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Maturation and spawning of Indian mackerel

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ABSTRACT

The relation between body length and mature ovary is curvilinear whereas a straight line relation exists between the weight of the fish and weight of the ovary. Mackerel is a prolific breeder. Ova diameter studies indicated the presence of 6 batches of ova in the mature ovary at a time, the first batch ripening in a short period. Histological studies revealed the presence of early perinucleolar oocytes even in partially spawned ovaries, suggesting a continuous oogenesis and production of more than six batches of ova. Intensive spawning takes place from April to July. Monsoon and upwelling with consequent replenishment of nutrients effect a plankton bloom in the surface waters causing a spurt in the reproductive output of mackerel resulting in intensive spawning, reduced larval mortality and better recruitment.

Introduction

Mackerel with ripe, oozing gonads are common in the commercial fishery of the Malabar area from February to August. But the products of spawning are recruited to the fishery in abundance only during the monsoon season from June to September in two distinct batches. The size of these new recruits implied that they originated some time in May and July. Another minor recruitment observed in March/April indicated their origin in November. These observations demanded a detailed study of the maturation and spawning of the fish.

Devanesan and John (1940) initiated the study of maturation and spawning of mackerel. Subsequently, contributions to these aspects were made by Devanesan and Chidambaram (1948), Chidambaram and Venkataraman (1946), Bhimachar and George (1952), Sekharan (1958), Radhakrishnan (1965), Rao *et al.* (1965), Rao (1967), Gopakumar *et al.* (1991) and Yohannan (1993).

Material and methods

Material for this study was collected from different landing centres in the Malabar area, especially Calicut during January 1994 – December 1995. Length in mm from the snout to the tip of the upper caudal lobe and weight in g of mackerel collected were noted. Initially gentle pressure on the abdomen with fingers was applied to check whether

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the gonads were in oozing stage. Gonads were then removed and weighed. The ovaries in stage V and VI only were used. The ovaries were cut and the ova teased out for studying the diameter frequency distribution under a microscope using calibrated ocular micrometer.

Classification of ovaries: Different developmental stages of gonads as given by Pradhan and Palekar (1956) were followed except in the case of stages V and VI. Stage VI in this study refers to ovaries containing transparent ova with oil globule. The gonads are yellowish with typical 'plum pudding' appearance as the white, opaque ova of stage V and the transparent ova of stage VI are visible externally. During certain periods such ovaries were found to be large and filling the body cavity. This is termed as stage VIa. Subsequently these ovaries reduce in size and weight and become flabby, but still containing healthy transparent ova with oil globule. These are partly spawned but can continue to spawn, and hence termed as VIb. The testes in stage VIa is white and fill the body cavity. Stage VIb is in oozing stage. A mild pressure on the abdomen will result in the oozing out of eggs or milt from gonads in stage VIa. Slightly more pressure will be needed to ooze out the eggs or milt from stage VIb gonads stage Va and Vb ovaries are almost similar to stage VIa and VIb except that the transparent ova with oil globule are absent.

Results

Relation between body length and ovary weight: A total of 90 female mackerel with ovaries in stage Va were used for this study. The length of the smallest fish in stage Va was 187 mm in length and its ovary weighed 10.24 g. The largest fish measured 268 mm with an ovary weight of 24.73 g. The heaviest ovary had a weight of 30.23 g found in a fish measuring 262 mm.

The relation between the length of the fish and weight of ovary was curvilinear. Hence, their log 10 values were used to estimate the regression of the ovary weight on total length of the fish. The parameters estimated were:

$a = -5.24263$; $b = 2.7357$

This straight line relation was transformed to the form:

$W = aL^b$ to get a curvilinear relation as:

$$W = 0.00000572\ L^{2.7357}$$

where W is the weight of the gonad in g and L the total length of the fish in mm. The correlation coefficient (r) was 0.90.

Relation between the weight of the fish and ovary weight: The relation of gonad weight to body weight was found to be direct and straight as given below:

$$W = 1.7437 + (0.1123\ X)$$

where W is the weight of the ovary in g and X the weight of the fish in g. The correlation coefficient was 0.89.

Ova diameter studies : Ten ovaries each in stage Va, Vb, VIa and VIb, collected at different periods were cut in fresh condition and teased on a plankton counting chamber and 500 ova from each ovary were measured at random. The frequencies were grouped into 2 micrometer division intervals like 0-1, 2-3, and so on, mid-points of which had a difference of 0.015 mm. The distribution showed a similar pattern in ovaries of each stage. Typical distribution in

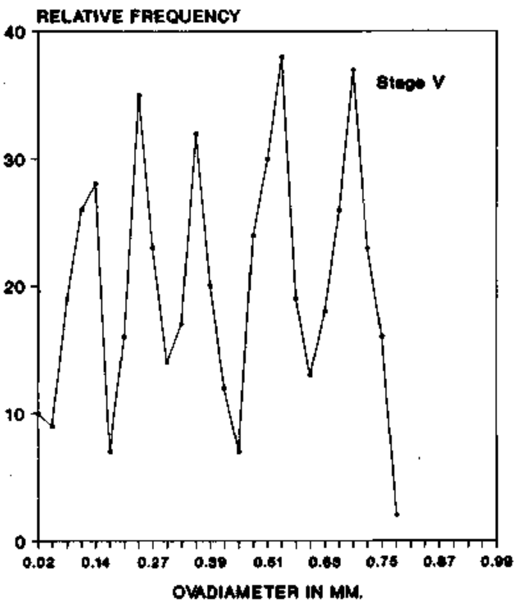

Fig. 1. Ova diameter frequency distribution in an ovary in stage V.

each stage is shown in Fig. 1 and 2.

Ovaries in stage Va contained ova with diameter upto 0.78 mm. The distribution showed altogether 6 modes. The modal size varied from gonad to gonad, but in general there were regular modes at every 0.125 mm. The distribution in stage Vb also was similar.

Ova found in stage VIa measured up to 0.96 mm. The major difference between the ovaries in stage V and VI was the presence of ova of the last mode in stage V. The ova in the last mode of the ovaries in stage V were white, opaque with modal size around 0.68 mm whereas those in stage VI were transparent and contained an oil globule. The ova had a diameter range of 0.69 to 0.96 mm with modal values from 0.8 to 0.9 mm with oil globule of 0.227 mm in diamter. There was a gap in the distribution between the largest opaque ova and the smallest transparent ova while the distribution of opaque ova was continuous. The diameter distribution of ova in stage VIb was found to be similar to that of stage VIa.

Histology of the ovary : An ovary weighing 2.3 g in stage I collected from a fish of 182 mm in length and another in stage VIb collected from a fish measuring 237 mm were used for this study. Terms used by Pollard (1972) while studying the biology of *Galaxias maculatus* (Jenyus) are followed here in explaining different stages of ova.

The ovary in stage I contained only early perinucleolar oocytes and a few late perinucleolar oocytes. In the sections of the ovary in stage VIb the mature transparent ova were not seen. Pollard (1972) found that oocytes in final stages of yolk mass formation tended to crumple during sectioning due

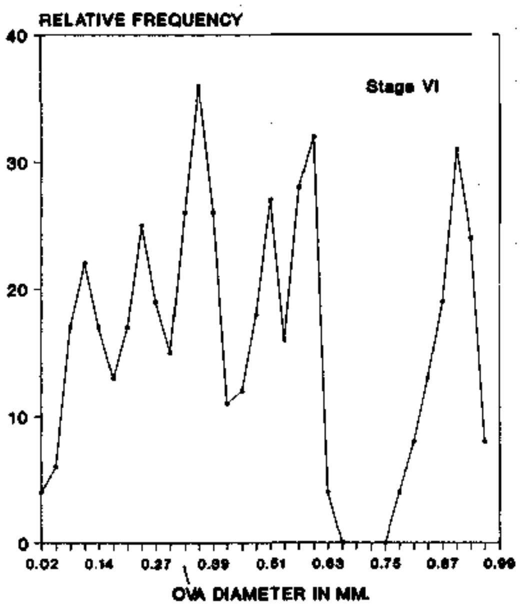

Fig. 2. Ova diameter frequency distribution in an ovary in stage VI.

to hardening of yolk during processing. The absence of mature ova in the present sections also can be due to the same reason. However, ova in different developmental stages from early perinucleolar oocytes to secondary yolk stage were present.

Mackerel is a partial spawner. Even in mature ovary all the oocytes due to be spawned in one spawning cycle are not differentiated as shown by the presence of early perinucleolar oocytes even in partially spawned ovaries suggesting that the oogenesis is still going on. The presence of six modes in the ova diameter frequency distribution in gonads of stage VIb and the presence of early stages of oogenesis reveals that a single mackerel spawns intermittently for a long period and hence the estimation of their total fecundity is not possible. Rao (1967) estimated a total number of 1,1,0000 eggs in 3 batches in the ovaries of mature mackerel while estimates of Devanesan and John (1940) is 94,000 eggs. In the light of the present observation these estimates are thought to be underestimates since they counted only the yolked ova present in the ovary and not the ova already spawned and those to be produced subsequently. The actual fecundity must be much higher.

Spawning period: Yohannan (1997) observed three important broods in the mackerel fishery of the Malabar area. The first brood was originated in May, the second brood in July and the third one in November. The first two broods dominate the fishery. Fig. 3 shows the months when mackerels in stage V and VI dominate in different broods. It can be seen that mature fishes are present in all the months indicating spawning all through the year. However, from the appearance of juveniles, their relative abundance and study of recruitment pattern it can be reasonably assumed that intensive spawning takes place during April – July. It can also be seen that the July brood spawn during this period. Due to the disappearance of the May brood early from the fishery the maturation of this brood could not be studied. It can be assumed that this brood might have spawned in the premonsoon period. These two broods together take part in the peak spawning during April-July period. The November brood is the products of the same brood of the previous year.

The Fig. 3 also indicates that mackerel mature at a size of around 21 cm but they take part in the intensive spawning when they are around 24 cm or at the completion of one year. For the November brood the size is slightly less-around 22 cm.

The July brood was seen in stage Va in trawl catches in the beginning of February. By the end of February gill nets (*Ayilachalavala*) operating in the

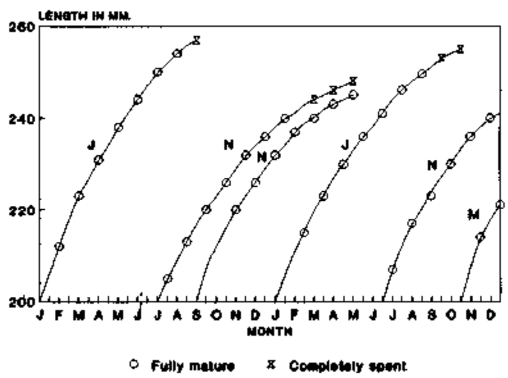

Fig. 3. Months when May brood (M), July brood (J) and November brood (N) are mature and spent, and the corresponding mean length of the fishes.

bottom at a depth of about 40 m at sunset catch mackerel in stage VI. The size of the gonads were generally small and were found to decrease in size till March end, still containing healthy transparent ova. The gonads of the fish caught by trawls in the daytime during the same period were in stage V. The operation of the gill nets at sunset ends by the end of March. Trawl catches continue but the fish with gonads in stage VI were not caught by this gear operated in the daytime. They were all in stage V. But by the end of March the size of the gonads were found to increase. Heavier gonads were observed in June/July. Completely spent gonads were encountered mostly in September.

Discussion

Sekharan (1958) indicated the possibility of Indian mackerel spawning intermittently releasing the ova in batches. Radhakrishnan (1965) observed the multimodal distribution of the ova diameter frequencies in the gonads. The present study fully supports these observations. The observations denote the spawning to take place throughout the year. *Ayilachalavala* catches confirm that the spawning takes place from February to March. During the other months the fishery was not available and hence the studies could not be conducted throughout the year. However, mature gonads were observed throughout the year. But intensive recruitment was observed only during monsoon season though a weak recruitment was encountered in March (Yohannan, 1997). The reason for this is to be found from a study of the environment.

The surface circulation in the Arabian Sea observed by Varadachari and Sharma (1967) shows that though the coastal drift is equatorward during February/March to April the general movement is southwest. With this, it is possible that the eggs and larvae drift to the open ocean and perish. Moreover, it was observed that January-March is the period of low plankton production over the shelf along the southwest coast (Anon., 1976). By May the strength and speed of the drift decreases considerably and the movement becomes southeasterly and the chances of the currents moving westward taking the eggs and larvae from the coastal waters to the open Arabian Sea are rather rare. The condition continues in June with a branch of south moving current going round the peninsula to the east coast with increased strength of the drift. This drift can perhaps take the eggs and larvae towards south and to the east coast.

Monsoon and upwelling with consequent replenishment of nutrients to the surface waters effect a plankton bloom giving better chance for the larvae to survive as food is plenty. Growth becomes fast and the larvae pass quickly through the critical stage. The increase in the weight of the gonads during this period also can be attributed to increased food supply. Thus the spawning and recruitment improve substantially diuring monsoon.

The recruitment in April from the products of spawning in October/November is not strong as that of May and July broods because the conditions are not so ideal. Perhaps the transition from the equatorward flow to poleward may be giving more chances for survival of eggs and larvae resulting in recruitment, though weak.

This observations are in conformity with those made on the scombroids elsewhere. Tropical scombroids spawn serially over a protracted period (Schaefer, 1987). But it is possible that some increase in reproductive output occurs during certain periods and many spawn during every month of the year with peaks during or just before the upwelling period (Lauth and Olson, 1996). Woton (1979) observed that when food is abundant the reproductive output of adults increases due to energy surplus. The spawning season of anchoveta (*Engraulis mysticetus*) in the Gulf of Panama is correlated with upwelling periods (Smayda, 1966). Spawning time and duration in fish are often synchronised with zooplankton cycles, resulting in better larval survival (Cushing, 1982). The releasing of multiple batches of ova over an extensive area during a protracted spawning period was termed as "bet-hedging" strategy by Lambert and Ware (1984). This pattern, characteristic of many fishes that inhabit lower latitudes (Qasim, 1955), is considered adaptive in situation where prey availability is unpredictable. Risk of total recruitment failure is avoided by many independent spawning bouts.

The larger recruitment of the May and July broods may be due to the greater food availability as these broods are produced during or just before upwelling. Two factors that contribute to larval mortality in marine fishes are starvation and predation (Theilacker 1986, Bailey and Houde, 1989). Histological analysis made by Marguiles (1993) showed high incidence of malnourishment and starvation among larvae of *Auxis* spp., *Euthynnus lineolatus* and *Scomberomorus seirra* caught during non-upwelling period off the southern Azuero Peninsula. Poor condition of larvae can also result in increased predation rates.

Bakun and Parrish (1982) observed that fine-scale prey aggregations may be disrupted by turbulent mixing and transport during upwelling period. Rothschild and Osborn (1988) opined that small-scale turbulence may increase contact rates between predator and prey. Research in other upwelling regimes has shown that recruitment success of pelagic marine species increases with upwelling intensity when wind speed is low to moderate (5-6 m/s), but decreases when speed increases further (Bakun *et al.,* 1991). Food abundance and higher temperature can promote growth rate of fish larvae, reducing larval stage duration and exposure to predation resulting in better recruitment (Houde, 1987). The southerly surface drift along the southwest coast of India is rather slow around May and the speed increases with intensity of monsoon in July. Temperature is high in May and starts decreasing in July. The amount of solar energy reaching the sea surface also decreases with intensity of monsoon. The influence of these factors on the recruitment of the mackerel fishery during this period is not well understood. However, the importance of upwelling and surface drift with recruitment to the fishery is very clear from these observations.

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