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On some aspects of the Biology of *Coilia dussumieri* (Cuv. and Val.)[1]

BY

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(With six figures)

The smaller sized individuals of *C. dussumieri* apparently inhabit shallower and inshore waters, while the larger fish live in deeper and offshore waters. The inshore waters are fished intensively during the monsoons, resulting in a preponderance of fish below a length of 110 mm. in the catch.

Due to the protracted spawning period of the fish, there is no progression of modes in the monthly length frequency distributions.

The size at first maturity has been estimated at 131-140 mm.

The sex ratio of 53.41 males: 46.59 females deviates significantly from the 50:50 ratio. Males outnumber females in higher length groups, probably because the females migrate to offshore grounds at a smaller size.

The spawning season probably extends from September to March.

The fish has a protracted spawning period and spawns more than once in each spawning season.

The total number of possible spawnings has been estimated at three, from the ratio of the number of ova in the last batch to the number of remaining maturing eggs.

The ponderal index curve changes slope at 130 mm., considered to be the size at first maturity. There are no regular seasonal variations in the ponderal index.

Fecundity is estimated at 1200 to 4200 eggs per spawning.

INTRODUCTION

Coilia dussumieri is common in the estuaries of Bombay and Orissa. This fish, locally known as *Mandeli*, is very important commercially and is landed in appreciable quantities throughout the year at Bombay. It is fished, along with a variety of other fishes and prawns, in a type of bag-net called the *dol*.

Earlier accounts of the species include skeletal system (Joshi & Bal 1953 *a* and *b*), eggs and early development (Delsman 1932), post-larval stages (Jones & Menon 1952), seasonal changes in the gonad condition

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(Palekar & Karandikar 1953), food and feeding habits, sex composition and length-weight relationship (Bal & Joshi 1956) and food and feeding habits at different growth stages (Bapat & Bal 1950). Verghese (1961) has given an account of the biology of *Coilia borneensis*.

Our knowledge of the reproductive biology of the fish is meagre. Palekar & Karandikar (1953) could only conclude that *C. dussumieri* is an offshore breeder with a protracted spawning period. This paper deals for the first time with the length-frequency distribution, size at first maturity, ponderal index, and fecundity of *C. dussumieri*. It also attempts to define more precisely the breeding season, and the number of spawnings per season, and records the occurrence of spent specimens.

Methods

Samples were collected once a week over a period of one year from October 1963 to September 1964 from commercial landings of the *dol* fishery at Sassoon Docks, Bombay. Altogether 1,567 specimens were examined for the study of length-frequency distribution. Of these 493 male, 430 female, and 230 juvenile specimens were examined to ascertain the state of development of the gonads. Ova diameter frequencies were determined for 125 representative ovaries by Clark's method (Clark 1934). 21 ovaries were used to estimate fecundity by counting directly the number of ova in the last mode from a known fraction of a previously weighed ovary.

Length frequency distribution

The data pertaining to the length frequency distribution of each month are presented in Figure 1 after grouping at intervals of 5 mm.

Monthly length frequency polygons are well marked in Figure 1 and seem to be of two different types. Those of the seven months from October to April show a very similar pattern. During these months a large proportion of individuals fall in the size range 151 to 165 mm. (modal group *a*). The remaining fish are distributed over a wide range, extending from 61 mm. upwards, forming a number of small modes. The distribution in the month of May is similar to that found during the period October-April, except that no fish smaller than 120 mm. was present. The pattern of distribution is different during the four months of monsoon viz. June to September. In these months a modal group is present in the size range 151 to 155 mm. (modal group *a*), but is much less prominent. On the other hand, the proportion of the smaller sized individuals is greater. The size groups 131-135 mm, 106-110 mm. and 126-130 mm. form distinct modes (modal groups *b*), in the months of June, August and September respectively.

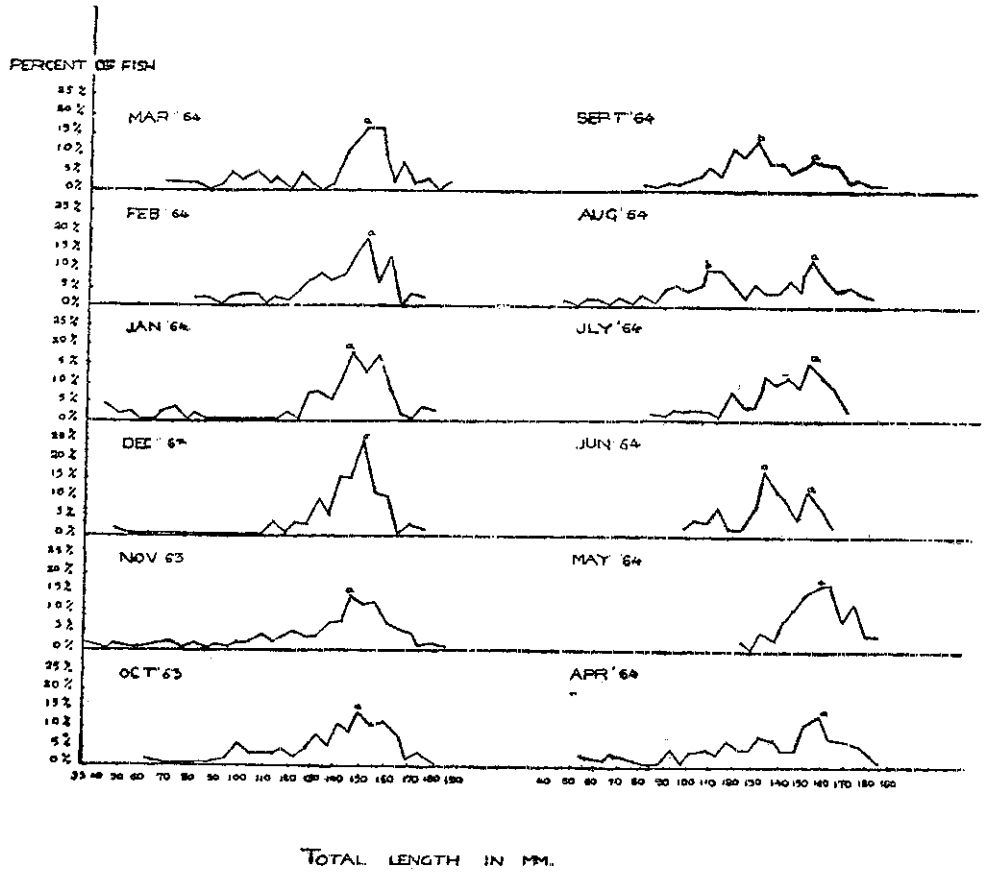

Fig. 1. Length frequency distribution of *Coilia dussumieri*.

Neither the fishing gear, nor the fishermen exert any selective action with respect to the size of the fish caught, as the *dol* net collects even very small fishes including the shrimps *Acetes* and the fishermen retain the entire catch.

Enquiries with local fishermen revealed that the operation of *dol* nets is concentrated in shallow and more inshore waters during the monsoon months. Apparently, *Coilia dussumieri* are distributed with the smaller specimens occurring in shallower waters, closer to the coast, and the larger specimens occurring in deeper waters farther off the coast, as in the case of the classical example of the distribution of Plaice *Pleuronectes platessa* (Graham 1956). As the shallower and more inshore waters are fished intensively only during the monsoon, the smaller sized fish predominate in the catches during these months.

No progression of modes is apparent in the length frequency distribution from month to month. The principal mode falls in the range 151-165 mm. from October to May. A distinct mode occurs in this range during the June-September period as well. That the length frequency

distribution remains without much progress from month to month may be due to the prolonged spawning period of the fish which extends from September to March (see page 63).

Breeding

(a) *Stages of Maturity*

The female *Coilia dussumieri* was distinguished as belonging to five stages of maturity on the basis of the stage of development of intraovarian eggs. These growth stages were designated as (i) Immature, (ii) Maturing, (iii) Ripening, (iv) Ripe, and (v) Spent (Qasim 1957 *a* and *b*, Qayyum & Qasim 1964 *a*, *b* and *c*).

Stage I. *Immature*

Ovaries small, translucent, and elongated; ranging from 10 mm. to 22.5 mm. in length, and containing a large number of small, fully transparent ova without yolk, diameter varying from 0.07472 mm. to 0.1868 mm.

Stage II. *Maturing*

Ovaries granular and somewhat enlarged, ranging from 13 mm. to 36 mm. in length. In addition to the stock of fully transparent, immature ova, a number of maturing ova are also present. These are whitish and opaque, and well supplied with yolk. Maturing ova grow up to 0.7472 mm. in diameter, the average size being 0.5604 mm.

Stage III. *Ripening*

Ovary greyish, flat and densely packed with ova which are clearly distinguishable with the naked eye. Size of the ovary ranges from 19 to 38 mm. in length. Ova large, spherical, and heavily laden with yolk. They develop a narrow perivitelline space after reaching a diameter of 0.08406 mm. They grow up to a diameter of 1.0274 mm. but the majority are larger than 0.5604 mm.

Stage IV. *Ripe*

No fish in ripe condition were present in the samples. Palekar & Karandikar (1953) also failed to encounter any ripe specimens although Bal & Joshi (1956) came across a few fish in this condition.

Stage V. *Spent*

Specimens of *C. dussumieri* in spent condition have not been recorded from Bombay waters before. Four specimens in this condition were obtained during the course of the present investigation. Ovaries flaccid, bloodshot and shrunken, measuring between 26 to 28 mm. in length. In addition to the numerous immature and small maturing ova up to a diameter of 0.5604 mm., the ovaries contained a few large residual ova

of about 1.0 mm. to 1.23 mm. diameter. These were fully transparent with segmented yolk and included 10 to 15 oil globules.

(b) *Size at first Maturity*

For the purposes of determination of size at first maturity, all females with eggs larger than 0.1868 mm. were considered as maturing and classed among fish that would spawn within the next few months. The percentages of females maturing at each length group are given in Table I. The curve was found not to be a normal one when plotted on arithmetic probability paper. Holt (1959) suggests that in such a case the curve should be specified in terms of the median length of attainment of maturity and its interquartile range. The median length of attainment of maturity for *C. dussumieri* is 155.96 mm. and the interquartile range extends from 148.01 mm. to 161.83 mm.

No female *C. dussumieri* smaller than 96 mm. in total length was found to be in maturing condition. Approximately 50% of the fish in the

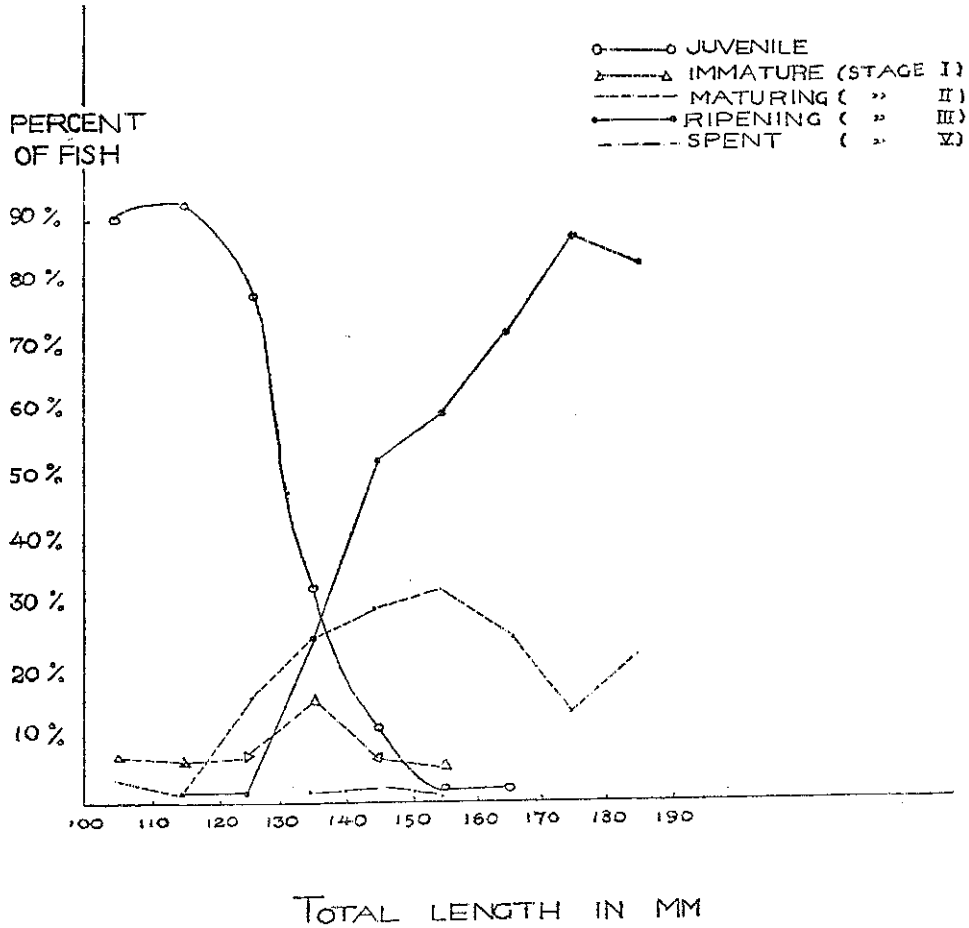

Fig. 2. Percentage of *Coilia dussumieri* at various stages of maturity in different length groups.

TABLE I

THE PERCENTAGES OF FISHES IN STAGE II AND ABOVE OF MATURITY IN EACH LENGTH GROUP

Length groups in mm.	101–105	106–110	111–115	116–120	121–125	126–130	131–135	136–140	141–145	146–150	151–155	156–160	161–165	166–170
Percentage ..	8.7	0	0	5.3	14.3	14.7	41.1	59.6	70.0	88.6	90.6	95.9	88.0	100.0

TABLE II

SEX RATIO IN THE HIGHER LENGTH GROUPS

Length group in mm.	171–175	176–180	181–185	186–190	191–195
Number of Males	32	19	14	4	2
Number of Females	22	9	3	1	0
Percentage of Males	59.3	67.9	82.4	80.0	100.0

size range 131–140 mm. and 90% of the fish at a length of 151 mm. were observed to be in maturing condition.

Figure 2 illustrates the distribution of maturity stages over the length groups at 10 mm. interval. The size range for different stages of maturity are seen to overlap to a considerable extent.

Palekar & Karandikar (1953) consider all fish over a length of 155 mm. as recurrent maturing. However, during the course of the present investigation some fish as large as 167 mm. in length were noted to be in juvenile condition, i.e., possessing undifferentiated gonads whose sex could not be distinguished. These fish had definitely not spawned before. It was not possible to class any fish as maturing for the second or subsequent times.

(c) *Sex Ratio*

Out of the 923 fish sexed, 493 were males and 430 were females. This gives a ratio of 53.41 males : 46.59 females ; this deviates significantly from the 50 : 50 ratio.

Another feature of interest is the steady decrease in the proportion of females in the higher length groups (Table II). In view of the fact that fish in ripe condition were absent in the sample, it would appear that females migrate to areas beyond the normal fishing grounds at a smaller size than males, resulting in a preponderance of the latter in higher length groups.

(d) *Spawning Cycle*

The various stages of maturity for female *C. dussumieri* obtainable in the various months of the year are shown in Table III and Figure 3. Juveniles over 100 mm. in length have also been included in the analysis; 100 mm.

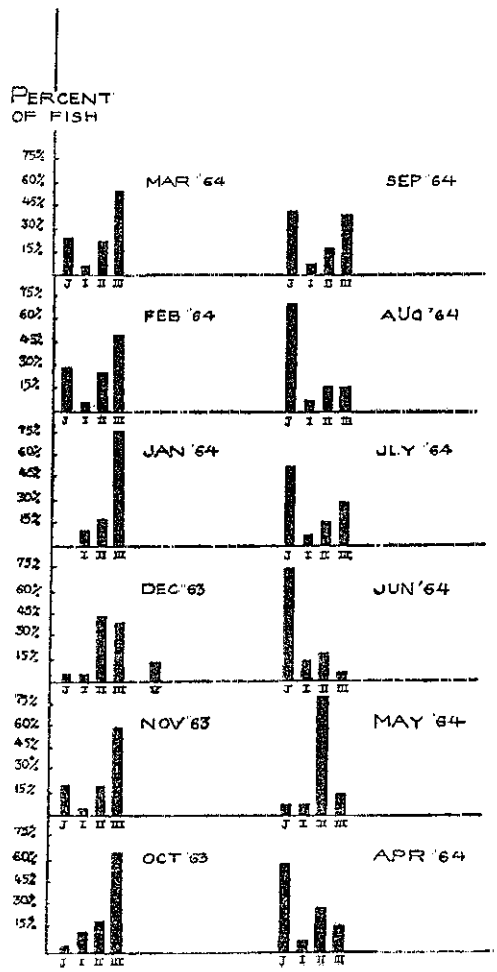

Fig. 3. Percentage of *Coilia dussumieri* ♀ at various stages of maturity in different months.

J—Juvenile; I—Immature; II—Maturing; III—Ripening; V—Spent

TABLE III

NUMBER AND PERCENTAGES OF JUVENILES LONGER THAN 100 MM. AND FEMALES IN VARIOUS STAGES OF MATURITY IN EACH MONTH OF THE YEAR

		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Juvenile	No.	1	23	1	0	7	7	32	1	32	31	48	22
	%	1.4	20.0	3	0	24.2	29.9	55.2	5.9	71.2	51.7	69.6	41.5
Immature Stage I	No.	9	3	1	3	1	2	1	1	5	4	3	3
	%	12.7	2.6	3	9.5	3.3	3.2	3.5	5.9	11.1	6.7	4.3	5.7
Maturing Stage II	No.	14	23	14	5	7	7	15	13	7	3	8	8
	%	19.7	20.0	42.4	16.2	24.2	21.9	25.8	76.5	15.5	4.3	11.6	15.1
Ripening Stage III	No.	47	66	13	23	14	17	9	2	1	3	10	20
	%	66.2	57.4	39.4	74.3	48.3	53.0	15.5	11.7	2.2	5.7	14.5	37.0
Spent Stage V	No.	0	0	4	0	0	0	0	0	0	0	0	0
	%	0	0	12.2	0	0	0	0	0	0	0	0	0

is about the lowest limit at which females could be identified correctly by an examination of the gonads.

The entire absence of ripe and the very rare occurrence of spent fish in the samples studied is of special interest. Probably as has been pointed out by Palekar & Karandikar (1953) and Bal & Joshi (1956), *C. dussumieri* migrates to offshore grounds for spawning. This is further supported by the absence of eggs, larvae, and post-larvae of this fish in the inshore plankton of Bombay waters (Bal & Pradhan 1952).

Ripening (stage III) fish occur in a substantial proportion (39.4% to 74.3%) from October to March. Spent specimens are obtained only in December. The proportion of ripening (stage III) females is much lower in April (15.5%) and May (11.7%). However, it is the juveniles which occur in the largest proportion in April (55.2%), the maturing (stage II) females preponderate in May (76.5%).

It has been noted above (see Length Frequency Distribution) that there is a change in the location of fishing ground during the four months of monsoon, viz. June to September, resulting in the sampling of a different population made up of smaller and, presumably, younger individuals. The data for these four months are, therefore, not directly comparable with the data for the rest of the year. The proportion of ripening (stage III) females is lowest in June (2.2%) and quite low during July (5.7%) and August (14.5%), but rises again in September (37.0%). Palekar and Karandikar (1953) also found the ripening (stage III) fish occurring in low percentages in June, July and August.

The data suggest that the spawning season of *C. dussumieri* may extend from September to March, which months have a high proportion of ripening (stage III) females. The presence of spent fish in December is in agreement with this conclusion. However, in the absence of more direct data from fully ripe specimens or eggs and larvae, no definite conclusions can be drawn.

(e) *Spawning Periodicity*

The stages of maturity in *C. dussumieri* vary considerably among individuals, and generally at any one time of the year fishes at all stages of maturity are commonly seen. In order to demonstrate any periodicity in spawning, the data were grouped according to the location of the largest mode in the diameter frequency of the ova from each fish (Clark 1934 ; Howard & Landa 1958 ; Joseph 1963).

Table IV and Figure 4 show the mean percentage ova diameter distribution of the ova measurements of females grouped into nine classes resulting from this method. Classes B, C, D and E are maturing stage (III) females ; classes F, G, H and J are ripening (stage IV) females, and class

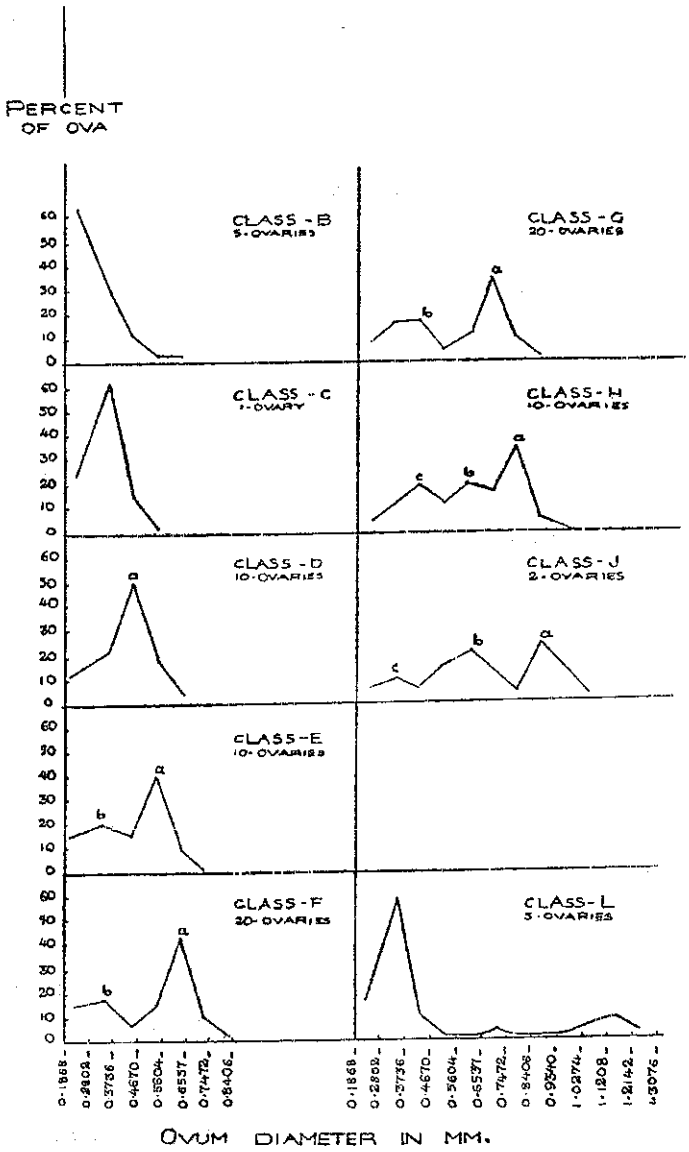

Fig. 4. Size frequency distribution of intraovarian eggs of *Coilia dussumieri* in various stages of maturity.

L belongs to the spent stage of maturity. Ova diameter measurements were not actually carried out from immature females. Eggs smaller than 0.1868 mm., which were present in large numbers, were omitted.

The ova diameter frequency polygons indicate that the fish has a protracted spawning period. The batch of maturing eggs is not sharply differentiated from the general egg stock. Other groups of ova, with distinct modes lying between the general egg stock and the last mode, appear to be progressing towards maturity. This multiplicity of mods in the

TABLE IV

FREQUENCY PERCENTAGES OF OVA DIAMETERS IN VARIOUS CLASSES

Class	B	C	D	E	F	G	H	J	L
No. of ovaries	5	1	10	10	20	20	10	2	3
0.2055 to 0.2802 mm.	60.0	24.0	14.6	14.8	14.8	6.2	3.0	4.7	20.0
0.2989 to 0.3736 mm.	28.7	60.4	19.8	18.3	16.2	15.5	11.4	7.7	55.1
0.3923 to 0.4670 mm.	8.3	14.6	47.8	14.3	5.0	16.2	18.0	5.3	9.7
0.4857 to 0.5604 mm.	1.4	1.0	16.3	39.8	13.0	4.2	11.5	13.6	1.4
0.5791 to 0.6537 mm.	0.2		0.6	10.2	41.7	10.5	2.0	19.5	0
0.6724 to 0.7472 mm.				0.7	8.8	37.6	15.0	11.5	0.4
0.7659 to 0.8406 mm.					0.5	9.5	33.0	2.9	0
0.8592 to 0.9340 mm.						6.3	5.0	22.7	0
0.9527 to 1.0274 mm.							1.1	11.7	1.3
1.0460 to 1.1208 mm.								0.8	4.8
1.1395 to 1.2142 mm.									6.5
1.2329 to 1.3076 mm.									0.8

frequency curves of ova diameters from maturing females suggests that each individual spawns more than once during the breeding season.

An estimate of the total number of possible spawnings may be made from the ratio of the number of ova in the most advanced mode to the number of remaining maturing eggs (MacGregor 1957). This data is presented in Table V. The eggs in the most advanced mode are quite sharply defined in class F and the following classes. In the class F gonads,

TABLE V

PERCENTAGES OF SMALLER YOLKED OVA AND OVA IN THE MOST ADVANCED GROUP (MODE A) IN THE VARIOUS CLASSES

Class	F	G	H	J
% of ova other than included under mode a	33.50	40.0	44.9	63.35
% of ova in mode a	66.50	60.0	55.1	36.65

the eggs in the advanced mode make up 66.5% of the total as compared to 33.5% made up by the remaining maturing eggs. This ratio falls from 66.5% in class F to 60.0% in class G, to 55.1% in class H, and further to 36.65% in class J. Thus, it appears that new eggs are constantly being added to the stock of maturing eggs. Assuming that all the maturing eggs are spawned, the number of possible spawnings may be fixed at a minimum of three, the number of ova in the most advanced mode in class J being about $\frac{1}{3}$ the total number of maturing ova. Since there is no information concerning this ratio in a ripe ovary, no definite estimate of the number of spawnings can be made. It is possible that more ova are added to the stock of maturing ova as the ovary ripens and that this ratio falls below $\frac{1}{3}$. The eggs may then be spawned in more than three batches.

(f) *Ponderal Index*

In the present investigation the ponderal index was calculated by the formula :

$$K = W/L^3 \times 10^7$$

where K = Ponderal Index
W = Weight of fish in gm.
L = Total length of fish in mm.

The values of the ponderal index were pooled in two ways to find the arithmetic means of each size group and of each month. These have been presented in Figures 5 and 6.

Hart (1946) pointed out that since adolescent fish have higher K values than older fish, the variation in the K values at different lengths

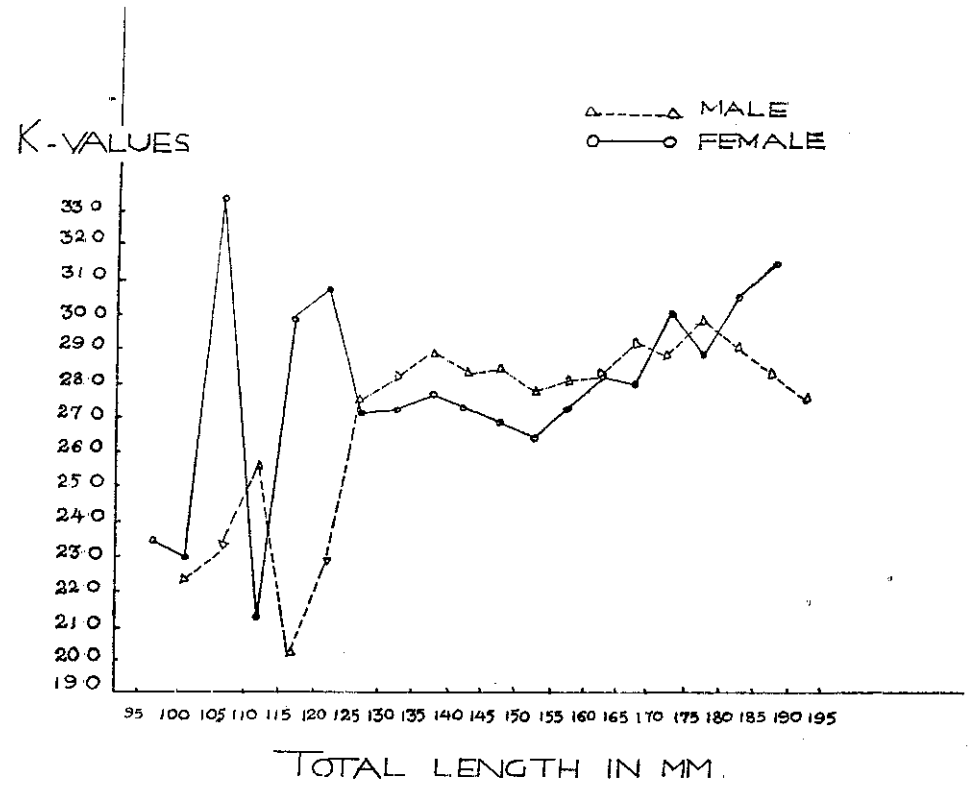

Fig. 5. Mean condition factor (K) of *Coilia dussumieri* at different lengths.

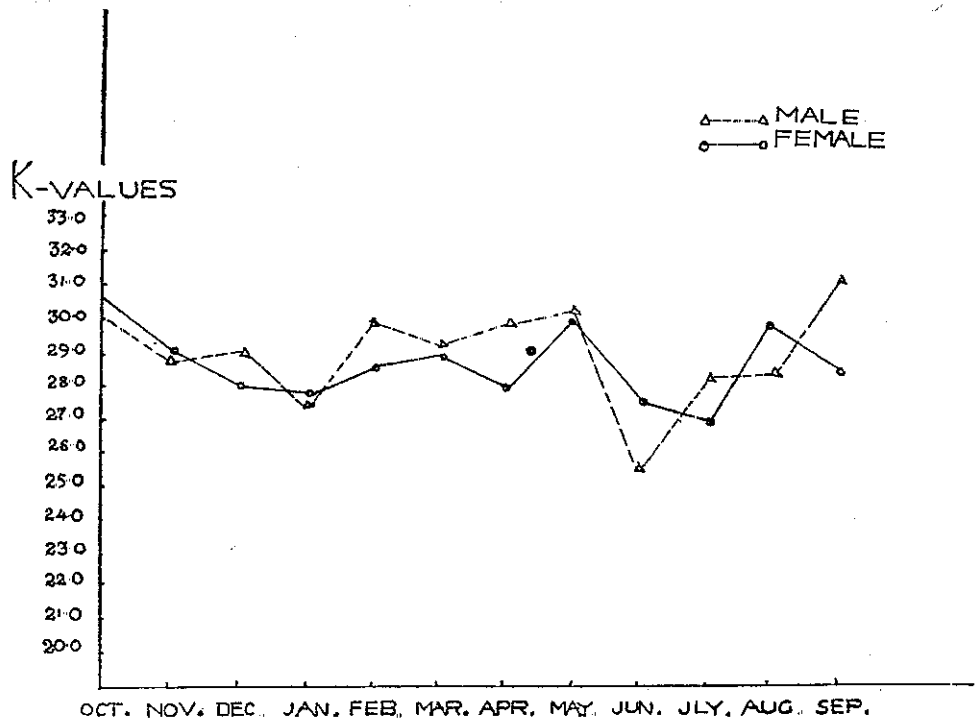

Fig. 6. Mean condition factor (K) of *Coilia dussumieri* in different months.

can be employed to determine the size of first maturity, at which point an inflexion may be expected to occur.

In the present case, there is no point of inflexion in the curve which may indicate the size at first maturity. The values of K seem to be fluctuating without much indication between the 91-95 mm. and 121-125 mm. length groups in both sexes. Thereafter, the fluctuation is within narrower limits. On the basis of gonadial studies, 131-140 mm. was considered to be the size at first maturity in females. The curves for both the sexes change slope at this point, which is more marked in females than in males. One may regard this point as corresponding to the point of inflexion as suggested in *Ophicephalus punctatus*, by Qayyum & Qasim (1964 *a*). The absence of any distinct pattern in K values at various lengths groups may be due to the wide range of size of the fish at various stages of maturity.

Seasonal variations in the ponderal index have been illustrated in Figure 6. As no ripe fish and only a few spent fishes were found, the condition factor may not be expected to record a fall due to metabolic strain consequent upon spawning. The seasonal fluctuations in K values, therefore, do not indicate the spawning season of the fish.

(g) *Fecundity*

Estimates of fecundity from 21 specimens ranged from 1,200 to 4,200. The total number of eggs spawned by each individual in a season may be estimated at 3,600 to 12,600 as the spawning probably occurs thrice during the season. The details of fecundity counts are given in Table VI.

TABLE VI

TOTAL LENGTH, BODY WEIGHT, GONAD WEIGHT AND FECUNDITY ESTIMATES OF 21 SPECIMENS OF *Coilia Dussumieri*

Total length	Body weight	Gonad weight	Fecundity
15.1	10.8	0.127	1191
14.7	8.2	0.368	1556
17.1	13.3	0.678	2033
14.9	16.3	0.408	2047
16.3	12.9	0.928	2150
17.0	12.0	0.435	2234
16.4	12.0	0.516	2267
16.3	11.9	0.598	2361
16.3	13.9	0.717	2407
15.9	12.4	0.545	2450
16.1	11.4	0.633	2480
15.5	9.8	0.470	2508
16.0	11.8	0.601	2535
17.3	15.7	0.964	2682
15.9	10.4	0.490	2715
16.7	13.2	1.068	2743
14.5	10.5	0.713	2760
15.6	12.2	0.725	2888
15.8	17.0	0.458	2899
17.7	16.8	0.942	3004
17.3	16.4	1.1015	4214

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