BULL. INST. OCEAN. & FISH., A.R.E. VOL. 4, 1974

EXPERIMENTAL REARING OF TWO MULLET SPECIES MUGIL CEPHALUS AND MUGIL CAPITO IN EGYPTIAN FISH FARMS

By

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INTRODUCTION

Fish as a source of protein for human consumption is essential to help considerably in correcting the state of malnutrition, especially in densly populated countries where the production of animal protein is either expensive or comparatively low (Borgstrom, 1961 and Guha, 1962).

In Egypt, fish production from water masses is not sufficient to provide all the protein requirements mainly due to the obvious decline in the fishery resources of the Mediterranean and as a result of the present prevailing conditions in the Red Sea. Therefore, fish production is to be obtained from two main sources : (1) extending the marine fisheries into areas outside the continental shelf (the high seas) and (2) the full utilization of the inland waters, *i.e.* lakes, ponds and streams for maximum fish production by means of developed techniques of fish culture.

The progress and development of fish culture in different parts of the world has been reviewed by several investigators (Shaperclaus, 1993 ; Drews, 1961 ; Tamura, 1961 ; Hickling, 1962 ; Hora and Pillay, 1962 ; Pillay, 1966 and Yashouv, 1966). Fish culture is well established in Asia and the Far East where several species of fish are reared by means of hybridization such as *Tilapia* spp, induced breeding of carps (*Calta calta, Labeo rohita, Cirrhina miragla* and the chinese carps, namely *Ctenopharyngodon idella, Hypothalmichthys molitrix* and *Aristichthys nobilis*), and the common carp besides *Anguilla* spp. In Europe, several species have been used for fish culture which include the common carp, *Cyprinus carpio* L., the tench (*Tinca tinca*), the pike (*Escox lucius*), the pike-perch (*Stizostedion lucioperca*), *Tilapia* spp, the grey mullet (*Mugil cephalus*) and the rainbow trout (*Salmo gairdnerii*). In Africa, fish culture has not yet been fully developed though there exists a commense area of inland waters that are very productive and are most suitable for the raising of fish.

In Egypt, recently, attention has been paid to develop fish culture by means of research aiming to obtain the highest possible yields of fish from ponds. The research activity included the use of the fast growing fish, supplementary feeding, the use of fertilizers and proper management of fish ponds.

The grey mullets (*Mugil cephalus* Risso. and *Mugil capito* Cuv.) are considered highly valued fish food in Egypt. They are also the most important salt water fishes used for culture either in brackish or fresh waters. Mullet

fry are available in large quantities and in definite seasons in the estuarine waters of different localities in Egypt; especially in the Mex-tunnel, Alexandria (Wimpenny, 1932 ; Faouzi, 1936 ; El-Zarka and Kamel, 1965 ; Bishara, 1967 and Eisawy *et al,* 1973). Moreover, the increased production of mullets in the inland lakes, Mariut and Quarun has resulted from the transplantation of the mullet fry into them since 1920 and 1928 respectively (El-Zarka and Kamel, 1965).

The main objectives of the present studies are to assess the growth rate, survival and production of the grey mullet (*M. cephalus* and *M. capito*) reared in brackish and fresh water ponds (Manzalah and Serow Fish Farms). The mullet fry were stocked at different rates per feddan ; either as a monoculture or as a mixed-culture.

The experimental work was carried out to cover one growing season in the Serow ponds to determine the best harvesting time, since the ponds are annually dried in January for economical purposes in rearing carp and *Tilapia* spp. and it was impossible to separate the reared mullets from other fishes. In Manzalah ponds, the improper management through the past five years resulted in a considerable increase in salinity. Therefore, it was found that drainage of the ponds and cropping the fish at end of the first growing season would help to reduce the salinity to a level at which mixed culture of mullets, carp and *Tilapia* is possible in the next season.

MATERIAL AND METHODS

Experimental ponds :

The experimental ponds used for this study are located at the Serow Fish Farm and at the Manzalah Fish Farm, Dakahlia Governorate, Egypt.

Serow Fish Farm

Seven experimental ponds were used, ponds No. 6, 7, 8, 9, 11, 12, and 13. Each of the first four ponds has an area of two feddans* and the other three ponds are of 2.5 feddans each. The bottom and banks are of mud. All these ponds have a common water supply from the navigation canal which is mainly of fresh water.

* One feddan =0.44 hectare

Manzalah Fish Farm :

Fifteen ponds were used, each of an area of about 20 feddans. The ponds have a common supply of water from two sources ; (1) the main supply from the navigation canal which is slightly brackish, salinity ranges between 1 and 3 ‰, and (2) the fresh water supply from El-Twabra stream. The bottom and banks of the ponds are of mud.

For both Serow and Manzalah ponds, the water level was maintained at a depth of 60 cm by means of two iron gates erected on each pond and supplied with a fine-mesh screen to prevent the enterance of undesirable fish. The water was adjusted to circulate in the ponds throughout the rearing period.

Preparation of Ponds :

Serow Fish Farm :

During December, 1969, the ponds were drained. The inlet, outlet and gates of each pond were checked and the embarkments were repaired. The undesirable plants (*Cyprus* spp) were removed. On the first week of March, 1970, the ponds were fertilized, using organic manure at a rate of one cubic meter per feddan. The fertilizer was spreaded in small heaps along the ponds. The ponds were then filled with water and were stocked with fish after two or three weeks.

Manzalah Fis Farm

During August, 1969, the ponds were drained and the undesirable fishes were collected. The ponds were left to dry for a short period. During September 1969, the ponds were filled with water. Organic fertilizer was applied as previously indicated in Serow ponds.

Experimental Fish :

M. cephalus and *M. capito* fry were collected from the brackish waters of the Mex tunnel, Alexandria as they are attracted to the water current of Lake Mariut pumped by the Pumping Mex Station. The fry were collected along the side walls of the tunnel by means of a scoop net, and were kept in special boats until they were transferred to the fish farms.

The presence of the *M. cephalus* fry in the Mex tunnel extends from July to September, while the occurrence of *M. capito* extends from January to March.

Carp, *Cyprinus carpio* L. fry used for this study are a progeny of a stock maintained at the Serow Fish Farm. Spawning took place during May 1970 in special incubation ponds. The fry were kept in the ponds until they were transferred to the experimental rearing ponds.

Transportation of Mullet Fry :

The experimental fry were transported to the experimental site in polyethylene bags. Each bag contained the appropriate number of fry in 15 l of water (2 gram fish per liter) and suppllied with oxygen.

Stocking Rates :

In the Serow ponds, three stocking rates were used :

1. 8000 *M. capito* fry + 3000 *C. carpio* fry per feddan.
2. 8000 *M. capito* fry + 7000 *C. carpio* fry per feddan.
3. 6000 *M. capito* fry + 3000 *C. carpio* fry per feddan.

In Manzalah ponds five stocking rates were used as follows :

1. 5300 *M. cephalus* fry per feddan.
2. 600 *M. cephalus* fry + 600 *M. capito* fry per feddan.
3. 520 *M. cephalus* fry + 1250 *M. capito* fry per feddan.
4. 500 *M. cephalus* fry + 2150 *M. capito* fry per feddan.
5. 900 *M. cephalus* fry + 3650 *M. capito* fry per feddan.

Supplementary Feeding :

The fish reared in the Serow ponds were regularly supplied with artificial food. The ingredients of the diet were cotton seed cake and rice bran in the ratio of 1 : 4 respectively. The diet was offered to the fish in the wet form. Cotton seed cakes were weighed and soaked in water for one day and then thouroughly mixed with the proper amount of rice bran.

During the rearing period, the fish were fed once daily at 9.00 A.M. and six days a week. The feeding rate was 10% of the body weight of carp and *Tilapia* as a result of biweekly estimates.

The fish reared in Manzalah ponds received supplementary food occasionally.

Growth Measurements :

Monthly random samples of at least 50 fish of each species were taken from each pond. Individual measurements of the fish were recorded, the length was measured to the nearest millimeter and weight to the nearest 0.5 gram.

Fish Cropping :

At the end of the rearing period, the ponds were drained. The fish were collected and then sorted out to the different species.

The yield of the fish in each pond was estimated by weight and numbers of the collected fishes of each species. Individual measurements of representative samples were taken for the different species of fish in each pond.

RESULTS

The ponds of the Serow fish farm were stocked with *M. capito* fry of an average weight of 0.05 g during April 1970 ; and with *C. carpio* fry of an average weight of one g during June 1970. The duration of the rearing period was 300 days for *M. capito* and 270 days for *C. carpio*. *Tilapia* spp and other catfishes were not stocked in regular numbers since they are filtrated to the ponds in spite of the precautions made to prevent their enterance.

In Manzalah ponds, *M. cephalus* and *M. capito* fry were stocked. *M. cephalus* were of an average weight of 0.1 g and introduced to the ponds during October 1969 ; while *M. capito* fry were of an average weight of 0.05 g and were stocked during April 1970. The rearing period was 400 days for *M.cephalus* and 300 days for *M. capito*. *Tilapia* spp, *Lates* spp and other fishes were not stocked as they entered the ponds mainly through the navigation canal.

The average monthly water temperature during the rearing period was recorded for both Serow and Manazalah fish farms (Table, 1). The physico-chemical characteristics of the water are given in Table 2.

Growth Rate and Survival :

The monthly average weights and lengths of *M. capito* reared at the Serow farm and representing the three experimental stocking rates are shown in Table 3. The average growth rate of *M. capito* reared in Serow (average weight and average length) based on the monthly measurements are graphically shown in Figs.1 and 2 respectively. The average growth per fish per day and the percentage loss are also given in Table 4.

TABLE 1.—AVERAGE WATER TEMPERATURE OF SEROW AND MANZALAH FISH FARMS DURING 1969–1970 AT 11 A.M. TEMPERATURE°C

Month	Serow	Manzalah
December 1969	17.0	12.0
January 1970	15.5	15.0
February 1970	16.0	16.0
March 1970	18.5	17.0
April 1970	24.2	17.4
May 1970	25.2	22.4
June 1970	30.8	25.5
July 1970	30.8	26.5
August 1970	31.0	28.7
September 1970	26.8	27.7
October 1970	24.2	21.8
November 1970	22.0	21.8
December 1970	16.9	11.2
January 1971	15.1	14.1

TABLE 2.—AVERAGE WATER CHARACTERISTICS OF SEROW AND MANZALAH FISH PONDS.

	Concentrations	
	Serow	Manzalah
Dissolved O_2	6.3 ppm	6.5 ppm
Total alkalinity	292.5 ppm	99.0 ppm
Phosphate	0.15 ppm	0.2 ppm
Nitrate	0.2 ppm	0.3 ppm
Chlorosity	0.7 ppm	6.9 ppm

From Table 3 and Fig. (1) it is obvious that trhee distinct phases of growth can be distinguished for *M. capito* in Serow. The first period is characterized by low gain in weight and extended for about 60 days after stocking. The fish grew from an average weight of 0.05 g to an average of 12 g i.e. 0.2 g/fish/day. At this period the relative growth was very high (23900 %). The second phase is a rapid gaining period that extended for about 180 days (from June to November) and the fish grew from an average weight of 12 g to an average of 143.9 g, i.e. 0.73 g/fish/day. At this period the percentage relative growth was lower than the former and was calculated as 110 %. The third phase of this experiment was about 60 days (December and January) up to the time of fish cropping, where the fish dropped from an average weight of 143.9 g to an average of 134 g ; thus representing an average of 6.8 % loss in weight.

This pattern of growth was also observed for *M. capito* stocked at the three experimental stocking rate (Table, 3). However, the absolute growth rate of *M. capito* that was stocked at a rate of 8000 fry and 7000 carp fry was relatively higher than that for the other experimental stocking rates. At this stocking rate, the average gain in weight was 0.48 g/fish/day as compared to 0.45 g/fish/day at the stocking rate of 8000 *M. capito* and 3000 carp fry/feddan ; and 0.43 g/fish/day for the stocking rate of 6000 *M. capito* and 3000 carp fry/feddan, as shown in Table 4.

It is also apparent from Fig. (3) that two peaks of growth occur after May and September, showing an average gain of 0.69 and 1.09 g/fish/day respectively. During July, the gain in weight is relatively low (0.41 g/fish/day). From the end of November to January (harvesting time), the fish lost on the average 0.16 g/fish/day. These results coincide with the fluctuation of the natural food and the gut contents of the fish during these months.

The total numbers of fish that survived and the percentage loss of both *M. capito* and *C. carpio* at the different stocking rates are given in Table 4. It is apparent that the survival rate of carp is significantly higher than they of *M. capito*. The per cent survival of *M. capito* ranged between 15.4 and 22.5 % with an average survival of 18.5 % ; while that of carp ranged between 83.5 and 87 % with an average survival of 85.4 %. There were no obvious effects on the survival of *M. capito* due to the heavy stocking of carp.

The average growth rate of *M. cephalus* and *M. capito* reared in Manzalah ponds (based on average monthly weight and length measurements) is presented in Table 5 and graphically shown in Figs 1 & 2.

TABLE 3.—AVERAGE GROWTH IN WEIGHT AND IN LENGTH FOR *M. capito* REARED AT DIFFERENT STOCKING RATES WITH CARP AND *Tilapia* IN SEROW FISH FARM.

Month	Days after stocking	8000 M. capito + 3000 C. carpio				8000 M. capito + 7000 C. carpio				6000 M. capito + 3000 C. carpio				Grand average	
		Weight		Length		Weight		Length		Weight		Length		Weight	Length
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	gm.	cm.
May	60	6 — 22.9	14.4± 3.7	8—13	11.1	6 —22.9	11.5±3.8	8—13	10.3	6 — 14	10 ± 2.9	8—11	10	12	10.5
June	90	14 — 52	32.8± 8.7	11—17	14.5	19.6—52	29.8±9.0	12—17	14.2	19.6— 43.4	36 ± 6.8	12—16	14.8	32.9	14.5
July.	120	28.5— 80.8	46.0± 8.7	14—20	16.3	28.4—66.9	47.5±6.8	14—19	16.4	28.4— 58.6	42.2±7.4	14—18	15.8	45.2	16.2
Aug.	150	43.4— 80.8	58.5± 9.0	16—20	18	43.4—88.4	68.5±12.1	16—29	18.1	43.4— 66.9	61.3±8.5	16—19	18.4	62.8	18.2
Sept.	180	52 —143.5	84.7± 17.5	17—25	20.5	58.6—123.1	93.8±14.6	17—23	21.4	58.6—100.3	81 ±12.5	18—22	20.0	86.3	20.6
Oct.	210	80.8— 178	112.5± 24.6	20—27	23.2	80.8—178	126.5±25.7	20—27	24.2	108.9—153.5	118.3± 7.7	23—25	23.7	119.1	23.7
Nov.	240	88.4—222	140 ± 315	21—27	24.8	108.9—220	150.0±23.6	23—29	25.3	108.9—163.7	141.7± 15.4	23—26	24.8	143.9	25.0
Jan.	300	100.3—178	136 ± 23.5	22—29	24.6	108.9—220	144.8±24.7	23—29	25.2	108.9—163.7	128 ± 13.8	23—26	24.2	134	24.7

* Samples were taken on the *25th.* day of each month.

* Each value represents a minimum of 20 fish in each monthly sample.

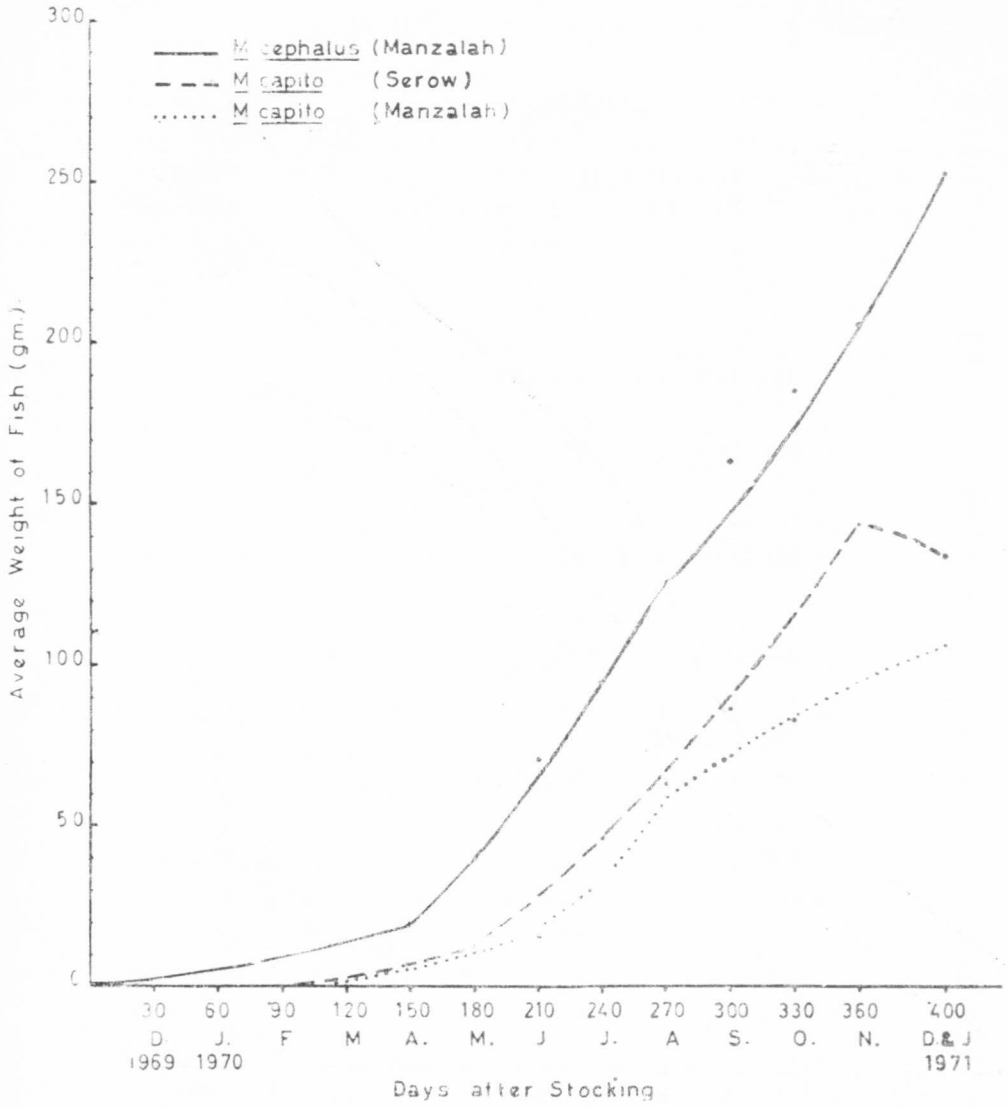


Fig. 1 Average growth rate in weight of reared mullets

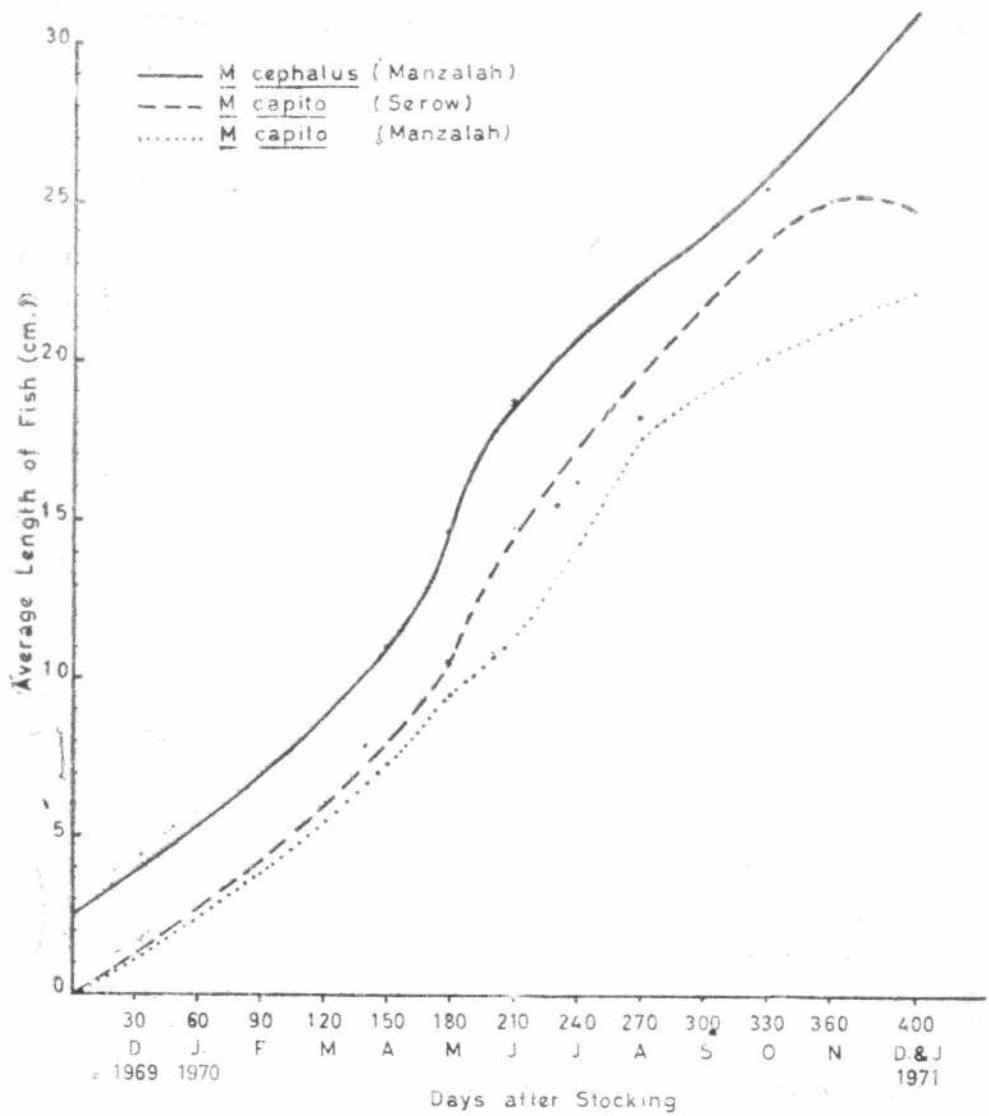


Fig. 2 Average growth rate in length of reared mullets.

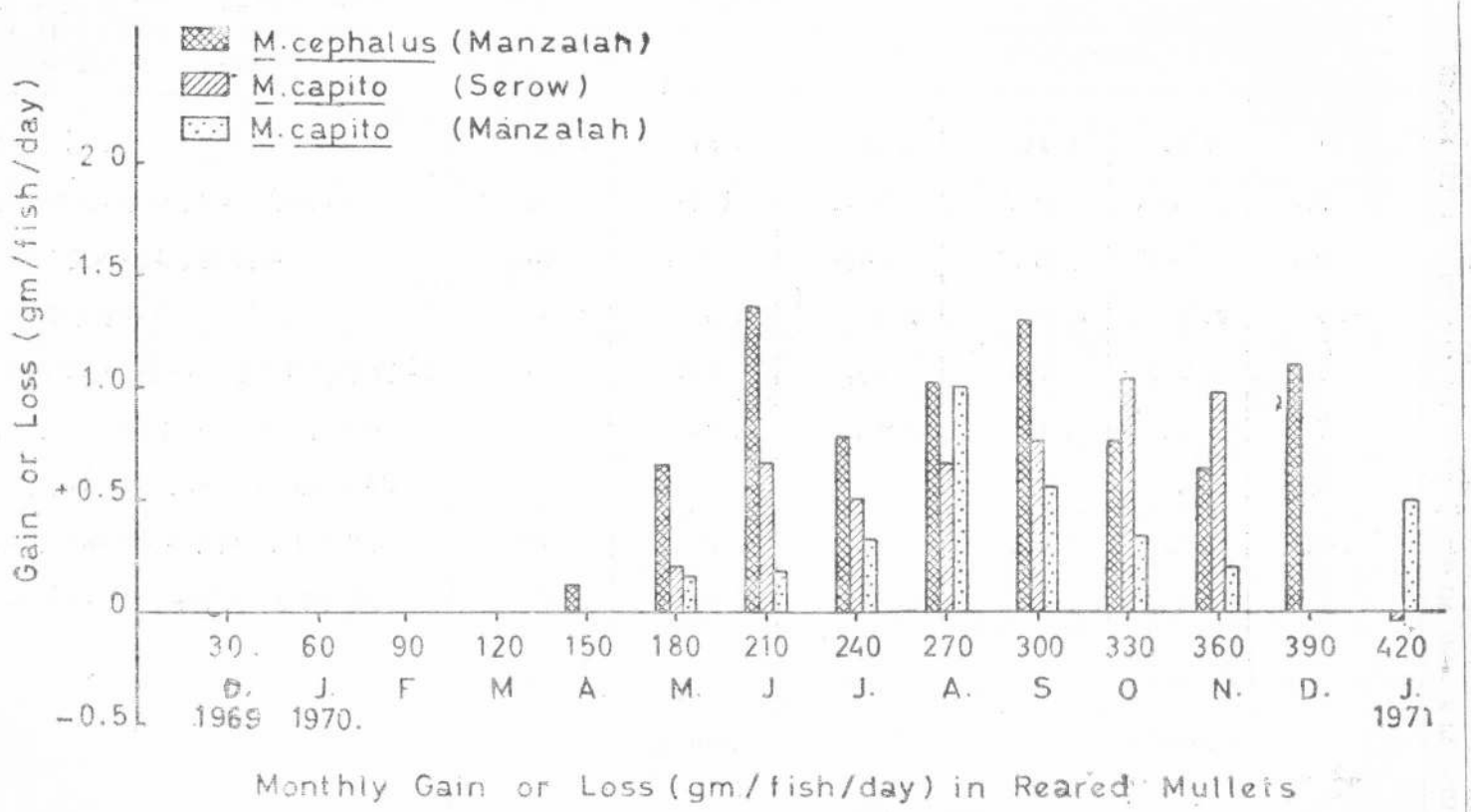

M.cephalus (Manzalah)
M.capito (Serow)
M.capito (Manzalah)
Gain or Loss (gm/fish/day)
2.0
1.5
1.0
+0.5
0
-0.5
30 60 90 120 150 180 210 240 270 300 330 360 390 420
D. J. F M A M J J. A. S O N. D. J.
1969 1970. 1971
Monthly Gain or Loss (gm/fish/day) in Reared Mullets

Fig. 3

TABLE 4.—AVERAGE GROWTH AND SURVIVAL OF *M. capito* AND *C. carpio* STOCKED IN A MIXED-CULTURE AT DIFFERENT STOCKING RATES IN SEROW FARM.

Item	Stocking Rates*					
	M. capito			*C. carpio*		
	I	II	III	I	II	III
Average initial weight of fish (g) . .	0.05	0.05	0.05	1	1	1
Final average weight of fish (g) . .	136	145	128	152.4	76.7	179.1
Initial average length of fish (cm) . .	2	2	2	3	3	3
Final average length of fish (cm) . .	24.2	25.5	23.1	21.5	17	22.5
Duration of the rearing period (day)	300	300	300	270	270	270
Gain/fish/day (g)	0.45	0.48	0.43	0.56	0.28	0.66
Initial No. of fish/feddan	8000	8000	6000	3000	7000	300
No. survived at harvest/feddan . . .	1236	1416	1352	2505	6090	2568
Loss (%)	84.6	82.5	77.5	16.5	13.0	14.4

* Stocking rates : fry/feddan.

I. 8000 *M. capito* and 3000 *C. carprio.*

II. 8000 *M. capito* and 7000 *C. carpio.*

III. 6000 *M. capito* and 3000 *C. carpio.*

TABLE 5.—AVERAGE GROWTH IN WEIGHT AND IN LENGTH FOR *M. cephalus* AND *M. capito* REARED IN MANZALAH FISH FARM.*

Month	*Mugil cephalus*					*Mugil capito*				
	Days after stocking	Weight (g)		Length (cm)		Days after stocking	Weight (g)		Length (cm)	
		Range	Mean**	Range	Mean**		Range	Mean**	Range	Mean**
April	150	6— 38	19± 5.9	7.5—14.5	11	—	—	—	—	—
May	180	12— 88	39± 9.1	9.0—19.5	14.6	60	4.5— 15	10.5± 3.9	7.5—11 0	9.5
June	210	23—197	70±18.2	12.0—25.5	18.7	90	10 — 17	15.5± 2.7	79.0—12.5	11.4
July	240	25—255	94±21.7	12.5—28.0	20.0	120	13 — 43	25.8± 5.0	10.5—16.0	13.1
August	270	35—260	125±24.1	14.5—29.0	21.7	150	14 — 77	58.5±14.7	12.0—19.0	17.6
Sept.	300	63—315	163±32.8	17.0—31.5	24.0	180	16 — 92	71.8±13.8	15.0—20.5	19.2
Oct.	330	75—429	185±25.2	18.5—35.5	25.5	210	28 —148	82.2±14.9	15.0—24.0	20.1
Nov.	360	78—430	205±33.5	19 —35.5	27.2	240	34 —172	89.5±14.4	17.0—25.5	21.0
Jan. (Harvest)	400	75—525	252±34.2	19 —38.0	31.0	300	16 —176.1	105.2±17.2	13.0—27	22.2

* Samples were taken on the 25th. day of each month.

** Each value represents a minimum of 50 fish in each monthly sample ± standard deviation.

It is apparent that the gain in weight for *M. cephalus* is relatively low during the first five months after stocking; where the fish grew from an average weight of 0.1 g to an average of 19 g, thus representing an average daily gain of 0.13 g/fish. During this period, the relative growth was calculated as 18900 %. Thereafter, the absolute growth rate increased rapidly at an average gain of 0.9 g/fish/day for the remaining experimental period. The relative growth during this period decreased to 1230 %.

The growth of *M. capito* reared in Manzalah ponds was obviously inferior to that reared in Serow for the same experimental period. The average gain in weight for *M. capito* in Manzalah was low for the first two months after stocking ; the fish grew from an average of 0.05 g to 10 g thus showing an average gain of 0.17 g/fish/day, while the relative growth was 19900 %. Thereafter, the fish gained weight rapidly, from an average of 10 g to 105 g/fish ; thus representing an average gain in weight of 0.4 g/fish/day. The relative growth decreased to 950 %.

It is also obvious from Table 6 that the stocking rate affected the growth of the reared mullets. At the highest stocking rate of 5300 *M. cephalus* fry/feddan, the average gain/fish/day was considerably low low (0.32 g), while at the stocking rate of 520 fry/feddan the average gain was 0.73 g/fish/day. For *M. capito,* the average gain in weight ranged between 0.31 and 0.35 g/fish/day at the different stocking rates Table 6.

The total numbers of *M. cephalus* and *M. capito* that survived and the per cent loss at the experimental stocking rates are presented in Table 6. It is obvious that the mortality rate in Manzalah ponds is relatively high. The per cent loss of *M. cephalus* ranged between 85.4 and 90.4 % with an average of 87.7 % ; while that of *M. capito* ranged between 36.7 and 93.9 % with an average of 74.8 %. The minimum mortality percent was observed for *M. capito* stocked at a rate of 600 fry/feddan. The predacious fish, *Lates* app were caught in considerable numbers.

Length-Weight Relationship

The relation between length and weight for the reared fish, *M. cephalus* and *M. capito* in Manzalah farm and for *M. capito* in the Serow farm was determined by using the equation (Beckman, 1948 ; Le Cren, 1951 and determined by using the equation (Beckman, 1948 and Le Cren, 1951)

$$W = c\ L^n$$

TABLE 6.—AVERAGE GROWTH AND SURVIVAL OF *M. cephalus* AND *M. capito* STOCKED AT DIFFERENT RATES IN MANZALAH PONDS.

Item	Stocking Rates*								
	I	II		III		IV		V	
	cephalus	*cephalus*	*capito*	*cephalus*	*capito*	*cephalus*	*capito*	*cephalus*	*capito*
Initial average weight of fish (g)	0.1	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05
Final average weight of fish (g) . .	131	250	93	292.4	101.2	278.5	104.4	258.2	99.8
Initial average length of fish (cm) .	2.5	2.5	2.0	2.5	2.0	2.5	2.0	2.5	2.0
Final average length of fish (cm) .	22.5	28.8	21.5	31.0	22	30.2	22.2	29.0	21.5
Duration of rearing period (days) .	400	400	300	400	300	400	300	400	300
Average growth/fish/day (g)	0.32	0.63	0.31	0.73	0.33	0.70	0.35	0.65	0.33
Initial Number of fish/feddan . . .	5300	600	600	525	1250	500	2150	900	3650
Average No. recovered/feddan . . .	775	53	380	73	248	68	246	110	223
Loss (per cent)	85.4	90.4	36.7	86.2	80.2	86.5	88.5	87.8	93.9

* Stocking rates as fry / feddan :

I. 5300 M. cephalus

II. 600 M. cephalus + 600 M. capito.

III. 520 M. cephalus + 1250 M. capito.

IV. 500 M. cephalus + 2150 M. capito.

V. 900 M. cephalus + 3650 M. capito.

where :

W = weight in grams

L = total length in millimeters

c and n are constants

The logarithmic form of the equation is :

$$\log W = \log c + n \log L$$

The values of log c and log n were calculated from the following equations :

$$\log c = \frac{\log W \Sigma (\log L)^2 - \log L (\Sigma \log L . \log W)}{N \Sigma (\log L)^2 - (\Sigma \log L)^2}$$

$$n = \frac{\log W - N \log c}{\log L}$$

N = number of length intervals taken

For this study a total number of 2561 fishes of unidentified sexes were considered. *M. cephalus* in Manzalah, ranged from 70 to 380 mm in total length, *M. capito* in Manzalah ranged from 70 to 270 mm total length, and *M. capito* in Serow ranged from 70 to 290 mm total length as shown in Tables 7, 8 and 9 respectively. The data were presented by grouping the fish by ten millimeters total length intervals. The fish samples were collected to represent the whole rearing period. The following equations were derived from the calculations :

a- For *M. cephalus* reared at Manzalah

$$\log W = -4.9270 + 2.9998 \log L$$

b- For *M. capito* reared at Manzalah

$$\log W = -4.2368 + 2.6675 \log L$$

c- For *M. capito* reared at Serow

$$\log W = -5.1427 + 3.0628 \log L$$

It is obvious that the reared *M. cephalus* increased in weight at almost the cube of length. *M. capito* reared in the Serow ponds showed a value of n significantly higher than that reared at Manzalah. This shows that for a given length, *M. capito* of Serow were heavier than that of Manzalah.

TABLE 7.—LENGTH-WEIGHT RELATIONSHIP FOR *M. cephalus* REARED AT MANZALAH FISH FARM.

(CALCULATED WEIGHTS ARE OBTAINED BY USING THE EQUATION : LOG W = — 4.9270 + 2.9998 LOG L)

Total length (mm.)	No. of fish examined	Average Emp. wt.	Calculated wt.	Difference
70	5	6	4.0	—2.0
80	5	10	6.0	+4.0
90	15	11.9	8.6	—3.3
100	40	14.9	11.8	—3.1
110	55	19.2	15.7	—3.5
120	30	23.6	20.4	—3.2
130	25	29.6	25.9	—3.7
140	45	54.3	52.7	—2.6
150	66	41.2	39.8	—1.4
160	34	49.2	48.3	—0.9
170	55	61.8	57.9	—3.9
180	60	67.9	68.9	+1.0
190	48	81.6	80.9	—0.7
200	90	91.6	94.4	+2.8
210	71	112.1	109.4	—2.7
220	91	125.7	125.6	+0.1
230	75	141.7	143.5	+1.8
240	83	161.0	163.3	+2.3
250	116	174.0	184.5	+10.5
260	106	189.8	207.5	+17.7
270	77	216.0	232.3	+16.3
280	38	237.5	259.4	+21.9
290	30	263.9	287.7	+23.8
300	30	270.0	318.4	+48.4
310	20	300.8	351.6	+50.8
320	7	322.1	386.4	+64.3
330	8	359.1	423.6	+64.5
340	6	365.0	463.4	+98.4
350	7	403.3	505.8	+102.5
360	6	446.6	550.8	+104 2
370	3	494.0	598.4	+104.4
380	3	525.3	647.1	+121.8

TABLE 8.—LENGTH-WEIGHT RELATIONSHIP FOR *M. capito* REARED AT MANZALAH FISH FARM.

(CALCULATED WEIGHTS ARE OBTAINED BY USING THE EQUATION: LOG W = — 4.2368 + 2.6657 LOG L)

Total length (mm.)	No. of fish examined	Average Emp. weight	Calculated weight	Differnnçe (gm)
70	15	4.6	4.8	0.2
80	—	—	—	—
90	10	10.5	9.4	+ 1.1
100	51	13.1	12.5	+ 0.7
110	21	16.2	16.1	+ 0.1
120	29	19.1	20.4	— 1.3
130	49	24.4	25.2	— 0.8
140	45	29.6	30.7	— 1.1
150	45	36.8	36.9	— 0.1
160	28	45.1	43.9	+ 1.2
170	27	55.2	51.6	+ 3.6
180	39	63.1	60.1	+ 3.0
190	56	70.7	69.1	+ 1.3
200	41	79.9	79.6	+ 0.3
210	48	93.2	90.7	+ 2.5
220	30	104.7	102.7	+ 2.0
230	17	110.2	115.6	— 5.4
240	11	128.8	129.5	— 0.7
250	7	131.8	144.4	—12.6
260	1	154.0	160.4	— 6.4
270	1	176.3	177.8	— 1.5

The discrapenses between the empirical and calculated weights for the different lengths of *M. cephalus* (Manzalah), *M. capito* (Manzalah) and *M. capito* (Serow) are given in Tables 7, 8, and 9 respectively, and also shown graphically in Figs. 4,5, and 6 respectively. The smooth curve represent the calculated weights and the dots represent the empirical ones. It is apparent that the differences are not significant except for the large sizes of *M. cephalus*. This may be partially due to the small numbers of the large sizes that were used for the calculations.

TABLE 9.—LENGTH-WEIGHT RELATIONSHIP FOR *M. capito* REARED AT SEROW FISH FARM (CALCULATED WEIGHTS ARE OBTAINED BY USING THE EQUATION :

$$\text{Log } W = -5.1427 + 3.0628 \log L$$

Length (mm)	No. of fish	Av. Emp. Wt.	Calculated Wt.	Difference
80	7	6.0	4.8	— 1.2
90	10	7.6	6.9	— 0.7
100	20	10.3	9.6	— 0.7
110	37	14.0	12.8	— 1.2
120	13	19.6	16.8	— 2.8
130	9	22.9	21.4	— 1.5
140	35	28.4	26.9	— 1.5
150	36	38.5	33.3	— 5.2
160	51	43.4	40.5	— 2.9
170	35	52.0	48.8	— 3.2
180	40	58.6	58.2	— 0.4
190	41	66.9	68.6	+ 1.7
200	33	80.8	80.3	— 0.5
210	30	88.4	93.2	+ 4.8
220	23	100.3	107.5	+ 7.2
230	36	108.9	123.2	+ 14.3
240	64	123.1	140.4	+ 17.3
250	75	143.5	159.1	+ 15.6
260	28	163.7	179.5	+ 15.8
270	11	178.0	201.4	+ 23.4
280	3	197.0	225.1	+ 28.1
290	3	222.0	250.6	+ 28.6

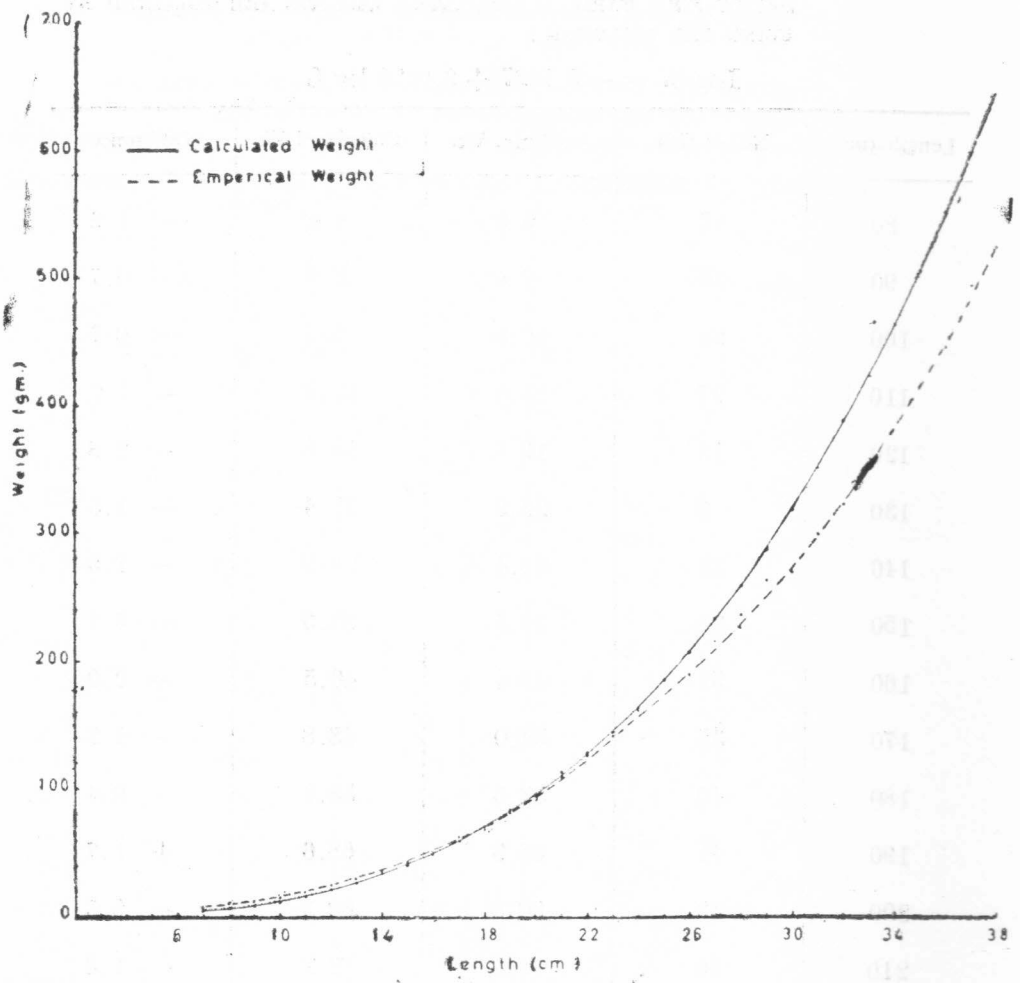


Fig. 4 Length weight relationship of *M. cephalus* at Manzalah fish Farm

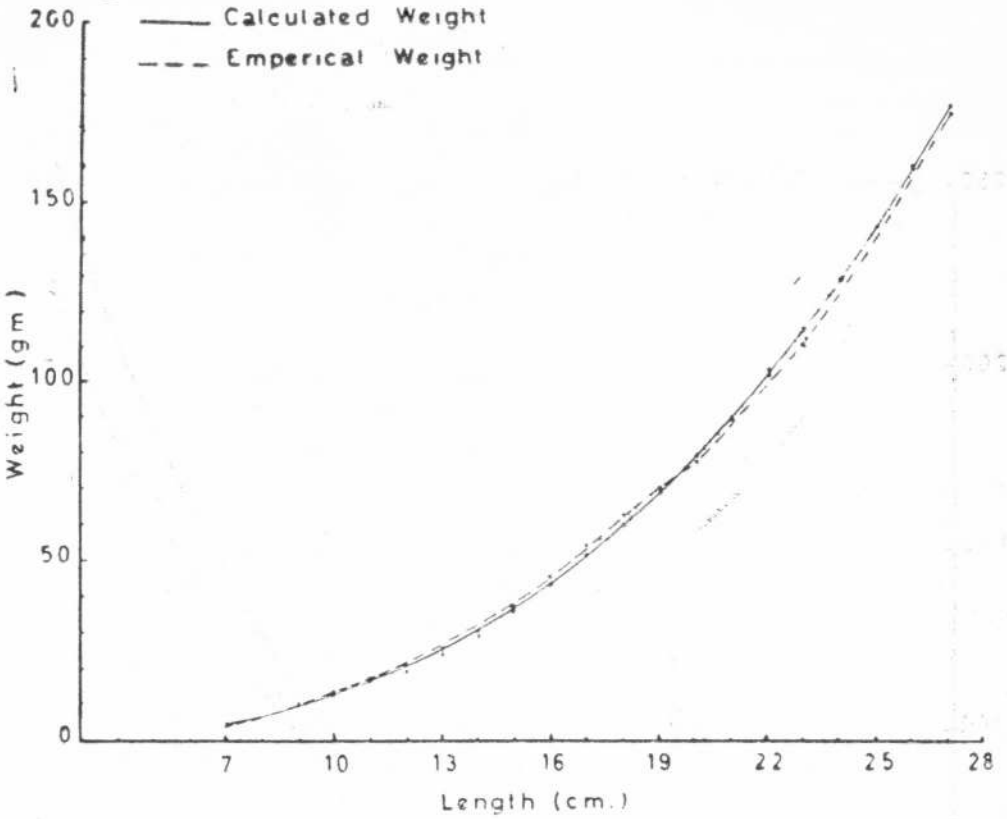
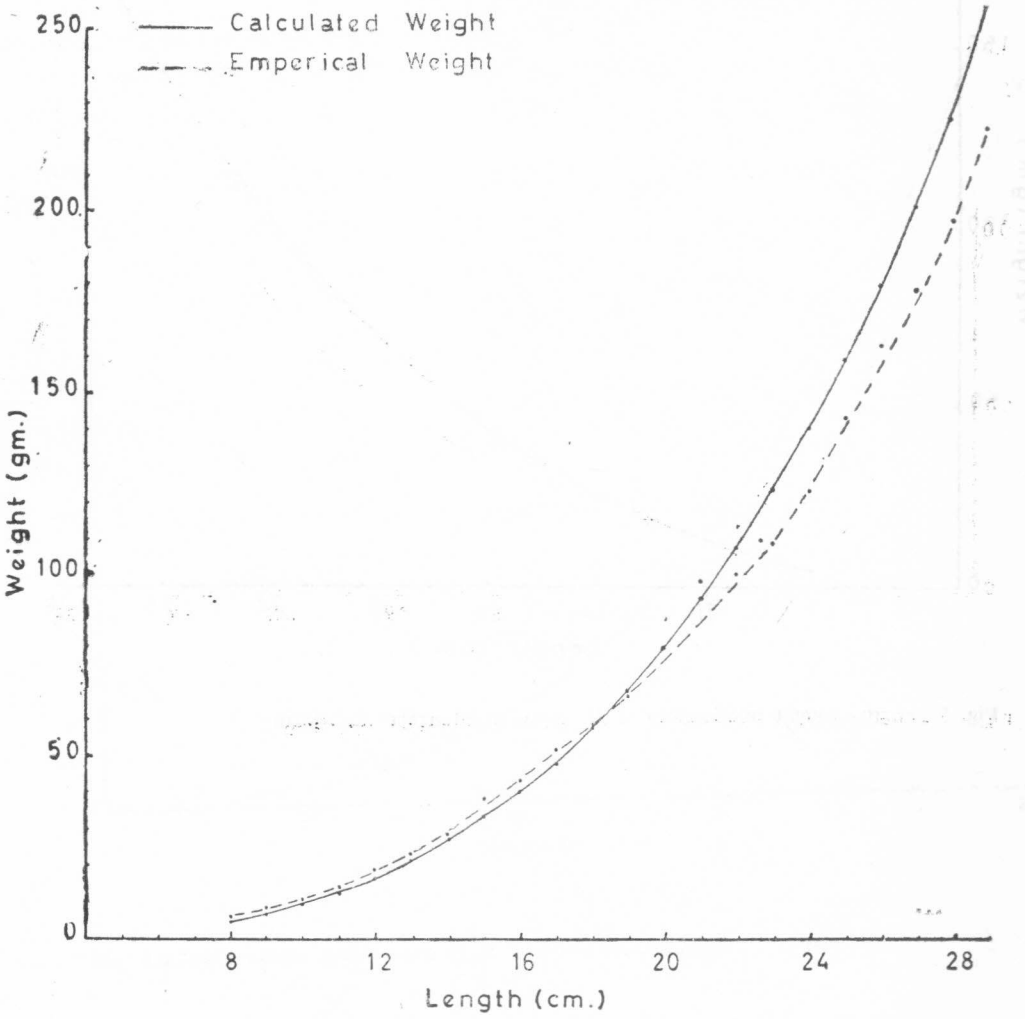


Fig. 5 Length–weight relationship of *M. capito* at Manzalah fish farm



Length-Weight Relationship of M capito at Serow Fish Farm.

Fig. 6

Condition Factor

The condition factor or the coefficient of condition "K" is an expression from the length-weight relationship and its values are interpreted to express the relative well-being of fishes. The coefficient of condition "K" is determined by the following formula $K = \frac{100\ W}{L^3}$

Where : W = weight of fish in grams

L = total length in centimeters

The coefficient of condition "K" values for *M. cephalus* and *M. capito* reared in the Manzalah and Serow ponds and distributed by one centimeter total length class intervals are presented in Table 10. It is apparent that the "K" values for *M. cephalus* were relatively higher than those of *M. capito* of the same lengths. Maximum "K" values for *M. cephalus* were observed for fishes ranging from 7 to 11 cm length, being of an average of 1.4 ; whereas for fish over 12 cm the average "K" value was 1.1. The minimum values of "K" were observed for lengths above 30 cm. The average "K" for all sizes was 1.15.

The "K" values for *M. capito* reared at Serow were slightly lower than those reared at Manzalah farm, the average of all sizes being 0.94 and 1.03 respectively.

It is evedint that the condition factor of the reared mullets (*M. cephalus* and *M. capito*) is higher than the recorded values for these species in the natural habitat (Bishara, 1967).

Production of Fish :

A. Serow Fish Farm :

The data on stocking and cropping of the experimental fish are preented in Table 11. The total production of the fish at the end of the rearing period clearly shows the effect of the different stocking rates, Table 12. For the ponds that were stocked at a rate of 8000 *M. capito* and 7000 carp fry/feddan, the highest yield of fish was obtained, an average of 996 kg/feddan. *M. capito* represented 20.5% of the total production (205 kg/feddan), while carp constituted about 47% (an average of 467 kg/feddan). The average size of *M. capito* was the highest (145 g weight and 25.5 cm in total length), while the average size of carp was the least

TABLE 10.—MEAN VALUES OF CONDITION FACTOR "K" FOR REARED *M. cephalus* AND *M. capito*.

Location	Serow		Manzalah			
Species	M. capito		M. capito		M. cephalus	
Length (cm)	N*	K**	N*	K**	N*	K**
7	—	—	15	1.09	5	1.42
8	7	1.10	—	—	5	1.78
9	10	0.96	10	1.32	15	1.44
10	20	0.95	51	1.19	40	1.32
11	37	0.92	21	1.12	55	1.31
12	13	1.07	29	1.01	30	1.22
13	9	0.98	49	1.05	25	1.26
14	35	0.98	45	1.05	45	1.15
15	36	1.12	45	1.01	66	1.28
16	51	1.01	28	1.06	34	1.11
17	35	1.00	27	1.10	55	1.15
18	40	0.96	39	1.01	60	1.12
19	41	0 94	56	0 98	48	1 11
20	33	0 94	41	0.97	90	1.10
21	30	0.92	48	0.96	71	1.14
22	23	0.91	30	0.94	91	1.10
23	36	0.87	17	0.88	75	1.15
24	64	0.86	11	0.91	83	1.05
25	75	0.89	7	0.88	116	1.05
26	28	0.91	1	0.89	106	1.02
27	11	0.88	1	0.91	77	1.00
28	3	0.83	—	—	38	1.04
29	3	0.86	—	—	36	1.08
30	—	—	—	—	30	0.96
31	—	—	—	—	20	0.98
32	—	—	—	—	7	1.25
33	—	—	—	—	8	0.99
34	—	—	—	—	6	0.90
35	—	—	—	—	7	0.94
36	—	—	—	—	6	0.95
37	—	—	—	—	3	0.97
38	—	—	—	—	3	0.92
Total N . .	640	—	571	—	1350	—
Average K .	—	0.94	—	1.03	—	1.15

* Number of fish examined

** Condition factor

TABLE 11.—PRODUCTION OF *M. capito* AND CARP STOCKED AT DIFFERENT RATES IN THE SEROW FISH FARM.

No. of ponds	Area of pond (fed.) *	Species	Stocking					Cropping				
			Date	Total No.	Avg. No./fed.	Total wt. (gms)	Avg. wt./fed. (gms)	Date	Total No.	% Survival	Total wt. (kg)	Avg. wt./fed. (kg)
2 (7, 8)	2	*M. capito*	15-4-70	16000	8000	800	400	26-1-71	2472	15.45	335	168
		C. *carpio*	15-5-70	6000	3000	6000	3000	26-1-71	5010	83.50	763	382
		Tilapia	—	—	—	—	—	26-1-71	—	—	440	220
		Catfish	—	—	—	—	—	26-1-71	—	—	58	29
2 (6, 9)	2	*M. capito*	15-4-70	16000	8000	800	400	28-1-71	2832	17.73	410	205
		C. carpio	15-5-70	14000	7000	14000	7000	28-1-71	12180	87.00	933	467
		Tilapia	—	—	—	—	—	,,	—	—	610	305
		Catfish	—	—	—	—	—	,,	—	—	38	19
3 (11,12, 13)	2	*M. capito*	15-4-70	15000	6000	750	300	18-1-71	3380	22.54	433	173
		C. carpio	15-5-70	7500	3000	7500	3000	28.1-71	6442	85.60	1150	460
		Tilapia	—	—	—	—	—	,,	—	—	533	213
		Catfish	—	—	—	—	—	,,	—	—	52	21

* one feddan = 0.44 hectare.
fed. = feddan.
wt. = weight.

TABLE 12.– PRODUCTION PER FEDDAN OF *M. capito* AND OTHER FISHES REARED AT THE SEROW FISH FARM.

Stocking rate per feddan *	Species	Fish yield kg/feddan*		% of total production
		Range	Mean	
8000 *M. capito*	*M. capito*	144—191	168	21.0
+	*C. carpio*	311—452	382	47.8
3000 *C. carpio*	*Tilapia spp.*	193—247	220	28.8
	Catfish	19— 39	29	2.4
	Total	667—929	799	
8000 *M. capito*	*M. capito*	205	205	20.5
+	*C. carpio*	423—510	467	46.8
7000 *C. carpio*	*Tilapia spp.*	265—350	305	30.8
	Catfish	15— 23	19	1.9
	Total	708—1085	996	
6000 *M. capito*	*M. capito*	160—196	173	20.0
+	*C. carpio*	420—484	460	53.0
3000 *C. carpio*	*Tilapia*	200—240	213	24.6
	Catfish	20— 22	21	2.4
	Total	800—942	867	

* One feddan = 0.44 hectare.

At higher stocking rates, the yield of reared mullets ranged from 44 to so kg/feddan, but the average size of the fish was lower, Tables 6 and 14.

The filtrated fishes that were collected from the ponds after being drained were *Tilapia* spp (of which *T. zillii* of small sizes constituted a high percentage of the catch) and *Lates* spp. The average production of *Tilapia* was 55 kg per feddan.

(about 77 g weight and 17 cm in total length). The lowest fish production was obtained from the stocking rate of 8000 *M. capito* and 3000 carp fry/feddan, as an average of 799 kg/feddan. The production of mullet and carp was 168 kg/feddan and 382 kg/feddan respectively. The average size of the fish was 136 g weight and 24.2 cm total length for *M. capito ;* and 152 g weight and 21.5 total length for carp. At the stocking rate of 6000 *M. capito* and 3000 carp fry per feddan, the average total production was 867 kg/feddan. The production of *M. capito* was 173 kg/feddan and the fish were of an average weight of 128 g and 23.1 cm toatl length ; while the production of carp was 460 kg/feddan and the fish of an average size (179 g weight and 22.5 cm total length).

The ponds when drained contained other fishes that filtrated, such as *Tilapia* spp, *Clarias lazera* and few specimens of *Lates niloticus.* It is obvious from Table 12 that the average production per feddan of these fishes is almost in the same range for the different experimental stocking rates. The production of *Tilapia* ranges between 193 and 350 kg/feddan, with an average of 246 kg/feddan. For *Clarias* spp, the total production per feddan ranged between 19 and 39 kg with an average of 23 kg/feddan.

B. Manzalah Fish Farm :

The effect of the experimental stocking rates on the production of *M. cephalus* and *M. capito* reared for a period of 400 and 300 days respectively, are presented in Tables 13 and 14. It is apparent that the highest production of mullet as an average of 101 kg/feddan was obtained when *M. cephalus* was stocked at a rate of 5300 fry/feddan. The average size of the fish at harvest was rather low ; 131 g for weight and 22 cm for total length.

At the stocking rate of 600 *M. cephalus* and 600 *M. capito* fry/feddan the yield per feddan was 14.4 kg and 35.3 kg respectively. The average size of the fish is given in Table 6.

The stocking rate of 520 *M. cephalus* and 1250 *M. capito* fry gave an average yield of 21.2 kg/feddan for *M. cephalus* and 25.1 kg/feddan for *M. capito.* The average size of *M. cephalus* was the highest, 292.2 g weight and 31 cm total length, while that for *M. capito* reached an average weight of 101.2 g.

TABLE 13.—DATA ON STOCKING AND PRODUCTION OF *M. cephalus* AND *M. Capito* REARED AT MANZALAH FARM.

No. of ponds	Area of Pond (fed.)*	Species	Stocking					Cropping					
			Date	Total No./fed.	Avg. No./fed.	Total wt. (gm)	Avg. wt./fed.	Date	Total No.	% Survival	Total wt. (kg.)	Avg. wt./fed.
2 (1,2)	20	*M. cephalus*	15 11.69	106000	5300	10600	530	20.12.70	15500	14.62	2025	101
		Tilapia									1453	73
		Other fish									5	0.3
2 (9,10)	20	*M. cephalus*	5.12.69	12000	600	1200	60	10. 1.71	1150	9.58	288	14.4
		M. capito	10. 3 70	12000	600	600	30	10.1 .71	7000	63.3	705	35.3
		Tilapia									1028	51.4
		Other fish									8	0.4
4 (4,8,14, 15)	20	*M. cephalus*	20.12.69	10400	520	1040	520	12. 1.71	1450	13.8	424	21.2
		M. capito	12. 4.70	25000	1250	1250	625	12.1 .71	4930	19.8	501	25.1
		Tilapia									969	48.5
		Other fish									10	0.5
4 (4,7,11, 13)	20	*M. cephalus*	20.11.69	10000	500	1000	50	20.12.70	1250	13.5	376	18.8
		M. capito									1005	50.3
		Other fish									6	0.3
3 (3,6,12)	20	*M. cephalus*	1.12.69	18000	900	1800	90	6 .1 .71	2200	12.2	568	28.4
		M. capito	5. 3.70	72000	3650	3650	182.5	6 . 1.71	4467	6.1	446	22.3
		Other fish									934	46.7
											5	0.3

* One feddan = 0.44 hectare

TABLE 14.—PRODUCTION PER FEDDAN FOR *M. cephalus* AND *M. capito* AND OTHER FISHES REARED AT MANZALAH FARM.

Stocking rate per feddan	Species	Yield of fish kg/feddan		% of total yield
		Range	Mean	
5300 *M. cephalus*	*M. cephalus*	93—110	101	58.0
	Tilapia spp	69— 76	73	41.9
	Other fishes	0—0.3	0.2	0.1
	Total	168—179	174.2	
600 *M. cephalus* + 600 *M. capito*	*M. cephalus*	5.8— 23	14.4	14.21
	M. capito	27.5— 43	35.3	34.83
	Tilapia spp.	50.8— 52	51.4	50.77
	Other fishes	0 —0.4	0.2	0.19
	Total	101.3	101.3	
520 *M. cephalus* + 1250 *M. capito*	*M. cephalus*	13—32.1	21.2	22.28
	M. capito	19.3—40.3	25.1	26.39
	Tilapia spp.	35—61.5	48.5	51.02
	Other fishes	0—1.2	0.3	0.31
	Total	84.8—124.3	95.1	
500 *M. cephalus* + 2150 *M. capito*	*M. cephalus*	8.5—27.5	18.8	19.74
	M. capito	13.5—34.5	24.7	27.02
	Tilapia spp.	39—53.5	50.3	52.93
	Other fishes	0—1.0	0.3	0.31
	Total	77.1—115	95.1	
900 *M. cephalus* + 3650 *M. capito*	*M. cephalus*	10—43	28.4	22.83
	M. capito	20.6—87.5	48.5	40.00
	Tilapia spp.	39.3—53.2	47.2	37.94
	Other fishes	0—0.5	0.3	0.23
	Total	106.6—146.8	124.4	

DISCUSSION

Fish culture for the production of food has been practised in many countries according to the prevailing conditions. The ultimate goal is to obtain the maximum yield of fish from natural waters and ponds. Therefore several techniques have been employed to achieve this objective, which include :

(1) improving the productivity of soils and waters by means of addition of chemicals and either organic or inorganic fertilizers.

(2) Increasing fish production by means of supplementary food or intensive feeding especially in flowing waters.

(3) Through biological means such as rearing the quick-growing species, and

(4) By means of proper management for maximum utilization of both productivity and space of the water body.

Recent concepts of fish culture stress the importance of rearing the efficient fish species, species-combinations (mixed culture), temporary stocking, timing of stocking and control of reproduction, in relation to their efficient role to obtain the maximum production of fish. It is well known among fish culturists that the maximum standing crop of a pond can be increased where two or more fish species of complementary feeding habits are stocked ; so that a wider range of the foods produced in the ponds be utilized (Hickling, 1962 ; Hora and Pillay, 1962 and Swingle, 1966). Moreover, the full utilization of the natural food is made possible by the adequate stocking of the combination of fish of different sizes.

From the present study in the Serow farm, it is evident that carp, *Cyprinus carpio* and *Tilapia* are the most important secondary fishes for mixed-mullet culture in Egyptian fish ponds. The following advantages are evident : (1) when searching for food, both carp and mullet grub up mud and consequently help to increase the production of natural food that is essential for mullet, (2) carp and *Tilapia* reared in the Serow farm were supplied with artificial food, thus giving the opportunity for mullet to utilize a great deal of the available natural food, (3) the excreta of both carp and *Tilapia* fed on the supplementary diet, contain a large portion of undigested or partially digested materials that were utilized by mullet and was termed as unidentified materials in the guts (Eissawy *et al,* 1974), and (4) according to the scheme followed in Serow ponds for mullet mixed culture, it is apparent that carp does not raise the problem of reproduction in the rearing ponds since it reaches maturity in the second year ; but the major problem is

the frequent reproduction of *Tilapia* during the rearing that result cause overpopulation and consequently competition for food. However, the expenimental observations showed that the control of reproduction of *Tilapia* can be managed by introducing a small numbers of a predatory fish such as *Clarias lazera.*

The results of this study clearly demonstrate that the growth rate of *M. capito* reared in the Serow ponds was higher than that reared in Manzalah ponds; being on the average 0.45 and 0.33 g/fish/day respectively. The differences in the growth rates may be mainly attributed to two factors that affect the fish either directly or indirectly. First, the physico-chemical properties of both water and soil of the Serow ponds are more productive than those of Manzalah ponds that were not properly managed through the past five years. Second, *M. capito* in Serow were reared in a mixed-culture with carp and *Tilapia* that received a regular supplementary food (a mixture of rice bran and cotton seed cake) that could be utilized either directly or indirectly by the fish. Moreover, the residue of the artifical food may act as an organic fertilizer thus increasing the natural productivity of the water. The fish reared in Manzalah received very small amounts of the supplementary food that was not regularly given.

The absolute growth rate of the reared *M. capito* was characterized by a slow growing period that extended for about two and four months after stocking in Serow and Manzalah ponds respectively. This observation was also recorded for *M. capito* in the natural habitat by (Paget, 1922, 1923 and Wimpenny, 1934) who indicated that the growth actually begins when the water temperature reaches about 20°C, and that June and July months are the period of rapid growth. Several investigators indicated that the low growth rate during the winter months to be due to the prevailing low temperatures that lower the feeding and metabolic activities of the fish even food is present in sufficient quantities (Brown, 1957 ; Swift, 1961 and Brett *et al,* 1969).

This investigation showed that the growth rate of *M. capito* reared in fish farms is significantly higher than that of the natural habitat. Wimpenny (1934) indicated that *M. capito,* after one year in lake Mariut attained a length of 16 and 14 cm in the respective years 1927 and 1928 ; and in lake Borollus, El-Sedfy (1971) indicated that it reached a maximum length of 13.5 cm in the first year. The results showed that the reared fishes attained an average of 21.8 cm and 105g in Manzalah ponds while in Serow it attained an average of 24.3 cm and 148 g after about 10 months. It is worth mentioning that similar weights and lengths are attained after two years in the natural habitat (El-Sedfy, 1971).

Although the reared *M. capito* attained large sizes but their sex was not differentiated. In the natural habitat, Faouzi (1937) found that the smallest mature female ia attained at 19 cm in length and for males is attained at 13 cm.

The growth data of *M. capito* reared in the Serow ponds indicated that the fish lost on the average about 7 % of their weight during the period from the end of November to January, the time when the fish were harvested. This loss in weight may be partially due to the fact that the fish stopped feeding during this period as a result of the considerable drop of the water temperature. This is supported by the examination of the gut contents of the fish that were found empty during this period (Eissawy et al, 1974 b). Moreover, the supplementary food for carp and *Tilapia* was suspended since these fishes do not consume the food if offered during this period of the year. It is recommended that fish cropping in the Serow farm be carried out not later than the first week of December.

The growth of *M. cephalus* reared in Manzalah fish farm is similar to that naturally found in lake Mariut (Paget, 1922). After one year, the fish reached 20 to 30 cm in length and weighed from 80 to 450 g. The growth rate of *M. cephalus* was relatively low during the period from September to May.

The effect of stocking density on the growth of *M. cephalus* was evident in this investigation. Increasing the rate of stocking from 600 fry/feddan to 5300 fry/feddan lowered the average gain in weight/fish/day from 0.73 g to 0.32g Table, 6. This may be due to the inavailability of sufficient quantities of the natural food on which *M. cephalus* mainly depends (Eissawy *et al,* 1947 b).

The growth rate of *M. cephalus* was approximately twice that of *M. capito* reared in Manzalah ponds. During the period of high growth, from July to December, *M. cephalus* gained weight at an approximate rate of one g/fish/day. To obtain maximum growth and full utilization of the growing period, it is recommended to culture *M. cephalus* as fingerlings of an average length of 10 to 12 cm in a mixed culture of carp and *Tilapia*. Stocking should be carried out during April and May. Supplementary food and the use of fertilizers is essential in this respect.

In this investigation, the length-weight relationship for the reared mullets were expressed by the following equations :

log W = -4.9270 + 2.9998 log L for ***M. cephalus*** (Manzalah)
log W = -4.2368 + 2.6675 log L for *M. capito* (Manzalah)
log W = -5.1427 + 3.0628 log L for *M. capito* (Serow)

It is exvident that the exponent of length of the reared *M. cephalus* is higher than that for the same species collected from the Mex-Kandak canal and from lake Maruit. According to Bishara (1967) the calculated equation for the latter fishes was : $\log W = -4.732 + 2.865 \log L$

This means that *M. cephalus* reared at Manzalah fish farm gained weight faster than those of similar length naturally found in lake Mariut. However, the present results agree with that of Hotta (1955) who found that the exponent value for *M. cephalus* was equal to 2.9755.

For *M. capito* reared in Serow fish farm, and on length ranges between 70 and 290 mm, the obtained exponent of length (3.0628) was significantly higher than that of both *M. capito* reared in Manzalah and that naturally found in lakes Mariut and Borollus (Bishara, 1967 and El-Sedfy, 1971). The exponent values of *M. capito* in lakes Mariut and Borollus were 2.9133 and 2.8071 respectively. However, the high exponent values obtained in lake Borollus were attributed to the mature females that added more weight, while the reared *M. capito* of the same lengths did not reach sexual maturity.

The data obtained from the present study showed that the average mortality of the transplanted fry was as high as 87.5 % for *M. cephalus* and *M. capito* reared in Manzalah, and 81.5 % for *M. capito* in Serow ponds. High mortality percentage was also recorded for *M. cephalus* reared in the Mex fish farm (El-Zarka and Fahmy, 1966). The high per cent mortality among the transplanted mullets may have resulted from several factors that include : (1) physiological and metabolic disorders that occurred to the fry when subjected to a sudden change into fresh water or even to brackish water of different salinities, (2) significant differences in the physico-chemical properties of the water in the site of collection and that of the water in the experimental ponds, (3) sensitivity and distress of the fish under the various conditions especially during transportation and after being stocked, and (4) the presence of the carnivore fishes that may consume large numbers of the transplanted fry. *Lates niloticus* was found in considerable numbers in Manzalah ponds and *Clarias* spp were found in Serow ponds.

It is suggested that acclimatization and conditioning of the fry should be carried out before transporting and stocking them in the rearing ponds. This process can be carried out in the ponds of the Mex fish farm, which is close to the site of fry collection, through gradual reduction of the salinity of the

water to the desired level. The work of Ganapati and Alikunhi (1952) in India, indicate that for the mullet fry of 1.5 to 5 cm in length, reducing the salinity by 5 % at four-hour intervals is satisfactory for the process of acclimatization. Further studies aiming to minimize the mortality rate of transplanted mullets are needed.

The mortality rate of *C. carpio* stocked as a mixed culture with mullet, was relatively low (an average of 14.6 %. There were no obvious effects on the survival of *M. capito* as a result of the heavy stocking of carp.

The rate of stocking is an important factor in relation to fish production in ponds. It is known that if the stocking rate is low, a low production of large fish is attained. On the contrary, if the stocking rate is high, the production will be high but with under-sized marketable fish. In the present study, it is evident that the production of mullet and other fishes obtained from the Serow fish farm is considered satisfactory when compared with mullet culture in different parts of the world (Hora and Pillay, 1962). The average highest fish production obtained was about 2495 kg/ha, of which mullet production was 312.5 kg/ha. This production was obtained from the stocking rate of 8000 fry *M. capito* and 7000 fry *C. carpio*. The only disadvantage of this rate of stocking was the production of large numbers of under-sized carps, as compared with the other experimental stocking rates Table 4. It is recommended to reduce the stocking rate of carp fry to 3000 - 4000/feddan.

The production of mullets in the Manazalah fish farm is rather low when compared with other experiments on mullet culture in brackish waters. The production of mullet in the ponds of the Phillipines averaged 336 kg/ha (Carbine, 1948). However, in the slightly brackish waters of Hong Kong, the average production of mullet was 1500 kg/ha, besides other fishes, (Hora and Pillay, 1962).

The production of mullets and other fishes in Manzalah fish farm can be significantly raised through the proper management. This farm has been neglected for several years and due to evaporation, salinity increased in the ponds and fluctuated between 7 % and 16 % However, at present the ponds receive a fresh water supply from El-Twabra canal and thus the salinity is expected to drop to 1 % within one or two years at the most. The introduction of carp in a mixed culture with mullet and following the above proposed stocking rate for the Serow farm would give a better yield. In this respect, the use of fertilizers and a regular scheme of supplementary feeding are essential.

SUMMARY

Experimental studies were carried out on rearing two mullet species, *M. cephalus* and *M. capito* in two Egyptian farms, Manzalah of brackish water and Serow of freshwater. Mullet fry were collected from the Mex-tunnel and transported into the experimental ponds. In the Serow farm, a mixed-culture of *M. capito* and *C. carpio* at three stocking rates was followed : (a) 8000 *M. carpio* and 3000 *C. carpio* fry/faddan ; (b) 8000 *M. capito* and 7000 *C. carpio* fry/faddan; and (c) 6000 *M. capito* and 3000 *C. carpio* fry/faddan. The average weight of *M. capito* fry was 0.05 g and stocked during April 1970, and the average weight of carp fry was 1 g and stocked during May 1970. The rearing period was 300 days for *M. capito* and 270 days for *C. carpio*. At the end of the rearing period the ponds were drained and the fish were collected and sorted out to the different species.

In *Manzalah* ponds, five stocking rates were followed: a) 5300 *M. cephalus* fry/faddan; b) 600 *M. cephaalus* and 600 *M. capito* fry/faddan; c) 500 *M. cephalus* and 1250 *M. capito* fry/faddan; d) 500 *M. cephalus* and 2150 *M. capito* fry/faddan; and e) 900 *M. cephalus* and 3650 *M. capito* fry/faddan. *M. cephalus* fry, of an average weight of 0.1 g were stocked during November 1969, and *M. capito* fry were of an average weight of 0.05 g and stocked during April 1970. The rearing period was 400 days for *M. cephalus* and 300 days for *M. capito*.

The results showed that the growth rate of *M. capito* reared in the Serow farm is higher than that reared in Manzalah ponds. In the first two months, the gain in weight was rather low, 0.2 g/fish/days, thereafter the fish gained an average of 0.73 g/fish/day. From the end of November 1970 to January 1971 (60 days) the fish lost an average of 6.8 % of its weight. It is recommended to harvest the fish in Serow ponds not later than the first week of December.

The average percentage survival of *M. capito* of Serow farm was relatively low, 18.5 %. This was partially attributed to the differences in salinity between the Mex-canal water, from which the fry were collected and that the Serow ponds; and to the presence of predacious fishes. Conditioning of the fry before being transported is recommended. The average survival rate of carp was high, 85 %.

The growth rate of *M. cephalus* in Manzalah was approximately twice that of *M. capito* in the same farm. The absolute gain in weight was low during the first five months after stocking (from December to April), while thereafter the fish gained weight rapidly at an average of 0.9 g/fish/day. The gain in weight for *M. capito* was low (0.17 g/fish/day) during the first two months after stocking (May and June), thereafter the fish gained weight at an average of 0.4 g/fish/day. Stocking rates showed an obvious effect on the gain/fish.

The survival rate of both *M. cephalus and M. capito* in Manazalah ponds was relatively low ; the percent loss of *M. cephalus averaged* 87.7 and that of *M. capito* averaged 74.8%. The high mortalities are attributed mainly to the presence of large numbers of the predacious fish, *Lates* spp. ; and to the change in water salinity of the ponds.

The length-weight relationship was calculated for the reared fishes. The obtained exponents of length of *M. cephalus* (Manzalah) and *M. capito* (Serow) were higher than those for mullets found in natural habitat. The equations were :

M. cephalus (Manzalah) : Log W = —4.9270 + 2.9998 Log L

M. capito (Manzalah) : Log W = —4.2368 + 2.6675 Log L

M. capito (Serow) : Log W = —5.1427 + 3.0623 Log L

The calculated condition factor for the reared *M. cephalus* and *M. capito* were higher than that recorded for these species in the natural habitat.

The production of fish at Serow was obtained from the stocking rate of 8000 *M. capito* and 7000 carp fry/faddan, as an average of 996 kg/faddan, of which mullet constituted 20.5% of the catch (205 kg/faddan). The only disadavantage of this stocking rate was the production of large numbers of under-sized carp. It is recomended to reduce the number of the stocked carp fry to 3000-4000 fry/faddan. The filtrated fishes, *Tilapia* sp. constituted an average of 23 kg/faddan.

The production of *M. cephalus* in Manzalah was 101 kg/faddan when stocked at a rate of 5300 fry/faddan, but the average size of the fish was rather low. The highest average size fish of both *M. cephalus* and *M. capito* was obtained at a stocking rate of 520 *M. cephalus* and 1250 *M. capito* fry/faddan. At higher stocking rates the yield was low and ranged from 44 to 50 kg/faddan. The filtrated fishes were mainly *Tilapia* spp. and and *Lates* spp.

REFERENCES

BECKMAN, W.C. 1946.—The length-weight relationship, factors for conversions between standard and total lengths, coefficients of condition for seven Michigan fishes. Trans. Am. Fish. Soc. 75 : 237-256.

BISHARA, N.F. 1967.—A study on growth and feeding of two species of Mugil at the Mex Experimental Station. M.Sc. Thesis, Alexandria University, 116 pp.

BORGOSTROM, G. 1961.—Fish as Food. Vol. I, Academic Press, New york and London.

BRETT, J.R. ; SHELBOURN, J.E. and SHOOP, C.T. 1969.—Growth rate and body composition of fingerling sockeye salmon *Onchorhynchus nerka*, in relation to temperature and ration size. J. Fish. Res. Bd. Canada 26 : 2363-2394.

BROWN, M.E. 1957.—Experimental studies on growth *In* Physiology of Fishes (Edt. M.E. Brown) Vol. 1, Chapter IX : 361-400. Academic Press Inc., New York.

CARBINE, W.F. 1948.—Bangos elture in the Philippines. Progr. Fish Cult., 10 (4) : 187-197.

DREWS, R.A. 1961.—Raising fish for food in Southeast Asia. *In* Fish as Food (G. Borgostrom, edt.) Chapter 5 : 121-143. Academic Press, New York and London.

EISSAWY, A.M. ; ABDEL MALEK, S.A HAMZA, A. and EL BELBASY, M.F. 1974 a.—Improvement of transporting method of fish larvae in A.R.E. Bull. Inst. Ocean. Fish A.R.E (in press).

EISSAWY, A.M. ; ABDEL MALEK, S.A. and HAMZA, A. 1974 b.—Food and feeding habits of three species of Mugilidae reared in Egyptian fish farms. Bull. Inst. Ocean. Fish. A.R.E (in press).

EL ZARKA, S. and KAMEL, F. 1965.—Mullet fry transplantation and contribution of the inland brackish lakes in Egyt, U.A.R. Proc. Gen Fish. Coun. Medit., No. 24 : 209-226.

EL-ZARKA, S. and FAHMY, F.K. 1966.—Experiments on the culture of the grey mullet, *Mugil cephalus* in brackish water ponds in the U.A.R. FAO Fisheries Reports No. 44, 5 : 255-266.

EL-SEDFY, H.M.H. 1971.—A biological study of the mullet fishery in Lake Borollus. M. Sc. Thesis, University of Alexandria 165 pp.

FAOUZI, H. 1936.—Successful stocking of lake Quarn with mullet. Intern. Rev. Gesamten Hydrob. v. Hydrogr., 33.

FAOUZI, H. 1937.—Quelques aspects de la biologie des Muges en Egypte. Cons. Pern. Int., Mer. Medit., Rapp. Proc.-Verb. XI : 63-68.

GANAPATI, S.V. and ALIKUNHI, K.H. 1952.—Experiments on the acclimatization of saltwater fish seed to freshwater. Proc. Indian Acad. Sci., 35 : 93-109.

GUHA, B.C. 1962.—The role of fish in human nutrition *in* Fish in Nutrition (E. Heen and R. Kreuzer, edts) 39-42, Fishing News (Books) LTD, England.

HICKLING, C.F. 1962.—Fish Culture, Faber and Faber, London 295 pp.

HORA, S.L. and PILLAY, T.V.R. 1962.—Handbook on fish culture in the Indo-Pacific Region. FAO Fish tech pap. (14) 204 pp.

HOTTA, H. 1955.—On the matudo Mugilid fishes from Kabashima, Nagasaki Pref. Japan. J. Ichthyology, 4 : 162–169. (In Japanese, With English summary).

LE CREN, E.D. 1951.—The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*) Jour. Animal Ecol., 20 (2) : 201–219.

PAGET, G.W. 1922.—On the spawning period and rate of growth of Bouri (**M. *cephalus***) and Tobar (***M. capito***) with a note on the age composition of the Manzalah catch. Rep. Fish Serv. Egypt, for 1921, Cairo Government Press pp. (28–32).

PAGET, G.W. 1923.—The determination of the rate of growth of Bouri (***Mugil cephalus* L.**) in lake Mariut. ***In*** Report on the Fisheries of Egypt for the year 1922. Cairo Government Presses, pp. **43–49.**

PILLAY, T.V.R. 1966.—Proceeding of the World Symposium on warm-water pond fish culture. FAO Fisheries Reports No. 44, Vol. I.

SCHAPERCLAUS, W. 1933.—Textbook of pond culture, U.S. Fish Wildl. Ser., Fish. Leaflet 311 260 pp.

SWIFT, D.R. 1961.—The annual growth rate in brown trout (*Salmo trutta* Linn) and its cause. J. Exptl. Biol. 38 : 595–604.

SWINGLE, H.S. 1966.—Biological means of increasing productivity in ponds FAO Fisheries Reports No. 44, 4 : 243–257.

TAMURA, T. 1961.—Carp culture in Japan In Fish as Food (Edt. G. Borgostrom) Vol. I, Chapter 4 : 103–120.

WIMPENNY, R.S. 1932.—Observations on the size and growth of two Egyptian mullets, ***Mugil cephalus*** L. and ***Mugil capito*** Cuv. Coastguards and Fisheries Service, Cairo.

WIMPENNY, R.S. 1934.—An analysis of arabian seine net hauls on the sea coast near Ashtoum El-Gameel, August 1928 to to May 1929. Coastguards and Fisheries Service, Cairo. Notes and Memoires No. 2.

YASHOUV, A. 1966.—Mixed culture - An ecological approach to increase productivity. FAO Fisheries Reports No. 44, 4 : 258–273.