SOME ASPECTS OF THE BIOLOGY OF 'GHOL', *PSEUDOSCIAENA DIACANTHUS* (LACÉPÈDE)

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INTRODUCTION

Sciaenids popularly called 'croakers', 'Drums', 'Jewfish', and 'Whitings', contribute substantially to the fisheries of India. Sciaenids form about 6% of the total annual marine fish catch of the country. About 30% of the landings of the trawlers at Bombay is composed of Sciaenids. *Pseudosciaena diacanthus* (ghol), *Otolithoides brunneus* (Koth), *Otolithus ruber*, *Otolithus argenteus*, *Pseudosciaena sina*, *Johnius dussumieri* are the important species contributing to the sciaenid fishery besides other species of lesser importance. Smaller sciaenids, mostly *Johnius spp.*, and *Otolithus spp.*, locally called 'Dhoma' constitute the bulk of the catches of the trawlers (20-23%) at Bombay. *Pseudosciaena diacanthus* locally called 'ghol', ranks first as a commercially very important offshore sciaenid, forming 5 to 8% of the trawler catches.

'Ghol' is a highly esteemed table fish. The price ranges from Rs. 1. 75 nP. to Rs. 2.00. per kilogram. The air bladders of this species are valuable costing: Re. 1.00 to Rs. 1. 25 nP. per piece and exported to other countries also.

The work done on sciaenids in India is limited to the following : Dharmarajan (1936) studied the osteology and anatomy of *Otolithus ruber*. Karandikar and Thakur (1951) worked out the anatomy of 'Koth', (*Sciaenoides brunneus-Day*). Gopinath (1942) made some observations on the feeding of the post-larvae of *Scieaena albida* from Travancore coast. Mookerjee, et al (1946) studied the food of adult *Scieana albida* of Bengal. Bapat and Bal (1952) studied the food of young *Sciaena miles*, *Scieeana albida*, *Sciaena semiluctosa*, *Sciaena glauca* and *Otolithus argenteus* of Bombay. Chacko (1949) made observations on the food and feeding of *Sciaena albida*, *Sciaena glauca*, *Otolithus ruber* and *Otolithus maculatus* from the Gulf of Mannar. Observations on the larval development and breeding of the Gangetic whiting, *Pama pama* were made by Pantulu and Jones (1951) and Karamchandani et al (1954). The larval development of *Pseudosciaena coitor* was described by Karamchandani and Motwani (1954). Bal and Pradhan (1945, 46,) and John (1951) made observations on the eggs and larvae of a few sciaenids from Bombay and Madras Coasts respectively. Jacob (1948) has given an account of the fishery and bionomics of thirteen species of sciaenids of the west coast of Madras Province.

In this connection mention may be made of the studies of Welsh and Breder (1923) on the lifehistory of the Sciaenidae of the eastern U.S.A., Pearson (1929) on the natural history and conservation of the red fish and other sciaenids on the Texas coast. Kuntz (1914), Hildebrand and Cable (1930, 34) worked out the life histories of a few sciaenids.

Saishu et al (1954), Ikeda (1954), Misu (1954) studied the fishery and biology of some sciaenids in the east China and Yellow Seas. Lin (1935, '38, 40) studied the important sciaenid fishes of China.

Very little work has been done on the fishery and biology of *Pseudosciaena diacanthus*. Hefford (1922) has given an account of the abundance and distribution of 'ghol' as seen from the variations in the catch per hour of this species according to locality, depth and season. Jacob (1948) has given a short note about *P. diacanthus* while Jayaraman et al (1959) have given an account of the fishery and distribution of this species as seen from the trawling operations in Bombay and Saurashtra waters during 1949 to 1954-55.

From the above account it can be seen that no systematic efforts appear to have been made for collecting information on the different aspects of the fishery and biology of 'ghol', *Pseudosciaena diacanthus*. In view of this, work on the fishery and biology of this commercially important sciaenid was initiated in February 1958 at the suggestion of Dr. S. Jones, Director, Central Marine Fisheries Research Institute, Mandapam Camp. The results of studies on age determination in this species by means of scales and Otoliths have been published (Rao, KVS 1961). The present paper deals with length-weight relationship, maturation and spawning and food and feeding habits.

MATERIAL AND METHODS

Material was collected from the landings of the bull-trawlers of New India fisheries Ltd., Government of India deep Sea fishing vessels and the local boats fishing with 'dol' net at Sassoon Docks and Versova. Visits to Sassoon Docks were made at the time of unloading of the catches of the trawlers besides regular weekly visits to Versova and Sassoon Docks. Each time random samples of 'ghol', 50 to 100 in number were measured with a fish measuring board and weights of some of them taken with a spring balance. In view of the high cost of the big specimens about 6 to 10 specimens, were examined each time from the landings of the bull trawlers for detailed biological studies. After noting the total length, standard length, weight, the specimens were cut open, the stomach and gonads dissected out intact duly labelled for examination in the laboratory. Colour, condition and stage of maturity of the gonads as could be made out by naked eye were noted in the field. In the laboratory the stomachs were cut open, the different constituents identified as far as possible and assigned points. The weight, length, and breadth of gonads were recorded and then preserved in 5% formaldehyde for ova diameter frequency and fecundity studies. Scales and otoliths were taken out in the field itself and kept in scale or otolith packets with date, length, sex and other details of the specimen duly labelled. It was not possible to make detailed biological studies on big 'ghols' from the landings of the local boats ('Dol' net) for various reasons. Only length measurements of small and big 'ghols' and weights of some of the big 'ghols' were noted. Scale samples were collected whenever possible. About 10 small 'ghols' (5 to 30 cm) were purchased during each visit for detailed biological studies in the laboratory. The details of various techniques employed in this investigation are described in the respective sections. Length measurements given in this paper refer to the total length of the fish *i.e.* from the tip of the snout to the tip of the longest ray of the caudal fin.

Distribution : Pseudosciaena diacanthus has a wide distribution. According to Weber and Beaufort (1936) it occurs in Singapore, Pinang, Banka, Java (Batavia), Madura, Borneo (Sandakan, Sarawak), British India, Ceylon, Malay Peninsula, Burma, Southern China (Shanghai, Hongkong, Canton, Macao), Philippines-in sea and mouth of rivers. Day (1878-88) has stated that the distribution of this species extends from seas of India to Malay Archipelago and China. It ascends tidal rivers and estuaries and is found in the Hooghly as hgih as Calcutta.

Hefford (1922) has mentioned that the maximum density of distribution of 'ghol' in Bombay (Maharashtra and Gujarat) waters lies inside the 20 fathom line. Jayaraman et al (1959) have observed that the 'ghol', occurs in quantities a little to the seaward side of the 20 fathom line and that it occurs in considerable but varying quantities in all the regions Jacob (1948) has recorded this species from Calicut. Devanesan and Chidambaram (1948) have observed that this species is commonly fished from both the coasts of Madras Province.

Length-Weight Relationship.—Besides its practical utility in estimating the weights of fish of known lengths or *vide versa,* the length-weight relationship is usuful in assessing the size at first maturity, spawning season, and the condition cycle of fish. With this view the length weight relationship in *P. diacanthus* was studied from the total length and weight data of 829 fish (284 males, 294 females and 251 juveniles). The size range of males was 30·0—102.5 cm., females 28·5—108·0 cm. and that of juveniles 5·0—29·5 cm. For calculating the length-weight relationship a general equation of the form $W=AL^B$ was considered, where W and L represent the weight and length of fish respectively, 'A' a constant and 'B' an exponent usually lying between 2·5 and 4·0. The relationship was determined on the basis of individual measurements and not on size group averages The equations for the data relating to males, fem ale and juvenile fish were framed separately and found to be as follows :

Males	$W=0{\cdot}01101\ L^{2.9738}$
Females	$W=0{\cdot}01379\ L^{2.9257}$
Juveniles	$W=0{\cdot}005626\ L^{3.1654}$

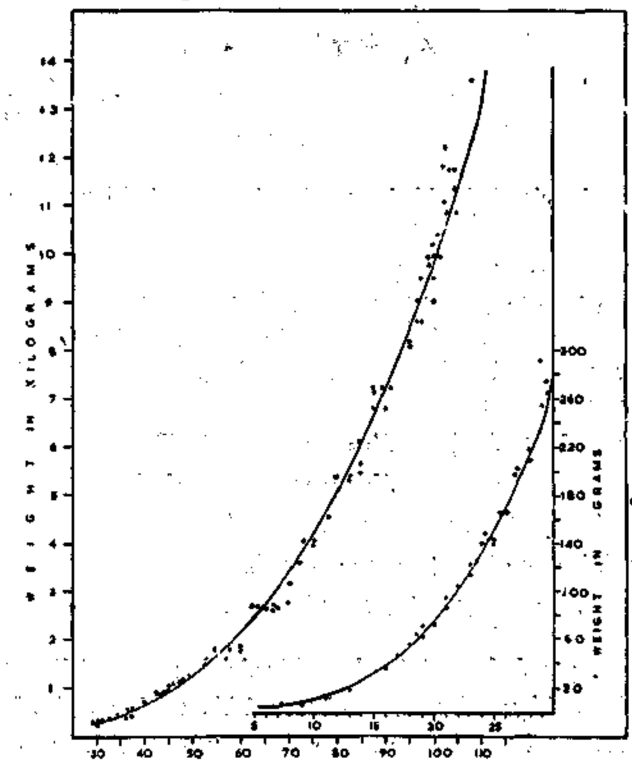

Fig. 1.A. Length-weight relationship in *Pseudosciaena diacanthus.* Observed values have also been plotted in the graph.

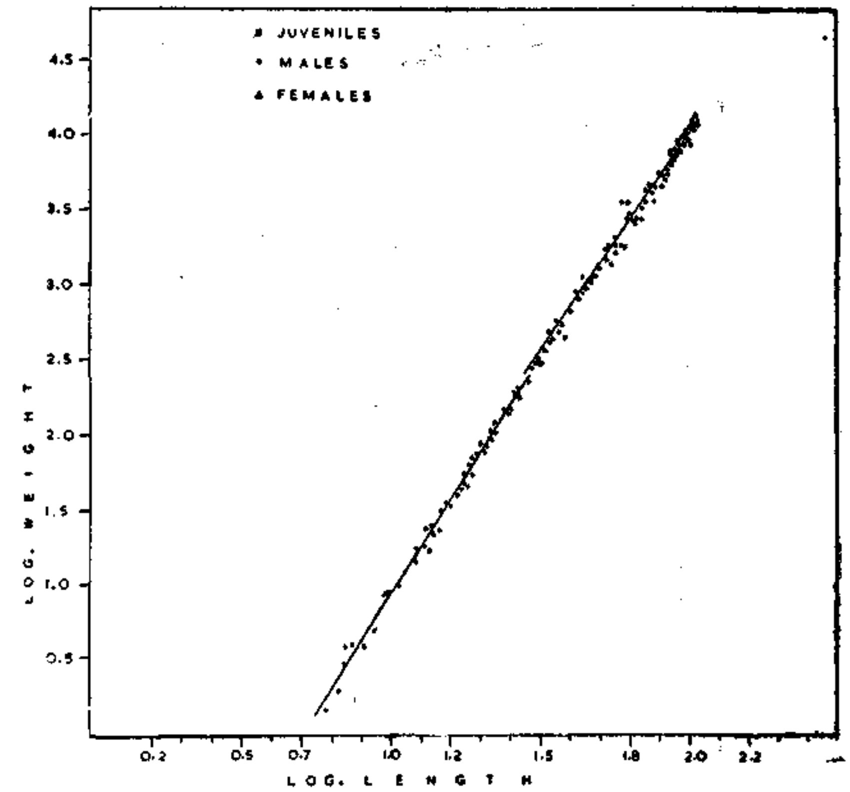

Fig. 1B. Logoarithmic relationship between length and weight in *Pseudosciaena diacanthus*

Comparison of the regression coefficients (B) of males and females showed no significant difference between them (t 1·67 df 574) but the regression coefficient of Juveniles was found to differ significantly from that of males (t 6·39 df 531) and females (t 10·46 df 541). So the data of males and females were pooled and equations were framed separately for adults (males and females) and Juveniles as follows :

Adults (males and females) $W=0 \cdot 01286\ L^{2.9400}$

Juveniles $W=0 \cdot 005626\ L^{3.1654}$

The logarithmic equations were found out to be

Adults $\text{Log. } W = -1 \cdot 8908 + 2 \cdot 9400 \text{ Log. } L.$

Juveniles $\text{Log. } W = -2 \cdot 2498 + 3 \cdot 1654 \text{ Log. } L.$

The length-weight parabola and its logarithmic form are delianated in Fig. 1A and B respectively for adults and juveniles. The observed Values have also been plotted in the figures to show their fitness. It can be seen from Figure 1A that fish upto 50 cm and 15·0 cm amongst adults and juveniles respectively increase in weight at a lesser rate than the

MATURATION AND SPAWNING

The ovaries are of the cystovarian type opening to the exterior by the oviducts. The testes are thread or ribbon like structures opening to the outside by the vasa deferentia. *Males* : Detailed studies on this aspect were confined only to the females, as it was found to be difficult in the males to trace the development of the testis from the immature to mature stage. However, an attempt has been made to classify the stages of development of testes in those of the males examined during the course of work. The following three stages of the testes are made out by visual examination in the field.

1. *Immature* : The testis is long, narrow, thread or ribbon like structure extending upto 2/3 or 3/4 of the body cavity. Width 0·1 to 0·50 cm. In recovering spents the testes are broader than in virgins. No milt expressed by pressure on the gonad or from the cut surface. Virgin (Juvenile) stage is difficult to separate from females.

2. *Mature* : Testes white or creamy in appearance, broader and thicker than the immatures, extending up to 3/4 body cavity. Milt can be expressed by pressure on the gonad or from the cut surface.

3. *Spent* : Testes broad, flaccid, blood shot extending upto 2/3 body cavity. No milt expressed with pressure or from the cut surface.

Females : Development of ova from immature to ripe stage.

Based on the microscopic studies of the size (diameter), the cytological changes as seen in the nature and deposition of yolk and oil globule, the following four groups of ova which represent in sequence the development of ova from immature to ripe condition, could be made out clearly :

Group 'a' ova. Immature. 0·02 to 0·20 mm in diameter. Polygonal, completely transparent. Nucleus visible.

Group 'b' ova. Maturing. 0·20 to 0·40 mm in diameter. The central portion is opaque due to deposition of yolk. Nucleus faintly visible. The larger ova fully opaque.

Group 'c' ova. Mature. 0·40 to 0·80 mm in diameter. Completely opaque. Yolk deposition complete.

Group 'd' ova. Ripe. 0·80 to 1·00 mm in diameter. Completely transparent and fully ripe. A single oil globule 0·20 to 0·30 mm in diameter could be made out.

Development of the gonads from immature to ripe condition and the stages of maturity

For interpretation of the stages of maturity and correct assignment of the phase of development of the ovaries to the different stages, the general appearance of the ovary, its relative length to the abdominal cavity, development of ova and the percentage composition of different groups of ova have been taken into consideration.

In specimens below 30 cm the gonad is a colourless thread of tissue extending about ¼ body cavity and sexes are hardly distinguished.

Stage I. In developing virgins the ovary is thin, pencil or thread-like extending to ½ body cavity while in the recovering spents it is broader extending up to 2/3 body cavity. Colour : light pinkish, red or pink. Only group 'a' ova present. Ova not discernible.

Stage II. Similar to stage I in external appearance. In this stage also only group 'a' ova are present but the larger ova more numerous.

Stage III. Ovary long and thin as in the previous stage occupying about 2/3 body cavity. Light red or reddish gray in colour and difficult to distinguish from the previous stages externally. 'a' and 'b' groups of ova present, the former being more numerous. The ovaries of the recovering spents in stages I to III are longer, broader, hollow and sac-like; not pencil or thread like as in virgins. The ova are similar in appearance to those in the ovaries of virgins. Besides group 'a' ova, disintegrating group 'c' ova which are being reabsorbed are often present as black unhealthy thread like masses inside the lumen of the ovary of recovering spents. The comparative rarity of stage II and III in the recovering individuals suggests that development through those stages is fast.

Stage IV. Ovary broad and long filling 2/3 to 3/4 body cavity. Colour : light yellow or reddish yellow. 'a', 'b', and 'c' groups of ova are present. Group 'a' ova form about 50%, group 'b' about 10% and group 'c' about 40%.

Stage V. Ovary broad and long, completely swollen, almost filling the body cavity Colour : reddish, yellow, or orange. Veination conspicuous. 'a', 'b', 'c', and a few 'd' groups of ova present. Composition of the first three groups of ova more or less same as in stage IV. Ova 0·60 to 0·70 mm becoming transparent peripherally. Ova 0·80 mm in diameter and above, which are very few in number are completely transparent. Oil globule may or may not be present.

Stage VI. Ovary broad and long almost filling the body cavity. Veination conspicuous, Colour: reddish yellow or orange. All the 4 groups of ova present. Group 'a' ova form 45%, group 'b' 10%, group 'c' 20%, and group 'd' 25% roughly. Group 'd' ova are fully ripe and completely transparent with single oil globule. Ova expressed from the vent under stripping pressure on the abdomen. Only very few specimens in this stage have been come across.

Stage VII. Spent. Ovary completely hollow, sac like, flaccid and blood shot. Deep red in colour. Veination very conspicuous. The ovaries are shrunken extending up to ½ or 2/3 body cavity, and contain immature transparent group 'a' ova on the ovigerous lemellae. A few disintegrating group 'd' ova present.

Partially spent stage. Ovary shrunken, flaccid but not as completely hollow and sac like as in stage VII. In external appearance they resemble the ovaries in stage IV or V and it is very difficult to differentiate a partially spent ovary from one in stage IV or V except for the fact that these partially spent ovaries are slightly flaccid and hollow *i.e.* not as turgid as those in stage IV. Colour : Red or reddish yellow. The weights of these ovaries have been observed to be more than those of completely spent ovaries and less than the normal weight of those in stage IV or V. Mostly group 'a' and 'c' ova are present besides a few disintegrating group 'd' ova. Few group 'b' ova may also be present. The same difficulty was experienced by Fairbridge (1951) in the case of ovaries of *Neoplatycephalus macrodon* which is an intermittent spawner. Karekar and Bal (1960) have come across partially spent ovaries in *Polydactylus* *indicus*. A few partially spent ovaries in 'ghol' were encountered during the course of observations. The partially spent condition may be due to a group of mature eggs lagging behind in development being left unspawned. These may be shed after some time. It can be seen from the above that the maturity stages as fixed by the International council for the exploration of the seas for the herring scheme can be applied to this species broadly.

For purposes of field work based on the external appearance of the ovaries, the following four stages can be adopted :

1. *Immature* : Stages I to III. Ovaries long and thin, pencil or thread like in virgins or long and broad in recovering spents, extending from ½ to 2/3 body cavity. Colour : light red or pinkish gray. Ova not visible to the naked eye.

2. *Mature*. Stages IV and V. Ovaries broad and long, swollen, extending from 2/3 to 3/4 body cavity. Colour : light reddish yellow or orange. Larger opaque ova visible to the naked eye.

3. *Ripe. Stage VI*. Ovaries long and broad, fully swollen and almost filling up the body cavity. Colour : Reddish yellow or orange. Larger transparent (transluscent) and fully ripe ova and opaque mature ova visible to the naked eye. Veination conspicuous. Ova expressed out under stripping pressure on the abdomen.

4. *Spent*. Ovary blood shot, deep red in colour, completely hollow and sac like, flaccid. Ovaries shrunken extending from ½ to 2/3 body cavity. Immature transparent ova not visible. Unspawned disintegrating ova which are being reabsorbed are often present as black thread like masses inside the lumen of the ovary in the recovering spents.

5. Partially spent ovaries are difficult to be distinguished from those in mature stages from external appearance.

Frequency and duration of spawning

Hickling and Rutenberg (1936) have demonstrated that the size frequency distribution of oocytes in the teleost ovary is related to the duration of the spawing season and to the number of spawnings within that time.

This aspect of maturation and spawning of *Pseudosciaena diacanthus* was studied using the ova diameter measurements of intraovarian eggs in the mature and ripe ovaries. The procedure is similar to that adopted by Clark (1934), Dejong (1939), Arora (1951), Prabhu (1956), Palekar and Karandikar (1952, 1953) and Dharmamba (1959). The diameters of nearly 1000 ova were taken irrespective of which axis lay parallel to the micrometer. The diameters of eggs were measured under the microscope with an occular micrometer at a magnification which gave a value of 0·02 mm to each micrometer division. The ova diameter measurements were grouped into size intervals of 5 md. (0·10 mm) and the percentage frequency curves of some presented in text figures 2, A to E. Ovaries preserved in 5% formaldehyde were used for these studies. Ova diameter studies were made on 23 ovaries in stages IV, V and VI from specimens of different lengths. Ova smaller than 5 occular divisions were not measured as they are present in all the stages of ovaries in large numbers and are of little interest in the study of the growth of the ova to maturity. However, for a few specimens, ova less than 5 md were also measured for knowing roughly the composition of the different size groups of the ova in the ovaries. There was not much of difference in the frequency curves of ova diameters taken separately from the anterior, middle and posterior regions of the ovary. Hence the pooled ova diameter frequencies from the 3 regions of the ovary are presented in Figures 2, A to E.

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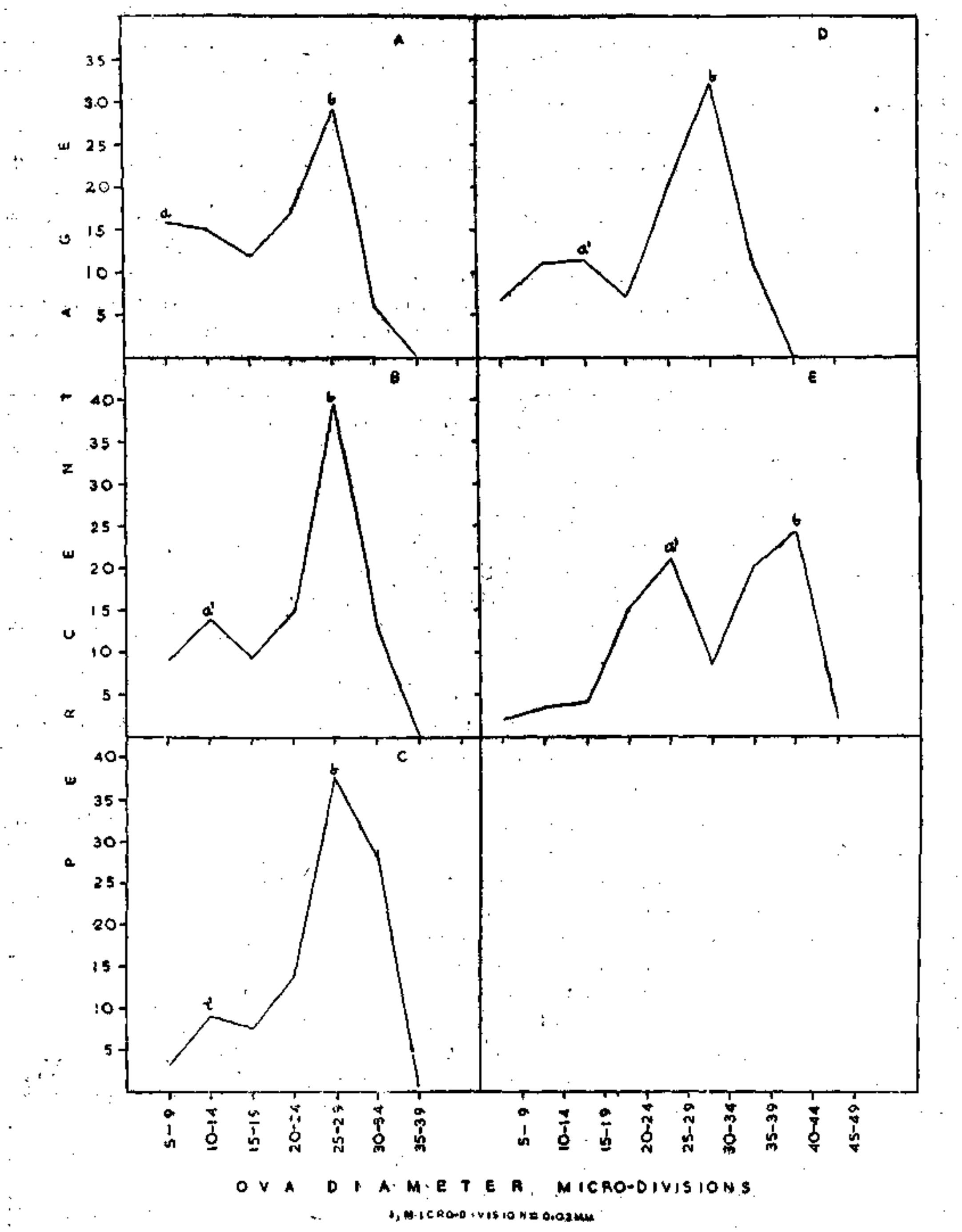

Fig. 2. Size frequency distribution of ova in the ovaries of *Pseudosciaena diacanthus* to show the sequence of maturation and the spawning.

Figures 2A and B represent the ova diameter frequency curves of ovaries in stage IV. Figure 2A shows two modes 'a' and 'b', the later being not sharply separated from the former Mode a represents the immature ova while 'b' represents mature ova. In Fig. 2B in addition to these two modes, another mode a^1 which is not prominent is observed. This represents the maturing ova. All the ova ranging 20-35 md (mode b) in diameter are fully yolked and opaque whereas in ova 10-20 md yolk formation has commenced around the nucleus and ova less than 10 md are completely transparent and devoid of yolk. Fig. 2A shows only one distinct group of mature ova which has a wide range 20-35 md and it is likely, therefore, that the actual period of spawning during which ova of this group are discharged, may be a prolonged one. The second mode a^1 (maturing ova) is not evident in the frequency curves for some stage IV ovaries while in others it is observed but not prominent. Figures 2C and D represent the ova diameter frequency polygons for ovaries in stage V. These are similar to those in stage IV except for the slight shift in the modal positions in Fig. 2D. The presence of an intermediate group of maturing ova represented by mode a^1 may not necessarily indicate a second spawning season. They may be shed after those under mode *b* are shed in the same spawning season. This indicates a prolonged spawning season for this species wherein at least two batches of eggs are spawned.

Fig. 2E shows the ova diameter frequency polygon for ovary in fully ripe condition and ready to spawn (stage VI). Here the mature ova represented by mode a^1 at 30 md and the ripe ova represented by mode b at 45 and are not sharply separated but give a bimodal picture. The eggs under both the modes are likely to be shed during the same spawning season. The eggs under mode b are fully ripe and probably shed in the same month of collection *i.e.*, June. By the time these eggs (mode b) are shed, the eggs under mode a^1 get ready to be shed subsequently and the time interval may not be long, because the eggs under mode a^1 are in a sufficiently advanced stage of development.

From Fig. 2B to E it can be seen that there is a gradual shifting of the modes. The modes a^1 (maturing) and *b* (mature) at 10-15 md. and 25-30 md in Fig. 2B persist in Fig. 2C which represents the ova diameter frequency curve for an early stage V ovary. But in Fig. 2D representing the frequency curve for ovary in stage V, the mode a^1 has shifted to 15-20 md and the mode b to 30-35 md. The mode a^1 at 15-20 md and the mode b at 30-35 md in Fig. 2D have shifted to 30-35 md (a^1) and 40-45 md (b) respectively in Fig. 2E representing the ova diameter frequency curve for a ovary in the fully ripe condition (stage VI). Thus the eggs represented by mode a^1 in stage IV frequency curve at 10-15 md can be traced through stage V to mode a^1 at 25-30 md in the ova diameter frequency curve of ovary in stage VI. Similarly the mode b at 25-30 md in the frequency curve for stage IV ovary can be traced to mode *b* at 40-45 md in the frequency curve for a stage VI ovary.

Specimens in stage IV of maturity were encountered in the catches of the trawlers from April and those in stage V and VI in May and June. Thus there is a gradual shifting of the modes in the ova diameter frequency curves in time *i.e.*, the ova gradually develop from mature (stage IV) in April to ripe condition (stage VI) in June. Since the eggs represented by mode 'b' in stage VI ovary collected in June, are in a fully ripe condition it is very likely that they may be shed the same month followed by the second group represented by mode 'a'[1] subsequently in the same season, the time gap being short. This is further supported by the results of studies on the monthly distribution of maturity stages, monthly size progression of the ova, seasonal variations in the gonad weight : body weight ratio, ponderal index or condition factor and occurrency of post-larvae and juveniles.

Clark (1934) has pointed out that if several groups of maturing eggs are present in an ovary, but only one batch is spawned by each female, the numbers of eggs in the maturing groups should maintain a constant ratio to the numbers of eggs in the mature group throughout the entire breeding season. If on the other hand, more than one batch of eggs are spawned each seasor, as the season advances succeeding batches of eggs will progress from maturing to mature group and the number of eggs in the maturing group should decrease in proportion to the number of eggs in the mature group. To test the applicability of the above statement to this species, the ratio of the maturing eggs to the mature eggs from the pooled ova diameter frequency data for ovaries in stage IV, the only stage available in sufficient number for such a comparison, was found out for the months of April, June and July 1958, and presented below :

Ratio of ova 0.20 to 0·40 mm (Group 'b') to ova above 0·40 mm (Group 'c') in Stage IV ovaries of *P. diacanthus*.

Month	No. of ovaries studied for ova diameter frequency	Ratio of ova 0.20 to 0.40 mm to ova larger than 0.40 mm
April, 58	2	1:3.13
June	5	1:2.76
July, 58	5	1:2.18

It was observed that the ratio of maturing eggs to mature eggs gradually decreased from 1:3·13 in April 1958 to 1:2·18 in July, 1958. It is therefore possible that more than one batch of eggs are shed during the same spawning season.

Spawning Season.—The cycle of events of maturation and spawning clearly show that *P. diacanthus* spawns during the period June to August. Specimens with ovaries in stage VI ready to spawn were observed towards the later part of June and it may be safely assumed that the spawning starts by the end of June. From April to June mostly mature and ripe specimens in stages IV, and VI were encountered in the trawler landings. In April and May the percentage of specimens in stage IV and V was observed to be high while in June-July the percentage of specimens in late stage V or VI was more. From July onwards the percentage of spent individuals gradually increased reaching the peak in August-September. From October onwards only spent recovering and immature individuals were observed and this continued till March. From March specimens in Stage III and IV started appearing and in April most of the specimens examined were in stage IV. This cycle of events was observed to be same each year during the four years of these investigations. The percentage of females in different stages of maturity in each month for the period 1958 to 1961 are given in Table I. In Table II the percentage of immature, mature ripe, and spent individuals in different months for the period 1958-61 are given. These clearly show that October to March is the resting period, April to June the period of active maturation and June to August the spawning period.

TABLE I A

Monthly percentages of P. diacanthus *above* 40 *cm* i. e. *excluding the juveniles in different stages of maturity. Data from the landings of the bull trawlers.*

1958

Month	I	II	III	IV	V	VI	VII	Recov. I	Recov. II	Recov. III	Partially spent.	Total No. of specimens examined.
February	..	..	..	..	..	..	..	..	100 (5)	..	..	5
March	28·57 (4)	14·28 (2)	..	..	..	..	..	21·42 (3)	35.71 (5)	..	..	14
April	38·46 (10)	..	..	15·38 (4)	..	..	..	34·61 (9)	7·69 (2)	3·84 (1)	..	26
May	57·14 (4)	..	..	..	..	..	..	42·86 (3)	..	..	..	7
June	25·0 (5)	..	..	60·0 (12)	5·0 (1)	5·0(1)	..	5·0 (1)	..	..	..	20
July	..	..	..	100 (11)	..	..	..	..	..	..	..	11
August	..	..	..	..	..	..	.. 100(2)	..	..	..	..	2
September	..	..	..	..	..	..	..	..	..	..	..	..
October	38·46 (5)	..	..	..	..	..	..	46·15 (6)	..	..	15·38 (2)	13
November	26·66 (4)	..	..	..	..	..	13·33 (2)	60·0 (9)	..	..	..	15
December	47·36 (9)	..	..	..	..	..	5·26 (1)	47·36 (9)	..	..	..	19

Figures in brackets indicate the actual numbers of specimens examined.

TABLE I B

Monthly percentages of P. diacanthus *above* 40 *cm i. e. excluding juveniles in different stages of maturity. Data from the landings of the bull-trawlers.*

1959

Month	I	II	III	IV	V	VI	VII	Recov. I	Recov. II	Recov. III	Partially spent	Total No. of Sp. Exmd.
January	38·88 (7)	..	..	..	..	..	..	61·12 (11)	..	..	..	18
February	29·42 (5)	..	..	..	..	..	..	70·58 (12)	..	..	..	17
March	25·0 (7)	..	..	..	..	..	..	75·0 (21)	..	..	..	28
April	41·66 (10)	..	..	41·66 (10)	..	..	..	16·66 (4)	..	..	..	24
May	42·86 (3)	..	..	42·86 (3)	..	..	..	14·28 (1)	..	..	..	7
June	..	..	..	100·0 (5)	..	..	..	..	..	..	..	5
July	..	..	..	..	..	..	..	..	..	..	..	..
August	..	..	..	..	33·33 (4)	..	25·0 (3)	..	16·66 (2)	..	25 (3)	12
September	..	..	..	..	..	..	40·0 (4)	10·0 (1)	..	..	50·0 (5)	10
October	25·0 (2)	..	..	..	..	..	75·0 (6)	..	..	..	..	8
November	25·0 (2)	12·5 (1)	12·5 (1)	..	..	..	25·0 (2)	12·5 (1)	12·5 (1)	..	..	8
December	75·0 (6)	..	..	..	..	..	12·5 (1)	..	12·5 (1)	..	..	8

Figures in brackets indicate the actual numbers of specimens examined.

TABLE I C

Monthly percentages of P. diacanthus *above* 40 *cm i.e. excluding the Juveniles in different stages of maturity. Data from the landings of the bull trawlers.*

1960

Month	I	II	III	IV	V	VI	VIII	Recov. I	Recov. II	Recov. III	Partially spent.	Total No. of specimens examined
January	29·62 (8)	..	..	..	..	..	..	70·38 (19)	..	..	..	27
February	50·0 (2)	..	..	..	..	..	..	50·0 (2)	..	..	..	6
March	..	..	..	25·0 (2)	..	..	..	37·5 (3)	12·5 (1)	25·0 (2)	..	8
April	..	..	..	..	..	..	..	..	..	..	..	..
May	..	..	..	14·28 (1)	14·28 (1)	..	28·57 (2)	42·86 (3)	..	..	..	7
June	..	..	..	40·0 (2)	40·0 (2)	20·0 (1)	..	..	..	..	..	5
July	..	..	..	..	..	..	50·0 (2)	..	..	..	50·0 (2)	4
August	20·0 (1)	..	..	..	..	..	60·0 (3)	..	..	..	20·0 (1)	5
September	..	..	..	..	..	..	100·0 (7)	..	..	..	..	7
October	44·44 (4)	..	..	..	..	..	..	55·55 (5)	..	..	..	9
November	33·33 (4)	..	..	..	..	..	..	66·66 (8)	..	..	..	12
December	50·0 (2)	..	.	..	..	..	..	55·0 (2)	..	..	..	4

Figures in brackets indicate the actual number of specimens examined.

TABLE I D

Monthly percentages of P. diacanthus *above* 40 *cm i. e. excluding the juveniles in different stages of maturity. Data from the landings of the bull trawlers.*

1961

Month	I	II	III	IV	V	VI	VII	Recov. I	Recov. II	Recov. III	Partially spent	Total No. of specimens examined
January	33·33 (2)	..	..	..	..	..	..	66·66 (4)	..	..	..	6
February	42·3 (11)	..	..	..	..	..	..	57·7 (15)	..	..	..	26
March	61·53 (16)	3·84 (2)	..	..	..	..	..	34·61 (9)	..	..	..	27
April	..	..	..	100 (5)	..	..	..	..	..	..	..	5
May	..	..	..	..	..	..	..	..	..	..	..	..
June	..	..	..	50·0 (4)	..	12·5 (1)	37·5 (3)	..	..	..	..	8
July	..	..	..	..	..	..	50·0 (1)	..	..	..	50·0 (1)	2
August	40·0 (10)	..	..	..	..	..	36·0 (9)	..	..	..	24·0 (6)	25
September	..	..	..	..	..	..	37·5 (3)	62·5 (5)	..	..	..	8
October	71·5 (5)	..	..	..	..	..	..	28·5 (2)	..	..	..	7
November	14·28 (1)	..	..	..	..	..	..	85·72 (6)	..	..	..	7
December	42·86 (3)	..	..	..	..	..	..	57·14 (4)	..	..	..	7

Figures in brackets indicate the actual number of specimens examined.

TABLE II

Monthly percentages of Immature, mature and spent P. diacanthus (*females*) *in the landings of the bull trawlers for the years* 1958, 59, 60 *and* 61

		1958	1959	1960	1961
Jan.	I	..	100	100	100
	M	..	..	..	..
	S	..	..	..	..
Feb.	I	100	100	100	100
	M	..	..	..	..
	S	..	..	..	..
Mar.	I	100	100	75	100
	M	..	..	25	..
	S	..	..	..	..
Apl.	I	84·62	58·34	..	..
	M	15·38	41·66	no data	100
	S	..	..	..	..
May	I	100	57·14	42·86	..
	M	..	42·86	28·51	no data
	S	..	..	28·51	..
June	I	30	..	..	..
	M	70	100	100	62·5
	S	..	..	..	37·5
July	I	..	..	..	..
	M	100	no data	..	..
	S	..	..	100	100
Aug.	I	..	16·66	20	40
	M	..	33·33	..	..
	S	100	50·00	80	60
Sep.	I	..	10	..	62·5
	M	..	..	..	..
	S	..	90	100	37·5
Oct.	I	84·62	25	100	100
	M	..	..	..	..
	S	15·38	75	..	..
Nov.	I	86·66	75	100	100
	M	..	..	..	..
	S	13·33	25	..	..
Dec.	I	94·74	87·5	100	100
	M	..	..	..	..
	S	5·26	12·5	..	..

I—Immature (Stage I to III).
M -Mature (Stage IV to VI).
S Spent and Partially spent.

TABLE III

Monthly size progression of ova in P. diacanthus. *The range in size of ova found in any particular month is represented by columns of circles. The majority of females had ova of the sizes indicated by (black) solid circles.* 1 *micrometer division*—0·02 *mm.*

Maturity	Diameter in micrometer divisions	JAN.	FEB.	MAR.	APR.	MAY.	JUN	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
IMMATURE	1—5	●	●	●	●	●	●	●	●	●	●	●	●
	5—10	●	●	●	●	●	●	●	●	●	●	●	●
MATURING	10—15			○	○	○	●	●	●	○	○		
	15—20			○	○	○	●	●	●	○	○		
MATURE	20—25			●	●	●	●	●	●	●	○		
	25—30			●	●	●	●	●	●	●	○		
	30—35			○	○	●	●	●	●	●	○		
RIPE	35—40			○			●	●	●	●	○		
	40—45						●	○		○			
	45—50						○	○		○			
	50—55									○			

These observations regarding the spawning season are further supported by the studies on the size progression of ova during different months. The immature ova occur in every adult female in all the months. Largest eggs in the fully ripe condition were observed in June. Mature and ripening ova in stage IV, V and VI were observed in the ovaries up to August. This indicates that the spawning season in this fish extends from June to September. The data of the monthly size progression of the ova is given in Table III. Jacob (1948) observed ripe specimen of *P. diacanthus* in full roe in the month of September ι Calicut on the west coast.

Minimum size at First Maturity

In Fig. 3 are plotted the percentage of mature female 'ghols' in each size group. It can be seen from the figure that only 5% of fish were mature in 75-80 cm group, 36·8% in 80-85 cm group, 91% in 85-90 cm group and 100% in 90-95 cm group and above. 85 cm may be taken as the average size of the fish at first maturity. *P. diacanthus* of the size group 85-90 cm show 3 or 4 annual rings on their scales and otoliths (Rao, K.V.S.'61) and it may therefore be infered that they attain their first mturity when they are 3 or 4 years old.

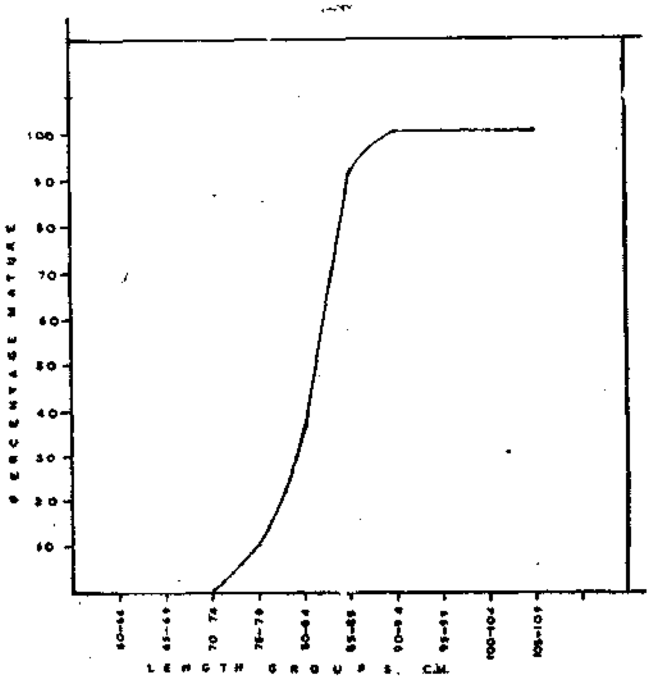

Fig. 3. Size at first maturity of *Pseudosciaena diacanthus*

Seasonal changes in the gonad weight : Body weight ratio

Though the seasonal variation of gonad weight : body weight ratio by itself was not sufficient as an indicator of spawning and reproductive activity, it was a valuable accessory to the visual assessment of gonad activity.

The seasonal changes in the weight of gonads are indicative of the changes undergone by them in the reproductive cycle due to maturation and spawning. The monthly mean gonad weight : body weight ratio were determined for 408 (298 females and 110 males) fish. These values for the years 1958, '59, '60 and '61 are plotted for females and males separately in Fig. 4 and 5. The pooled average values for the period 1958-61 for males and females are also shown in the above figs. The data for 1958 is incomplete for females and not available for males.

Females.—It can be seen from Fig. 4 that the gonad weight : body weight ratio values gradually increase from February to June when it attains the peak and thereafter gradually drop down reaching the minimum in November or December. In January there is slight increase in the values followed by a decline in February. This trend was observed each year during the period 1958 to '61. The decline in the value in May 1958, is due to the fact that the data was available for only one specimen.

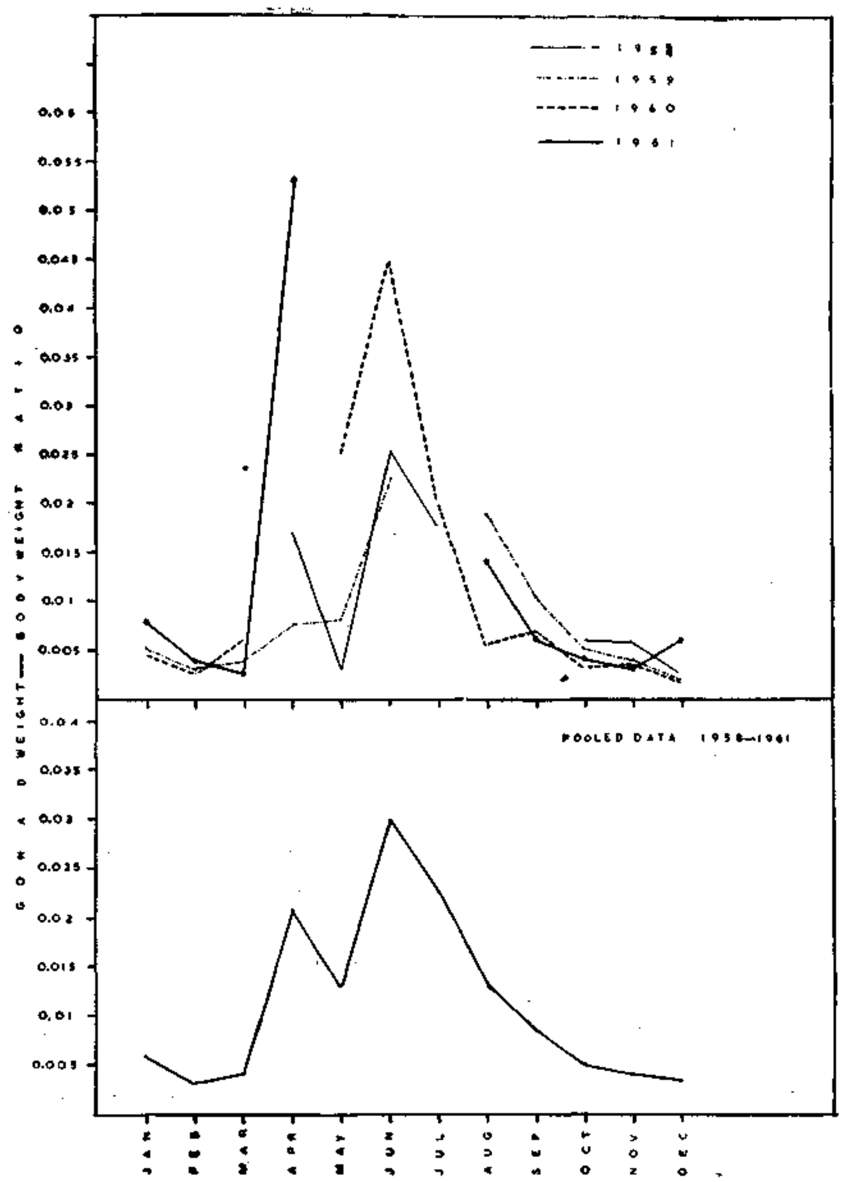

Fig. 4. Seasonal variations in the gonad weight: body weight ratio of female *Pseudosciaena diacanthus*.

Males.—The same trend was observed in the males. The pooled average values and the data for 1960 (Fig. 5) show a steep fall in August and a rise in September. In 1960 there was a gradual increase in the values from September to November and a fall in December while the data for the pooled average values shows a gradual decline from September onwards reaching the minimum in December. Again a slight increase in the values can be noticed in January.

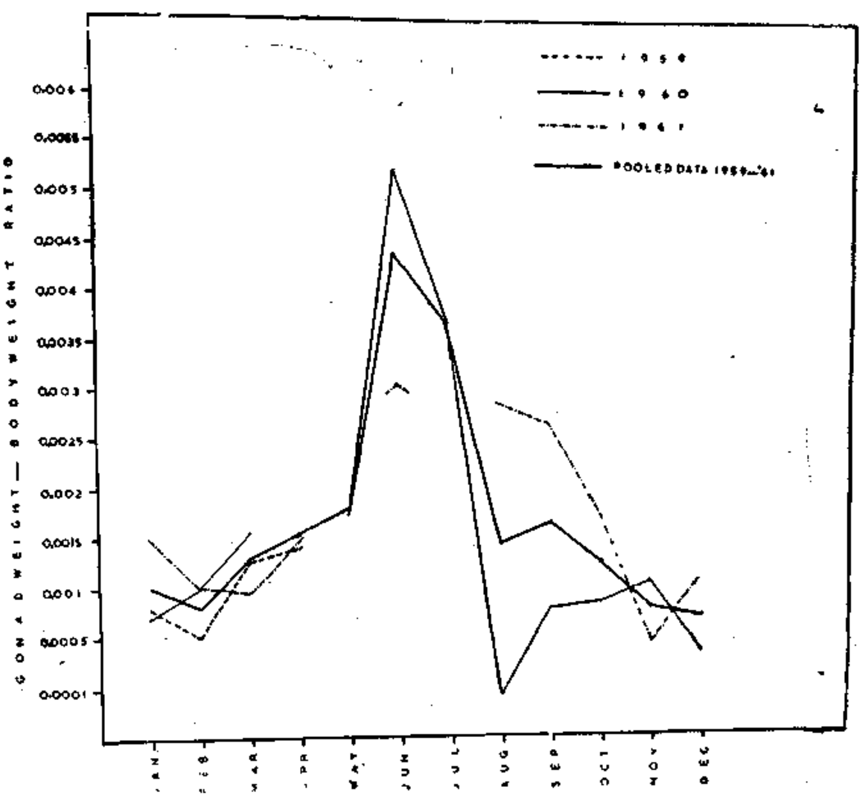

Fig. 5. Seasonal variations in the gonad weight: body wieght ratio of male *Pseudos iena diacanthus.*

The gradual increase in the mean gonad weight : body weight ratios from February onwards reaching the maximum in June in males and females may be due to the active maturation of the Spermatocytes and oocytes taking place in the gonads during this period. The gradual fall in values of the ratio from July to October is assumed to be due to the increased metab lic strain of spawning. The rise and fall in the gonad weight : body weight ratics due to the level of metabolic activity may in turn be influenced by the environmental conditions especially the availability of food and the intensity of feeding. The fish recover from the strain of spawning by December and that is probably why they show slightly higher values in January Thus the seasonal variations of this ratio offer not only an additional proof of the duration of the spawning season but also indicate the major phases of the reproductive cycle.

Misu (1954) made similar studies and inferred that the spawning season for *Nibea imbricata* in the East China and Yellow Seas is from August to September, because the monthly mean of the ratio of gonad weight to body weight shows the maximum in August and the minimum in September. Fairbridge (1951) studied the seasonal variations in the gonad weight of the Australian flathead, *Neoplatycephalus macrodon* and correlated it with the general cycle of maturation and spawning. Davies (1956) correlated the seasonal changes in the gonad weight of the South African Pilchard, *Sardinops occellatus* with gonad activity. Pillay (1958) studied the seasonal variations of the gonad weight : body wight and visceral weight : body weight ratio in *Hilsa ilisha* and correlated them with gonad activity and the spawning season.

Ponderal Index or condition factor

Hickling (1930), Hart (1946), Morrow (1951), Menon (1950) have correlated fluctuations in the Ponderal index with the attainment of maturity and spawning. Pillay (1958) correlated the fluctuations in the relative condition values with spawning season in *Hilsa ilisha*. Davies (1956) could not find correlation between seasonal variations of condition factor and spawning season in the South African pilchard but found correlation between seasonal variation of 'K' factor and the oil yield.

Condition factor (K) was calculated by employing the formula $K = \frac{W}{L^3} \times 100$ where W is the weight of fish in grams, L the length of fish in centimetres and 'K' the Ponderal index or condition factor. 'K' values were found out for 1042 fish and the mean 'K' values for each length-group are plotted in Fig. 6. The 'K' values of Juveniles upto 30·0 cm in length show a steady increase while the curves for males and females show rises and falls for the immature specimens below 60·0 cm which cannot be explained with the available biological data. This may be due to small number of fish in the intermediate length-groups in the samples. It can be seen from Fig. 6 that there is a steady rise in 'K' values from 60·0 to 109·9 cm in females while in the case of males there is a steady increase from 65·0 to 99·9 cm and thereafter there is a decline. The inflexion on a curve showing the diminution of 'K' with increasing length is a good approximate indication of the length at which sexual maturity is attained. The steady rise in 'K' values from 60·0 cm after the peak condition in immature fish and the inflexion at 75·0 cm in the curve for females is probably bound up with the onset of maturity. From the study of gonadial condition it has been inferred that the females attain matruity at 85·0 cm. It is not possible to detect the actual point of inflexion in the curve for males.

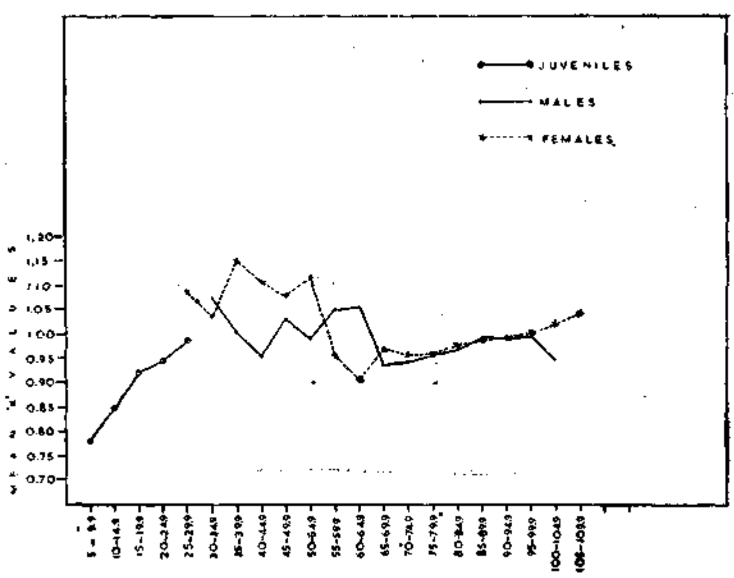

Fig. 6. Mean 'K' values at different lengths of *Pseudosciaena diacanthus*.

Seasonal Variations in 'K' Factor

For studying the interseasonal Variations in the 'K' factor, 'ghols' 70 cm and above in total length were taken into consideration as the data available for the smaller fish was limited. Length and weight measurements were available for a good number of specimens which were not cut open for detailed biological studies. 'K' values of these fish were pooled with those of males and females and the monthly mean 'K' values of all fish are presented in figs. 7A, B and C as "All combined". 'K' values of 852 fish were used for studying the inter-seasonal Variations.

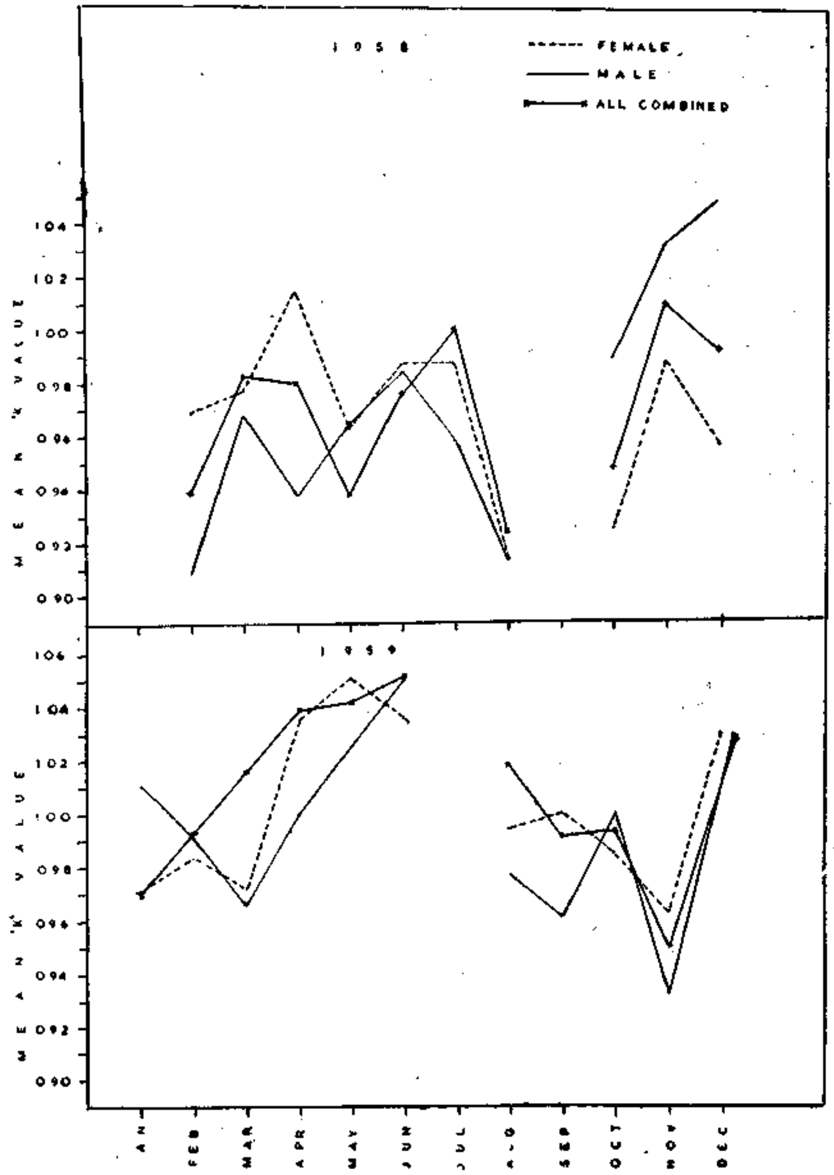

Fig 7A. Seasonal variations in the mean 'K' values of *Pseudosciaena diacanthus* during 1958-1959.

In Figs. 7A, and B are plotted the monthly average 'K' values for males, females and all combined for the years 1958, 1959, 1960 and 1961. The pooled data for the period 1958—'61 is plotted in fig. 7C. The curves show a gradual rise from February reaching the peak in June and suddenly fall down in July-August. Again from September there is a sudden rise followed by a decline in October or November. In December and January there is an upward trend in the years 1959 and '61 while the curves for 1958 and '60 show a downward trend. The apparent downward trend observed in April-May 1958 may be due to the sample being small. The gradual rise in the 'K 'values from February reaching the maximum in June in males and

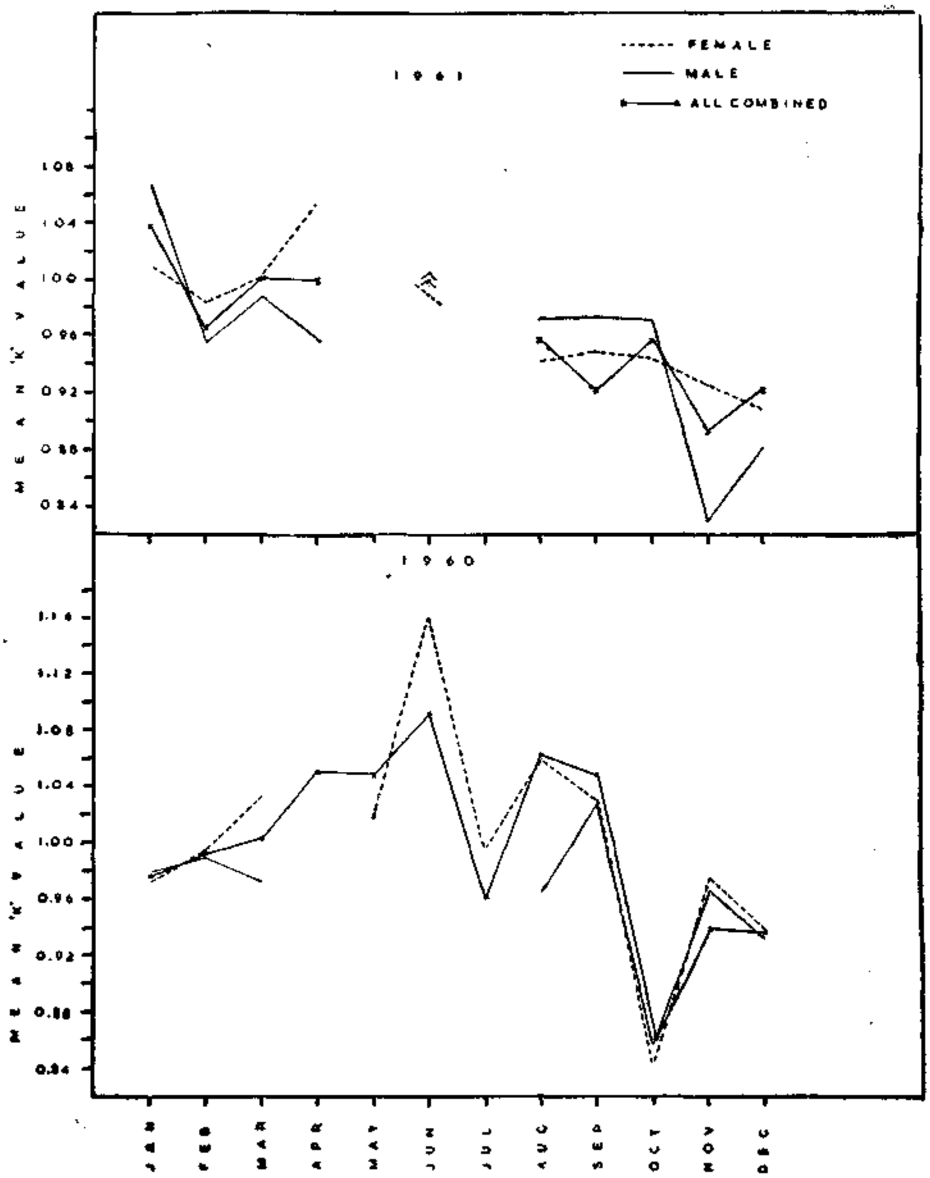

Fig. 7B. Seasonal variations in the mean 'K' values of *Pseudosciaena diacanthus* during 1960-1961.

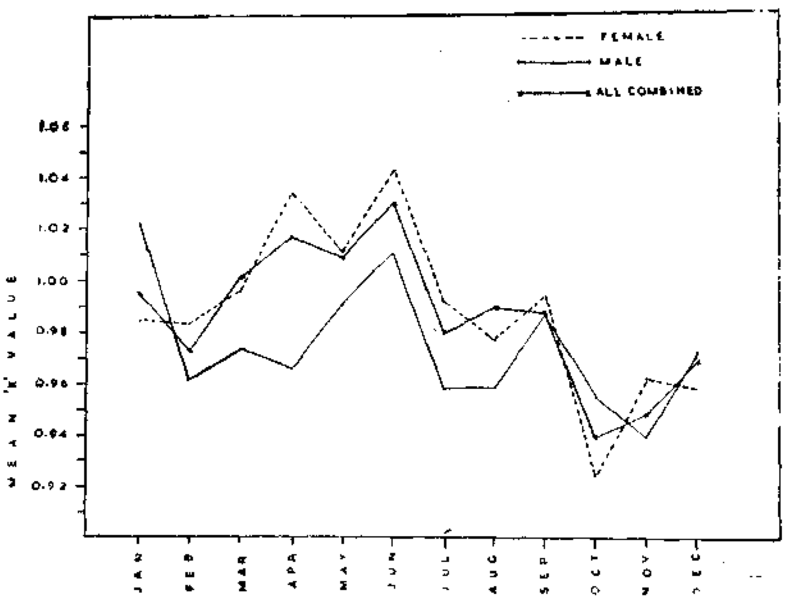

Fig. 7C. Seasonal variations in the pooled 'K' values of *Pseudosciaena diacanthus* during the period 1958-1961.

females may be attributed to the factor of active maturation during this period. The fall in the 'K'values in July-August indicates the beginning of spawning season in this species since the lowering of 'K' values is assumed to be consequent upon the lower level of condition due to the increased metabolic strain of spawning. The availability of food, level or intensity of feeding and other environmental conditions may influence in raising or lowering the metabolic activity and thereby raise or lower the level of "condition" prior to and during spawning.

The second peak observed in September or October may be due to the recovering condition of the fish after spawing. The second fall in the 'K' values observed in October-November may indicate a 'poor condition' of the fish for a second time which may be due to some other factor. Jayaraman and Gogate (1957) observed that the bottom temperatures were low during the period November to February in Dwaraka and Cutch regions (22°N latitude). It has been observed in the temperate countries that in the cold winter season fishes show cessation of feeding or low intensity of feedi. g probably resulting in the lowering of 'K' values. Though the studies on the food and feeding habits of *P. diacanthus* do not provide direct evidence for such a view, the possibility that a similar cause (viz. poor condition due to unfavourable environmental condition) may be responsible for the second fall in the 'K' values observed cannot be completely ruled out. The upward trend in December-January may indicate a second recovery.

It is interesting to note that the monthly mean gonad weight : body weight ratio and the 'K' factor values show similar seasonal trends lending support to the conclusions arrived at by either means.

Growth rate of gonads :

The average length and breadth of the ovary and testis in each size group (5 cms interval) was determined from a total of 428 fish (300 females and 128 males). The actual average lengths of fish in each size group were taken into consideration for calculating the theoretical values of the sizes of the gonads. To express the relation between the two variables X and Y (X being the length of fish in cm, Y the length of ovary or testis in cm) the equation for the regression line Y=a+b X, where 'a' and 'b' are the constants, was used. The equation for this linear relationship in the case of ovary and testis were found to be :

$$Y = -6{\cdot}089 + 0{\cdot}2828\,X \text{ and}$$
$$Y = -2{\cdot}85 + 0{\cdot}2307\,X \text{ respectively.}$$

The observed values for Y were plotted against their respective calculated values and the points were more or less closely located near the linear regression line. The data are plotted in Figs. 8 and 9. It could be inferred that for every 10 cm increase in the length of fish, the lengths of ovary and testis increase approximately 2·82 and 2·30 cm respectively.

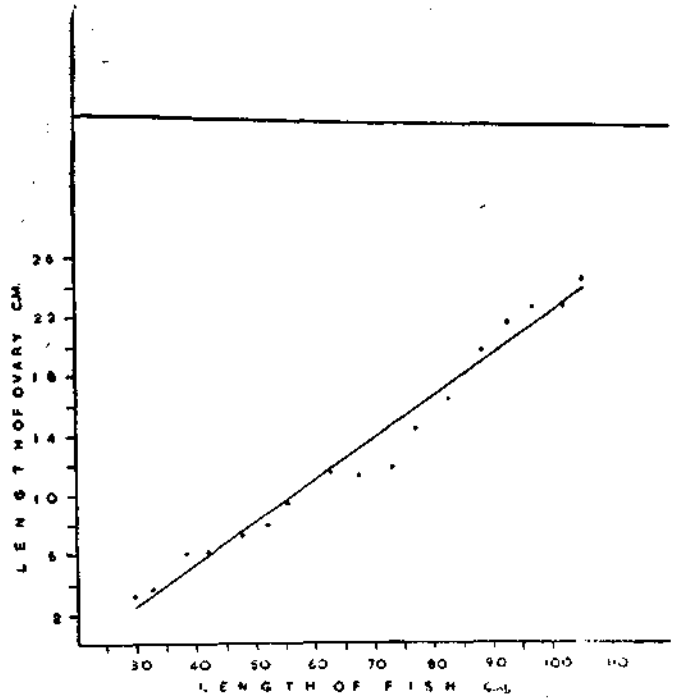

Fig. 8. Relationship between the length of ovary and length of fish in *Pseudosciaena diacanthus*.

The equations for the regression lines to show the relationship between the breadth of ovary or testis and the length of fish were found out to be :

$$Y = -1{\cdot}448 + 0{\cdot}0411\,X \text{ (Females)}$$
$$Y = -0{\cdot}888 + 0{\cdot}024\,X \text{ (Males).}$$

The linear relationship between the breadth of gonads and length of fish cannot be expressed correctly by the above equations as the observed values do not show a good fit to the regression

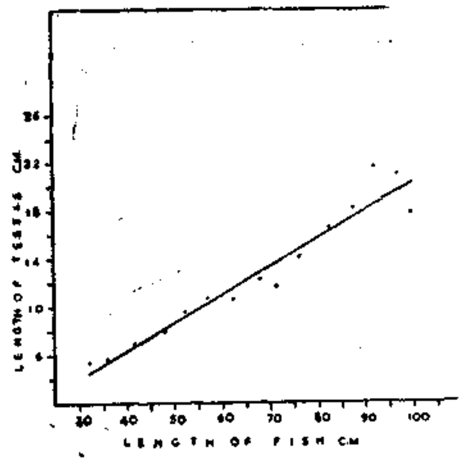

Fig. 9. Relationship between the length of testis and length of fish in *Pseudosciaena diacanthus*

lines. This indicates a disproportionate growth between the breadth of the gonads and the length of fish probably due to the maturation and spawning i.e. the growth in the breadth of gonads is related to the maturation and spawning events and not to the length of the fish.

Fecundity :

The entire ovary was weighed and a small portion of the ovary (fixed in 5% formaldehyde) was taken out and weighed. This weighed piece was teased and the ova evenly spread on a glass slide. All the mature ova in the piece teased were counted. From the number of mature ova obtained from the portion (piece) of ovary of known weight, the number of ova in one gram sample of the ovary and in the entire ovary was computed on the basis of its total weight. Fish with mature and ripe ovaries (Stage IV to VI) were considered for study. The estimated number of ova per gram sample and for the entire ovary for 12 specimens of different lengths are given in table IV.

The estimation of fecundity becomes a difficult task in fishes which spawn in more than one batch in the same season. In the absence of definite knowledge of the number of batches spawned during the season, the time between successive spawnings and the number of eggs that disintegrate and are reabsorbed at each shedding, correct fecundity estimates cannot be given. Hence for estimating the number of mature ova that are likely to be spawned, ova count per gram sample of the ovary was taken into consideration as was done by Karekar and Bal (1960) for *Polydactylus indicus*. This gives a reasonable rough estimate of the potential stock of the ova irrespective of the number of batches it has spawned besides minimising the apparent disparity in the fecundity estimates due to differences in the weights of the ovaries. The fecundity estimate of specimen 86·6 cm in length (vide table) is low (2,09,1220) while the ova count per gram sample shows the maximum (12,222). The low fecundity estimate is due to the low weight of the ovary. So, the ova count per gram sample is a more reliable index of fecundity.

TABLE IV

Estimated number of mature ova in *P. diacanthus*.

Total length of fish cm.	Ova count in one gram sample of ovary	Estimated number of ova in the ovary
93	6,678	17,43,010
93·2	9,210	39,19,388
86·6	12,222	20,91,220
97·5	12,114	68,68,638
84·8	8,296	19,91,200
94·8	5,770	19,73,340
94·4	8,150	23,63,500
94·0	10,890	37,78,820
96·5	7,368	34,62,960
91·8	5,658	34,45,722
103	9,095	67,03,924
106	6,950	48,26,775

It can be seen from the table IV that the fecundity estimates show wide variations in individuals of more or less the same length because it is likely that some individuals are getting ready for spawning for the first time in the season while others may have already spawned one batch. The number of eggs per gram sample spawned in one batch may vary from 4000 to 5000. The individuals with 5000 to 8000 ova per gram sample are probably those which have discharged one batch of eggs while fish with 9000 to 12,250 estimated ova per gram sample are probably those getting ready to spawn for the first time in the season and have these eggs as a potential stock which may be spawned in atleast two batches.

Jacob (1948) has given the fecundity estimate of a ovary in full roe (length-19 cm; breadth-5 cm.; weight-445 gms.) of *P. diacanthus* observed by him at Calicut market on 8-9-'47 as 62,50,000.

Sex ratio :

The sex composition of the random samples examined each month for detailed biological studies from the landings of the trawlers during the period of investigation are given in table V. It was observed that the females formed a high percentage in most of the months and in each year. The percentage of females in the total specimens examined in 1958, '59, '60 and '61 worked out to be 62·39, 63·85, 63·4, 55·7 respectively. The consistent preponderance of females in almost all the months and all the four years of this investigation is very striking. This suggests a segregation of the sexes. The males and females seem to move in separate shoals. This preponderance of females may be due to differential fishing also.

TABLE V

Sex ratio (percentage) in P. diacanthus. *Data from the landings of the Bull Trawlers*

Year	1958			1959			1960			1961		
Month	Total No. of fish examined	Males	Females	Total No. of fish examined	Males	Females	Total No. fish examined	Males	Females	Total No. of fish examined	Males	Females
January	..	..	..	31	35·48	64·52	42	28·57	71·43	16	62·50	37·50
February	7	28·57	71·43	38	31·57	68·43	9	22·32	77·68	44	40·90	59·10
March	26	46·15	53·85	49	28·57	71·43	10	30·00	70·00	54	51·85	48·15
April	48	33·33	66·67	44	40·90	59·10	..	..	..	6	16·67	83·33
May	12	41·66	58·34	15	53·33	46·67	10	30·00	70·00	..	..	..
June	30	33·33	66·67	13	61·53	38·37	12	58·34	41·66	12	33·33	66·67
July	20	40·00	60·00	..	..	..	5	20·00	80·00	2	..	100·00
August	6	66·67	33·33	17	29·41	70·59	7	28·57	71·43	44	43·18	56·82
September	..	..	..	15	33·33	66·67	13	46·15	53·85	14	42·85	57·15
October	21	28·57	71·43	10	20·00	80·00	16	43·75	56·25	16	56·25	43·75
November	27	44·44	55·56	13	38·37	61·53	20	40·00	60·00	8	12·50	87·50
December	29	38·48	65·52	15	40·00	60·00	9	55·55	44·45	12	41·66	58·34
TOTAL	226	37·61	62·39	260	36·15	63·85	153	36·60	63·40	228	44·29	55·71

Spawning ground and occurrence of post-larvae :

It was not possible to make collections of eggs and larvae of this species in the inshore waters. Post larval forms and small Juveniles 25 to 40 mm in length were observed in catches of the 'Dol' net operated in 20-40 metres depth around Bombay during June and July. Mature and ripe specimens examined during these investigations were landed by the bull-trawlers which fished mostly in 25-60 metres depth in the Cutch, Dwaraka and Veraval regions. This suggests that the spawning may take place in the offshore waters. The post-larvae and Juveniles seem to enter the inshore waters by June or July where they remain for six to eight months i.e. till January or February during which period they are landed in fairly large numbers by the 'Dol' nets at Versova and Sassoon Docks.

DISCUSSION

The studies on ova diameter frequencies in 'ghol' clearly indicate that the spawning season for this species is protracted and that the eggs are spawned in *atleast two batches* in the same season. It is unlikely that the species spawns a second time as the second batch of maturing eggs represented by mode a^1 in the ova diameter frequency curves for stage V and VI ovaries is not clearly and sharply separated from the eggs (mature or ripe) represented by mode b.

Since the larger eggs in stage VI ovary observed in June are in a fully ripe condition, spawning is not delayed and the first batch of eggs may be shed in the same month i.e. June or atleast in the beginning of July followed by the second batch subsequently, probably in August or early September, the time interval being short. At the close of the breeding season, the early ripening oocytes left after the last spawning, without undergoing further ripening, after a short time, are reabsorbed as the ovary enters the spent stage as indicated by the disintegrating ova in the spent ovaries. On the basis of observations made by Hickling and Rutenberg (1936); Walford (1932); De jong (1939); Prabhu (1956) and others the following four types of spawning can be distinguished.

A. Spawning taking place only once a year during a definite short period. The mature ova in the ovary are distinctly separated from the immature egg stock.

B. Spawning taking place only once a year, but with a longer duration. The range in size of the mature ova, irrespective of the number of modes representing them, has been found to be nearly half the total range in size of the entire intraovarian eggs.

C. Spawning twice a year. In addition to the ripe batch of eggs, another batch of eggs which has undergone more or less half the process of maturation, becomes evident.

D. Spawning throughout the year, but intermittently. In this type the different batches of eggs in the ovary are not sharply differentiated from one another thereby indicating that the passing of one batch of eggs into next stage is more or less a continuous process.

In *P. diacanthus* the presence of two batches of eggs not sharply separated from each other may superficially indicate that it belongs to the type 'D' of spawning mentioned above. In an intermittent spawner, spawning more or less throughout the year, more number of batches of eggs undergo maturation. But in this case the presence of only two batches indicates that it may not spawn throughout the year but in a definite period of longer duration (protracted) in two batches. More over in the ovaries of *P. diacanthus* the fully ripe eggs were not observed throughout the year or atleast during most of the months. The ripe eggs were observed in the ovaries only during the period May to September and not during other periods. The range in size of the mature ova irrespective of the number of modes representing them, in *P. diacanthus* has been observed to be nearly half (25 to 50 md) of the total range (1 to 50 md) in size of the entire intra ovarian eggs in the whole ovary. These facts indicate that *P. diacanthus* shows the B type of spawning. At least it may be said that it exhibits a modified B type of spawning i.e. spawning taking place once a year, but with a longer duration wherein the ova are shed in atleast two batches.

The partially spent ovaries refered earlier are those wherein the first batch of eggs has been shed and the second batch not yet developed to the ripe condition. These may be shed after a short time. The possibility of the reabsorption of the second batch of eggs in case they fail to develop to the ripe condition before the close of the spawning season cannot be completely ruled out.

According to Fulton (1899) the presence of intermediate group of ova in large numbers is associated with a prolonged spawning season and this appears to hold good in *P. diacanthus*.

The following points clearly show that *P. diacanthus* has a prolonged spawning season during which at least two batches of eggs are spawned.

1. Mature and ripe specimens were observed from April to August and completely spent or partially spent ones from June to September. From October to March only spents or recovering spents in stages I or II were encountered during the period of this investigation.

2. Completely spent ovaries (with only immature oocytes and few disintegrating mature or ripe ova) and partially spent ones (with a batch of unspawned mature ova) occur during the same period-June to September. This cannot happen if there is a second spawning season. All of them should be either completely spent or partially spent, unless there are different races or populations with overlapping or different spawning periods, which cannot be said at this stage.

3. In the ova diameter frequency curves the modes 'a[1]' and 'b' representing maturing or mature and ripe eggs are not sharply separated from each other with the result all the eggs under these modes (fig. 2E) can be considered as belonging to one group, the larger of which have become ripe earlier than the smaller ones. Some times ova represented by more than one mode adjacent to each other actually may indicate ova in the same stage of maturity as observed by Prabhu (1956).

4. Post-larvae and juveniles of *P. diacanthus* 25 to 40 mm in length were observed in the 'dol' net catches from June to August during the four years of this investigation. They were not obsereved for a second time in the year.

5. The length frequency data for juvenile 'ghols' from the 'dol' net landings shows the persistence of the modes for 2 or 3 months indicating prolonged recruitment due to prolonged spawning season.

6. The ratio of maturing eggs to mature eggs in pooled ova diameter frequencies for ovaries in stage IV shows a gradual decline from April 1958 to July 1958 indicating that more than one batch of eggs may be spawned during the same spawning season.

7. Studies on the seasonal variation of gonad weight : body weight ratio and the condition factor (Ponderal index) afford corraborative proof.

FOOD AND FEEDING HABITS

The quantitative analysis was done by the points method (Hynes, 1950). In allotting points the size of the fish and the fullness of the stomach were also taken into account, a full stomach, irrespective of the size of the fish, receiving a total of about 20 points and a distended (gorged) stomach receiving a total of about 30. Finally the points were summed up and scaled down to percentages, to give percentage composition of the food of all fish examined. The prevalence of the each item of food in the diet during different months was calculated by the occurrence method (Hynes, 1950). In this method, the number of occurrences of all items was summed and scaled down to a percentage basis to show the percentage composition of the diet.

When the food was not subjected to much digestive action, identification of the components up to genus and sometimes up to species was possible. Often the identification upto the broader group only was possible *viz*. Penaeid Prawns-carid prawns-diggested fish etc,

TABLE VI—A

Monthly percentage composition of different items of the stomach contents of P. diacanthus *by the points method from March* 1958 *to March* 1959

Items	March 58	April 58	May 58	June 58	July 58	August 58	Sept. 58	Oct. 58	Nov. 58	Dec. 58	Jan. 59	Feb 59	March 59	Average
PRAWNS	2·53	9·78	..	83·00	89·69	83·55	71·42	77·43	83·01	48·60	58·94	7·69	23·07	66·75
Unidentified prawns	2·53	5·43	..	5·00	11·85	50·76	71·42	26·58	25·47	5·30	17·89	4·61	..	21·78
Unidentified carid prawns	..	..	..	19·00	5·57	4·04	..	0·38	..	..	4·73	..	..	2·31
Unidentified Penaeid prawns	..	2·17	..	19·20	10·72	11·32	..	9·59	2·83	4·46	8·42	..	..	7·82
Hippolysmata ensirostris	..	..	..	4·00	8·58	..	..	2·59	..	5·30	13·15	..	..	3·44
Acetes indicus	..	..	..	30·00	53·21	8·08	..	35·66	9·43	17·03	6·84	3·07	..	21·70
Metapenaeus spp.	..	..	..	..	..	9·43	..	..	..	4·19	..	..	..	1·96
Solenocera indicus	..	2·17	..	..	..	..	..	2·59	39·15	12·29	6·31	..	23·07	6·88
Leander sp.	..	..	..	6·00	..	..	..	..	..	..	..	..	..	0·23
Parapenaeopsis sp.	..	..	..	..	..	..	..	..	6·13	..	1·57	..	..	0·62
FISHES	93·67	69·56	..	12·00	10·30	16·44	..	20·62	11·32	45·81	28·42	70·76	76·92	28·62
Unidentified fish	..	14·13	..	1·00	4·72	8·35	..	1·29	3·30	..	3·68	..	15·38	3·51
Lactarius lactarius	93·67	11·95	..	..	..	..	..	0·51	..	..	2·10	..	30·76	4·41
Trichiurus sp.	..	3·26	..	..	..	..	..	..	..	..	..	..	30·76	0·89
Otholithus sp.	..	21·73	..	..	..	..	..	..	..	..	..	..	..	0·78
Sciaenids - Johnius sp.	..	16·30	..	..	..	2·69	..	0·77	..	..	..	30·76	..	1·99
Polynemus heptadactylus	..	2·17	..	..	..	5·39	..	2·33	0·94	3·07	..	7·69	..	2·26
Bregmaceros macclellandi	..	..	..	3·00	..	..	..	9·46	..	41·89	5·26	23·07	..	9·81
Coilia dussumieri	..	..	..	5·00	5·57	..	..	..	..	..	..	9·23	..	0·98
Anchoviella sp.	..	..	..	3·00	..	..	..	0·64	..	..	..	..	..	0·31
Drepane sp.	..	..	..	..	..	..	..	1·29	..	..	..	..	..	0·39
Eels-Muraenesox sp	..	..	..	..	..	..	..	0·51	3·77	0·83	..	..	..	0·58
Upeneus sp.	..	..	..	..	..	..	..	2·85	3·30	..	..	..	..	1·13
Harpodon nehereus	..	..	..	..	..	..	..	0·90	..	..	..	..	..	0·27
Cynoglossus sp.	..	..	..	..	..	..	..	..	..	..	17·36	..	..	1·29
OTHER CRUSTACEA.	1·26	11·95	..	5·00	..	..	28·57	1·94	4·24	5·58	12·62	21·53	..	4·61
Squilla sp.	..	..	..	4·00	..	..	28·57	1·03	4·24	4·46	6·84	3·07	..	2·26
Crabs	1·26	11·95	..	1·00	..	..	..	0·90	..	1·11	1·05	..	..	1·01
Portunid crabs, Neptunes sp.	..	..		..	..	..	..	..	..	..	4·73	18·46	..	0·82
MOLLUSCS	2·53	8·68	..	..	..	..	..	..	1·41	..	..	..	..	0·50
Sepia sp.	2·53	7·60	..	..	..	..	..	..	1·41	..	..	..	..	0·46
ropods	..	1·08	..	..	..	..	..	..	..	..	..	..	..	0·03

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TABLE VI—B

Monthly percentage composition of different items of the stomach contents of P. diacanthus *by the points method from April,* 1959 *to March* 1960

Items	April 59	May 59	June 59	July 59	August 59	September 59	October 59	November 59	December 59	January 60	February 60	March 60	Average
PRAWNS	..	..	..	..	..	84·72	83·00	55·20	46·26	50·00	..	..	66·71
Unidentified prawns	..	..	..	..	..	41·78	13·80	10·85	5·60	..	..	..	19·49
Digested unidentified carid prawns	..	..	..	..	..	9·36	2·8	..	0·41	16·66	..	..	3·86
Digested unidentified penaeid prawns	..	..	..	..	..	18·44	16·2	9·50	2·48	..	..	..	11·81
Hippolymata ensirostris	..	..	..	..	..	14·84	7·8	5·42	4·97	..	..	..	8·53
Acetes indicus	..	..	..	..	..	0·28	17·0	2·03	13·48	..	..	..	7·23
Metapenaeus spp.,	..	..	..	..	..	..	2·0	3·39	..	..	..	..	1·12
Solenocera indicus	..	..	..	..	..	..	22·2	11·53	9·33	..	..	..	9·29
Leander spp.,	..	..	..	..	..	..	1·2	..	..	..	..	..	0·26
Parapenaeopsis spp.,	..	..	..	..	..	..	..	4·52	..	33·33	..	..	1·34
Metapenaeopsis novae-guinae	..	..	..	..	..	..	..	3·61	..	..	..	..	0·71
Parapenaeopsis hardwickii	..	..	..	..	..	..	..	4·29	4·56	..	..	..	1·84
Atypopenaeus compressipes	..	..	..	..	..	..	..	..	4·35	..	..	..	0·94
Alpheids	..	..	..	..	..	..	..	..	1·03	..	..	..	0·22
FISHES	100	100	..	..	..	12·68	15·4	36·42	46·47	..	..	..	28·21
Polynemus heptadactylus	..	..	..	..	..	1·15	4·6	2·17	4·14	..	..	..	2·83
Anchoviella spp.,	..	..	..	..	..	6·48	..	..	..	..	..	..	2·02
Small sciaenids -Johnius spp.,	..	..	..	..	..	3·17	0·6	..	0·82	..	..	..	1·30
Lactarius lactarius	80·62	..	..	..	..	..	1·4	..	..	..	..	..	2·92
Rastrelliger kanagurta	..	60·00	..	..	..	..	..	..	..	..	..	..	0·53
Otolithus spp.,	..	40·00	..	..	..	..	..	..	..	..	..	..	0·35
Harpodon nehereus	..	..	..	..	..	1·87	3·8	..	..	..	..	..	1·43
Unidentified fish	19·38	..	..	..	..	..	5·0	7·69	2·90	..	..	..	3·27
Bregmaceros macclellandi	..	..	..	..	..	..	..	20·13	35·89	..	..	..	11·76
~~Apogon novemfasciatus~~	..	..	..	..	..	..	..	0·67	..	..	..	..	0·13
Muraenesox spp., (young eels)	..	..	..	..	..	..	..	0·90	1·24	..	..	..	0·44
Trypauchen vagina	..	..	..	..	..	..	..	2·26	..	..	..	..	0·44
Coilia dussumieri	..	..	..	..	..	..	..	2·03	1·45	..	..	..	0·71
OTHER CRUSTACEA	..	..	..	..	..	2·59	1·6	7·91	5·80	16·66	..	..	4·22
Squilla spp.,	..	..	..	..	..	2·59	1·6	7·91	5·80	..	..	..	3·99
Crabs-charybdis callianasa	..	..	..	..	..	..	..	..	..	16·66	..	..	0·22
MOLLUSCS	..	..	..	..	..	..	..	0·45	1·45	33·33	..	..	0·85
Sepia spp.,	..	..	..	..	..	..	..	0·45	..	..	..	..	0·08
Loligo spp.,	..	..	..	..	..	..	..	..	1·45	..	..	..	0·31
Octopus spp.,	..	..	..	..	..	..	..	..	..	33·33	..	..	0·44

TABLE VI—C

Monthly percentage composition of different items of the stomach contents of P. diacanthus *by the points method from April* 1960 *to March* 1961

Items	April 60	May 60	June 60	July 60	August 60	September 60	October 60	November 60	December 60	January 61	February 61	March 61	Average
PRAWNS	..	35·00	95·84	91·71	96·77	95·04	76·97	43·89	51·92	73·33	Nil	Nil	81·21
Unidentified prawns (digested)	..	..	92·45	2·07	24·19	12·07	18·42	12·21	4·80	6·66	..	..	21·87
Unidentified carid prawns .	..	..	..	..	..	..	..	..	..	..	..	..	..
Unidentified penaeid prawns .	..	5·00	1·13	12·95	27·41	7·12	7·89	1·90	..	..	..	..	6·83
Hippolysmata ensirostris .	..	10·00	0·75	..	12·90	35·84	4·60	..	12·50	40·00	..	..	12·67
Acetes indicus . . .	..	10·00	..	66·83	..	10·09	13·15	12·97	17·30	26·66	..	..	21·76
Metapenaeus sp. . . .	..	..	1·50	..	32·25	..	..	..	..	..	..	..	1·32
Solenocera indicus . .	..	..	..	..	..	..	..	3·05	9·60	..	..	..	0·99
Leander sp.	..	10·00	..	..	..	3·96	..	..	..	..	..	..	1·21
Parapenaeopsis stylifera . .	..	..	..	..	..	20·79	..	6·48	7·69	..	..	..	7·16
Parapenaeopsis sp. . .	..	..	..	9·84	..	5·34	30·92	7·25	..	..	..	..	7·21
Parapenaeopsis hardwickii	..	..	..	..	..	..	1·97	..	..	..	..	..	0·16
Alpheids	..	..	..	5·18	..	..	..	..	..	..	..	..	1·10
FISHES	..	65·00	3·77	Nil	3·22	2·97	21·71	54·19	41·34	26·66	Nil	85·70	15·53
Unidentified fish . . .	..	..	3·77	..	3·22	..	9·93	1·52	4·80	26·66	..	71·42	3·19
Polynemus heptadactylus .	..	..	..	..	..	..	3·31	3·05	..	..	..	..	0·71
Anchoviella sp. . . .	..	..	..	..	..	..	..	..	..	..	..	..	..
Small sciaenids—Johnius sp. .	..	..	..	..	..	..	..	7·63	..	..	..	..	1·10
Otolithus spp., . . .	..	..	..	..	..	1·98	..	..	..	..	..	..	0·45
Harpodon nehereus . .	..	..	..	..	..	0·59	3·94	..	..	..	..	..	0·58
Bregmaceros macclellandi .	..	50·00	..	..	..	..	..	41·22	36·53	..	..	..	8·58
Young eels (Muraenesox sp) .	..	15·00	..	..	..	..	..	0·76	..	..	..	14·28	0·38
Coilia dussumieri . . .	..	..	..	..	..	0·39	1·31	..	..	..	..	..	0·22
Thrissocles sp. . . .	..	..	..	..	..	..	3·31	..	..	..	..	..	0·27
OTHER CRUSTACEA . . .	..	..	0·37	3·10	..	1·98	1·31	1·90	6·72	..	..	14·28	2·14
Squilla sp.	..	..	..	3·10	..	1·98	1·31	1·90	1·92	..	..	..	1·70
Crabs	..	..	0·37	..	..	..	..	..	4.80	..	..	14·28	0·44

Prawns and fishes formed the major food items. Other crustanceans like crabs, *Squilla* spp., Alpheids, and molluscs like *Sepia spp*, *Loligo spp.*; gastropods (shell remains) were observed occasionally in small proportions. The following genera/species of crustaceans, molluscs and fishes were encountered in the course of this investigation in the stomach contents of *P diacanthus* :

Crustacea

Penaeid Prawns :	*Solenocera indicus*
Metapenaeus Spp.,	*Acetes indicus*
Parapenaeopsis Spp.,	*Carid Prawns :*
Parapenaeopsis stylifera	*Hippolysmata ensirostris*
Parapenaeopsis hardwickii	*Leander stylifera*
Atypopenaeus compressipes	*Leander tenuipes.*
Metapenaeopsis novae-guinae	

Other Crustacea :

Alpheus Spp.,
Squilla Spp.,

Crabs :

Neptunus Spp.,
Charybdis callianasa

Molluscs :

Sepia Spp.
Loligo Spp.
Octopus Spp.
gastropod shell remains — *Oliva Spp.*

Fishes :

Order *Acanthopterygii*
Family *Percidae*

1. *Apogon novemfasciatus.*	7. *Otolithus ruber*
Squampinnes	*Trichiuridae*
2. *Drepane Spp.*	8. *Trichiurus Spp.*
Mullidae	*Carangidae*
3. *Upenoides Spp.*	9. *Lactarius lactarius*
Polynemidae	*Scombridae*
4. *Polynemus heptadactylus*	10. *Rastrelliger kanagurta*
Sciaenidae	*Gobidae*
5. *Johnius Spp.*	11. *Trypauchen vagina*
6. *Otolithus Spp.*	

Order *Anacanthini*

Family *Gadidae*

12, *Bregmaceros macclellandi*

Pleuronectidae

13. *Cynoglossus Spp.*

Muraenidae

18. *Muraenesox Spp.*,

19. *Neenchelys buitendijki*

Order *Phystostomi*

Family *Scopelidae*

14. *Harpodon nehereus*

Clupeidae

15. *Anchoviella Spp.*

16. *Thrissocles Spp.*

17. *Coilia dussumieri*

Acetes indicus, Hippolysmata ensirostris, Solenocera indicus, Parapenaeopsis stylifera.—were the important prawn species that were often encountered in the stomach contents while among fullout fishes *Bregmaceros macclellandi* ranked first, *Polynemus heptadactylus, Lactarius lactarius, Johnius* spp. coming next in the order of importance.

The monthly percentage composition of the different categories of food taken by *P. diacanthus* for the years 1958 to 1961 analysed by the points and occurrence methods are given in table VI (A, B, C) and VII (A,B,C). The broad trends in the results of analysis by the two methods appear to be similar.

In Figs. 10A, B and C are shown the monthly percentages of Prawn and fish items during the period 1958 to 1961. The percentage of *prawns* was high (70-90%) from July to November, especially in the juveniles. From December onwards the percentage of prawn item diminished and that of fishes increased. Fish items formed about 50% of the stomach contents in December. From March to May the percentage of fish items was high.

During September to November when prawns formed 80-90% of the stomach contents of the juveniles, peak landings of prawns were observed from the 'dol' nets. This suggests that the high percentage of prawns in the stomachs of juveniles from 'dol' net during this period may not be due to 'selective feeding' but may be due to the fact that they feed on whatever was available in abundant quantities in the inshore waters.

The food and feeding habits of 'ghol' was studied with reference to two size groups. 1. Big and medium sized ones above 50 cm in length landed by the trawlers 2. Juveniles less than 50 cm in length landed by the 'Dol' nets. In all 1624 specimens were examined for these studies.

Big Ghols—A very interesting feature observed was that 95% of the 679 specimens examined from the trawlers, had their stomachs extroverted partly or fully and disgorged the food. The monthly percentages of specimens with extroverted stomaches is given in table VIII.

TABLE VII—A

Monthly percentage prevalence of different items of the stomach contents of **P.** diacanthus *by the occurrence method from March* 1958 *to March* 1959

Items	March 58	April 58	May 58	June 58	July 58	Aug. 58	Sept. 58	Oct. 58	Nov. 58	Dec. 58	Jan. 59	Feb. 59	March 59	Average
PRAWNS	22·22	25·00	..	65·00	80·77	80·00	50·00	75·61	76·74	56·00	60·52	22·22	25·00	65·53
Unidentified prawns	22·22	16·66	..	10·00	19·23	51·42	50·00	34·14	32·55	12·00	21·05	11·11	..	26·89
Unidentified carid prawns	..	..	..	10·00	7·69	2·85	..	1·62	..	..	2·63	..	..	2·08
Unidentified penaeid prawns.	..	4·16	..	10·00	7·69	11·42	..	8·13	4·65	10·00	7·89	..	..	7·57
Hippolysmata ensirostris	..	..	..	5·00	3·84	..	..	0·81	..	6·00	7·89	...	..	2·34
Acetes indicus	..	..	..	25·00	42·30	5·70	..	29·26	16·27	14·00	13·15	11·11	..	19·23
Metapenaeus spp.	..	..	..	..	..	8·57	..	..	..	2·00	..	..	...	1·04
Solenocera indicus	..	4·16	..	..	..	..	..	1·62	18·60	12·00	5·26	..	25·00	5·22
Leander spp.	..	..	..	5·00	..	..	..	..	..	..	...	...	..	0·26
Parapenaeopsis spp.	..	..	..	..	..	..	..	..	4·65	..	2·63	..	..	0·78
FISHES	55·55	50·00	..	25·00	19·23	20·00	..	21·13	18·60	34·00	23·68	55·55	75·00	26·63
Unidentified fish	..	16·66	..	5·00	11·53	14·28	..	2·43	6·97	..	5·26	..	25·00	5·74
Lactarius lactarius	55·55	8·33	..	..	..	..	..	0·81	..	..	2·63	..	25·00	2·61
Trichiurus spp.	..	4·16	..	..	..	..	..	..	..	..	..	..	25·00	0·52
Otolithus spp.	..	8·33	..	..	..	..	..	..	..	..	..	..	..	0·52
Sciaenids—Johnius spp.	..	8·33	..	..	..	2·85	..	2·43	..	..	..	11·11	..	1·82
Polynemus heptadactylus	..	4·16	..	..	..	2·85	..	2·43	2·32	4·00	..	11·11	..	2·34
Byegmaceros macclellandi	..	..	..	5·00	..	..	..	7·31	..	28·00	5·26	22·22	..	7·31
Coilia dussumieri	..	..	..	10·00	7·69	..	..	..	..	..	..	11·11	..	1·30
Anchoviella spp.	..	..	..	5·00	..	..	..	0·81	..	..	..	..	..	0·52
Drepane spp.	..	..	..	..	..	..	..	0·81	..	..	..	..	..	0·26
Eels—Muraenesox spp.	..	..	..	..	..	..	..	1·62	6·97	2·00	..	..	..	1·56
Upeneus spp.	..	..	..	..	..	..	..	1·62	2·32	..	..	..	..	0·78
Harpodon nehereus	..	..	..	..	..	..	..	0·83	..	..	..	..	..	0:26
Cynoglossus spp.	..	..	..	..	..	..	..	..	..	..	10·52	..	..	1·04
OTHER CRUSTACEA	11·11	12·50	..	10·00	..	..	50·00	3·25	4·65	10·00	15·78	22·22	..	7·57
Squilla spp.	..	..	..	5·00	..	..	50·00	1·62	4·65	8·00	5·26	11·11	..	3·39
Crabs	11·11	12·50	..	5·00	..	..	..	1·62	..	2·00	2·63	..	..	2·34
Portunid crabs, Neptunes	..	..	..	..	..	..	..	..	..	..	7·89	11·11	..	1·04
MOLLUSCS	11·11	12·50	..	..	..	..	..	..	..	..	..	..	..	1·04
Sepia spp.	11·11	8·33	..	..	..	..	..	..	..	..	..	..	..	0·78
Gastropods	..	4·16	..	..	..	..	..	..	..	..	..	..	..	0·26

TABLE VII—B

Monthly percentage prevalence of different items of the stomach contents of P. diacanthus *by occurrence method from April 1959 to March 1960*

Items	April 59	May 59	June 59	July 59	Aug. 59	Sept. 59	Oct. 59	Nov. 59	Dec. 59	Jan. 60	Feb. 60	March 60	Average 60
PRAWNS	..	..	..	..	..	88·60	85·71	57·81	61·97	50·00	..	..	72·12
Unidentified prawns	..	..	..	..	..	53·16	23·8	14·06	11·26	..	..	..	25·78
Unidentified carid prawns	..	..	..	..	..	7·59	3·17	..	1·40	25·00	..	..	3·48
Unidentified penaeid prawns	..	..	..	..	..	15·18	15·87	9·37	2·81	..	..	..	10·45
Hippodysmata ensirostris	..	..	..	..	..	11·39	7·93	6·25	2·81	..	..	..	6·96
Acetes indicus	..	..	..	..	..	1·26	15·87	9·37	22·53	..	..	..	11·49
Metapenaeus spp.,	..	..	..	..	..	..	1·58	4·68	..	..	..	..	1·39
Solenocera indicus	..	..	..	..	..	..	15·87	9·37	12·67	..	..	..	8·71
Leander spp.,	..	..	..	..	..	..	1·58	..	..	..	..	..	0·34
Parapenaeopsis spp.,	..	..	..	..	..	..	..	1·56	..	25·00	..	..	0·69
Metapenaeopsis novae-guinae.	..	..	..	..	..	..	..	1·56	..	..	..	..	0·34
Parapenaeopsis hardwickii	..	..	..	..	..	..	..	1·56	2·81	..	..	..	1·04
Atypopenaeus compressipes	..	..	..	..	..	..	..	..	4·22	..	..	..	1·04
Alpheids	..	..	..	..	..	..	..	..	1·40	..	..	..	0·34
FISHES	100·00	100	..	..	..	8·86	12·69	34·37	30·98	..	..	..	27·87
Polynemus heptadactylus	..	..	..	..	..	1·26	..	3·12	2·81	..	..	..	1·74
Anchoviella spp.,	..	..	..	..	..	2·53	..	..	..	—	—	..	0·69
Small sciaenids—Johnius spp.	..	..	..	..	..	3·79	1·58	..	1·40	..	..	..	1·74
Lactarius lactarius	75·00	..	..	..	..	..	1·58	..	..	..	..	..	1·39
Rastrelliger kanagurta	..	50·00	..	..	..	..	..	..	..	..	..	..	0·34
Otolithus spp.,	..	50·00	..	..	..	..	..	..	..	..	..	..	0·34
Harpodon nehereus	..	..	..	..	..	1·26	1·58	..	..	..	..	..	0·69
Unidentified fish	25·00	..	..	..	..	..	7·93	9·37	5·63	..	..	..	5·57
Breymaceros macclellandi	..	..	..	..	..	..	..	12·50	18·30	..	..	..	7·31
Apogon novemfasciatus	..	..	..	..	..	..	..	1·56	..	..	..	..	0·34
Younge-Eels-Muraenesox spp.,	..	..	..	..	..	..	..	1·56	1·40	..	..	..	0·69
Trypauchen vagina	..	..	..	..	..	..	..	4·68	..	..	..	..	1·04
Coilia dussumieri	..	..	..	..	..	..	..	1·56	1·40				0·69
OTHER CRUSTACEA	..	..	..	..	..	2·53	1,15	6·25	5·63	25.00	..	..	4·18
Squilla spp.,	..	..	..	..	..	2·53	1·15	6·25	5·63	..	..	..	3·82
Carbs-charybdis callianasa	..	..	..	..	..	..	..	..	..	25·00	..	..	0·34
MOLLUSCS	..	..	..	..	..	..	..	1·56	1·40	25·00	..	..	1·04
Sepia spp.,	..	..	..	..	..	..	..	1·56	..	..	..	..	0·34
Loligo spp.,	..	..	..	..	..	..	..	..	1·40	..	..	..	0·34
Octopus spp.,	..	..	..	..	..	..	..	..	..	25·00	..	..	0·34

TABLE VII—C

Monthly percentage prevalence of different items of the stomach contents of P. diacanthus *by the occurrence method from April 1960 to March 1961*

Items	April 60	May 60	June 60	July 60	Aug. 60	Sept. 60	Oct. 60	Nov. 60	Dec. 60	Jan. 61	Feb. 61	March 61	Average
PRAWNS	..	66·66	92·00	95·12	83·33	90·19	70·37	56·75	56·25	66·66	..	..	77·98
Unidentified prawns	..	..	80·00	4·87	16·66	19·60	22·22	21·62	6·25	16·66	..	..	22·47
Unidentified carid prawns	..	..	..	..	..	..	..	..	..	..	..	..	..
Unidentified penaeid prawns	..	16·66	4·00	21·95	33·33	7·84	7·40	2·70	..	..	..	..	9·17
Hippolysmata ensirostris	..	16·66	4·00	..	16·66	27·45	3·70	..	18·75	33·33	..	..	10·55
Acetes indicus	..	16·66	..	56·09	..	15·68	14·80	13·51	12·50	16·66	..	..	20·18
Metapenaeus sp.	..	..	4·00	..	16·66	..	..	..	..	..	..	..	0·91
Solenocera indicus	..	..	..	..	..	..	..	5·40	12·50	..	..	..	1·82
Leander sp.	..	16·66	..	..	..	1·96	..	..	..	..	..	..	0·91
Parapenaeopsis stylifera	..	..	..	..	..	13·72	..	5·40	6·25	..	..	..	4·58
Parapenaeopsis sp.	..	..	..	12·19	..	3·92	18·51	8·10	..	..	..	..	6·88
Parapenaeopsis hardwickii	..	..	..	..	..	..	3·70	..	..	..	..	..	0·46
Alpheids	..	..	..	2·43	..	..	..	..	..	..	..	..	0·46
FISHES	..	33·33	4·00	Nil	16·66	5·88	25·92	40·54	31·25	33·33	..	66·66	17.43
Unidentified fish	..	..	4·00	..	16·66	..	11·11	2·70	6·25	33·33	..	33·33	4·58
Polynemus heptadactylus	..	..	..	..	..	..	3·70	2·70	..	..	..	..	0·91
Small sciaenids—Johnius sp.	..	..	..	..	..	..	..	2·70	..	..	..	..	0·46
Otolithus sp.	..	..	..	..	..	1·96	..	..	..	..	..	..	0·46
Harpodon nehereus	..	..	..	..	..	1·96	3·70	..	..	..	..	..	0·91
Bregmaceros macclellandi	..	16·66	..	..	..	..	..	29·72	25·00	..	..	..	7·33
Young eels (Muraenesox sp.)	..	16·66	..	..	..	..	..	2·70	..	..	..	33·33	1·37
Coila dussumierei	..	..	..	..	..	1·96	3·70	..	..	..	..	..	0·91
Thrissocles sp.	..	..	..	..	..	..	3·70	..	..	..	..	..	0·46
OTHER CRUSTACEA	..	..	4·00	2·43	..	3·92	3·70	2·70	12·50	..	..	33·33	4·11
Squilla sp.	..	..	..	..	..	3·92	3·70	2·70	6·25	..	..	..	2·29
Crabs	..	..	4·00	2·43	..	..	..	..	6·25	..	..	33·33	1·82

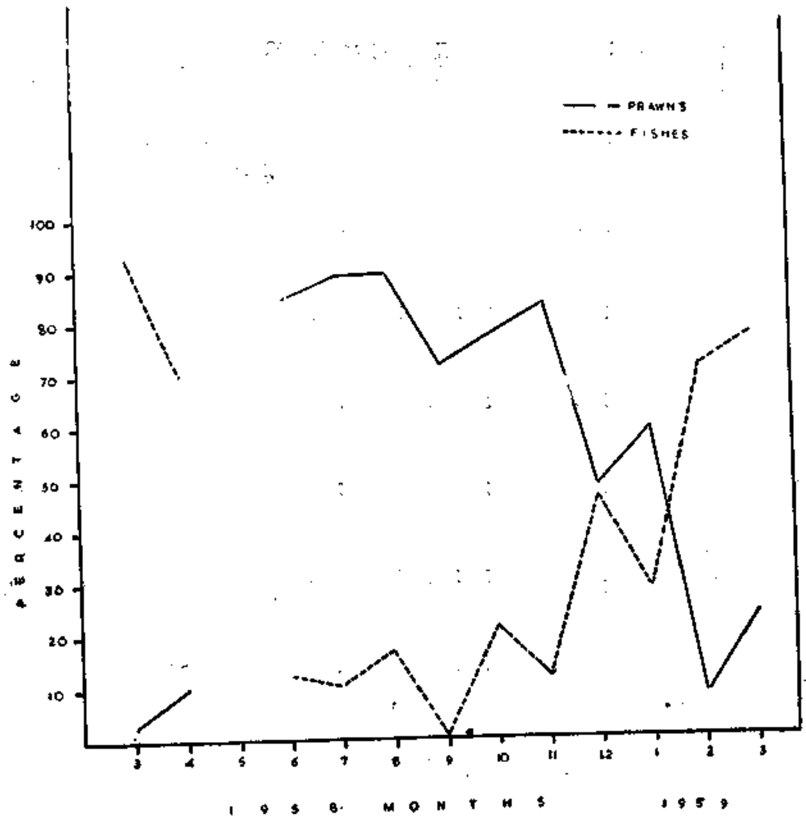

Fig. 10A. Monthly percentages of prawn and fish items from the stomach contents of *Pseudosciaena diacanthus* during 1958-1959.

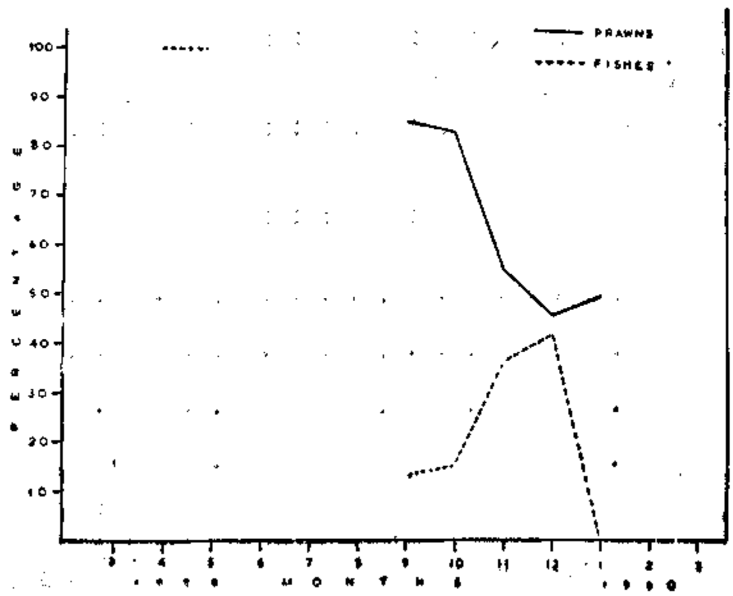

Fig. 10B. Monthly percentages of prawn and fish items from the stomach contents of *Pseudosciaena diacanthus* during 1959-1960.

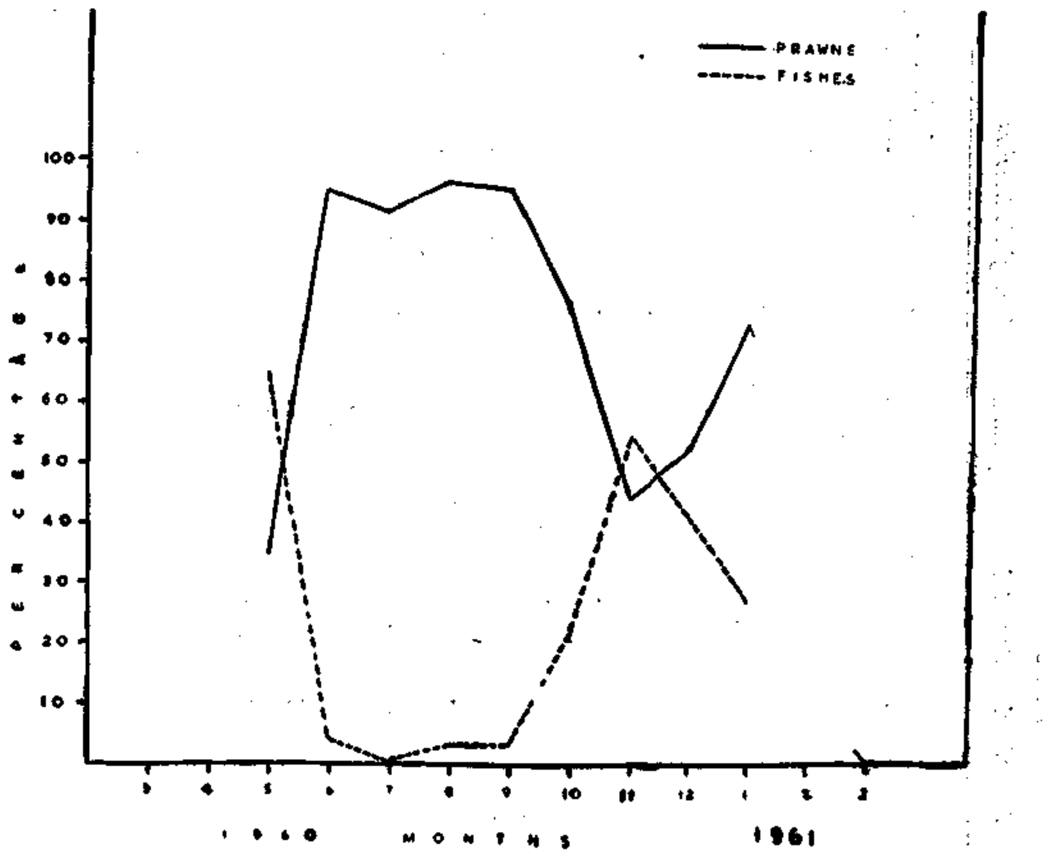

Fig. 10C. Monthly percentages of prawn and fish items from the stomach contents of *Pseudosciaena diacanthus* during 1960-61.

The percentage of specimens with extroverted stomachs amongst juveniles from 'dol' net landings was very small and insignificant. Hence the studies on the food and feeding habits of big and medium sized 'ghols' can only be of doubtful validity. The small percentage of big 'ghols' which had food in their stomachs showed that fishes and prawns formed the major food items. The percentage of prawn items in the food was not high as in juveniles. Judging from the percentage of fish item it can be said that the adults show a strong piscivorous tendency.

The intestinal contents of 174 big 'ghols' with extroverted stomachs were examined and almost all of them had digested food in the intestine indicating that they had not been starving. Remnants of fish and prawns formed the major items of the intestinal content while remnants of crabs squids, shell of small bibvalves and gastropods were observed occasionally.

Juveniles—From a study of 594 juveniles from the 'dol' net landings at Bombay, the intensity of feeding was observed to be more from September to December. In table IX are shown the monthly percentage of juveniles with empty stomachs. During 1958 and 1959

TABLE VIII

Monthly percentage of P. diacanthus *(above 50 cm.) with extroverted stomachs from the landings of the trawlers*

Year / Month	1958			1959			1960			1961		
	Total examined	No. of extroverted stomachs	% of extroverted stomachs	Total examined	No. of extroverted stomachs	% of extroverted stomachs	Total examined	No. of extroverted stomachs	% of extroverted stomachs	Total examined	No. of extroverted stomachs	% of extroverted stomachs
January	..	..	..	27	26	96·20	33	33	100·00	10	10	100·00
February	..	..	..	41	40	97·50	5	5	100·00	34	34	100·00
March	..	..	..	40	37	92·50	10	10	100·00	32	30	96·80
April	48	42	87·50	46	42	91·30	..	..	..	..	..	..
May	13	13	100·00	15	14	93·30	10	10	100·00	..	..	..
June	33	33	100·00	13	13	100·00	12	11	91·60	..	..	..
July	34	34	100·00	..	..	..	5	5	100·00	..	..	..
August	32	32	100·00	17	17	100·00	7	7	100·00	..	..	..
September	..	..	..	15	15	100·00	13	11	84·60	..	..	..
October	21	18	85·70	10	10	100·00	15	7	46·60	..	..	..
November	18	17	94·50	13	13	100·00	15	12	80·00	..	..	..
December	27	27	100·00	9	9	100·00	6	6	100·00	..	..	..
Total	226	216	95·58	246	236	95·94	131	117	89·32	76	74	97·37

the percentage of empty stomachs, was low from September to December. In September 1958 and November 1959 there were no empty stomachs in the specimens examined. In 1960 the percentage of empty stomachs was comparatively low from June to December and was practically nil in August and October. The numbers of juvenile 'ghols' landed by 'dol' nets gradually decreased from January onwards and by March they practically disappeared from the catches. This suggests that the post-larvae and juveniles enter the inshore waters in June-July and remain there till January or February during which time they actively feed mostly on prawns. The peak landings of prawns from the inshore waters ('dol' net) was observed to be high from September to November and from January onwards the prawn landings gradually declined reaching the minimum by March. The juveniles, perhaps move to the deeper waters due to scarcity of prawns, their major food item, from February-March. It cannot be said at this stage whether the movement of the juvenile 'ghols' is directly related to the abundance or movement of prawns. Their similar seasonal abundance in the inshore waters may be incidental also. Prawns formed the major food item of the juveniles of other species like *Otolithoides brunneus*, which were caught from the same locality.

P. diacanthus is an active carnivorous feeder, prawns and fishes forming the major food items. The slightly oblique jaws, the enlarged distantly placed conical teeth resembling the canine teeth of *Otolithus spp.*, in the jaws are suggestive of the same. It may not be a strict bottom feeder but may feed on anything that swims off the bottom.

Jacob (1948) states "shoals of *Sciaena diacanthus* are observed to follow shoals of *Rastrelliger kanagurta* (mackerel) and on one occasion an entire mackerel was obtained from the s omach of this fish". During the present investigation also, *Rastrelliger kanagurta* was observed once on 11-5-1959 from the stomach of a specimen 86·5 cm. in length landed by the bull trawlers.

DISCUSSION

Disgorging the food and extroverting the stomachs during trawling or hauling up is not uncommon in dermersal fishes. Mohamed (1955) observed that *Sciaena diacanthus* and *Otolithus ruber* often showed extroverted stomachs while *Polydactylus indicus* taken from the same place in the same haul did not show disgorging of the food and extroversion of the stomachs.

Extroverting the stomach and disgorging its contents had been observed in gadoids (Menon, 1950), European hake (Hickling, 1927) and flathead in Australian waters (Fairbridge, 1951). The incidence of extroversion and disgorging of the stomach contents was only 0·8% in *Gadus minutus* (Menon, 1950). According to Fairbridge (1951) a large proportion of flathead disgorge their stomach contents when brought to the surface. This observation seems to be similar to that found in 'ghol' but the percentage of extroverted stomachs may not be as high as in this species (95%). Aflalo and Martson (1904) explain that many fishes have the habit of throwing their last meal when captured as a result of shock sustained. Philips (1929) has also observed the same in the trout and Hardy (1924) more or less agrees with these observations as far as young herring is concerned. Job (1940) mentions that live specimens when suddenly thrown into the preserving fluid very often vomit the food materials in the stomach.

TABLE IX

Monthly percentage of empty stomachs in the juvenile P. diacanthus *(less than 50 cm) from the 'dol' net catches at Bombay*

Year / Month	1958 Total examined	1958 No. of empty stomachs	1958 % of empty stomachs	1959 Total examined	1959 No. of empty stomachs	1959 % of empty stomachs	1960 Total examined	1960 No. of empty stomachs	1960 % of empty stomachs	1961 Total examined	1961 No. of empty stomachs	1961 % of empty stomachs
January	..	..	..	8	Nil	Nil	..	..	..	2	Nil	Nil
February	..	..	..	2	Nil	Nil	..	..	..	..	..	..
March	..	..	..	..	..	..	..	..	..	..	..	..
April	..	..	..	..	..	..	..	..	..	..	..	..
May	..	..	..	..	..	..	1	Nil	Nil	..	..	..
June	13	1	7·69	..	..	..	21	1	4·76	..	..	..
July	35	11	31·42	..	..	..	34	5	14·70	..	..	..
August	35	6	17·14	..	..		5	Nil	Nil	..	..	..
September	2	Nil	Nil	126	47	37·30	50	7	14·00	..	..	..
October	69	10	14·49	54	7	12·96	8	Nil	Nil	..	..	..
November	25	4	16·00	25	Nil	Nil	21	1	4·76	..	..	..
December	27	4	14·81	24	1	4·16	7	1	14·28	..	..	..

The following may be the probable causes for the extroversion and disgorging of the stomach contents observed in 'ghol' :

1. Due to shock at the time of capture or trawling. The fish after entering the net, especially the cod end, are strangled due to lack of space and experience a shock. They struggle violently and try to escape through the meshes and in trying to do so vomit their previous meal by regurgitation.

2. Due to sudden change of pressure from the deeper waters to surface when quickly hauled up. At depths of 40 metres the pressure is considerably high, about 4 atmospheres. When 'ghols' under this pressure are quickly hauled up to the surface where the pressure is only 1 atmoshphere, this quick change in pressure may lead to the sudden expansion of the body cavity due to which the stomach and a part of the oesophagus may be forced out (extroverted) disgorging the food. This quick change in depth and pressure along with other factors connected with such a change in environment may disturb the normal physiology of the fish directly or indirectly which may be responsible for the extroversion of the stomach, so characteristic of this species. *P. diacanthus* may be more susceptible for quick changes in pressure and environment while other species like *Polydactylus indicus*, *Otolithoides brunneus* etc. may not be so. That is probably why most of the 'ghols' from the trawler catch have extroverted stomachs while the other species taken from the same locality, depth, and haul do not have. Though regular data could not be collected, there are indications that the incidence of extroverted stomachs may not be so high in the 'ghols' from the 'dol' net landings.

Hickling (1927) states that the habit of disgorging the stomach contents, is in the hake, correlated with the condition of the fish and also with the depth from which it is trawled.

Tandon (1960) has observed that the absence of food in the stomachs of 'choo Parai', *Seleroides leptolepis* from Tangachimadam was not due to any reguirigitaion when hauled up but due to difference in the time of catching as the fish showed indications of cessation of feeding during night. In the present case trawling was done mostly during day time (6 A.M. to 8 P.M.) and this suggests the reverse. *i.e.*, the feeding in'ghol' may be confined to night and stopped during day time. This could not be verified in the course of these studies by conducting night trawling operations. It seems quite unlikely that this may be a reason for the high percentage of extroverted stomachs in 'ghols'. Comparative studies on the incidence of extroverted stomachs in 'ghols' caught by different nets at different times and places to find out whether this could throw light on this problem was not possible for various reasons.

SUMMARY

1. The extent of distribution of *Pseudosciaena diacanthus* is given.

2. The weight of the fish was found to increase as an exponential function of its length and described by a general equation of the form $W=AL^B$.

There is no significant difference between the length-weight relationships of male and female fish ; but the length-weight relationship of the juvenile fish is significantly different

from the males and females (adults) the respective equations being :

Adults : $W=0\cdot01286L^{2\cdot9400}$
(Males and Females)
Juveniles : $W=0\cdot005626\ L^{3\cdot1654}$.

3. A classification of the different stages of maturity has been given.

4. The study of frequency distribution of intraovarian eggs indicate that the fish has a single prolonged spawning period extending from June to August or September and that the eggs are spawned in at least two batches during the course of the spawning season. This is further supported by the studies on the seasonal variations in the gonad weight : body weight ratio and condition factor.

5. The gonad weight : body weight ratio values were found to be high during April to June and declined there after reaching the minimum in November or December.

6. The fluctuations in the Ponderal index indicate the size at maturity to be about 75·0 cm. From the percentage of mature specimens in different size groups it has been infered that the fish matures for the first time at an average length of 85·0 cm.

7. The 'K' (Ponderal index) values were observed to be high from April to June, falling down suddenly in July-August. This fall has been assumed to be consequent upon the low level of condition due to increased matabolic strain of spawning.

8. From a study of the growth rate of gonads the length of ovary was found to increase at a greater rate than testis. The relation between the breadth of gonads and length of fish was not proportional probably due to spawning and maturation events.

9. The fecundity estimates showed disparities which is due to the fact that the eggs are spawned in more than one batch. The maximum and minimum fecundity estimates were 68,68,638 and 17,43,010 respectively. The number of eggs per gram sample of ovary spawned in one batch may vary from 4,000 to 5,000.

10. A consistent preponderance of females throughout this investigation was noticed in the trawler landings.

11. Prawns and fishes formed the major food items. A list of the different organism found in the gut contents and the monthly percentage composition of the different component of food are given. 95% of the 'ghols' examined from the trawler landings had extroverted stomachs and the intestinal contents of those examined had remains of prawns and fishes mostly. The feeding intensity in the juveniles from the inshore waters ('dol' net catches) was observed to be high from September to December.

12. The probable causes for the extroversion of the stomachs in the 'ghols' from the trawler catches have been discussed.

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