1.—INTRODUCTION

Lake Quarun is in the lowest part of the Fayoum depression located in the Western Desert, 83 kilometers S.S.W. of Cairo (Fig. 1). This lake has an area of about 53,000 acres and a maximum depth of 8 m. However, most of the lake is less than 6 m.

Lake Quarun represents the remnant of Lake Moeris and has undergone pronounced ecological changes which affected its fauna and flora. In ancient times, when this lake was used as a resrvoir for the Nile flood it was probably inhabited by most of the species of Nile fishes (Faouzi, 1936). Since it became a drainage reservoir for the Fayoum irrigation system, the amount of fresh water which reaches it from the Nile has been greatly reduced. It now receives only brackish drainage water (Gorgy, 1959). The salinity has changed as follows : 11. 6 p.p.m. in 1920, 17.19 p.p.m in 1930, 22.4 p.p.m in 1932 and 23.4 p.p.m in 1934. At present the salinity varies between 17.45 p.p.m and 29.43 according to the distance from the drainage canals. The average air temperature at 2 p.m. varied from 17.6 C°in January to 31.9°C in August. The rate of evaporation for the year of 1950 ranged from 11.6 mm in December to 282.9 mm in June and the total evaporation for that year was 1,873.3 mm (Gorgy, 1959).

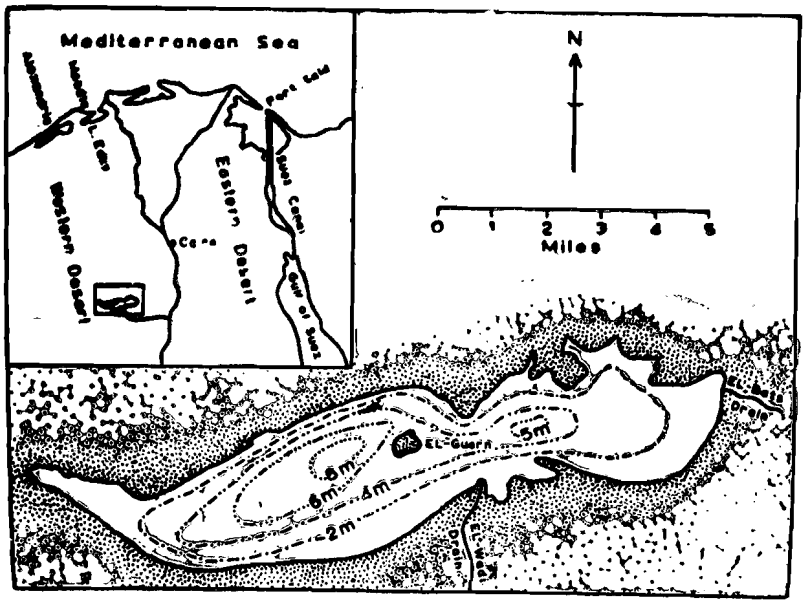

FIG.—1.—Map of Lake Quarun,

The salinity increase has directly affected the fresh water fishes which were of Nile origin. The principal species were *Lates niloticus, Clarias lazera, Labeo niloticus, Barbus bynni* and *Tilapia* spp. Remnants of these with the exception of

Tilapia nilotica were listed in the 1935 citation report on the fisheries of Egypt. *Tilapia zillii* is the only one left of the original species. It is the dominant fish in the lake and contributes the most weight of the fishery. *Tilapia nilotica* on the other hand is rarely found in the catch. Only 150 specimens appeared in the samples collected from May, 1958 to June, 1959 (El-Zarka, 1961).

2.—RESTOCKING WITH MEDITERRANEAN FISHES

To compensate for the loss of fresh water fishes, the Institute of Hydrobiology and Fisheries Research stocked the lake with Mediterranean fishes including *Solea vulgaris* and *Mugil* sps. The first lot of fry was planted in 1928 and stocking was continued each year thereafter. The introduction was so succes sful that in 1935 the yield from Mullet alone reached 341,726 kg (Faouzi, 1936). The increase in adult *Mugil capito* in 1934 and 1935 was due to natural productin (Wimpenny & Faouzi, 1935.).

Wimpenny (1936) described the ova and Larvae of *Mugil capito* which is found in a plankton haul from the lake. However, investigations carried out since 1958 show *Mugil capito* to be rare in the catch. *Mugil saliens* is the dominant species of Mugilidae with *Mugil cephalus* next in importance. The lack of *Mugil caipto* in the lake may be explained by one or more of the following:

1.—Unfavourable conditions prevented spawning in recent years.

2.—The eggs and larvae described by Wimpenny and Faouzi (1935) and Wimpenny (1936) as *Mugil capito* may have been identified incorrectly. Recent correspondence with Wimpenny shows that he was not satisfied with vertebral counts of *Mugil capito* larvae. The number of vertebrae exceeded that expected for this species.

3.—The increase of *Mugil saliens* fry resulted from recent more favourable salinities for the development of this species.

The present paper is confined to the study of the fishery of *Mugil saliens* and its biological aspects. Such biological information will be needed for the proper management of the fishery.

3.—COMMERCIAL CATCH OF MUGIL SALIENS

The usual gear used in the commercial fishery was the gill net (26 mesh/50 cm). Nets were usually 100 cm in depth and varied in length from 25 to 50 m. Two men generally operated one net from one boat. These single layer nets are well adapted to catch the larger *Mugil saliens* (14 cm length minimum length).

Fishing for this species goes on throughout the year except for June and July when the season is closed. Fishing is most productive on dark nights when there is little or no moon light and the largest catches were made in November and December with 84,448 kg and 89,927 kg respectively. About 90% of the total

catch is taken near the north shore where the bottom of the lake is sandy due to wind action. The lowest catches were in May with 4,297 kg when *Tilapia* fishing is at its best. The total catch of *Mugil saliens* for the period from August, 1961 to May, 1962 (10 months) was 334,950 kg. This is 13.6% of the toal yield for the lake (Table 1).

4.—DISCOVERY OF MUGIL SALIENS FRY

Mugil saliens shows changes in gonad development not found in *Mugil cephalus* or *Mugil capito*. In all three of these species the ovaries become ripe at the beginning of the spawning season but only in *Mugil saliens* do the ovaries appear spent after spawning is over (El-Zarka, 1963).

Mugil fry were found in December, 1961 during experiments on *Atherina* and this was during a period when no fry had been stocked from the Mex farm near Alexandria. A large number of fry were taken December 30, 1961, near the inlet from the Saeed drain (Fig. 2). The net used was a special beach seine (100 mesh/50 cm) about 100 meters long and 2 meters deep. It was hung so as to float from the surface when in use. The fry taken were identified as *Mugil saliens* using the characteristic shape of the pyloric caeca and no other species of Mugil fry were found (El-Zarka, 1963). They averaged 56 mm in total length and ranged from 50 to 70 mm. It would appear that *Mugil saliens* is the only species of the Mugilidae that can successfully reproduce in lake Quarun. Fry were concentrated near the mouths of the drains where salinities were lowest at first and after reaching about 80–100 mm they distributed themselves throughout the lake.

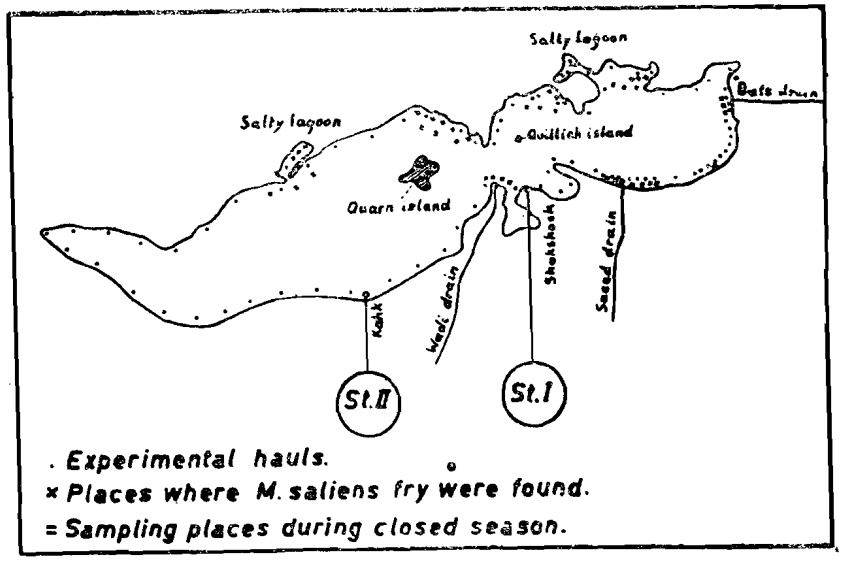

FIG. 2.—Distribution of *Mugil saliens* fry in the different regions of Lake Quarun.

5.—MATERIAL AND METHODS USED IN THE STUDY OF THE FISHERIES OF MUGIL SALIENS

Monthly collections were made from the commercial catches of two stations from August, 1961 to May, 1962. The station at Shakshouk represents the eastern part of the lake and the one at Kahk the western part (Fig. 2).

TABLE 1.—MONTHLY COMMERCIAL CATCH OF *Mugil saliens* FROM LAKE QUARUN (1961 - 1962).

Month	Mugil saliens		Total yield (all species) (kg)
	Catch (kg)	Percentage of the Total	
August 1961	12,206	3,22	378,643
September	12,624	3.94	319,833
October	39,403	12.58	313,278
November	84,448	26.2	322,846
December	89,927	27.7	324,470
January 1962	46,690	16.4	283.879
February	20,986	10.3	204,375
March	13,777	11.2	124,963
April	10,232	11.1	91,381
May	4,297	4.4	97,362
TOTAL	334,590	13.6	2,461,032

Total lengths were taken to the nearest millimter and weights to the nearest gram. Scales were taken from the area below and behind the pectoral fin. Age and growth determinations were based on the examination of scales from 628 fish. Scales were cleaned in a 10% solution of Ammonia and were mounted between two glass slides. They were then examined under a binocular microscope at a magnification of 10x.

During June and July, which is the closed season, samples were taken from the same areas used during the open season, however, trammel nets of the same mesh were used instead of gill nets. Fig. (2) shows the collecting statoins in June and July.

6.—AGE COMPOSITION

The age composition studied was based on the commercial catch of the lake. The age composition from month to month reflects the intensity of fishing and its effect on the fish stock. The percentage of occurrence in each age group for monthly collection are shown in Fig. 3.

Fishes in each age group were not exactly one year old; but were in age group I plus the current season growth which depended on the time of capture. It is a common pratice in age growth studies to place fish in the next higher age group in January (Hile, 1948; El-Zarka, 1959). However, we hesitate to add one year on our fish because of the extended spawning period. Moreover, the full season's growth in lake Quarun was attained by September and it was found more convenient to move the age of fish to the next higher age group in September instead of January (El-Zarka, 1960).

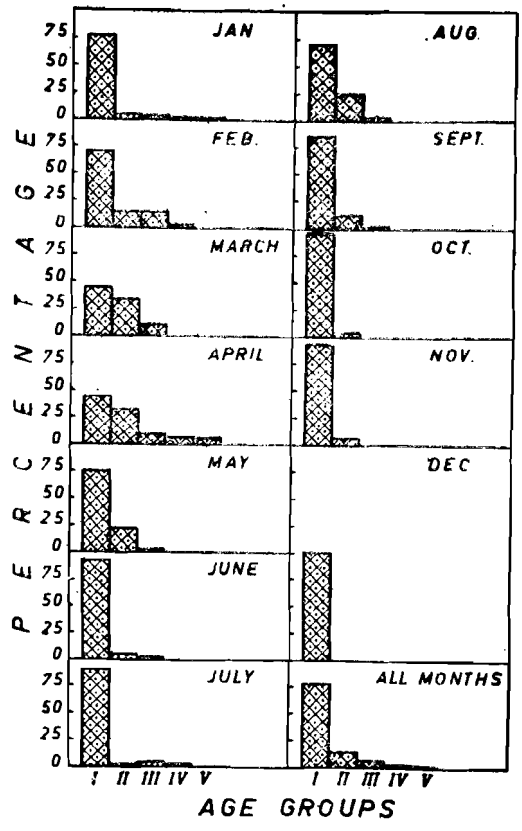

FIG. 3.—Age composition of *Mugil saliens* on different dates of capture.

The commercial catch was dominated by age group I (78.4%). Fishes of age group II were also present in appreciable amounts constituting 14% of the catch. Older age groups (groups III, IV and V) had not constituted more than 7.6% of the examined samples.

Information on the seasonal fluctuation in age composition indicated that age groups I and II dominate the catch in practically all the months. Age group III was absent from the samples of October, November and December. As regards the groups IV and V, they were only found among the catches of January, February and April. The presence of some of the old fishes in the samples of January and February was due to the action of the specially designed nets for catching *Mugil cephalus* and *Mugil capito*. These nets fish only in the deep waters and some of the older *Mugil saliens* might have been caught together with the mullet species.

7.—SIZE DISTRIBUTION

The size distribution of *Mugil saliens* from Lake Quarun was based on monthly collection from the commercial catch. These covered a period of 10 months. Sexes were combined because no distinct differences in length were observed.

The usual length was between 160 and 180 mm with a range of 140 to 250 mm (Fig. 4). The intensive fishing during the season and the reduction of mesh size of the gill nets caused a drop in average length from 186 mm in November to 174 mm in December and to 165 mm in January.

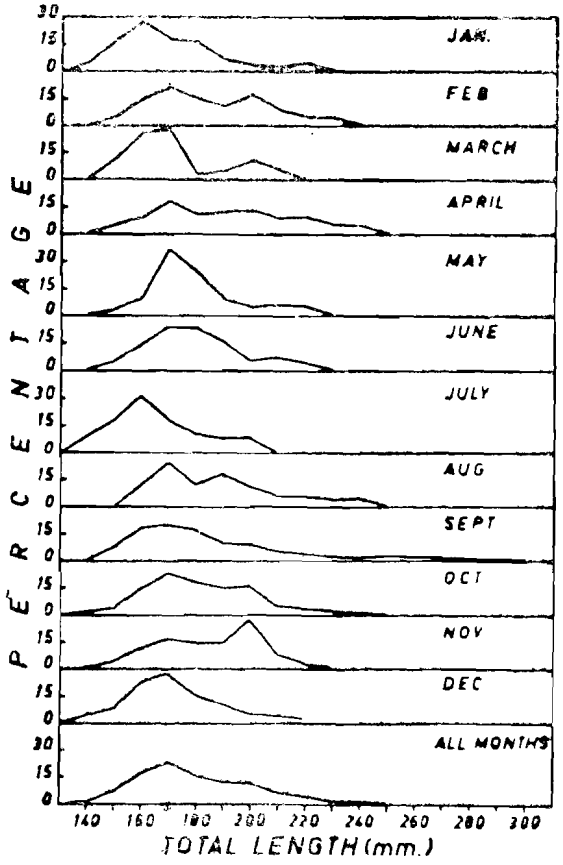

FIG. 4.—Length frequency distribution of *Mugil saliens* on different dates of capture.

TABLE 2.—LENGTH FREQUENCY DISTRIBUTION OF *Mugil saliens* ACCORDGING TO AGE GROUPS

Total length (mm)	Number of Fishes in age Groups										Grand Total		
	I		II		III		IV		V		M	F	Both
	M	F	M	F	M	F	M	F	M	F			
130	1										1	—	1
140	2	4									2	4	6
150	20	6									20	6	26
160	53	25									53	25	78
170	44	52									44	52	96
180	38	57									38	57	95
190	21	52	1	1							22	53	75
200	22	35	3	2							25	37	62
210	5	12	7	9							12	21	33
220			12	21							12	21	33
230			5	9							5	9	14
240			6	8	2	3					8	11	19
250			2	3	4	10					6	13	19
260					4	5					4	5	9
270					1	4	1	2			2	6	8
280					1	1		2			1	3	4
290						1		1		1	—	3	3
300							1			1	1	1	2
310										1	—	1	1
340										1	—	1	1
Total Number	206	243	36	53	12	24	2	5		4	256	329	585
Av. Length	173	181	221	223	257	257	300	295		305	183	182	181

The high catch of large *Mugil* in November and before that in August, September and October, yields a drop in length at Janaury. The reduction in the average size disappear after that because of the concentration of fishing on other species.

Net selectivity affected the average size of the fish taken. The gill net used in Lake Quarun takes fish mostly over the minimum legal length and limits the size distribution of the commercial catch. There is a much greater range in length of the fish taken in trammel nets of similar mesh size.

7.1—Length frequency according to age :

Sexes were kept separate in the study of age and growth. Although there was little difference which could be attributed to sex, length ranged between 150 and 340 mm for all fish. The size ranged between 130 and 210 mm in age group I and 190 to 250 mm for age group II for both males and females. In age group III the length varied from 240 to 280 mm for the males and from 240 to 290 mm for the females. Fish in the first year of life can be easily separated from the other age groups but there is considerable overlapping of sizes for the older age groups (Taple 2).

8.—LENGTH-WEIGHT RELATIONSHIP

It is well known among fishery biologists that the weight increase as an exponential function of its length. The formula used is $W = c L^n$ where W = the weight in grams, L = the length in millimeters, c and n are constants whose values were computed by the logarithm of the total lengths and weights. The computation of these constants give the following equation :

TABLE 3.—LENGTH - WEIGHT RELATIONSHIP OF *Mugil saliens* (1961–1962)

Total length (mm)	Empirical Weight (gram)						Calculated weight (gm)
	Male	weight	Female	weight	Both Sexes	weight	
130	1	21	—	—	1	21	19.4
140	4	28	2	25	6	27	23.8
150	22	28	5	29	27	28	28.8
160	60	33	26	34	86	33	34.5
170	51	34	61	41	102	38	40.8
180	39	43	59	46	98	45	47.8
190	24	51	58	53	82	52	55.5
200	23	62	41	62	64	62	64
210	16	70	23	76	39	73	73.2
220	13	80	22	85	35	82	83.3
230	6	86	10	96	16	91	94.2
240	9	100	13	108	22	104	106
250	7	124	14	102	21	113	118.7
260	4	149	5	134	9	142	132.3
270	2	165	6	163	8	164	147
280	1	175	3	156	4	166	162.5
290	—	—	3	168	3	188	179.1
300	2	195	1	169	3	182	196.7
310	—	—	1	225	1	225	215.5
340	—	—	1	280	1	280	278.5

$$\text{Log } W = -4.5700 + 2.7709 \log L$$

The determination of length-weight relationship of *Mugil saliens* in Lake Quarun was done by combining both sexes (Table 3).

The relation can be explained by the last equation which in return can be written in the form: $W = 2.6920 \times 10^{-5} L^{2.7709}$. There is a very close agreement between the empirical and calculated weight (Fig. 5). It has been found for many species that the weight increases as the cube of the total length and *Mugil saliens* is no exceptions. In fish with total lengths between 130 mm and 210 mm the rate is slightly less than the cube of the total length or about 2.8.

At greater lengths reached after the second year, the difference between the empirical and calculated weight shows an increase in weight seven times that of total length. Variations in the weight of fishes of the same length are shown in Fig. (6).

8.1—Seasonal variation in weight :

The trend in the seasonal variation of weight of *Mugil saliens* in Lake Quarun can best be shown for fishes of size group 150-200 mm total length. These selected size groups represent the largest percentage of the commercial catch of the fish. This method of handling the data will exclude the effect of the accidental presence of largest and smallest fishes (Fig. 7).

The average weight of fish had the tendency to increase progressively from February to May when it reached the maximum condition. Then a sharp decline in the average weight was observed in the period from June to October. The male lost 7.6 grams and the female 12.9 grams. A second improvement was noticed in November when the male added 6.7 grams to its weight and the female 5.7 grams. The rise and decline in the average weight of fish is affected to a certain degree by the condition of gonad. Periods in which the average weights of fish were heavier were periods when the gonads were ripe whereas periods of low average weights were those in which the gonads were either in the spent condition or in the process of maturation.

8.2—Variation of weight according to sex and condition of gonads :

The average weights of fish were noticed to vary according to their sex. When comparing the weights of males and females of the same size, the females were heavier than males in all months except in October and November. In these two months the males were slightly heavier than females by 2 and 3 grams for the two months respectively. In some other months (May and September) the males and females were nearly of the same weight (Fig 7).

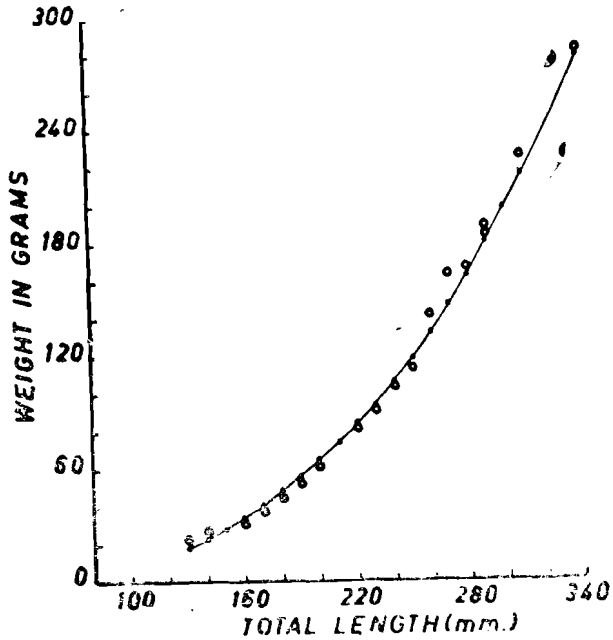

FIG. 5.—Length-weight relationship of *Mugil saliens*. Smooth line represents the calculated weights and circles represent empirical weights.

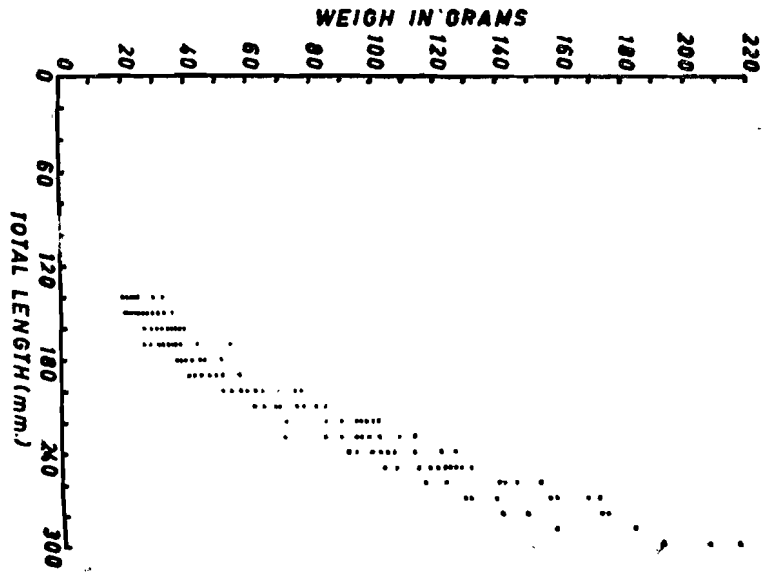

FIG. 6.—Variation in the weight of *Mugil saliens* according to their lengths.

As regards the variation of weight in relation to gonad condition, the data in Table 4 indicates a loss of weight between ripe and spent fishes. The percentage loss of weight of females at spawning varied between 3.6% to 20%. For the males the loss of weight was less and it varies between 3.8 and 10.7%. The average percentage loss of the whole sample was 10.8% for the females and 7.3% for the males. In certain size groups (total lengths 140, 130 and 170 mm) the males did not show any difference in their weight after spawning.

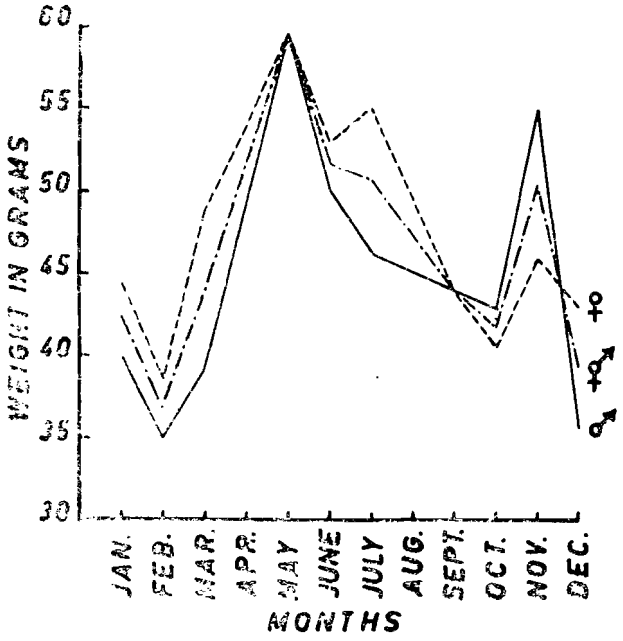

FIG. 7.—Monthly variation in the weight of *Mugil saliens* in the size range 150–200 mm total length.

9.—GROWTH CHARACTERISTIC

Although other structures such as vertebrae, spines and fins have been used satisfactorily for determining the age of fishes, the scales were the most satisfactory for *Mugil saliens*.

The use of annular rings for age determination and growth calculation were proved to be valid and an annulus is laid each year. Beside the true annuli, false and accessory rings were found on the scales causing some difficulty in aging the fish. The true and false annulii were differentiated according to the features adopted for aging *Tilapia zillii* from Lake Quarun (El-Zarka 1961).

TABLE 4.—WEIGHT DISTRIBUTION OF *Mugil saliens* ACCORDING TO SEX AND STATE OF MATURITY

Total length (mm)	Male				Loss or gain (gm)	Percentage	Female				Loss or gain (gm)	Percentage
	Ripe		Spent				Ripe		Spent			
	No.	Weight (gm)	No.	Weight (gm)			No.	Weight (gm)	No.	Weight (gm)		
140	2	25	2	25	0	0	3	28	1	25	— 3	—10.7
150	3	26	2	26	6	0	2	32	4	26	— 6	—18.7
160	17	26	13	25	—1	— 3.8	23	43	22	37	— 7	—16.3
170	24	27	24	27	0	0	36	55	37	44	—11	—20
180	13	37	16	35	—2	— 5.4	22	55	24	53	— 2	— 3.6
190	12	56	12	49	—6	—10.7	28	62	53	54	— 8	—12.9
200	10	77	13	71	—6	— 7.8	10	67	19	64	— 6	— 8.8
210	10	76	13	69	—7	— 9.2	18	72	15	69	— 3	— 4.2
220	5	82	13	77	—5	— 6.1	25	82	12	77	— 5	— 6.1
230	5	85	12	80	—5	— 5.9	10	103	12	94	— 9	— 8.7
240	8	96	13	90	—6	— 6.2	12	111	13	102	— 9	— 8.1
250	6	121	13	103	—13	—10.7	10	117	13	103	—14	—12.0
Total No. of Fish and Average	117		146			7.3	204		195			10.8

9.1—Time of Annulus formation :

Scales collected in the latter half of March showed an annulus and a narrow band of growth beyond which averaged 11 mm in width. All scales collected from fish in April showed a new annulus. New growth beyond the annulus in fish of age group I averaged 13 mm for the males and 14 mm for females. In age group II this growth was about 8 mm for males and 4 mm for females. Ths situation was not so easily derived in older fish since no new annulus was discernible in some but present in others. However, it is presumed that a new annulus is immanent for those not having it (Table 5, Fig. 8). El-Zarka (1956) showed that prolonged spawning period of *Tilapia zillii* Gerv. in Lake Quarun had no effect on the time of annulus formation.

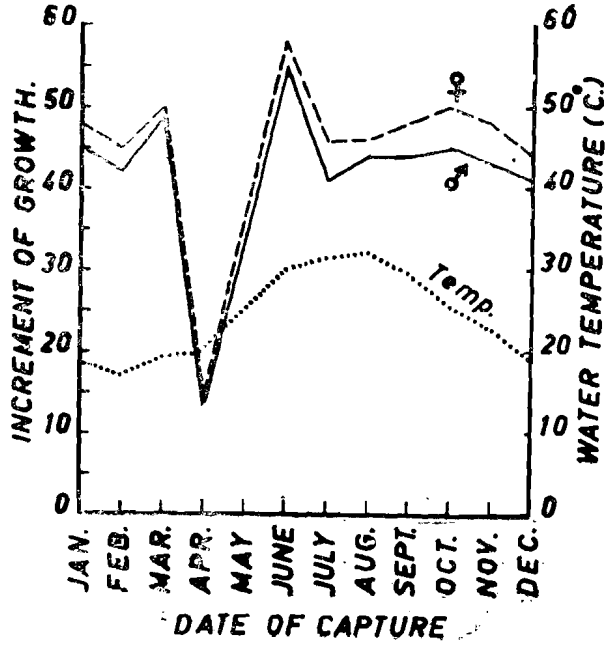

FIG. 8.—Average increment of growth completed at different dates of caputre for fishes of age group I.

All samples of all the ages taken after April had distinct annuli near scale margin. The growth increment for May was about 34 mm for males and 36 mm for females. In June the growth increment was greatest reaching 55 mm for males and 58 mm for females of age group I. In age group II the increment was 51 mm for males and 60 mm for females. Between June and the following March the growth increment averaged about 46 mm for males and 48 mm for females in age group I and 37 mm for males and 39 mm for females in age group II. It is thus apparent that the full season's growth flor *Mugil saliens* in Lake Quarun was attained in June and the annulus was formed on the scales in March.

TABLE 5.—AVERAGE INCREMENT OF GROWTH OF *Mugil saliens* OF AGE GROUPS I AND II, COMPLETED AT DIFFERENT DATES OF CAPTURE

Month	Water Temperature °C	Age group I				Age group II			
		Male		Female		Male		Female	
		Number	Increment mm	Number	Increment (mm)	Number	Increment (mm)	Number	Increment (mm)
January	18.5	17	45	21	48	2	38	2	45
February	17.6	21	42	24	45	2	30	7	33
March	19.6	9	49	6	50	3	44	—	—
April	20.9	12	13	10	14	7	8	9	9
May	25.2	17	34	17	36	4	29	6	30
June	30.4	19	55	16	58	1	51	7	60
July	31.5	13	41	27	46	—	—	1	30
August	31.9	8	44	26	46	1	37	13	32
September	29.5	29	44	10	48	3	38	3	39
October	26.1	31	45	12	50	—	—	2	38
November	22.8	18	43	49	48	1	37	4	43
December	18.7	15	41	22	44	—	—	—	—
Total Number of Fish		214		240		29		54	

The time of annulus formation and the progressive increase of growth beyond the last annulus was affected to a more or less degree by water temperature (Table 5). The percentage increase of growth was only 23.9 and 28.2% in March and April when the water temprature was 19.6 and 20.9°C respectively. In May, as the water temperature rose to 25.2°C the fish gained the maximum amount of its season's growth (50%). In June, although the temperature increased to 30.4°C, the fish added 29.1% of its annual growth completing the full season's growth. The rise of water temperature after that did not have any effect on the average annual growth increment. The sessation of growth with increase of water temperature was also observed when studying the growth of *Tilapia zillii* from Lake Quarun (El-Zarka, 1960). However, for *Tilapia zillii*, the active growth period extended from April to August in comparison to *Mugil saliens* which was from March to June.

9.2—Growth Calculation :

Scales from 585 fish were read and this was deemed adequate for the determination of the body - scale relationship. The graphical representation of the relation between body length and the scale radius is based on the data for the sexes combined (Fig. 9). The linear relation shown in Fig 9 gives the following equation : $L = 30.6 + 1.478\ S$ where L is the total length in millimeters and S is the magnified scale radius in millimeters.

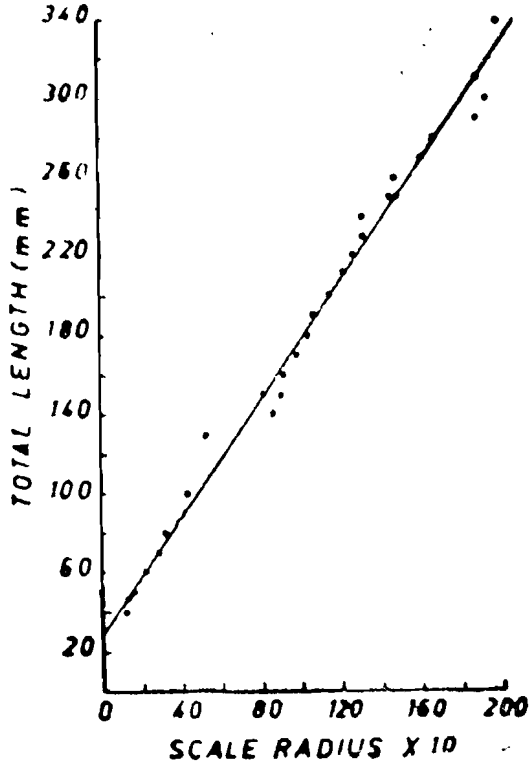

FIG. 9.—Relation between total length and scale radius of *Mugil saliens*.

The calculated lengths of *Mugil saliens* from Lake Quarun were computed by the following formula:

$$L_n = 30.6 + \frac{(L_t - 30.6)}{S_t} S_n$$

where L_n = calculated length at the end of n year.

L_t = total length at capture.

S_n = Scale radius to n annulus.

S_t = Total scale radius.

9.3—Growth in Length:

The average calculated lengths of males and females of *Mugil saliens* taken from the commercial catch from August, 1961 to July, 1962 are shown in Table (6). There are differences in calculated lengths of the various age groups especially in the first year group. Such differences have been discussed by many investigators (Van Oosten 1929, Jobes 1952, Smith 1956, El-Zarka 1959, 1961).

They attributed these differences to one or more of the following:

1.—Net selectivity.

2.—Selection due to segregation by sexual maturity.

3.—Natural mortality of fish with rapid growth.

Net selectivity hardly existed for *Mugil saliens* of Lake Quarun, because only one kind of net was used. The long spawning period of *Mugil saliens* greatly affects the length frequency for the first year. Two main length groups are present and cover a wide range of size which complicate the calculated lengths of the first year of life.

TABLE 6.—CALCULATED TOTAL LENGTH AT DIFFERENT YEARS OF LIFE OF *Mugil saliens*

(Increments in parentheses)

Age Group	No. of Fish	Calculated length (mm) at the end of the year				
		1	2	3	4	5
MALE :						
II	36	122	182 (60)	—	—	—
III	13	131	189 (58)	209 (20)	—	—
IV	1	112	166 (54)	207 (41)	234 (27)	—
V	1	104	181 (77)	220 (34)	267 (47)	300 (33)
Grand Average increment of growth	51	123	59	23	37	33
Sum of average increment		123	182	205	242	275
FEMALE:						
II	55	123	195 (59)	—	—	—
III	26	134	194 (60)	232 (38)	—	—
IV	3	108	160 (52)	218 (58)	267 (49)	—
V	1	116	189 (73)	231 (42)	272 (41)	308 (36)
Grand Average increment of length	83	125	89	40	40	36
Sum of Average increment		125	184	224	271	307

The fishery of *Mugil saliens* depended mainly on fish in their first and second years of life ranging in length from 13 to 21 cm. Older fish were rarely taken in the catch. A growth curve based on an average calculated lengths does not show the typical growth expected in fish population, because there were no or few older fish. To avoid such difficulty, the growth curve was based on the grand average annual increments of length (Fig. 10). This procedure was used by Hile and Jobes, 1941, 1942 ; Jobes, 1952 ; El-Zarka, 1959, 1961. Both sexes have about the same growth increment during their first and second years of life, then females were larger than the males. By the end of the third year, females were more than 17 mm larger than males. At the fourth and fifth years the difference was only 10 and 7 mm respectively. The maximum difference in growth increments between the males and females occurred during the third year of life.

9.4—Growth in Weight :

The calculated weights and annual weight increments of both sexes were derived from the length - weight equation $W = 2.6920 \times 10^{-5} (L^{2.7709})$. The calculated weights of the males and femles were nearly the same for the first year. Females increased 23.3 and 21.4 grams respectively in the second and third years as contrasted to males which showed 15.1 and 5.4 grams respectively. After the third year there was little difference in the weight increments of males and females (Fig. 11).

10.—MATURITY

The gonads of 248 males and 344 females of *Mugil saliens* over 12 cm in length were examined. Ripe gonads first occured in fish of about 13 cm and this means that spawning did not take place before fish passed their first winter. It was found that it was impossible to distinguish between the testes that were increasing in size preparatory to spawn and partly spent testes. In practice the field worker tend to classify the males as the condition of the females from the same catch. In studying the female gonad stages the following classes were recognized :

I.—*Immature*	: Sexes indistinguishable, gonads a colourless threads of tissue..
II.—*Mature*	: Ovary quite distinct, short, but plump, clear and glassy.
III.—*Moderately ripe*	: Individual ova indistiguishable by the naked eye. These may be immature or fish recovering from spawning.
IV.—*Nearly ripe*	: Ova round of variable size and easily seen with the naked eye. Colour varies from Pale yellow to yellow.
V.—*Ripe*	: Eggs are large and yellowish. They can be extended easily by slight pressure.
VI.—*Spent*	: Ova small and few, colour yellowish - orange, ovary flaccid and its tissue has a black tinge.

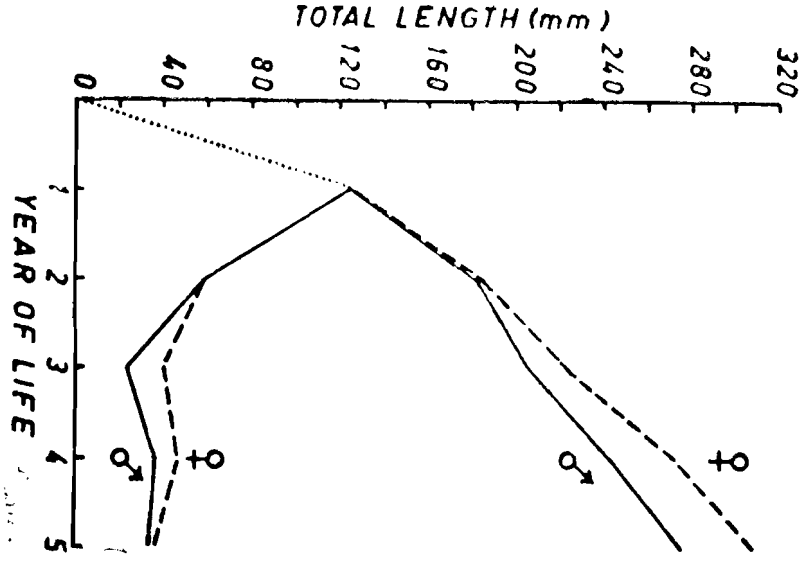

FIG. 10.—General growth in length and annual increments of *Mugil saliens* from lake Quarun.

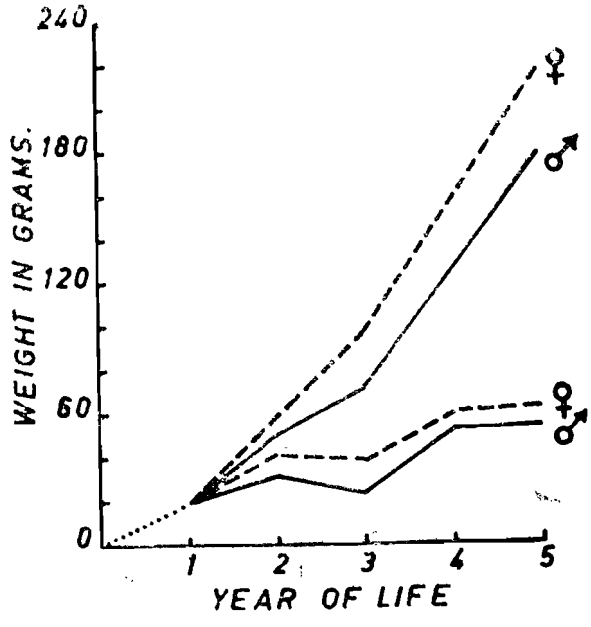

FIG. 11.—General growth in weight and annual increments of *Mugil saliens* from Lake Quarun.

10.1—Time of Spawning :

The first sign of ripe gonads were found in fishes of 13 cm, but spent testes were not detected in fish less than 15 cm. Two spawning periods take place each year in Lake Quarun. One occurs in the spring months (March-June) and the other in autumn (October - December). Samples colleted from August 1961 to July 1962 show that ripe fishes can be found throughout the year, but are most numerous in the summer. Thomson (1957) indicated that the breeding season of the yelloweye mullet was during the winter months, but he found some ripe fish throughout the year.

The condition of gonads for both males and females for different months of the year are shown in Fig. (12). Those with mature gonads in November made up 17.8%, this incresed to 69.5% in December and to 84% in January with slight decrease in February to 70.6%.

Fishes with advanced stages of maturity can be followed after that in the following months. In March, 97.9% of fish (sexes combined) had nearly ripe gonads. In April, all fish were in the ripe condition and ready for spawning, The percentages of the fishes with spent gonads increased from 67.8% in May to 86.2% in June and declined to 27.2% in July to 16.1% in September. This indicates that the peak of first spawning period was in June.

The second developmental stages of gonad maturation started in July, when the percentage of mature fish increased from 49.3% to 60% in August. In September, fishes with mature gonads were 16.9%, while those with nearly ripe gonads increased to 23.7%. In October and November the percentage of nearly ripe fish declined or disappeared while the percentage of fishes with ripe gonads increased to 78.8%and 55.8% respectively. Likewise, as the percentage of ripe fish started to decline in November and December, the percentage of spent fish increased to 53.7% and 20.2% respectively. This also indicates that the peak of the second spawning period was in November.

The ripening of *Mugil saliens* gonads seems to be controlled by water temperture. In January and February there was a change from 84% Mature fish to 70.6% when temperature were declining. In March, when the temperature of 19.6°C was reached, no mature fish were found. In August and September, the temperature was 31.9 and 29.5°C respectively and the percentage of mature fish decreased from 60% to 16.9% respectively.

The spawning of *Mugil saliens* is also affected by temperature. The two spawning periods take place at a minimum temperature of 20°C and an optimum of 30°C (Fig. 12). The preliminary work on *Mugil saliens* of the coastal lakes Borollos found spent fishes and ripe ones in the second half of December when the temperature reached 17.1°C.

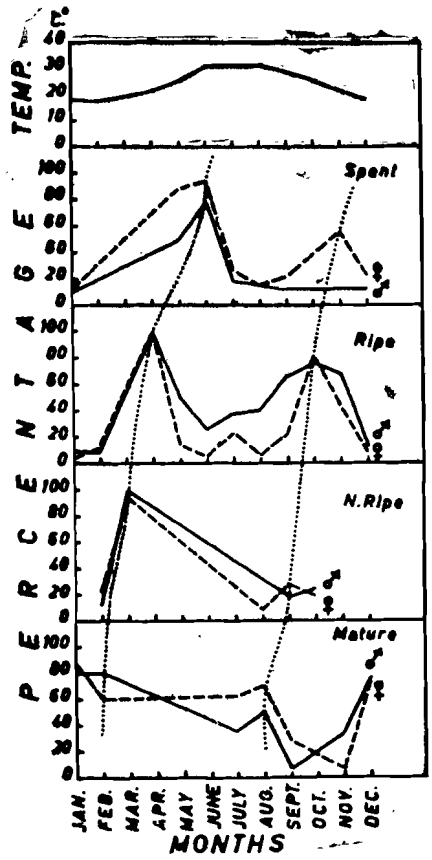

FIG. 12.—Stages of devlopment of gonad maturation of *Mugil saliens* from lake Quarun.

11.—SEX RATIO

Data suggests sex ratio for *344* females and 284 males or approximately *1.4* female for each male (Table 7). Sample taken from August 1961 to July 1962 show that those in March, September and October had more males than females. In other months, the females were dominant especially in August, November and July when the percentage of females were 80%, 71% and 66% respectively. The dominance of females is a common characteristic of Mugilidae. Thomson (1957) during his work on yelloweye mullet *Aldrichitta forsteri* (Cuv. and Val.) in Western Australia reached the same conclusion and gave a sex ratio of 1.2 female per male. Smith (1956) listed the following factors which might be responsible for sex composition :

1.—Segregation of the sexs through various periods of the year including segregation resulting from sex differences in age and size of maturity.

2.—Gear selectivity in relation to sex differences in activity and morphology.

3.—Differences in natural and fishing mortality between the sexes.

In Lake Quarun the higher percentage of females throughout the year and especially just previous to the breeding season may be due to their greater activity chance of their being captured. This would make them more vulnerable to capture.

TABLE 7.—SEX COMPOSITION OF *Mugil saliens* IN DIFFERENT MONTHS, EXPRESSED AS PERCENTAGE OF FEMALES (NUMBER OF FISH IN PARENTHESES, MALES AT LEFT, FEMALES AT RIGHT).

Month	No. of Fish	Percentage of females	Sex ratio
August–1961	50	80 (10–40)	4.0
September	51	27 (37–14)	0.38
October.	50	32 (34–16)	0.47
November.	76	71 (22–54)	2.45
December	39	56 (17–22)	1.20
January–1962	48	56 (21–27)	1.28
February	69	52 (31–38)	1.22
March	50	44 (28–22)	0.78
April	52	54 (24–28)	1.16
May	50	56 (22–28)	1.27
June	46	52 (22–24)	1.10
July	47	66 (16–31)	1.93
Total and Average.	628	55 (284–344)	1.45

12.—SUMMARY

— The salinity increase of lake Quarun has directly affected the fresh water fishes which were of Nile Origin.

— To compensate for the loss of fresh water fishes, the lake was stocked with Mediterranean fishes including *Solea vulgaris* and *Mugil* spp.

— Several members of the family Mugilidae (*Mugil cephalus, Mugil capito* and *Mugil saliens*) were transplanted. The first lot of fry was planted in 1928 and stocking was continued each year thereafter. Of the mullet species, only *Mugil saliens* was able to spawn in the lake.

— *Mugil saliens* fry were found in December, 1961, near the inlet of Saeed drain and this was during a period when no fry had been stocked from Mex farm near Alexandria.

— The total catch of *Mugil saliens* for the period from August, 1961 to May, 1962 was 334,950 kg which was 13.6% of the total yield for the lake. The largest catches were made in November and December with 84,448 kg and 89,927 kg respectively. The lowest catches were in May with 4,297 kg when *Tilapia* fishing is at its best.

— The age and growth studies were based on the examination of scales from 628 fish collected from the commercial catch in the period from August, 1961 to May, 1962.

— The commercial catch was dominated by age group I (78.4%). Fishes of age group II were also present in appreciable amounts constituting 14% of the catch. Older age groups (groups III, IV and V) had not constituted more than 7.6% of the examined samples.

— The total length of fish in the commercial catch was between 160 and 180 mm with a range of 140 to 250 mm (sexes combined). The size ranged between 130 and 210 mm in age group I and 190 to 250 mm for age group II. In age groups III the length varied from 240 to 280 mm for the males and from 240 to 290 mm for the females.

— The length - weight relationship is explained by the formula : $W=2.6920 \times 10^{-6} L^{2.7709}$ where W= weight in grams and L= total length in millimeters.

— The average weight of fish had the tendency to increase progressively from February to May when it reached the maximum condition. A sharp decline in the average weight was observed in the period from June to October.

— The females were heavier than males in all months except in October and November. The percentage loss of weight of females at spawning varied between 3.6% to 20% and for the males between 3.8% to 10%7%.

— The annulus was formed on the scales in March and the full season's growth was attained in June. The growth increment was greatest in June, reaching 55 mm for males and 58 mm for females of age group I. In age group II, the increment was 51 mm for males and 60 mm for females The time of annulus formation and the progressive increase of growth beyond the last annulus was affected to a more or less degree by water temperature.

— The calculated lengths of *Mugil saliens* were computed by the formula :

$$L_n = 30.6 + \frac{(L_t - 30.6)}{S_t} Sn$$

— The males and females have about the same growth increment during their first and second years of life, when females were larger than males. By the end of the third year, females were more than 17 mm larger than males. The maximum difference in growth increment between males and females occured during the third year of life.

— The calculated weights of males and females were nearly the same for the first year. Females increased 23.3 and 21.4 grams respectively in the second and third years as contrasted to males which showed 15.1 and 5.4 grams respectively.

— Two spawning periods for *Mugil saliens* were noticed to take place in lake Quarun : One in spring extending from March to June with a peak in June ; the other in autumn extending from October to December with a peak in November The two spawning periods take place at a minimum temperature of 20.0° Cand an optimum of 30°C'

— The sex ratio for *Mugil saliens* suggests a ratio of 1.4 female for each male. The females were dominant in all months except in March, September and October.

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