STUDIES ON THE MATURATION AND SPAWNING HABITS OF SOME COMMON CLUPEOIDS OF LAWSON'S BAY, WALTAIR

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Introduction

Clupeoid fishes, chiefly represented by the sardines (*Sardinella* spp.), the whitebaits (*Anchoviella* spp.), the anchovies (*Thrissocles* spp.) and the rainbow sardines (*Dussumieria* spp.), form an important fishery at Lawson's Bay, Waltair and the catch statistics for a period of seven years (1950–56) show that on an average about 393 tons of these fishes are landed annually constituting about 37·5 per cent. of the total catch. The sardines rank first in importance and form on an average about 22 per cent. of the total catch.

It is common knowledge that fishes exhibit definite spawning periodicities. Based on the principle that the spawning period is short and definite when the batch of transparent and yolkless eggs destined to mature and be spawned will be withdrawn in a single group, sharply distinguishable from the general stock of small eggs and that the spawning period is long and indefinite when there will be no such differentiation between the batch of maturing eggs and the general egg-stock, maturation being a continuous process, many workers have determined the spawning periodicities of fishes by taking diameter measurements of ova from ovaries ripe or in penultimate stage of ripeness (Clark, 1925, 1934; Hickling and Rutenberg, 1936; De Jong, 1940; Palekar and Karandikar, 1952 and Prabhu, 1956). De Jong (1940) advocating systematic observations for a minimum period of one year, is further of opinion that " apart from the time factor the problem of periodicity of spawning of the single individual may be solved with a little luck by the investigation of one specimen". Prabhu (1956) suggests that the observations on the spawning period and its duration, as determined by a study of the intra-ovarian eggs would be more accurate if ova represented by various modes are studied in relation to the different stages of maturity represented by the respective modes in the ova-diameter frequency curves.

Although the different aspects of biology of clupeoid fishes from both the coasts of India are dealt by Devanesan, 1932; Devanesan and Chacko,

1944; Chacko, 1946 and 1949; Chidambaram and Venkataraman, 1946; Devanesan and Chidambaram, 1948; Sekharan, 1955 and Venkataraman, 1956, very little is known about the biology of these fishes from the Andhra Coast. Only recently Ganapati and Rao (1957) have given an account of the bionomics of *Sardinella gibbosa* off Waltair Coast along with notes on the maturity and spawning of the fish. The present investigation on the spawning habits of *Sardinella gibbosa* (Bleeker), *Thrissocles mystax* (Bloch and Schneider), *Thrissocles dussumieri* (Valenciennes), *Anchoviella commersonii* (Lacépède), *Anchoviella heterolobus* (Rüppell) and *Dussumieria hasselti* Bleeker, some common clupeoids of Lawson's Bay, was undertaken with a view to determining the spawning periodicities of these fishes based on ova-diameter measurements.

Material and Methods

Material for this study was collected during July 1956 to August 1957 from the commercial catches at Lawson's Bay. The fishes were brought to the laboratory in as fresh a condition as possible and the ovaries were removed, fixed in 10 per cent. formalin and allowed to harden for several days before ova measurements were taken. As there was no difference in the distribution of different size groups of ova in the different parts of the ovary, small bits of samples from the middle region were teased out and spread uniformly on a slide and ova-diameters were measured by means of an eye-piece micrometer fitted in a compound microscope at a magnification giving a value of $19{\cdot}6\,\mu$ to each micrometer division. In order to avoid selection of the longest or the shortest diameter in measuring the ova, the method adopted by earlier workers like Clark (1925, 1934), De Jong (1940) and Prabhu (1956) was followed. In *Anchoviella commersonii* and *Anchoviella heterolobus*, the ova were peculiar in that they were elongated and in the former they were also provided with a knob at one end. In these cases, the measurement of the longer axis of the ova was taken.

Four to ten ovaries of each species in different stages of maturity were utilised and diameters of 1000 ova from each ovary were measured. Ova less than 5 mic.div. were not measured since they were present in large numbers in the ovaries at all stages of maturity. In drawing the frequency polygons the diameter frequencies were grouped into 2 micr.div. groups as 5–6, 7–8, etc. The 5–6 micr.div. group included all ova measuring 5 micr.div. and ova between 5 and 7 micr.div. Similarly 7–8 micr.div. group consisted of all the ova measuring 7 micr.div. and ova between 7 and 9 divisions. The 5–6 micr.div. group is not shown in the graph since it formed a very high percentage and its omission did not affect the nature of the curves and their interpretation.

TABLE I

The classification of intra-ovarian eggs in different species

Stages of ova	State of maturity	Appearance of ova under microscope	Diameter range of ova in various stages (Range of longer axis of the ova in *Anchoviella commersonii* and *Anchoviella heterolobus*)					
			Sardinella gibbosa	*Thrissocles mystax*	*Thrissocles dussumieri*	*Anchoviella commersonii*	*Anchoviella heterolobus*	*Dussumieria hasselti*
Stage A ..	Immature	Very small, transparent and yolkless ova and semitransparent ova with yolk formation seen only at the periphery.	1–7 micr. div. (0·019–0·13 mm.) 7–11 micr. div. (0·13–0·21 mm.)	1–17 micr. div. (0·019–0·13 mm.) 7–15 micr. div. (0·13–0·29 mm.)	1–12 micr. div. (0·019–0·23 mm.)	1–12 micr. div. (0·019–0·23 mm.)	1–14 micr. div. (0·019–0·27 mm.)	1–12 micr. div. (0·019–0·23 mm.)
Stage B ..	Maturing	Yolk formation has taken place in the ova. Ova small, semiopaque, a central semitransparent area can be made out.	11–17 micr. div. (0·21–0·33 mm.)	15–20 micr. div. (0·29–0·39 mm.)	12–20 micr. div. (0·23–0·39 mm.)	12–20 micr. div (0·23–0·39 mm.)	14–18 micr. div. (0·27–0·35 mm.)	12–20 micr. div. (0·23–0·39 mm.)
Stage C ..	Maturing	Medium-sized opaque ova.	17–22 micr. div. (0·33–0·43 mm.)	20–28 micr. div. (0·39–0·54 mm.)	20–28 micr. div. (0·39–0·54 mm.)	20–40 micr. div. (0·39–0·78 mm.)	18–26 micr. div. (0·35–0·50 mm.)	20–34 micr. div. (0·39–0·66 mm.)
Stage D ..	Maturing	Large-sized opaque ova, densely packed with yolk.	22–31 micr. div. (0·43–0·60 mm.)	28–44 micr. div. (0·54–0·86 mm.)	28–39 micr. div. (0·54–0·76 mm.)	40–57 micr. div. (0·78–1·12 mm.)	26–34 micr. div. (0·50–0·66 mm.)	34–49 micr. div. (0·66–0·96 mm.)
Stage E ..	Mature	Large transparent ova free from the follicle. Yolk vacuolated or segmented. Without oil globule in the case of *T. mystax*.	..	44–58 micr. div. (0·86–1·13 mm.)	..	..	..	..

The maturity scales adopted by the International Council for the Exploration of the Sea have been followed in determining the stages of sexual maturity of the ovaries. The intra-ovarian eggs are classified as stage A, B, C, D and E according to their size and nature of yolk formation (Table I).

Maturation and Spawning Habits

1. *Sardinella gibbosa* (Bleeker)

Sardinella gibbosa, locally known as *Kavallu*, is a small-sized sardine growing to a size of about 16·0 cm. and is one of the two common species of sardines forming a major fishery at Lawson's Bay. Good catches of this fish are obtained from November to April and poor catches during May, June and July. Maturing specimens of *S. gibbosa* were collected from February to May. No fully mature specimen was collected during the course of this investigation. Ovaries from 8 specimens of this species were taken for ova-diameter measurements.

Figure 1 gives three different stages of development of ova in the ovaries of this species. In *A* is shown the frequency polygon of ova in an ovary

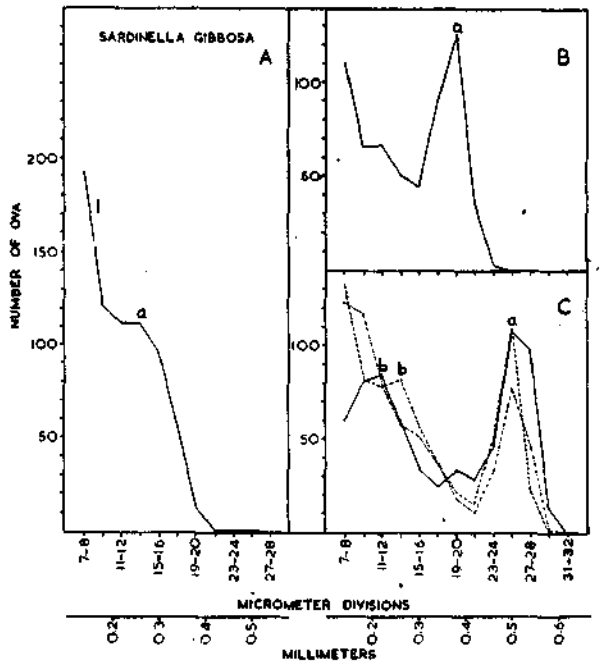

Fig. 1. Ova-diameter frequency polygons of *Sardinella gibbosa*.

which is in an early stage of maturity (Stage II). There is a low mode *a* at 13–14 micr.div. formed by the small maturing ova in Stage B. This gives an indication of the withdrawal of a batch of eggs from the general egg-stock for maturation. In *B* this batch of eggs has developed further. There is a distinct mode at 19–20 micr.div. and ova forming this mode are in Stage C. *C* shows the frequency polygons of ova in the ovaries of three specimens in Stage IV of maturity. There is a distinct mode *a* at 25–26 micr.div. in all the three polygons. It can be seen that the mode at 19–20 micr.div. in *B* has shifted to this mode at 25–26 micr.div., thereby showing a further increase in the size of the ova. The group of ova forming this mode is in Stage D and this is the batch of ova that will ripen and be spawned in the ensuing season. Besides the mode *a* there is a low peak *b* formed by the ova in Stages A and B. As the batch of big maturing ova, represented by a clearly defined mode *a*, is sharply separated from the rest of the stock of eggs, the spawning is strictly periodic in the individuals of this species. It is not likely that the small maturing ova included in mode *b* will ripen and be spawned in the same season as they are only in Stage B. Since there is only one mode formed by the big maturing ova and as they are sharply separated from the rest of the stock of eggs, spawning in this species is restricted to a definite period and most probably each individual spawns only once during each season. Similarity in the pattern of curve of frequency polygons of ova from the ovaries of three different individuals in the same stage of maturity probably shows that there is no variation in the periodicity of spawning between individuals of the species (Fig. 1 C).

Specimens of *Sardinella gibbosa* in Stage IV of maturity occurred in the catches during the period February to May and continued to appear in June and July in very small numbers. The peak period of occurrence of these specimens was in February and March. No mature fish in Stages V and VI was collected during this period and most probably this sardine after attaining Stage IV of sexual maturity, migrate for the purpose of spawning farther from the coast beyond the present fishing grounds (Ganapati and Rao, 1957). Based on the occurrence of fishes in Stage IV of maturity, it can be said that the spawning season commences in February and extends up to June, with the peak period of spawning from February to April. Further evidence that spawning takes place during this period is given by the occurrence of juveniles ranging in size from 2·6–8·5 cm. in the catches during March, April and May.

2. *Thrissocles mystax* (Bloch and Schneider)

Thrissocles mystax is the common anchovy caught at Lawson's Bay. Locally known as *porava*, it is fairly large, attaining a length of about

21·0 cm. It is landed during the period February to October, with heavy catches in February and from July to September. Specimens in Stage IV of maturity occurred in the catches from January to March and in August, and fully mature specimens were taken during January, June and August. During the rest of the period immature fish occurred. Ova-diameter measurements were taken from the ovaries of 10 specimens.

Figure 2 gives a clear picture of different stages in the development of the ova in the ovaries of *Thrissocles mystax*. *A* represents the frequency

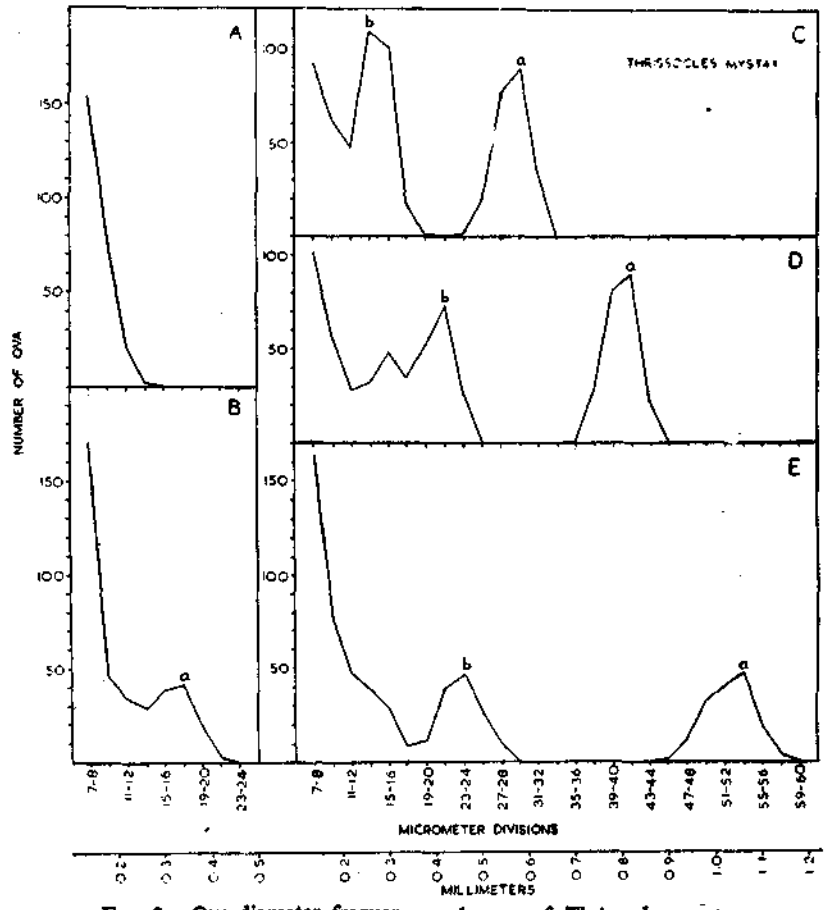

FIG. 2. Ova-diameter frequency polygons of *Thrissocles mystax*.

curve of a very young ovary where all the ova are immature. Even though there are a few larger ova measuring 7–14 micr.div. with evidences of yolk formation, withdrawal of a batch of eggs from the general egg-stock is not indicated. In *B* there is a distinct batch of eggs in Stage B, separated from

the general egg-stock and represented by the mode *a* at 17–18 micr.div. *C*, *D* and *E* show the further development of this maturing batch of ova. In *C* can be seen two successive batches of ova widely separated from one another, undergoing maturation. The mode *a* in *B* can be followed here at 29-30 micr.div. showing the further development of the first batch of maturing ova. The second mode *b* is formed at 13–14 micr.div. indicating that a second batch has been withdrawn from the general egg-stock. *D* is the frequency polygon of ova from the ovary in Stage IV of maturity. The same pattern of curve as in *C* is seen with the difference in the position of the modes, showing an increase in the size of the ova. The mode *a* is at 41–42 micr.div. and the ova forming this mode are in Stage D. The second mode *b* is at 21–22 micr.div. and the ova forming this mode are in Stages B and C. In *E* the frequency polygon of ova from a fully mature (Stage VI) ovary is indicated. Mode *a* is at 53–54 micr.div. and ova forming this mode are fully mature in Stage E. The mode *b* which lies at 23–24 micr.div. is formed by Stage C ova. The mature ova in mode *a* are the ones to be spawned in the following season. As they are completely separated from the rest of the stock of eggs, the spawning in this fish is strictly periodic extending over a short period only. The second batch of ova in mode *b* are very small when compared to the mature ova and are not likely to mature in the same period as the first batch of eggs. Here, unlike in *Sardinella gibbosa*, there is a possibility of a second spawning of the individual within a year as there is a second well defined batch of maturing ova (mode *b*).

Specimens of *Thrissocles mystax* in Stage IV of maturity were obtained in January, February, March and August and mature fish in Stage VI were collected in June and August. Hence it is possible to say that the spawning in this species is restricted to a definite short period from June to August and each individual spawns only once in a season. A second spawning appears to take place from December to February, as mature and just recovering spent fishes were collected along with fish in Stage IV of maturity in January. Also juveniles of this species measuring from 4·5–6·9 cm. in length were observed during March and April which suggested that spawning should have taken place during December, January and February.

3. *Thrissocles dussumieri* (Valenciennes)

Thrissocles dussumieri is a small-sized anchovy attaining a length of about 13–14 cm. Good catches of this fish are obtained in February and from June to September. Immature fish were noted throughout the period of occurrence of the fish and maturing fish were obtained in small numbers

from February to August. The ovaries of 5 specimens were examined, for ova-diameter measurements.

Figure 3 *A* gives the frequency curve of ova from an ovary in Stage II of maturity. There is a distinct mode *a* at 15–16 micr.div. which shows the

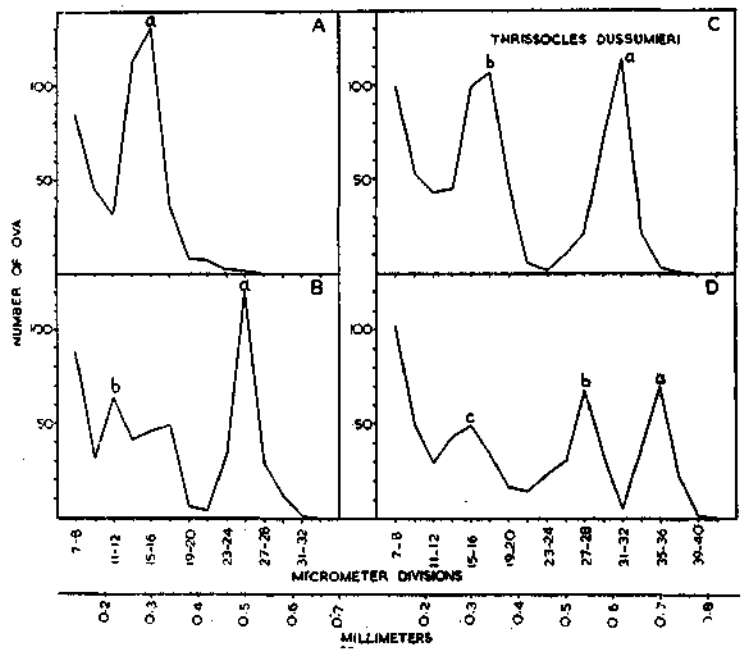

FIG. 3. Ova-diameter frequency polygons of *Thrissocles dussumieri*.

group of eggs withdrawn from the general egg-stock for maturation. The ova forming this mode are in Stage B of development. This mode *a* can be seen in *B* at 25–26 micr.div. and the ova are in Stage C. There is another mode *b* at 11–12 micr.div. formed by the Stage B ova. This is an indication of the simultaneous maturation of a second batch of ova which has been differentiated from the general stock of eggs. These two modes can be followed in *C*. The mode *a* is located at 31–32 micr.div. and ova forming this mode are in Stage D. The mode *b* is now more prominent and the ova are in Stage B. *D* gives the frequency polygon of ova from an ovary in Stage IV–V of maturity with three modes. The mode *a* is at 35–36 micr.div. and the ova forming this mode are the first batch of ova to be shed during the ensuing season. The mode *b* lies at 27–28 micr.div. and the ova included in this mode are nearly in the same stage of development (Stage D) as the ova in mode *a*. The third mode *c* is at 15–16 micr.div. and the ova forming this mode are in Stage B. By the time the first batch of ova at mode *a* is shed,

the ova at mode *b* will shift and occupy the position of *a* by further development and they will be spawned subsequently. The ova at mode *c* are not likely to be spawned during the same season as they are only in Stage B. Most probably they will be spawned in the next season. As the large maturing ova are represented by different well defined modes, it is assumed that the eggs are shed in batches with a definite periodicity. The time taken by the second batch of eggs to be spawned subsequently will be equal to the time required by them to attain maturity which again will be very much shorter than the time taken by the immature ova to attain maturity, as these ova are already well advanced in development. However, the exact time lapse between two successive spawnings cannot be determined by this method of study. Since two batches of eggs are to be shed one after another with an interval of time, it is probable that spawning period for individual fish is of longer duration. Specimens of this fish in Stage IV of maturity were observed from February to August and it can be inferred that the spawning period of this species is a prolonged one extending from February/March to August/September. Small juveniles of size range 3·8–5·5 cm. occurring in the catches in April, May and July, further confirm that spawning takes place during the period February to September. Moreover, from September onwards the fish occurring in the catches were all found to be immature. It is therefore reasonable to assume that this species has a prolonged spawning season, each fish spawning twice in each season.

4. *Anchoviella commersonii* (Lacépède)

Anchoviella commersonii is one of the large-sized whitebaits growing to a size of 13 cm. This species is quite common at Lawsons's Bay though not caught in very large quantities. Ovaries of *A. commersonii* in advanced stages of maturity were collected from March to September. Five ovaries of this species were taken for ova-diameter measurements. The eggs of this fish are peculiar in that they are elongated and provided with a knob at one end. Delsman (1931) also describes ovarial eggs of *Stolephorus commersonii* (*Anchoviella commersonii*) with a terminal knob. In this case, only the length of the ova was measured. All ova measuring above 9 micr.div. (0·17 mm.) are elongated and provided with a knob, while those below 9 micr.div. are more or less round.

Figure 4 *A* shows the frequency curve of ova in an ovary in Stage II of maturity. A batch of ova is seen getting differentiated from the general egg-stock as indicated by the mode *a* at 13–14 micr.div. *B* gives the frequency polygon of ova from an ovary in Stage III of maturity. There is a mode at 37–38 micr.div. formed of the ova in Stage C and another at

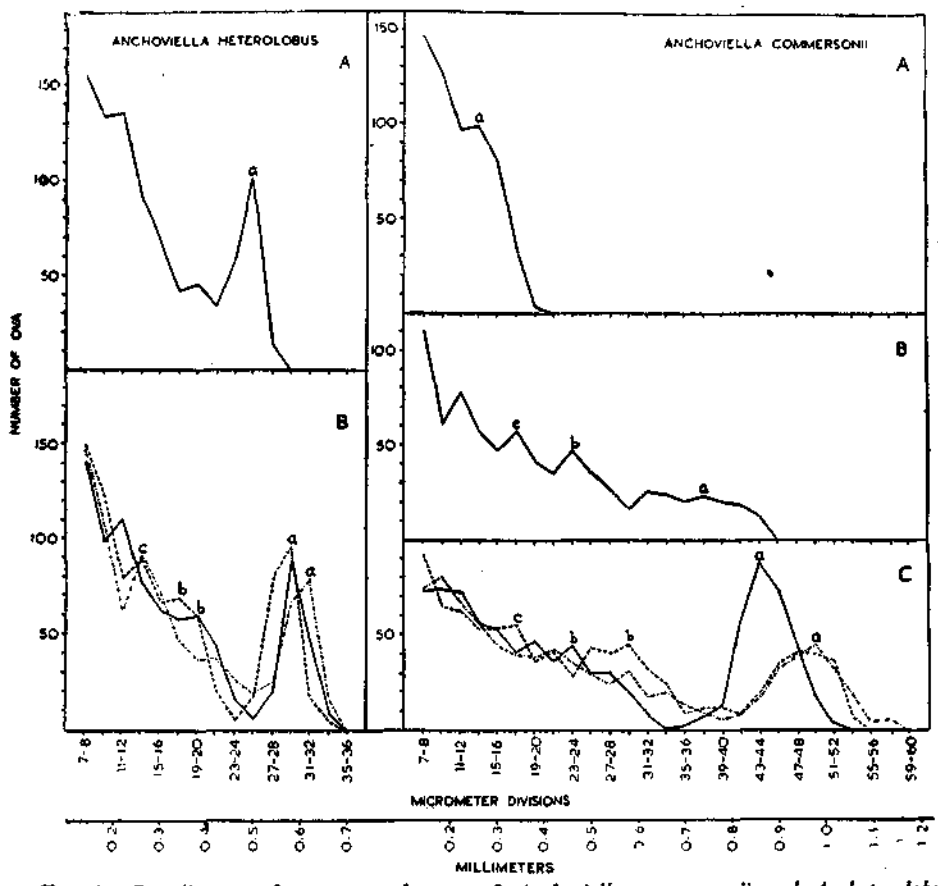

Fig. 4. Ova-diameter frequency polygons of *Anchoviella commersonii and A. heterolobus.*

23–24 micr.div. formed of ova in the same stage, as judged from the nature of yolk formation in them. There is another mode at 17–18 micr.div. The ova forming this mode are in Stage B. *C* gives the frequency polygons of ova from three ovaries in Stage IV of maturity. There is a prominent mode *a* formed by the ova ranging in size from 40–57 micr.div. and they are in Stage D. Besides this group of ova, there are intermediate stages of maturing ova belonging to Stages B and C present in good numbers though not represented by prominent modes. However, a low mode *b* can be seen formed by Stage C ova ranging in size between 26 and 35 micr.div. and another mode *c* formed by Stage B ova. These two groups of ova are not sharply separated from each other. The ova at mode *a* are well defined and separated from the rest of the stock of eggs and these form the first batch of ova to be spawned. By the time the first batch of ova is shed, the ova at *b* will get

differentiated from the rest of the stock and shift to *a*, and they will form the second batch of eggs to be spawned. In the meantime, the ova at *c* will develop further and shift to *b* replacing the ova there. Thus the process of development of ova from one stage to another is continuous. As there is no sharp separation between the maturing ova and the general stock of eggs, and as the maturing groups of ova pass one into another showing continuous process of maturation, the spawning period in this species appears to be long. It can be inferred that this species spawns at regular intervals for a long time.

Specimens of *Anchoviella commersonii* in Stage IV of maturity were collected intermittently throughout the year. Spawning or spent individuals were not collected during the period of investigation. Most probably these fishes have their spawning grounds farther from the coast, beyond the fishing area. This is further confirmed by the fact that pelagic eggs of this species do not occur in the plankton of the inshore waters.

5. *Anchoviella heterolobus* (Rüppell)

Anchoviella heterolobus is another common species of whitebait occurring in small shoals. It is a small-sized fish and the longest specimen collected measures 9·5 cm. Ovaries of 5 specimens of this species were used for this study. The ovarian ova of this fish are also elongated in shape but without a knob. In the case of this whitebait also the length of the egg was taken into consideration. All the ova above 7 micr.div. (0·13 mm.) are elliptical and the rest are more or less round.

In *A* (Fig. 4) which gives the frequency curve of ova from an ovary in Stage III of maturity a well-defined group of ova represented by the mode *a* at 25–26 micr.div. can be seen clearly separated from the general stock of eggs. These ova are in Stage C of development. *B* gives the frequency curves of ova from three different ovaries in Stage IV of maturity. All the three show the same pattern of ova maturation and further development of the maturing group of ova. The mode *a* lies between 25 and 35 micr.div. and is formed by the ova in Stage D. This is the first batch of ova to be spawned. Besides the large maturing ova and the immature ova of the general egg-stock, there are others in intermediate stages of maturity present in large numbers. Though they do not form prominent modes, ova in Stages B and C can be seen represented by low modes *c* and *b* respectively. By the time the ova at mode *a* are shed, the ova at mode *b* can be expected to develop further after differentiating from the rest of the stock, shift to mode *a* and then subsequently be spawned. Meanwhile the ova at *c* will

shift to *b* replacing the ova there. Thus a continuous process of maturation of ova in batches is seen. Specimens of this species in advanced stages of maturity occur in the catches at intervals throughout the year. Hence this species, like *Anchoviella commersonii*, also has a prolonged spawning period and probably spawns intermittently throughout the year.

6. *Dussumieria hasselti* Bleeker

Dussumieria hasselti, locally known as *morava*, is the common rainbow sardine contributing to a good fishery at Lawson's Bay. It is caught throughout the year intermittently and fairly good catches are obtained from November to March and in May. It grows to a size of about 19–20 cm. Specimens nearing maturity were collected during February, March and June. Five ovaries were taken for ova-diameter measurements.

In Fig. 5 *A* is represented the frequency polygon of ova from an ovary in a very early stage of maturity. An indication of the withdrawal of a batch

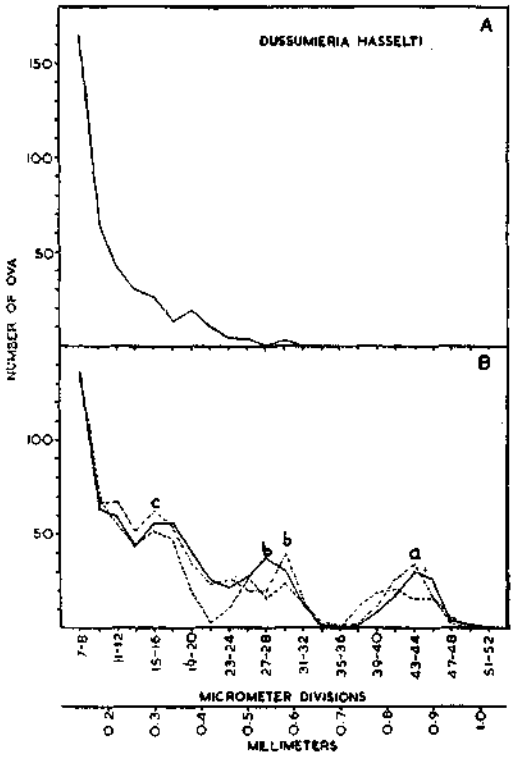

FIG. 5. Ova-diameter frequency polygons of *Dussumieria hasselti*.

of eggs from the general egg-stock can be seen at 19–20 micr.div. *B* gives the frequency curves of ova from three ovaries in Stage IV of maturity. In

all the three, we see three distinct batches of maturing ova represented by the modes *a*, *b* and *c*. Mode *a* is formed by the ova in Stage D, ranging in diameter from 35-49 micr.div. The second mode *b* is composed of medium-sized maturing ova in Stage C ranging in diameter from 21-34 micr.div. and a low mode *c* is formed by Stage B ova ranging in diameter from 13-20 micr. div. The ova at mode *a* are the first batch of ova to be spawned in the following season as they are in Stage D of development. Even before the first batch of eggs are shed, there is a second batch of fairly mature ova (mode *b*) well differentiated from the immature ova. This batch of ova at *b* is likely to be shed subsequent to the spawning of the first batch of eggs indicated by mode *a*. The time interval between two successive spawnings will be equal to the time taken by these ova (at *b*) to mature and this again will be much shorter than the time taken by the immature ova to attain maturity. The ova at mode *c* may not ripen and be spawned during the same season as they are only in Stage B and they may form the first batch to be spawned in the next season. The sharp separation between the successive batches of maturing ova suggests that this species exhibits a definite periodicity in spawning. The time taken by individual fish to spawn probably will be of long duration as two batches of eggs are to be shed one after another with an interval in between. Hence it can be concluded that spawning period is prolonged with the individual fish spawning twice during a season. Since specimens in advanced stages of maturity were collected in February, March and June, the spawning season is likely to occur during this period starting in February and extending up to July.

Conclusions

The present study shows that all the clupeoid fishes investigated exhibit a periodicity in spawning, but the duration and frequency of spawning vary from species to species, similar to conclusions drawn by De Jong (1940) and Prabhu (1956). Three types of spawning are exhibited by the six species of fishes studied.

Type I: Spawning restricted to a definite short period with individuals spawning only once in each season.—This type of spawning is shown by *Sardinella gibbosa* and *Thrissocles mystax*. In the mature or nearly mature ovaries of these fishes there is a single batch of mature or large maturing ova sharply separated from the general stock of small eggs. This type can be further divided into two sub-types, *a* and *b*.

(*a*) *A single spawning season a year.*—This type is represented by *Sardinella gibbosa*. In the ovaries of this fish in Stage IV of maturity, there is only a single batch of maturing ova.

(*b*) *Two spawning seasons a year.*—This type is represented by *Thrissocles mystax*. In the frequency polygon of a fully mature ovary, besides the batch of mature ova, there is a well-developed batch of maturing ova and the former is completely and widely separated from the latter.

Type II: Spawning extending over a long period with individuals spawning twice in each season.—In the nearly mature ovaries of the fishes showing this type of spawning, in addition to the maturing group of large ova, there are two more well-defined groups of maturing ova, one of which is well advanced to maturity and is represented in the frequency curve by a prominent mode not widely separated from the mode formed by the large maturing ova. This type of spawning is shown by *Thrissocles dussumieri* and *Dussumieria hasselti*.

Type III: Spawning throughout the year but intermittently.—This type of spawning is seen in *Anchoviella commersonii* and *A. heterolobus*. In the penultimate stage of maturity, the ovaries of these fishes have several intermediate stages of maturing ova between the immature stock and the large maturing ova. They are not differentiated into well defined groups but they nearly merge with the adjacent ones indicating a continuous process of maturation.

Summary

Spawning habits of six species of clupeoids are given as determined by the ova-diameter measurements from the ovaries, mature or in advanced stage of maturity. Spawning periods for different species based on the occurrence of mature fish or fish in the penultimate stage of maturity are given. The six species of fishes exhibit three types of spawning. (1) *Sardinella gibbosa* and *Thrissocles mystax* have a spawning period of short duration, each fish spawning only once in a season. (2) *Thrissocles dussumieri* and *Dussumieria hasselti* have a prolonged spawning period, each individual spawning more than once in a season. (3) *Anchoviella commersonii* and *Anchoviella heterolobus* spawn throughout the year but intermittently.

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