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Ovary as an Indicator of Frequency of Spawning in Fishes

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In majority of the marine fishes from tropical areas, maturation is a continuous process resulting in the occurrence of mature fishes throughout the year. In several Indian marine fishes, because of multiple spawning, a truly spent fish is scarcely found and also difficult to identify. Instead, partially spent fishes have been reported in a number of cases. As the eggs contained in the ovary are progressively ripened and shed, the ovary itself grows smaller, and to the naked eye, seems to reverse the stages by which it attained full maturity. The ovaries of such fishes, though superficially resemble the normal stages III to V, differ from them in macroscopic appearance as well as microscopic structure to some extent. It occurred to the authors that such partially spent ovaries of fishes yield clues to the frequency of spawning in different species. In the present paper, the occurrence and nature of such ovaries and their relation to the frequency of spawning in two species of ribbon-fishes and a sciaenid have been discussed with supporting evidence from data on other fishes.

Key Words: Ovary as indicator, Spawning frequency

Introduction

Hickling and Rutenberg (1936) have shown that measurement of diameters of eggs in ovaries well advanced towards spawning may give evidence of the duration of spawning in a fish, viz., whether spawning period is short and definite or long and indefinite. In the former case, the batch of transparent, yolkless, small eggs destined to mature and be spawned will be withdrawn from the egg stock in a single group, sharply distinguishable atleast in the later stages of maturation, from the stock of small eggs from which it was derived. In the latter case, the withdrawal of eggs from the egg stock, to undergo maturation, will be a continuous process, and there will be no sharp separation between the general egg stock and the maturing eggs. This method has been widely used for studying the spawning period of several Indian marine fishes (Prabhu 1956, Luther 1963, Venkatasubba Rao 1963, Antony Raja 1964, Raju 1964, James 1967, Venkataraman 1970, Devaraj 1977).

The senior author's experience in the study of maturation and spawning of a few commercially important marine fishes indicated that the ovary, in addition to being an indicator of the short or long spawning period as explained above, could also be used as an indicator of the frequency of spawning as has been pointed out by some authors (Clark 1934, June 1953, Mcgregor 1957, Luther 1973, Devaraj 1977). Evidence in support of this contention is presented in

this paper especially based on studies on maturation and spawning in two species of ribbon-fishes ard a sciaenid, with supporting evidence from data on other fishes. In this connection, the significance of occurrence, nature and relevance of partially spent ovaries to frequency of spawning has been emphasised which have not been taken note of or atleast stressed in earlier studies.

Material and Methods

Material for this study included specimens of two species of ribbon-fishes viz., *(i) Eupleurogrammus intermedius* collected from the Palk Bay and Gulf of Mannar during the period March 1959 to February 1961, and *(ii) Trichiurus lepturus* collected off Mangalore from January 1970 to May 1971 and of the sciaenid *Johnieops osseus* collected along the South Kanara coast from April 1976 to March 1977.

Maturation and spawning of the above mentioned three species were studied by the two conventional methods, viz., recording the seasonal changes in the condition of gonads and the ova diameter frequency distribution in ovaries of different stages of maturity.

Maturity and Frequency of Spawning of *E. intermedius*

Maturity: Fish of maturity stages I to III were present throughout the year except in June. Similarly, fish with ovaries in the most advanced stage of development (Stage IV) were recorded in February, March, April, August, November and December. Partially spent fish (Stage VI A) were recorded from January to May and August to December. Fully spent fish (VI B) were recorded from January to June and August to December. The occurrence of fish in Stage III almost throughout the year and Stage IV in a number of months with simultaneous occurrence of partially spent or spent fish indicates that there is a continuous addition of mature fish every month.

Frequency of spawning: The ova diameter frequency polygon of the most advanced stage of development (IVB) shows a mode of the largest group of eggs at 1.57 mm (figure 1). The second batch of eggs which remained stationary from Stage III A with a mode at 0.34 mm shows little advance in this stage to a mode at 0.43 mm. The ovary, after the extrusion of the first group of eggs returns to a partially spent condition (Stage VI A). The ova diameter frequency polygon of this stage resembles that of Stage III A (figure 1) where, in addition to the three groups of ova typically found in a mature ovary, a few residual eggs are also present. While the absence of residual eggs in the ovaries may not be accepted as a proof that the fish has never spawned, their presence constitutes good evidence that spawning has occurred. The mode of the largest group of eggs falls at 0.62 mm. In the fully spent ovary (VI B), the first group measures a maximum of 0.28 mm and the second group varies in size between 0.28–0.47 mm, with a mode at 0.34 mm. This condition of ovary is expected to result when all the batches of mature ova have been extruded. In

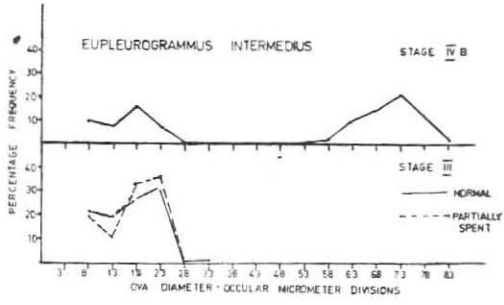

Figure 1

the partially spent ovary, at least one batch of eggs was eliminated which is evidenced by the remains of residual eggs in such ovaries. The second batch of mature eggs which will be spawned in due course has already made its appearance with a mode at 0.62 mm. In the fully spent ovary, all the mature eggs were presumably spawned out and the ovary contains only two groups of eggs, the largest group with a mode at 0.34 mm only. The partially spent ovary returns to spawning state soon after as they contain mature group of eggs whereas the fully spent ovary evidently takes a longer time to return to spawning activity. The presence of these two types of spent ovaries leads to an inference that an individual fish spawns twice, releasing two batches of eggs. The distinct separation of mature group of ova from the maturnig group in the advanced stage of maturity indicates that spawning at a time may be of short duration.

Maturity and Frequency of Spawning of *T. lepturus*

Maturity: Observations on the distribution of maturity stages indicated that mature fish (Stage III and above) and spent fish occur in almost all the months of the year which indicates that the maturation process is a continuous one. Fishes in Stages IV, V, VI and VII were recorded in February, March, April, May, November, December. Samples of fish were not available from June to August since fishing remains suspended during this period due to south-west monsoon.

Frequency of spawning: From the ova diameter frequency curves, it was seen that from Stage III onwards, two groups of ova are present, of which the first group developed faster and gets distinctly separated from the second group. In Stage VI (figure 2) the size range of the largest group of ova extends from 75 to 110 oc.m.d. with a mode at 93 oc.m.d. The wide size range of the largest group of ova in this stage indicates that these ova may ripen and are shed over a long period, probably in spurts, releasing each time a batch of eggs when the ovary comes to resemble the next lower stage (from VI to V, V to IV and IV to III). These partially spent ovaries resemble the normal stages V, IV and III in microscopic structure (figure 2) but differ from them macroscopically, viz., in size, compactness and colour. That these stages were involved in recent spawning is indicated by the occurrence of residual eggs in such ovaries. In Stage VI, the prominent second group of ova found in the previous stages was not represented. Instead, atleast four inconspicuous groups are seen with modes at 63, 48, 28 and 13 oc.m.d. These are expected to be matured and spawned after the ova ranging in size from 75 to 110 oc.m.d. are eliminated, in a similar manner, in batches. The ovary then seems to return to a stage when two modes are present at 38 and 18 oc.m.d. The cycle of maturation repeats again. Thus, in this species, two major lots of ova seem to mature and succeed one

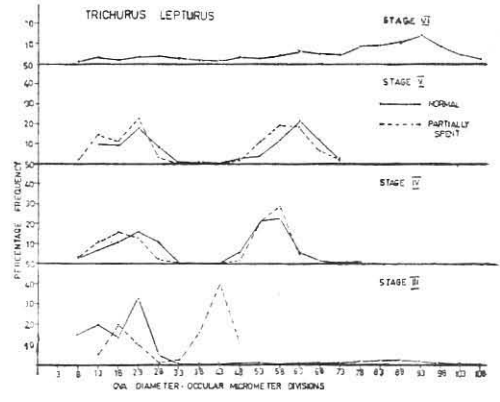

Figure 2

another, each lot being released in atleast three batches, as indicated by the partially spent ovaries resembling Stages III, IV and V (James et al. 1972).

Maturity and Frequency of Spawning of *J. osseus*

Maturity: Fishes in the partially spent condition dominated almost throughout the year. These partially spent ovaries were flabby and collapsed occupying varying amount of space in the body cavity. But they resembled normal Stages III, IV and V in microscopic appearance but different in size, compactness and colour. They could be recognised as distinct from the normal stage only in the fresh condition.

Observations on the distribution of maturity stages from the three localities viz., Mangalore, Malpe and Kulai—Hosabettu indicated that fishes in almost all stages of maturity were found throughout the year. Freely oozing males were observed only at Kulai—Hosabettu in the month of October. Partially spent and fully spent fishes were dominant in all the months except in September and October, indicating spawning throughout the year.

The study on the gonado-somatic index also revealed a difference between these partially spent ovaries and the normal stages. In the case of females, the partially spent ovaries had a gonado-somatic index ranging from 15 to 60 whereas fish with the normal Stage III, IV and V ovaries had a gonado-somatic index of more than 60. The partially spent males had an index of less than 8, while those in normal Stages III, IV and V had an index of more than 8.

Frequency of spawning: In the ova diameter frequency polygon of an ovary in Stage V (figure 3), four batches of ova are demarkated. The most advanced batch of ova is represented by a mode at 0.513 mm.

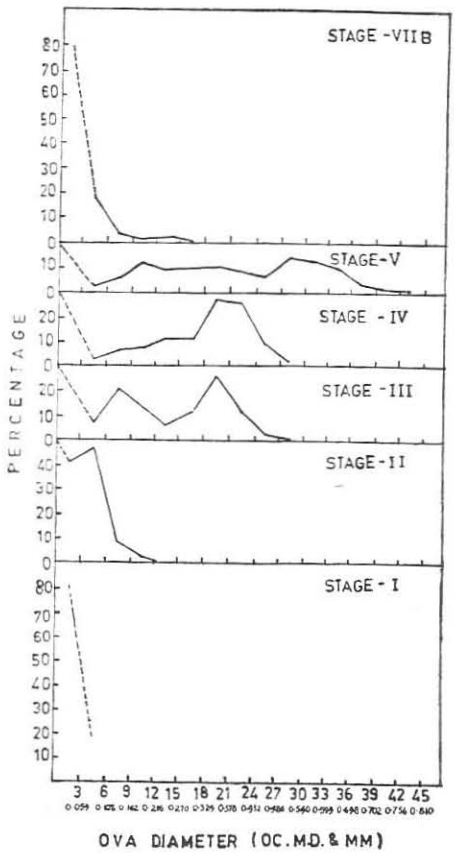

Figure 3

These ova which are transparent with oil globules constitute the batch that would be spawned first. Two more groups of ova with modes at 0.351 mm and 0.189 mm follow this group. The rest of the ova belong to the immature group. The succession of maturing groups of ova indicates that each individual fish spawns more than once. Such a contention is supported by the occurrence of fish in partially spent condition almost throughout the year.

Ovaries in Stage VI have not been recorded in the present study. After the first spawning, the ovaries may attain a condition shown in figure 4A, wherein the

percentage of ova of the most advanced group at 0.567 mm shows a decline. These ova are almost transparent with oil globules, but most of them are shrunken and distorted in shape. These are evidently the residual ova, destined to degenerate. The ovaries show considerable reduction in size. Hence, there may not be a possibility of release of another batch of ova immediately. Such ovaries, on recovery, may attain a condition shown in figure 5A where the largest group shows a mode at 0.351 mm. They are all opaque. Figures 5B and 5C represent further recovery of ovaries as seen by the change in size and characteristics of ova. The opaque ova become vacuolated and form a mode at 0.459 mm (figure 5B) which in turn become completely transparent with oil globules constituting the most advanced group of ova at 0.621 mm (figure 5C). These ova which are ripe, would be the second batch to be spawned. After the release of these ova, the ovaries may indicate a condition shown in figure 4B, where the most advanced group of ova show a minor mode at 0.297 mm. They are mostly opaque but some vacuolated ova may also be seen. It is expected that fish with such ovaries would recover further through the stages mentioned above (figures 5A, B and C) and then spawn a third time. By this time, most of the ova originally withdrawn from the general stock would have been eliminated due to repeated spawning, resulting in a condition shown by the fully spent ovaries (Stage VIIB).

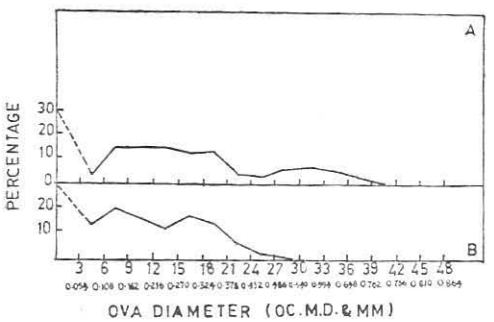

Figure 4

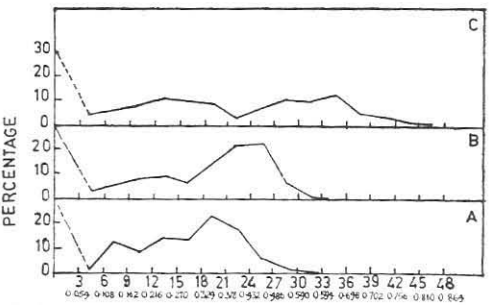

Figure 5

The occurrence of partially spent fishes with ovaries resembling those of virgin fishes in Stages III to V further supports the view that individual fish after each spawning returns to the next lower stage up to Stage III thereby indicating that it has spawned thrice. Based on the above evidence, it can be said that there is a possibility of individual fishes releasing as many as three batches of ova in a year (Baragi 1977).

Discussion

Because of the prolonged spawning habits of the three species dealt with in this account and the consequent release of eggs periodically, in addition to the usual stages of maturity, certain additional stages are met with, which are designated as partially spent. These stages superficially resemble stages III, IV and V, depending on the species. Although they resemble them in microscopic appearance, they differ macros-

copically in size, compactness and colour. Their partially spent nature is confirmed, if not very long after spawning, by the occurrence in such ovaries of residual eggs in various states of degeneration. For, as the eggs contained in the ovary are progressively ripened and shed, the ovary itself grows smaller, and to the naked eye, seems to reverse the stages by which it attained full maturity. Thus, in some fishes, it is possible, the ovary after spawning reverts back from Stage VI to V, V to IV and IV to III, depending on the frequency of spawning. In some cases, it may directly revert from Stage VI to III, this partially spent ovary returning to spawning condition sooner than the fully spent fish, because of the presence of a batch of eggs which has undergone half the maturation process. Therefore, the maturity scale developed primarily for temperate water fishes which have a definite spawning season within which the stages of maturity are fairly uniform throughout the population at any one time (Hjort 1910, Graham 1924, Hickling 1930) is not suitable for tropical fishes in which successive batches of ova are developed for multiple spawning (Clark 1934, June 1953, Yuen 1955, Yuen & June 1957 and Qasim 1973). In such fishes, the maturity scale should be based more on the modal positions of different batches of ova.

In order to reveal the natural sequences in the origin, growth and spawning of the different batches, the ova-diameter frequency polygons of as many fishes as possible from the population may be studied, compared and like-moded polygons pooled to arrive at a natural series of finer maturity stages in a progressive order. Inferences as to all or a few or none of the preceding batches of ova would be spawned can be drawn from this series. Supporting evidences for the inference can be sought for from (i) the ratio of the number of all smaller yolked ova to the number of ova in the most advanced batch to find out the number of batches of ova spawned and (ii) presence of residual eggs as done by Clark (1934) and others. Applying these model concepts, Devaraj (1977) found that the king seer *(Scomberomorus commerson)*, spotted seer *(S. guttatus)* and streaked seer *(S. lineolatus)* pass through more then 12, 10 and 12 finer maturity stages respectively (designated from A upwards) spawn 2.27, 2.23 and 2 batches of ova respectively, begin to develop the second batch of ova at E, C and B stages respectively, spawn the first batches at L, H and J stages respectively and the second batch at L plus, J and L stages respectively (figures 6, 7 and 8). Based on a time-batch model for a year, fitted after the concept of the Petersen's method of age determination, Devaraj (1977) found the time taken from the onset of maturity to the spawning of the first batch of eggs and also the time interval from the spawning of first batch to the spawning of second batch in seer fishes.

Clark (1934) pointed out that, if only one batch is spawned, the ratio between the number of eggs in the maturing group and the number of eggs in the mature group should remain constant and on the other hand, if more than one batch is spawned, the ratio gradually decreases. Based on this principle, she proved that individual California sardine spawns an average of three batches. For infering multiple spawning, she provided four lines of evidence viz., multiplicity of modes in the ova diameter frequency curves, a high degree of correlation between the growth of successive groups of eggs, occasional presence in the ovary of a few ripe, unspawned eggs and the decrease in ratio of the number of eggs in the maturing group and the mature group as the breeding season advances. June (1953) also used

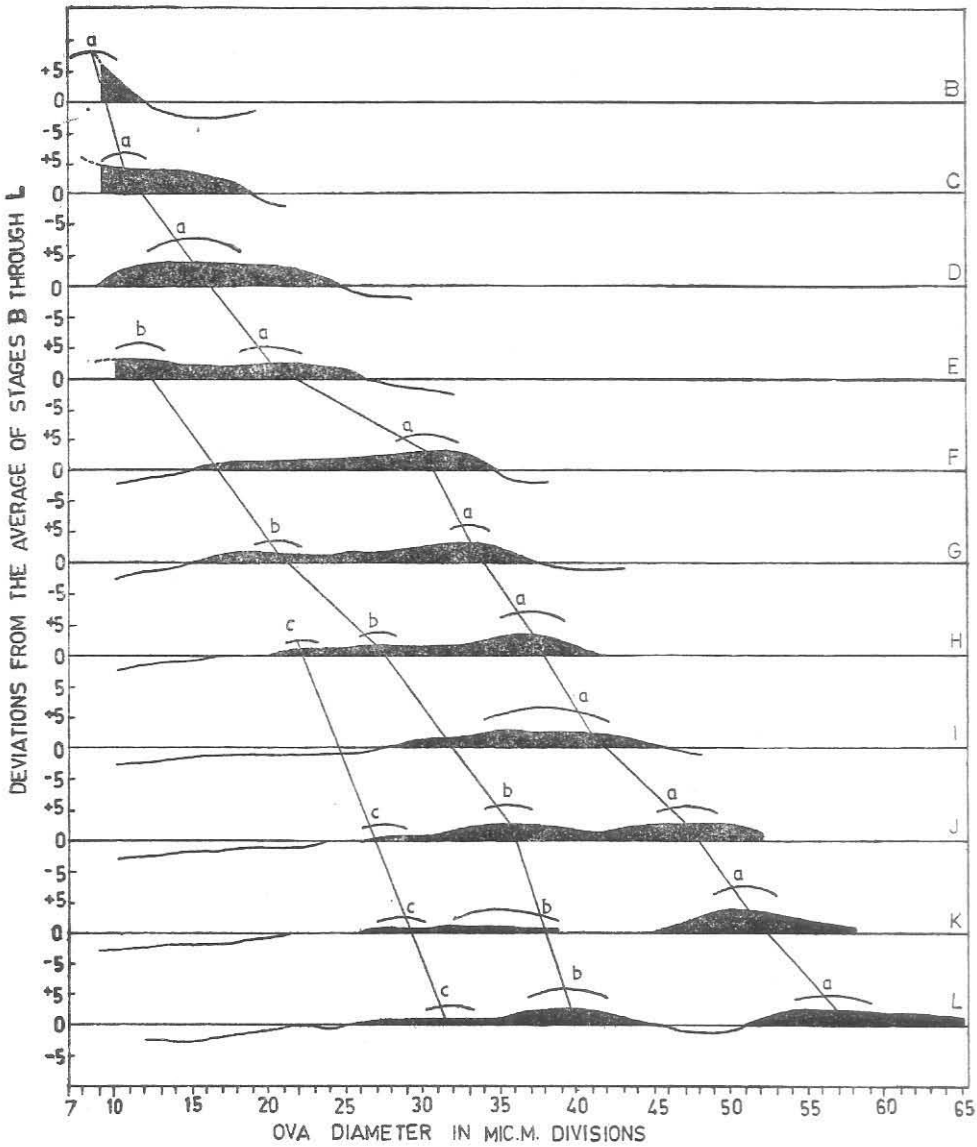

Figure 6

these evidences for the study of the spawning habits of the yellowfin tuna, *Neothunnus macropterus*. Though he stated that the fish spawns more than once in a breeding season, the number of batches have not been estimated. Raju (1962) stated that the skipjack *(Katsuwonus pelamis)* in Minicoy waters has fractional multiple spawning providing evidences on similar lines as Clark (1934). McGregor (1957) pointed out that presence

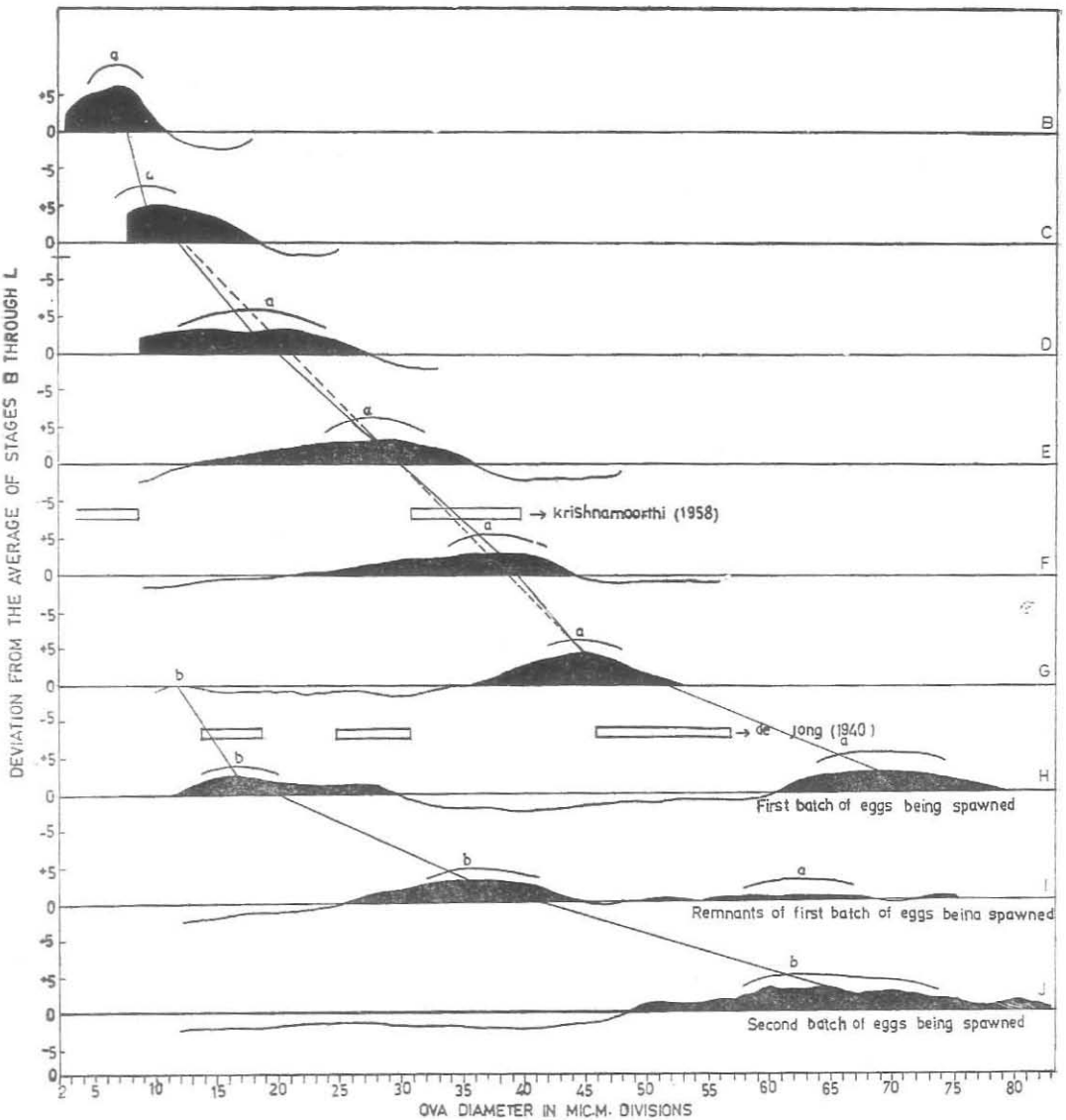

Figure 7

of different size groups of yolked ova in the developing ovaries of any species of fish is an indication of multiple spawning. Luther (1973), based on ova diameter studies, found out that three batches of ova are shed by the Indian mackerel (*Rastrelliger kanagurta*) from Andaman islands. Dhulkhed (1967) expressed the view that eggs of the more advanced mode in oil-sardine *(Sardinella longiceps)* show differential ripening and

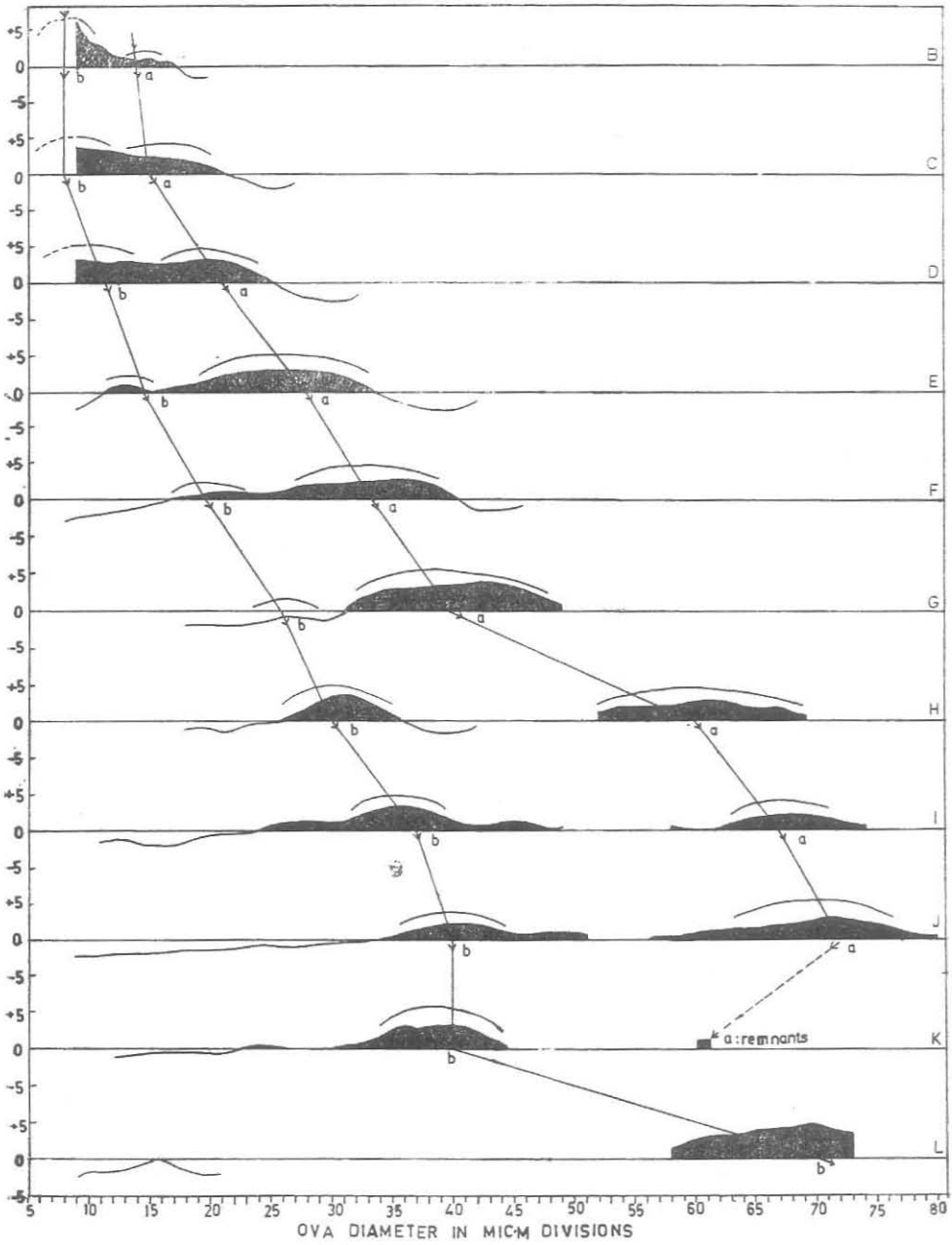

Figure 8

consequently are released in three to four batches during the season.

Thus, while some attempts have been made to study the frequency of spawning and the number of batches released by some Indian marine fishes which are multiple or fractional spawners, the classification of maturity stages itself in a majority of species already studied seems to be confusing. Individual species to appear differ greatly from one another in this respect, as shown in the three examples for which data are presented here. The retrogressive progression of an ovary after spawning in multiple spawners need as much careful recognition and classification as the progressive development of ovary to maturity. In addition, the sequential development and progression of different modes in the ovadiameter frequency curves have to be followed in finer series covering all possible stages a fish might pass through in order to find the time from the onset of maturity to the first batch and to fix the number of batches as well as the interval of time between batches of eggs spawned in a season.

References

Anothy Raja B T 1967 Some aspects of spawning biology of Indian Oil-Sardine, *Sardinella longiceps* Val; *Indian J. Fish.* (1964) **11A** 45–120

Baragi V M 1977 Biology of *Johnieops osseus* (Day) with notes on the sciaenid fishery of the South Kanara coast; *M.F.Sc. Thesis, Univ. Agri. Sci. Bangalore* 277 pp

Clark F N 1934 Maturity of the California Sardine (*Sardina caerulea*), determined by ova diameter measurements; *Calif. Div. Fish. Game, Fish Bull.* **42** 1–49

Devaraj M 1977 The biology of and fishery for the seer fishes of India; *Ph.D. Thesis. Madurai University*, Madurai 357 pp

Dhulkhed M H 1967 Observations on the spawning behaviour of Indian Oil-Sardine, *Sardinella longiceps* Valenciennes determined by ova diameter studies; *Indian J. Fish.* (1964) **11A** 371–376

Graham M 1924 The annual cycle in the life of the mature cod in the North Sea; *Fishery Invest. Lond. Ser.* 27 1–77

Hickling C F 1930 The natural history of the hake Pt. III. Seasonal changes in the condition of the hake; *Fishery Invest., Ser.* 2 **12** 1–78

—— and Rutenberg E 1936 The ovary as an indicator of spawning period in fishes; *J. mar. biol. Ass. U.K.* **21** 311–317

Hjort J 1910 Report on herring investigation until January 1910; *Publs Circonst. pern. int. Explor. Mer* **53** 1–36

James P S B R 1967 *The ribbon-fishes of the family Trichuridae of India. Memoir* 1, 226 pp. Marine biological Association of India

——, Gupta T R C, Shanbhogue S L 1972 Present status of the ribbon-fish fishery of India, with special reference to the biology of *Trichiurus lepturus* Linnaeus; *J. mar. biol. Ass. India* (Press)

June F C 1953 Spawning of yellowfin tuna in Hawaiian waters; *U.S. Fish and Wild. Serv. Fish. Bull.* 148 **59** 287–305

Luther G 1963 Some observations on the biology of *Liza macrolepis* (Smith) and *Mugil cephalus* Linnaeus (Mugilldae) with notes on the fishery of grey mullets near Mandapam; *Indian J. Fish.* **10** 642–666

—— 1973 Observations on the biology and fishery of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) from Andaman islands; *Indian J. Fish.* **20** 425–447

McGregor J S 1957 Fecundity of the Pacific sardine (*Sardinops caerulea*). *U.S. Dept. Interior, Fish* and *Wild Life Service, Fish. Bull.* 121 **57** 427–449

Prabhu M S 1956 Maturation of intra-ovarian eggs and spawning periodicities in some fishes; *Indian J. Fish.* **3** 59–90

Qasim S Z 1973 An appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters; *Indian J. Fish.* **20** 351–371

Raju G 1964 Studies on the spawning of the Oceani skipjak *Katsuwonus pelamis* (Linnaeus) in Minicoy waters. *Symposium on scombroid fishes part II*; 744–768. Marine Biological Association of India

Rao K Venkatasubba 1963 Some aspects of the biology of 'Ghol', *Pseudosciaena diacanthus* (Lacepede); *Indian J. Fish.* **10** 413–459

Venkataraman G 1970 The Indian Mackerel. IV. Bionomics and Life history; *C.M.F.R.I. Bull No.* **24** 17–40

Yuen H S H 1955 Maturity and fecundity of bigeye tuna in the Pacific; *U.S. Fish. Wild. Serv., Spc. Sci. Rept., Fish.* **150** 1–30

—— and June F C 1957 Yellowfin tuna spawning in the central equatrial pacific; *U.S. Fish. Wild. Serv., Fish. Bull.* 112 **57** 250–264