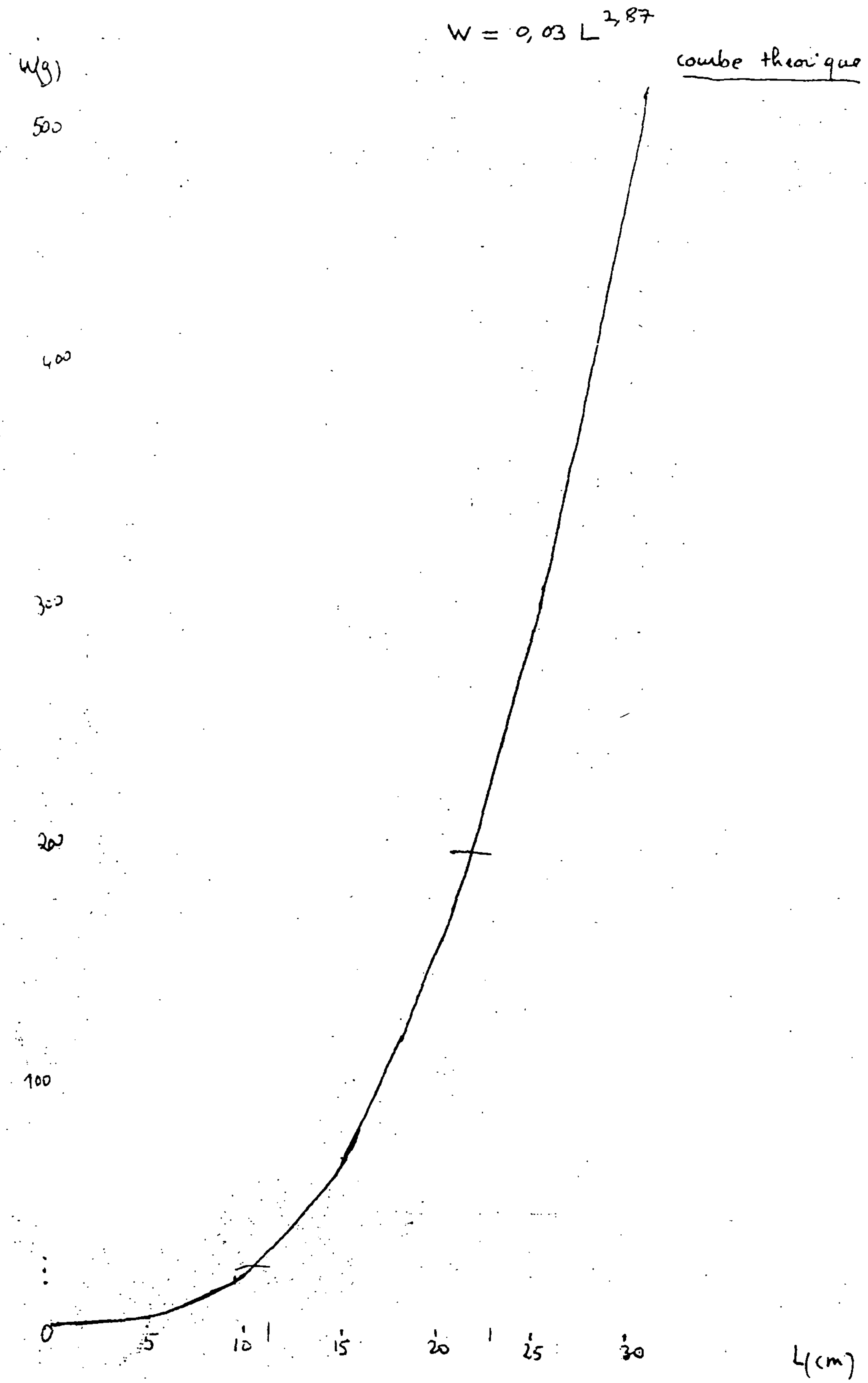


$a = -1{,}547450349 \Rightarrow \alpha = \text{antilog } a = 0{,}02884 \simeq 0{,}03$

$b = 2{,}86995563$

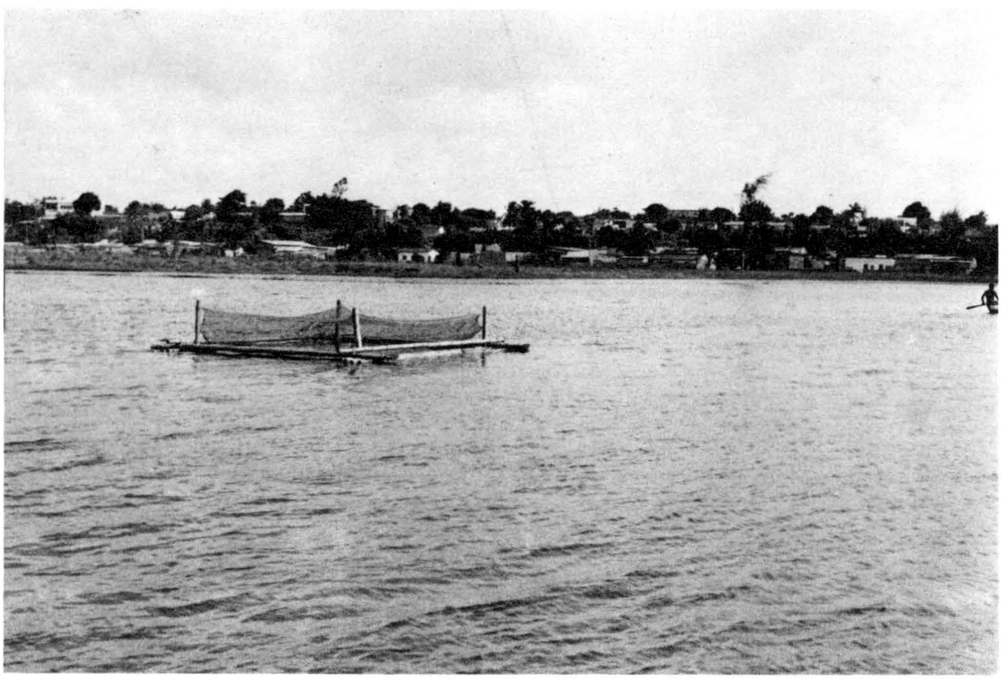
$r = 0.997796929$

$$W = 0{,}03\, L^{2.87}$$



W = 0,03 L^2,87
courbe théorique
W(g)
500
400
300
200
100
0
5
10
15
20
25
30
L(cm)

1. Mise en eau d'une cage semi-commerciale. Lagune de Lomé.



2. Cage mise en place. Lagune de Lomé.

Summary : Fish Culture in Cages in Togo - Issifou and Amégavie.

Fish represents some 50% of available animal protein in the average diet in Togo, although annual per capita consumption is low at 9 kg. Much fish is imported to supplement low national production.

The cage culture research project was designed to ensure fry production; to study behavior (growth, mortality etc.) of fish in cages; to develop cage designs based on local materials; to study stocking densities, feed formulation and other aspects of a cage culture system.

Experiments were conducted at three sites : Lomé Lagoon (low salinity 2.5 ppt., high productivity because of domestic waste disposal), Lake Togo (salinity variable 0,5 - 12,5 ppt); Notsé Reservoir (fresh water). Two types of cages were developed both using imported netting and bamboo for struture and flotation-a semi commercial cage of volume $18m^3$ and an experimental cage of $3m^3$.

Early trials with Tilapia heudelotii and Tilapia zillii gave poor growth results and later experiments focussed on Tilapia nilotica. Fry were produced at a station some distance from experimental sites and difficulties were experienced with transport mortality. Two types of feed were used, compounded from agricultural by products, one with 23% protein, the other with 34%. The latter included a small amount of fish meal and gave FCR's of 2,9 -3,4. Growth in Lomé Lagoon was 0,5 - 1,0gm/day without supplemental feed at densities of 10 - $50/m^3$ but this was for a short period as a theft occured. In Notsé Reservoir growth was very poor without feed at similar densities. Attempts to produce fry in hapas were successful on a small scale.

The length-weight relation for T. nilotica and a cost benefit analysis for semi-commercial culture are given.

AQUACULTURE IN THE SUDAN; PRESENT STATUS, RESEARCH TRENDS AND PROSPECTS.

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1. INTRODUCTION

Sudan, (Fig. 1) Africa's largest country (8.3 % of the African Continent), has an area of 596.6 million acres (2.5 million km^2) of which about 200 million acres are fertile land. The Nile and its tributaries have permitted intensive agricultural development in an economy otherwise dominated by livestock production. Under the command of this major river system and through modern irrigation schemes, an agricultural transformation occured which brought the Sudan to the forefront of world cotton exporters. Therefore, agriculture accounts for over 95 % of the total hard currency earnings.

Besides agricultural wealth, the Nile has offered the people of Sudan a source of fish supplies to supplement their protein intake derived predominantly from livestock. A stretch of 6,500 km river waters covering a surface area of 20,000 km^2 of which 17,000 km^2 is represented by the vast swamps areas of the "Sudd Region" and 3,000 km^2 by the five major reservoirs on the White and Blue Niles form the major inland water resources. Also there are thousands kilometers of irrigation canals in agricultural schemes and hundreds of rain-water catchment areas or "haffirs". With the exception of irrigation canals in the agricultural schemes, particularly the Gezira Scheme, these water resources have not yet been very much polluted with domestic, industrial and agricultural pesticides hence the biological factors relating to the aquatic living organisms are not very much affected (George, 1975 a, 1976; George and EI Moghraby 1978).

Inspite of this enormous water resource, capture fisheries and aquaculture did not receive due attention and therefore at present, make a marginal contribution to the Sudanese economy. The national average per caput consumption of fish in the Sudan is 1.6 kg per annum.

Fish supplies in most areas of the Sudan, including the capital, lack far behind demands. The Sudan is, of course, a substantial meat producer, but fish are highly regarded and a strong market exists which awaits further exploitation. However supplies solely from capture fisheries cannot meet the market demands because of inaccessibility of many of the inland waters, inadequate means of transport and infrastructure, heavy fishing efforts in some more accessible areas (Table 3); and seasonal fluctuations in availability and price of fish.

Thus aquaculture development becomes important as a supplementary source of fresh fish supplies. Possible approaches are in the Southern Region (Equatoria Province) and in the "haffirs" or reservoirs of Kassala Province (Eastern Sudan), Kordofan and Darfour Provinces (Western Sudan) which are far away from the country's great river systems; combination of aquaculture with poultry farming or agriculture in urban areas or Sugar State farms; aquaculture in irrigation canals of agricultural schemes to promote biological control of aquatic weeds and water-borne vectors of diseases and ultimately supply animal protein.

The Gezira Agricultural Scheme, the largest single irrigated scheme of its kind in the world (total canal length 93,500 km) suffers continous heavy infestation of about twenty-three species of submerged aquatic macrophytes. These decrease the velocity of water flow, cause siltation and water loss through transpiration and they have caused an increasing effect on water-borne vectors of diseases (malaria and bilharzia).

Existing methods to control aquatic macrophytes have disadvantages. Manual control is becoming expensive, because of the scarcity of labourers. Mechanical control is limited by high cost of machines, spare parts and shortage of kerosene. Herbicides are not normally used because irrigation canals provide the sole source of drinking water for the people. Because insecticides are expensive, decreasingly effective due to development of resistant strains, long lasting and hence growing public concern over polluting the environment, control by biological means has become a high priority.

The main objective of this paper, is to account for the progress so far achieved in aquaculture in the Sudan and highlight its future research trends, needs and development prospects.

2. AQUACULTURE IN SUDAN

2.1 History & Status :

In Sudan, as in almost all other African Countries, aquaculture is not a traditional practice. The first Experimental Aquaculture Farm was established on the White Nile at Shagara, 13 km South of Khartoum, in 1935 (George, 1975 b).

To date most of the aquaculture experimental work is carried out at this Farm. However, progress has mainly been achieved after 1970. This was due to lack of trained personnel and proper research and extension facilities; the outcome of poor Government recognition and support for aquaculture as an integral part of agriculture development policy and strategy. At present, aquaculture is still at the development stage in Sudan and is not widely practiced but restricted to few private and public farms.

2.2 Public and Private Aquaculture Farms :

There are a few government, semi-government and private farms. Practically all these farms are small-scale fish farms.

In the Western Districts of Equatoria, Southern Sudan more than fifty fish ponds were constructed by the Fisheries Department. These ponds provided the local inhabitants with fish but all the ponds fell into disuse during political disturbances and now need rehabilitation.

Semi-government farms were recently established in Sugar State Factories such as Kenana, Sennar, El Guneid and Halfa El-Gadida. In El Guneid, for example, there are eleven ponds ranging in size from 0.3 to 1.9 acres.

In the vicinity of Khartoum there are about fifty private ponds while at Wad Medani area there are about 25 ponds with a total area of 20 acres.

There is only one large-scale fish farm at Essillat consisting of six ponds each 4 acres (1.6 ha) in area. This farm is not yet in operation.

The Aquaculture Extension Section within the Fisheries Administration Department assists the farm owners in pond design and management through on-farm visits. It also provides fingerlings at minimal prices and assists in stocking, sampling and havesting.

2.3 Aquaculture Systems in Use :

Extensive pond culture system is the sole practice in all public and private fish farms. However, the prospects for other culture systems such as pen and cage culture are great in Sudan (George, 1979).

2.3.1 Fish Species Cultivated :

In Sudan Oreochromis niloticus an indigenous species, is the main fish cultivated in all public and private farms although other species such as the Nile Perch (Lates niloticus), Labeo niloticus, etc. may find their way to the ponds which receive water directly from the Nile.

Exotic species such as the common carp Cyprinus carpio (mirror and scale) and the grass carp, Ctenopharyngodon idella have been introduced in 1975 at the Experimental Fish Farm at Shagarra with the main objective of adopting the polyculture production system. These species have been successfully bred under Sudan conditions but there are certain technical limitations for their use in the public and private farms (George, 1982 a).

2.3.2 Management Techniques And Present Production Levels :

The ponds are manured with a high dose of poultry droppings of about 240 kg/ha and also triple - superphosphate when available; artificial feed in the form of oil seed cakes and wheat bran are also used. Fingerlings of O. niloticus are stocked at 3000 - 4000/ha. In some farms, hand sexing of male O. niloticus is done before stocking.

One of the best production figures achieved in a private farm was 1.7 tons/ha/year, where in addition to fertilizer application, supplementary feeding with cotton seed cake was given.

2.3.3 Limitations And Problems :

There are several factors which handicap aquaculture development. Frequent spawning and resultant stunted populations of O. niloticus represents the major problem in those farms. The research is fully aware of such a problem but due to lack of technical facilities at the Experimental Fish Farm, hybridization work could not be initiated. No doubt there is need to set up a well designed and controlled hybrid hatchery operation for this purpose.

2.4 Aquaculture Research :

Aquaculture research is a national responsibility of the Fisheries Research Centre, Agriculture Research Corporation. Research in Aquaculture aims at maximizing production and reducing cost. Recent aquaculture research which has been successfully completed includes : acclimatization and breeding of cultivable exotic fish species; improvment of management techniques by the use of prey/predator method to control O. niloticus reproduction or through monosex culture; the effect of organic fertilizers and supplemental feed on the growth and production of marketable size O. niloticus through proper stocking densities. Also research on the use of cultivable fish species as biological control agents in irrigation canals of agricultural schemes has been attempted.

2.4.1 Fish Acclimatization, Breeding And Production of Seed.

C. carpio and C. idella, introduced in Sudan in 1975, were successfully acclimatized and bred naturally and artifically. The sexes of C. carpio are segregated in separate ponds two months prior breeding and are well fed. The spawners, one female and two males are put in a "hapa" provided with aquatic weeds. After spawing the parents are removed and the eggs attached to the weeds are allowed to hatch. After hatching and yolk sac absorption, the fry 2 - 3 cm in length are stocked in nursery ponds at the rate of 30 - 50 fry per sq. meter.

The grass carp, C. idella in Sudan attained an average length of 64 cm and weight of 4.50 kg in 3.5 years, i.e. a daily growth of 3.5 g. The female grass carp reached maturity after 3.5 years but the males matured a year earlier. To breed the grass carp, the female is injected intramuscularly, with a dose of 0.1 cc/lb (0.5 kg) body weight human chorionic gonadotropin and after 24 h again injected with HC G at a rate of 0.5 cc/3 lb body weight. After a further period of 24 h the females and also the males are injected interperitoneally with a dose of dry pitutary gland at a rate of 0.1 cc/lb and 0.05 cc/lb body weight respectively. After a further 8 h stripping and artificial inseminations begun. The fertilized eggs are put in plastic hatching containers with continous water agitation, aerotion and flow until hatching takes place (George, 1982 a).

2.4.2 Improvements of Management Techniques :

2.4.2.i Monosex Culture

In a comparative study of monosex culture of O. niloticus it was found that the weight of males was threefold that of females and about four times that of mixed stocks (George, 1972).

2.4.2.ii Prey/Predator Method :

A study was conducted (Bedawi 1980) to evaluate the Nile Perch (Lates niloticus) and the African catfish (Clarias lazera) as predators on O. niloticus. Lates or Clarias -tilapia ratios of 1:5, 1:10 and 1:15 were tested. Lates reduced young tilapia population and increased percentage of preferred-size tilapia. When stocked at a size of 7.5 cm (both Lates and tilapia) Lates did not prey on the original stock of tilapia but preyed on the young produced. The ratio of 1:10 and 1:15 were promising, while the ratio of 1:5 was established to be the most desirable for Lates. The former ratios produced 2106 kg/ha and 2153 kg/ha of tilapia with 44 % and 17 % preferred-size (200 g) tilapia, respectively. The ratio of 1:5 produced 2428 kg/ha with 47 % of preferred-size tilapia. This ratio produced the highest net return. It appears that O. niloticus should be stocked three months ahead of L. niloticus for Lates to best reduce the first spawn of tilapia. Clarias consumed the food given to tilapia, thus reducing tilapia growth and production. According to Sudan conditions where market demand is for large fish, the use of C. lazera as a predator in tilapia ponds did not appear to be feasible.

2.4.3 Effect of Organic/Inorganic Fertilizers And Supplemental Feed On Fish Production :

Trials with O. niloticus stocking rates were made for an extensive type of culture aimed at the small farmer with limited capabilities. An experiment was designed (Ahmed et al., 1982) to test four stocking rates; 2500, 3500, 4500 and 5500 fingerlings/ feddan (1 feddan = 4200 m^2) using chicken manure as a fertilizer (no supplemental feeding) for a growing period of five months. Based on the results obtained in this study (Fig. 2), the stocking rate of 3500 fish/feddan was recommended as the optimum.

In another study (Ahmed et al., 1983) varying doses of chicken manure (CM) and triple superphosphate (SP) were tested with the objectives of 1) to determine amount of CM required for satisfactory production of O. niloticus 2) to find out whether SP is required in manured ponds, and 3) to establish a definite fertilizer regime using CM with or without SP in optimum levels for pond production of tilapia under local conditions. Three doses of CM (1.25, 2.5 and 5.0 kg/pond/2 weeks) were tested separately and in combination with two doses of SP (60 and 120 g/pond/2 weeks) using male fingerlings of O. niloticus at a rate of 3500/feddan in ten concrete ponds (10 x 4 m^2 each) for a growing period of six months. The results obtained in this study (Table 4), indicated that SP increases fish production (and net returns) in manured ponds, and that less SP is needed as the manure dose is increased. With the higher manure dose, no SP is required. Based on both production and cost, the medium CM dose of 2.5 kg/pond (612 kg/ha) with the lower SP dose (15 kg/ha), is recommended as it produced the highest fish production and the highest income above fertilizer cost. In case sufficiently large amounts of manure are not available, the lower manure dose 360 kg/ha) with the higher SP dose (30 kg/ha) is recommended as it generated the second highest income above fertilizer cost. In case SP is not available to a small farmer, which is most likely, the medium CM dose alone is recommended, though its fish production was less than that of the higher manure dose. This is because the increment in net income is negligible and the hazards of using excessive amounts of organic fertilizer cannot be overlooked.

Efforts to improve productivity and profitability of pond culture included use of local feedstuffs to formulate effective diets for production of marketable tilapia. An experiment (Ahmed et al., 1985) was just terminated to evaluate three oilseed meals (cotton seed, sesame and groundnut as major protein-course feeds. The experiment (15 weeks) consisted of four treatments each replicated in two ponds. Fish in each treatment received one of the three feeds, where as the fourth treatment was maintained as a control with no feeding. Stomach contents were frequently examined, and abdominal fat depots of sacrificed samples were weighed. Plankton samples were collected weekly for identification and counting. Measurements of other parameters were conducted at regular intervals. Preliminary results (Table 3, Fig.3) indicated that fish fed sesame meal grew faster than those fed groundnut or cotton seed meal. They gained 63.8 % and 17.8 % more than fish fed cotton seed or groundnut meal respectively. The latter gained 39 % more than those of the cotton seed treatment. Fish in the control ponds lost weight during the experiment. A comprehensive interpretation of the results and observations is awaiting some important analysis (e.g. proximate analysis, plankton etc.) to be completed. A similar experiment was simultaneously run in the laboratory for a period of one month using eight 70-litre glass aquaria to test the three meals in the absence of natural food. Each two aquaria received one of the three feeds, and the two remaining aquaria were used as control. Results show that sesame meal caused a 37.8 % increase in fish weight, compared to 26.8 % for the groundnut meal and 22.6 % for cotton seed meal. Fish in the control aquaria lost 7.4 % of their weight during the experiment. Food conversion coefficients were 2.9, 3.9 and 4.5 for sesame meal, groundnut meal and cotton seed meals respectively.

2.4.4 Biological Control Studies :

The use of the phytophagus fish, the grass carp or White Amur, C. idella has been considered for biological control of aquatic macrophytes in the Gezira irrigation canals, along with common carp and O. niloticus.

In 1977 wire mesh had been fixed on the water pipes at two concrete bridges about 500 m apart along the minor canal (Soriba) which was heavily infested with aquatic weeds, mainly Potomogeton spp. In March 34 grass carp (average length 29 cm) and 57 male common carp were introduced. At the beginning of May two wire mesh partitions enclosing a distance of 32 m were fixed in the same canal and 32 grass carp (32 cm) were introduced. In July, 17 male common carp were introduced in the same area and 25 grass carp were stocked in another length of the canal extending south of the wire mesh and the concrete bridge, a distance of 113 m.

There was a marked difference in the partitions of the canal with grass carp and common carp as compared to other lengths of the same canal with no grass carp. Besides, all the snails, Bulinus and Biomphalaria species, which mostly adhere to the leaves of weeds (84 % on leaves, 16 % on stem) were eaten along with the leaves. As the grass carp continued to feed, it was observed that the leaves were nibbled off while the stems floated. The floating stems were later eaten by the grass carp (George, 1982 a).

In November 1984 a one-year small-scale trial on the effectiveness of C. idella, C. carpio and O. niloticus in the biocontrol of anopheline larvae and snail hosts of schistosomiasis was initiated in two minor canals of the Gezira Scheme. Each canal was separeted by a wire mesh into four compartments. In one of the two canals each compartment is stocked with each species separately while the fourth compartment remained without fish as a control, in the other canal, each compartment was stocked with combinations of the three mentioned species. This trial is supported by TDR, WHO and its results will be published after the trial terminates in November 1985.

2.5 Future Research Trends, Needs And Development Prospects :

2.5.1 Research needs :

Research should be conducted on the following :

a) Use of polyculture systems;

b) integration of agricultural and aquacultural food production systems;

c) use of cage and pen culture systems in special environments such as large reservoirs where limits to stock exploitation are reached.

2.5.2 Development Prospects :

Development prospects for pond aquaculture are good in Sudan, only if the required technology is made available. This is because the basic resources exist. Also the prospects for development of pen and cage culture is great.

In the International Workshop on Pen And Cage Culture held in the Philippines, George (1979) recommended applications of such a practice in the following localities :

a) in the stretch of the White Nile from Shagarra to Jebel Aulia reservoir;

b) in the "haffirs" or reservoirs of Western Sudan (only cage);

c) in Lake Nubia.

Cage culture was not recommended in the irrigation canals of agricultural schemes because the water flow to the field plates will be hampered.

At present the Jebel Aulia reservoir is a priority area for pen and cage culture.

2.5.2.i Development of Pen and Cage Culture in Jebel Aulia Dam :

Jebel Aulia Reservoir is a man-made lake created as a result of the construction of Jebel Aulia Dam in 1936 (Table 4).

In general fish is abundant in Summer (56.4 %) and least abundant in Winter with the peak harvest occuring in the preflood period (A/Rahman 1985). The available statistics imply that the fisheries at Jebel Aulia Reservoir have reached an equilibrium with the stress imposed upon them. The lake-like conditions prevailing in the reservoir are favourable for high plankton productivity (Saeed, 1976; Adam, 1977).

Very interesting conclusions were drawn from the stock assessment study conducted by the fisheries research centre (A/Rahman, 1985) with regard to the dynamics of the genus Tilapia, a suitable fish for cultivation. This study revealed that the exploitation ratio of Tilapia spp. amount to 0.41, a figure which approaches the optimal ratio and with a total mortality of 0.423. Moreover, this commercially important fish was found to constitute 9.5 % of the total landings, of which Oreochromis nilotidus comprises 4.6, Tilapia gallelei 3.5 and T. zilli 1.3 % respectively.

Jebel Aulia reservoir, similar to other tropical man-made lakes, offers high primary productivity (Saeed 1976 & Adam 1977). This situation offers better opportunities for extensive and/or semi - intensive cage and pen culture. It is generally accepted that extensive culture and semi - intensive methods of raising fish are suitable for planktivorous or those fish that feed on benthos and detritus (Malkolm & Beveridge, 1984). In the Sudan the endigenous species O. niloticus provides an excellent candidate best suited for this system of culture due to its low protein requirement.

3. CONCLUSION

From the foregoing account in this paper, it becomes obvious that the Sudan has tremendous potential and prospectives for aquaculture development. The future development of aquaculture must, however, adopt the concept of rural aquaculture pursued by independant producers of under cooperatives. This will help alleviate dietary deficiencies and provide local fishermen with a product of high subsistance and commercial value.

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Table 1 : Present and Potential Production of Inland Fisheries in the Sudan (FAO, 1975)*

System	Area km^2	Productivity kg/ha/year	Potential Yield tons/year	Present Production tons/year
Sennar	160	71	1,100	1,100
Jebel Aulia	1,500	104	15,000	7,100
Khashm-el-Girba	125	69	800	800
Roseires	290	58	1,700	1,500
Lake Nubia	1,000	51	5,100	500
Nile and other riverine waters	2,000	30	600	
Southern Provinces	15,000	50	75,000	11,000
	20,075		104,700	22,000

* FAO Report to the Government of the Democratic Republic of the Sudan on the Fisheries of the Reservoirs of Central Sudan, Cairo 1975.

Table 2 : Production of *O. niloticus* and Net income (above fertilizer cost only) for the different treatments.

Treatment (per two weeks per pond)	Initial Av. Fish wt. (g)	Final Av. Fish wt. (g)	Net fish production (kg/ha)	Revenue less fertilizer (l£/ha)
control	17.9	67	410	-
1.25 kg CM	20.6	166	1212	1668
2.5 kg CM	19.1	191	1433	1850
5.0 kg CM	22.0	224	1683	1925
1.25 kg CM + 60 g SP	21.1	188	1390	1828
2.5 kg CM + 60 g SP	19.5	260	2005	2599
5.0 kg CM + 60 g SP	20.5	232	1762	1935
1.25 kg CM + 120 g SP	18.9	250	1926	2523
2.5 kg CM + 120 g SP	19.8	238	1819	2213
5.0 kg CM + 120 g SP	18.3	222	1698	1730

* Based on 1984 prices :

Fish = 1.5 L£/kg.

Chicken manure (CM) = 0.04 L£/kg.

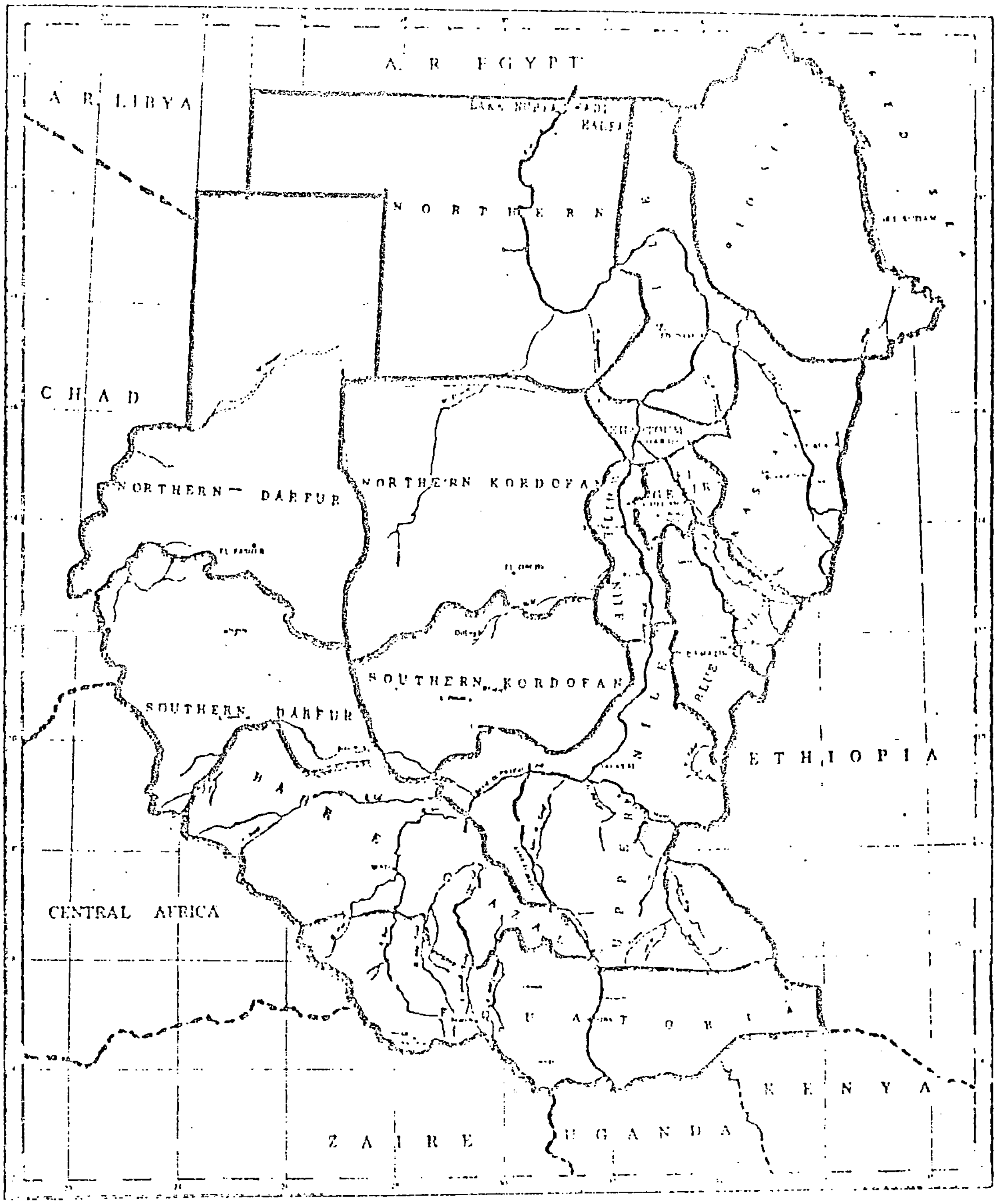
superphosphate (SP) = 0.60 L£/kg

Table 3 : Weight gain, net production and food conversion coefficient for *O. niloticus* (culture period = 15 weeks)

	Control	Cottonseed meal	Groundnut meal	Sesame meal
Initial average weight (g)	54.0	55.0	54.0	53.5
Final average weight (g)	52.0	160.3	200.2	225.9
Net production (kg.ha)	-	1348	1904	2294
Food conversion coefficient	-	2.61	2.14	1.94
Average daily gain (g/day)	-	0.99	1.37	1.62

Table 4 : Basic Characteristics of Jebel Aulia Reservoir

Total length	500 km
Area at high water level	600 km^2
Maximum Depth	12.5 m
Minimum Depth	5 m
Storage Capacity	3.5×10^9 m^3
Water Storage	July - January (Max. Sept.)
Water Release	February - May
Fish Potential	30 kg/ha (1964)
Actual landing	8,200 t (1984)
Number of Fishermen	1760
Number of boats	526



Scale 1 : 8.000.000

Fig. 1. Map of Sudan.

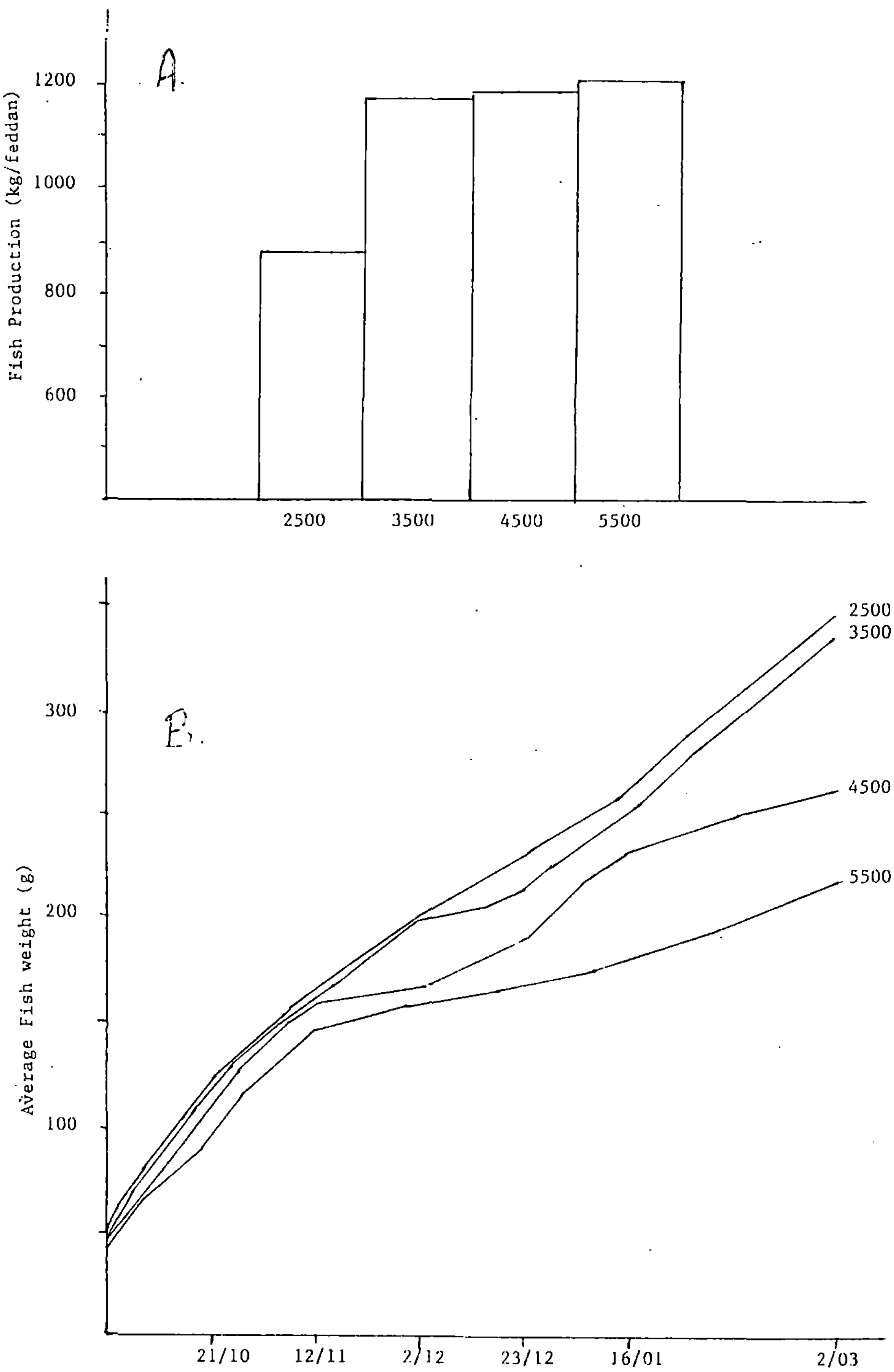


Figure 2. A. Determination of optimum stocking rate for T. nilotica (1 feddan = 0.4 ha)

B. Growth at various stocking rates.

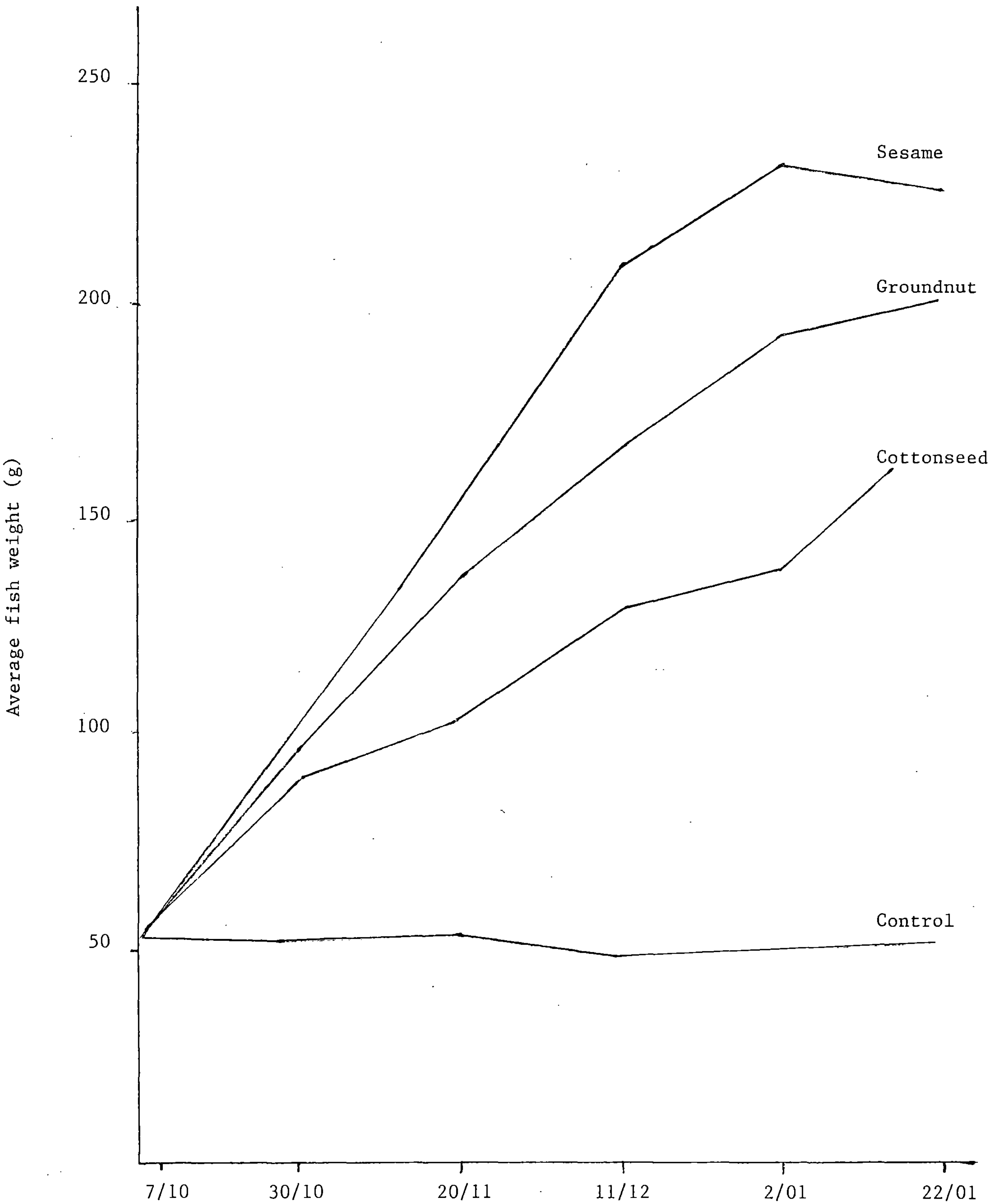


Figure 3. Growth rate of *Tilapia nilotica* fed on sesame meal, groundnut meal, cottonseed meal and a non-fed control.

L'AQUACULTURE AU SOUDAN: ETAT ACTUEL, TENDANCES DES RECHERCHES, ET AVENIR

T.T. George, El - N. B. M. Ahmed, O.M. Saeed

Résumé français

Malgré l'existence de plans d'eau importants, surtout associés au Nil, les pêches ne se sont pas beaucoup développées au Soudan, et il existe une demande insatisfaite pour le poisson. L'aquaculture pourrait aider à augmenter l'offre du poisson, par exemple dans les "haffirs" (lacs) des régions est et ouest du pays; en association avec l'agriculture ou l'élevage de la volaille sur les fermes; ou dans les canaux d'irrigation, afin de contrôler les plantes aquatiques et les vecteurs aquatiques des parasites.

Il existe actuellement des piscicultures semi-gouvernementales sur des fermes de sucre à plusieurs endroits; quelques 75 étangs privés à Khartoum et à Wad Medani; et une seule grande pisciculture (6 étangs de 1.6 ha chaque) à Essillat. Le Service de vulgarisation aquicole aide les fermiers, et le Centre de recherches en pêches, basé à Shegarra (près de Khartoum) est responsable pour les recherches. L'espèce principale élevée est le O. niloticus; quelques essais ont été faits avec la carpe commune (C. carpio), la carpe herbivore (C. idella), et le Lates niloticus.

Les recherches ont porté notamment sur la propagation de C. carpio et C. idella; sur l'incorporation des prédateurs L. niloticus et C. lazera à l'élevage des tilapias; sur les augmentations des rendements résultant de l'utilisation des engrais et des aliments; et sur le contrôle des plantes et des vecteurs de maladies par les poissons dans les canaux d'irrigation. Les détails de ces études se trouvent dans l'article.

A l'avenir, il sera important de faire des recherches sur la polyculture; sur l'intégration des systèmes agricoles et aquicoles; et sur l'élevage en cages ou en enclos dans les réservoirs, où la production maximale des stocks naturels est pleinement utilisée. On considère que le réservoir de Jebel Aulia, près de Khartoum, serait un endroit propice pour le développement de la culture en cages.

REVIEW OF AQUACULTURE DEVELOPMENT AND PROGRESS IN SIERRA LEONE

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Abstract

Sierra Leone is a wet country with a water surplus such that most streams and rivers flow for most of the year. Aquaculture endeavours to date have included a ten-year Oyster Culture Research Project and a number of small development programmes administered by the Fisheries Division of the Ministry of Agriculture and Natural Resources partly with limited foreign assistance.

Systematic aquaculture has only recently been introduced to Sierra Leone and has made slow but favourable progress. Climatic conditions are ideal, and prospects are good for further development.

To date over 250 ponds averaging 100-250 meters square have been built through the extension services. Fish ponds are generally integrated into existing rice-paddy schemes and waste from farm produce is used as fish feed.

There is however, an urgent need to train more extension agents. Aspects of pond management and nutrition need also further development.

Introduction

Sierra Leone whose capital is Freetown has a coastline of 340 kilometers (Fig 1) (210 miles) and a population of 3.5 million. The country lies on the southwest coast of West Africa between 6° 55' and 10° N and 10° 10' and 13° 18' W with a total area of 73,326 sq. km (27,925 sq miles).

The climate is tropical with a very marked rainy season from May to October and dry season lasting for the rest of the year. Annual rainfall can exceed 500cm (156 inches) in some areas, and generally decreases inland (Fig.2) Sierra Leone's abundant water supply with almost perennial flows and high rainfall has not generated the need for water storage reservoirs for domestic or irrigation purposes, except in the Western Area (Freetown).

There are three estuaries, the Scarcies in the north, the Sierra Leone River in the middle and Sherbro in the south. These estuaries form coastal brackish water lagoons before entering the sea.

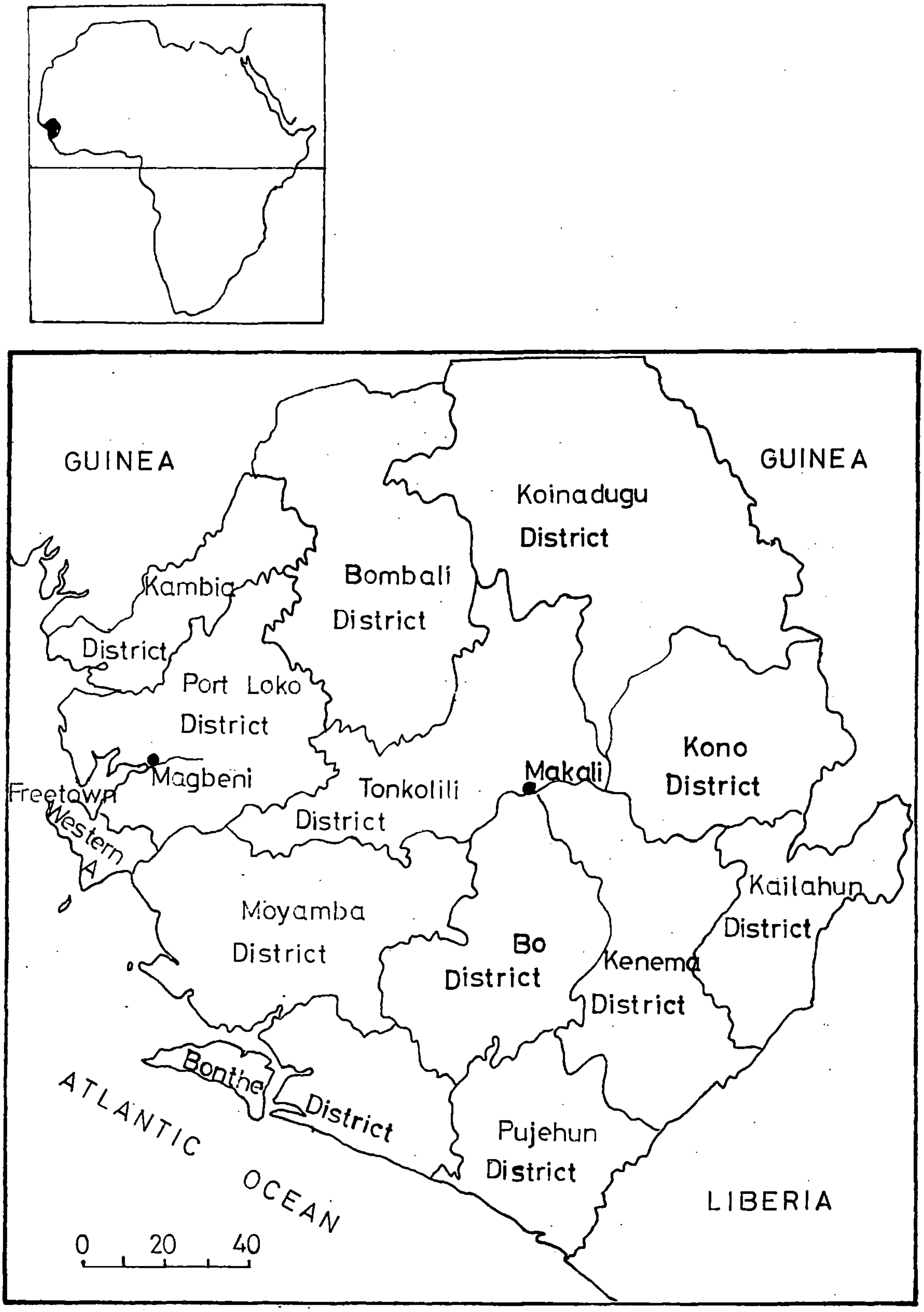


Fig.1 : Location map of Sierra Leone

Although cattle is reared in the north, fish is the most common source of protein. The fishing industry in Sierra Leone is based on the traditional artisanal inshore small boat fisheries. One-fifth of the total consumption is imported. About 70% of the rural community eat fish. Per capita fish consumption of the country is 17.6kg per year and ranges from 34.0kg in the Western Area to 15.0kg in the Southern and Eastern Provinces and to a low 9.0kg in the Northern Province, the farthest away from the sea and the productive floodplains of the rivers situated in the Southern and Eastern parts of Sierra Leone. The total marine and fresh water fish production exceeds 60,000 metric tons annually and this supplies about 20% of the protein needs of the country and is supplied by fin fish alone.

Government's ardent priority has been to enhance the living standard of her rural communities both nutritionally and economically. Because of the steady decline in catch of the marine fisheries, the increase in production cost in artisanal fisheries, and an increase in demand for protein, the development of rural aquaculture was deemed convenient.

In Sierra Leone, systematic aquaculture practice is new as in many African countries but nevertheless a lot has been achieved. Traditional aquaculture has a long history in this country. We practise both mariculture and fresh water aquaculture.

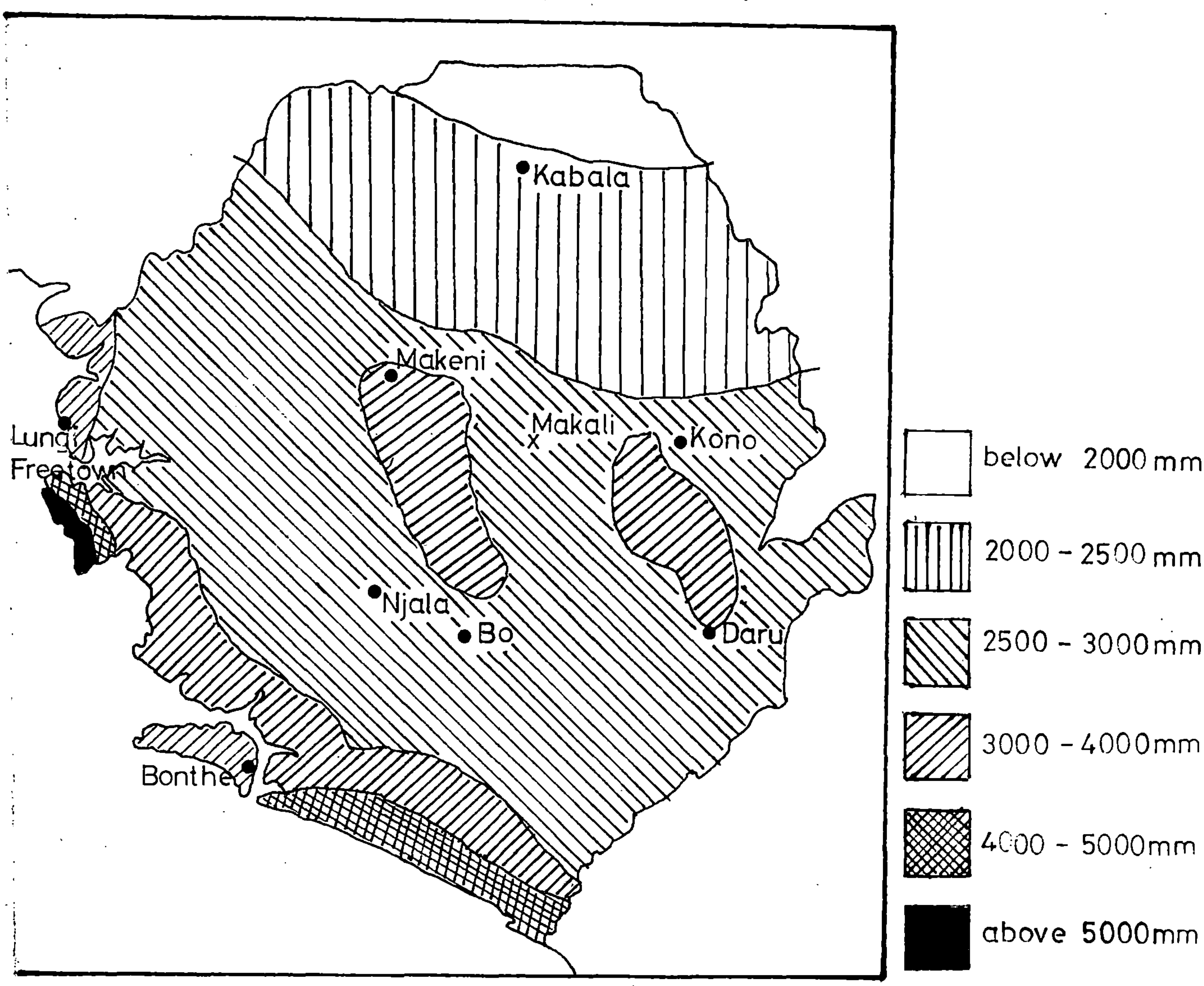
Mariculture

In mariculture, only one species is under cultivation: the mangrove oyster, *Crassostrea tulipa*. Its biology, culture method and economic cultivation studies have been established. *Crassostrea tulipa* grows at a rate of 1cm or 1gm per month and it is grown for 7 - 9 months to market size. This study was made possible by a project funded by IDRC (International Development Research Centre) and the Sierra Leone Government from 1974 - 1982; the aim of the project was to increase the growth rate of the mangrove oysters and established a practical and economic system of cultivation and marketing.

The economic cultivation of *Crassostrea tulipa* in all the three stations have been established. In 1983, thirty-five metric tons of harvested wild oysters produced two metric tons of shucked oysters. The production of experimentally produced oysters that year was very minimal. Suspended raft culture was found to provide the best growth for our region as market size oysters can be produced within 7 months. However the project has been forced to promote the rack culture system because of the high cost of raft construction materials. The raft culture utilizes empty 44 gallon (2001) oil drums which are coated with a mixture of pitch and tar for floating the raft of oyster strings and connected by bamboo frames. Oyster shells proved most economic as spat collectors. Growth rates greater than wild mangrove oysters were attained. Problems encountered were predation, fouling, disintegration of cultch spat collector, poor site selection due to excessive currents and high fresh water run-off causing low seasonal salinity. These results are well discussed in Kamara and McNeill (1976), Kamara (1979a,b) Kamara, McNeill and Quayle (1976) Dabo (1979) and Kamara (1982).

Other areas researched in this programme were fouling, larval life history, plankton studies and management. The best means of overcoming problems of fouling, water quality and predation lay is site selection and effective management. Dry season production

Fig. 2: Distribution of mean annual rainfall in Sierra Leone (PEMSU 1983)



(high salinity), harvesting before the rains and regular raft inspection are recommended. However the price of raft construction materials in the interim had risen drastically such that it is no longer economically feasible to use the raft culture system. In the absence of a suitable substitute we have reverted to the rack system of culture which utilizes bush sticks for frames and support for the oyster strings. With rack culture the only capital input is the cost of strings. Cost/benefit studies in order to be able to recommend an economically viable package for the oyster farmers are being presently undertaken. With experiments conducted so far, the rack oysters grow to market size within 9 months and it is becoming evident that the rack system will be most suitable for rural oyster farmers.

Fresh Water Aquaculture

Fresh water fin fish farming (systematic aquaculture), started in Sierra Leone in mid 1978 and by the end of that year, four 750 sq meter earth ponds were constructed by the Fisheries Division at the town of Makali, Tonkolili District (Fig. 1). The four fish ponds were stocked with 1,000 fingerlings of *Tilapia nilotica* transplanted from Ivory Coast in 1978. Presently at the Makali Aquaculture Station, there are four 750 sq meter ponds, four 250 sq meter ponds and several incomplete ponds. From this fish station, fish seeds have been distributed to other parts of the country.

A two year project funded by the Sierra Leone Government USAID and Peace Corps to test the receptivity of fish farming with the different tribes in the North Eastern Region of Sierra Leone (Bombali, Koinadugu, Kono and Tonkolili Districts)was started in 1981. There was some positive success; the programme was later extended for a year. Currently over 70,000 sq meters of pond area is under cultivation within Sierra Leone using *Tilapia nilotica* alone, and about 90,000 *Tilapia nilotica* fingerlings have been distributed to fish farmers. Two other species which are gaining popularity with small-scale fish farmers are *Notopterus afer* and *Clarias lazera*. Fish farmers are encouraged to use either *N.afer* or *C.lazera* as predators to control reproduction of *T.nilotica* in ponds.

Aquaculture in Sierra Leone could be classified as village fish farming or small-scale rural fish farming. Farmers own one to three small fish ponds of average surface area of 100-300 square meters with yields of 10-30kg fish per/100m²/year. Fish farmers in this category consume most of their production and market the small surplus. Investment is typically partly financed by the programme (shovels and head pans) and the farmers (land and labour), and the fish ponds are managed by the owner and his family. In the past year, there have been several farmers who have shown interest in more intensive fish culture.

Presently, production between 1 to 2 tons per/ha/year is being achieved. Fish are fed irregularly with rice bran (with husk), termites and household food scraps. The anaerobic compost pile method is used; organic matters (rice straws, spoiled fruits, leaves etc, and cattle or chicken manure) are stacked underwater in a pile in the corner of the filled pond within a small fenced enclosure or crib made of wood poles and bamboo.

Fish ponds are usually harvested partially several times prior to the final total harvest. Some fingerlings are kept in holding ponds for use as seed for the next culture period or given to new fish farmers. The ponds are normally dried for about one to two weeks; some repairs are done to the pond banks before they are refilled with water. Table I shows fish pond distribution.

Economics Of Aquaculture Systems In Use

In 1978, the oyster culture project did some, prepliminary cost benefit analyses on the production of raft cultured oysters from three test stations. In Kamara (1982), the cost of construction of one raft was Le64.50 and the cost of processing one raft of oyster was Le150. The selling price to obtain a break even point varies according to each station, reflecting production per site.

In small-scale village fish farming, very little economical analysis has been done. In this paper a typical budget for such a system is presented (Table II). In this computation, land and fish feed (rice bran, termites etc) were not costed. Although fish fingerlings were not paid for by farmers they were costed for in the budget analysis prepared in table two.

Cage Culture

In April 1982, cage culture trials were attempted at the town of Magbeni in the Port Loko District situated on the banks of the river Rokel. (Fig 1). Three rafts each measuring 6 meters by 5 meters were constructed to hold six cages each measuring one meter square. The cages were constructed with timber and nylon netting materials (210d/9/½") mesh. Each raft was floated with four 44 gal. empty drums coated with tar.

Each cage with 150 fingerlings of *Tilapia nilotica* measuring 6-7cm and an average weight of 10 gms. These fish were taken from Makali Fish Station. Supplementary feed in the form of rice bran was given to fish in cages of raft A and formulated pelleted feed consisting of rice bran and fish meal was given to fish in cages of raft B. Raft C cages were left as control.

Fish fed with pelleted feed grew faster than those fed on rice bran only. The use of the formulated feed had to be discontinued because of high cost. There were high percentages of feed losses on both rice bran feed and formulated. In August 1982, all three rafts which were anchored to the shore drifted due to heavy current causing loss of all the fish and rafts. Other problems encountered were predatory fish (Hemirampus sp.) which migrated up river between the months of February and May as the selected site became euryhaline, poaching by people in the area at night, unstable political atmosphere in the area and site selection.

TABLE 1. DISTRIBUTION OF FISH PONDS AND EXTENSION WORKERS (AGENTS).

Districts	Chiefdoms	Towns	EXTENSION AGENTS			Fish Ponds
			F.D	P.C.V.	Others	
Koinadugu	Niene	Yifin/ Funemba		1		18
	"	Kumala	1			
	Warawara	Kabala				
		Yagala		1		13
	Diaing	Kondembia		1		13
		Bambukoro	1			4
Kono	Sando	Kayima/ Yarya	1	1		25
	Tankoro	Kongor-Wakor	1	1		38
	Gbense	Sefadu	1			10
	Nimi-Koro	Yengema				6
	Gbane	Kanekor				35
Tonkolili	Konike-Barima	Makali	1			20
	Konike-Falawusu	Makeniti	1			8
	Bendugu	Bendufu				4
Bombali	Safroko	Binkolo		1		8
	Bombali Sebora	Teko				3
Port Loko	Koya	Makolo/ Mansumana				4
		Songo	1			2
Bo	Kukua	Bo				6
	Wunde	Gboyama-Wunde	1			6
	Baoma	Yamandu	1			6
Pujehun	Bogbor	Jimi				5
Kenema		Kenema				6
Kambia	Tonko-Limba	Madina				6
Western Area		Pa Loko				5
						251

F.D. - Fisheries Division Extension Workers

P.C.V - Peace Corps Extension Workers

Potential For Cage Culture

The exceptional rainfall means that Sierra Leone is well endowed with waterways. These are divided into rivers and streams, lakes, swamps, and both inland and enstuarine mangrove swamps. Only about 40% of the mean annual rainfall is lost as evaporation so there is a high runoff. Majority of these rivers flow for most of the year although a seasonal low occurs during the dry season. Not only are these natural bodies available, there are also mined out areas filled with water in Kono, Kenema and Moyamba Districts. The proposed Bunbuna hydro-power dams in the river Seli, another on the River Mano and the newly completed small Goma Hydro Electric Dam in the Kenema District, could all be utilized for extensive cage culture.

TABLE II

Budget For A Small-scale Village Fish Farm (100m²)

For 280 days production

Capital Cost [a/]	Unit	Qty	Le/Unit	Total (Le)
Labour	Man/day 6hrs/ days)	20	2.35	47.00
Tools	Shovels	2	25.00	50.00
"	Head pans	4	30.00	120.00
Fish seed *	Fingerlings	100	0.02	2.00
				229.00
Operating Cost				
Labour	Man/day	24 [b/]	2.35	56.40
Depreciation on Tools	25% investment cost			42.50
" "	10% investment cost			4.70
				103.60
Revenue				
Sale of fish	kg	22 [c/]	8.0	176.00
Sale of fish seed	Fingerlings	200	0.02	4.00
				180.00

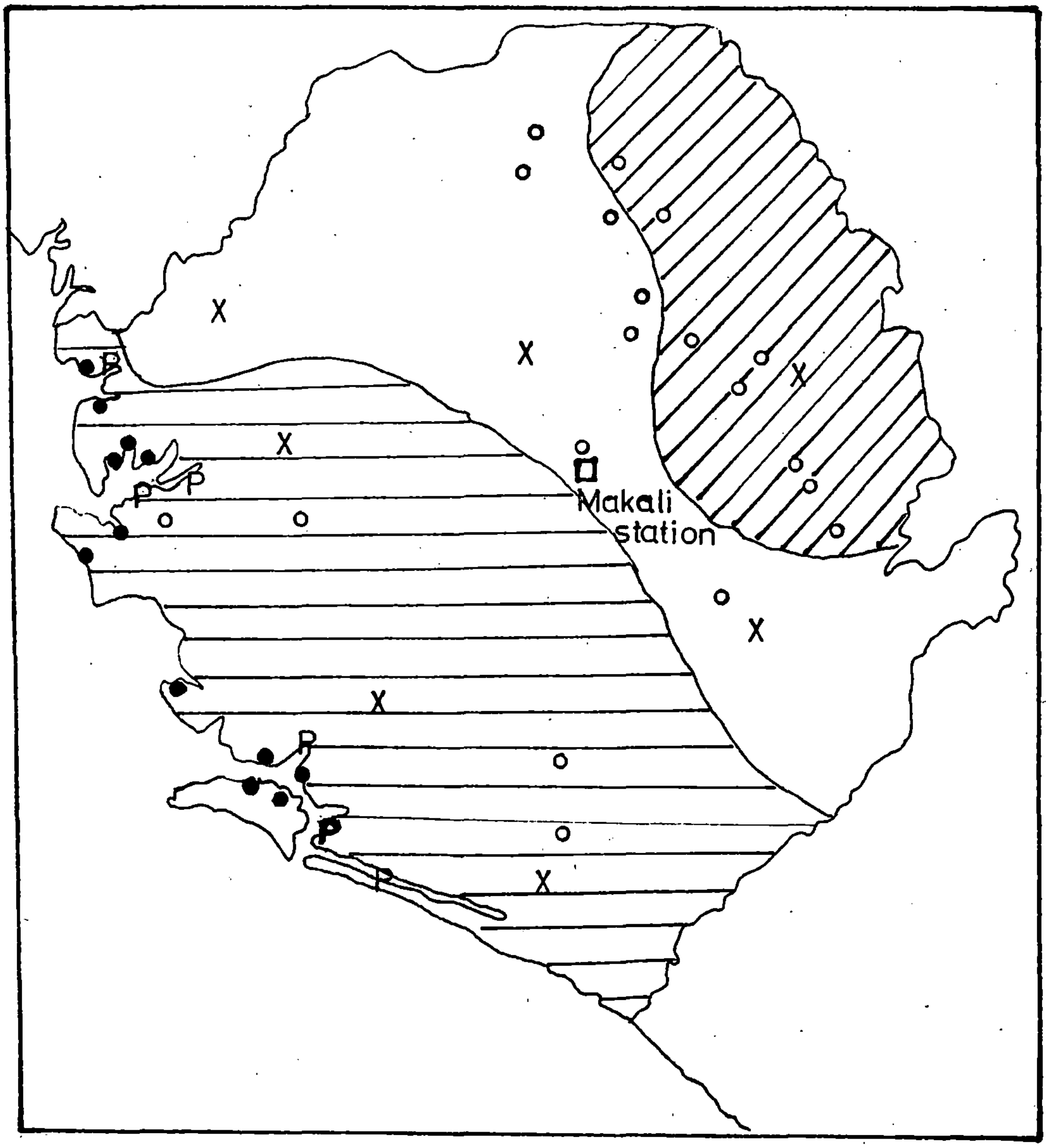
Foot Note

a/ No value was calculated

b/ Estimated 0.5 hr/day

c/ Production = 2,200 kg/ha/yr

* Fish seed was supplied free to farmers but cost was computed.



Temperatures above 20°C favour all year production of intensive warmwater fish culture

Intensive warmwater fish culture with one month when temperatures may affect production

Medium-high altitude zone where cool winter may affect warmwater fish production for 1-2 months. Cold tolerant fish favoured.

o Fish ponds sites

● Potential oyster culture sites

X Potential cage culture sites

P Potential brackish water (cage or pen culture) sites.

Fig. 3 : Tentative potential aquaculture zones in Sierra Leone

Between December and June most of these rivers average a flow of 0.24 - 1.0 m/s. With high planktonic growth and transparency (secchi disc) of about 1-2 meters. This period is suitable for cage culture of filter feeding fish species.

In the brackish estuaries and lagoons, there are a marked euryhaline belts. The water temperatures were comparable throughout the year (26-30 ^{o}C). However salinity varies from 1ppt in the rainy season to above 30ppt in the height of the dry season.

Some of the species in Sierra Leone that could be used for cage culture are Tilapia nilotica, T. Loaka, T.brevimanus, T.malanopleura Arius heudelotii and Liza falcipinnis.

Sierra Leone could be classified into three potential aquaculture zones (fig 3). On this map, the description of each zonation is characterised and the kinds of potential aquaculture are shown.

Constraints

The Senior Staff of the Aquaculture section of the Fisheries Division, consist of highly trained personnel and the extension agents also have excellent field experience. But the total staff number is small; inadequate financial support is available for large scale research and extension. There is no staff conversant with more intensive culture methods. Also there is shortage of trained middle level man-power and the training of Aquaculturists to become National trainers is of paramount importance.

Conclusion

Recongnizing that Sierra Leone has an unbalanced food budget and that in a few decades, it cannot economically and substantially increase its fish harvest, from wild stocks, there is a need to develop aquaculture as an alternative protein source. This is important, for the hinterland populated areas where premium prices would be paid for fresh fish. There is scope therefore not only for development of subsistence practices but also for semi-commercial operations. The climatic conditions are particularly suited to warm-water fish production with year round growth and abundant water reserves.

Before aquaculture can develop to any great extent, there is an urgent need to train more personnel, in different dystematic aquaculture practices, to create additional demonstration stations and seed centres, and lastly for adequate financial support.

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LE DEVELOPPEMENT DE L'AQUACULTURE AU SIERRA LEONE

Naib Balogun Iscandari

Résumé français

Le Sierra Léone possède d'abondantes ressources en eau, et les rivières y coulent pendant toute l'année. Les activités aquicoles entreprises jusqu'à présent sont un Projet de recherche ostréicole qui a duré 10 ans, et quelques programmes de développement d'ampleur restreinte, administrés par la Division des pêches du Ministère de l'Agriculture et des Ressources Naturelles, quelques-uns avec une aide étrangère.

L'aquaculture continentale a été introduite en 1978; les progrès ont été lents mais constants. Actuellement, il existe quelques 250 étangs de superficie moyenne 100 - 250 m^2, construits avec l'aide des services de vulgarisation. Les étangs sont généralement intégrés à la culture du riz en paddy. Les déchets des productions agricoles sont utilisés comme aliments et on utilise également des composts. La production moyenne est de 1-2 t/ha/an. Un bilan d'exploitation d'une petite pisciculture familiale est présenté.

AN ECONOMIC ANALYSIS OF CAGE CULTURE OPERATIONS : A SUGGESTED FRAMEWORK

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ABSTRACT

The application of basic and fundamental tools of economic analysis in cage culture operations are demonstrated. The use of the budgeting process is to show what can be accomplished with available resources, or production inputs at the disposal and management of the operator. It also reveals whether the use of the resources to produce fish in cages is efficient.

Partial budget, on the other hand, points out to the cage culture operator what can be done to further improve the efficiency of his operation through small changes.

In contrast, income statement or costs and returns analysis provides a measure of profitability. Like the budget, income statements can tell the operator whether his cage culture operation is profitable.

INTRODUCTION

However the objectives of cage culture operations are defined, ultimately its economics cannot be ignored. Resources, or factors of production and consumption, are not unlimited. Economics is at the very heart of our daily lives. Sound economics means profitability, or finding the most beneficial use of available production factors.

Before we go into any great detail of what economic analyses can do to better understand the profitability picture of cage culture operations, it is essential to distinguish the stages at which economic analyses can be carried out.

Fundamentally, economic analyses are carried out at two points in time. One, before you begin cage culture operations to evaluate whether your investment in cage culture operations is going to be profitable or not (ex-ante analysis or analysis before the fact). At this time, you would also want to find out at what scale of operation or level of intensity of production your cage culture operation will be most profitable.

Second, when cage culture operations are already underway, the value of economic analyses is to determine if in fact your cage culture operations are profitable or carried out efficiently (ex post analysis or analysis after the fact)? If not efficient, how can they be improved, especially in cutting the costs of production further. Aquaculture Economists can do this by examining the input output relationships, which depend upon the biology and technology of production.

More specifically, an itemized break down of the production costs and the percentage each cost component represents of the total cost can be a powerful tool in identifying means to reduce costs. Such itemized break down can help to identify the strengths and weaknesses of the cage culture operations and so single out areas for improvements.

For example, by applying biological or technological means, fish mortality can be reduced; the efficiency of feed utilization can be increased by reducing waste, or demand feeding; or labor efficiency can be improved.

Even so, the world we live in is not static. Prices do not remain stable for long in particular, prices of inputs are continuously rising, very rarely slowly. On the other hand, output (fish) prices increase very slowly, and often fluctuate reflecting supply and demand conditions. In economics, this is called cost price squeeze, where prices of inputs increase faster than the price of output.

Thus, given the dynamics of market prices and continually improving techniques of cage culture, we need to continuously monitor and evaluate production operations to maximize the difference between income (returns from the sale of fish) and the costs to produce the fish. At the same time, we constantly estimate the break even point of our operations.

The break even point indicates to the operator the level of output of fish whose returns cover the production costs. In other words, no economic or pure profits are earned. No losses are incurred in producing the fish in cages.

Sensitivity analysis and/or partial or full budgeting are important tools of economic monitoring, details on these techniques are given below.

SUBSISTENCE VS COMMERCIAL OPERATIONS

Africa and the Middle East do not have a long history in aquaculture, let alone cage culture of fish. The latter is a recent innovation. Cage culture operations can be carried out either as a subsistence or commercial proposition, depending on the needs, goals and resources at the disposal of the operator.

Whether it is a subsistence or commercial proposition, every effort must be made to operate the fish cage culture as a business. Other approaches will result in inefficient resource allocation and transformation.

Often, it is argued that since the fish is cultured for subsistence, it is not essential to be very strictly economically oriented. This is a wrong attitude.

Every input or factor of production, for example, the farmer's labor, has an opportunity cost. If the farmer or fisherman or fish farmer does not grow fish in cages, he can devote his time to some other productive activity such as working as hired labor for another farmer. By working as a hired laborer, he will earn a wage. This then is his opportunity cost.

Opportunity cost is the amount of money he could have possibly earned by working at his next best alternative.

PRODUCTION TECHNIQUE AND ECONOMIC ANALYSIS

Ex ante economic analysis assumes that the technique of production adopted for the cage culture operations is the best available or at least it is proven to work well. In the jargon of the Aquaculture Economists, we are operating on the production frontier or production possibility curve. Refer to Figure 1.

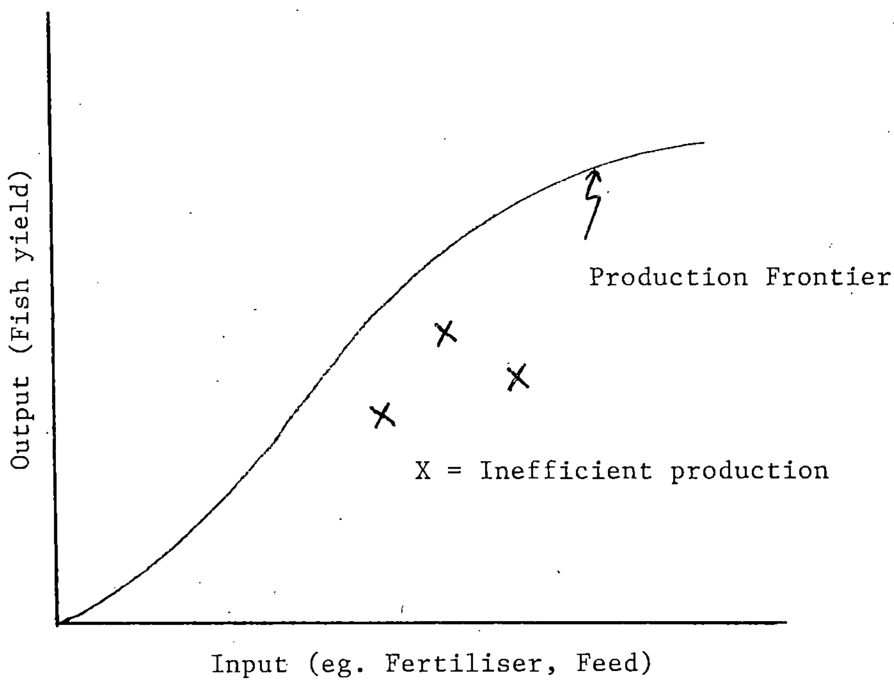

Figure 1. An input output relationship.

While every effort is made to strive to produce on the production frontier, this is difficult in reality. Along the frontier, all the points on it describe the most technically efficient combination of inputs to produce that level of output.

However, along the production frontier there is a most profitable level of output and combination of inputs given prevailing prices of inputs and output. Points above the frontier are unattainable and below it are inefficient and thus unprofitable.

Efforts are, however, continuously mounted to push the production frontier outward so as to produce larger quantities of output with the same set of inputs. This is referred to as a technological change.

To produce on the frontier is thus a continuous challenge for profit oriented cage culture operators. The most profitable level of output and input combination will shift along the frontier as input/output prices change. Most operators will be producing below this production possibility curve.

Given such a reality, economic analyses carried out ex post or once the production operations are underway, imply that input combination and production level can be improved by examining the cost and return structure.

In essence then, economic analysis helps to search for ways and means to reduce production costs or maximize the difference between costs and returns. This can be done either by further increasing output with the same set of inputs or to produce the same output level with less inputs. Of course, if output prices can somehow be raised (for example, through market development), the better shape the producers will be in.

CAPITAL INVESTMENTS

The methods used to confine the fish will influence the capital investment costs. The confinement/containment methods can either be floating net cages, or net pens hung in water bodies with or without outer nets for extra protection. Additional investments are indicated if materials to prevent fouling are also used.

The same applies if synthetic or imported materials (e.g. metal frame, PVC or galvanized iron pipes, synthetic nets and plastic floats) are relied upon instead of using locally available materials like bamboos, used rubber tyres and timber or wood. The latter involves lower investments and thus has implication for cash-poor rural people. See, for example Table 1 which shows how capital investments can be estimated.

Table 1. An example of capital investment cost calculation.

	BASIC FRAME STRUCTURE	VALUE IN YOUR CURRENCY
1.	Frame	
2.	Inner Nets	
3.	Outer Nets	
4.	Flotation Devices	
5.	Feeding Trays/Demand Feeders	
6.	Anchors/Weights	
7.	Wire Mesh	
8.	Cables/Wires	
9.	Ropes	
10.	Anti-Fouling Chemicals (tar/paint)	
11.	Boat/Raft	
12.	Walkway/Bridge/Platform	
13.	Perimeter/Boundary Net/Fence	
14.	Pump for Water Circulation	
15.	Shed for Storage	
16.	Guard House	
17.	Brood Stock	
18.	Construction Cost (labor)	

FINANCIAL AND ECONOMIC ANALYSES

One of the surest ways to find out whether your cage culture operation is profitable or not is to make a budget. Budgeting is a systematic way to organize your data from your records to see the patterns of your costs and returns. The costs and returns analysis will tell you whether you are incurring more costs than you are able to get in return from your cage culture operations, that is, whether you are losing money by growing fish. Or you are making money, that is, a profit is being earned. If so, it means you should stay in business and continue to grow fish.

Thus, budgeting can help you to make decisions on the use of your scarce factors of production such as your capital, land, labor and management or entrepreneurial skills. In other words, budgeting is one way to plan, to examine on paper the various alternative production activities before the production factors or resources are tied up or committed.

TYPES OF BUDGETS

There are at least four types of budgets which can be prepared to assist a cage culture operator to make sound decisions.

1. Cash flow budget
2. Enterprise budget
3. Partial budget
4. Whole farm budget

Only two will be explained below since the other two are variations of the enterprise budget and whole farm budget. The whole farm budget comprises several different enterprise budgets. The reader who is interested in further details is referred to Calkins and DiPietre (1983) and Castle, et al (1972).

As another aside, there is a difference between financial analysis and economic analysis. For the purpose of this paper, we need only to recognize this difference.

Enterprise Budget: An enterprise budget is the first basic tool of analysis which the cage culture operator must learn to master in order for him to make decisions regarding the allocation of inputs or factors of production under his management responsibility.

Broadly, an enterprise budget is a cost estimate of the combination of inputs to achieve the optimal level of output.

Referring to Figure 1, an enterprise budget represents a single point in the input output space; it can also represent a point on the input output relationship. The cage culture operator can construct and compare various levels of input use and various levels of output and then decide for himself the most profitable or economic level of output to produce.

There are three (3) main components in an enterprise budget. These are the Gross Returns, Variable Costs, and Fixed Costs. From these three components the net returns or profits is calculated as the difference between the gross returns and the combined variable and fixed costs.

<u>Gross Returns</u> is the market value of the output of the cage culture operation, that is, the quantity of fish harvested multiplied by the market price of the fish the operator receives. Note, however, the total cage culture production (yield) must be accounted for in calculating the gross returns.

This is because in many developing countries, fish often are harvested before they reach market size, or rarely are harvested at one time. Instead multiple harvests are made either for home consumption, as gifts for visitors to the farm or the house, or as in-kind wages for hired labor.

Sometimes escapes or loss of fish from poaching, predation, bad weather, damaged cages or nets, or even fish kill due to pollution or diseases, especially towards the end of the production cycle when the fish is ready for market, must somehow be reflected in the enterprise budget. Of course, it will represent a loss.

Failure to take this into account gives a false economic picture of the cage culture operation.

<u>Variable Costs</u> can be defined as expenditures directly related to the production of fish, that is, if no fish are raised, no expenditures are incurred. Variable costs are direct costs or operating costs (no operation, no costs). They can be both cash and non-cash expenditures incurred to produce the fish.

<u>Fixed Costs</u> are costs which will be incurred whether fish are produced or not.

Table 2 provides the categories of variable and fixed costs in a typical cage culture operation. The table is presented as a possible format for an enterprise budget. It can be varied to suit each particular situation.

From the enterprise budget, various measures of performance of the cage culture operation can be calculated. These performance measures reveal the economic efficiency and thus profitability of the cage culture operation.

Commonly used economic yardsticks are the gross, or net profits (returns); net returns over variable costs; net returns to operator's capital, labor and management or some variations of it; net returns to investment, and net returns to equity. Other yardsticks commonly used are net returns over all feeds fed or returns per $100.00 feed fed, total cost per 100 kg of fish, or the unit cost of production, or net profit per cage.

Table 2. Enterprise budget showing gross returns, variable and fixed costs for cage culture operation.

Budget Items	Estimated	Actual
Gross Returns		
1. Species A x Price		
2. Species B x Price		
3. Species C x Price		
Variable Costs		
1. Stocking Materials		
a. Species A x Price		
b. Species B x Price		
c. Species C x Price		
2. Feeds		
a. Compound		
b. Single Ingredient		
c. Others		
3. Labor		
a. Stocking		
b. Feeding		
c. Clean Fouling/Silting		
d. Guard/Security		
e. Repair/M'tenance		
f. Net Damage Inspection		
g. Fish Harvesting		
h. Fish Transporting		
4. Miscellaneous Costs		
a. Utilities (fuel)		
b. Depreciation		
c. Marketing Cost		
d. Interest Expense		
e. Others		
Fixed Costs		
1. Rental		
2. Taxes		
3. Interest on Capital Investment		
4. Others		
Gross Profits		
Net Profits		
Returns to Management		

(Note: If you like, you can also depreciate the value of your broodstock, especially if they are very valuable).

Once this is done, it is also worthwhile to determine the distribution of (net) returns to each of the factors of production used to see whether a fair (?) return is earned and paid to each of the production factor. By closely examining the distribution of net income to the factors of production, the cage culture operator will find out whether the most economic or profitable use of the factors of production has been achieved on his farm.

The economic implications of this net returns distribution to each of the factors of production like capital, labor, management are very important in economic efficiency analysis (as opposed to technical efficiency). If low or negative returns to management is found, it means that cage culture operation is not necessarily the most economic use of the resources at the disposal of the operator. Other alternative uses of the same set of resources or inputs can bring in higher net returns when compared to fish cage culture.

The cage culture operator will be better off by working elsewhere or at any other activities which give positive returns to management, other than the cage culture operations (negative returns).

Enterprise budgets are reformulated each year to reflect the prevailing situation. Note, however, the technical coefficients (e.g. growth rates, feed conversion ratios) rarely change unless major technical changes are made.

Partial Budgeting: In direct contrast, partial budgeting is resorted to when the cage culture operator feels that he is already operating at a satisfactory level and he wants to further fine-tune his operation. In other words, he would not make any big changes to his existing system of production.

Since he will continue with his present production system, fixed costs will remain the same as he fine-tunes his operation. What will change is his level of output and/or his variable costs.

Partial budget only traces the effect of small changes on the farm, that is, the net increase/decrease in the farm income picture as a result of the proposed small change. These usually take the form of either increases in output or decreases in input use.

Some examples of small changes on the farm which can be considered once the cage culture operations are underway include but are not limited to the following: the difference between stocking different size fingerlings; the difference between feeding in the daytime and nighttime; the difference between acclimatizing the stocking materials before release into the cages and not acclimatizing; the difference between varying stocking densities.

The important thing to remember in partial budgeting is to calculate four (4) sets of costs and returns. The standard procedure is to compare:

Increased Returns	Decreased Costs
Increased Costs	Decreased Returns
Sum1	Sum2
===============	=================

Alternatively,

Increased Costs	Increased Returns
Decreased Returns	Decreased Costs
Sum3	Sum4
=================	================

Sum1 and Sum2 are then compared to see which of the two sums is greater. If the summation of the increased returns resulting from the small change is greater than the summation of increased costs, it is obvious that the proposed small change is profitable and thus should be made. The converse is true.

SENSITIVITY ANALYSIS

What if prices of inputs or outputs change? One way of determining the impact of changes on budgets and profitability is to carry out a sensitivity analysis. The sensitivity analysis can show the range or the working margin in which such prices or technical coefficients can change before the profitability of the cage culture operation is affected. It shows how sensitive a particular output level and its associated input combination is to changes in prices. The key variables assuming different values are altered or varied one at a time.

RECORD KEEPING

To accomplish the above analysis in the most ideal fashion, you need to keep records of your operations. The more details you collect the better your performance assessment. Good records are indispensable for evaluating the operations of your cage culture operations.

At the minimum, records kept must include input use and resulting output. Input application rates for stocking materials, feeds (supplementary, or complete), medicines and chemicals and labor need to be recorded in some detail to be useful. This is because the levels and rates of input use will influence the yield and productivity of the operations.

To measure growth and feed conversion efficiency, it is very important that the stocking materials (either fry or fingerlings) be weighed before being stocked in the cages, and also at harvest. Also at regular intervals, the growth of the fish should be checked. This provides a measure of feed and growth efficiency.

The source of the inputs, either purchased or produced on the farm must also be recorded. Similarly, important environmental and climatic factors should be recorded as these will also affect yields. In cage culture operations where the basis of production is feeds, the feed conversion rate (feed efficiency) has great economic ramifications.

CONCLUSIONS

You will note from the foregoing presentation that we have taken a very narrow view of economics, that is, from the point of view of the individual firm or entrepreneur. We have not taken into account the broader picture of Welfare Economics or how the cage culture operations affect other individuals or firms or the community or society where the cage culture operations are located. It is conceivable that the cage culture operations can affect either adversely or in a positive way the production activities, livelihoods and liberty of the other members of the community.

We are here only concerned with the private costs and benefits to the individual cage culture operator, and not the (larger) social costs and benefits. The latter social costs and benefits are not included in the accounting configuration of the cage culture operator. He is more concerned about his own welfare than that of the society/community he is doing business in. Many governments are beginning to require private firms to fully account for their production activities and actions taken on their premises which spillover into other properties. These spillovers normally result in economic losses to others.

An important aspect which we have not dealt with here is whether there are any significant economies of scale in fish cage culture.

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L'ANALYSE ECONOMIQUE DES ACTIVITES DE PISCICULTURE EN CAGES

Kee-Chai Chong

Résumé français

L'application des analyses économiques simples aux activités de culture en cages est décrite dans cet article. On peut faire des analyses économiques avant d'entreprendre la culture en cages (analyse ex. ante), afin de déterminer si l'activité pourra être rentable; ou après le début des activités (analyse ex. post), afin de maximiser l'efficacité économique. Il est important de refaire régulièrement les analyses, car les conditions économiques (prix du poisson sur le marché; améliorations aux techniques de production) sont en évolution constante.

Les coûts fixes (coûts en capital) et les coûts variables (coûts d'opération) d'une pisciculture en cage sont discutés et des tableaux présentés pour faciliter les analyses. La préparation et l'analyse d'un budget d'entreprise sont détaillées, et on souligne l'importance du maintien de registres détaillés des coûts et des revenus.

SUMMARY DISCUSSION

1.0 Site selection

1.1 Site selection criteria for cage culture are generally well established, and there should be no major problems with this.

1.2 Running waters and still waters may require different adaptations to the cage design; for exemple, rigid cages may be required in running waters.

2.0 Cage structure

2.1 Two types of cage structure have been used by workshop participants : one made of flotation elements (empty barrels) supporting wood or metal structures, the other using bamboo for both structure and flotation. The first type is more expensive but lasts longer. Shortage of bamboo may be a problem in some regions but this can be compensated for by growing bamboo.

2.2 Opinions were mixed as to whether cage structure should include walkways permitting workers to stand beside cages. The supplementary costs for flotation and structure may decrease profitability. A wide boat, built relatively cheaply, may provide a working platform almost as stable as the cage structure at lower cost.

2.3 Regular, frequent maintenance is essential to successful cage culture (cleaning, repairing holes).

3.0 Species

3.1 Choice of species for culture should be determined by market conditions.

3.2 Research on tilapia genetics, with the objective of maintaining pure strains, should be a high priority.

4.0 Feeds and feeding

4.1 Supplementary feeding is almost always necessary with tilapias - the exception is in highly eutrophic waters. However, growth without feed should be assessed early in cage culture research (perhaps on a small scale) to determine whether production without supplementary feeding may be profitable. Other species (eg. Silver carp) may show good growth on natural water productivity in less productive water bodies. Feed costs represent the biggest variable costs in cage culture systems.

4.2 Feed quality is the research area which could have the greatest short-term impact on warm water cage fish culture. Research should be carried out not only on complex compounded feeds (which may be practical in countries where a wide range of feedstuffs is available, and where an animal feed production system is in operation), but also on simple feedstuffs and combinations (for example, on agricultural byproducts).

4.3 Feeding pattern (timing and frequency) is an important variable. Feed utilisation may be more efficient if feeding frequency is increased. Some experiments have shown better utilisation with night feeding than by day (but this needs more work).

5.0 Culture cycles

5.1 Sorting, to maintain homogeneous size in the cages, and reducing density of fish in cages, can lead to increased yields. Yields increased in the Sri Lanka experiments when densities were reduced after several months' culture. In the Ivory Coast commercial system, fry cages were sorted every 2 weeks to maintain a constant size for stocking grow-out cages while the latter were sorted at 1 - 2 month intervals to maintain optimum biomass. Best time(s) for density reduction may be determined in experiments, by noting time when growth curves for fish at different densities diverge (See figure and discussion in Muthukumarana and Weerakoon paper).

5.2 Stocking size is another important variable to be investigated in developing efficient cage culture systems.

5.3 Species combinations should be considered for cage culture, although the cage environment does not have the diversity of ecological niches characteristic of ponds.

5.4 Males only tilapia cage culture gives better yields than mixed species culture, but research is needed to determine whether the increased benefits from higher yields outweigh the costs of producing monosex populations.

6.0 Fry production

6.1 All the projects described at the workshop were based on fry production in ponds, although the Togo project had some success in producing tilapia fry in hapas (small mesh cages). Tilapia fry production in hapas is highly developed in the Philippines and should be considered for incorporation into cage culture research projects in future.

6.2 Broodstock selection is an important though often neglected, aspect of fry production.

6.3 Good fish handling techniques are essential to successful fry production.

7.0 Economic aspects

7.1 Economics data and analyses are essential in cage culture research projects. Research teams should include economists from the start of the project, to ensure that projects are properly planned and executed.

DISCUSSION GENERALE

1.0 Sélection des sites

1.1 Les critères de sélection des sites pour la culture en cages sont bien établis, et on n'anticipe pas de problèmes à ce sujet.

1.2 Les eaux courantes et les eaux tranquilles nécessitent des adaptations différentes au système de culture; par exemple des cages rigides seront peut-être nécessaires dans les eaux courantes.

2.0 Structures des cages

2.1 Les participants ont utilisé deux sortes de structures en général : une sorte incorporant des éléments de flottaison (des barils vides), avec des structures de bois ou de métal; l'autre utilisant du bamboo pour la flottaison et la structure. La première sorte coûte plus cher mais dure plus longtemps. Le manque de bamboo peut être en problème dans certaines régions mais on peut pallier à ce problème en cultivant le bamboo.

2.2 Les avis étaient partagés quant au besoin d'avoir des structures permettant aux culturistes de marcher autour des cages. La flottaison et la structure supplémentaires nécessaires sont ajoutées aux coûts; il se peut qu'un bateau large et peu couteux soit presqu'aussi bien comme plateforme de travail que la structure de la cage même.

2.3 L'entretien régulier et fréquent est essentiel à la réussite de la culture en cages (nettoyage, réparation des trous).

3.0 Espèce

3.1 Le choix des espèces doit être déterminé en général par les marchés.

3.2 Les travaux de recherche sur la génétique des tilapias, dans le but de maintenir des souches pures, représentent un domaine de recherche prioritaire.

4.0 Les aliments et l'alimentation

4.1 L'alimentation supplémentaire est presque toujours nécessaire pour les tilapias en cages, sauf dans les eaux eutrophiques. Néanmoins, il est important d'évaluer la croissance sans nourriture (peut-être à petite échelle) pour déterminer si la la production sans aliment supplémentaire peut être économiquement rentable. Certaines autres espèces (ex. la carpe argentée) peuvent démontrer une bonne croissance en exploitant la productivité naturelle des eaux moins productives. Les coûts de l'aliment sont les coûts variables les plus importants dans les systèmes de culture en cages.

4.2 La qualité de l'aliment est sûrement le domaine de recherche qui pourrait avoir le plus grand impact sur la culture des espèces d'eaux chaudes en cages. Les recherches devraient se poursuivre non seulement sur les aliments composés complexes (utilisables dans les pays où plusieurs ingrédients sont disponibles et un système de production d'aliments existe) mais aussi sur les aliments et combinaisons simples (par exemple des sous-produits agricoles).

4.3 Le rythme et la fréquence de l'alimentation sont des variables importantes. Il arrive quelquefois que les aliments soient utilisés plus efficacement en les offrant aux poissons le plus souvent. Certaines expériences ont démontré que les poissons nourris pendant la nuit, ont une meilleure croissance que ceux nourris pendant la journée, mais des recherches plus détaillées sont nécessaires à ce sujet.

5.0 Cycles de culture

5.1 Le tri (pour maintenir les poissons à une taille homogène dans les cages) et la réduction de la densité des poissons dans les cages, résultent souvent en une augmentation des rendements. Dans les expériences au Sri Lanka, les rendements ont augmenté suite à une réduction des densités après quelques mois d'élevage. Dans le système commercial en Côte d'Ivoire, le tri des poissons dans les cages d'alevinage se fait toutes les 2 semaines, afin d'assurer une taille constante pour la mise en charge des cages de production; et le tri des poissons dans les cages de production se fait aussi tous les 1 - 2 mois afin de maintenir une biomasse optimale.

5.2 La taille à l'empoissonnement est une autre variable importante à considérer dans le développement des systèmes de culture en cages.

5.3 On devrait considérer des combinaisons d'espèces pour la culture en cages, même si la cage n'offre pas la diversité de niches écologiques qui caractérisent l'étang.

5.4 Des populations monosexes mâles de tilapias fournissent un meilleur rendement en cage que les populations des deux sexes, mais on a besoin de recherches pour établir si les bénéfices résultant des rendements accrus contrebalancent les coûts de production des populations monosexes.

6.0 Production d'alevins

6.1 Toutes les expériences décrites se sont basées sur la production d'alevins en étang, quoiqu'on a eu quelques succès au Togo avec la production d'alevins de tilapia en hapa (cage à maille fine). La production d'alevins dans les hapas est bien développée aux Philippines et pourrait être considérée pour des expériences de culture en cages à l'avenir.

6.2 La sélection des géniteurs est un aspect important de la production d'alevins, qui est souvent négligé.

6.3 De bonnes techniques de manipulation des poissons sont essentielles à la réussite de la production d'alevins.

7.0 Aspects économiques

7.1 Les données et les analyses économiques sont essentielles aux projets de recherche sur la culture en cages. Les équipes de recherche devraient inclure un économiste dès le début pour s'assurer que les projets soient bien planifiés et entrepris.

DISCUSSION - RESEARCH PRIORITIES

The following points (approximately in order of priority) were noted as research needs in the final discussion session.

1.0 Production economics

This was identifed as the most important area for research. Marketing (including processing where appropriate) should be researched, as well as cost-benefit relationships. One should not spend too much time on overly-sophisticated analyses.

2.0 On-farm research

This is a methodology rather than a research theme, and was not considered in detail during the workshop. However, it was agreed that "real-life" trials of production systems were a high priority for cage culture research. Research teams have developed several production systems which can produce fish in a variety of economic and ecological milieux, as has been shown during this workshop. What is needed now, is to test the attractiveness of these systems to farmers.

3.0 Feeds

As was noted above (Summary Discussion 4.1), research on feed quality could yield great benefits, since feed costs are the biggest variable costs in cage culture. Non traditional feedstuffs (eg. leafy matter) should be considered.

4.0 Culture systems

This subject could be divided into a number of sub-themes; but the various aspects of culture systems (cage designs; stocking rates; feeding rates etc.) will remain the central theme for research for the foreseeable future.

5.0 Integrated systems and Polyculture

These two themes were identified as important for research in future, although they were not considered in detail during the workshop. An integrated system using ducks and tilapias on a raft/cage structure has produced interesting economic yields in Egypt. This system was enthusiastically discussed by participants.

6.0 Genetics

This is an important area for research, especially for tilapias (see Summary Discussion 3.2), but it was agreed that research should be done in a regional or world centre rather than in national aquaculture research programs.

7.0 Fry production

Many participants were of the opinion that this is no longer an appropriate research topic, except for specialised areas such as production of monosex populations. Efficient fry production techniques exist for species of most interest, and their application does not require further research.

Other participants did not agree, believing that further research was required to develop efficient systems for making fry available to producers. For example, where government infrastructure is weak, it may be necessary to develop fry production systems which can be managed by farmers.

The difference in opinion is probably due to regional differences; existing fry production systems may be quite appropriate in some regions, while in others considerable innovation may still be necessary.

PRIORITES DE RECHERCHE

L'établissement des priorités de recherche peut être difficile dans des discussions en atelier, surtout à 16:00 hrs la dernière journée. Cependant, on a relevé les points suivants (très approximativement en ordre de priorité décroissante).

1.0 Les aspects économiques de la production

Ceci semble être le thème de recherche le plus important.

La mise en marché (y compris la transformation si appropriée) est aussi importante que les analyses coûts-bénéfices.

Il ne faut pas perdre de temps avec des analyses trop sophistiquées.

2.0 La recherche auprès du fermier

Une méthodologie plutôt qu'un thème de recherche, ce sujet n'a pas été considéré en détail lors de l'atelier. Cependant, on a convenu que des recherches sur le système de production dans un contexte de "vie de tous les jours" représentent une haute priorité pour la culture en cages. Les équipes de recherche sur la culture en cages ont mis au point des systèmes expérimentaux qui ont la possibilité de produire du poisson dans des milieux écologiques et économiques variés, comme on a pu le voir lors de l'atelier. Ce qui est essentiel maintenant, c'est de vérifier auprès des fermiers si les systèmes sont attrayants.

3.0 Les aliments

Comme on a noté plus haut (Discussion générale 4.1), les recherches sur la qualité des aliments pourraient produire des résultats importants, puisque les coûts des aliments sont les coûts variables les plus importants dans la culture en cages. Des aliments non-traditionnels (par exemple les feuilles des plantes) devraient être considérés.

4.0 Les systèmes de culture

Ce sujet pourrait être divisé en plusieurs sous-thèmes; cependant, les divers aspects des systèmes de culture resteront le thème central pour la recherche pour l'avenir immédiat.

5.0 Systèmes intégrés/Polyculture

Les deux thèmes semblent importants pour la recherche à l'avenir, même si on ne les a pas considérés en détail lors de l'atelier. Un système intégré incorporant des canards et des tilapias, sur une structure radeau/cage, a produit des rendements économiques intéressants en Egypte; ce système a été discuté avec enthousiasme par les participants.

6.0 La génétique

C'est un thème de recherche prioritaire, surtout pour les tilapias (voir Discussion générale 3.2), mais on a convenu que les recherches devraient se faire dans un centre régional ou mondial plutôt qu'à l'intérieur des programmes nationaux en aquaculture.

7.0 La production d'alevins

Plusieurs participants ont considéré que ce n'est plus un sujet pour la recherche, sauf pour des aspects spécialisés telle la production de populations monosexes. Des méthodes efficaces de production d'alevins existent pour les espèces de grand intérêt, et leur mise en application ne nécessite pas de recherches.

D'autres participants n'étaient pas d'accord, croyant que des recherches restaient à faire pour mettre au point des systèmes efficaces pour mettre des alevins à la disposition des culturistes. Par exemple, dans une situation où l'infrastructure du gouvernement est faible, il faudra peut-être développer des systèmes de production d'alevins qui pourront être gérés par les fermiers eux-mêmes.

Il se peut que le différend soit dû à des différences régionales d'approche; des systèmes déjà développés pourraient convenir dans certaines régions, mais des innovations seront nécessaires dans d'autres.

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