Chapter 11
Aquaculture Development

As previously mentioned, Lake Nasser is very rich in natural food of fish. Habib & Aruga (1987) estimated the average primary net productivity of phytoplankton in the whole Lake as 4.01 kg (dw) / m^2 / year, and accordingly the annual net primary production as 10.3 x 10^6 and 21.0 x 10^6 ton (dw) / year at water levels 160 and 180 m respectively. The latter authors pointed out that tilapia catch should be 22.7 x 10^3 and 46.2 x 10^3 ton / year at water levels 160 and 180 m respectively. However, the total fish production from Lake Nasser was only 20,601 ton in 1997 at a mean water level of 177.38 m. Therefore, it is necessary to conduct applied research in the field of aquaculture to maintain and increase the natural fishery resources of the Lake.

In Lake Nasser, there are three important problems to be solved, viz.,

1- Utilization of coastal areas, through mass production of Nile tilapia fry and their release to the khors.

2- Utilization of the open water area, through introduction of new pelagic fish species.

3- Restocking of indigenous fish species.

UTILIZATION OF THE COASTAL AREA

The coastal area of Lake Nasser is highly eutrophic, and very rich in both phyto-and zooplankton. It is almost suitable for *Tilapia* spp. *(Oreochromis niloticus* and *Sarotherodon galilaeus)* as feeding, breeding and also fishing grounds. Its area is great and reaches about 0.25 million acre, and it represents about 20% of the total surface area of the Lake. The coastal area produces about 95% of the total fish catch. Therefore, mass production of tilapia fry and their release to the coastal areas of the khors is of utmost importance in order to increase their fishery resources.

It was reported by FMC (Fishery Mangement Center) that the percentage of *0. niloticus* decreased to 41.8%, while that of *S. galilaeus* increased to 51.9%. The proportion of landed *0. niloticus* in the total catch of tilapia showed seasonal variation, with a maximum level (60-70%) during February to April, and a minimum (10-20%) during June to September, in each year. This tendency suggested an indication of danger to *0. niloticus* resource in the Lake in the future. It should be mentioned that *0. niloticus* grows about twice in weight as *S. galilaeus* when 4 years old (page 251). Therefore, it was inevitable to carry out some trials on mass production of *0. niloticus* fry and their release in khors.

Mass Production of *Oreochromis niloticus* Fry

The Fishery Management Center (FMC) at Aswan worked on mass production of fry of Nile tilapia to stock Lake Nasser, as one of the economical methods for fisheries development. Most of the biological studies on *0. niloticus* were covered and the technique of mass production of fingerlings was applied to the hatchery constructed for that purpose.

Nomura (1983) worked out a plan to produce one million fry of *Oreochromis niloticus.* A summary of the plan is presented.

1. **Number of brood fish**

Brood fish, about 30 cm in body length and 1 kg in body weight, produces about 1000 eggs during a spawning season (Fig. 231). Survival rate from eggs to fry (5 g in body weight) is 50%. Hence, the number of eggs required is two million. The number of female brood fish required to produce one million is 2000 (2,000,000 ÷ 1000). As the recommendable sex ratio at spawning time is 1:1, hence 2000 male brood fish are also required. Thus the total number of brood fish needed is 4000.

2. Kinds, area and number of ponds

a- Brood fish-spawning ponds. Total area 4,000 m^2 – size/pond= 8 x 12.5 x 1.5 m (1 m water depth), number = 40 ponds

Where : total weight of brood fish = 4000 kg (an average weight 1 kg, total number of fish = 4000), carrying capacity of brood fish 1 kg/m^2.

b- Nursery ponds

Area (m^2)	Number	Total area	Height of wall	Water depth (m)
10 x 15m = 150	15	2,250 m^2	1.3m	(0.8)
5 x 10 = 50	40	2000	1.3	(0.8)
3 x 5 = 15	30	450	1.0	(0.6)
2 x 4 = 8	25	200	1.0	(0.6)
1 x 4 = 4	25	100	1.0	(0.6)
Total	135	5,000		

Where : total weight of fry produced = 5000 kg (an average weight 5 g, 1 million in number), carrying capacity of fry = 1 kg/m^2.

Total area of ponds (a + b) = 9000m^2 = (0.9 ha).

3. Water supply system

Elevated tanks. Two tanks with a water capacity of 40 m^3 (4 x 2.5 x 4m). Water is supplied to each elevated tank by pumping up at a rate of 20 l/sec from the middle layer of the Lake, and the water in the tanks is supplied to each pond through pipes by gravitation. Pumping activity is regulated by the automatic on-off switch set on the elevated tanks.

4. Fish feeds preparation house

Total weight of brood fish is 4000 kg. As the feeding rate for brood fish is 1.5% of total body weight at 25°C water temperature, the daily amount of feeds required = 60 kg (4000 x 0.015) or 22 ton per year. On the other hand, total weight of fry produced is 5000 kg (1,000,000 X 5 g). By using a conversion factor 1.8, the total weight of feeds required to produce 1 million fry (from alevin to 5 g fry) is 9,000 kg (5000 x 1.8). It takes 40 days to grow up to 5 g from alevin, so daily amount of feeds is 225 kg (9000 ÷ 40). From the above calculations, the average amount of feeds to be prepared daily for both brood fish and fry is 285 kg (60 + 225), or 31 ton per year.

For the preparation of these large amounts of feeds, equipment for mixing, chopping, drying and sieving is necessary. Also, it is essential to set up cold storage for feed materials and fish feeds (30 ton capacity at – 5°C). The area of the house needed is about 65 m^2 (6.5 m x 10 m), including a cold storage area.

Shenouda (1997a) reported on the intensive production of Nile tilapia fry in the Fishery Management Center at Aswan (FMC). The report includes the followings:

a. Preparation of fishing equipment and collection of the brood fish (males and females) during January to April 1995.

b. Preparation of a wet lab and nursery equipment at the end of March 1995.

c. Intensive production of *0. niloticus* fry during 1995 was carried out from May to October 1995 at an average water temperature of 25.5 ± 3.0 °C with a maximum in September and a minimum in October. The relation between body weight and number of mature eggs / female for *0. niloticus* (Fig. 231) shows that the number increases with increase of body weight.

Feeding of Nile Tilapia Fry with Natural and Artificial Feeds

Sufficient and continuous supply of suitable and economical food for Nile tilapia fry is one of the most important items in a tilapia hatchery. On running an experiment, Shimura (1992b) observed that *0. niloticus* fry of total length 0.9-1.5 cm prefer *Moina* sp. Small fry being 0.9 cm long aggressively catch *Moina* sp., especially small ones (about 0.6 mm long). Large fry (i.e. 1.5 cm long) easily catch mature *Moina* sp. (i.e. 1.2 mm long). They feed on not only zooplankton, suspended materials, but also bottom dwelling organisms: *Chironomus* larvae (Insecta, Diptera). Nile tilapia fry seem to be omnivorous and feed on many kinds of food items.

Artificial diet composed of scrap tilapia fish meal containing 48.1% crude protein was used as food for *0. niloticus* fry (Shenouda 1995a).

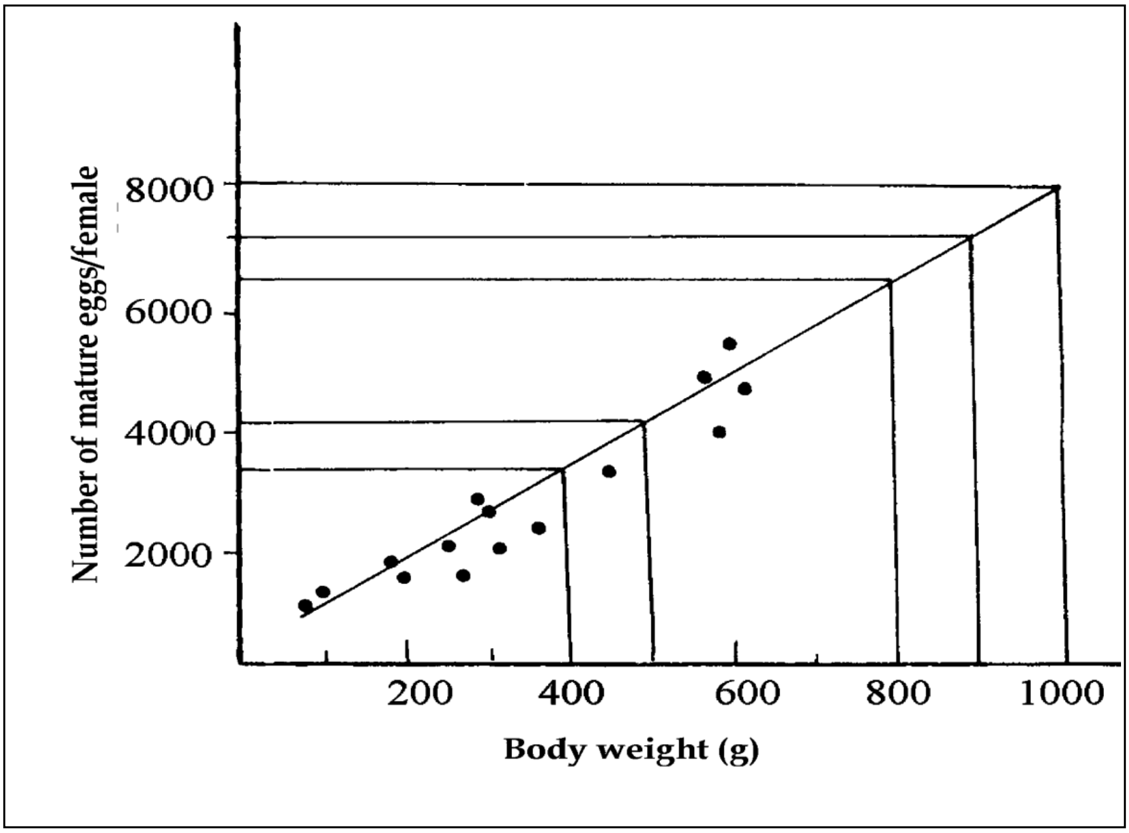


Fig. 231 **Relation between female body weight and number of mature eggs of *Oreochromis niloticus* (Shenouda 1997a).**

Effect of Dietary Protein Levels on Growth Performance, Feed Conversion Ratio and Protein Utilization in Fry of *0. niloticus*

Shenouda (1995a) used readily available scrap tilapia meal in formulating seven diets with different levels of protein (Table 168), which he used to feed Nile tilapia fry (average weight 1.89 ± 0.029g) stocked in eight glass aquaria (60 x 50 x 40 cm) with 100 l water. The latter author carried out the experiment for 30 days, and the fry were fed daily with 10% of their body weight. The feed was offered in equal amounts, as a paste, twice a day. The result of the experiment may be summarized as follows :

1. The growth of Nile tilapia fry (Fig. 232), survival rate and feed conversion ratio (FCR) (Table 169) indicate that the highest growth and best feed conversion ratio were obtained when using a diet containing 31.6% crude protein.

Table 168 **Composition of experimental diets of** ***Oreochromis niloticus*** **fry (Shenouda 1995a).**

Ingredients	**Diet No. & %**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Control**
Fish meal	10	20	30	40	50	60	70	Unfed
Wheat flour	24	24	24	24	24	24	24	
Feed oil	1	1	1	1	1	1	1	
Vitamin mix.	1	1	1	1	1	1	1	
Mineral mix.	1	1	1	1	1	1	1	
Cellulose	63	53	43	33	23	13	3	
Crude protein (%)	7.5	12.4	17.2	22	26.8	31.6	36.4	
Crude fat (%)	2.7	4	5.3	6.5	7.8	9.1	10.3	

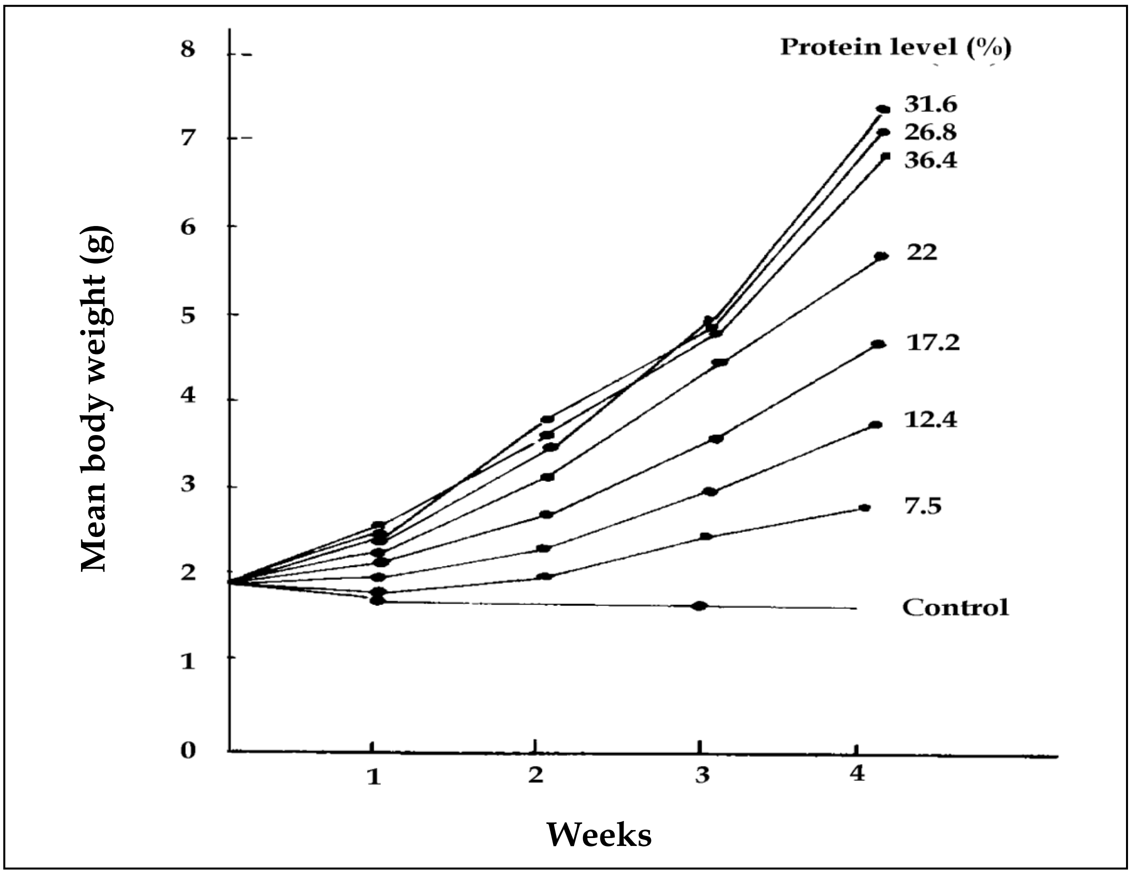


Fig. 232 **Growth of** ***O. niloticus*** **fry fed on diet of different protein levels** (Shenouda 1995a)

2. The gain in weight increased progressively with increasing the level of protein up to 31.6% (Table 169, and Figs. 233 and 234).

2. Protein efficiency ratio decreased with increasing levels of crude protein more than 25% (Table 170 and Fig. 237).

Table 169 **Stocking rate, survival rate, growth and food conversion ratio (FCR) of *O. niloticus* fry with different levels of dietary protein for 30 days (Shenouda 1995a).**

*Diet No.	Number and weight of fry: At the beginning			At the end			Weight increment					
	No. of fry	Total weight (g)	Mean weight (g)	No. of fry	Total weight (g)	Mean weight (g)	Total (g)	%	Mean weight (g)	Average daily growth (g/fry/ day)	Feed (g)	FCR
1	50	95	1.9	50	143	2.86	48	50.5	0.96	0.032	240.6	5
2	50	92	1.48	50	191	3.82	99	107.6	1.98	0.066	261.6	2.64
3	50	94	1.88	50	236	4.72	142	151	2.48	0.094	279.1	1.97
4	50	94	1.88	50	310	6.20	216	229.7	4.32	0.144	304.1	1.42
5	50	96	0.92	50	361	7.22	265	276	5.30	0.176	345.6	1.3
6	50	96	1.91	50	372	7.44	276	287.5	5.52	0.184	328.1	1.19
7	50	95	1.9	50	347	6.94	252	265.2	5.04	0.168	335.1	1.33
8 (control)	50	95	1.9	45	77	1.71	-18	-18.9	-0.19	-0.006	-	-

Food conversion ratio (FCR) = feed weight (g) /g live gain (g). * Refer to table 168 for diet composition.

Table 170 **Growth, protein efficiency ratio and food conversion ratio (FCR) of *0. niloticus* fry fed on different protein levels (Shenouda 1995a).**

Diet (% protein)	Initial (wt. g)	Final (wt.g)	SGR*	PER"""	FCR
7.5	1.9	2.86	1.36	2.66	5
12.4	1.84	3.82	2.43	5.050	2.64
17.2	1.88	4.72	3.06	2.958	1.97
22	1.88	6.20	3.97	3.197	1.42
26.8	1.92	7.22	4.41	2.861	1.3
31.6	1.92	7.44	5.51	2.666	1.19
36.4	1.9	6.94	4.31	2.066	1.33

*** SGR (specific growth rate) = 100 (final weight / initial weight / days).**

**** PER (protein efficiency ratio) = weight gain / days/protein intake.**

4- Specific growth rate and average daily growth increased with increasing dietary protein level up to 31.6%, while it decreased with 36.4% protein level (Tables 169 and 170, and Figs. 235 and 236).

Shenouda (1995a) concluded that the best dietary protein level for fry of Nile tilapia *(0. niloticus)* was 31.6% at the feeding rate 10% of body weight per day, and the available scrap tilapia meal is a suitable protein source for Nile tilapia fry diets.

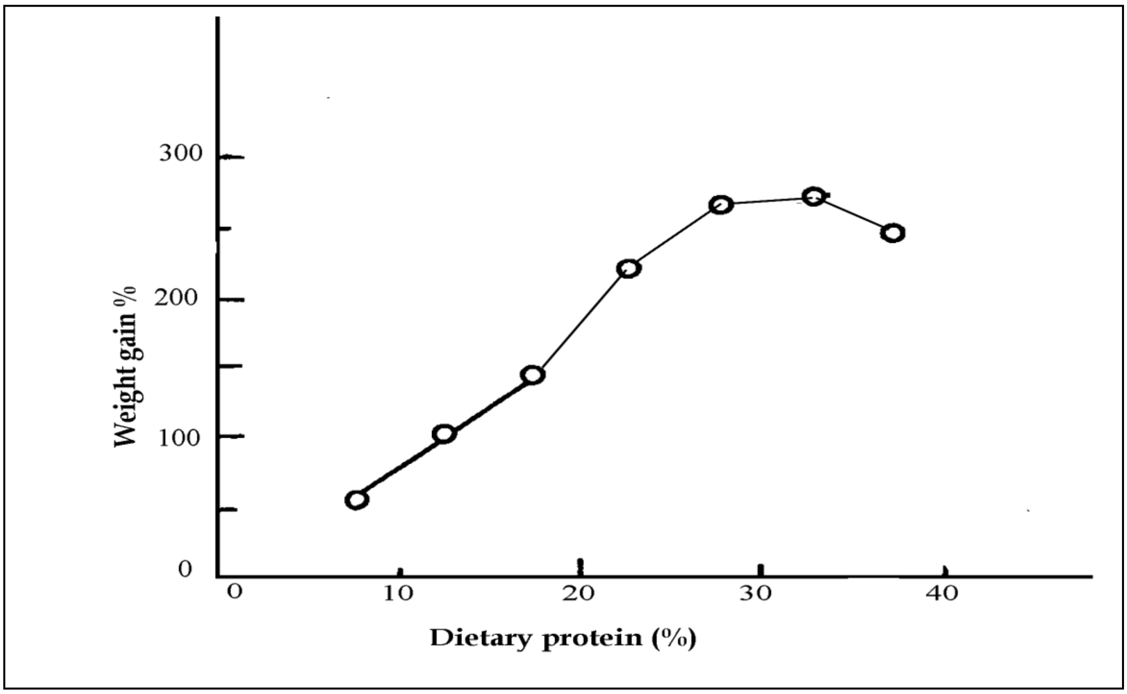


Fig. 233 **Relation between protein level of diet and body weight gain in *0. niloticus* fry (Shenouda 1995a).**

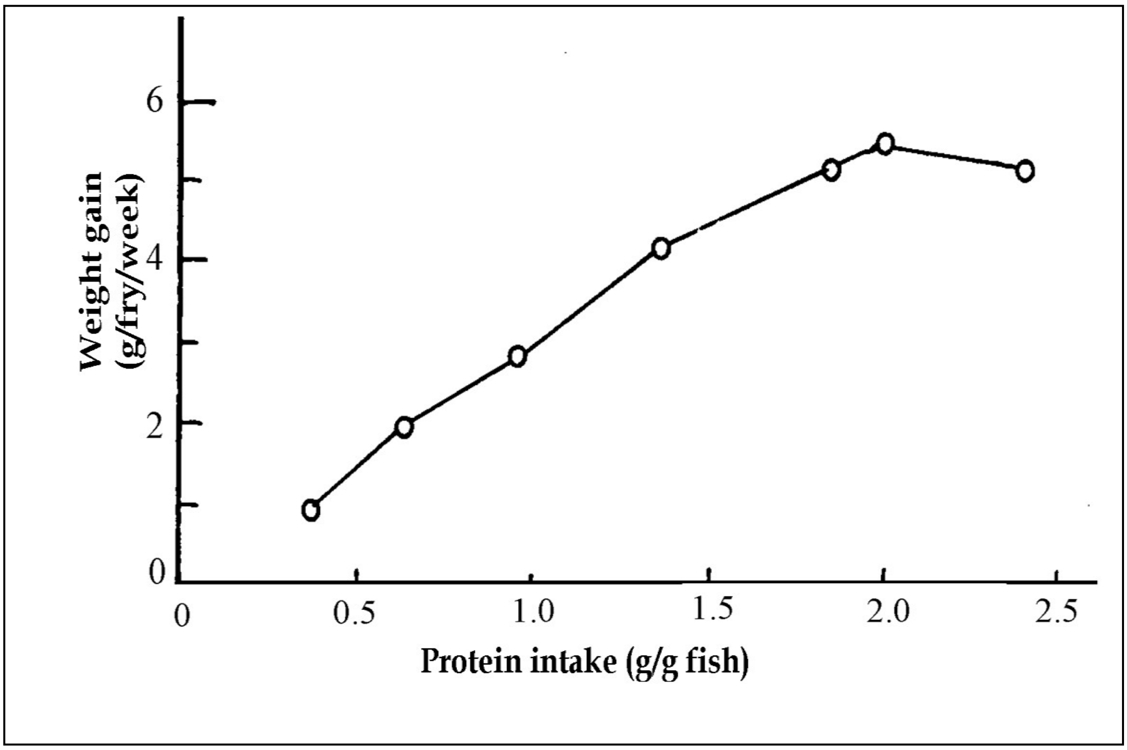


Fig. 234 **Relationship of dietary protein intake to weight gain in *0. niloticus* fry (Shenouda 1995a).**

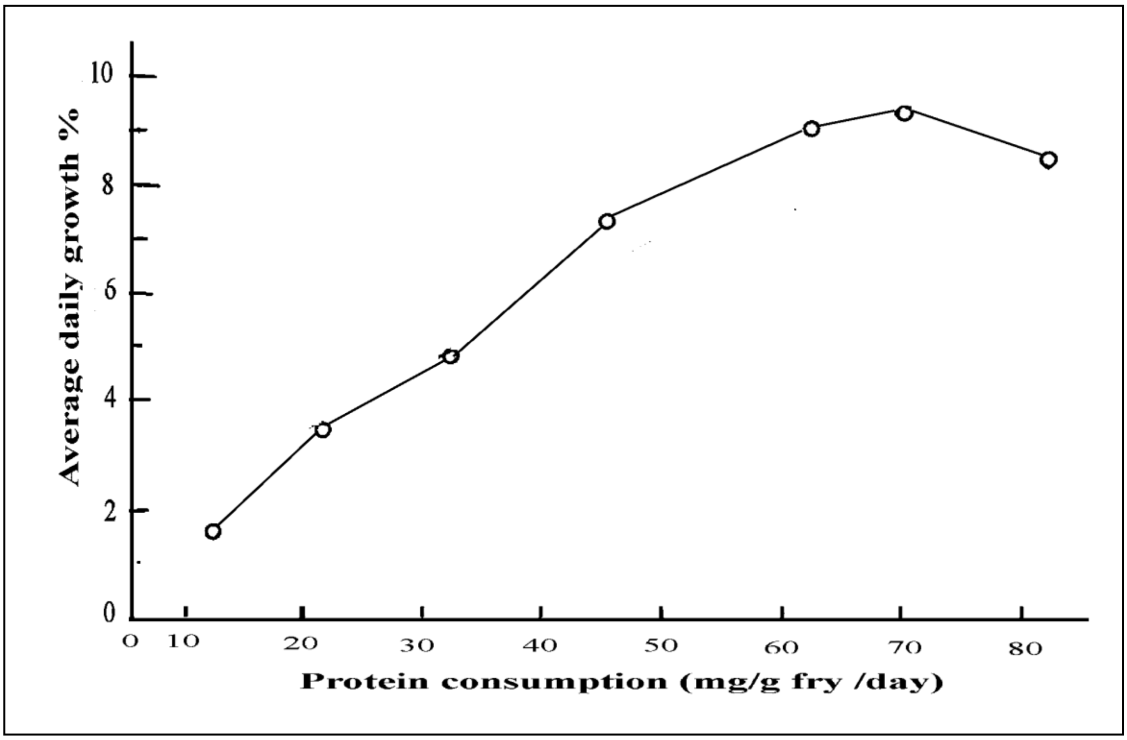


Fig. 235 **Relationship of average daily growth percent (ADG%) to protein consumption of *0. niloticus* fry (Shenouda 1995a).**

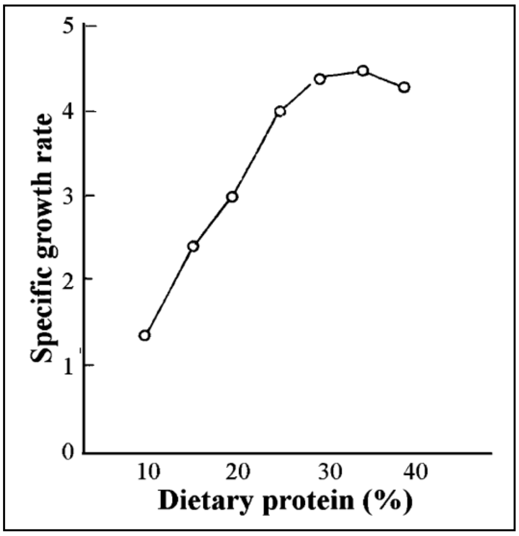


Fig. 236 **Effect of dietery protein levels on specific growth rate of *O. niloticus* (Shenouda 1995a).**

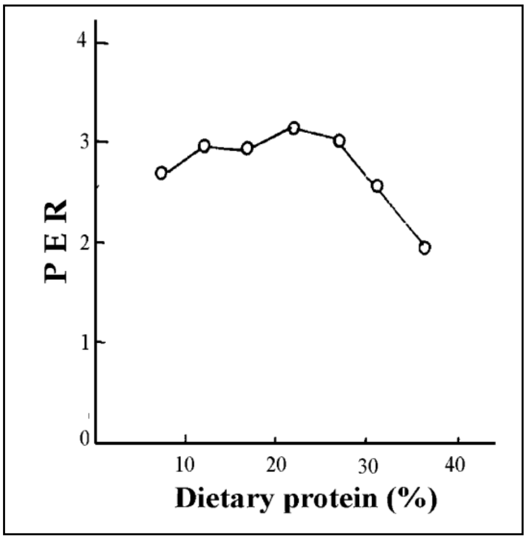


Fig. 237 **Effect of dietary protein levels on protein efficiency ratio (PER) of *O. niloticus* fry (Shenouda 1995a).**

Nile Tilapia Fry Release to Lake Nasser and Their Effect on Fish Production

The Fishery Management Center at Aswan (FMC) released fingerlings of *0. niloticus* in the southern area of Khor Kalabsha (Fig. 238) every year since 1988 till 1993. The number of released fry and the results are shown in Table 171 and Figs. 239-243. It is noticed that in the area where the fry are released, (southern area) a decrease of the percentage of fish yeild occurred only in 1989, which may be related to stopping of fishing from January to June (Agaypi, 1995a). The percentage increase of the catch compared with the catch of 1988 shows the effectiveness of fry releasing in the southern area of the Khor. The catch ratio in the southern area is higher than in the other areas. Moreover, the effectiveness of fry releasing is more evident in 1991 and 1992 than in 1993. The effect of fry releasing depends on minimum water level and the shape of the shoreline. The minimum water level was 150.62 m in 1988, while it was 164.3 m in 1989. When the water level increases in Khor Kalabsha (with a flat shoreline), the shallow water area expands and so the spawning grounds increase, and thus natural spawning increases. Detailed information on the number of operating fishing boats, composition of *0. niloticus* and *S. galilaeus,* interviews with fishermen, experimental fishing, tag experiment, etc. are necessary for a precise evaluation (Agaypi 1995a).

***Table 171* Effect of release of *0. niloticus* fry in the southern area on tilapia catch of Khor Kalabsha.**

	Year					
	1988	1989	1990	1991	1992	1993
Minimum water level (m)	150.62	164.30	163.72	162.23	163.84	167.24
No. of fry released	522,000	425,000	557,000	417,000	556,000	977,000
Mean body weight (g) of released fry	7.4	4.4	2.0	5.4	2.5	3.2
Total fish catch (ton)	663(100%)	652(100%)	949(100%)	2741(100%)	1963(100%)	1078(100%)
Catch from:	%	%	%	%	%	%
Entrance	209(31.5)	420(64.4)	269(28.3)	767(28)	297(15.1)	323(30)
North	293(44.2)	134(20.6)	228(24.1)	962(35.1)	919(46.8)	396(36.7)
South	161(24.3)	98(15.0)	452(47.6)	1012(36.9)	747(38.1)	359(33.3)
% increase and % decrease of catch compared with catch of 1988:						
Entrance (%)	--	+ 101	+ 29	+ 267	+ 42	+ 55
North (%)	--	- 54	- 22	+ 228 *	+ 214	+ 35
South (%)	--	- 39	+ 181	+ 529	+ 364	+ 123

Data are based on report by Agaypi (1995a).

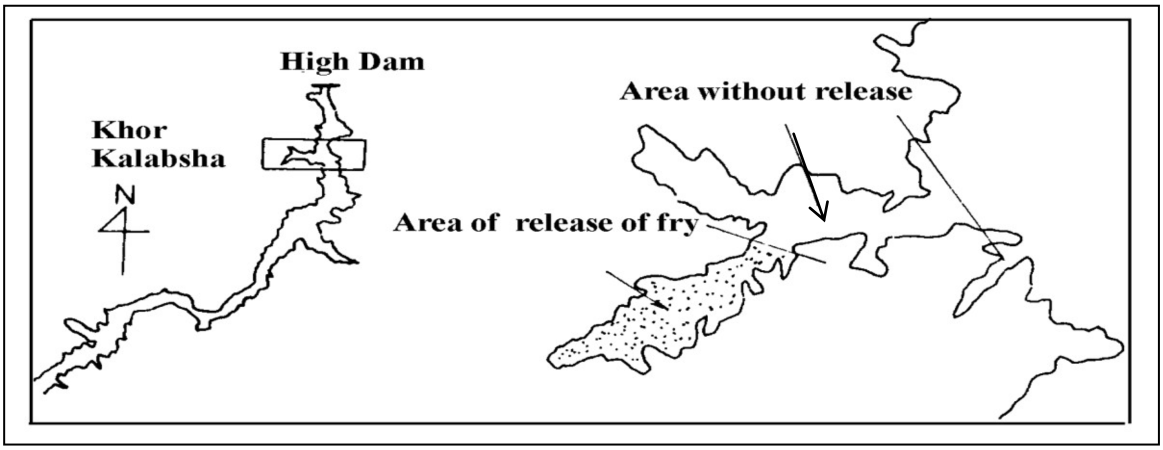


Fig. 238 **Location of Khor Kalabsha in Lake Nasser (Agaypi 1995a).**

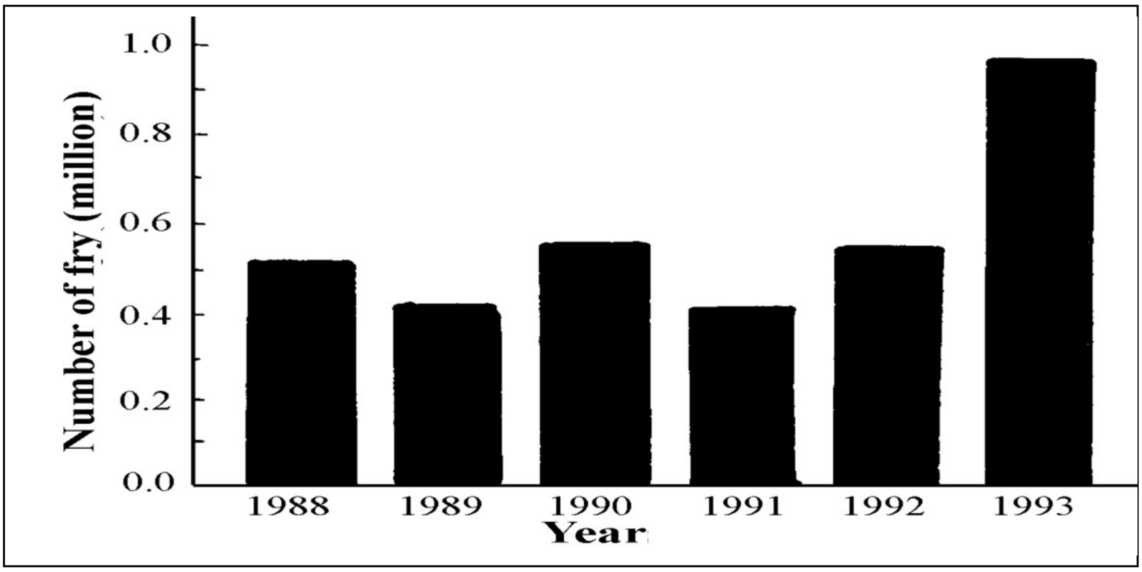


Fig. 239 **Number of *O. niloticus* fry released in the southern region of Khor Kalabsha (Agaypi 1995a).**

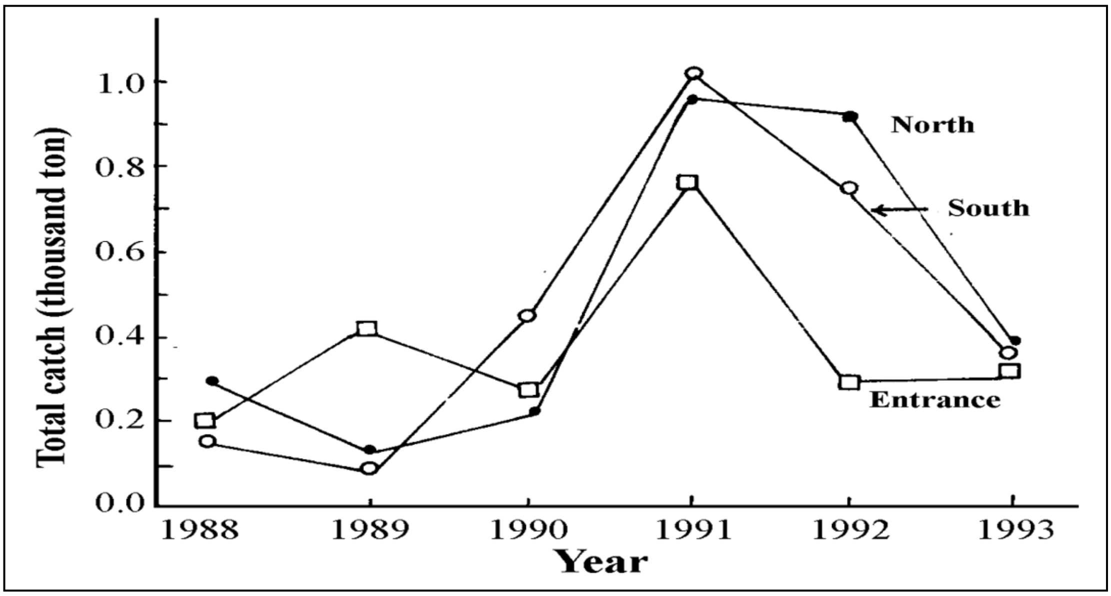


Fig. 240 **Yearly total catch of the three areas in Khor Kalabsha (Agaypi 1995a).**

Agaypi (1996a) pointed out that release of *0. niloticus* fry in Khor El Ramla started from 1991 to 1994 with increase of the released fry from 164,000 to 1,175,000 (Fig. 242). The results were manifested in 1994 by an increase of tilapia catch from 1197 ton in 1993 to 1870 ton in 1994 (Fig. 244). Thus assuming that fish are caught at an average age of 2 years, so the release of about one million tilapia fry in 1992 led to an increase of the total catch by 56%. It should be mentioned that during 1993 and 1994, the total Lake catch of *0reochromis niloticus* was decreasing from about 14,884 ton to 9,111 ton from about 20% of the total Lake area. Thus, it can be concluded that fry stocking of khors and applying proper fishery management (prohibiting the use of illegal gear, care to the fry released, no overfishing, etc.) may increase fish production from Lake Nasser.

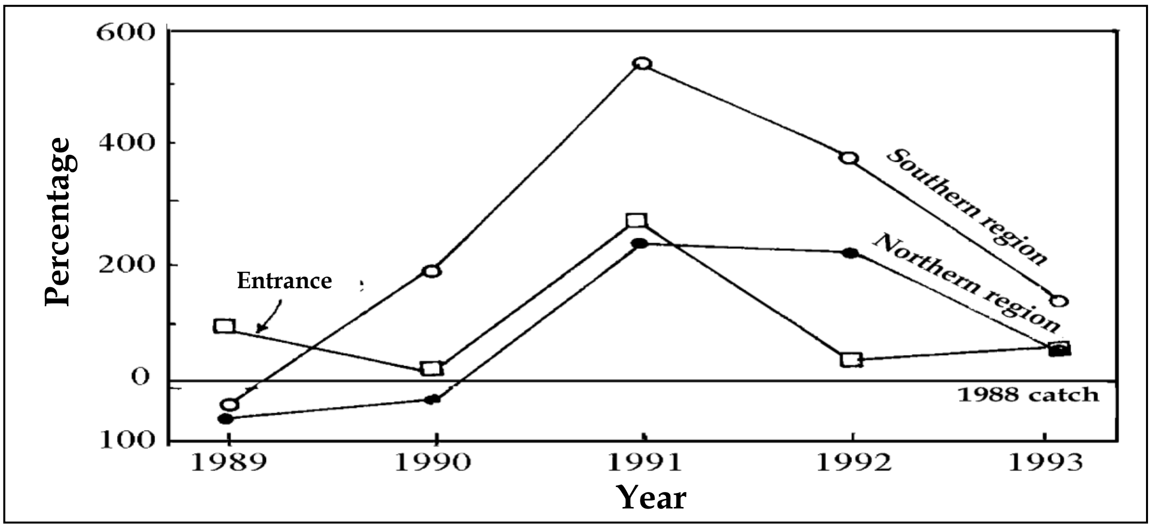


Fig. 241 **Percentage increment and decrease of catch in Khor Kalabsha compared with 1988 (Agaypi 1995 a).**

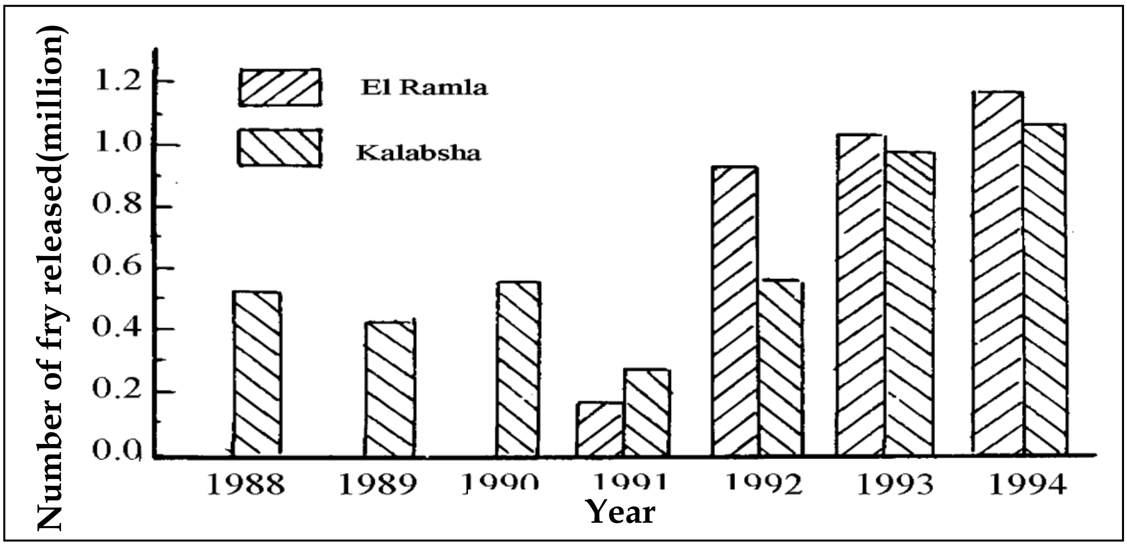


Fig. 242 **Number of fry released in Khors El Ramla and Kalabsha (Agaypi 1996a).**

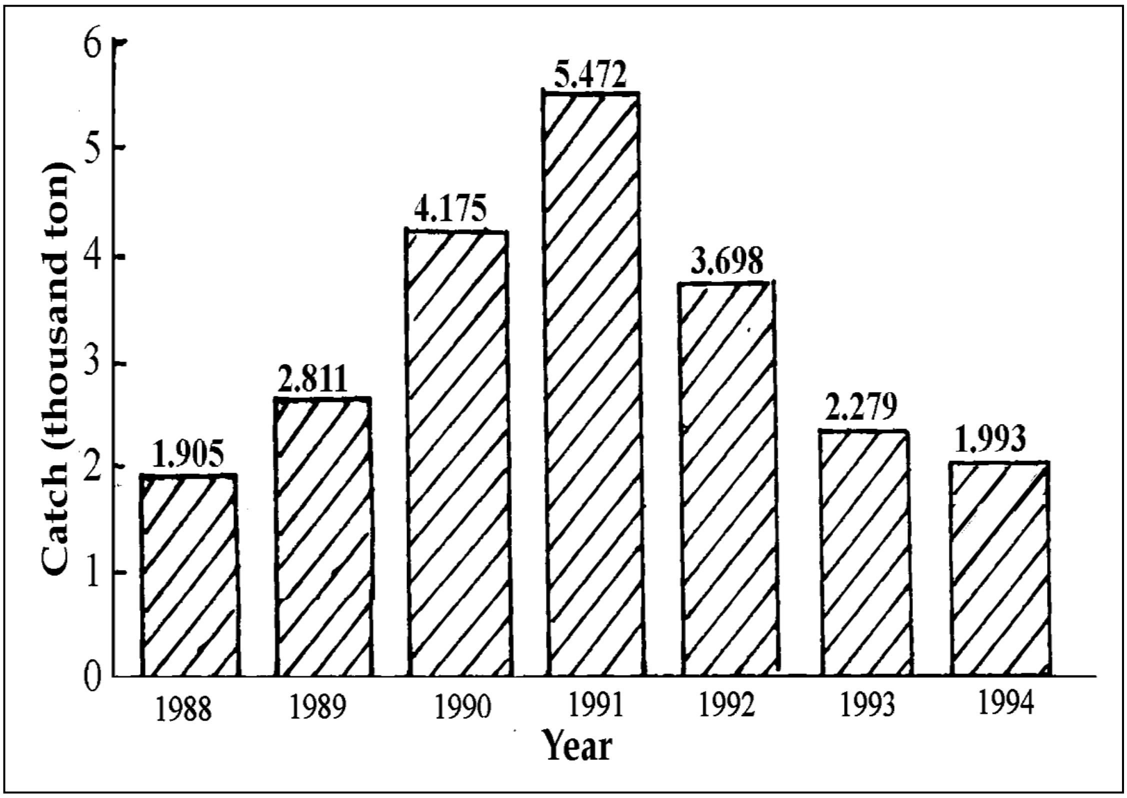


Fig. 243 **Total amount of catch in Khor Kalabsha (Agaypi 1996a).**

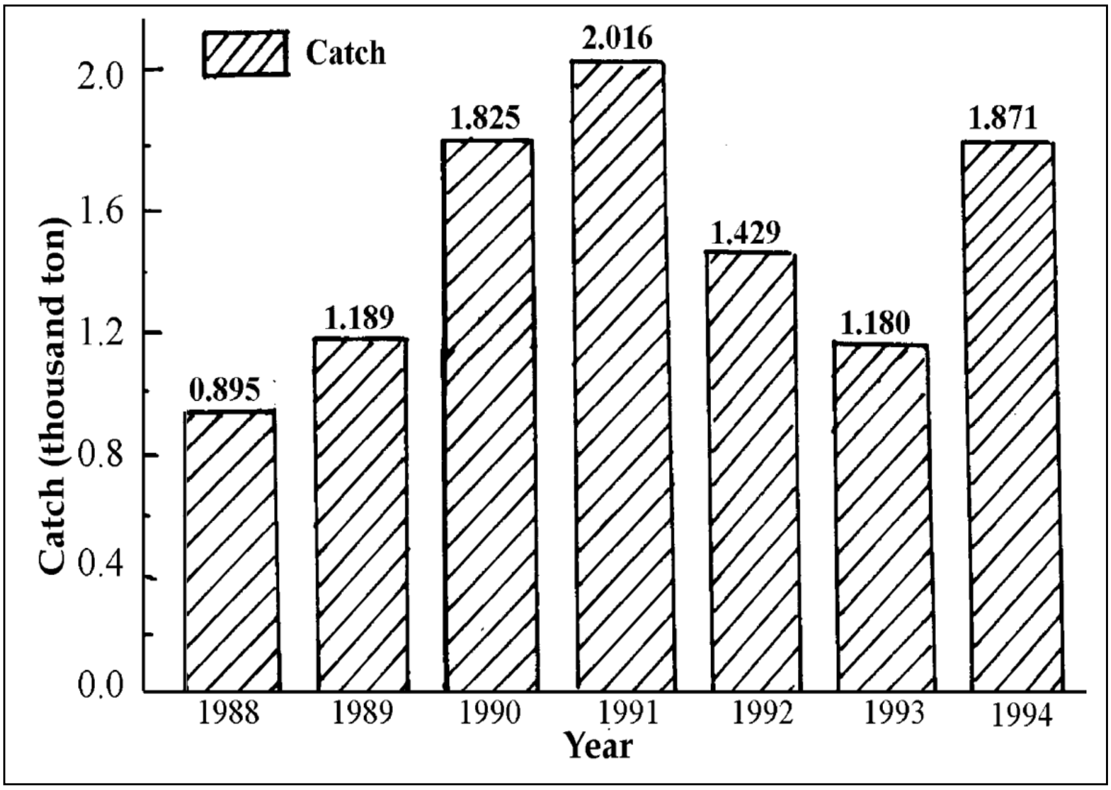


Fig. 244 **Total amount of catch in Khor El Ramla (Agaypi 1996a).**

UTILIZATION OF OPEN WATER AREA

The total fish production from Lake Nasser was only about 19,203 ton in 1998, about 90% being *Tilapia* spp. *(Sarotherodon galilaeus* and *Oreochromis niloticus)* caught from the coastal areas and khors of the Lake. The offshore area (about 80% of the total Lake area) is not well utilized, except for a minor catch of *Hydrocynus* spp., *Alestes* spp. and others.

Attention has been focused on the insufficiently utilized open water area in order to increase fish production of the Lake by introducing a new commercial fish suitable for the Lake environment. The first survey of the new species introduction into Lake Nasser was conducted in 1979 by the Japanese expert Dr. M. Nomura (Professor of Fisheries in Tokyo University), who suggested in 1983 to introduce the following : freshwater herring, silver carp, bighead carp and *Labeo* spp., as they are suitable for the open water area in the Lake. Later on, Nomura suggested not to introduce the freshwater herring, because its fry might inhabit the coastal zone and compete with *0. niloticus* for food (zooplankton) and space. In 1984, Nomura suggested only the introduction of silver carp into the Fishery Management Center (FMC) in Aswan.

Introduction of Silver Carp *(Hypophthalmichthys molitrix)*

First Introduction. Silver carp was originally transported from China to Serw Fish Station in the Delta (National Institute of Oceanography and Fisheries). Nine fish were donated from Serw Fish Station to the Fishery Management Center (FMC) in Aswan. The introduction of silver carp into FMC for the first time was carried out in February 1984. The specimens were small, immature and not suitable for artificial spawning (FMC, 1992).

Second Introduction. Silver carp was originally transported from Hungary in 1982 to Fuwa Hatchery in the Delta. The fish were raised at the Fuwa Hatchery in a clay pond of about 0.2 ha and about 1 m deep. Eight silver carp specimens were introduced from Fuwa Hatchery to FMC in Aswan, where notes on their release into the pond, observation record of fish and scale measurements were recorded (Shimura 1992a).

Induced Spawning of Silver Carp

In l984 Shenouda (1992) carried out an experiment on induced spawning of silver carp with pituitary injection. Female silver carp grew up to the mature stage but did not ovulate. The latter author attributed the unsuccessful ovulation to low activity of spawners, limited number of mature spawners and that the trials of hormone injection were beyond the suitable spawning period of silver carp. Later, in 1987 and 1989, Shenouda & Abdel-Shaheed (1993 a and b) carried out experimental studies on induced spawning of silver carp using pituitary gland. After many trials using different doses of the pituitary gland of silver carp, they were successful when using injections of pituitary gland of one dose (3mg/kg) injected twice (0.3 mg and 2.7 mg/kg) within 12 hours interval. The success of spawning was 80% during May and June and 14% during July. The percentage of fertilization was 99.1, 99.6 and 65.7 in May, June and July respectively.

Feeding of Silver carp Fry with Natural and Artificial Feeds

It is well known that silver carp changes its food from zooplankton to phytoplankton as it grows beyond 15 mm in body length (Iwata 1977). The morphological changes in its feeding organs make silver carp able to filter algae. The length of intestine of large fish may range from 7 to 15 times its body length (Sandor *et al.* 1989).

Shenouda (1995b) carried out an experiment on feeding silver carp fry with cultured zooplankton (*Moina* sp.) to find out the effect of different daily rations of live weight on growth of silver carp fry. The experiment was carried out for 20 days, and *Moina* was cultured in a concrete pond (2 x 3 x 0.6m depth). The results of growth, survival rate and food conversion ratio (Table 172 and Fig. 245) indicated that the survival rate decreased with the increase of ration percent, and the best one occurred when using 60% and 80% ration. The best weight increment (16.3 g) was obtained by using 80% ration. After 20 days, the highest growth for silver carp fry occurred, when using 120% ration, followed by 100% ration. The best food conversion ratio was obtained with 60% ration. As during the period of initial fry rearing, the most important factors are survival rate and food conversion ratio. Therefore, for initial rearing of silver carp fry, using live zooplankton like *Moina* sp., the recommendable rations are 60 and 80%.

Abdel-Shaheed (1995a) carried out experimental studies on feeding silver carp fry with natural and artificial food. Thus he fed the fry (0.46 ± 0.13g) on phytoplankton, phytoplankton and artificial food (36% protein) at a feeding ration of 10% of body weight, zooplankton at 120% feeding ration and artificial feed only (36% protein) at 10% ratio of the body weight. The latter author found that the best growth and 100% survival occurred when using phytoplankton together with artificial food (Fig. 246). Thus, it is concluded that the high primary production of open water of Lake Nasser can support large populations of silver carp when reared in net cages.

Table 172 **Results of feeding experiment of silver carp fry on fresh *Moina* sp. (Shenouda 1995b).**

	Daily ration of live weight %					
	20	**40**	**60**	**80**	**100**	**120**
At the beginning						
Number	33	33	33	33	33	33
Total weight (g)	2	2	2	2	2	2
Mean weight (g / fry)	0.061	0.061	0.061	0.061	0.061	0.061
After 20 days						
Number survived	32	32	33	33	15	23
Total weight (g)	4	7	11.9	18.3	9.6	17.9
Mean weight (g / fry)	0.125	0.218	0.361	0.554	0.642	0.778
Weight increment (g)	2	5	9.9	16.3	7.6	15.9
Weight increment (g/fry)	0.064	0.157	0.30	0.493	0.581	0.717
Weight increment (%)	105	257	492	808	952	1175
Food consumption (g)	10.12	25.6	47.1	85.8	130.6	161.8
FCR	4.9	5.1	4.8	5.3	6.8	6.8
% Survival	96.9	96.9	100	100	45.5	69.7

Food conversion ratio (FCR) = feed wt (g)/ live gain (g).

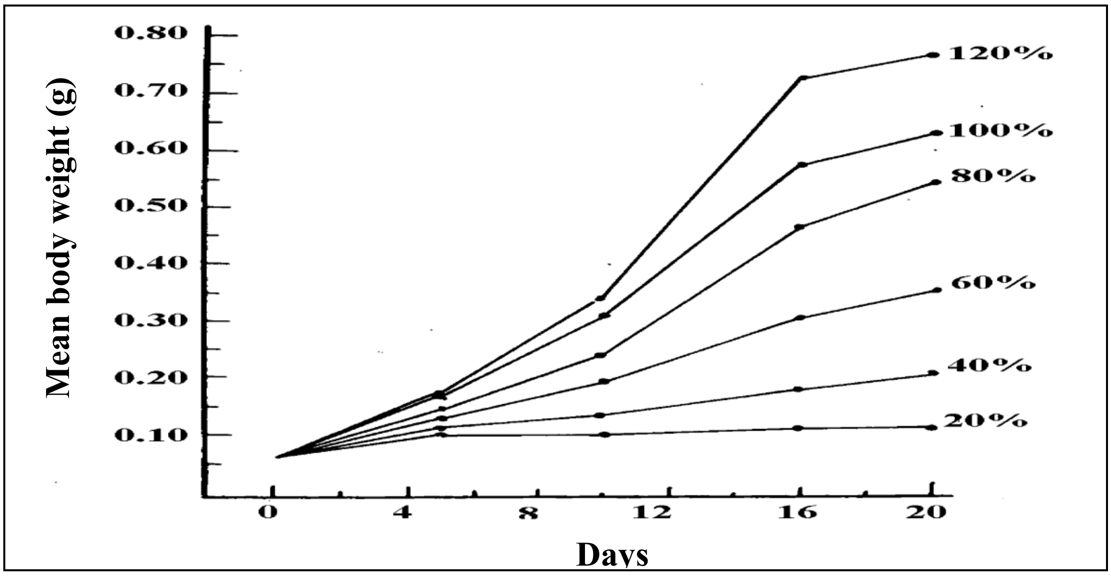


Fig. 245 **The effect of daily ration levels of *Moina* sp. on the growth of silver carp fry (Shenouda 1995b).**

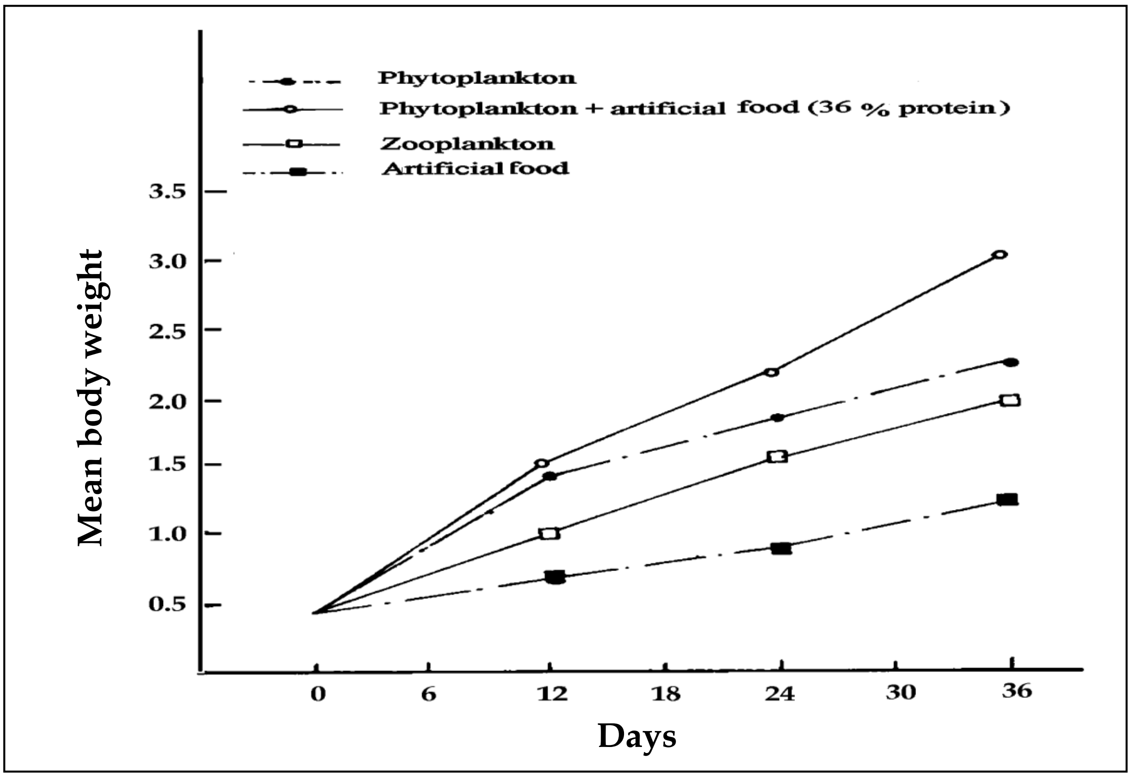


Fig. 246 **Growth of silver carp fry in relation to different kinds of food (Abdel-Shaheed 1995a).**

Food Competition Between Silver Carp and Nile Tilapia

Abdel-Shaheed *et al.* (1996) in their experimental studies on the food of *Hypophthalmichthys molitrix* and *Oreochromis niloticus* reared in cages and ponds at Abu Simbel found that both species feed mainly on the same planktonic organisms (Fig. 247). However, the growth rate of silver carp was slightly higher than that of Nile tilapia. Thus, the daily increment of silver carp ranged between 0.84 and 1.46 g/day, while that of Nile tilapia ranged between 0.71 and 1.05 g/day (Table 173). As a matter of fact, further experiments are needed to elucidate the food competition between both fish species.

Net Cage Culture of Silver Carp

In the Fishery Management Center (FMC) in Aswan, artificial hatching of silver carp, acclimatization and mass production of fingerlings are carried out aiming to utilize the deep open area of the Lake, rich in phytoplankton. However, no stocking of the Lake was done, but silver carp was reared in net cages. The FMC in Aswan succeeded to obtain the technique of silver carp culture in net cages floating in the open area of the Lake, without artificial feeding. Shenouda & Naguib (1993) carried out an experiment to study the effect of stocking density on growth of silver carp in net cages without artificial feeding.

Table 173 **Growth of Nile tilapia and silver carp in experimental ponds (Abdel-Shaheed *et al.* 1996) (average in parentheses).**

	Nile tilapia			**Silver carp**		
	Initial B.wt. (g)	**Mean wt. gain (g).**	**Daily increment g/day**	**Initial B.wt. (g)**	**Mean wt. gain (g).**	**Daily increment g/day**
Concrete pond (0 - 0.15ha, water depth 1.2m)	10 - 20 (15)	156.8	0.77	10 – 20 (15)	226.3	1.15
(Amoun Village)	100 – 200 (150)	300.95	0.82	100 – 200 (150)	417.7	1.46
Earthen pond (0 - 0.452 ha, water depth 2.0 m)	10 – 20 (15)	163.75	0.71	10 – 20 (15)	191.7	0.84
(Near new hatchery)	100 – 200 (150)	371.0	1.05	100 –200 (15)	400.7	1.19

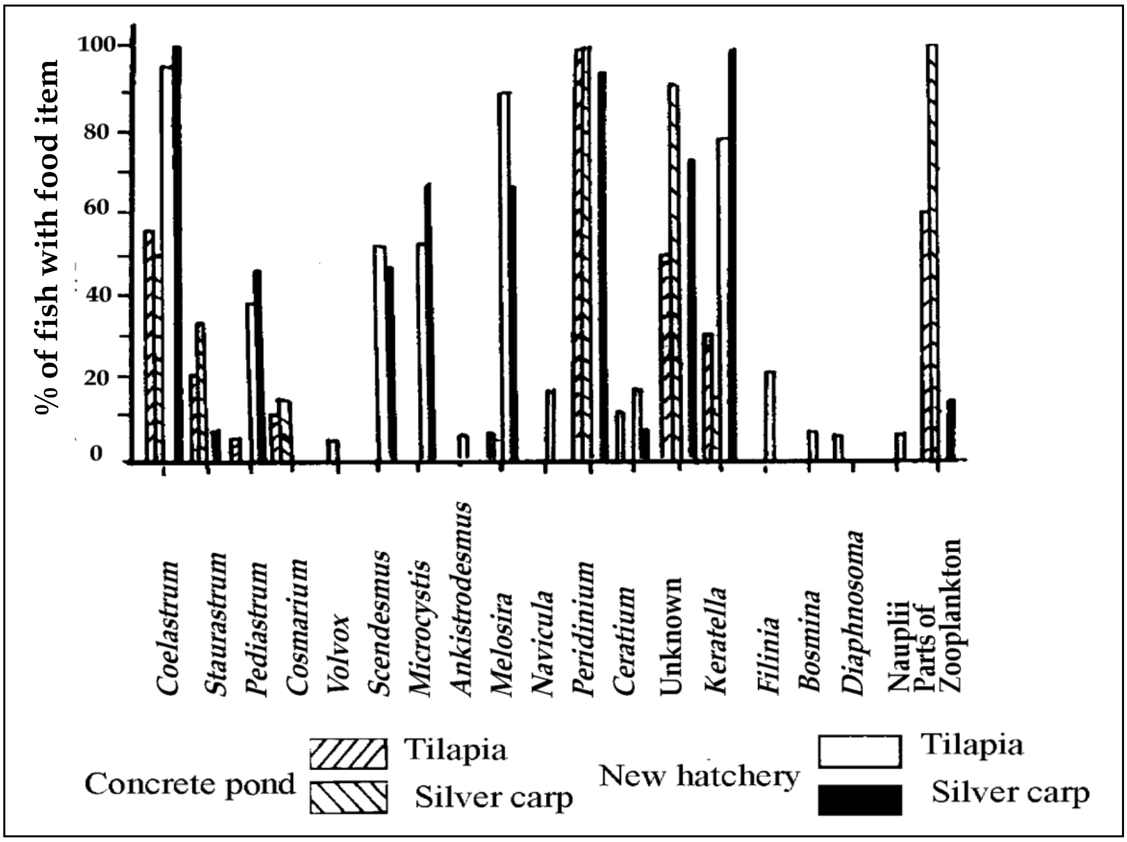


Fig. 247 **Percentage occurrence of different food items of Nile tilapia and silver carp at different sites (Abdel-Shaheed *et al.* 1996).**

Three net cages were used and the capacity of each was 100 m^3. The stocking density was 400,700 and 1397 fingerlings with an average weight 28 g in cages no. 1,2 and 3 respectively. After about 15 months the final average weight was 1.62 , 2.02 and 1.23 kg / fish in cages no. 1,2 and 3 respectively (Table 174). The net production for cages was 420.5 , 760.9 and 1081.7 kg respectively (Table 174). The experiment was carried out from March 1990 until June 1991.

Table 174 **Results of silver carp culture in floating net cages without artificial feeds at Abu Simbel in Lake Nasser. (Duration of experiment: 15 months - from March 1990 to June 1991 (Shenouda & Naguib 1993).**

At stocking				At harvest				Net production (kg)	
Cage No.	Fish No.	Average weight (g)	Total weight (kg)	Fish No.	Average weight (g)	Total weight (kg)	Survival rate (%)	per cage	per m^3
1	400	28	11.2	266	1,620	431.7	66.5	420.5	4.2
2	700	28	19.6	385	2,020	780.5	55.5	760.9	7.6

3	1397	28	39.1	907	1,230	1120.8	64.9	1081.7	10.8

To compare the growth rates of silver carp reared in floating net cages at different regions of Lake Nasser, Shenouda (1997b) located the cages in the northern (Harbour area), middle (Garf Hussein) and southern (Tushka) areas of the Lake. Shenouda (1997b) concluded (Table 175 and Figs. 248-251) that at Tushka (southern area) the highest daily weight gain was attained, being 20.06%, as compared to 2.8 and 16.15% at the northern and middle areas of the Lake. However, it would be better to compare the three areas by using the same stocking density and rearing period.

The suitability of silver carp for net cage culture is not significant without acceptability of its meat to Egyptian people. The reasons why the people do not accept to eat the fresh silver carp, are as follows :

1. There are many fine spines in the muscles. It is too difficult to eat as a daily food and dangerous for children.

2. Its meat is watery and too soft.

3. It has a bad smell, which becomes strong with time after death and storage.

4. Its taste is bitter and strange.

Table 175 **Results of silver carp culture in floating net cages, without artificial feeds, at northern, middle and southern areas of Lake Nasser (Shenouda 19**

Area	Date at:		Average length (cm) at:		Average weight (g) at:		Stocking density (ind./m²)	Daily weight gain (%)
	stocking	harvest	stocking	harvest	stocking	harvest		
North (Harbour)	April, 1987	Dec., 1987	8.1	17.3	14.4	107	55	2.8
Middle (Garf Hussein)	April, 1987	Sept. 1987	**8.5**	25.7	15	410	83	16.15
South (Tushka)	Sept, 1986	**Dec.,** 1987	13.0	44.5	20	2000	80	20.06

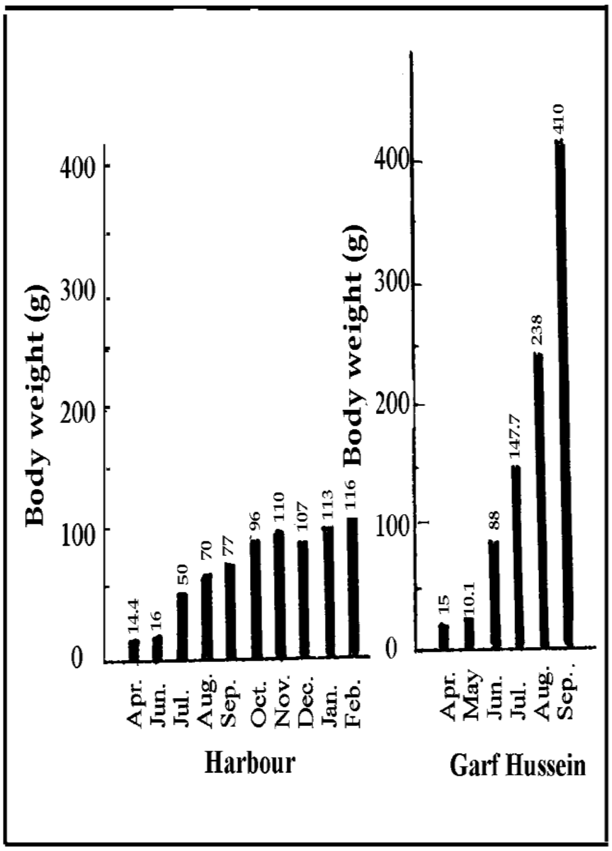


Fig. 248 **Growth of silver carp in net cages at the Harbour area and Garf Hussein (Shenouda 1997b).**

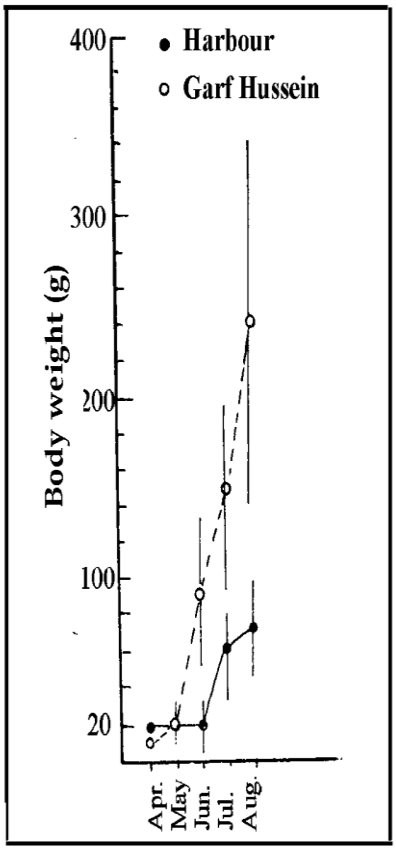
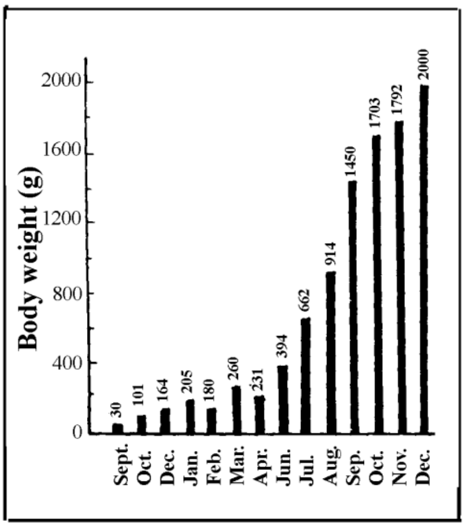


Fig. 249 **Growth range of silver carp in net cages at the Harbour area and Garf Hussein (Shenouda 1997b).**



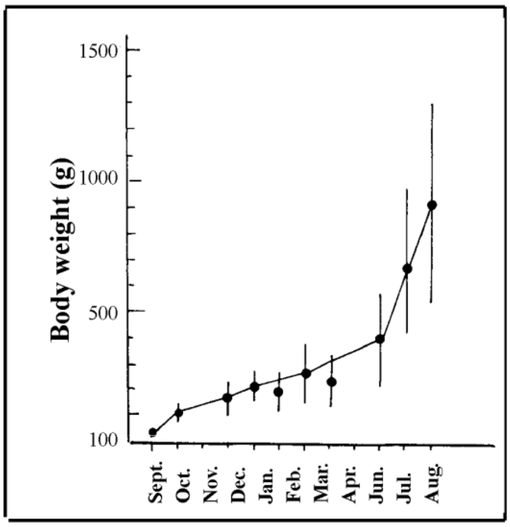


Fig. 250 **Growth of silver carp in net cages at Tushka (duration about 15 months) (Shenouda 1997b).**

Fig. 251 **Growth range of silver carp in net cages at Tushka. (Shenouda 1997b).**

The fishermen and staff of aquaculture section of Fishery Management Center succeeded to solve the aforementioned problem through processing of salted fish. The Egyptian people accept the salted fish. In the processing, the head, keel of abdomen, and fatty tissue are removed and gutted. The meat is dressed up to exclude the bad smell and bitter taste. Watery and soft meat is improved after dehydration with much salt. The fine spines are not a problem in the eating of salted fish. From the economical point of view, the culture of silver carp in net cages is more effective to control and regulate the amount and timing of supply and fish size at harvest. Furthermore, it seems, as previously mentioned, that silver carp competes with tilapias for food. In addition, escape of certain individuals from cages into the Lake is a possibility, the effects of which are difficult to elucidate. Hence, to take the decision of its culture in cages at Lake Nasser needs further studies.

RESTORING OF INDIGENOUS FISHES

Catch Decrease of some Indigenous Fish Species

As a matter of fact, the catches of some indigenous fish species such as *Labeo* spp., *Barbus bynni, Lates niloticus* and *Bagrus* spp. are sharply decreasing from year to year (Table 176 and Fig. 252). Consequently, the mass production of fry of these indigenous fishes is inevitable. The release of large numbers of fry into Lake Nasser and its khors may be one of the useful measures to increase natural fishery resources.

Table 176 Percentage of catch of indigenous fish species (1966-1995).

Year	Indigenous fish species		
	Labeo spp. & *Barbus bynni* (%)	*Bagrus* spp. (%)	*Lates niloticus* (%)
1966	17.69	3.29	0.76
7	21.90	4.90	1.94
8	28.20	2.40	2.89
9	20.40	2.40	6.19
1970	14.40	3.10	7.95
1	13.70	3.60	7.59
2	9.90	3.10	5.41
3	1.98	1.52	3.69
4	0.68	1.01	4.00
5	0.03	0.83	3.59
6	0.00	0.48	2.84
7	1.96	0.36	3.05
8	0	0	0
9	1.23	0.17	1.38
1980	1.24	0.10	1.43
1	1.27	0.06	1.17
2	1.07	0.04	0.96
3	0.64	0.02	0.84
4	0.89	0.02	0.55
5	0.64	0.01	0.52
6	2.50	0.01	1.60
7	2.64	0.01	1.83
8	2.28	0.01	3.40
9	2.00	0.001	4.53
1990	0.41	0.001	2.18
1	0	0	0.82
2	0	0	2.20
3	0	0	3.00
4	0	0	3.00
5	0	0	3.50

Preparation for Artificial Propagation of Fry

Before conduction of mass propagation of fry, the following trials are needed:

i. *Induced spawning*. Techniques of artificial spawning and hormonally induced spawning, for mature brood fish are very necessary for an adequate supply of fry, with which to stock the Lake. Success of induced spawning is strongly dependent on brood fish reaching the right stage of gonadal development.

ii. *Mass culture of plankton*. Live food organisms available for the hatched fry are quite different, in general, from species to species and also from place to place. Although suitable food organisms for hatched fry are still unknown, preparation for mass culture of phytoplankton and zooplankton is necessary before the initiation of spawning by the brood fish. In general, *Moina* sp. is one of the most suitable zooplankton, since it is relatively easily mass cultured and proved to be effective as food for fry of Nile tilapia and its utilization depends on fish size and species. Mass culture of a rotifer such as *Brachionus plicatilis* is also necessary as an initial live food organism for fry, just after yolk-sac absorption. Few ponds for mass-culture of plankton should be provided.

iii. *Rearing of hatched fry to stocking size.* After feeding with plankton, the fry must be reared up to a suitable stocking size. A large amount of suitable diet should be prepared for that purpose. Some equipment for preparation of diet will be necessary. The dietary ingredients available in Aswan may be evaluated.

iv. *Facilities* . Outdoor ponds, hatchery building, acclimatization ponds, etc., are required to accomplish the above-mentioned requirements.

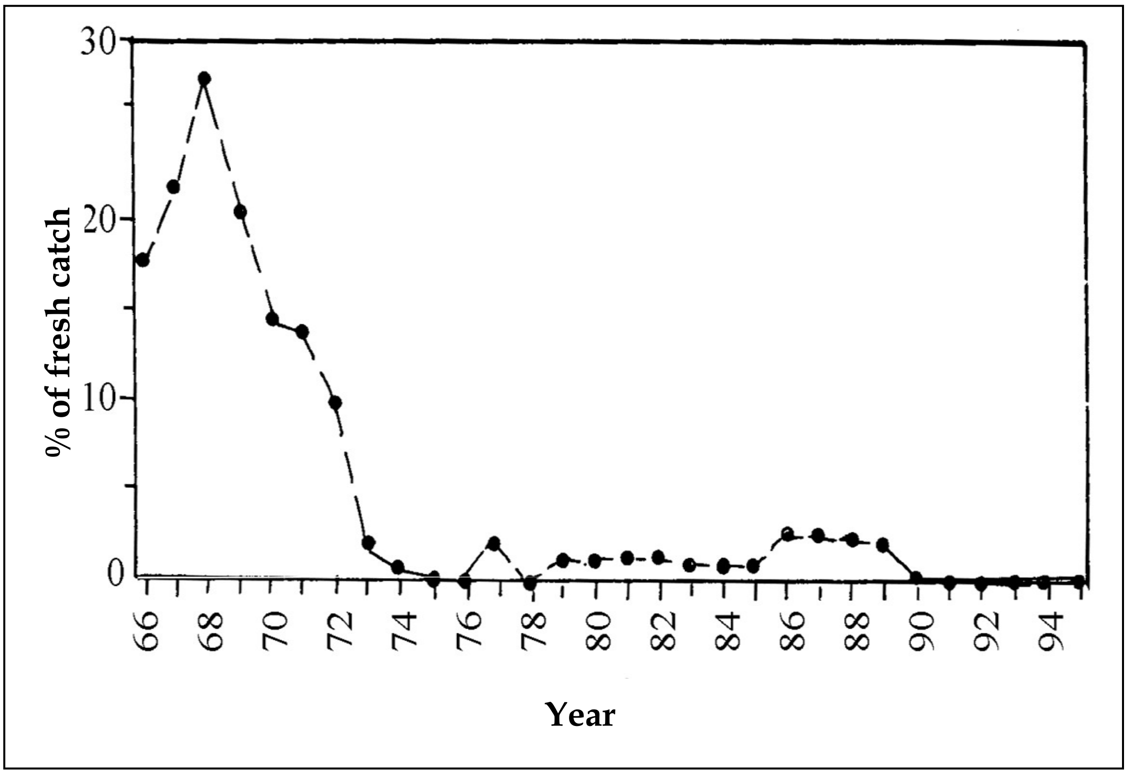


Fig. 252 **Percentage of fresh catch of *Labeo* spp. and *Barbus bynni* (1966-1995).**

Trials on some Important Indigenous Fish Species

Due to the declining of the catch of some important indigenous fish species, and the necessity of giving priority to local species for artifical propagation, so the

Fishery Management Center in Aswan (FMC) carried out experiments on the induced spawning and rearing of fry of *Labeo* spp., *Barbus bynni* and *Lates niloticus* . In view of the importance of these trials, a detailed account of these experiments will be given to evaluate their results and to improve methods of propagation.

a. *Labeo* spp. This species is one of the common and commercially important fish in both River Nile and Lake Nasser, and it is consumed as salted or as fresh fish. However, the catch of *Labeo* species (Family Cyprinidae) is decreasing year after year (Table 176 and Fig. 252). Therefore, restocking of *Labeo* spp. in Lake Nasser, by releasing of fingerlings into the Lake, is necessary for increasing fishery resources.

Abdel-Shaheed (1996) tried to induce spawning of *Labeo* spp. *(Labeo niloticus* and *Labeo coubie)* using pituitary gland injection at different doses, injected once or twice. The trials were unsuccessful and only one female reached stage IV after injection. Injected males, however, produced milt after pressure on belly. It is important to determine the effective dose of pituitary gland to induce the maturation and ovulation of *Labeo* spp. Generally, *Labeo* spp. particularly *Labeo niloticus,* are very sensitive and need great care in selection and handling.

b. *Barbus bynni* (benni). This species is one of the common commercial fish species in Lake Nasser whose annual production is declining (Table 176). Therefore, restocking of benni in Lake Nasser is very necessary for increasing fish resources by artificial propagation, and release of the reared fingerlings into the Lake and khors. From their studies on the maturity and gonado-somatic index (GSI), Abdel-Shaheed *et al.* (1993) found that the most suitable time for artificial propagation of *Barbus bynni* was during spring and autumn, when the highest GSI values were recorded. The technique of the fingerlings production was determined and studies concerning their mass production are in progress.

Rearing experiments of *Barbus bynni* fry in concrete ponds. Abdel-Shaheed & Shenouda (1993b) carried out an experiment on rearing the fry of *Barbus bynni* in concrete ponds, and the results are presented in Tables 177 and 178 and Figs. 253 and 254. The latter authors concluded that for successful rearing, water temperature should be maintained above 24°C.

c. *Lates niloticus* (samoos). *Lates niloticus* is one of the most important fishes in coastal areas of Lake Nasser, whose catch is declining year after year. Hence, fry production of samoos becomes necessary. Shenouda (1993) worked on the induced ovulation of *Lates niloticus* by hormone injection in May 1983. The result of his experiment is given in Table 179. However, further studies are needed to accelerate the spawning of samoos *(Lates niloticus)*.

Table 177 **Monthly average body weight and length increment of experimentally reared *Barbus bynni* fry (Abdel-Shaheed & Shenouda 1993b).**

Month	Average body weight (g)	Monthly increment of body weight (g)	Body weight increment (%)	Average total length (cm)	Monthly increment of total length (cm)	Total length increment (%)	Average water temp. (°C)	Dissolved O_2 (ppm)
Jul.	0.03	-	-	1.6	-	-	25.6	9.9
Aug.	0.05	0.02	66.7	2.1	0.5	31.3	24.9	9.2
Sept.	0.33	0.28	560.0	3.4	1.3	61.9	24.3	9.0
Oct.	0.80	0.47	142.4	4.6	1.2	35.3	23.0	10.0
Nov.	1.30	0.50	62.5	5.1	0.5	10.9	17.5	10.6
Dec.	1.41	0.11	8.5	5.2	0.1	2.0	15.2	10.5

Table 178 **Feed conversion efficiency and feed conversion factor of experimentally reared *Barbus bynni* fry (Abdel-Shaheed & Shenouda 1993b).**

	Total No. of fry	Survival rate (%)	Total weight of fry (g)	Monthly feeding amount (g)	Daily feeding rate (%)	Monthly body wt. increment (g)	Feed conversion efficiency (%)	Feed conversion factor
Jul.	1,100	100	330	3,432	40	-	-	-
Aug.	10,300	94	515	5,356	40	185	5.4	18.0
Sept.	10,100	92	3,333	26.000	30	2818	52.6	1.9
Oct.	9,950	90	7,960	51,740	25	4627	17.8	5.6
Nov.	9,500	86	12,350	48,178	15	4390	8.5	11.8
Dec.	9.000	82	12,690	33,020	10	340	0.7	141.7

Table 179 **Experiment on induced spawning of *Lates niloticus* by hormone injection (Shenouda 1993).**

Group	Number of fish		Maturity stage	Dose of injection			
	♀	♂		1st injection	Interval (hours)	2 nd injection	Remarks
A	1	2	IV	HGC 4000 lU/kg	24	HGC 4000 lU/kg	Ovulated but unfertilized
B	1	1	IV	Pit. 50mg/kg	24	Pit. 50 mg/kg	Ovulated but unfertilized
C	2	-	III	HGC 4000 lU/kg	24	-	Ovulated but unfertilized
	2	-	III	**0.9** NaCl	24	-	No ovulation

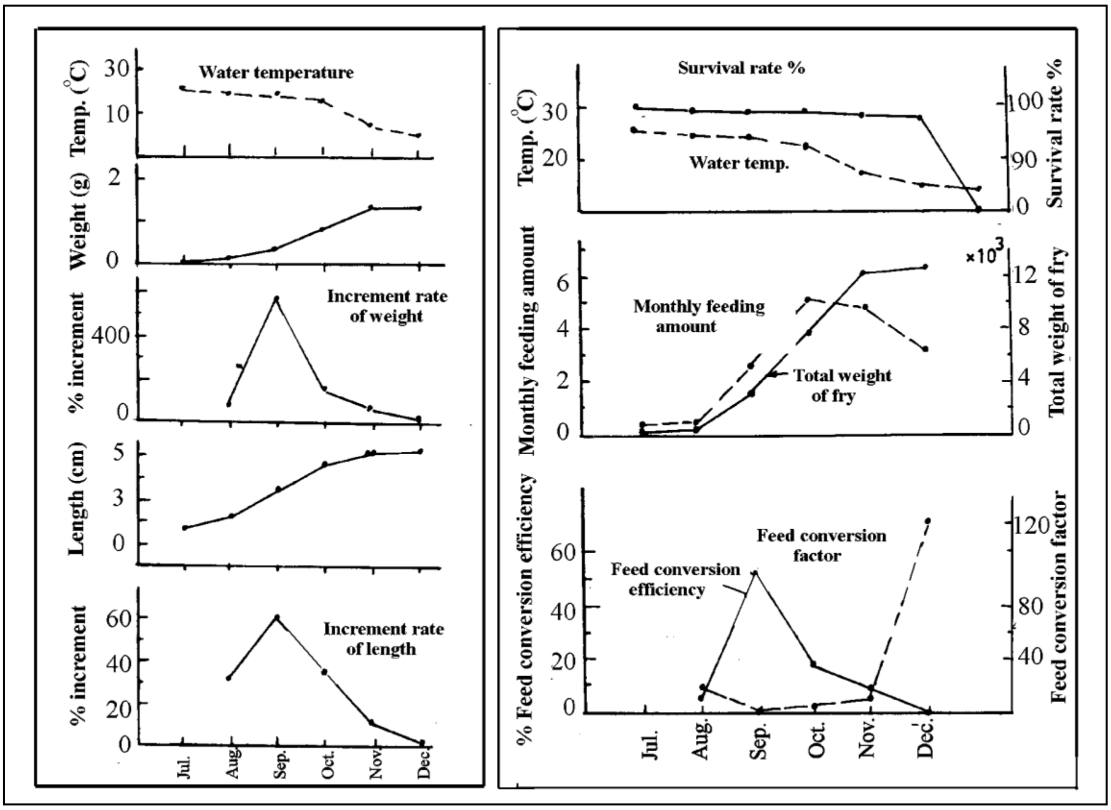

Water temperature
Temp. (°C)
Weight (g)
Increment rate of weight
% increment
Length (cm)
Increment rate of length
% increment
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Survival rate %
Water temp.
Survival rate %
Monthly feeding amount
Total weight of fry
Total weight of fry
Monthly feeding amount
Feed conversion factor
Feed conversion efficiency
% Feed conversion efficiency
Feed conversion factor

Fig. 253 **Monthly water temperature, body weight, length and increment rate of length of *Barbus bynni* fry (Abdel-Shaheed & Shenouda 1993b).**

Fig. 254 **Variation of water temperature, survival rate, weight, food conversion efficiency and feed conversion factor of *Barbus bynni* fry (Abdel-Shaheed & Shenouda 1993b).**

CONCLUSIONS

For aquaculture development in Lake Nasser three important problems have to be solved. These problems are :

1. Utilization of the coastal area through mass production of Nile tilapia fry, (*Oreochromis niloticus*) with the high growth rate and their release to the khors.

2. Utilization of open water area, through introduction of a new pelagic fish species to feed on the dense plankton populations in this area.

3. Restocking of indigenous fish species.

Mass production of fry of *0. niloticus* is very necessary and a plan to produce one million fry per year is presented. Sufficient and continuous supply of suitable and economical food for Nile tilapia fry is one of the most important items of a tilapia hatchery. *0. niloticus* fry of total length 0.9-1.5 cm prefer *Moina* sp. They feed on not only zooplankton and suspended materials, but also on bottom dwelling organisms such as *Chironomus* larvae. Nile tilapia fry seem to be omnivorous and eat various kinds of food items. Artificial diet composed of scrap tilapia fish meal containing 48.1% crude protein was used as food for *O. niloticus* fry. The best dietary protein level for fry of Nile tilapia was 31.6% at the feeding rate of 10% of body weight per day, and the available scrap tilapia meal is a suitable protein source for Nile tilapia fry diets.

Fry stocking of the khors and applying proper fishery management (prohibiting the use of illegal gear, care to the released fry, no overfishing, etc.) may increase fish production from Lake Nasser.

The offshore area is not well utilized except for some catch of *Hydrocynus* spp, *Alestes* spp. and others. Silver carp *(Hypophthalmichthys nwlitrix)* was suggested to be introduced into Lake Nasser, by using net cage culture. The first introduction of silver carp in 1984, to the Fishery Management Center in Aswan, was from Serw Fish Farm, however, the trial was unsuccessful. The second introduction was from Fuwa Hatchery was successful.

Some trials, for induced spawning of silver carp, were carried out. The last trial for the induced spawning of silver carp by hypophysis injection was in 1989, and the success of spawning trial was 80% during May and June, and the percentage of fertilization was 99.1 and 99.6% in May and June respectively.

Silver carp changes its food from zooplankton to phytoplankton as it grows beyond 15 mm in body length. For initial rearing of silver carp fry, it is advisable to use live zooplankton like *Moina,* the recommendable rations are 60 and 80%. At a later stage, the best growth of silver carp fry occurred by using phytoplankton together with artificial feed. When rearing silver carp in net cages in Lake Nasser, the high primary production can support a large population of silver carp. However, the southern area of Lake Nasser proved to be the best one for culturing silver carp in net cages without artificial feeds. Egyptian people accept the salted silver carp as food. It should be mentioned that precautionary measures should be undertaken not to release silver carp in Lake Nasser, since the impact of such release is unpredictable.

The catch of some indigenous fish species such as *Labeo* spp., *Barbus bynni, Lates niloticus* and *Bagrus* spp. are decreasing from year to year. There is a great need for mass production of fry of these aforementioned fishes. The release of large numbers of their fry into Lake Nasser and khors is one of the useful measures to increase fisheries production.

Before conduction of mass propagation of fry some trials such as: induced spawning, mass culture of plankton, rearing of hatched fry to stocking size and facilities are needed. Trials on some important indigenous fishes such as *Labeo* spp. *Barbus bynni* and *Lates niloticus* have been carried out but until now mass production of fry was unsuccessful. It is always preferred to propagate local species to increase their production without affecting the Lake's ecosystem.

When discussing the possibility of introducing a pelagic fish species into Lake Nasser – to consume the large quantities of plankton in the open water area - with specialists (Dr. R. Lowe-McConnel; Dr. J. Balarin, and Prof. R. Marshall) they suggested the introduction of Tanganyika sardine *Limnothressa miodon* (Boulenger, 1906). This species was introduced from Lake Tanganyika to Lake Kariba in 1967/68, and since spread down the middle Zambezi to Lake Cahora Bassa. Also it was introduced into Lake Kivu. In Lake Kariba, Tanganyika sardine is a major commercial species, where up to 25,000 tonnes per annum may be harvested (Skelton 1993). This species breed in the Lake at about 40 mm or 6 to 8 month age and may attain a maximum of 140 mm total length at about a year. The bulk of the commercial catch is about 30 – 50 mm.

The authors recommend that before introduction of any new species into Lake Nasser, careful and thorough study must be carried out taking in consideration what happened in Lake Victoria after the introduction of *Lates niloticus* which caused disastrous effects on the Lake and its fisheries.