STUDIES ON SAURIDA UNDOSQUAMIS (RICHARDSON) FROM THE GULF OF SUEZ

Monthly Peculiarities of Gonads

BY

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I. INTRODUCTION

Fishes live under adverse ecological condition and they vary greatly in the character of their spawing. Thus, while some fishes lay their eggs in the summer, others spawn in winter. Moreover, some species have usually a short spawning season while this becomes longer in some others. Some female usually shed the eggs in a singie batch in the spawning season along one sexual cycle but still others deliver a number of batches (Kazansky, 1949, Latif, 1966, etc.)

Furthermore, fecundity designated as the number of eggs discharged in the oviparous species is variable in the different species as well as in the different populations living under diffferent environmental conditions or in different years (Nikolsky, 1965). Besides, the fecundity being a species peculiarity responsible for preservatior of species through the different years, we find that fecundity is closely connected with the characters of species. Thus, the species, guarding or protecting the eggs are less fecund than the species not doing so. In other words, the smaller is the degree of mortality of individuals of a species, the less is their fecundity. Among oviparous fishes, species laying pelagic eggs are more productive than those discharging demersal eggs. Besides, the extreme condition of protecting the eggs is found in the viviparous or ovovivivіparous eggs where few individuals are delivered.

It is well-kown that the different species of fishes attain sexual maturity at different ages. Thus, some fishes as the gobiids *Aphyra and Crystallogobius* mature before reaching an age of one year. The white sturgeon *Huso huso L* matures at at an age of 15 - 20 years. In between these two extremes, lie other species of fishes. Besides, the onset of sexual maturity of one and the same species varies from one region to another. Thus, the roach in Finland matures at an age of 5 - 6 years, in cetnral Europe at 4 - 5 years and in southern Europe, at 3 years (Nikolsky, 1963). Besides, the males and females of one species may become sexally mature at different agess. Thus, males reach sexual maturity at 14 years of age in *Acipenser fulvescens*, at 7 - 9 years in *A. sturio*, at 8 - 14 years in *A. guldenstadii*, at 3 - 7 years in *A. baeri* and at 12 - 14 years in *Huso huso*. The females of these species attain sexual maturity at ages of 23, 13 - 20, 12 - 14, 5 - 12 and 16 - 18 years respectively (Roussow, 1957). These data. besides, refer to the fact that the species of one genus may be sexually mature at different ages.

The present work represents our third contribution on the biology of *Saurida undosquamis* (Richardson) from the Gulf of Suez and entails macroscopic peculiarities of the gonads of both males and females along different months.

II. MATERIALS AND METHODS

Samples of *Saurida undosquamis* were collected from the commercial catch landed at the Suez fish receiving center or on board the trawlers during their fishing trips. At least 100 specimens were examined monthly and from September 1965 up to 200 or 300 specimens were examined monthly. Standard and total lengths (cm.) weight (gm.), date and region of of capture were recorded. After opening the abdominal cavity, the sex was identified, gonad extirpated and then weighed. The gonad index is computed as percentage weight of the gonad to that of the body. The maturity stages of the gonads were sorted out according to Hjort's description (1910). Scales were adopted for age determination.

For studing the fecundity, the ovaries in general were removed intact from the abdominal cavity and preserved in 10 % formalin or aqueous Bouin. Egg counts were based on gravimetric method. For this purpose, the weight of the preserved ovaries of both sides was recorded. Afterwards, 3 specimens representing the different parts of ovary were taken and weighed. The eggs of these specimens were stripped by the help of a curved dissecting needle or camel-hair brush. Due to the variation in the size of the yolky eggs, they were assorted into two groups, of which the first includes the largest eggs, while the second included the smaller and subsequent generations of eggs. In most instances, eggs count of the first group was carried out by the naked eye while for the latter egg count was undertaken by the help of a binocular microscope. Egg diameter was measured by an ocular micrometer.

III. OBSERVATIONS

1. *Monthly Frequency of Maturity Stages*

In general, towards the spawning season, the gonads, in both males and females, increase in size whereby the so-called mature gonads are formed in advance to the spawning season. The mature eggs on the presence of the factors suitable for spawning (e.g. temperature, suitable ground, presence of the other sex, ...etc.) become ripened, ovulated and then discharged into surrounding medium in the oviparous species.

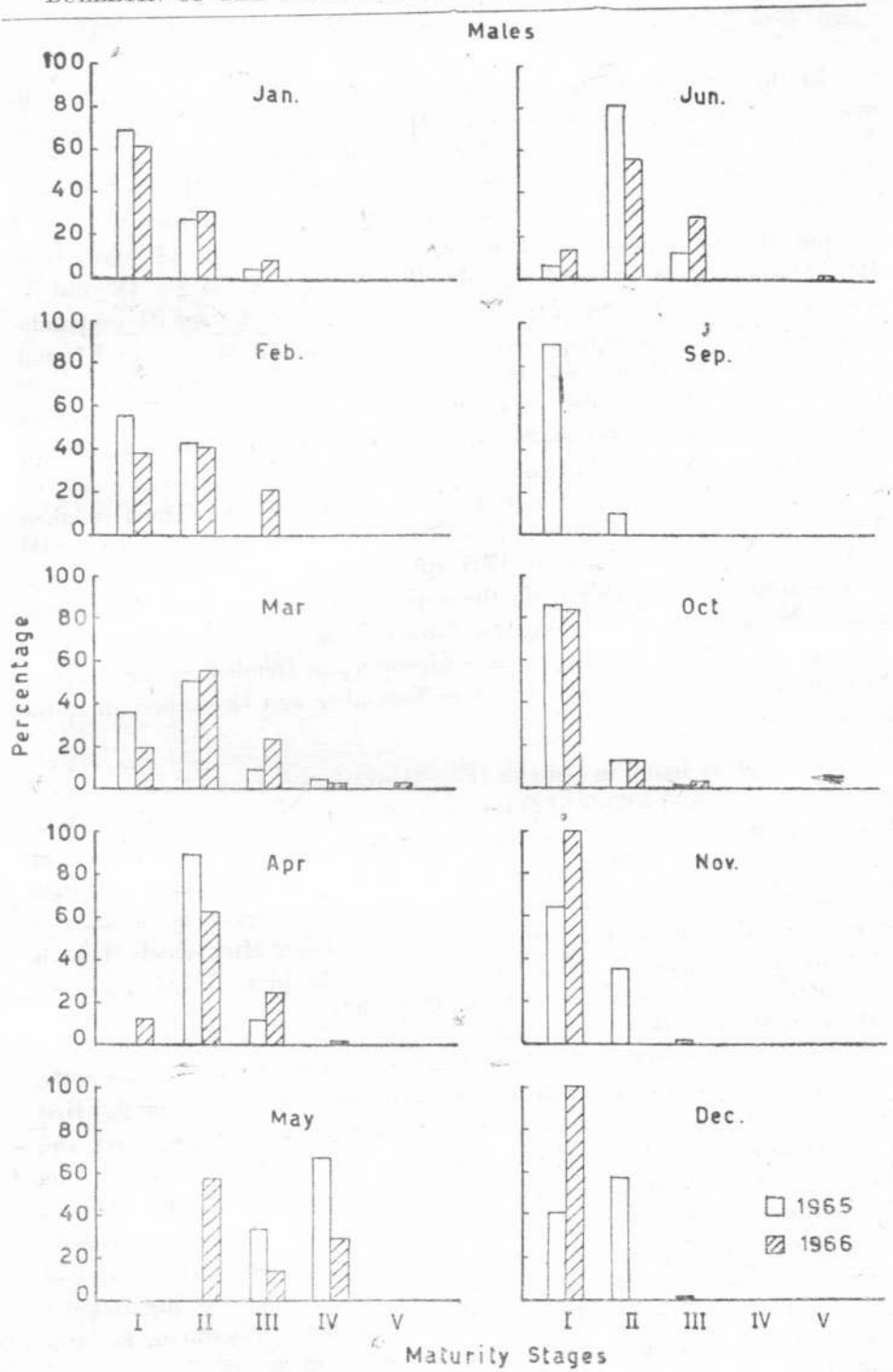

FIG. 1. Monthly frequency of maturity stages of testis

In the present study, the conditions of the gonads in the different months were followed by applying the Hjort-scale (1910) of maturity stages. In males (Fig.1) most testes belonged - in January - to stage I, while those of stage II are much less frequent. Testes of stage III are very few. In February, there is a decrease in frequency of representation of stage I accompanied by an increase in the percentage of the testes of stages II & III. The same can be said for March but testes of stages IV and V, although few, can be distinguished. In April, testes of stage II preponderate and stage III is represented to a less extent. In May, stage I is not represented, stage II may or may not be represented, stage III and IV are more common than in the preceding month and in 1965 about 66% of testes belong to the latter stage. In June, testes of stage II preponderate, those of stage III occur but to a less degree, and testes of stage I appear. In September, only stages I and II are distinguished, the former is much more represented. In October, November, and December, stages I to III may be distinguished. Thus, in 1965, the testes of stage II increase progressively in number and this is on the expense of testes of stage I, whereby about 55% of the testes belong the former stage in December. Those of stage III are of low magnitude. However, in October of 1966, about 84% of testes belong to stage I, but in November and December, all testes belonged to this stage.

On the other hand, in females (Fig. 2) ovaries of stage I have a frequency of about 40 and 50% in January of 1965 and 1966 respectively. These figures decreased from this month onwards, so that in April ovaries of stage I may not be distinguished, but they are altogether lacking in May. In June onwards, and as clear from 1965, the magnitude of stage I increases so that the highest value is seen in October after which there is a fall in the frequency of ovaries of this stage. Besides, while in January, reprsentatives of stages II and III are characterized, but in February and March, stage IV makes its appearance. Stage V is mainly distinguished in April, May, and June, with the highest frequency in May. Apparently, the appearance of stages III to V takes place on the expense of the first and second stages. Furthermore, in September, ovaries of stages III and V are comparatively few. The vast majority of ovaries belonged to the first stage and to a lesser extent to the second one. In October, besides the increase in the magnitude of ovaries of stage I, there is a decrease in that of stage II. In November and further to December, ovaries of this stage become more frequent. Stage III was detected during October through November. Stages IV and V were detected in December, but this may be abormal and does not follow the sequence of growth of the ovaries formerly expressed.

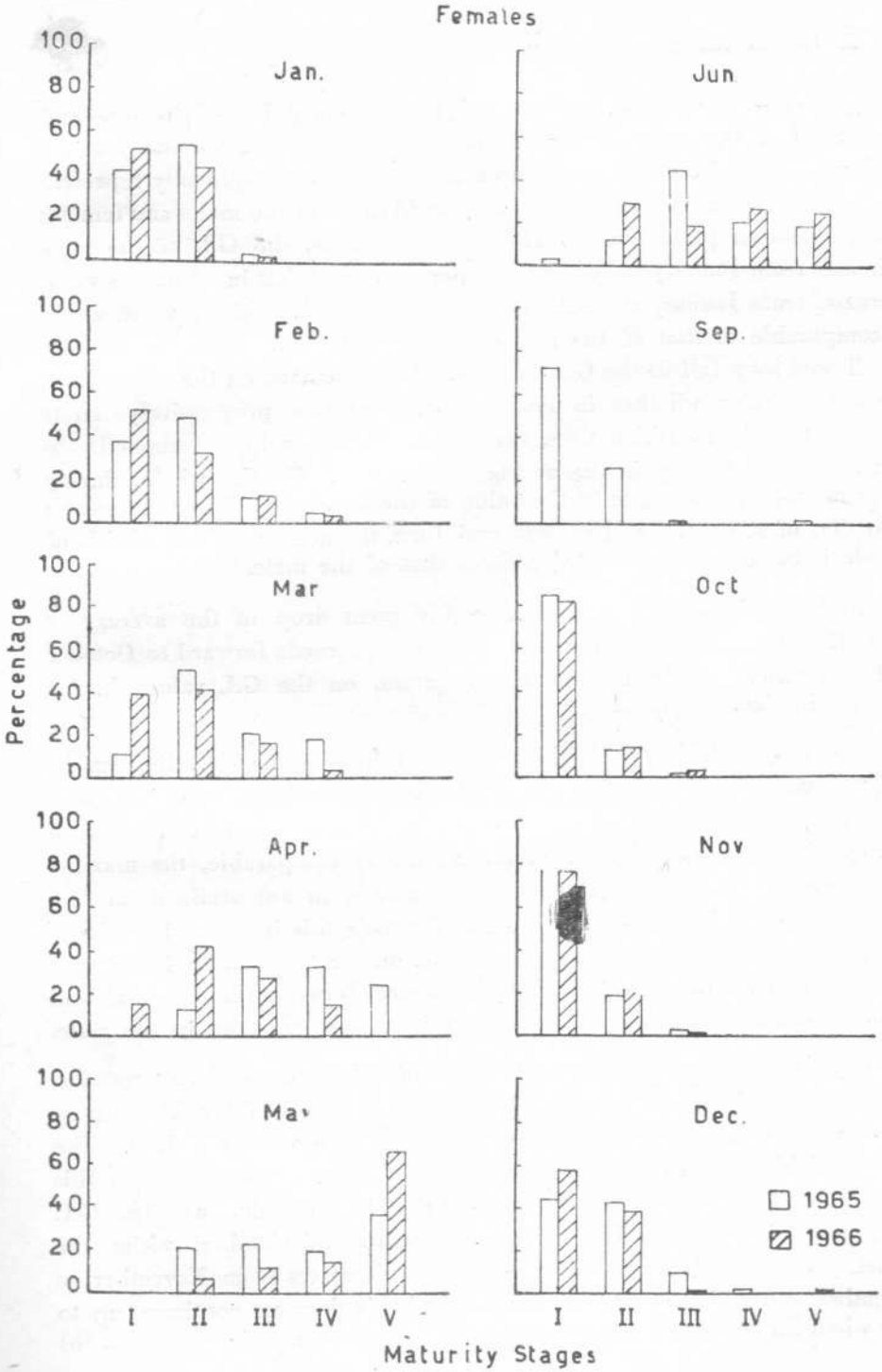

FIG. 2. Monthly frequency of maturity stages of ovary in 1965 and 1966

2. *Gonad Index*

A detailed examination of the gonad index calculated as percentage of the weight of the gonad to that of body was undertaken for the years of 1965 and 1966. The average, maxima and minima are graphically represented by Figs. 3 & 4 which show that the gonad index of the males and females shows different peculiarities. Thus, while in 1965, the G.I. of the male increases from January to June progressively, we find that in 1966, this value increases from January through April whence the G.I. attains a value which is comparable to that of the following month (May). Such an inrcease is followed by a fall in the G.I. in June. In the female, on the other hand, the gonad index whether in 1965 or 1966 increases progressively from January to May by which time, the highest average value is attained. In June, there is a drop in the average of the G.I. On the whole, during these months, the increase in the value of the G.I. in the female is greater than that of the male, and in May and June, the average values of G.I. of female is more than two or three times that of the male.

In September, there is a considerably great drop in the average of the G.I. in both males and females. This fall proceeds forward to October and November, but in December, the gonad, on the G.I. values, begins to grow in size.

The range within which the different values of the G.I. lie, can be attained only by considering the minimal and maximal values of this parameter in the different months. Thus, in different months and as shown in Fig. 4, while the minimal values are nearly comparable, the maxima are different. Thus, whereas the highest maximum was attained in the female in May of both 1965 and 1966, in the male this is attained in March and April in 1965 and 1966 respectively i.e. one or two months in advance of the female. On the whole, the difference between the maximal and minimal values is much more significant in the female than in the male.

Due to such wide ranges of the values of G.I. in the different months, the frequency of fishes of comparable gonads was examined. for this purpose the values of G.I. were divided into groups, each with a range of 1.00. The data available are graphically represented by Figs. 5 and 6. From this table, as well as, these figures, it is clear that in the male, (a) The G.I. of all males is less than 1.00 during September and October, while the fequency of males having this value of G.I. decreases from November to December and still forwards to January, and this decrease continues up to May when the number of males of first G.I. group or range is the least, (b)

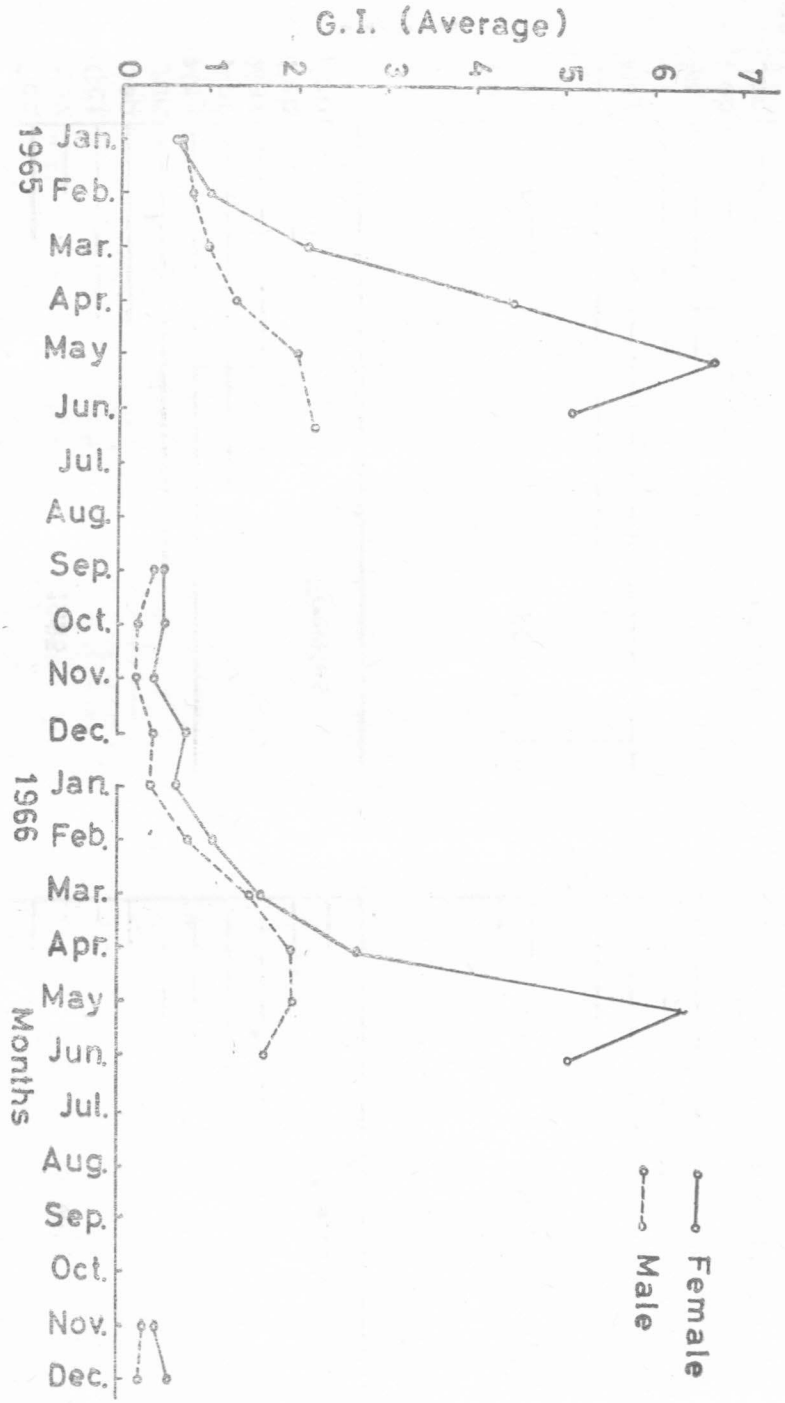

FIG. 3.—Monthly average values of gonad index (G.I.) in males and females.

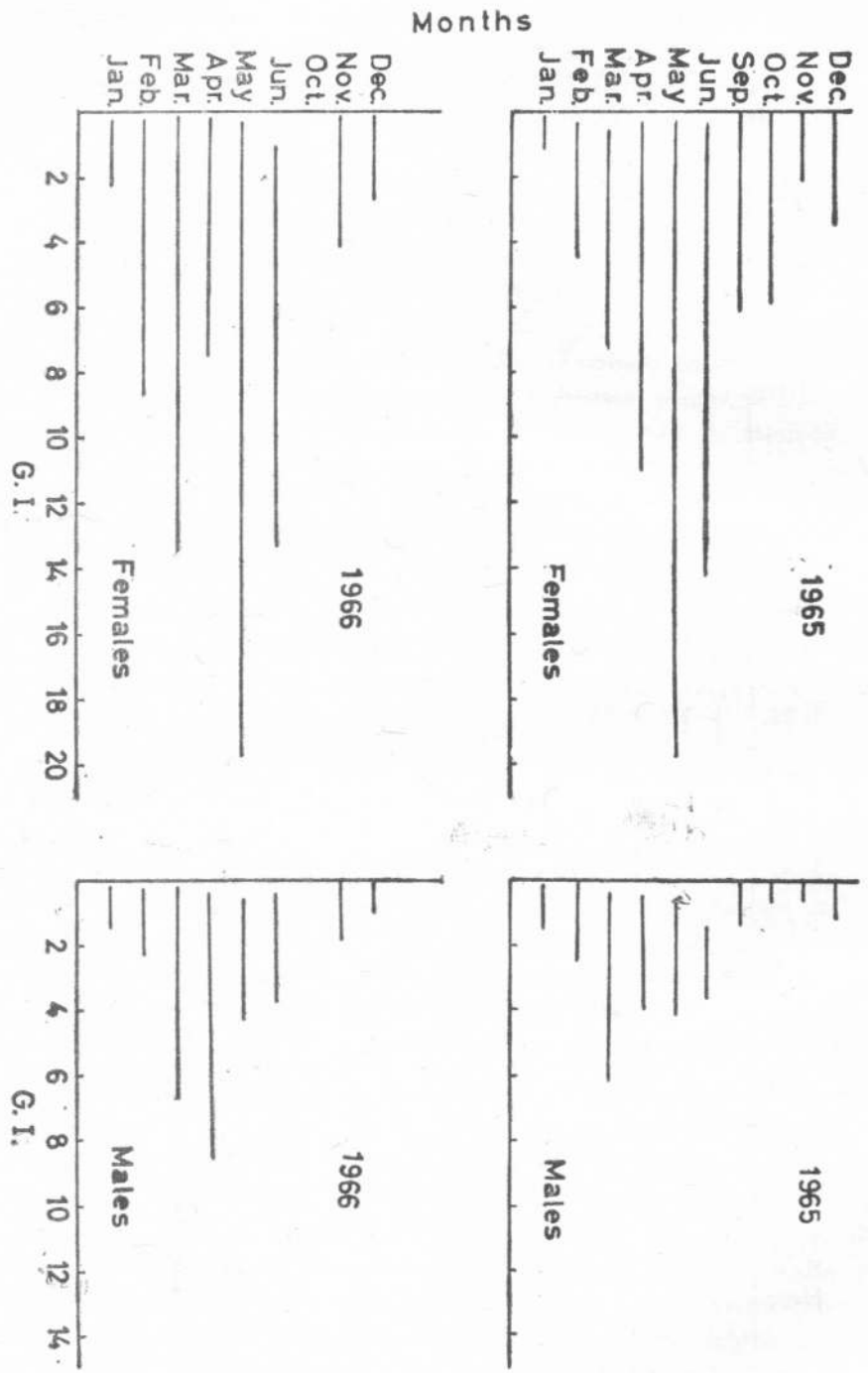

FIG. 4. Range of values of gonad index of both females and males in differnt months in 1965 and 1966

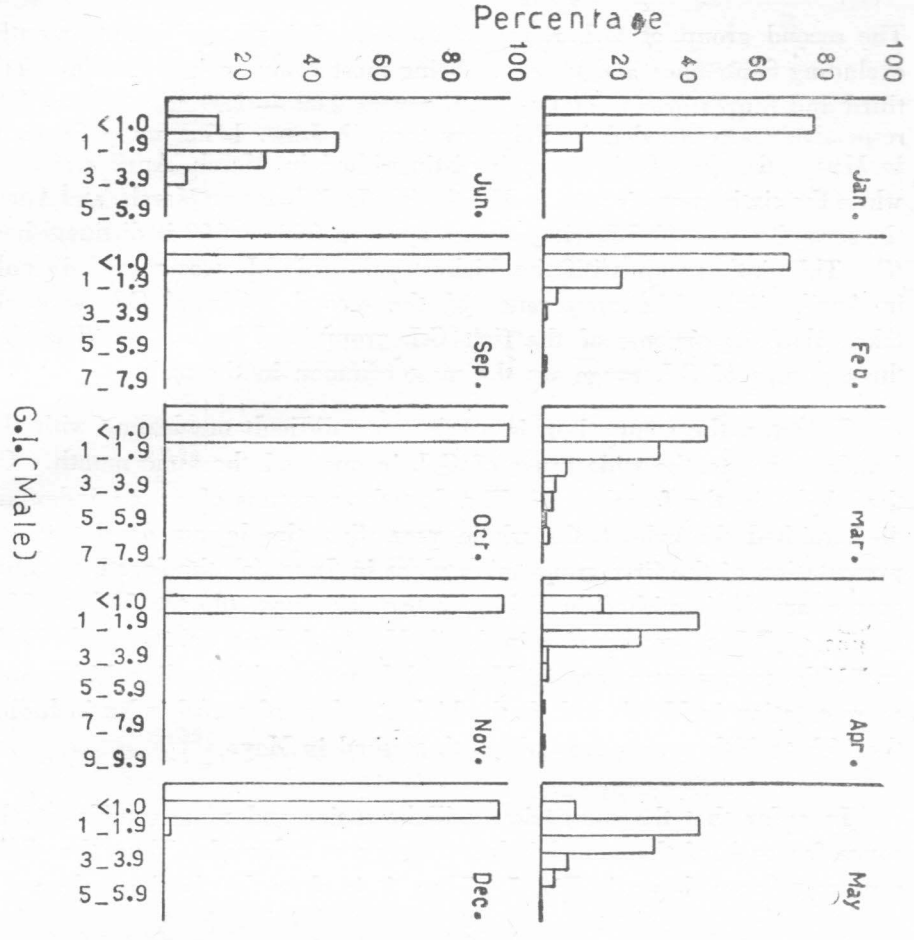

FIG. 5.—A series of histograms showing the frequency of males of different G.I. groups in different months in 1965.

The second group of G.I. range is represented in the different months excluding September and October, being most common in June, (c) The third and fourth groups of G.I. with ranges 2.00 — 2.99 and 3.00 — 3.99 respectively are recoded in February through June, being more frequent in May, (d) The fifth group is distinguished in March, April and May, while the sixth group is seen in March. (e) In February, March and April, the seventh group of G.I. with a range between 6.00 — 6.99 is distinguished, (f) Thl ninth group with the highest value of G.I. was recorded only in April, (g) The appearance of the second group of G.I. onwards takes place on expense of the first G.I. group, and lastly, (h) The first three groups of G.I. range are the most common in the male.

However, the comparison is much more difficult on dealing with the female owing to the wide range of G.I. in one and the same month. On the whole, in the females, (a) The first three groups of gonad index are distinguished throughout the whole year, (b) the lowest degrees of representation of the first group takes place in June, (c) the fourth to ninth groups are distinguished in February through June, (d) the 11th to 12th groups of G.I. ranges occured in April, May and June, (e) the 13th, 14th, and 15th, groups were seen in May and June, notwithstanding 14th group representation in March and (f) the highest values of gonad index including the 16th to 20th groups are only distinguished in May.

In order that the comparison will be easier and more significant, the range for each of the gonad index groups was enlarged. Thus, the different groups are shown in Fig. 7. Thus, it is clear that in the male :

(*a*) Most of males have G.I. less than 3. This G.I. group is the only one represented in September through January. The frequency of fishes of this group is the least in May.

(*b*) The second group, including the G.I. range from 3.00 to 5.99 represented in the months of February through June in 1965, or March through June in 1966 being most frequent in May.

(*c*) The third group is distinguished in February & March 1956 and in March & April of 1966. The fourth group was detected only in March & May of 1966.

(*d*) The occurrence of the 2nd to 4th groups is on the expense of the frequency of the first group.

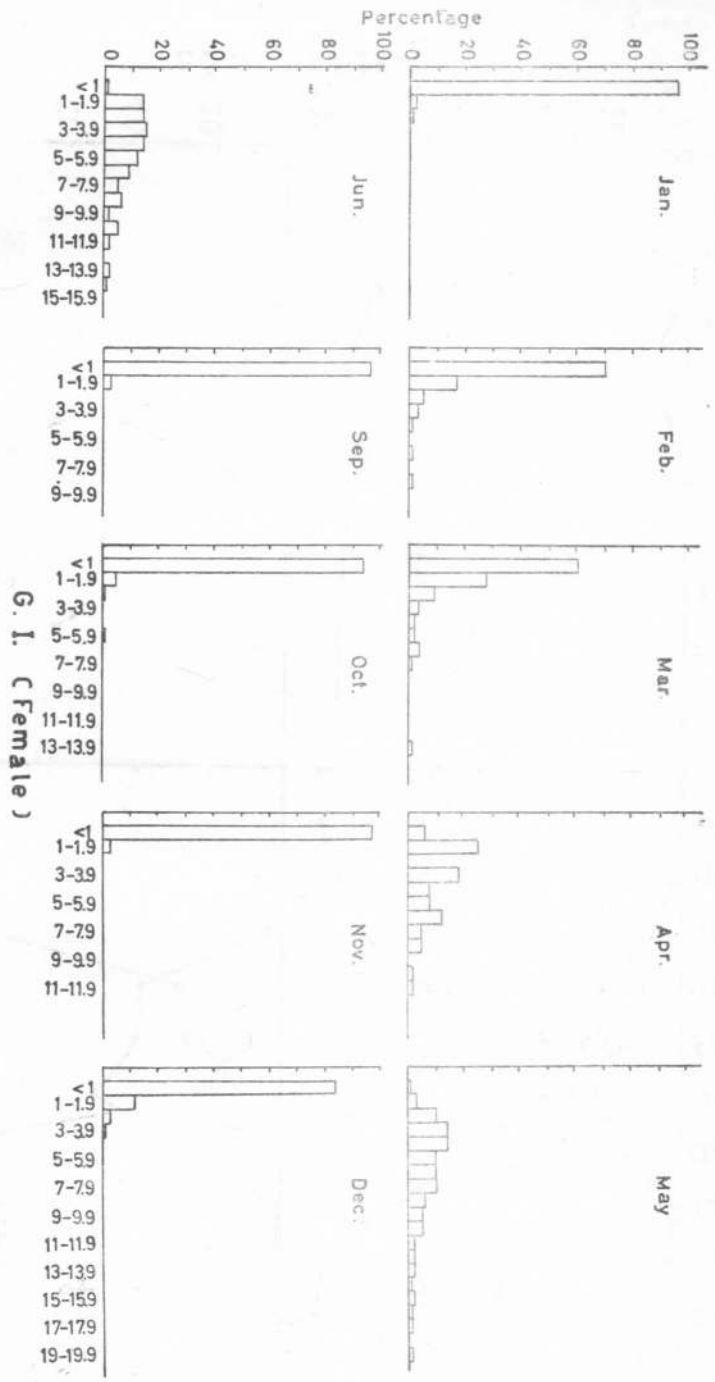

FIG. 6.—A series of histograms showing the frequency of females of different G.I. groups in the different months in 1965.

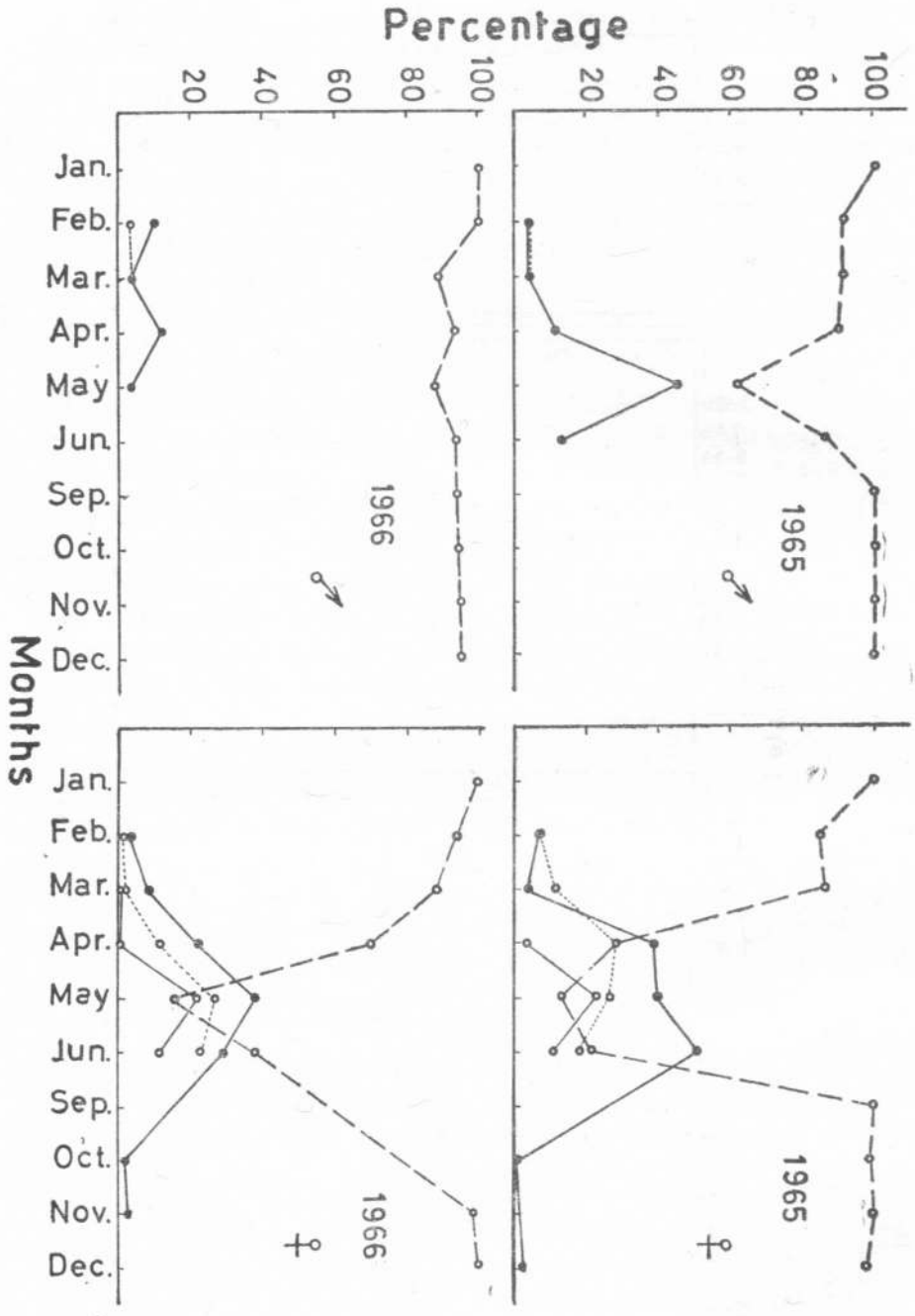

FIG. 7.—Frequency of females and males of different G.I. groups in different months of 1965 and 1966.

On the other hand, in females :

(*a*) The fishes of the first group, although represented in the different months, yet, the frequency decreases towards the spawning season, thus being the least in May.

(*b*) The second and the third groups are distinguished mainly from February to June, being most frequent in May & June of 1965 and May of 1966.

(*c*) Fishes belonging to the last group or having G.I. more than 9.00 are distinguished in April, May & June or March & June in 1965 or 1966 respectively.

(*d*) The appearance of the second to fourth groups proceeds on the expense of the first group, i.e. with the decrease in frequency of fish of the first group, there is the increase in the frequency or appearance of fishes of other groups.

Comparing males and females it can be concluded that :

(*a*) The frequency of the second, third and fourth groups, when distinguished, is much less in the former than in the latter.

(*b*) The decrease in the frequency of the first group during May and June is much more manifested in the female than in male. It is besides, tried to examine the frequency of the different G.I. groups (5.00, 5.00—9.99, 10.00—14.99 and 15.00) in either halves of the months, April, May, and June (Fig. 8 in the female). It is quite clear that :

(*a*) The first group is represented throughout the whole period. Its frequency is nearly comparable in the first and second halves of April, but the least value was shown in the first half of May, while from the second half of this month onwards, ovaries belonging to this G.I. group increase progressively in abundance.

(*b*) The frequency of ovaries belonging to the second G.I. group is nearly comparable in the two halves of April, is the highest in the first half of May, and tends to decrease from the second half of May onwards.

(*c*) The frequency of ovaries of the third group of G.I. is of low magnitude in April. There is a tendency for increase in magnitude in the first half of May. Such an increase is again extended in the 2nd half of May when a value is attained and which is comparable to that of the frst half of June, and lastly there is a sharp drop in the seoond half of June.

(*d*) Ovaries of the fourth G.I. group appear only in first and second halves of May.

(*e*) The first and second groups of G.I. dominate in the three months under examination.

(*f*) With the decrease in the number of ovaries of the first group there is, on the whole, an increase in the number of fish of the remaining groups and vice versa.

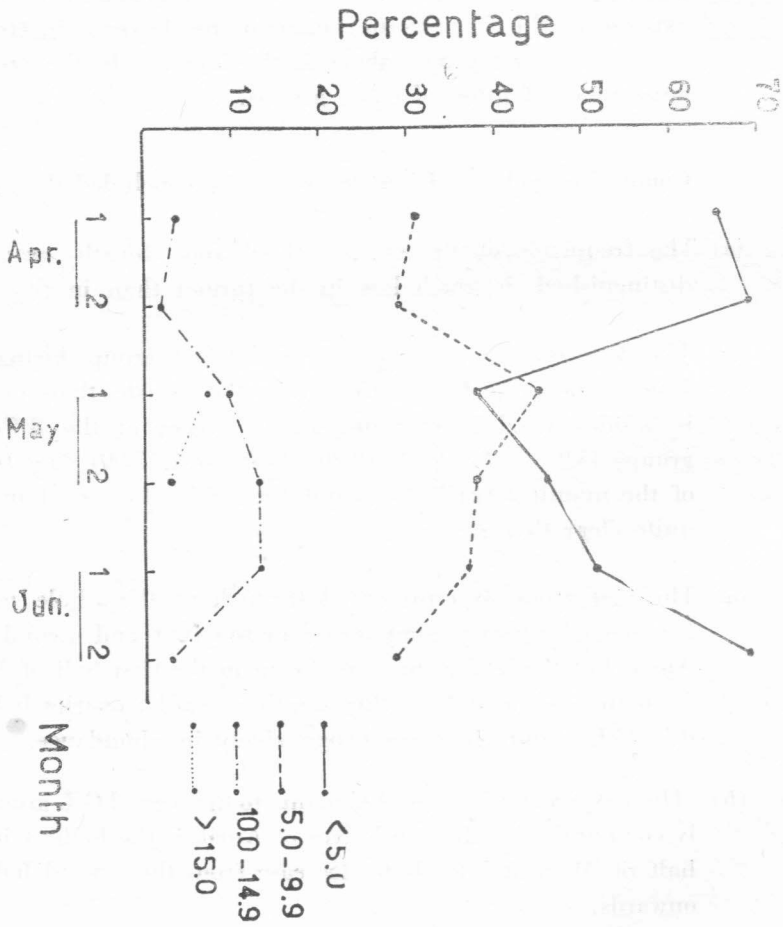

FIG. 8.—Frequency of females of different G.I. groups in different halves of April, May and June of 1965.

3. *Eggs Diameter*

In *Saurida undosquamis*, the ovary was found microscopically to contain different generations of eggs, and their diameter varies in the differnt periods of the year. On the whole, towards the spawning season, the eggs inclined for discharge in the following spawning season progressively increase in size so that in the prespawing period, the different generations are of varying levels of vitellogenesis. On discharge of one portion, the eggs of the following fraction proceed towards maturation and ripening. Thus, there is always whether sometime before the spawning season or during it, a group of eggs whose diameter is larger than that of the subsequent group. Dealing with an estimation of the diameter of the largest eggs of the ovaries of *S. undosquamis*, Figure 9 is available. Thus, there is a wide range in the diameter of these eggs (Fig. 9 b). Besides, it appears that, from January to April, there is a progressive increase in the size of the oldest eggs. In May, there is a fall in the average of the diameters for the ovaries examined as representing for this month, but on the whole, the range of diameter of largest eggs ranged from 557 to 844 u, which shows that the different ovaries may have the largest eggs in different stages or degrees of vitellogenesis. The same can be again attained when considering June. In September, the egg diameter of largest eggs is on the average 426 u ranged from 383 to 557 u and the largest eggs show yolk content. October has the smallest egg diameter but this again goes on rising from November onwards. These facts collectively point to the long spawning season of *S. undosquamis*. In the pre-spawning period, it is possible to assort four groups of comparatively large eggs of varying size. In table(1), the range values of the diameter of eggs of each group is shown for 14 ovaries. It appears that the four groups of eggs show decreasing egg diameter from one group to the following. Thus, the diameters of eggs of the successive four generations are on the average, about 885, 660, 470 and 295 u. The ranges of the diameter of these successive groups are from 565 to 1010u, 350 to 775 u, 220 to 625 u and from 130 to 420 u.

c. *Fecundity*

Fecundity is defined as the total number of ripe eggs produced by female in a spawning season or in a year. On the whole, two terms are generally applied on studying the fecundity of fishes. The first or "absolute fecundity" entails the examination of the number of the eggs in the ovary. The second or "relative fecundity" is defined as the number of eggs for unit length or weight of fish.

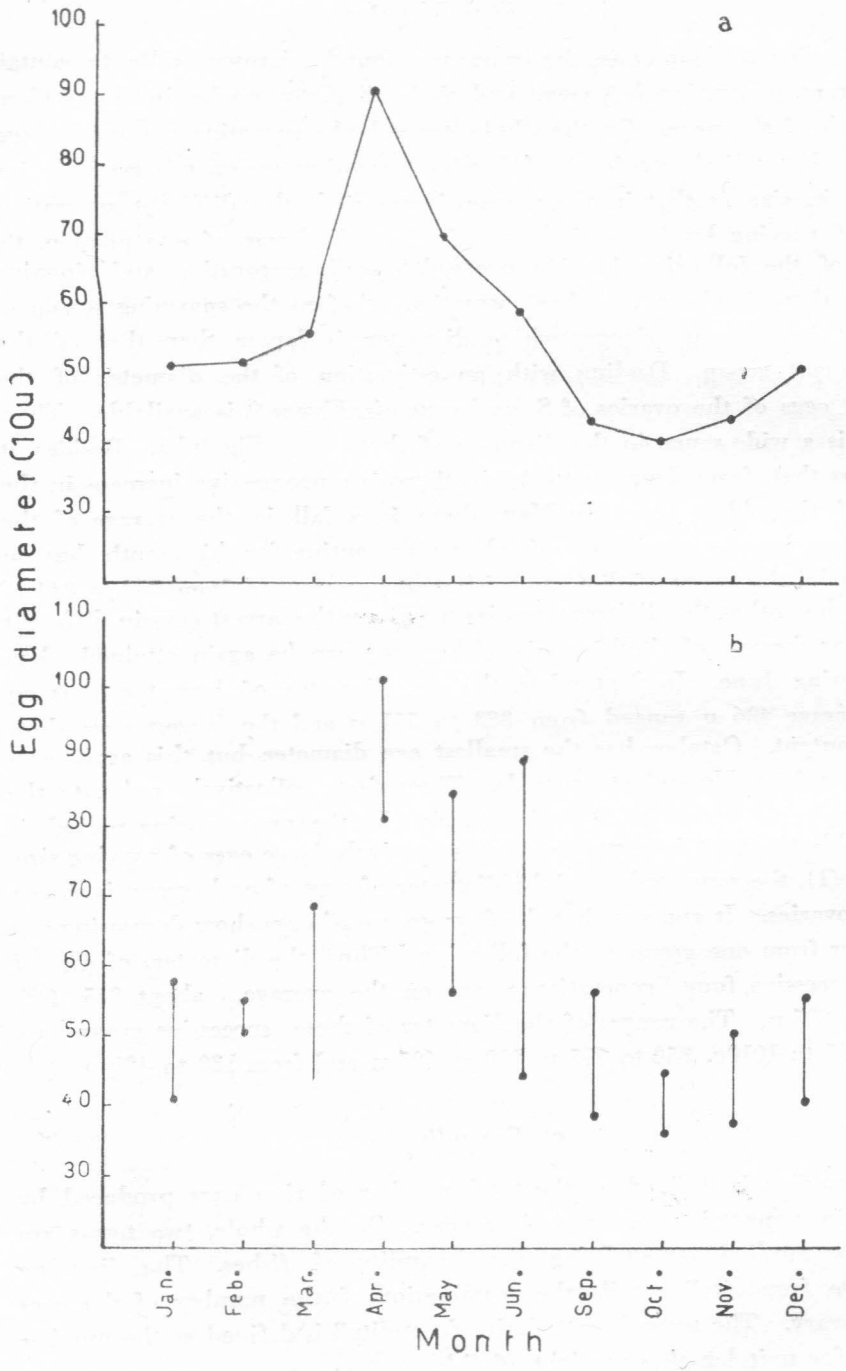

FIG. 9.—(*a*) Average egg-diameter of females in different months of 1965.
(*b*) Range of egg-diameter of females in different months of 1956.

TABLE 1.— EGG DIAMETER OF THE SUCCESSIVE FOUR GROUPS OF EGGS
(Late in April and early in May 1965)

No. of Specimens	Egg Group			
	I	II	III	IV
1	565	350	220	130
2	696	590	460	280
3	975	730	520	340
4	940	710	495	310
5	1010	730	535	255
6	910	695	470	280
7	960	695	470	290
8	915	625	435	270
9	825	610	445	260
10	975	610	435	260
11	870	660	425	280
12	880	695	580	355
13	915	755	590	385
14	955	775	625	420
Average	885	660	470	795

Egg diameter (u)

Different methods are generally adopted for the study of fecundity, and among these, the gravimetric method is more commonly used. This method is here adopted, but as was formerly mentioned, the species under study has a long spawning season, and during this season a number of fractions of eggs is delivered. Estimation of the number of eggs of the different protions of eggs is found difficult due to the smallness of the eggs of the 2 *nd* to 4 *th* generations in advance of the spawning season. Such

a difficulty was overcome by dealing with females early in May or late in April , and these have the eggs of the oldest generations in mature or ripe codition. The eggs of this generation were counted. The yolky eggs of the following generations were of different sizes and counted together. In such a way, the percentage of the eggs of the first portion to the total number of yolky eggs produced by the female in a spawning season was estimated.

Specimens chosen for egg count represent the different age-groups including the different lengths and weights.

A. Fecundity-length Relation

The fishes for 1 cm. interval of body length are grouped togther in 161 specimens of *S. undosquamis*. The relation between the number of eggs in the first portion of eggs and the standard length was plotted graphically (Fig. 10) by adopting the method of least squares of

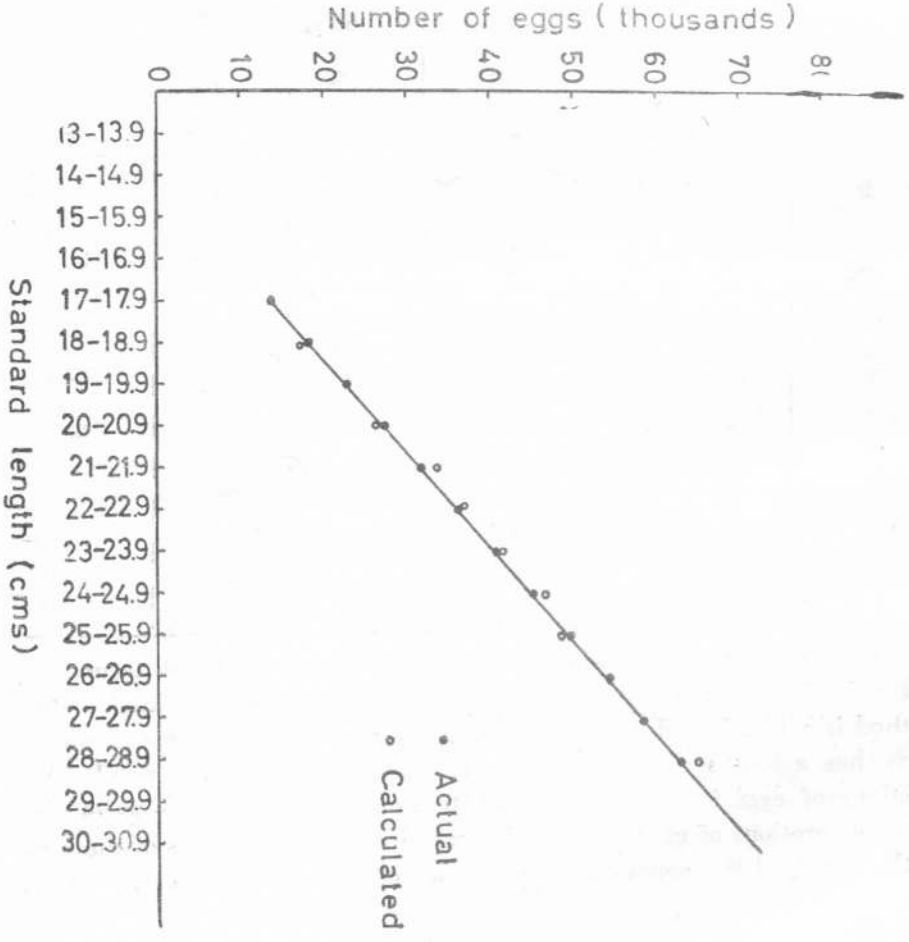

Fig. 10.—Relation between standard length of fish (in cm.) and number of oldest eggs.

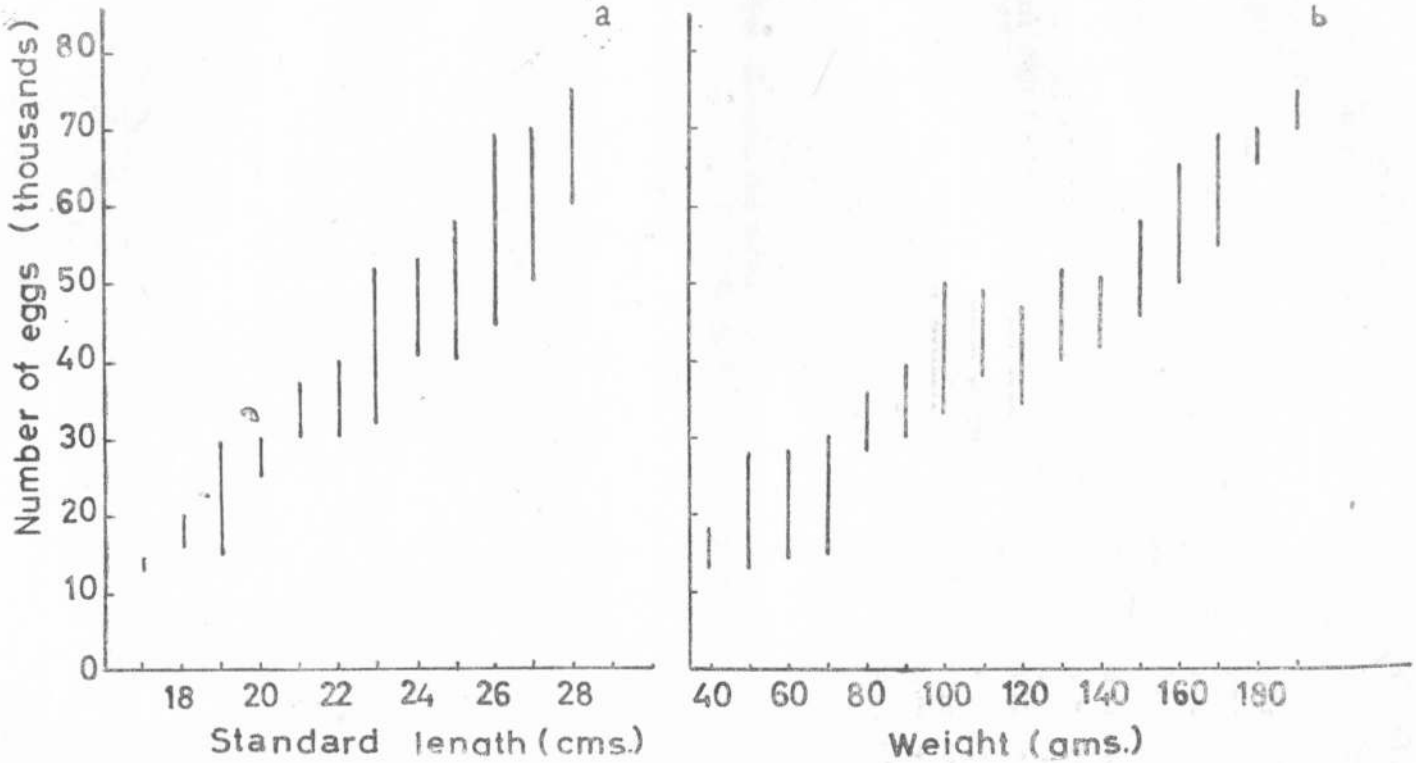

FIG 11.— Ranges of number of oldest eggs of different (a) lengths(in cm.) and, (b) weights (in gms.)

the form Y = a + b (where Y = the average number of eggs in thousands for each group, X = the mean standard length of fish, a & b are constants). The application of this formula led to the following equation : Y = —65.45 + 4.55 X

Within each group of fishes of 1 cm. interval, the number of eggs produced show great variation, but on considering the range of egg production for each fish interval, it is quite clear that, on the whole, the production of eggs increases with increase in the fish standard length (Fig. 11 a).

On considering the relative fecundity for the number of eggs of the first portion of eggs, it is found that this increase with the increase in fish length .Thus, the relative fecundity - on the average - ranges from about 800 to 2300 for fishes of an average length ranging between 17.3 to 28.8 cm. respectively. On the whole, as clear from Fig. (12), a straight line relationship exists between the relative fecundity and the length of fish i. e. the increase in the length of fish is accompanied by an increase in the relative fecundity.

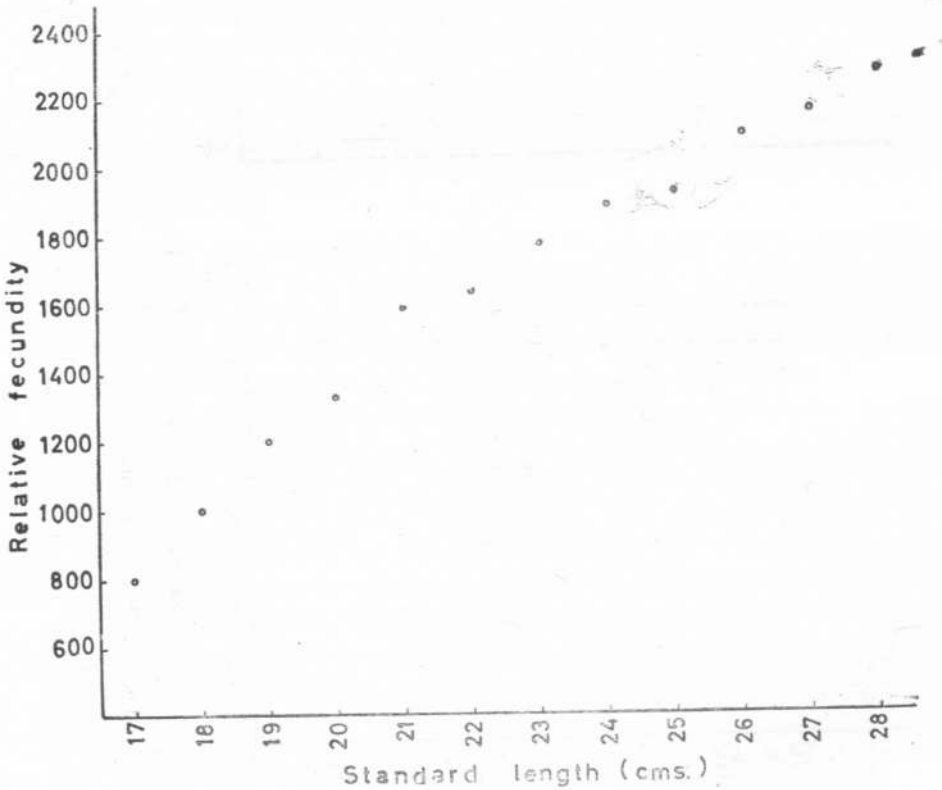

FIG. 12.—Relation between length of fish(incm.)and relative fecundity(number of oldest eggs for 1 cm. standard length).

B. Fecundity-weight Relation

The relation between the number of eggs of the first portion and the weight of fish was examined in 161 individuals of *S. undosquamis*. The fishes of an interval of 10 gm. were treated together. The relation between the average of fecundity and the average weight of fishes of the different weight groups was examined by applying the method of least squares of the formula $Y = a + bX$ (where Y = the number of eggs in thousands, X = the average weight of the different weight groups, a & b are constants). The following equation was thus attained :

$$Y = -1.58 + 0.368\ X$$

For fishes of each weight group, the number of eggs shows a comperatively wide range (Fig. 11 b) However, grophical representation of the relation between the range of the number of eggs and the average weight of fish may even show that direct relation exists between these two variances (number of eggs and fish weight). In other words, in most cases, the minima and maxima how increase from one group to antoher. Furthermore, the relative fecundity designated as the number of eggs for one gram of body weight does not vary greatly in different fish groups as the minimal and maximal values are 320 and 390 eggs respectively.

On this account, the relative fecundity when related to body weight can be considered as more specific to the species than when related to body length.

C. Fecundity-age Relation

Fishes of the different lengths and weights were assorted into age-groups as was determined from scales. Actually, the data available was based on fishes of age-groups II, III and IV. The average number of eggs for fishes of each age-group was calculated, as shown in table (2). From this table, it is clear, that, the average number of eggs discharged by fishes of age-group III is nearly twice that of fishes of age-group II. Besides, the egg productions by fishes of age-group IV is approximately 3 1/2 and 1 2/3 that produced by fishes of age-groups II and III respectively. On the whole, graphical representation of the relation between the average number of eggs and the age-groups reveals that, a comparatively straight-line relation exists between two variances (Fig. 13 a). However, in fishes of any age-group, the number of eggs produced varies and apparently the variation is much less significant in fishes of age-group II (Fig. 13 b). Besides, in fishes of age-groups III and IV, the range of variation is nearly comparable.

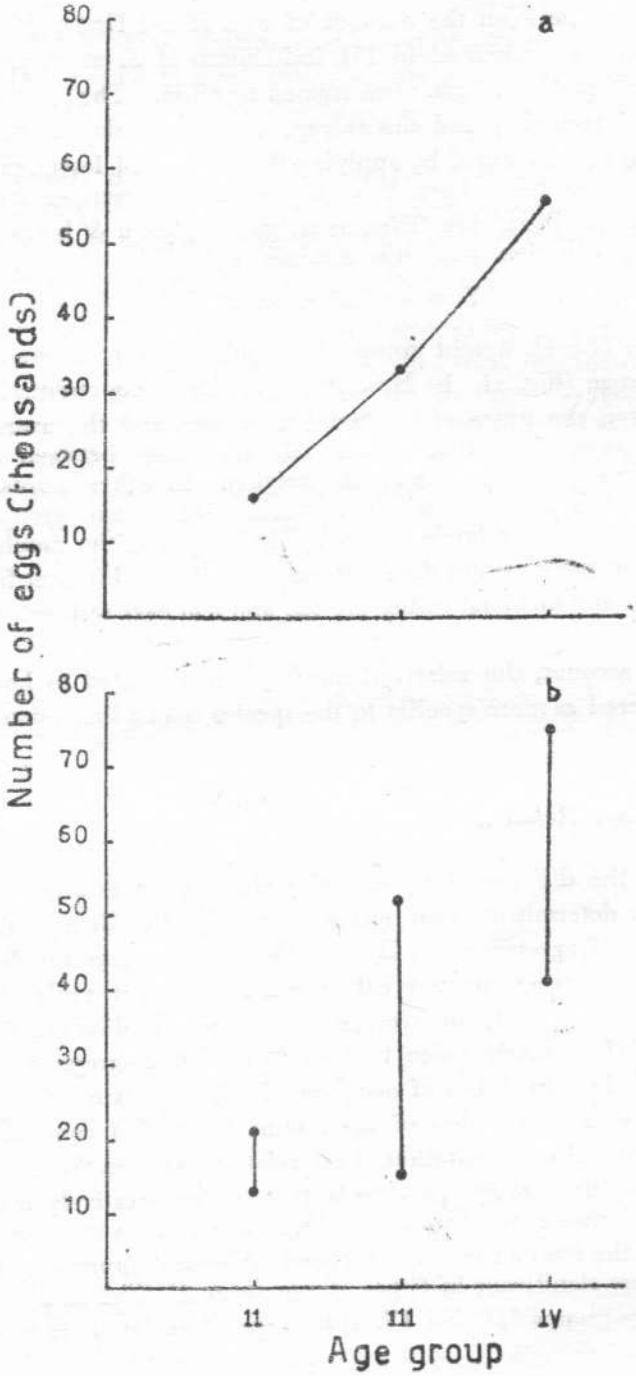

FIG. 13.—(*a*) Relation between age of fish and number of oldest eggs. (b) Ranges of number of oldest eggs for different age groups.

TABLE 2.—OLDER EGG PRODUCTION OF *S. undosquamis* BY AGE-GROUPS

Age-groups	Fish No.	Absolute fecundity		
		Min.	Max.	Aver.
II	22	13160	20600	16141
II	67	15225	52126	32727
IV	72	41064	75096	55311

D. Proportionality Coefficient

As was formerly pointed out, the ovary of *S. undosquamis* has in the pre-spawning season yolky eggs belonging to different generations and having different diameters. Estimation of the number of eggs of these different generations in sometimes desirable, but in the present studied species, it was found difficult to assort the individual generations for subsequent eggs counting. On this account, as was formerly mentioned, the eggs of the oldest generation are separated and counted, while the eggs of the remaining and following generations were treated collectively. On this basis, the proportionality coefficient (P.C.) designated as the percentage of the eggs of oldest generations to the total number of yolky eggs was deduced. The data available for 14 specimens collected early of May are shown in table (3). Thus, the P.C. for *S. undosquamis* ranged from 20.2 to 45.6%. In other words, the eggs of the oldest gereration formed 20.2 to 45.6% of the total number of ovarian yolky eggs. while the eggs of the remaining generations compose from 45.4 to 79.8% of eggs discharged in the spawning season. The average percentage of these two assorted groups is 33.55 and 66.45% for the oldest generation and the following generations of eggs respectively.

5. *Length and Age at First Sexual Maturity*

The study of age and length at first sexual maturity was based on examination of the gonad index in fishes of the samples collected in different months. Unfortunately, due to the fact that the present study is based

on sampling from the commercial catches, fishes smaller than 14 cm. long are not available and consequently it was not possible to include smaller fishes in the present study. On the whole, fishes of 1 cm. length interval were treated togther.

TABLE 3.—PROPORTIONALITY COEFFICIENT OF *Saurida undosquamis*

Specimen No.	Percentage of eggs	
	Ist fraction	Other fractions
1	22.3	77.7
2	33.3	66.7
3	39.4	60.6
4	31.6	68.4
5	37.3	62.7
6	40.4	59.6
7	39.2	60.8
8	45.6	54.4
9	31.4	69.6
10	20.2	79.8
11	38.9	61.1
12	29.2	70.8
13	33.4	66.6
14	27.5	72.5
Average	33.55	66.45

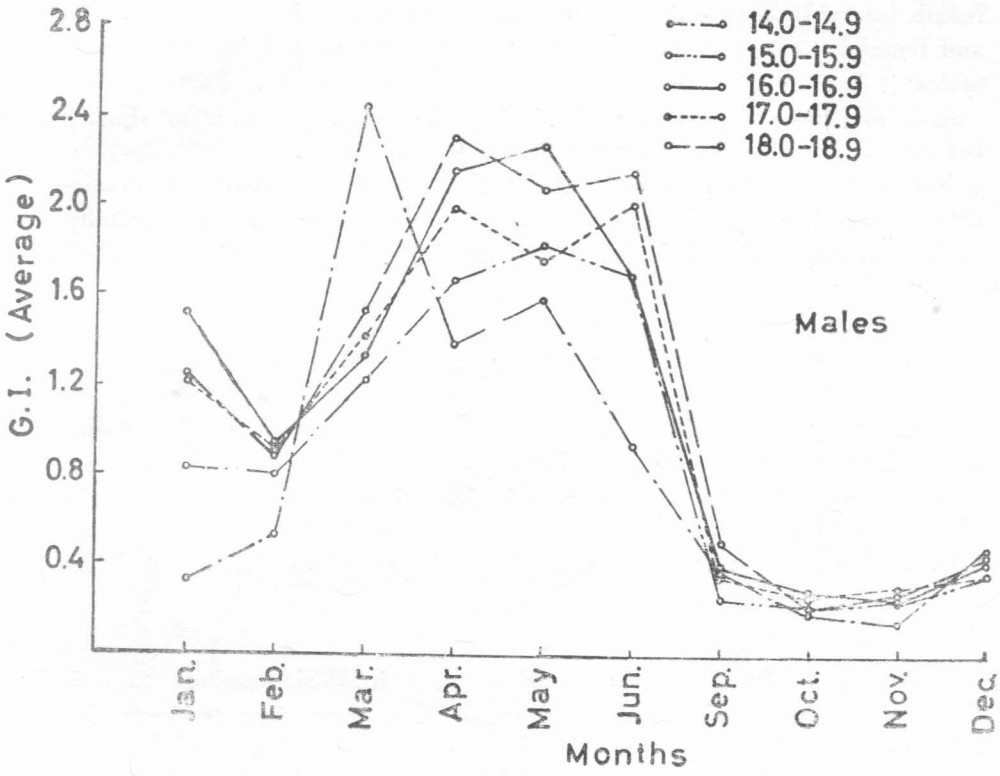

Fig. 14.—Average G.I. of males of different standard lengths (incm.) in different months.

The average of the gonad index of different length intervals in the different months is examined for both males (Figure 14) and females. It is quite clear from these tables and figure that towards the spawning season, the gonad index of fishes of 14 cm. long or more, increases so that it becomes comparatively high in April, May and June. On considering the age-groups of these fishes, we found that fishes of 14 & 15 cm. interval are of age-group I while fishes of 16 cm. interval belong either to age-group I or II. Besides during the spawning season and shortly before it is possible to discriminate between the mature or immature gonads. The average of the gonad index thus gives only a generalized picture during the period concerned, but for a precise idea on the maturity condition of different individuals, these must be treated individually. On these bases, we considered the actual values of the gonad index for the available individuals of standard

length intervals of 14 - 17 cm.,during April, May, and June for both males and females. The data available are shown in tables 4 & 5. From these tables, it is clear that all the males of 14 cm. long or more have mature gonads and they appear whitish during the spawing season or shortly before it. On the other hand, the females of 14 cm. intervals may be either sexually mature or immature but the former condition preponderates. The females of 15 cm. length intervals onwards are sexually mature during the period April through June.

6. *Sex Ratio*

In the present work, the sex ratio was studied from the fish samples taken from the commercial catches. The fluctuation in this sex ratio, expressed as the percentage of the individual sexes among the sample was examined for the different months of the years 1965 and 1966. The data available are given in table (6) and graphically represented by figure (15).

It appears from the data available that in 1965, passing towards the spawning season i.e. January through May, there is a tendency for gradual decrease in the percentage of males in the commercial catch. In other words, January, shows the highest number of males, while May has the least. Again from June through November, the percentage of males again increases gradually. During December, there is a drop in the number of males found in the fish samples. On the other hand, the females behaved reversely.

In 1966, the males behaved differently. Thus, from January through April, there is an increase in the percentage of males but in May, there is a strong fall in this percentage. In June, the number of males again increases greatly, but, again towards the end of the year, this number falls gradually.

On the whole, in 19 months of sampling of 1965 and 1966, only in 4 months the prcentage of males in the samples available in higher than 50 %. Again, in only two months viz. January 1965 and June 1966, this percentage in only 52 %. The percentage of males recorded in April 1966 is exceptionally high.

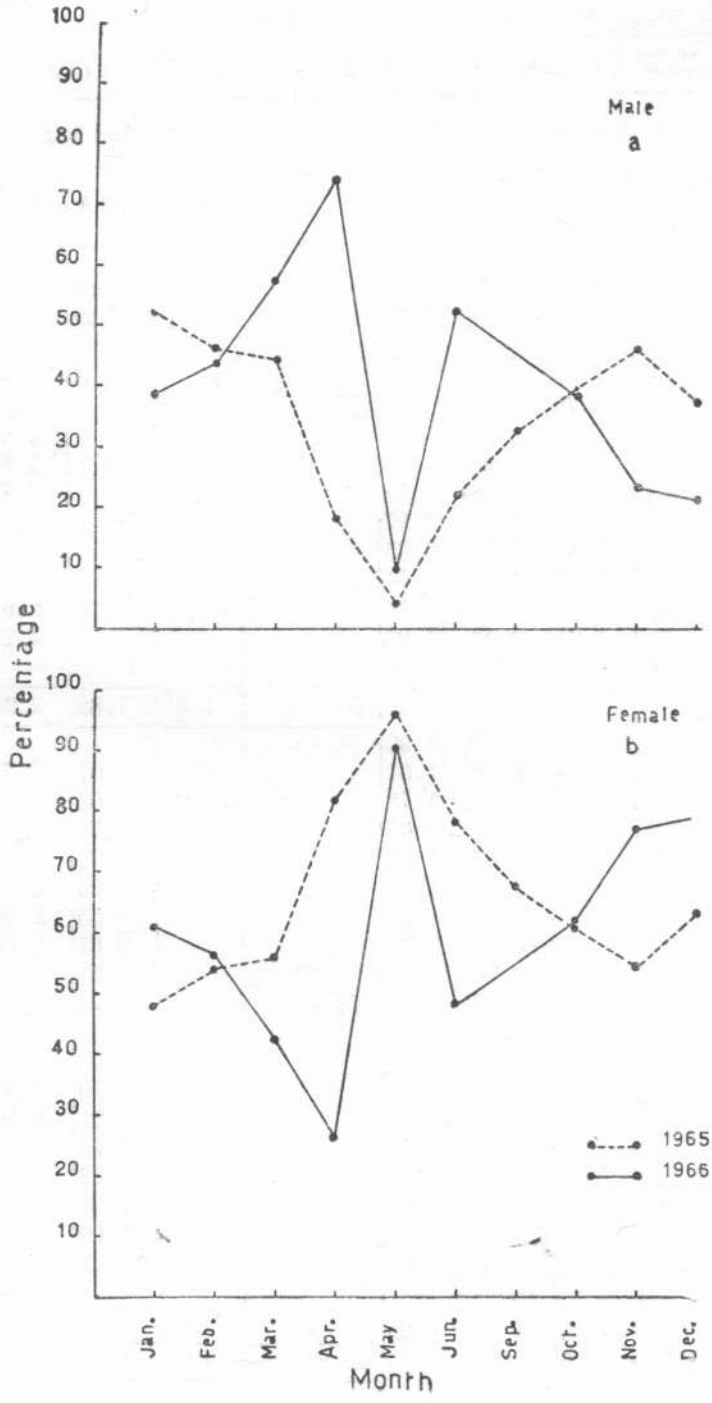

FIG. 15.—Graphicalpresentation of frequency fmales (a) and (b) females in fishing methods of 1965 and 1966.

TABLE 4—GONAD INDEX OF MALES IN APRIL, MAY AND JUNE

Month	Standard length (cms.)				Month	Standard length (cms.)			
	14.0	15.0	16.0	17.0		14.0	15.0	16.0	17.0
	0.88	1.40	1.82	1.02		1.25	2.66	2.34	2.80
	0.81	1.89	8.50	1.75		2.06	1.32	1.52	1.31
	2.42	0.68	1.91	1.48			1.28	2.23	1.93
	1.38	2.32	2.10	1.89			1.51	2.57	1.47
		0.76	3.58	1.11	May			3.06	
		2.49	1.31	0.85	(cont.)			1.64	
		2.91	1.63	1.03				1.50	
		2.06	1.09	1.32				0.77	
		1.06	1.81	1.97				2.10	
		1.59	1.63	2.65				1.84	
		1.16	1.10	1.94				1.95	
		1.49	1.51	2.96				2.09	
April		1.74	3.23	1.93				4.26	
			2.64	2.66					
			0.97	6.56	Average	1.58	1.82	2.26	1.76
			2.85	1.90					
			1.75	1.51		0.92	3.01	0.79	2.24
			2.28	1.73			1.09	1.72	1.79
			1.31	2.08			0.78	1.85	1.60
			1.03	2.50			2.74	1.42	1.21
			2.71	1.72			0.96	2.62	3.85
			1.69	1.34			0.55	2.50	1.85
			0.99				0.81	2.56	2.20
			1.70				1.51	1.08	
			2.07		June		1.73	1.06	
			3.31				1.01	0.94	
			1.66				1.71	1.19	
			1.98				1.70	1.98	
			1.74				1.21	1.70	
			2.71				2.48	1.52	
							1.77		
							2.01		
							2.19		
Average	1.37	1.66	2.15	1.99			2.43		
May	1.00	1.96	4.18	1.93					
	2.02	2.20	1.81	1.09	Average	0.92	1.69	1.68	2.10

TABLE 5—GONAD INDEX OF FEMALES IN APRIL, MAY AND JUNE

Month	Standard length (cms.)			
	14.0	15.0	16.0	17.0
April	3.08	1.64	1.91	1.81
	0.24	1.08	3.24	2.41
	1.10	1.53	2.15	1.96
		1.59	5.00	6.11
		2.00	1.82	1.75
		7.85	1.63	4.12
		12.21	1.94	0.71
		5.76	1.38	1.56
			1.63	8.21
			1.40	1.73
			2.90	3.64
				1.30
Average	1.47	4.21	2.27	2.94
May	3.36	9.82	9.09	10.40
		4.50	1.41	4.44
		5.18	1.16	10.80
		2.58	9.04	13.00
		5.31	11.73	
		3.40	1.35	
		1.39	5.54	
			3.25	
			4.61	
			4.01	
			4.22	
			4.75	
Average	3.36	4.60	5.01	9.66
June	2.29	1.91	2.67	1.76
	6.20	3.01	1.89	8.99
		1.70	1.99	2.11
		2.23	1.46	1.02
				2.86
Average	4.24	2.21	2.02	3.35

TABLE 6—SEX RATIO IN THE DIFFERENT SUB-SAPMLES OF MARCH THROUGH JUNE IN 1965.

Date of Sacple	PERCENTAGE	
	Male	Female
14 March	44	56
21 March	40	60
6 April	12	88
18 April	24	76
7 May	16	84
15 May	12	88
22 May	—	100
29 May	—	100
9 June	8	92
20 June	32	68
29 June	24	76

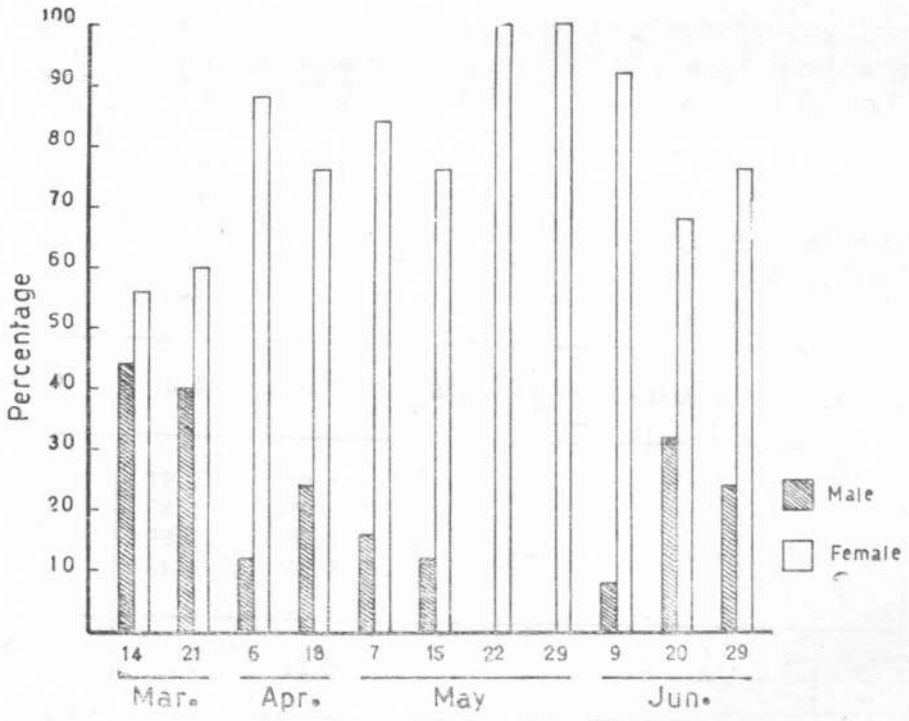

FIG. 16.—Sex ratio in different sub-samples of Marcy, April, May and June 1965.

Furthermore, table (6) shows the percentage of males in the different subsamples collected at intervals of each of March, April, May, and June of 1965 (Figure 16). From this table, it is quite clear that the samples from the fishing catch of 22nd, and 29th of May are made up exclusively of females and this is apparently extraordinarily abnormal. On the whole, throughout March, April, May and June of 1965, the females are more frequent in the commercial catch than the males.

IV DISCUSSION

The study of reproduction of fishes is an important item in fish or fishery biology. The reproductive ability of the female can be considered as the clue for recruitment of young fish which on being older, form the commercial fish catch. On the whole, the morphological peculiarities of the gonads as well as their seasonal variation of *S. undosquamis* are here subjected to a detailed study.

It is generally observed that the gonads whether in the males or females grow larger towards the spawning season. For this purpose,the maturity stages are applicable for discrimination between the different conditions of the gonads in the different periods. Thus, on the basis of the morphology of the gonads, Hjort (1910) described five stages of gonads, Kesteven (1960) gave a schedule of eight successive stages for describing the variation in the condition of the gonads. These stages are referred to as : virgin, maturing virgin, developing, gravid, spawning, spawning/spent, and recovering spent. Nikolsky (1963) described seven successive stages, namely : immature, resting, maturation, maturity, reproduction, spent and resting.

In the present work, the maturity stages of the gonads of *S. undosquamis are* examined according to Hjort's description. Thus, towards the spawning season testes of stage I generally become fewer, and this is accompanied by an increase in the 2nd and 3nd stages. Besides, testes of stages IV and V to some extent, made their appearance in March. During April, stages I to IV are distinguished, but in May, the first stage was found lacking. This stage again made its appearance in June, together with the disapperaance of testes of stage IV. During September, only stages I and II are distinguished, although the first constituted about 90 % of the testes examined. In the remaining part of the year, the testes behaved differently in 1965 nad 1966. Thus in the former and from October onwards, testes of stage I progressively decreased in frequency

while stage II and III increased in magnitude. On the whole, in this year, September showed the highest frequency of testes of stage I. On the other hand, in 1966, during November and December, the testes belonged only to stage I. On the whole, the immature gonads decrease in number towards the spawning season but they again restore their number after the spawing season. The maturing or mature testes made their appearance on the expense of the immature ones.

Concerning the females, ovaries of maturity stages I, II and III are detected in January, October and November. Stage IV was detected from February through June, while the 5th stage was detected during April, May, and June, and to a much less extent in September. Thus, on the whole, May has ovaries of this stage to much higher degree than the remaining months. The appearance of stages IV and V in December of 1965 and 1966 can be considered extraordinary. On the whole, the immature gonads of stage I progressively decrease in frequency towards the spawning season so that in May and to some extent in April and June, these gounds are lacking. In the post-spawring period, October showed the highest frequency of the ovaries of stage I, and its magnitude gradually decreases. On the whole, the appearance of "maturing" or "mature" ovaries of stages II to V is on the expense of these of stage I.

Another way of expressing the variation of the condition of the gonads in the different periods of the year is the apelication of what is generally referred to as "gonad index", "maturity index" or "maturity coefficient". Such parameters are more accurate than the afore-mentioned maturity stages. The maturity coefficient (Alexceeva 1964, Tarnavsky 1965, ...etc.), gonad index (Latif 1966) and maurity index (Wydoski and Cooper 1966) are considered as the percentage weight of the gonad whether testes or ovaries. The gonad index expressed as the weight of gonads as related to the cube of the length of the fish was considered by many Japanese workers, (Mizue 1957, 1959 & 1961, Mizue et al. 1968, Tateishi et al. 1957, Mio 1961, Matsuura 1961, ... etc.).

In *S. undosquamis* and for the samples of 1965 and 1966, the gonad index (G.I.) was computed as percentage weight of gonad to that of the body. The data available showed that, whether in the male or the female, the mean gonad index increased progressively towards the spawning season, so that the highest values were found in May besides June 1965. There is slight decrease in this mean gonad index of testes in June 1966 and that of female in June of both 1965 and 1966. On the whole, the

highest means for female are much higher (nearly about three times) than of the males. Such a difference is due to the fact that the eggs as the end products of ovogenesis in the females are much heavier than the spermatozoa or the end products of the spermatogenesis of the male.

On considering the minimal and maximal values of the gonad index in the different months of the year we find that, for both sexes there is a wide range of this index. On the whole, this range is much more significant in the female than in the male. This agrees reasonably well with the presence of gonads in different maturity stages as is formerly expressed. In turn, the maximal values of G.I. of the ovary appeared in May, while those of male appear ealier, i.e. March of 1965 or April of 1966. Such an idea is in favour of reproduction as the mature eggs, as well known, are formed and remain "dormant", until the suitable environmental conditions prevail whence the egg passes over to the ripe conditon. This character necessitates the presence of males with viable sperms sometime before the prevalence of such suitable environmental conditions (Persov and Sakun 1962).

Estimation of the egg diameter in the different periods of the year is of double benefit. In the first place, this gives an idea about the maximum size of the mature egg, besides the growth channel of the egg on proceeding towards the spawning season. In the second instance, egg diameter estimation throws light on the peculiarity of fish spawning period whether stretched or short. In this connection, Hickling and Rutenberg (1936) expressed the view that, when the spawning season is short, only a single group of egg matures, while more than one group of egg mature one after the other under the condition of long spawning season. This is the basis for the presence of two or more modes of the ova size frequency in the ovary shortly before the commencement of the spawning season (June 1953, Higham and Nicholson 1964, Yoshida 1966, ... etc.).

With regard to *S. undosquamis* of the Gulf of Suez, the egg progressively increases in size from January onwards so that the highest mean egg diameter was recorded in April. However, the egg diameter has a wide range of distribution indicating that, during these months, the eggs of oldest generation are of varying diameters in the different ovaries collected. However, this range is widest in June. This conclusion, to some extent, agrees reasonably well with the presence of ovaries of different maturity stages besides different gonad index. On the whole, the mean

egg diameter of the largest eggs decreases from May through October whereby, during the latter the lowest mean of egg diameter is recorded. This mean grows higher towards November and December and thence to January of the following year.

In addition, the presence of three or four groups of yolky eggs in the ovary of *S. undosquamis* shortly before the spawning season allows one to conclude that this species is a fractional or portional spawner and has a stretched spawning season. The eggs of these groups have progressively decreasing diameters. In other words, the egg diameter of the first group of eggs is greater than that of the second and so forth. As well-known, when the eggs of the first or oldest generation are discharged, those of the second proceed to complete maturity and thence to ovulation and so on (Kazansky 1949, Mohammad 1967, ... etc.). However, in the present study, it is not possible to give an idea on the path followed by the ovary or the different groups of eggs during the different periods of the year. The seasonal variation of the ovary as well as the vitellogenesis of the eggs of the various groups inclined for discharge in a spawning season will be the subject of a forthcoming contribution.

Fecundity represents an item of common examination in the study of reproduction of fishes and is defined as the number of ripening eggs in the ovary prior to the next spawning period. In general, two terms are applicable in the study of fecundity of fishes. The first is the absolute fecundity and involves examination of the actual number of ovarian ripe eggs. The second is the relative fecundity and is defined as the number of eggs for unit length or weight of fish. On the whole, the fecundity, whether absolute or relative, varies not only in the different species, but also in the same species in the different years or different environmental conditions (Hickling 1940, Nikolsky 1965, etc).

In *S. undosquamis* the relation between the fecundity and length, weight, or age of fish is studied. Thus, for a given length or age, there is a wide range of fecundity, but in general, the average fecundity showed a straight line relationship with the different variables of length, weight or age. By applying the method of least squares, the relation of the fecundity and length is described by the equation: $Y = -65.45 + 4.55\ X$ (where Y = the number of the oldest eggs in thousands, X = the length of fish in cms.). For the fecundity-weight relationship, the equation $Y = -1.58 + 0.368\ X$ (where Y = the number of the oldest eggs in

thousands and X = the weight of fish in gms.) is established. It is worth-mentioning, that the number of eggs as related to the length, weight or age of the specimens examined is found progressively increasing. The decline in the egg production in the older fishes it no longer observed. This allows one to conclude that the oldest fishes here examined do not represent the senility age where the decrease in egg production takes place (Nikolsky 1963, 1965). The present idea agrees reasonably well with the afore-mentioned conclusion that the longivity of *S. undosquamis* may be more than that shown by the oldest fish specimens (IV age-groups). Besides, in *S. undosquamis* a straight line relationship apparaently exists between the length of fish and the relative fecundity (R.F.) designated as the number of eggs per 1 cm. of body length. On the other hand, the relative fecundity designated as the number of eggs for 1gm. body weight is apparently constant, and it is therefore possible to assume that this can be considered as specific for this species. It seems therefore, reasonable that this relative fecundity is connected with the nature of the eggs delivered. In other words, R.F. is higher in the species delivering pelagic eggs than in those laying demersal eggs. In *S. undosquamis*, the R.F. is higher than that of species laying demersal eggs and mouth-breeders as *Tilapia nilotica* (Mohammad 1967). On the whole, the general peculiarities of the egg of the present studied species will be discussed in the future study.

As is formerly mentioned, the female of *S. undosquamis* lay three or four portions of eggs in one spawning season. It was not possible to estimate the total fecundity, as the sum of the number of eggs of the different portions. This difficulty was overcome by estimating the proportionality coefficient or the percentage of the number of eggs of the first portion of the total number of eggs produced. On the average, the first portion constituted about 33.55 % of the eggs produced in a spawning season, and this percentage ranged from 22.3 to 45.6 %. On this account, *S. undosquamis* of the Gulf of Suez is different from the other species of the temperate regions as *Vimba bimba vimba carinata* where the first fraction constituted more than 50% (Tarnavsky 1965, Moroz 1965). Such a difference may be due to the differences in the environmental conditions between the subtropical and temperate regions. In other words, in the former region, the period of the comparatively high temperature is much longer than in the latter, a character which apparently assures the ability of the fish to lay its eggs. On the other hand, in the temperate regions as soon as the suitable temperature prevails, the females discharges the major part of the eggs as the first portion and if the conditions remain suitable the following portions are, as well, discharged in subsequent stages.

Fishes of different species attain their first sexual maturity at different lengths or ages. Thus, some species are mature in the first year of their life, while others are so after a longer period which may reach 20 years in the white sturgeon *Huso huso* (Nikolsky 1963, 1965, Roussow 1957, ... etc.). Besides, under different ecological conditions, one and the same species may become sexually mature for the first time at different lenghts or ages. In *S. undosquamis*, the average of the gonad index of females 14.0 cm. long or more is comparatively high in April, May and June. In turn, among fishes having body lengths 14 and 15 cm. there may be some individuals having immature gonads with low gonad index. but all the specimens 16 cm. long or more show high gonad index. Besides, the age of *S. undosquamis* at first sexual maturity is + 1. Apparently, immature specimens of 14.0 - 14.9 and 15-15.9 cm. intervals show the first sexual maturity in the following spawning season, whence these specimens are of age-group + 2.

Sex ratio designated as the percentage of males and females, is generally dealt with in the study of reproduction in fishes (Bagenal 1957, Al-Hamed 1962, Mckenzie 1964, Bodola 1966, ... etc.). In *S. undosquamis*, the percentage of males in the pre-spawning season behaved differently in 1965 and 1966. Thus, during January through April of the former year there is a gradual decrease in the frequency of the males in the commercial catch, and this decrease extends to May. On the other hand, in 1966 and from January through April there is a gradual increase in the percentage of males, but this is followed by a sharp decrease during May. In general, males are the fewest in this month in both 1965 and 1966. Consequently, among the commercial catches of this fish from the Gulf of Suez, the females show the highest frequency in May. After May, the magnitude of males among the commercial catch are considerable. It is worth-mentioning that such a peculiarity of the sex ratio during the spawning season is different from that recorded in other species (Al-Hamed 1962). It may be possible to assume that in *S. undosquamis*, the faint representa-toin of males among the commercial catch in May is due to the fact that most of the males accompany the females having "ripe" eggs and spawning in areas of irregular bottom inaccessible to fishing by trawlers. It may also be possible to assume that the females with "ripe" eggs accompanied by most of males show "vertical migration" away from the bottom. This if true, results in the low representation of males among the commercial catch. On the whole, the examination of the peculiarities of the mature egg whether sticky or not may throw some light on behaviour or fishes during the spawning season. It is hoped that these points raised in connection with *S. undosquamis* will be clarified in a following work.

V. SUMMARY

1. Maturity stages of gonads are examined according to Hjort scale (1910). Whether in males or females, gonads increase in size towards April, a character accompanied by progressive increase in the frequency of stages III to V, besides a decrease in stages I and II.

2. Gonad index is calculated as percentage of gonad weight to that of the body. G.I. of females is much higher than that of males. Highest G.I. is recorded in May for females, and in March or April for males. Whether in males or females, the highest mean of G.I. is represented in May.

3. *S. undosquamis* has a long spawning season and is a fractional spawning species laying three of four generations of eggs. These generations are closely discriminated through egg diameter estimations. Oldest generation increased in size on the average from about 500 u to about 900 u in diameter from January to April.

4. There was great variation in egg production of fish at any particular length, weight and age of fish.

5. The relation between the number of eggs of the oldest generation with length and weight of fish is described by the formulae ; $Y = -65.45 + 4.55\ X$ and $Y = -1.58 + 0.368\ X$ respectively, (Y = fecundity, X = body length in cms. or weight in gms.) Number of eggs of the first portion ranged from about 13000 to about 75000.

6. Proportionality coefficient (percentage of eggs of first fraction to total production) ranged from 22.3 to 45.6 percent and is on the average 33.55 %.

7. Gonads of fishes between 14.0 - 15.9 cm. in body length, may be mature or immature during spawning season. Those of fish 16.0 cm. long or more in body length are always mature by this period. Most individuals become sexually mature at an age-group of + 1; however, few attain their first sexual maturity at age-group + 2.

8. The frequency of males showed the minimum in May. Explanation of this observation is discussed.

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