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Reproductive biology of Horse mackerel *Megalaspis cordyla* (Linnaeus, 1758) along Ratnagiri coast of Maharashtra, India

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Original Article

Abstract

Aspects of reproductive biology such as maturity, spawning season, sex ratio and fecundity of *Megalaspis cordyla* were studied for a period of one year along the coast of Ratnagiri. Monthly distribution of maturity stages showed that the spawning season of *M. cordyla* was May-January with peak spawning during May-October. The observed sex ratio was 1:1.3 (male: female). The gonado-somatic index values were high during August for both the sexes. The fecundity increased with increasing length and weight. Fecundity of the fish was found in range from 92,268 to 5, 49,900 the average being 2,47,671 eggs.

Keywords: *Maturity stages, horse mackerel, spawning, fecundity.*

Introduction

Horse mackerel *Megalaspis cordyla* (Linnaeus, 1758) is a migratory pelagic species, abundant in inshore and offshore oceanic waters; distributed at a depth of 20-80 m. This species forms about 34.2% of the carangid catches and good food fish in fresh, salted and dried conditions. *M. cordyla* is one of the dominant species in drift gill net landings. Abundance of this species was identified for the first time along the northwest coast in Indian waters (Bapat *et al.*, 1982). *M. cordyla* is distributed throughout the tropical and subtropical waters of the Indian Ocean and west Pacific Ocean. .

They are mostly caught in trawls, purse seines and drift gill nets (Sivakami, 1995). The largest recorded individual was 80 cm long and weighed 4 kg, although it is common at lengths less than 40 cm. *M. cordyla* reach sexual maturity at 22 cm in female and 26.4 cm in male, with spawning occurring between March and July in India (Bal and Rao, 1984). In the present study, detailed investigations on the reproductive biology of *M. cordyla* were done to highlight the spawning behaviour, maturity stages and other aspects of gonad developments from northwest coast of India.

Material and methods

The present study is based on 1000 individuals ranging in size from 152 to 402 mm total length (TL) comprising of 326 males and 428 females and 246 indeterminants. Twenty five specimens of the fish were collected weekly during the fishing season 2011-2012 except in the month of June and July when fishing is suspended. The specimens of different size groups were collected randomly. Linear measurement like total length, fork length and standard length were recorded with the help of standard fish measuring board to an accuracy of 0.5 mm. Electronic weighing balance with precision of

0.1 mg was used to record the total weight and weight of the gonads of the fish sample. The fishes were cut open and the sex and the stage of maturity were noted. Gonads were dissected out and weighed to the nearest 0.001g. Testes and ovaries were preserved in 4% neutral formalin for the microscopic study of maturity stages. The gonads were kept in normal saline and cut into small pieces of 4-5 mm in size. Initially they were fixed in Mossman's fixative (10 ml formalin, 10 ml glacial acetic acid, 30 ml of 95% alcohol and 50 ml distilled water), dehydrated, embedded in paraffin wax, and sectioned at 6 μm then stained with Haematoxylin and Eosin and examined microscopically. The male and female maturity stages of *M. cordyla* were classified as per Sreenivasan (1978) and Sivakami (1995). The stages were I) Immature, II) Early maturing, III) Late maturing, IV) Mature, V) Ripe, VI) Running, VII) Spent and II R) Spent recovering. The smears and sections of the gonads were observed under microscope and the various stages were noted.

Gonado-somatic index (GSI) was estimated using the following equation (June, 1953; Yuen, 1955).

$$GSI = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \times 100$$

A total of 754 specimens belonging to a wide size range were examined during March 2011 to February 2012. Sex ratio was tabulated for each month and for different size groups. Data on sex ratio was analysed by x^2 (Chi square) test at 0.05 level of significance to find out whether dominance of either sex was significant or not.

A total of 20 ovaries were used to investigate fecundity of *M. cordyla*. For the determination of fecundity, fresh, ripe ovaries were used. The excess moisture was removed by using blotting paper and the ovaries were weighed to the nearest milligram. The sample was then taken in a watch glass and number of mature ova in the sub-sample was counted physically. The fecundity was determined by the formula of Sinha (1995).

$$F = \frac{TW}{SW} \times \text{number of ova counted in the sub-sample}$$

Where, F= Fecundity; TW= Total weight of the ovary;
SW = Sub-sample weight

Results and discussion

Gonado-Somatic Index (GSI): In the present work the monthly gonado-somatic index (GSI) was investigated for both sexes (Fig.1). GSI showed wide variations between sex and it was higher for female throughout the sampling period. Highest gonado-somatic index was seen in females during September (20.57) followed by August (19.64), October (18.66), May (15.54) and April (13.49) indicating the ripe stages. Higher GSI in males was seen during August (18.49) followed by September (18.23) and October (18.26).

Sivakami (1990) reported the GSI of males and females of *Alepes djedaba* from Cochin coast. In females, the GSI in size group I (151-200 mm) was 1.72 in July and 0.26 in March. In size group II (201-250 mm), the values reached upto 3.70 in July and 2.04 in November, but declining thereafter to 0.312 in April. In size group III (251-300 mm), the values were high during July to October and also in February. In males, the GSI in size group I ranged up to 3.75 in August with the lowest value of 0.133 in January. In size group II, higher value upt o 5.22 were obtained during July to October, decreasing

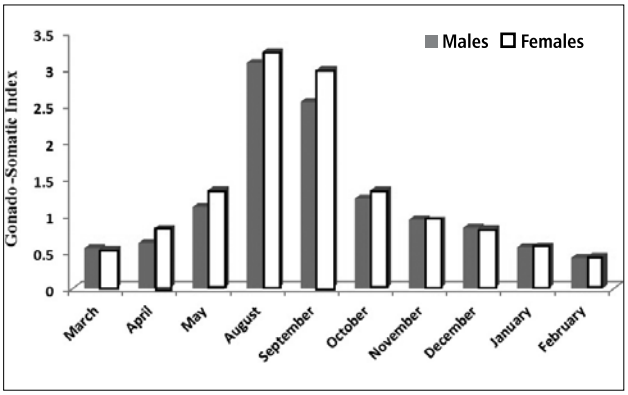

Fig. 1. Monthly variation in the GSI values of males and females of *M. cordyla* along Ratnagiri coast

thereafter to a minimum of 0.31 in March. The index was high in size group III also during July-October with a maximum of 8.68 in August.

Investigation on the reproduction of *M. cordyla* off Cochin (Sivakami, 1995) revealed that GSI values for both males and females show higher values during May to September with the peak index of 23.8 recorded in females during June. From this study, it was inferred that *M. cordyla* has prolonged breeding season extending from April to February with peak breeding during May-August. Female reproductive maturity is commonly quantified based on GSI values, because using fish size is generally inaccurate and the size at maturity varies greatly not only within a species but even within populations (Lowe-McConnell, 1982). It is also reported that determination of reproductive maturity using only the GSI is not adequate because structures within the ovary that can be predictive, such as oocytes developmental stage and accumulation of yolk within the interstitial tissue, cannot be obtained from weight alone.

Sex ratio: Monthly variation of sex ratio for *M. cordyla* is shown in Fig. 2. The average sex ratio of the males and females was found to be 1:1.3 for the entire period of study. Chi-square test applied for monthly sample indicated that

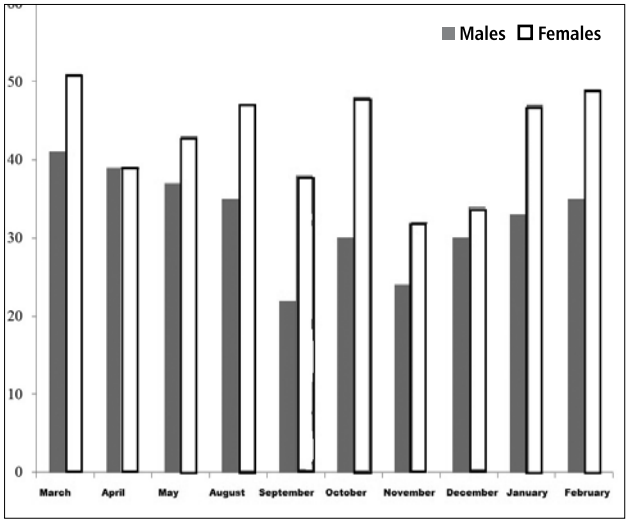

Fig.2. Monthly variation of sex ratio in *M. cordyla* along Ratnagiri coast

significant difference was noticed at 5 % probability level in the months of September and October (Table 1).

Sex ratio of fish population may be due to differential fishing or due to difference in growth rate of two sexes (Qasim, 1966). In the present study, data on sex-ratio of *M. cordyla* showed that in most of the months, females dominated over male and the overall male: female ratio was 1:1.3. The chi-square test showed significant deviation from 1: 1 during September and October.

Table 1. Result of Chi-square test applied to test the significance of observed differences in the sex ratio in monthly samples of *M. cordyla*

Month	Total	Male	Female	df	Chi-square
Mar	92	41	51	1	1.0870*
Apr	78	39	39	1	0.0000*
May	80	37	43	1	0.4500*
Aug	82	35	47	1	1.7561*
Sept	60	22	38	1	4.2667o
Oct	78	30	48	1	4.1538o
Nov	56	24	32	1	1.1429*
Dec	64	30	34	1	0.2500*
Jan	80	33	47	1	2.4500*
Feb	84	35	49	1	2.3333*
Total	754	326	428		1.7890

* Not significant at 5% level
° Significant at 5% level
* Tabulated value 3.84

Sreenivasan (1981) observed that females of *M. cordyla* were dominant in most of the months in Vizhinjam waters. Sajina *et al*. (2010) worked on stock structure analysis of *M. cordyla* along the Indian coast based on truss network analysis. The samples were collected from different location which contained a mixture of male and female adult fishes, and there was no external sexual dimorphism in this species. The sex ratio of the entire sample was 1:0.9 (male: female). Sivakami (1995) reported the monthly ratio of male and female *M. cordyla* during the period 1990-91 along with Chi-square values. It could be seen that females were significantly dominant only during January and February months. However the pooled data for the year showed a Chi-square value of 6.28 which was significant at 5% level thereby showing an overall dominance of females in the population. According to Sivakami (1990) the sex ratio of *A. djedaba* from Cochin during 1986-87 showed that males outnumbered females during all the months except during October, January, May and June.

Size at first maturity: During the present study, it was observed that *M. cordyla* attained first maturity at the size of 210 mm. According to Reuben *et al*. (1992) the size at first maturity of *M. cordyla* was estimated to be 250 mm. This clearly indicated the stock of *M. cordyla* maturing earlier than that reported elsewhere.

Maturity stages: Different stages of development were examined in 428 ovaries. It was seen that in females, stages I and II occurred from December to April, stage III from January to April and stage IV occurred from February to May. Stage V occurred in March to September, running stage VI was observed in September to January and stage VII was recorded in March and then from May to February. Spent recovering stage II R was observed in all the months except April as the peak spawning was observed from May onwards (Table 2). Thus spawning season generally appears to be from May to January with a peak spawning during May to October.

In males, immature stage I and stage II were observed during March-April and then from November to February. Stage III was reported during March-April and January-February. Mature (stage IV) males were observed from March to May and in February. The percentage of males in ripe stage V was observed to be increasing from March to September. Majority of males in running stage (VI) were recorded from April to January. Spent males (stage VII) were recorded from March to February with highest percentage from October to

Table 2. The average percentage of various gonadal stages in females of *M. cordyla*

Stages	I	II (Early)	III (Late)	IV	V	VI	VII	IIR
Mar	25	20	10	8	5	--	20	12
Apr	16	16	15	16	12	--	--	--
May	--	--	--	5	10	--	20	5
Aug	--	--	--	--	5	--	25	8
Sept	--	--	--	--	2	60	30	8
Oct	--	--	--	--	--	48	42	10
Nov	5	--	--	--	--	32	43	20
Dec	8	2	--	--	--	20	47	23
Jan	10	5	2	--	--	10	52	21
Feb	15	10	8	5	--	--	42	20

January. Spent recovering males were observed from March to February during the study period (Table 3).

In the present work, annual ovarian and testicular cycle of *M. cordyla* were studied throughout the period of investigation for both sexes to identify maturity stages and confirm time of spawning and structure of gonads. The histological studies of

Table 3. The average percentage of various maturity stages in males of *M. cordyla*

Stages	I	II (Early)	III (Late)	IV	V	VI	VII	IIR
March	23	20	12	8	5	--	20	12
Apr	13	15	12	15	10	25	5	5
May	--	--	--	10	10	55	20	5
Aug	--	--	--	--	7	60	23	10
Sept	--	--	--	--	5	57	30	8
Oct	--	--	--	--	--	45	45	10
Nov	6	--	--	--	--	29	45	20
Dec	8	2	--	--	--	21	47	22
Jan	10	5	3	--	--	10	51	21
Feb	15	12	8	5	--	--	40	20

the testis and ovaries were carried out under microscope and the stages were represented in Plates 1 to 16.

At immature stage oogenesis showed changes from oogonia to primary oocytes and then secondary oocytes. The oogonia were small rounded cells with relatively clear zone of cytoplasm (Plate 1).

In early maturing stage, the gonads were translucent with visible nucleus and cytoplasmic layer (Plate 2). In late maturing stage, the gonads were thick and transparent occupying half of the body cavity (Plate 3). The testes at this stage were flat, leaf-like but slightly thick. They had spherical nucleus with distinguishable nuclear membrane. The follicles were observed to contain spermatocytes, but no spermatozoa were seen (Plate 11).

In the female, ovaries were oblong, transparent and opaque eggs were present during mature stage (Plate 4). At this stage oocytes and their nuclei increased in size. Oocytes were surrounded by isolated layer of follicular epithelium. In case of testis spermatogonia, primary and secondary spermatocytes were detected at mature stage. Testis slightly swollen and extend to 3/4 of the body cavity (Plate 12).

The ovary during ripe stage occupied entire body cavity and few large eggs with oil globules were also observed. The yolk granules and nucleus appeared intermingled with cytoplasm in ripe stage (Plate 5). In ripe stage, the testis were observed occupying entire body cavity and flabby (Plate 13).

In running stage, ovary is flabby and fully occupying the body cavity. Large translucent ova with single oil-globule, opaque, yolked and small transparent ova also present (Plate 6). The testis are dull whitish with lobules are found during running stage (Plate 14).

In spent stage, the ripe ova were discharged from the ovary. Ovary is shrunken, partially withered with blood vessels and having a hollow appearance. Large, free oocytes were seen with distinct nucleus, rounded to ovate, follicles were closely packed without interspaces. Fully grown eggs with reduction in connective tissue were seen. In some cases, the follicular walls were found to be breaking (Plate 7). In spent stage, testis were loose, the follicles collapsed, residual sperms and phagocytes were present, while in females the gonads were observed to be loose, follicles were collapsed, residual eggs and phagocytes were present (Plate 15).

In case of ovary during spent recovering stage new generation of cytoplasmic growth cells were observed. The cytoplasmic yolk undergoes phagocytosis, and gradually the yolk vesicles become empty vacuoles. Then the yolk contents were completely reabsorbed and disappeared, empty follicles were observed in the ovary (Plate 8). In spent recovering stage, the sperm cells were discharged from seminiferous tubules which were reduced in size and the spermatogenesis was completely discontinued. New generation of spermatogonia were recorded at the periphery of many tubules (Plate 16).

In the present study, microscopic observations were made on the ovarian development of *M. cordyla*. Sequential development of gonads was observed from immature to

Maturity stages in horse mackerel, *Megalaspis cordyla*

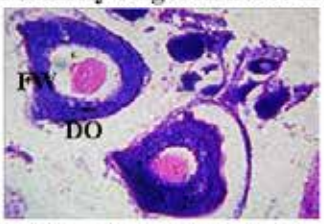

Plate 1. Stage I: Immature (Female)

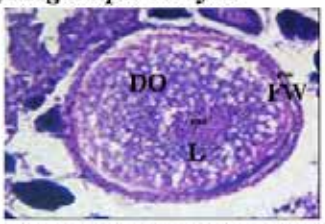

Plate 2. Stage II: Early maturing (Female)

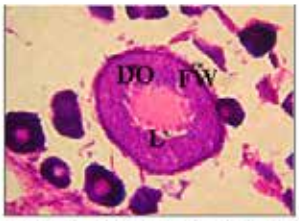

Plate 3. Stage III: Late maturing (Female)

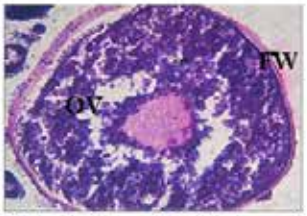

Plate 4. Stage IV: Mature (female)

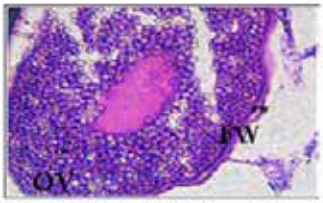

Plate 5. Stage V: Ripe (Female)

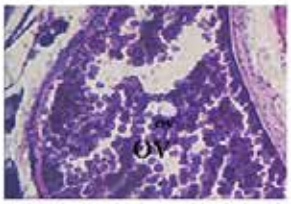

Plate 6. Stage VI: Running (Female)

Plate 7. Stage VII: Spent (Female)

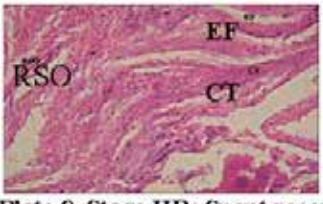

Plate 8. Stage IIR: Spent recovering (Female)

Plate 9. Stage I: Immature (Male)

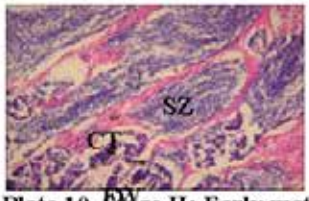

Plate 10. Stage II: Early maturing (Male)

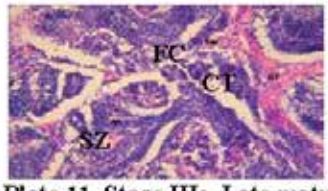

Plate 11. Stage III: Late maturing (Male)

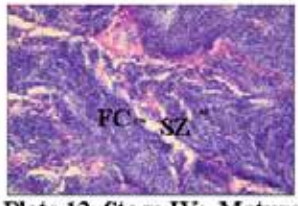

Plate 12. Stage IV: Mature (Male)

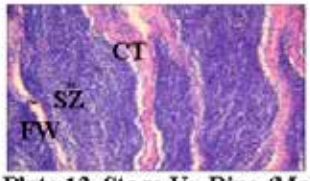

Plate 13. Stage V: Ripe (Male)

Plate 14. Stage VI: Running (Male)

Plate15. Stage VII: Spent (Male)

Plate 16. Stage IIR: Spent recovering (Male) (Magnification: 40X)

FW-Follicular wall, FC-Follicle, DO-Developing oocytes, L-Lumen, OV- Ova, RSO-Residual ova, EF-Empty follicle, CT-Connective tissue, SZ-Spermatozoa, RSZ-Residual spermatozoa

spent stage. A few large eggs were also observed with oil-globules. In running stage large translucent ova with single oil-globule, opaque, yolked ova and small transparent ova also present.

According to Sreenivasan (1978) the maturity stages of *M. cordyla* was classified as stage I and II - immature (Virgin), stage III as maturing, stage IV as mature, stage V- ripe, stage VI- running, stage VII- spent and stage IIR- recovered spent. Sivakami (1995) classified the maturity stages as I immature, II and III maturing, IV mature, V ripe, VI running, VII spent and IIR spent recovering stage. Pandey (1997) studied the influence of hypothalamo- neurosecretory system of *M. cordyla* (Linnaeus) using the histological examinations of gonads. It was seen that the gonad development was initiated by the nucleus preopticus (NPO), nucleus lateralis tuberis (NLT) and their axonal tracts of the systems.

In the case of *Caranx kalla*, Kagwade (1968) observed that the individual fish has one short spawning period, but the species as a whole was found to spawn all round the year with two peaks, the major one during December-January and a minor one during May-June. It is generally accepted that *M. cordyla* has a prolonged spawning season but the individual fish breeds only once. Sreenivasan (1978) found that in Vizhinjam it spawned intensely during the monsoon, beyond 5 km from the fishery belt and the probable time of spawning is night. He reported that each sex of the torpedo scad reach sexual maturity at different lengths; females are mature by 22 cm and males by 26.4 cm. Sivakami (1995) reported the spawning season as April to February and peak breeding during May to August.

Fecundity: To get an idea of number of mature eggs that are likely to be spawned in *M. cordyla*, fecundity was estimated by considering the stages prior to spawning. The fecundity of *M. cordyla* ranged from 92,268 to 5,49,900 eggs (length range of 290 – 395 mm and weight range of 205 - 487 g) with an average of 2,47,671 eggs.

Knowledge of the total number of eggs produced by a fish during a year is important in determining the spawning potential of fish. Raje (1993) examined the five ovaries of *A. djedaba* in the stage V. The fecundity of this fish increased with length and it ranged from 621600 to 806386. Sivakami (1995) reported the fecundity from ripe ovaries of 13 specimens of *M. cordyla* ranging in the total length from 295 to 360 mm. According to this study the total fecundity ranged between 91854 and 324292. The fecundity estimate was based on 22 females with stage V ovaries ranging in size between 157 and 217 mm in total length and 37.0 and 100.0 g in weight. All these indicate considerable variability in the fecundity of carangid sp. Size and species differences probably determined how fecund a female fish is at a given time. During the present study spawning season was observed to be from May to January with a peak spawning during May to October. It was evident from the study that *M. cordyla* has a prolonged spawning season along the Ratnagiri coast. The highest values of GSI for both females and males during August also differ from that reported by other workers.

M. cordyla is one of the important carangid fish landed along the Ratnagiri coast. The present study indicated that the fish matured at length smaller than that was reported by other workers. This observation would be helpful to determine the size suitable for fishing. Similarly, the spawning period extending from May to January was observed to be quite prolonged with peak during May to October, when maximum females were in ripe condition. As the fishing commences from July after the monsoon, it coincides with the peak spawning of this species. This study would therefore help to create awareness about the breeding, recruitment and sustainable exploitation of this fish.

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