Biostatistical evaluation and Management of Sciaenid Fishery with particular reference to *Otolithes ruber* (Schneider, 1801) and *Johnieops sina* (Cuvier, 1830) of Konkan coast

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D E C L A R A T I O N

I hereby declare that this thesis entitled "Biostatistical evaluation and Management of sciaenid fishery with particular reference to *Otolithes ruber* (Schneider, 1801) and *Johnieops sina* (Cuvier, 1830) of Konkan coast" is a record of original and bonafide research work carried out by me under the supervision and guidance of Dr.K.Alagaraja, Principal Scientist, Central Marine Fisheries Research Institute, Kochi, and that no part thereof has been presented for the award of any other degree, diploma, associateship, fellowship or other similar recognition.

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C E R T I F I C A T E

This is to certify that this thesis entitled "Biostatistical evaluation and Management of sciaenid fishery with particular reference to *Otolithes ruber* (Schneider, 1801) and *Johnieops sina* (Cuvier, 1830) of Konkan coast" embodies the bonafide original research work conducted by Shri. V.D.Nimbalkar under my supervision and guidance. I further certify that no part of this thesis has previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles or recognition.

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P R E F A C E

Fish, a natural resource, has received great attention from all over the world, since it provides a cheap protein, employment and income to the millions of people for centuries, So fishermen, industrialist and multinationals are trying to exploit the marine resources to their maximum benefit by using modern craft, advance fishing equipments and efficient gear. Fishery resources in the open system particularly in oceans, were considered to be unlimited. However, recent developments in the innovation of efficient craft and gear using well tested material fitted with modern equipments that have greatly enhanced the mobility of craft, agility of gear and the ability of equipments to locate fishery resources have proved otherwise. Hence as the exploitation increases with more effort entering the fishery, the catch per unit of fishing effort starts to decline due to the limitness of the resources. The heavy fishing pressure in the recent past led to commercial extinction of a number of stocks such as, the North Sea herring, California sardine, Japanese Sardine and Peruvian anchovy (FAO, 1968; Gulland, 1974). In India, seer fish from Palk-Bay declined due to uncontrolled fishing (Devaraj 1983).

After development of steam trawlers, the stocks of plaice in the North Sea showed signs of decline (FAO, 1968) convincing proof being that this decline was due to fishing.

During world wars, there was cessation of fishing activities. Due to this cessation there was immediately after each war, the catches of individual trawlers were often several times the prewar averages (FAO, 1968). This shows clearly not only how fish stocks can be depleted by fishing, but can be improved by effective managerial actions.

Taking advantage of this quickly recoverable nature of fishing resources, the fishery is to be so managed as to obtain sustainable yield without adversely affecting resources. The aim of rational exploitation and judicious management of any fishery resources is therefore to maximise the sustainable yield level.

The best example of successful management of an international fishery resources is the North Pacific furseal (Gulland,1974). The plaice, cod, haddock, sole etc, in the North sea were exploited heavily and were declining. To arrest this declining trend, the international regulations such as larger meshes in trawls and seines were imposed which in turn helped in increasing the catches in successive period. This shows that the proper management helps fish stocks to build up.

Management is based on the biological information of the stock. As indicated above, the objective of fisheries management in biological terms is the attainment of the maximum sustainable yield that is greatest physical yield that the stock can produce year after year without affecting itself. Keeping this aspect in view, the present study was carried out.

INTRODUCTION

Objective of the study:- "To indicate maximum sustainable yield after evaluating the sciaenid fishery and to suggest the measures for it".

In this case, the yield per recruit was estimated by using the growth parameters, mortality and lengh/age at first capture. These parameters were estimated by studying their age and growth aspects of these two species.

In that context, two species of sciaenids from Konkan coast were selected for the study. Konkan coast consists of Raigad, Ratnagiri and Sindhudurg districts of Maharashtra. This coast starts from Mora fish landing centre, the north end of Raigad district and ends at Reddi, the South end of Sindhudurg district (Fig. I). For years together, the coast is providing rich marine resources such as mackerel, sardine, prawn, sciaenid, ribbon fish, catfish etc. This region contributed about 27% to the total marine fish production of the state during 1983-84 where contribution of Ratnagiri was 16%. In the State 29% sciaenid landings came from Ratnagiri district (CMFRI, 1987). Ratnagiri fish landing centre is the biggest fish landing centre on the Konkan coast from where 460 small fishing trawlers, (32'-45') are in operation. Considering all these points, Ratnagiri fish landing centre was selected for the study.

As stated above, the sciaenids are landed in large quantities at Ratnagiri centre and it is consumed by many people covering all strata of the society. It also plays an important role in economy of fisherman. Now a days, the exporters are utilizing the sciaenids for fish meat to export. Here the major contribution comes from Johnieops sina and Otolithes ruber. Excent the food and feeding habits and reproduction studies on J. sina from Ratnagiri waters, no other work has been carried out. Because of its socio-economic importance, biostatistical study was necessary for evaluating the fishery. Hence a detailed study on Biostatistical evaluation of these two species, Johnieops sina and Otolithes ruber was undertaken

From Indian waters, different aspects of various sciaenids have been studied by scientists. Length-weight relationship and condition factor of Johnieops osseus from South Kanara coast have been studied by Baragi and James (1980). Length-weight relationships of Pennahia macrophthalmus and Johnius carutta from Waltair coast have been observed by Rao, T.Appa (1982). The length-weight relaion-ship and condition factor of Johnieops vogleri from Bombay water (Muthiah, 1982) and the length-weight relationship of Johnius carutta Madras Coast (Vivekanandan 1985) have been studied.

Rao K.V.S. (1963) has studied the biology of Pseudosciaena diacanthus from Bombay waters. Biometry of Pennahia aneus from Port Novo was studied by Gandhi (1982). Pillai (1983) observed the biometry, food and feeding and spawning habit of Otolithes ruber from Port Novo. Biology of Johnius (Johnieops) dussumieri, Johnius (Johnius) carutta from Kakinada have been studied by S.V.Murty (1979) where maturation, spawning, length-weight relationship and condition factor were taken into account.

Kutty, Narayanan (1961) has tried to estimate the age and growth of Otolithoides brunneus from Bombay waters by studying the scale and otolith. In the same year Rao , K.V.S.(1961) used the scale and otolith of Pseudosciaena diacanthus from Bombay waters for age and growth purposes. Also the age and growth studies were taken on, Pseudosciaena coiber by length frequency method from Chilka lake (Rajan 1968); Pseudosciaena diacanthus from Bombay waters by length-frequency analysis (Rao, K.V.S., 1966). Rao K.V.S.(1968) has estimated the growth parameters of Pseudosciaena diacanthus from Bombay waters by studying it's scales. Nair (1974) observed the length frequency data and scales of Johnieops sina from Calicut waters for estimation of age and growth. Jaypraksh (1977) estimated the age and growth of the juveniles of Otolithoides brunneus from Bombay waters. Age and growth of Johnieops Vogleri from Bombay waters (Muthiah, 1982) and that of

Johnius carutta from Madras (Vivekanandan, 1985) have been studied by length frequency analysis.

Food and feeding habits of many species of sciaenids have been studied by various workers. Bapat and Bal (1952) studied the same on Sciaena miles, Sciaena albida, Sciaena seimiluctosa, Sciaena glauca and Otolithes argenteus from Bombay waters. The studies on Food and feeding habits have carried out on Sciaena albida and Sciaena sina from Madras waters (Kuthalingam 1955, 1956); Pseudosciaena sina and Otolithus argentus from Cochin waters (George et al.,1968); Pseudosciaena sina from Ratnagiri waters (Bhusari, 1975); Johnius axillaris from Waltair coast (Srinivasa Rao and Janardhana Rao, 1979); Otolithes ruber and Johnieops Sina from Calicut waters (Nair 1979, 1980); Otolithes ruber from Goa waters (Jacob and Rajagopal 1980) and Pennahia Macrophthalmus from Mandapam coast(Mohan Lal, 1985).

The reproductive biology, larval development of Pama pama, Gangetic whiting was studied by Pantulu and Jones (1951). Karamchandani and Motwani (1954) have observed the larval development of Pseudosciana coiter. Rao T.A.(1967) has observed the maturity and spawning of Pseudosciaena aneus, Pseudosciaena bleekeri and Johnius carutta from Visakhapatnam. Similar works have been carried on many species and those are, maturity and spawning of Otolithes ruber and Johnius dussumieri from Bombay waters (Devadoss, 1969); the same aspects on Johnieops sina from Calicut waters (Nair 1977); reproductive biology of Johnieops osseus from South Kanara (Baragi and James 1980); frequency of spawning of Johnieops osseus from Mangalore waters (James, Baragi 1980); facundity and maturity of Pennahia aneus from Port Novo (Gandhi 1982); spawning habits of Otolithes ruber from Port Novo (Pillai 1983); maturation and fecundity of Sciaena glauca from Veraval (Rao 1985); maturity and spawning of Johnius carutta from Madras waters (Vivekanandan 1985) and maturity, spawning and facundity of Otolithes cuvieri from Veraval waters (Rao, 1985).

Relative abundance of sciaenids in Andhra-Orissa coast has been observed by Rao (1976). Muthiah(1982) has studied the fishery of Johnieops vogleri from Bombay waters. The same aspects on Johnius carutta from Madras waters have been studied by Vivekanandan (1985).

Little work, however, has been carried out regarding the population dynamics of sciaenids. Rao (1968) studied the mortality rate and yield per recruit of "Ghol", Protonibea diacanthus from Bombay waters. Murthy (1984, 89) has estimated the yield per recruit and assessed the stock of Johnius carutta from Kakinada waters.

Many species of sciaenids are found in Indian waters. The investigators Cuvier (1930), Bleeker (1945), Weber and de Beaufort (1939); Chu, Lo and Wu (1963), Talwar (1970), Mohan (1972, 1976, 1982), Druzhnin (1972), Trewaves (1977) and Day (1981), have enriched our knowledge on the group. The species occurring in the Indian waters are as follows (Trewaves 1977, FAO 1984).

I.	Argyorosomus:	1, *A. amoyensis*,	2. *A. hololepidotus*
II.	Chrysochiri:	3. *C. aureus*.	
III.	Dendrophysa:	4. *D. russelli*	
IV.	Johnieops:	5. *J. dussumieri*	6. *J. sina*,
		7. *J. voglerí*,	8. *J. aneus*,
		9. *J. macrorhynus*.	
V.	Johnius:	10. *J. belangerii*,	11. *J. carutta*,
		12. *J. dussumieri*,	13. *J. carouna*,
		14. *J. elongatus*	15. *J. glacus*,
		16. *J. macropterus*.	
VI.	Kathala:	17. *K. axillaris*	
VII.	Nibea	18. *N. albida*,	19. *N. maculata*,
		20. *N. soldado*	
VIII.	Otolithes:	21. *O. cuvieri*,	22. *O. ruber*
IX.	Otolithoides:	23. *O. biauritus* Restricted to NW	
X.	Panna:	24. *P. microdon* Restricted to SE	
XI.	Paranibea:	25. *P. semiluctosa*	
XII.	Pennahia:	26. *P. macrophthalmus*	
XIII.	Protonibea:	27. *P. diacanthus*	

XIV.	Umbrina:	28. *U. ronchus* Restricted to Pakistan
		29. *U. canariensis* "
XV.	Macrospinosa:	30. *M. cuja* Freshwater spp. (Hoogly estury)
XIV	Bahaba	31. *B. chaptis* Fresh water spp.
XVII	Pama	32. *P. pama* " " (Hoogly)

About the species:

Following species are regularly landed at Ratnagiri Fisheries Harbour.

Johnieops dussumieri	*Kathala axillaris*
Johnieops sina	*Nibea maculata*
Johnieops vogleri	*Otolithes ruber*
Johnius belangerii	*Otolithes cuvieri*
Johnius dussumieri	*Otolithoides biauritus*
Pennahia macrophthalmus	*Protonibea diacanthus*

However, the two species *Johnieops sina* and *Otolithes ruber* are found in good quantities at Ratnagiri Fisheries harbour (Table. 1). During 1980-84, an average percentage share of sciaenid landings in the total marine fish production of Maharashtra State was 6.6, whereas in Ratnagiri district it was 13.3 during the same period. Ratnagiri district contributed 29.6% sciaenids to the total sciaenid production of the State (CMFRI, 1987). From the present studies, it is observed that at Ratnagiri Fisheries harbour 20% and 17% sciaenids were landed during 1986-87 and 1987-88 respectively. (Table. I). *J.sina* and *O.ruber* contributed in good percentages to the total sciaenid landings at Ratnagiri (*J.sina* 43% for both the years; *O.ruber*, 15% during 1986-87 and 27% during 1987-88)

Two species studied are:-

Johnieops sina (Cuvier, 1830)(Plate I)

Common English name	Sin croaker
Other names	*Corvina sina*; Cuvier, 1830
	Sciaena parva; Gilchrist and Thompson 1908
	Wak sina; Chu.Lo and Wu, 1963
	Wak menoni; Talwar and Joglekar 1970.
	Johnius (*Johnieops*) *sina*;Trewavas,1977

Otolithes ruber (Schneider, 1801) Plate.I)

Common English name	Tiger toothed croaker
Other names :	*Otolithus argentus* Cuvier, 1830
	Otolithes argentus; Chu, Lo and Wu, 1963.

Classification

Class	Osteichthyes
Sub class	Actinopeterygii
Order	Perciformes
Family	Sciacnidae
Genus	*Johnieops*
	Species - *Johnieops sina*(Cuveir,1830
	Otolithes
	Species - *Otolithes ruber* (Schneider 1801)

Instead of repeating the full names of the species, names in short, J.sina and O.ruber are spelled in the text.

The following studies on J.sina and O.ruber were undertaken in this thesis. It includes two aspects; one Biological and second population dynamics. The details are as follows:-

Biological studies:

Food and feeding habits:

The significance of the studies on food and feeding habits of fish has been recognised by fishery biologists. The distributions and variations in the availability of food organisms of a species are important factors that may affect it's behaviour in respect of it's migration, growth, condition, breeding, shoal formation etc.

The best method for studying the food and feeding habits of fish is analysis of stomach contents (Jacob 1948; Pillay 1952; Bapat and Bal 1852; Kuthalingam 1956; George et al 1968; Rao 1979 and Nair 1979, 1980). The stomach contents were analysed qualitatively to know their major food items and quantitatively to understand their relative abundance and seasonal variations during September 86 to May 87 and Sept. 87 to May 88 for two species separately. Intensity of feeding and index of preponderance were considered (Natarajan and Jhingran, 1961). The results of above studies are given in Chapter First.

Reproductive Biology

The biological studies on reproduction of fish have significant importance in the knowledge of stock. This knowledge of stock is essential for successful management of it's fishery. These biological factors have been studied and results are given in this chapter.

This includes the classification of maturity stages based on their gonad structures and ova diameter studies of two species. The spawning season and the frequency of spawning were based on the studies of ova diameter frequency polygon and the seasonal variations in the maturity stages. The state of maturity and spawning were determined by calculating the gonado-somatic indices for the two species separately. The length at first maturity was assessed by percentage occurrence of mature fishes in various size groups. Fecundities of two species were based on the counting of mature and ripe ova of those destined to be spawned in the current spawning season. It's relations with the length of the fish, weight of the fish and weight of the ovary were studied. The pattern of sex ratio of J.sina and O.ruber in different months and different size groups were also observed in detail and Chi-square test was applied.

Age & Growth:-

Length-weight relationship:

Length is generally more easily and more accurately measured than weight. In fisheries, harvest is reported as the weight of total catch. Length and weight are highly correlated and relationship is in the mathematical form $W=aL^b$ This relationship helps in two ways, firstly in converting the length of fish into weight and vice-versa and secondly in calculating the condition factor. This condition factor gives the information about the changes in the life of fish at different ages or lengths, seasons, maturity etc. (Le Cren 1951).

Separate length-weight equations were derived for males and females respectively. The significance of variation in those regressions were tested for two speices. Using the length-weight equations the condition factors have been calculated for *J.sina* and *O.ruber* separately. The results of aforesaid observations are given in the third Chapter.

Age and growth:

The knowledge in age and growth of a fish is necessary for drawing inferences on asymptotic length, asymptotic weight, longevity etc. Such information is most essential for assessing the exploited fish stock. Attempts have been made to estimate the age and growth, usin length-frequency method and studying the hard parts of these species, The theoretical growths were estimated by fitting von Bertalanffy's growth equation using the results obtained from aforesaid methods. The results of all these observations are given in the third chapter.

Population dynamics:

Management is based on the assessment of the stock by using appropriate models. These models require biostatistical information of the species subjected for study. For micro-analytic models different tupes of paremeters at micro-level such as, growth and mortality rates are required. These models include Beverton and Holt model (1957), Ricker model (1975), Cohort analysis etc. Beverton and Holt model indicates that yield per recruit is a function of size at first capture and fishing mortality. On the other hand, macroanalytic models require information at macro level such as catch and effort. Under this group come surplus production model including Schaefer's model (1954), successive removal method, capture-recapture method, relative response model (Alagaraja, 1984).

For this study micro-analytic model was used. Estimates of different parameters obtained from biological studies have been utilised. The maximum sustainable yield (MSY) was estimated at different levels of fishing mortality (F) and length at first capture (Lc) and accordingly the appropriate measures were indicated for obtaining maximum sustainable yield.

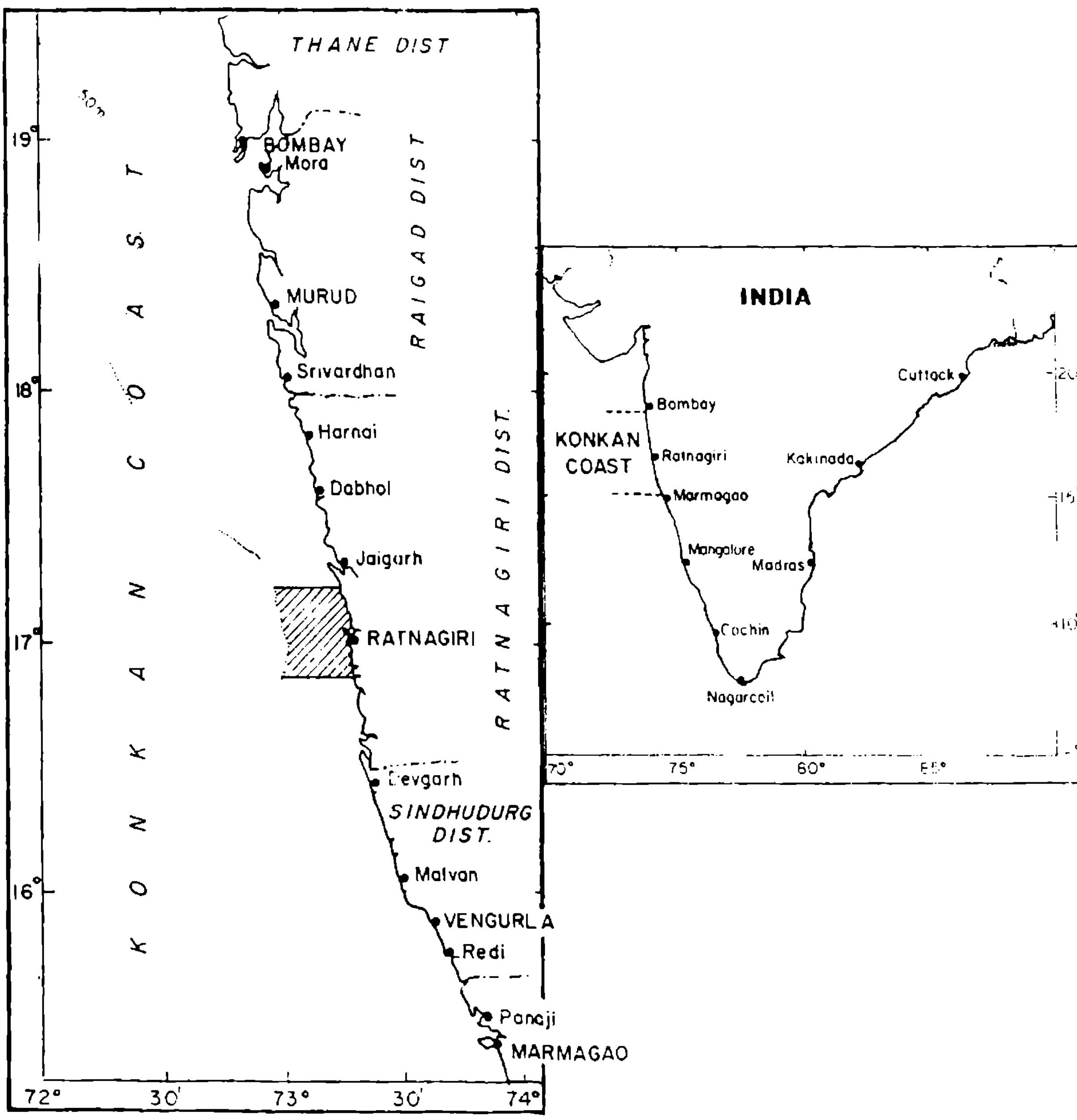


Figure 1 Area of trawling off Ratnagiri on Konkan coast.

Table 1 Total marine fish landings, sciaenid landings in Maharashtra State and Ratnagiri Dist. during 1980-84 (Quantity in Tonnes)

Year	1980	1981	1982	1983	1984
Total marine fish landing in the state	232000	273000	253000	270000	306000
Sciaenid landings in the state	13960	17470	15930	18270	22590
% of sciaenid in total landings of State	6.0	6.64	6.63	6.8	7.4
Total marine fish landings in Ratnagiri Dist.	26064	25327	44225	52799	50683
Sciaenid landings in Ratnagiri Dist.	2889	4012	5940	6797	6690
% of sciaenid in total landings of Dist.	11.1	15.8	13.4	12.9	13.2
% of sciaenid landings of Ratnagiri Dist in the total sciaenid landings of the state	20.7	23.0	37.3	37.2	29.6

Total marine fish and sciaenid landings at Ratnagiri harbour during 1986-88 (Quantity in Tonnes)

Year	1988-87	1987-88
Total marine fish landings	3200	6400
Sciaenid landings	650	1100
% of sciaenid in the Dist.landings	20	17

Species-wise landings at Ratnagiri harbour during 1986-88 (Quantity in Tonnes)

Year	1986-87	1987-88
Sciaenid landings	650	1100
J. sina landings	280 (43%)	470 (43%)
C. ruber landings	100 (15%)	300 (27%)

CHAPTER -1 FOOD AND FEEDING HABITS

Introduction :

Studies on food and feeding habits of fishes help in understanding the various aspects of the biology of the fishes such as, feeding adaptations, growth, fecundity, migrations and seasonal variations in the condition etc. It also helps commercial fisheries in forecasting the movements of fish into or out of their feeding grounds.

The food and feeding habits of fishes becomes difficult to observe in their natural surroundings unless with modern diving equipments which are costly and time consuming procedure. Though it can be studied by rearing the fish in aquarium tank maintaining as far as possible the same natural conditions, the behaviour of the fish under artificial conditions may be different and it may not give the correct information regarding the natural food and feeding habits of fish. Sometimes it may be impossible to determine accurately what it feeds on, since many factors like condition of the fish, kind of prey, choice of fish for the prey, defensive mechanism of the prey, attractive nature of the prey, the behaviour of the fish in the presence of its prey and its predator, migration, spawning, availability of food, environmental factors etc. are the variables which affect the food and feeding habits of fishes.

However, the best method of ascertaining its food is the examination of its gut contents. Though many times, the food in the gut gets partially or fully digested, the remains of food items help to trace the type of food and feeding habit of fish. This method has been adopted by many scientists,(Jacob, 1948; Pillay, 1952; Bapat and Bal,1952; Kuthalingam, 1956; George and et al., 1968; Rao, 1979; Nair, 1979 and 1980).

Brief studies on the food and feeding habits of J. sina have been made by Venkataraman (1960); George et al (1968); Nair (1980); Bhusari (1975). Some information on the feeding habits of O. ruber is published by Jacob (1948); Chacko (1949); Vaidya (1960); Venkataraman (1960); Suseelan and Nair (1969) and Nair (1979).

Literature shows that the studies on food and feeding habits of sciaenids have been made in Indian waters. However, details on food and feeding habits of these two species from Ratnagiri waters have not been studied except a brief information by Bhusari (1975) on J. sina. Hence in this Chapter, the food and feeding habits of these two species off Ratnagiri is considered and results obtained from the present studies have been compared with the earlier works.

Material and methods

Specimens were collected from Mirkarwada Fisheries harbour. A total of 1241 specimens of J.sina and 577 O.ruber have been used for the investigation After noting their degree of distension of stcmach, stomachs were preserved in 5% formalin for subsequent analysis.

Qualitative analysis was made by identifying food items upto generic/specifi level wherever possible. Partially and fully digested food items which could not be identified, were included under miscellaneous food items. The quantitative analysis of the stomach contents was carried out by points method (Hynes, 1950),volumetric method (Pillay, 1952) and occurrence method. In points method, points were alloted to different food items according their proportion in the stomach contents and later summed up and percentages were calculated.. The volumetric method was carried out by noting the volume displacement by each of the food items in the stomach. In occurrence method, the percentage occurrence of different food items for each fish were noted and scaled down to percentages, Since the two species under are known to carnivorous, the index of preponderance was attempted (Natarajan and Jhingran, 1961). The index was calculated for ev ry month by using the following equation.

$$\text{Inded of preponderance} = \frac{Vi \times Oi}{\sum Vi \times Oi} \times 100$$

Where, Vi = Percentage of volume

Oi = Percentage of occurrence.

6 The feeding intensity (Raw, 1964) was determined by noting down the degree of distension of stomach wall. The degree of distension of stomach wall depends upon the amount of food contained in it. It was classified as gorged, full $^3/_4$ full, $^1/_2$ full, $^1/_4$ full, trace and empty. Average feeding intensity was calculated by grouping fish as 1) actively fed when stomach was gorged, full and $^3/_4$ full, 2) moderately fed when $^1/_2$ full 3) poorly fed when $^1/_4$ full and 4) empty when traces of food is noticed or empty. Variation in feeding intensity with reference to size of fish, season and food preference was calculated.

Results :

Johnieops sina

Qualitative composition A qualitative analysis of the stomach contents of J. sina from Ratnagiri waters showed that, it feeds mainly on organism from the epi-and in-fauna of the shallow coastal waters. Larger fishes of the species frequent in mid and lower layers of the water column for more varied and larger prey organisms. The data showed that it preferred smaller organisms without hard spines etc. Some of the most dominent prey organisms were teleosts, penaeid prawns, squilla and Acetes spp. A detail list of the food components is given below :

Teleosts	Coilia dussumieri	Cynoglossus bilineatus,
	Trichiurus lepturus,	Lepturacanthus savala,
	Leiognathus spp.,	Stolephorus spp.,
	Pennahia macrophthalmus,	Nemipterus japonicus,
	Thryssa malabarica,	Thryssa mystax,

Prawns :	Penaeid prawns	Parapenaeopsis stylifera,
		Metapenaeus affinis,
		Metapenaeus dobsoni,
		Penaeus merguiensis
	Non penaeid prawns	Solenocera indica,
		Acetes indicus.

Stomatopod	Squilla	Oratosquilla nepa
	Other crustaceans	Crabs, Hermit crabs etc.
Molluscs :	Squid	Loligo duvauceli
	Cuttle fish	Sepiella inermis
Polychaetes	Nereis	
Miscellaneous	Partly and fully digested food, scales, sand, mud, crustacean remains, unidentifiable animals etc.	

Intensity of feeding :

It was ascertained from the degree of distension of the stomach. The percentage of occurrance of fishes with different intensities of feeding are given in Table(2) for the periods 1986-87 and 1987-88.

Monthly analysis of data (Table 2) showed that the percentages of actively fed J. sina were high during January 1987 (32.28) April 1987 (33.21), February 1988 (38.27) and April 1988 (53.78). The percentages of moderately fed fishes were high in March 1987 (44.90) and April 1988 (30.06). Poorly fed fishes occurred in low numbers during October 1986 (19.43%), March 1987 (21.83%), April 1987 (18.77%), February 1988 (25.13%), March 1988 (7.52%) and April 1988 (16.16%). Low percentages of fishes with empty stomach were noticed during January 87 (23.37), February 1988 (17.22) and April 1988 (0.00) and high in the rest of the months. It showed that _J. sina_ fed actively and moderately in some months and poorly in rest of the year.

Juveniles The percentages of poorly fed juveniles were high followed by the percentages of actively fed ones, fishes with empty stomachs and moderately fed ones during both the years (Table 4).

Adults During 1986-87, the percentage of adult fishes with empty stomachs was high followed by the percentages of poorly fed, actively fed and moderately fed ones, whereas during 1987-88, the percentage of poorly fed adults was high followed by the percentages of adults with empty stomachs, moderately fed and actively fed ones.

Variations in the percentage intensities were not noticed in juveniles during both the years but adults showed variations in the percentage intensities during both the years. The percentage of actively fed juveniles was higher than that of adults. This may be because of higher growth rates in initial stages of life when juveniles require more food. In adults the percentage of actively fed ones was low for which the reason may be that they might have digested the food quickly resulting into empty stomachs.

Food composition and seasonal variation :

The relative importance of food organisms was studied by index of preponderance method which are given in Fig. 2,3 and Table 5,7 and 8.

The food items were grouped into following main eight groups - (1) Teleosts small fishes and juveniles of wide variety of demersal fishes were included under this group. (2) Penaeid prawns It consisted of larvae and young ones of penaeid prawns (3) Acetes spp. It included Acetes indicus species only. (4) Squilla Squilla-(Oratosquilla nepa) only formed this group. (5) Crabs All small crabs and hermit crabs including young ones were put under this category. (6) Molluscs : Squid, cuttle fish and molluscan larvae were included in this group. (7) Polychaetes: It included all polychaete worms (8) Miscellaneous Partly and fully digested food items which were difficult to identify them, scales, mud, fish flesh and unknown animal remains were included under this group. In order to understand the seasonal fluctuations of different food items, the index of various food items during different months were calculated and prescribed in Fig. 3.

Teleosts formed the most important food item in J. sina penaeid prawn, Acetes spp. and squilla constituted the major food components while crabs, polychaetes, molluscs and miscellaneous items formed minor food constituents. During 1986-87 teleosts were consumed in highest quantities (54.91%) followed by penaeid prawns, squilla, miscellaneous, polycheaetes, Acetes spp., crabs and molluscs in their order of preference. Similarly during 1987-88, teleosts occupied the first rank (52.94%) followed by Acetes spp., penaeid prawns, squilla, polychaetes, miscellaneous, molluscs and crabs in their order of preference.

Teleosts Teleosts ranked first in the food item of J. sina during both the years (in 1986-87, 54.91% and in 1987-88, 52.94%). During 1986-87, it was the highest during December 1986 (70.46%) and the lowest during May 1987 (6.5%). During September to December, 1986 and March 1987 the values were high and low in other months. In 1987-88, the index was the highest during December 87 (78.92%) and the lowest during February 1988 (28.48%). In other months the indices were high. For the year 1986-87, the values varied widely as compared to that of the year 1987-88. Low indices were noticed during 1986-87 and high were during 1987-88 (Table7,8).

Penaeid prawns : It was an important food item of J. sina. During 1986-87, it ranked second (11.53%) next to teleosts and in the next year third rank (16.88%) next to Acetes spp. But the percentage was greater during 1987-88 than that of the previous year. The indices ranged from 0.68% (February 1987) to 32.26% (May 1987) during

1986-87 and from 1.65% (December 1987) to 45.72% (May 1988) during 1987-88. High percentage was noticed only in September 1986 (30.34%) and the low in rest of the months during 1986-87. During 1987-88 the indices were high during September 1987 (27.01%), October 1987 (25.18%), January 1988 (22.89%) and March 1988 (37.84%). Monthly values varied widely during both the years (Table 7,8).

Acetes spp. Acetes was represented by a species *Acetes indicus* formed one of the main food component of *J. sina.* During 1986-87, it ranked sixth (2.96%) and second during 1987-88 (20.51%) in order of importance. During 1986-87, it was low during December, 1986 (0.13%) and high in September 1986 (22.29%). Except the values during September 1986 (22.29) and May 1987 (12.90%) all values in rest of the months remained low. Similarly during 1987-88, the values were the highest during April 88 (41.94%) and the lowest in February 1988 (2.53%). The values during September 1987 (27.59%), October 1987 (31.45%) and January 1988 (31.48%) were high while in other months were low. Monthly fluctuations were wide during 1987-88 when compared to that of the previous year.

Squilla : It was another important food item of this species. Only juvenile squillas were noticed in the stomachs of this species. Very rarely adult squillas were occurred. It ranked third (10.15%) during 1986-87 and fourth (3.38%) during 1987-88. For the year 1986-87, the highest values were observed during February 1987 (62.68%) and the lowest during December 1986 (0.27%). For the year 1987-88, the indices ranged from 0.46% (September 1987, March 1988) to 34.80% (February 1988). Monthly as well as yearly wide fluctuations were observed.

Polychaetes This group was represented by wide specimen of bottom living free and tube dwelling forms. The indices of polychaetes, occupied fifth rank during both the years (in 1986-87, 8.31% and in 1987-88, 2.23%). The index values of 86-87 fluctuated within a narrow range from 1.12% (November 1986) to 12.18% (December 1986) except in April 1987 (36.30%). During 1987-88 the indices varied within a very narrow range from 0.50% (May 1988) to 2.74% (March 1988). High values were not noticed in both the years, except the value during April 1987 (36.30%).

Crabs Crabs secured seventh rank (1.48%) in food items of *J. sina* during 1986-87 and eight (0.84%) rank during 1987-88. The values varied within very narrow range and almost low in all months of the two years except during February 1988 (25.32%).

Molluscs This food item ranked eight (1.37%) among the other food items of *J. sina* during 1986-87 and seventh (1.34%) during 1987-88. In both the years the values were low and varied within narrow range.

Miscellaneous   Miscellaneous group of food item ranked fourth (9.29%) and sixth (1.87%) during 1986-87 and 1987-88 respectively. The indices varied within 0.99% (September 1986) to 22.57% (May 1987) during 1986-87 whereas during 1987-88, the same varied within a very narrow range from 0.00% (February 1988) to 2.10% (April 1988) except during November 1987 (17.84%).

Variations in food with size

The stomachs of fishes of length 5.0 to 21.0 cm were studied and the observations grouped into eight groups at 2.0 cm class sizes. Variations in food items were shown by index of preponderance (Fig. 2).

Fig. 2 showed that the food of juvenile fishes of length 5.0 to 7.0 cm was mainly constituted of *Acetes* spp. (64.00%) followed by miscellaneous, (24.00%) squilla spp., penaeid prawn and polychaetes (4.00% each). No teleosts as food was observed in their stomachs. In the next length groups i.e. from 7.0 to 9.0 cm, the juveniles consumed penaeid prawns in highest quantities (56.24%) and hence percentages of *Acetes* spp. was low (6.25%) as compared to that of the previous length groups. The fishes from 9.0 to 11.0 cm size groups gradually switched to teleosts as food but its percentage share was low (1.10%). Upto 11.00 cm length groups, *Acetes* spp., squilla and penaeid prawns formed the major food items of these fishes.

The Fig. 2 clearly showed that the juvenile fishes upto 11.0 cm size preferred crustacean diet.

The fishes from 11.0 cm length group onwards showed high percentages of indices of preponderance of teleosts. Besides teleosts, penaeid prawns, squilla spp. and *Acetes* spp. constituted important food items. In short, juveniles mostly fed on small prey organisms like *Acetes* spp., young ones of squilla spp., penaeid prawns and polychaetes. As the fish grow in size, they preferred large organisms like teleosts penaeid prawns, squilla spp. *Acetes* spp. etc. with fluctuating quantities.

Otolithes ruber :

Quantitative composition : This species is also a bottom feeder and highly carnivorous. Similar to *J. sina* this species also fed on organisms from the shallow terrains of the sea bottom. It also avoids the prey having hard spines or so. No bigger prey had been noticed in their stomachs. The details of the food items are given below.

Teleosts	*Coilia dussumieri*,	*Cynoglossus bilineatus*,
	Trichiurus lepturus,	*Lepturacanthus savala*,
	Leiognathus spp.,	*Stolephorus* spp.,
	Pennahia macrophthalmus,	*Johnieops dussumieri*,
		Johnieops sina,
	Saurida tumbil,	*Tachysarus dussumieri*,
	Nemipterus japonicus,	*Thryssa mystax*,
	Thryssa malabarica,	*Therapon jarbuo*

Prawns	Penaeid prawns	*Parapenaeopsis stylifera*, *Metapenaeus affinis*, *Metapenaeus dobsoni*, *Penaeus merguiensis*.
	Non penaeid prawns:	*Solenocera indica*, *Acetes indicus*.
Stomatopod	Squilla	*Oratosquilla nepa*
	Other crustaceans : Crabs, Hermit crabs etc.	
Molluscs	Squid	*Loligo duvauceli*
	Cuttle fish	*Sepiella inermis*
Polychaetes	Nereis	

Miscellaneous: Partly and fully digested food, scales, sand, mud, crustacean remains, unidentifiable animals etc.

Intensity of feeding

The percentage occurrence of intensities of feeding for the periods 1986-87 and 1987-88 are given in Table 3

The percentages of actively fed fishes were high during March to May, 1987 (27.71%, 42.32% and 37.05% respectively), November 1987 (26.28%) and April 1988 (36.49%) and it was low in the rest of the months. It was lowest during January and February 1987 and January 1988

(0.00% in each month). The percentages of moderately fed ones were high during March 1987 (29.13%), November 1987 (33.40%), December 1987 (29.30%) and January and May 1988 (45.17% , 28.27% respectively) while in other months it was low. During March 1988 it was lowest (0.00%). The percentages of poorly fed were low during November 1986, (16.49%), January to May, 1987 (14.82% 15.54%, 9.84%, 14.38% and 21.80% respectively). During 1987-88, it was high in March 1988 (44.00%) and April 1988 (32.19%) while in other months it was low. The percentage of fishes with empty stomachs were low during September 1986 (16.02%), May 1987 (16.59%), December 1987 (22.29%) and April 1988 (17.84%) and high in other months.

Juveniles Actively fed juveniles were the highest in percentage during both the years (in 1986-87, 32.86% and in 1987-88 35.29%) followed by the percentages of juveniles with empty stomachs in both the years (1986-87, 26.29% and in 1987-88, 33.36%). The pereentages of moderate and poor feeding intensities were low in both the years and different in different years. (Table 4).

Adult The percentages of fishes with empty stomach were the highest during both the years (in 1986-87, 42.64% and in 1987-88, 46.92) followed by those of poorly fed, moderately fed and actively fed (Table-4)

Percentages of actively fed ones were higher in juveniles than that of adults and in adults the percentages of empty stomachs were higher than that of juveniles. The reasons cited for J. sina may be applicable for this species also.

Food composition and seasonal variation :

The percentages of occurrence and volume and index of pre-ponderance of food items are given in Table 6,9 and 10 and Fig. 5

The food of O. ruber was grouped into seven major groups. (1) Teleosts Juveniles and small sized fishes were included in this group. (2) Penaeid prawns It included the larvae and juveniles of penaeid prawns (3) Acetes spp.: Acetes indicus was the only species found in the stomach of the fish. (4) Squilla : Squilla, (Oratosquilla nepa) had put in this category (5) Molluscs Juveniles of squid and cuttle fish were included under this group. (6) Polychaetes It included all polychaete worms. (7) Miscellaneous Partly and fully digested food items, scales, mud, flesh of big fish and unidentified material were put under this category. Fluctuations in different food items during different months were studied with the help of indices (Table9,10).

Teleost formed the major food item of O. ruber during both the years. During 1986-87, the index of the teleost was first (46.23%) followed by *Acetes* spp., Squilla, penaeid prawns, molluscs, miscellaneous and polychaectes in order of preference of food. In the next year (87-88) teleosts ranked first (47.23%) followed by *Acetes* spp., penaeid prawns, miscellaneous, squilla, polychaetes and molluscs in their order of preference of the food item. During both the years, except the indices of teleosts and *Acetes* spp., all other indices varied.

Teleosts During 1986-87 the indices varied from 13.83% (December 1986) to 69.35% (November 1986). Except the value (13.18%) during December 1986, the values in other months were high. During 1987-88, the indices ranged from 9.71% (February 1988) to 92.92% (September 1987). High values were noticed during October to December, 1987 (28.99%, 33.01% and 37.47% respectively) and it was low in next of the months. The indices varied widely during 1987-88 as compared to that of 1986-87.

Penaeid prawns : Penaeid prawns ranked fourth (11.21%) during 1986-87 and third (10.07%) during 1987-88. Except the value of December 1986 (32.65%), the indices varied within a narrow range from 0.17% (November 1986) to 11.12% (March 1987), Similarly during 1987-88 except the value during October 1987 (49.71%) all other values varied within a narrow range from 0.00% (February 1988) to 9.70% (January 1988).

Acetes spp., It was consumed in high quantities occupying second rank in food items during both the years (in 1986-87, 22.41% and in 1987-88 37.64%). It formed the major food item next to teleosts. The indices varied from 2.21% (November 1986) to 57.80% (May 1987) during 1986-87 and during 1987-88 it varied from 0.53% (September 1987) to 84.95% (February 1988). The values fluctuated widely during 1987-88 as compared to that of 1986-87. Low values were noticed during November 1986 (2.21%). September 1987 (0.53%) and October 1987 (13.02%). In the rest of the months the values were high.

Squilla Squilla was also an important food item of this species. It ranked third (13.65%) during 1986-87 and fifth (2.15%) during 1987-88. During 1986-87 the monthly values varied from 0.55% (December 1986) to 26.35% (November 1986), and during 1987-88 from 0.00% (October, December 1987) to 8.17% (November 1987). The indices fluctuated widely during 1986-87 as compared to that of 1987-88.

Polychaectes Polychaetes ranked seventh (0.12%) and sixth (0.49%) during 1986-87 and 1987-88 respectively. During both the years the values varied within a very narrow range from 0.00% to 1.83%. It formed a very minor food item of *O. ruber.*

Molluscs It's indices ranked fifth (4.60%) and seventh (0,20%) during 1986-87 and 1987-88 respectively. It was observed in very few months, November, December, 1987 (0.04%, 9.53% respectively), January 1988 (0.13%) and March, April 1988 (0.62%, 0.78% respectively) and absent in rest of the month during both the years.

Miscellaneous It occupied sixth position (1.78%) and fourth one (2.22%) during both the years respectively. Miscellaneous food items were noticed in all months of the two years but within very narrow ranges.

Variations in food with size: Two years data pooled together and the observations were grouped for 2 cm class sizes of fishes and the data were represented by index of preponderance (Fig. 4). Variations in food were observed between juveniles and adults.

The fishes from 5.0 to 21.0 cm length were considered as juveniles and 21.0 cm onwards adults, since the size at first maturity was 20.6 cm (Fig. 14). The juveniles from 5.0 to 15.00 cm were mainly fed on prawns (penaeid and *Acetes indicus.*) As they grow in size (15.0-21.0 cm), the juveniles gradually switched on to teleosts but its percentage was very low and mainly fed on crustaceans. In fishes, 21.0 cm length group onwards - high percentages of teleosts were noticed. The food of adults also included other food items in next order.

Penaeid prawns and Acetes indicus were the main food components of juveniles where as teleosts, penaeid prawns, Acetes indicus and squilla spp. formed the major food constituents of the adults. Squilla spp. was noticed in the food of adults but large variations observed in indices. The index values of polychaetes and miscellaneous food items varied in narrow ranges for all length groups.

Feeding habit

J. sina : This species being carnivorus, possesses teeth widely aparted. It is also demersal and mouth is little inferior, so mostly feeds on demersal organisms like penaeid prawns, Acetes indicus, polychaetes, crabs, molluscs, squilla spp. demersal fishes etc. But they prefer teleosts first.

Juveniles do not migrate to different levels of water column because of inability of quick and fast movement during danger of predation. So they remain mostly near the bed and has to feed on demersal fauna where they mainly feed on crustaceans. Since there is less fear of predation, as compared to that of juveniles, adults migrate to different strata of the sea and prefer teleosts. Hence the food of adult fishes contained high percentages of teleosts followed by other organisms including demersal ones. So between juveniles and adults, clear change over of food from crustaceovore to piscivore was seen.

O. ruber It is also a highly carnivorous fish, it's teeth are placed apart. Strong canines present and mouth is turned upward. So this fish feeds on all organisms available in all levels of water column mainly teleosts and followed by bottom fauna because of demersal habitat. It's upturned mouth helps it to catch the preyorganism from all layers.

Like J. sina, juveniles and adults showed two different types of habits. Juveniles remain near the bottom because of the same reasons cited for J. sina and feeds on the demersal organisms. It's food was mainly constituted by crustaceans followed by teleosts and other organisms. Adults migrate up the water column and prefer teleosts and it's food contained mainly teleosts. Adult also takes the demersal food organisms like, penaeid prawns, squilla spp. etc. Like J. sina as the fish grows, i changes it's food from crustaceans to teleosts.

Juveniles and adults of both the species take, teleosts, penaeid prawns, squilla spp., Acetes indicus, molluscs, polychaetes, crabs etc. But the food of juveniles of both the species consisted of more crustaceans whereas the food of adults included teleosts in high percentages.

Many times fish prey were observed in the mouths of these two species. In the mouth as well as in the stomach, the anterior end of the prey was in the direction of the tail of the predator. It showed that these two species do not chase or persue (behind it) the prey fish but attacked the prey face to face and engulf them. Mouths of these two species can be open widely so they can swallow the prey. They do not crush or tear the prey into pieces since no crushed as well as torn organisms were noticed in their stomachs. These two species prefer small fishes with linear shape and without any hard structures like spine etc.

Discussion

These two species, J. sina and O. ruber mostly occur in the inshore water feeding on benthic food available on the shelf region. The food in the fishes is generally dependent upon the ecological conditions and hence their food components are based on their habitat (Qasim, 1972). Body shape, mouth position and structure are different in different fishes and correlated to the type of food that the fish feeds (Keast and Webb , 1966; Chao and Musick, 1977). These two species being carnivorous, have widely spaced teeth which are morphologically adopted to feed on organisms in mid-water and lower region of the sea. In O. ruber, the teeth are larger than that of J. sina and mouth is upturned and hence this species is actively carnivore feeding in wide area.

Following Longhurst (1957), J. sina and O. ruber can be categorised as fishes feeding on slow and active members of the bottom and are also mainly ichthyophagus. Sciaenids generally prefer crustacean diet composed chiefly of shrimps (Rao , 1979). The most of the food organisms of J. sina and O. ruber were active swimmers. Juveniles of both the species fed mainly on penaeid prawns and Acetes indicus in large quantities. The adults are more active carnivore feeding mainly on teleosts following penaeid prawns, Squilla , polychaetes etc. These differences were observed because of their different habitats of juveniles and adults.

Number of fishes as food was more in O. ruber as compared to that of J. sina, small size fishes and juveniles of various species were noticed in the food of both the species. In O. ruber, the sizes of fish prey were larger than that of J. sina. Many fish species were common in the food of both the species, except Saurida tumbil, Tachysurus spp., Therapon spp. sciaenid spp. which were represented as food in O. ruber only. Crabs were almost absent in the food of O. ruber. The percentages of polychaetes and molluscs were also low in the diet of O. ruber as compared to that of J. sina.

Venkataraman (1960) reported that prawns, polychaetes, teleosts, Acetes spp. and amphipods were the chief food items of J. sina from Calicut waters. It showed that the bottom feeding nature of the species. George et al (1968) observed mysids, sergestidae, caridean, penaeid prawns and polychaetes in stomachs of J. sina from Cochin waters. The stomach contents of species along south Kerala coast as given by George et al (1970) consisted of fishes, amphipods, sergestidae, megalops and alima larvae, caridean, penaeid prawns, and polychaetes. According to Bhusari (1975) the food of J. sina from Ratnagiri waters consisted of teleosts, prawns, squilla, amphipods, polychaetes and molluscs. Mohan (1977) reported that, teleosts, prawns, crabs, and Acetes spp., were the food items of J. sina from Mandapam. Nair (1979) found planktonic forms in the diet of juveniles followed by small prawns, Acetes spp., amphipods, mysids and other miscellaneous items. In the food of adults, teleosts formed the chief food item followed by prawns, polychaetes, amphipods, squilla spp. etc. This shows that the food of J. sina includes almost the same food items with one or two additional organisms in many places. But the percentage composition of different food items are different from region to region.

Juveniles of O. ruber were fed on small oranisms like Acetes spp., prawn larvae, fish larvae, polychaetes etc. As fish grows it gradually changes on to more carnivorous and predaceous feeding mainly on teleosts, prawns, squilla etc., Jacob (1948) observed the piscivore nature of O. ruber. Chacko (1949) observed that this species was carnivorous and predaceous at surface and mid-waters feeding with the help of canines. Bapat and Bal (1952) reported that the prawns were the main food of juveniles of O. ruber and in more advance forms fish as food item was taken in increasing percentage untill finally it formed the major food item of the adults. Venkatraman (1960) reported that the fish was mainly a carniovore where teleosts formed major food item. Vaidya (1960) recorded that the adult from Bombay was carnivorous feeding on teleosts crustaceans and cephalopods The post larvae and juveniles were plankton feeders feeding on crustaceans. Suseelan and Nair (1969) observed the prawns and teleosts formed the major constituent of it's diet along Bombay coast. The other items like stomatopods, amphipods, isopods, copepods, cephalopods and salps formed part of food. Nair (1979) pointed out that the juveniles from Calicut waters fed mainly at surface on zooplankton and pelagic animals and the adults fed on prawns, teleosts on large scale.

In both species, high percentages of actively fed fishes were observed in few months otherwise poorly fed percentages were common in most of the months. No seasonal intense feeding activity and no regular periodicity were noticed in both the species over the two years of period of studies (Fig.3,5). The percentages of actively fed juveniles were higher than that of adults and percentages of poorly fed fishes increased with the length of the fish. High percentages of fishes with empty stomachs were occurred in higher length groups.

As compared to adults of O. ruber, percentages of actively fed adults of J. sina were more and occurred in most of the months. In O. ruber, the percentages of poorly fed and with empty stomachs were higher than those in J. sina particularly in adults. In juveniles of both the species high percentages of actively fed ones were noticed in O. ruber as compared to that of juveniles of J. sina. but in both species, percentage intensity is higher than other types of intensities. Similarly the percentages of juveniles with empty stomachs were higher in O. ruber as compared to that of juveniles of J. sina.

According to Nair (1980), J. sina was poorly fed and indicated no regular periodicity in the intensities of feeding in different seasons. He found comparatively high percentages of actively fed juveniles and adults during few months. Nair (1979) reported the predominance of poorly fed fish in most of the months and no seasonal intense feeding activity. According to him, the percentage of actively fed fishes was higher in smaller size groups than in larger size groups and the percentages of fishes with poor feeding activity generally increased with the length of the fish. Similarly in O. ruber, the fluctuations in the intensity of feeding were observed by Vaidya (1960) and Suseelan and Nair (1969) from Bombay. Pillai (1983) accounted that food intake in O. ruber from Port Novo, was intense in lower size groups and it was moderate and poor in larger size groups. So these findings are agreeing well with the present findings.

Both species being active carnivorous, fed mainly on teleosts and invertebrates those live at or near the sea bed. But they preferred teleosts first and hence they consumed teleosts in the highest quantities followed by prawns, stomatopods, polychaetes etc. In J. sina, during 1986-87, the order of importance of food items was teleosts, penaeid prawns, stomatopods, miscellaneous, polychaetes, Acetes indicus, crabs and molluscs and for 1987-88, teleosts, Acetes indicus, penaeid prawns, stomatopods, polychaetes, miscellaneous, molluscs and crabs. Similarly in O. ruber, during 1986-87, the order of preference was teleosts, Acetes indicus, Squilla, penaeid prawns, molluscs, miscelleneous and polychaetes and for 1987-88 teleosts, Acetes indicus, penaeid prawn, miscellaneous, Squilla, polychaetes and molluscs. In J. sina, during both the years, teleosts and polychaetes retained their ranks as first and fifth respectively and in O. ruber, teleosts and Acetes indicus ranked first and second respectively for the said two years. Except these indices, other values varied during both the years in two species. It showed that they preferred teleosts first and then other food items. In all months except teleosts, the values of indices of all food items varied during both the years and hence no regularity in indices of food items was observed in both species during different seasons. The indices of major food items varied within wide ranges whereas those of minor ones varied within narrow ranges.

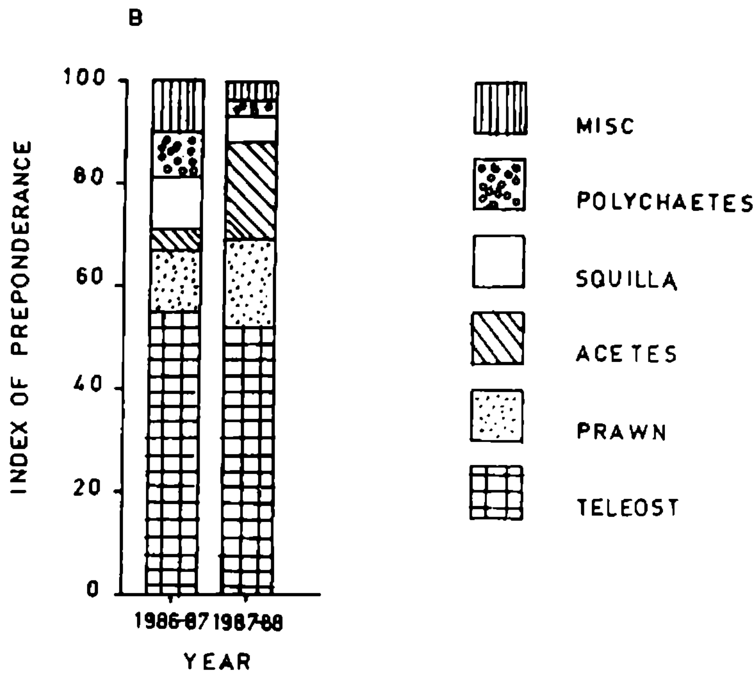
Nair (1979,80) reported that the order of preference for food in O. ruber was penaeid prawn, teleosts, Acetes spp. mysids and others and for J. sina it was teleosts, penaeid prawns, polychaetes, squilla and others. He pointed out that juveniles and adults of both the species preferred crustaceans and teleosts respectively. He also reported that dominent species in environment dominated in stomachs. Suseelan and Nair (1969) found that teleosts and Acetes spp. constituted the diet of these two species along Bombay coast. So these observations are well agreeing with the present findings. Nair (1979,80) reported that the indices of all food items for these two species fluctuated widely during all months and during the years of study. No similarity regarding food indices were noticed by him. He also reported that the food items like teleosts, prawns, polychaetes, molluscs, squilla were not observed in all months of the years. But in the present studies major food items like teleosts, penaeid proawns, squilla etc.

occurred in all months in both the species in varying percentages.

Juveniles of both species mostly fed on small prey organisms like Acetes spp., young ones of squilla, penaeid prawns, and polychaetes. As juveniles grow they changed over slowly to teleosts diet. In the beginning, percentages of teleosts were low but gradually became more as they grow in size. The percentages of teleosts food were high in large groups of both the species. Nair (1980) reported that prawns, Acetes spp., mysids formed the food of juveniles of J. sina with minor quantities of teleosts while teleosts, penaeid prawns, squilla and polychaetes constituted major food of adults. He also stated that the juveniles changed their food as they grow in size from more crustaceovore to piscivore, Nair (1979) reported that in O. ruber, teleosts were reported in all size groups in minor quantities and it's indices increased with increase in size. Bapat and Bal (1952) reported that prawns were the main food of juveniles of O. ruber and in larger fish classes fishes were found to dominate the diet untill finally it formed the major food item of the adults. These findings are in agreement with the present findings.

Juveniles and adults of both species showed two different feeding habits. Juveniles remained at the lower level of sea and hence their food consisted of bottom fauna while the adults being migratory their food contained prey organisms in wide range from all layears of water column. Both are carnivorous, so teeth are well developed and widely spaced. They catch the prey organisms from their front side and engulf them. They do not tear or crush the organism as evidenced by presence of whole intact organisms in their stomachs. As the juveniles of both species grow in size, slowly they switch on to piscivorous nature. Nair (1979, 80), in O. ruber and J. sina, showed the direct correlation between availability of food organisms in the environment and their occurrence in the gut. Also he reported that the species, O. ruber fed at the level slightly above the bottom.

In mature J. sina, percentages, of actively fed ones were low throughout the year and it is exactly apposite to the percentages of poorly fed ones and with empty stomachs which were high. This species is also a protracted spawner. Hence the spawning activity or development of gonads could not be responsible for low or high feeding activity of J. sina. But mature O. ruber spawns from September to January, still fed poorly throughout the year. Also the percentages of fishes with empty stomachs were high throughout the year. Even except this spawning period (September to January) no high percentages of actively fed ones were observed in rest of the months. Hence in this case also, spawning could not be a responsible factor for low or poor intake of food.



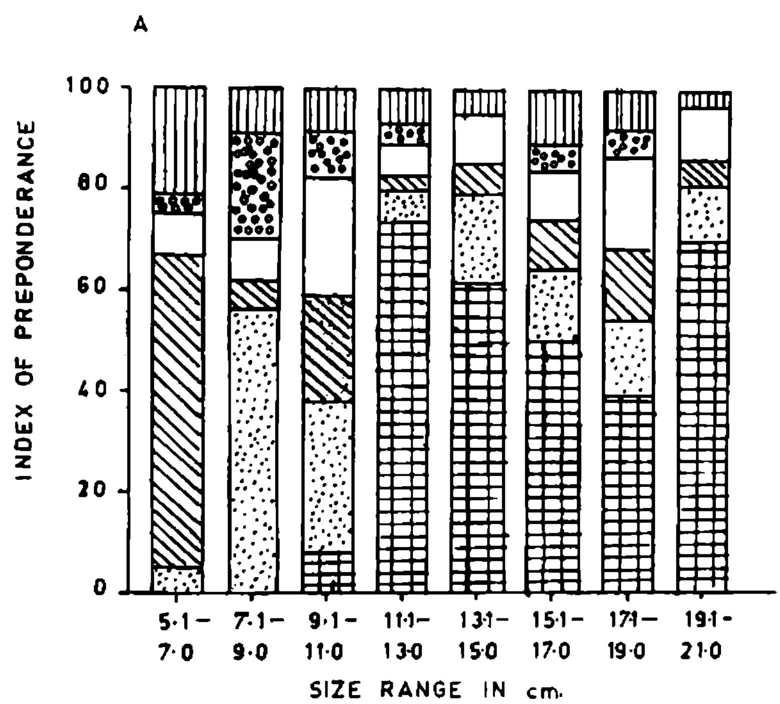


Figure 2 A. Index of preponderance of food items in different size groups of *J. sina*.

B. Index of preponderance of food items in different years in *J. sina* during 1986-88.

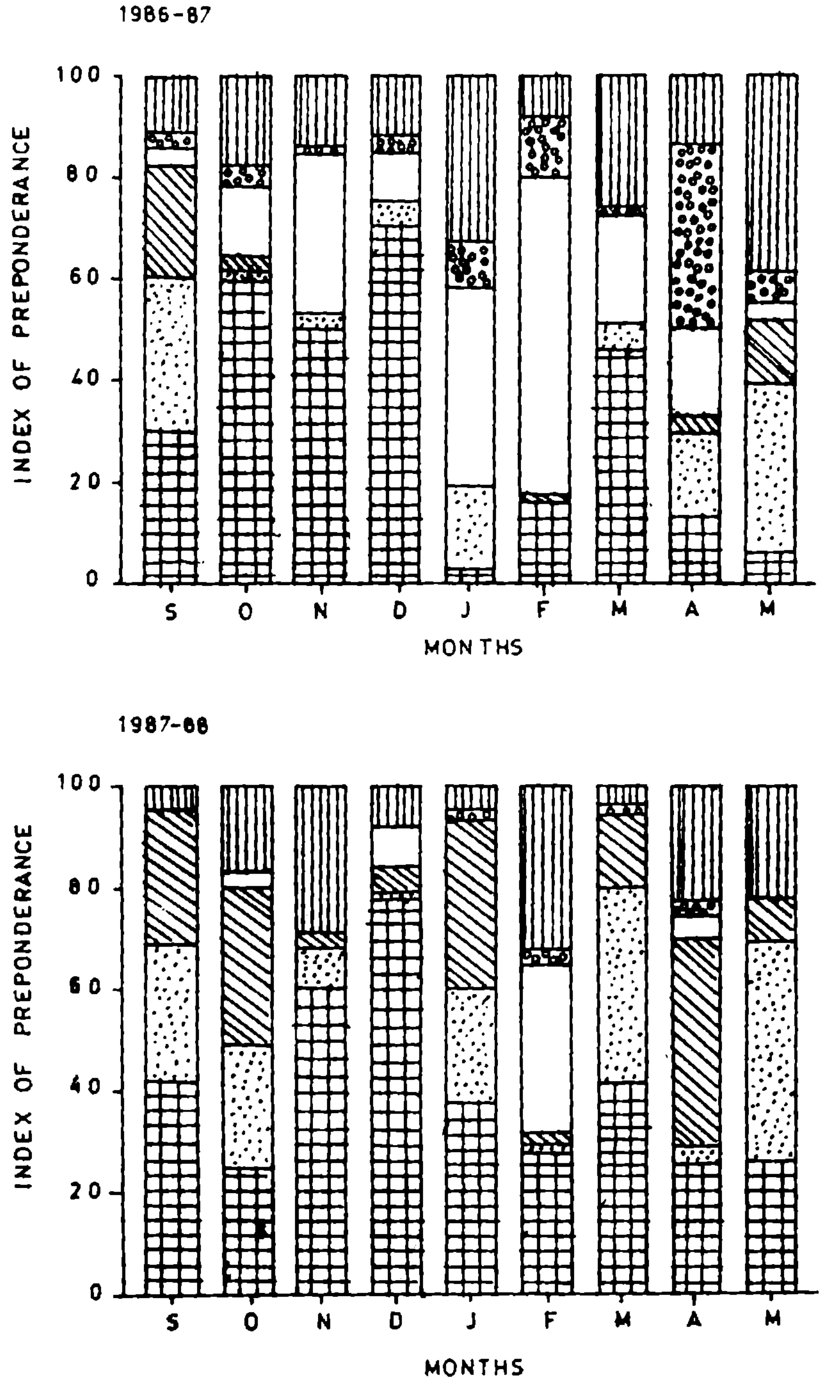


Figure 3 Index of preponderance of food items in different months in the stomach of *J. sina* during 1986-88.

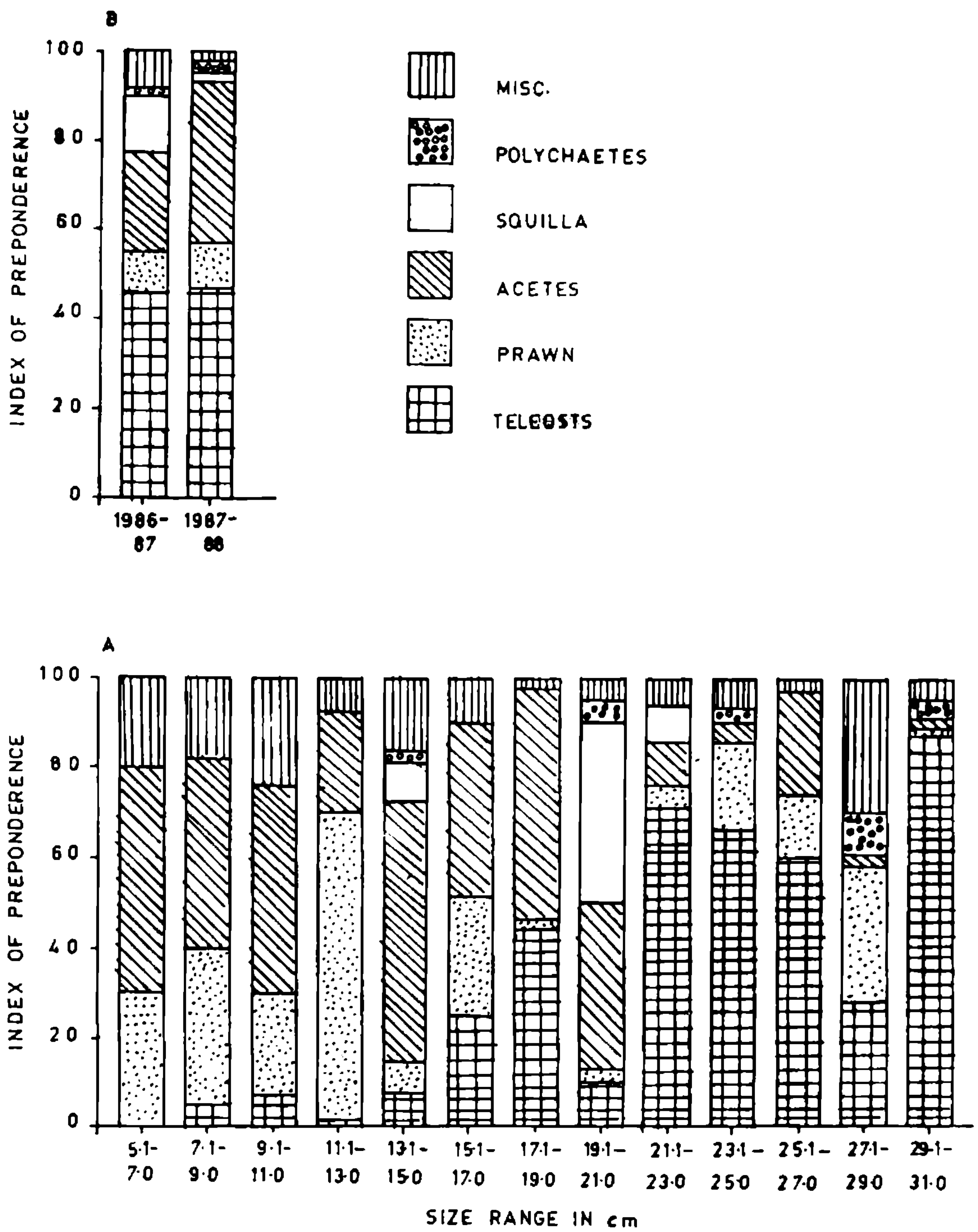


Figure 4

A. Index of preponderance of food items in different size groups of O. ruber.

B. Index of preponderance of food items in different years in O. ruber during 1986-88.

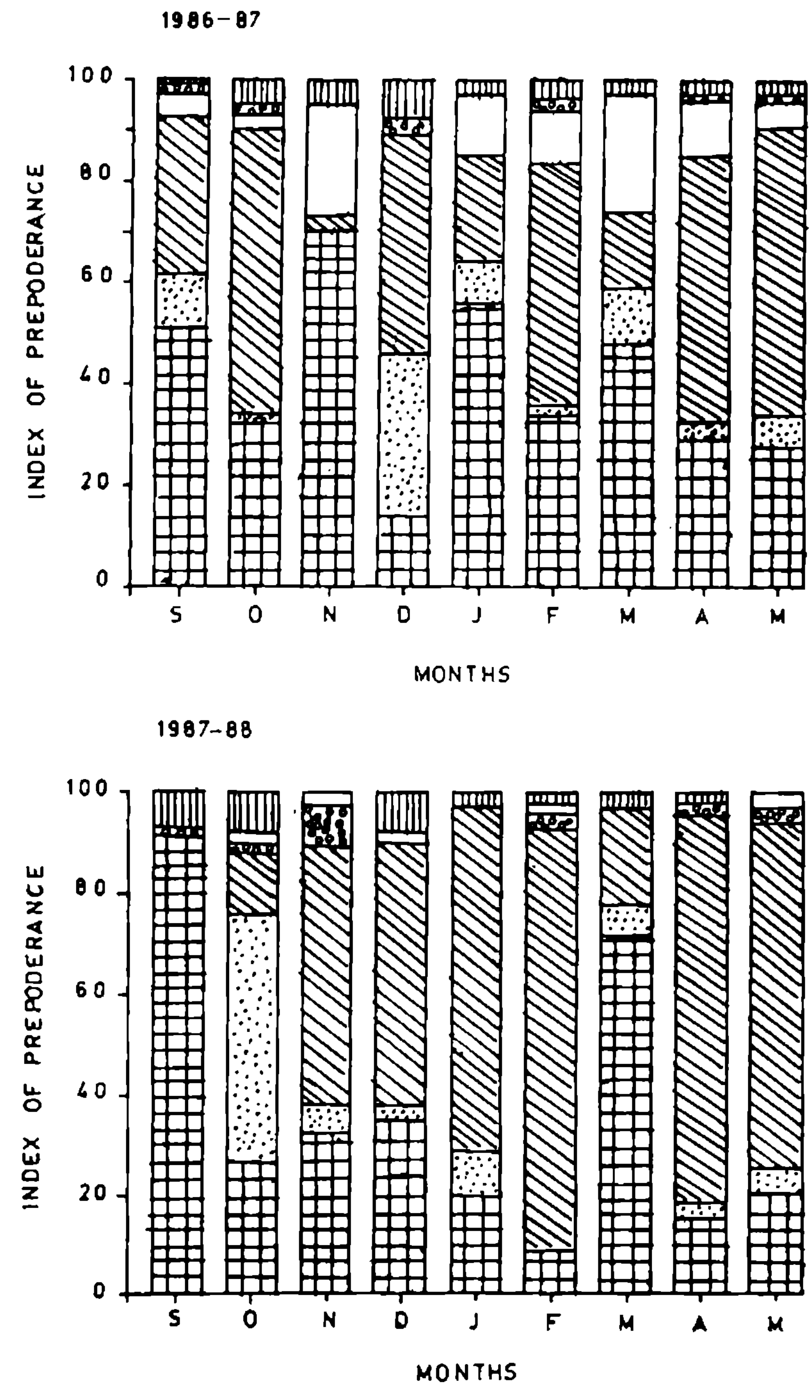


Figure 5 : Index of preponderance of food items in different months in the stomach of <u>O. ruber</u> during 1986-88.

Table 2 Intensity of feeding in Johnieops sina in percentage in different months during 1986-88

Year	Intensity of feeding	Months								
		Sept.86	Oct.	Nov.	Dec.	Jan.87	Feb.	March	April	May
1986-87	Active	00.00	02.18	10.08	14.23	32.28	09.16	00.00	33.21	07.40
(N-662)	Moderate	10.11	16.50	19.24	26.12	18.10	17.76	44.90	08.42	11.78
	Poor	31.39	19.43	30.68	27.38	26.25	42.64	21.83	18.77	41.29
	Empty	58.50	61.89	40.00	32.27	23.37	30.44	33.27	39.60	39.53
		Sept.87				Jan.88				
1987-88	Active	00.00	09.69	00.00	00.00	13.92	38.27	14.43	53.78	12.77
(N-579)	Moderate	07.34	07.14	12.15	00.00	21.84	19.38	13.32	30.06	00.00
	Poor	54.13	37.49	41.42	34.94	30.30	25.13	07.52	16.16	32.48
	Empty	38.53	45.68	46.43	65.06	33.94	17.22	64.73	00.00	54.75

Table 3 Intensity of feeding in _Otolithes ruber_ in percentage in different months during 1986-88

Year	Intensity of feeding	Months								
		Sept.86	Oct.	Nov.	Dec.	Jan.87	Feb.	March	April	May
1986-87	Active	17.86	06.79	10.48	19.21	00.00	00.00	27.71	42.32	37.05
(N-266)	Moderate	01.34	05.54	20.37	09.18	13.52	24.02	29.13	16.44	24.56
	Poor	64.78	33.81	16.49	36.26	14.82	15.54	09.84	14.38	21.80
	Empty	16.02	53.86	52.66	35.35	71.66	60.44	33.32	26.86	16.59
		Sept.87				Jan.88				
1987-88	Active	23.52	11.57	26.28	23.29	00.00	21.08	22.53	36.49	18.81
(N-577)	Moderate	08.19	06.25	33.40	29.30	45.17	17.60	00.00	13.48	28.27
	Poor	06.99	18.74	08.32	25.12	12.50	23.52	44.00	32.19	14.44
	Empty	61.30	63.44	32.00	22.29	42.33	37.80	33.47	17.84	38.48

Table 4 Intensity of feeding in percentage in juvenile and adult in Johnieops sina and Otolithes ruber during 1986-88.

Species	Year	No. of fish examined	Intensity of feeding			
			Active	Moderate	Poor	Empty
Juveniles						
Johnieops sina	1986-87	298	22.65	13.32	48.69	15.34
	1987-88	235	20.42	7.69	54.03	17.86
Otolithes ruber	1986-87	86	32.86	16.66	24.19	26.29
	1987-88	96	35.29	21.98	9.37	33.36
Adults						
Johnieops sina	1986-87	364	17.22	11.88	32.26	38.64
	1987-88	344	9.20	21.20	36.28	33.32
Otolithes ruber	1986-87	180	4.14	16.28	36.94	42.64
	1987-88	215	4.01	14.29	34.78	46.92

Table 5 Percentage composition of different food items by different methods and the index of preponderance of *J. sina* during 1986-88.

Food items	Percentages Point method	Occurrence method	Volumetric method	Index of prepond-erance	
1986-87					
Teleosts	22.22	22.83	39.61	54.91	(1)
Penaeid prawns	20.85	18.85	10.06	11.53	(2)
Acetes indicus	8.20	8.21	5.93	2.96	(6)
Squilla	11.36	12.43	13.45	10.15	(3)
Crabs	6.46	6.76	3.61	1.48	(7)
Polychaetes	10.14	10.63	12.88	8.31	(5)
Molluscs	6.07	5.80	3.90	1.37	(8)
Misc.	14.69	14.49	10.56	9.29	(4)
	100.00	100.00	100.00	100.00	
1987-88					
Teleosts	16.54	20.48	45.48	52.94	(1)
Penaeid prawns	14.45	16.19	18.34	16.88	(3)
Acetes indicus	19.94	24.30	14.86	20.51	(2)
Squilla	11.67	9.99	5.95	3.38	(4)
Crabs	6.58	6.19	2.40	0.84	(8)
Polychaetes	11.67	6.67	5.88	2.23	(5)
Molluscs	7.48	6.19	3.80	1.34	(7)
Misc.	11.67	9.99	3.29	1.87	(6)
	100.00	100.00	100.00	100.00	

(Figures given in parenthesis indicate the order of importance of food items).

Table 6 Percentage composition of different food items by different methods and the index of prepondenance of O. ruber during 1986-88

Food items	Percentages			Index of prepond-erance	
	Point method	Occurrence method	Volumetric method		
1986-87					
Teleosts	23.34	22.41	33.55	46.23	(1)
Penaeid prawns	12.58	15.52	11.75	11.21	(4)
Acetes indicus	21.48	24.14	15.10	22.41	(2)
Squilla	29.25	27.58	8.05	13.65	(3)
Polychaetes	3.35	2.30	0.84	0.12	(7)
Molluscs	4.45	3.45	22.66	4.60	(5)
Misc.	5.55	4.60	8.05	1.78	(6)
	100.00	100.00	100.00	100.00	
1987-88					
Teleosts	20.83	21.13	48.90	47.23	(1)
Penaeid prawns	20.31	19.72	11.17	10.07	(3)
Acetes indicus	30.58	32.39	25.42	37.64	(2)
Squilla	4.84	7.04	6.68	2.15	(5)
Polychaetes	5.13	4.22	2.55	0.49	(6)
Molluscs	3.85	3.52	1.23	0.20	(7)
Misc.	14.49	11.98	4.05	2.22	(4)
	100.00	100.00	100.00	100.00	

(Figures given in parenthesis indicate the order of importance of food items).

Table 7 : Monthly index of preponderance of food items in *J. sina* during 1986-87

Months	Teleosts	Penaeid prawns	*Acetes indicus*	Squilla	Crabs	Polychaetes	Molluscs	Misc.
	Index of preponderance of food items							
<u>1986-87</u>								
Sept. 86	30.70	30.34	22.29	4.45	1.32	3.96	5.95	0.99
Oct.	58.15	4.24	1.81	14.54	0.90	4.85	0.45	15.09
Nov.	50.28	3.49	0.28	31.28	0.84	1.12	0.42	12.29
Dec.	70.46	3.71	0.13	0.27	0.66	12.18	0.27	12.32
Jan. 87	2.59	16.17	1.55	49.16	1.30	9.31	0.52	19.40
Feb.	16.18	0.68	2.02	62.68	2.02	11.47	0.90	4.05
March	46.61	6.47	0.32	22.65	2.60	1.94	1.29	18.12
April	12.82	17.08	3.56	17.08	0.71	36.30	2.84	9.61
May	6.45	32.26	12.90	3.22	3.23	6.45	12.90	22.57

Table 8 Monthly index of preponderance of food items in *J. sina* during 1987-88

Months	Teleosts	Penaeid prawns	*Acetes indicus*	*Squilla*	Crabs	Polychaetes	Molluscs	Misc.
	Index of preponderance of food items							
1987-88								
Sept.87	42.30	27.01	27.59	0.46	0.00	0.92	0.69	1.03
Oct.	35.12	25.18	31.48	3.53	0.43	1.93	0.64	1.72
Nov.	59.53	9.13	3.71	0.53	3.97	1.06	4.23	17.84
Dec.	78.92	1.65	5.64	8.83	1.77	1.06	0.35	1.88
Jan. 88	38.16	22.89	33.81	0.93	0.00	2.49	0.47	1.25
Feb.	28.48	2.53	2.53	34.80	25.32	2.53	3.80	0.00
March	42.14	37.84	14.77	0.46	0.91	2.74	0.69	0.45
April	36.37	3.50	41.94	2.80	1.40	2.10	9.79	2.10
May	36.55	45.72	9.10	1.53	0.50	0.50	4.06	2.03

Table 9 : Monthly index of preponderance of food items in *O. ruber* during 1986-87

Months	Index of preponderance of food items						
	Teleosts	Penaeid prawns	Acetes indicus	Squilla	Polychaetes	Molluscs	Misc.
1986-87							
Sept 86	51.18	9.30	33.79	5.08	0.00	0.00	0.65
Oct.	32.60	1.20	56.93	3.00	1.10	0.00	5.17
Nov.	69.35	0.17	2.21	26.35	0.17	0.04	1.71
Dec.	13.83	32.65	42.82	0.55	0.07	9.53	0.55
Jan. 87	56.40	8.16	21.49	12.66	1.01	0.00	0.28
Feb.	34.19	2.35	48.97	10.19	0.23	0.00	4.07
March	48.16	11.12	14.98	23.21	0.47	0.00	2.06
April	28.23	5.14	52.97	11.61	1.65	0.00	0.40
May	30.14	3.70	57.80	5.05	1.23	0.00	2.08

Table 10 : Monthly index of preponderance of food items in *O. ruber* during 1987-88

Months	Index of preponderance of food items						
	Teleosts	Penaeid prawns	Acetes indicus	Squilla	Polychaetes	Molluscs	Misc.
1987-88							
Sept. 87	92.92	0.17	0.53	1.07	0.00	0.00	5.31
Oct.	28.99	49.71	13.02	0.00	1.18	0.00	7.10
Nov.	33.01	5.30	51.22	8.17	1.83	0.00	0.47
Dec.	37.47	2.53	53.17	0.00	1.27	0.00	5.06
Jan. 88	19.80	9.70	68.97	0.12	0.26	0.13	1.02
Feb.	9.71	0.00	84.95	2.91	1.46	0.00	0.97
March	71.39	5.93	20.02	0.04	0.38	0.62	1.62
April	16.61	2.35	77.52	1.57	0.78	0.78	0.39
May	21.15	4.80	69.48	2.82	1.01	0.00	0.76

CHAPTER -II REPRODUCTIVE BIOLOGY

Introduction

Fishery scientists and managers have been paying attention to the reproductive biology of individual species of fish as it provides valuable clue for rational exploitation of species concerned. The scientific knowledge of the reproductive biology of fish population is imperative for effective management and understanding of fish population dynamics (Nikolsky 1969). Most aspects of reproductive biology of population such as, length at first maturity, fecundity etc. respond to a number of environmental factors (Woofton, 1982). Information on the length at first maturity is of use in assessing the potential spawners lost from the stock by fishing. Sex composition of catches is essential in understanding whether any differential fishing exists, if so, it's possible effect on the fishery and whether sexual congregation takes place during spawning which can be effectively utilised for fishing.

Spawning season and spawning frequency within the season and in the life span of fish help in assessing the reproductive potential of it's population and help in taking decisions for managerial actions.

Reproductive biology of some species of sciaenids has been studied by earlier workers (Table 10). A perusal of literature shows that Jacob (1948) observed the spawing season of Otolithes ruber from Malabar waters. Vaidya (1960) has studied the fecundity, spawning season and periodicity of O. ruber from Bombay, Devadoss (1969) has worked on maturity, fecundity and spawning season and periodicity of O. ruber from Bombay waters and Nair (1977) has studied the fecundity, spawning season and frequency of J. sina from Calicut waters. Maturity, fecundity, spawning season, spawning frequency, sex ratio etc. of the two species have not been studied in detail from Ratnagiri except the work of Bhusari (1975) on Pseudosciacna sina where he studied length at first maturity, fecundity and spawning season. Hence, J. sina and O. ruber were studied in detail.

Material and Methods :

The fishes (J. sina, O. ruber) collected from Mirkarwada fish landing centre for length-weight measurement, study of food and feeding habits etc. were utilised for the study on the reproductive biology during September 1986 to May 1987 and September 1987 to May 1988.

After noting their lengths (cm) and weights (gms), the fishes were cut open ventrally to observe the general macro appearance of the gonad and it's extension in the body cavity for determinaing the different maturity stages (Devadoss, 1969; Nair, 1977; Baragi 1980; and Sreenivasan, 1981). The I.C.E.S. scale (Wood, 1930) was followd for the classification of maturity stages. The percentage occurrence of each sex and stages of maturity were assessed and gonads were preserved in 5% formalin. The ova less than 5 M.D. were found in enoromous numbers in all samples at all stages of maturity, hence those were not considered for ova diameter frequency studies. For this study, the middle portion of the two lobes of the ovaries were taken since no significant difference were observed in the distribution pattern of ova in the anterior, middle and posterior regions of the ovaries (Fig. 6,7).

Maturation and frequency of spawning

Maturation of ova and frequency of spawning were studied by the method adopted by Clark (1934), Hickling and Rutenberg (1936), Prabhu (1956) and James (1980). Ova diameter was measured under the microscope using an occular micrometer scale at 5 x 10X magnification (1 micrometer scale division = 0.013 mm). For determining the frequency of spawning, relative condition factor was also taken into account. From the two species, only adult fishes of both sexes were considered for the study.

Fecundity

The ovaries in mature and ripe stages (IV, V and VI) preserved in 5% formalin were used for estimating the fecundity. The ovary was weighed and sub-samples from the mid-portion of the two lobes, weighing about 300-500 mg were taken. This sub-sample was cut open and teased carefully all the intraovarian ova on a glass slide with needles and observed under the microscope for counting the number of yolked ova. For this study 24 ovaries of *J. sina* and 36 ovaries of *O. ruber* were examined.

In *J. sina*, ova diameter frequency polygon showed minor intermediate modes which were not clearly separated from each other as well as from the general immature stock of ova. In this type of ovary, it is difficult to distinguish the developing ova from the reserve ones (Gerking, 1967). In such cases it may not be correct to count the most mature ova alone for fecundity estimation. Macer (1974) studied histology of ovary of horse-mackerel, *Trachurus trachurus* (L.) a multiple spawner and showed that yolked oocytes alone form potential fecundity for the season. Such type of histological work was not possible during this study. So gross fecundity that is counting of all yolked ova, was estimated as attempted by Petrova (1960) for Baltic sprat and Nair (1977) for *J. sina*. Hence, for *J. sina*, all yolked ova which were destined to be spawned in the season were counted for fecundity estimation, whereas in the case of *O. ruber*, a single group of fully mature and ripe ova (ova diameter 26 M.D. and above) clearly demarketed from the maturing group of ova was noticed. This group was considered for fecundity estimation of *O. ruber*.

Gonado-somatic index

Applying the method of June (1953) and Yuen (1955) gonado-somatic indices of two species were calculated gutted body weights of fishes were taken with 0.5 gm accuracy and gonads (after removing adhering water) upto 0.005 gm accuracy. Gonad indices were calculated by following the formula

$$GSI = \frac{GW \times 100}{(BW - GW)}$$

Where, GW = gonad weight in gms

BW = gutted body weight in gms.

Monthly average was used to determine spawning season and maturity.

Length at first maturity

It was determined on the basis of (1) percentage occurrence of mature fishes in various size groups (2) relative condition factor, 'Kn' with resp^ct to size of the fish. In the first method, the length at which 50% of them attained maturity was considered as the length at first maturity.

Sex ratio

Sexes were noted to find out the sex ratio during different months and of various lengths. Chi-square test was used to find out whether differential sex ratios were present or not. This test was applied for monthly as well as length-wise pooled data.

Result

J. sina :

Classification of maturity stages

The description of different maturity stages are summarised in Table 11 for both the sexes.

Stage-I, Immature : Ovaries were thin, thread like, creamy in colour, occupying less than 1/4th the length of the body cavity. Ova were not visible to the naked eyes but transparent ova with clear nuclei were observed microscopically. The size of the ova ranged from 0.013 to 0.117 mm with a mode at 0.052 mm.

Testes were thin and thread like occupying less than 1/4th the length of the body cavity.

Stage-II, early mature   Ovaries were enlarged, yellowish-red in colour, occupying 1/4th to less than 1/2 the length of the body cavity. Ova were not visible to the naked eyes. Two groups of ova were noticed under microscope, smaller ones were non-yolked and bigger ones partly yolked at the centre. The size of ova ranged from 0.013 to 0.195 mm without showing any prominent mode.

Testes were whitish ribbon like occupying about 1/4th to 1/3rd the length of the body cavity.

Stage-III, late mature   Ovaries were cylindrical creamy-red in colour, occupying 1/2 to 3/4th the length of the body cavity. Three groups of ova were observed, immature, maturing-I, maturing-II. Ova of large size group became opaque because of yolk deposition. The size of ova ranged from 0.013 to 0.390 mm with the largest mode at 0.27 mm. Another mode was noticed at 0.14 mm.

Testes were ribbon like, white and opaque occupying about 1/2th the length of the body cavity.

Stage-IV, mature   Ovaries were yellowish pink occupying 2/3rd the length of the body cavity. Four groups of ova, immature, early maturing late maturing and mature one were observed. Size of ova ranged from 0.39 to 0.45 mm with the largest mode at 0.38 mm. Other modes were also noticed at 0.12, 0.20, 0.25, 0.32 mm which were not demarkated from one another. Yolk deposition progressed further.

Testes were white occupying 3/4th the length of the body cavity.

Stage-V, ripe   Ovaries occupied almost the entire body cavity by pushing aside the other organ. Ova were seen prominently through the thin wall of the ovary. Blood vessels were noticed on the dorsal side. Size of ova ranged from 0.45 to 0.48 mm with a mode at 0.40 mm. The other preceeding modes were at 0.14, 0.25 and 0.35 mm.

Testes were creamy white in colour; completely opaque and broad, extending almost the entire length of body cavity.

Stage-VI, spawning   Ovary was reddish in colour occupying the whole body cavity. Ova were clearly visible through the thin ovary wall. Ova were of large size and with an oil globule. At this stage the most mature group of ova which are destined to be spawned in the ensuing season were found liberated from the follicles and were found free in the lumen of the ovary. Ova oozed out on slight pressure on the abdomen. Size of the ova ranged from 0.48 to 0.53 mm with a mode at 0.50 mm. Other modes noticed at 0.14, 0.25, 0.32 and 0.40 were not sharply separated from one another.

Testes were white in colour, large, Occupying the entire length of the body cavity. Semen oozed out freely with pressure on abdomen.

Stage-VII-A, partially spent   Ovaries were reddish in colour, slightly flabby, occupying slightly less than the entire body cavity. Ova were resembling to that of III, IV and V stages. Modes were noticed at 0.22, 0.32 and 0.40 mm.

Testeswere white in colour, collapsed partially and slightly smaller in size than that in the previous stage.

Stage-VII-B, fully spent   Ovaries were completely collapsed, shrunken with bloood shot. Residual ova were shrunken. High percentage of immature ova were observed.

Testeswere flabby, reddish brown in colour.

Spawning frequency

Spawning frequency was determined by observing ova diameter frequency polygon of ovaries representing different stages of maturity (Fig. 8).

Small, immature innumerable ova with clearly visible nuclei were observed in first and second maturity stages. This group of immature stock of ova (from 0.013 to 0.195 mm in diameter) was present in all stages of maturity and could be named as general immature stock (Sreenivasan 1981). In the first stage, the diameter of ova ranged from 0.013 to 0.117 mm showing a mode at 0.065 mm. Similarly in the second stage of maturity, the diameter of ova ranged from 0.117 to 0.195 mm and the mode remained the same.

Some of the ova from the general stock were progressed and entered into the next maturity stage that is third. The diameters of ova at this stage ranged from 0.195 to 0.390 mm where dominant mode was observed at 0.27 mm. Another mode was observed at 0.14 mm prior to the mode at 0.27 mm. Ova from the last mode (0.27 mm) of the third stage, further increased in size and formed new group of ova entering into fourth maturity stage. Hence a mode was noticed at 0.38 mm. At the same time another batch of ova replaced from the general stock. In this stage, besides the mode at 0.38 mm, other modes were at 0.12, 0,195, 0.25 and 0.32 mm.

The ova from the above stage (IV) increased further and yolk deposited densely in them. Thus they formed fifth maturity stage. A prominent mode was clearly seen at 0.40 mm. In this stage various modes were noticed at 0.14, 0.25 and 0.35 mm and all these modes including the made at 0.40 mm were not sharply separated from each other.

In the sixth maturity stage, the ova further increased in size, became translucent and ripe, largest one bearing an oil globule and formed mode at 0.50 mm. Other preceeding modes were noticed at 0.14, 0.25, 0.32 and 0.40 mm. Now the ovary is ready for spawning.

In the next stage (VII-A), ova representing all maturity stages were observed with low percentages of mature and high percentages of immature and maturing ova. It was clear that, the species had spawned partially in the earlier period and hence contained low percentages of ripe and mature ova. Definitely it was preparing for the next spawning since the largest ova were not noticed in the degenerating state as in the case of fully spent fishes. Different modes were still noticed at 0.22, 0.32, 0.40 and 0.45 mm. in minor percentages. Such partial spawning has been observed in Johnius carutta from Visakhapatnam (Rao, 1967), Johnius dussumieri from Bombay (Devadoss 1969); Johnieops sina from Calicut (Nair 1977); Johnius osseus from Mangalore (Baragi 1980). The fully spent ovary (stage-VII-B) contained numerous, small, immature ova and few intermediate ones ranging from 0.195 to 0.40 mm in diameter and these ova may contribute for the next season by growth.

In J. sina, the ova-diammeter frequency polygon showed more than one mode of mature ova. Different batches of ova were not sharply differentiated from one another, thereby indicating that the passing of one batch of ova into the next stage was more or less a continuous process. So by following Hickling and Rutenberg (1936) and Prabhu (1956), J. sina could be placed under the fourth category of fishes which spawn throughout the year.

Spawning season

It was determined on the basis of percentage occurrence of different stages of maturity in each month (Fig. 9,10). A total of 2218 males and 2286 females of *J. sina* has been examined.

The fishes of advanced stages of maturity, stage-IV and V were observed almost in all the months from September to May. The percentage occurrence was high in September, October and March during 1986-87 and in October, November, December, January and March during 1987-88. Partially and fully spent fishes were recorded in November, December, January, March and April during 1986-87 and in September to January and April, May during 1987-88.

In short, all mature stages in *J. sina* occurred almost throughout the year and spent ones from September to January and March to May. From above it could be inferred that the population of *J. sina* spawned over a longer period of time with peak spawning periods from November to January and March to May. The length-frequency data (Fig. 25) also supported the prolonged spawning of the species as was evidenced by the continuous recruitment of juveniles. This view is also supported by Nair (1974, 1977).

Gonado-somatic index

Most of the maturity stages of *J. sina* occurred throughout the year. So in general, there were not much differences between gonadial indices in different months. The indices varied from 3.7 to 5.7 (Fig. 13). This showed that the spawning was a continous process. Slightly high values were observed during December-January and April-May which confirmed the two peak spawning periods. This inferrence agrees well with the results obtained by observations on the percenatage occurrence of mature stages.

The monthly values of 'Kn' (Fig. 24) varied within a narrow range strengthened the earlier conclusion that this species has a prolonged spawning.

Multimodes in ova diameter frequency polygon where modes were not sharply demarketed from one another (Fig. 8). occurrence of mature fishes throughtout the year (Fig. 9,10). and Kn and GSI values (Fig 13,24), varied within narrow ranges; brought to the conclusion that *J. sina* spawns almost throughout the year (Table 1 3).

Length at first maturity

Percentage occurrence of mature fishes in various size groups

The length maturity data of 2181 males ranging in size from 7.5 to 22.0 cm and females 2263, ranging from

7.5 to 23.6 cm were utilized to present the maturity curve (Fig. 14). Upto the size group of 11.0 cm, both males and females of the immature group were dominant. Majority of the fishes were mature within 11.0 to 12.0 cm length groups. This length group onward the percentages of mature male and female increased and reached up to 100% by 17.0 cm. Based on the above data, the sizes at first maturity for males and females were 11.2 and 11.6 cm respectively (Fig. 14).

Relative condition factor

In the Kn value of females at different size classes the lowest value noticed was at 12.0 cm indicating the size at first maturity, similary in males, the lowest value was observed at 11.0 cm when majority of males attained maturity (Fig.23)

Fecundity

Earlier it has been stated that, J. sina spawns more than once in a season and the most mature or ripe ova in ova diameter frequency polygon were not sharply separated from maturing groups. So accurate estimation of fecundity could not be made by counting the ripe and mature ova only, since development of ova was a continous process. In this case, for estimating the fecundity, the ripe ova including the other ova in which the deposition of yolk had taken were considered. This method is used by Petrova (1960) for Baltic sprat, Nair (1977) for J. sina. Such a method gives gross fecundity irrespective of the number of batches each of them would have already spawned.

In the present study, the fecundity is based on the examination of 23 ovaries of fishes ranging from 12.4 to 20.6 cm. The number of ova varied from 12,500 to 2,71,000 in various length groups. Nair (1977) observed the fecundity from 12,744 to 1,51 ,677 of J. sina ranging from 12.4 to 17.4 cm in lengths.

Relation between fecundity and length of fish

Significant relation has been observed between fecundity and length of fish (Coefficient correlation, r = 0.7506). Fecundity increases as the length of species increases. The relationship is expressed as $F = -131.392 + 11.5416 \times L$. where F = Fecundity and L = Total fish length in cm (Fig.15).(F.in '000)

Relation between fecundity and weight of fish

It showed a singnificant relationship (r = 0.7523) between fecundity and weight of fish. As the weight of the species increases the fecundity also increases. The relation is expressed as $F = -28.1751 + 1.3450 \times W$ were F = fecundity and W = weight as fish (gms) (Fig. 16). (F in '000)

Relation between fecundity and weight of ovary :

Significant relation has been noticed in between fecundity and weight of the ovary ($r = 0.8127$). Similar to above, in this case also fecundity increases with increase in weight of the ovary. The relationship is $F = 13.9341 + 12.7188 X OW$ where F = fecundity and OW = ovary weight (Fig. 16). (F in '000)

Sex ratio

During the two years of study, total 4504 specimens of *J. sina* were examined, where 2218 males (49.25%) and 2286 females (50.75%) were included. The male : female ratio was tested stastistically by using X^2 test (Snedecore and Cochran, 1980). It showed that the number of males and females did not differ from their 1:1 ratio (1:1.0306) (Table 16).

From the monthly sex distribution (Table 16), it was noticed that the differences in distribution of the sexes were significant during December 1986, March, April, October, November and December, 1987, March, April and May 1988. During these two years, the ratio varied in different months. Repeatation of ratio could not be noticed in same months of the two years.

Length-wise data of the two years were pooled together to know their size wise sex ratio (Table14 Fig.18).

It showed that the males out numbered females upto 12.5 on length with significant Chi-square values. In the subseqent length groups, from 12.5 to 15.5 cm, Chi-square values were not significant and both the sexes were in 1:1 ratio. In fishes of 15.5 cm and above the Chi-square values were significant with females dominating the landings and females alone were recorded in the size classes 21.0 cm and above.

Within 7.0 cm to 11.5 cm length groups, the percentage of males was higher (80%) than that of females (20%). This higher percentage of males decreased slowly as the length increased and further became negligible at 21.0 cm length and vice-versa in the case of females. The percentage of females was low (20.0%) in smaller length groups (7.0 to 11.5 cm), they increased slowly surpassing the percentage of males and reached to 100% in 21.0 cm.

Therefore in short, males were dominant in smaller length groups upto 11.5 cm and males and females were in equal numbers in size groups 12.5 to 15.5 cm and females were dominent in larger size groups above 15.5 cm.

It is interesting to note that the Chi-square test for the sex ratio was not significant between 12.5 to 15.5 cm length groups. This species mature within 11.0 to 12.0 cm, length groups. The data clearly shows that the adult males and females were congregated in equal numbers for breeding.

<u>O. ruber</u> :

Classification of maturity stages

The classification of different maturity stages are summerised in Table 12 for both the sexes.

Stage-I, immature Ovaries were thread like, white creamy in colour, occupying less than 1/4th the length of body cavity. Small transparent ova with clear nuclei were visible under microscope. Size of the ova ranged from 0.013 mm to 0.120 mm, with a mode at 0.026 mm.

Testes were thin, thread like, white in colour, occupying less than 1/4th of the body cavity.

Stage-II, early mature Ovaries were thicker, tubular in shape, yellow red in colour occupying 1/3rd to 1/2th the length of the body cavity. Ova were not visible to the naked eyes, yolk deposition just started around nucleus. Diameter of ova varied from 0.120 to 0.195 mm. A mode was noticed at 0.140 mm.

Testes were pale white in colour extending 1/3rd of the body cavity.

Stage-III, late mature Ovaries grew large, became tube-like, pink to yellowish red in colour, occupying 1/2 of body cavity. Ova were partially opaque since deposition of yolk and the nucleus was hidden partly or fully. The size of the ova ranged from 0.200 to 0.355 mm with a prominent mode at 0.30 mm.

Testes were white in colour, occupying 1/2 the length of the body cavity.

Stage-IV, mature Ovaries were creamy to yellow in colour extending to 2/3rd or more the length of body cavity. Ova ranged from 0.350 to 0.500 mm in diameter, were visible with naked eyes. Prominent mode was noticed at 0.46 mm. Blood vessels appeared on dorsal side. The ova enlarged further and yolked densely and appeared opaque.

Testes were whitish in colour, large in size, occupying 3/4th of body cavity.

Stage-V, ripe Ovaries were reddish in colour due to ramification of blood vessels and extended more than 3/4th the length of body cavity. Ova were large and within the size range of 0.50 to 0.66 mm in diameter with a mode at 0.57 mm. Ova packed with yolk becoming highly opaque and seen prominently with naked eyes.

Testes were whitish in colour occupying almost the entire length of the body cavity.

Stage-VI, spawning The ovary was reddish in colour occupying the entire body cavity and ova were seen through the thin ovarian wall. The diameter of ova varied from 0.66 to 0.82 mm with a mode at 0.70 mm. Ova were ripe containing an oil globule, oozed out on slight pressure on the abdomen.

The testes were white in colour and filled the entire body cavity.

Stage-VII, spent Ovary was blood shotted, shrunken because of extrustion of its contents. Ovary contained few large ova in the process of degeneration and with high percentage of small immature ones.

Testes were shrunken and occupied 3/4th or less the length of body cavity.

Spawning Frequency :

Fig. 8 shows ova diameter frequency polygon of O. ruber at different stages of maturity. In maturity stage-I, there was only one group of immature stock of ova represented by a mode at 0.026 mm. In maturity stage-II, a mode was formed at 0.14 mm by growth of a batch of ova from the previous stock. Deposition of yolk was noticed around the nucleus. The 0.14 mm mode shifted to 0.30 mm in maturity stage-III. Here ova were enlarged and nuclei were partly or fully hidden due to yolk deposition. This mode progressed to 0.45 mm in maturity stage-IV. In this stage the nucleus was completely hidden by intensive deposition of yolk. The 0.45 mm mode progressed further to 0.57 mm in maturity stage-V. In this stage ova were large, ripe and highly opaque. In maturity stage-VI, the ova had grown further. An oil globule was noticed in this stage and the modal size was 0.70 mm. Only a single mode was noticed in each maturity stage. The same mode progressed further from one maturity stage to the next one. The mature ova group was distinct and sharply separated from the general immature stock of ova.

Thus in the ova diameter frequency polygon of mature stage, the most mature group of ova was distinct and widely separated from the general stock. By following Hickling and Rutenberg (1936) and Prabhu (1956), spawning of O. ruber takes place only once and restricted to a definite short period.

In spent ones (Stage-VII), the ovary contained only immature ova with few degenerating ripe ones. This showed that no other mature group of ova would be formed during the same season after the fish had spawned once (Natarajan, 1980; Vasudevappa, 1980). Hence it can be concluded that O. ruber spawns once in a year. Vaidya (1960) and Devadoss (1969) also reported a similar condition in O. ruber from Bombay waters.

Spawning season

Percentage occurrences of different stages of maturity of O. ruber in each month have been depicted in figures (Fig. 11, 12). Total 1262 females and 958 males have been examined.

From the Fig. 12 , it is evident that the females in IVth and Vth mature stages occurred from September to January in higher percentages during 1986-88. This indicates that O. ruber spawns during September to January and peak spawning period is from October to December. This is further supported by the occurrence of spent females during the same period.

Fig. 11 shows the occurrence of mature and ripe males during September to January and spent ones from October to January. This supports the earlier view.

Gonado-somatic index

The indices varied from 0.8 to 9.8 in females and 0.2 to 6.2 in males. It is evident from the Fig. 13 that gonado-somatic indices were high during September to December with peak in November. In other words, it breeds during September to December period and intensively in November-December which is in agreement with the above findings.

Monthly Kn values (Fig. 24) were high during September to December and hence supported the earlier findings that this species spawns during September to December.

Length at first maturity :

By percentage occurrence of mature fishes in different length-groups:

227 males ranging from 13.5 to 31.5 cm and 330 females ranging from 13.5 to 33.5 cm have been examined and put into maturity percentage to length graph (Fig. 14). From the fig. it is clear that 50% of male population mature at 20.2 cm and 50% female population at 22.6 cm.

By relative condition factor :

Length-wise relative condition factor (Kn) values (Fig. 23) showed that male matures at 21.0 cm length and females at 23.0 cm.

Fecundity

Fecundity estimations were based on the examination of 36 ovaries of fishes ranging in size from 16.7 to 32.7 cm. The ovaries in IVth and Vth maturity stages were used for the study, and all the ova of size 0.40 mm and above were considered for estimating the fecundity. For the above length range fecundity varied from 54,600 to 4,40,000.

Relationship between fecundity and length of the fish :

Correlation has been found between fecundity and length of the fish ($r = 0.6427$). The estimated relationship is $F = -56.9704 + 7.6722 \times L$ (F in '000) (Fig. 15).

Relationship between fecundity and weight of fish

There was poor correlation between fecundity and weight of the fish ($r = 0.2688$). The relationship was estimated as $F = 47.2543 + 0.3890 \times W$ (wieght of fish) (Fig.17 (F in '000)

Relationship between fecundity and weight of the ovary

There was higher correlation between fecundity and weight of the ovary ($r = 0.6799$). The relationship was found to be $F = 29.0848 + 10.2055 \times W$ (wieght of ovary). (F in '000) (Fig. 17).

Sex ratio :

For the sex ratio studies, 2220 specimens of O. ruber (958 males and 1262 females) were examined during the two years of observation. For the pooled data, females were found to be more than males (Table 17 , Chi-square = 41.6268, for 1 D.F.).

The data on monthly sex distribution (Table 17). showed that the Chi-square values were significant during

September 1986, March, April, May, September and November 1987, January, February and May 1988. During December 1986 and 1987, the sex ratio was non-significant. This is because of peak spawning period when both sexes congregate in equal numbers.

The length-wise sex ratio for both the years pooled together and are shown in Table 15 . The ratio was significant for 12.0, 15.0, 16.0, 17.0, 19.0 and 20.0 cm length groups and not-significant for 11.0, 13.0, 14.0 and 18.0 on length groups. From 21.0 cm length group onwards except 24.0 cm length group all ratios were non-significant upto 29.0 cm lengths. The species, O. ruber matures after 20.0 cm lengths. It shows that the males and females congregated in 1:1 ratio after attaining maturity.

Discussion

Maturation at an early age is typical in sciaenids and in short lived fishes other than sciaenids (Schaefer, 1965; Marriner, 1976; Shlossman and Chittenden, 1981 and Ross, 1984). J. sina is a short lived and small sized species and hence small size at first maturity is not surprising. Males of this species mature first at 11.2 cm and females at 11.6 cm (Fig.14). The lengths at first maturity in male and female J. sina from Calicut water are 12.5 cm and 11.5 cm respectively (Nair, 1977). From age and growth studies it is concluded that J. sina matures before it becomes one year old.

O. ruber has higher growth rate, hence it is larger in size than *J. sina.* In this species, the length at first maturity is 20.2 cm for male and 22.6 cm for female. This species also matures before it becomes one year old. Vaidya (1960) noticed 22.0 cm as the length at first maturity in case of female *O. ruber* from Bombay waters. The length at first maturity for female from Bombay waters is 20.0 cm (Devadoss, 1969). Geographical or environmental factors may be responsible for this variation from two different places as observed by Shepherd (1984) in *Cynoscion regulis.* The lengths at first maturity of some female sciaenids are as, *Johnius dussumieri*, 16.0 cm (Devadoss, 1969); *Johnius (Johnieops) dussumieri*, 11.0 cm; *Johnius (Johnius) carutta*, 15.5 cm (Murty, 1979); *Johnieops osseus*, 12.5 cm (Baragi, 1980); *Johnieops vogleri*, 15.9 (Muthiah, 1982); Banded drum, 12.0 cm (Ross, 1984); and *Johnius carutta*, 14.0 cm (Vivekanandan, 1985).

Protracted spawning is also characteristic of many sciaenids (Welsh and Breder, 1923; Thomas, 1971; Merriner, 1976 and Warlen 1980). Spawning in *J. sina* occurs throughout the year in Ratnagiri waters especially from September to May. Samples could not be collected during monsoon because of closed fishing season. But occurrence of mature fishes in May indicates spawning in next months. It has two peak spawning seasons, November to January and April to May. Occurrence of spent fishes in several months strengthens the above argument. The same species from Calicut waters showed two peak spawning periods, December to February and April to May (Nair, 1977) which is in close agreement with the present findings.

O. ruber spawns in a restricted period, from October to January in Ratnagiri waters. Individually it spawns in a short time but population as a whole spawns from November to February. Young ones of O. ruber of size 7.0 to 8.0 cm have been collected in April and May which have born in February. In Bombay waters it spawns from July to October (Devadoss, 1969). It shows that spawning of O. ruber varies from place to place like Pennahia aneus which spawns at Port Novo from September to October (Gandhi, 1982); at Visakhapatnam from December to March (Rao, 1967) and at Madras from May to June (John, 1951).

As above some sciaenids spawn over a long period or in a restricted period. Gopinath (1946) observed post larval forms of Sciaena albida along the Trivandrum coast from November to March. From Bombay Bapat and Bal (1950) reported the occurrence of postlarval and young ones of various species of Sciaenids, namely Sciaena miles, S. semiluctosa, S. glauca, Otolithus argenteus S. albids, during winter, rainy and summer seasons. Chacko (1950) observed larval and postlarval forms of O. ruber during the period August to September in Gulf of Mannar. Pantalu and Jones (1951) stated that in the river Hooghly, *Pama pama* spawned throughout the year. From Bombay, Rao (1963) reported that in *Pseudosciaena diacanthus*, the spawning period extended from June to September. *Pseudosciaena bleekeri* and *Johnius carutta* spawn only once in a year (Rao, 1967), Longhurst (1964) while studying the spawning habits of sciaenids of Tropical West Africa, stated that *Pseudosciaena senegalensis* and *Pseudotolithus typus* spawned throughout the year. White croaker, *Genyonemus lineatus* is a protracted spawner which spawns about once every five day during spawning period (Love, 1984). It shows that most of the sciaenids spawn throughout the year and some in a restricted period, where the spawning seasons are different.

In some fishes all ova mature synchronously and are shed in a single batch over a relatively brief period of time each year (Bagenal, 1967). *O. ruber* comes under this type of reproduction. Here estimation of fecundity is a simple process of enumerating the number of ripening ova per female. However, in many fishes, like *J. sina*, ova mature in multiple batches that are spawned successively within spawning season or almost throughout the year. In such cases, determination of annual ova production is difficult. Frequency distributions of ova diameter of multiple spawners are characteristically multimodal (Prabhu 1956; Bagenal and Braum, 1971; Hempel, 1979; De Martini and Fountain, 1981; Gale, 1983; Snyder, 1983).

In most multiple spawners, synchronously maturing batch of ova accumulating the yolk sequentially arises from a much larter group of previtellogenic immature ova termed "recrutment ova" (Clark, 1925; Bagenal and Braum 1978; Jones, 1978; Hunter and Leong, 1981). According to Conover (1985) there are two main phases of oocyte production and growth in multiple spawners i.e. (1) previtellogenic phase during which new oocytes are produced and (2) a vitellogenic phase during which growth is faster and yolk accumulates in the ovum (Ball, 1960; Jones 1978; Tokarz, 1978; Baggerman, 1980). Vitellogenic growth and maturation of ova occur before spawning. Hence, in multiple spawners, the reservoir of recruitment of ova occurs in vitellogenic phase where all the oocytes form potential fecundity, likely to be extruded out successively after maturation.

In ova diameter frequency polygen of J. sina, no clear cut separation of modes was observed. So as above, only the ova containing yolk including ripe ones were considered for estimation of gross fecundity (Petrova, 1960; Rao, 1967; Nair, 1977). Fecundity of J. sina varied from 12,500 to 2,71,000 for 12.4 to 20.6 cm size fishes. Nair (1977) observed the fecundity for the same species from Calicut waters which ranged from 12,744 to 1,51,677 for 12.4 to 17.4 cm size fishes, Maximum length of the fish he observed was 17.4 cm, hence fecundity was very low. Since fecundity increases with length. Similarly the fecundity in *O. ruber* ranging from 54,600 to 4,40,000 for size 16.7 to 32.7 cm vary from the Bombay observation 44,621 to 1,79,659 for the size of fish 18.8 to 29.0 cm. Probably the same earlier reason holds good in this species also. Fecundity of *O. ruber* at Bombay varied from 49,216 to 1,91,932 (Vaidya, 1960) and from Port Novo varied from 43,810 to 1,70,130 (Pillai, 1983).

Different relationships have been found to exist between length and fecundity in different species (Clark, 1934; Simpson, 1951; Bagenal, 1957; Sarojini, 1957; Pillay, 1958; Varghese, 1961, 73, 76, 80; Pantulu, 1963). In case of *J. sina*, correlations were seen between fecundity and length of the fish (r = 0.8469), weight of the fish (r = 0.7523) and weight of the ovary (r = 0.8127). Nair (1977) found the correlation only between fecundity and weight of the ovary in *J. sina*. Similarly in *O. ruber*, high correlations were found in between fecundity and length of the fish (r = 0.6427) and weight of the ovary (r = 0.6797). Poor correlation was observed in between fecundity and weight of the fish *O. ruber* (r = 0.2688).

In case of *J. sina*, during 1986-88, number of males and females did not differ with their mean ratio as 1:1.03. In *O. ruber*, the females were more in numbers than males (1:1.3173 = male female) for two years together. Monthly variations in the sex ratio for two species have been observed.

The data showed that they congregated in equal numbers afterattaining first maturity for spawning in both species and sexes were equal in numbers in mature ones. Nair (1977) noticed that males and females of J. sina from Calicut waters were in equal distribution in most of the months but dominance of females in the population occurred at 11.5 cm length. Devadoss (1969) showed that O. ruber from Bombay waters segregated in certain months, as males in higher proportion prior to spawning. It shows that sex ratio differs in different regions. Antony Raja (1972) studied the sex ratio of Sardinella longiceps and he found variations in the sex ratio between different localities.

Differences in abundances between sexes may be genetic origin apart from the usual causes through differential accessibility, vulnerability, growth and mortality between sexes or it may be related to gear selectivity (Antony Raja, 1972). Also it may be separation of sexes in water column for feeding, migration etc. though both the species are demersal. So all these factors may cause differential distribution in sexes.

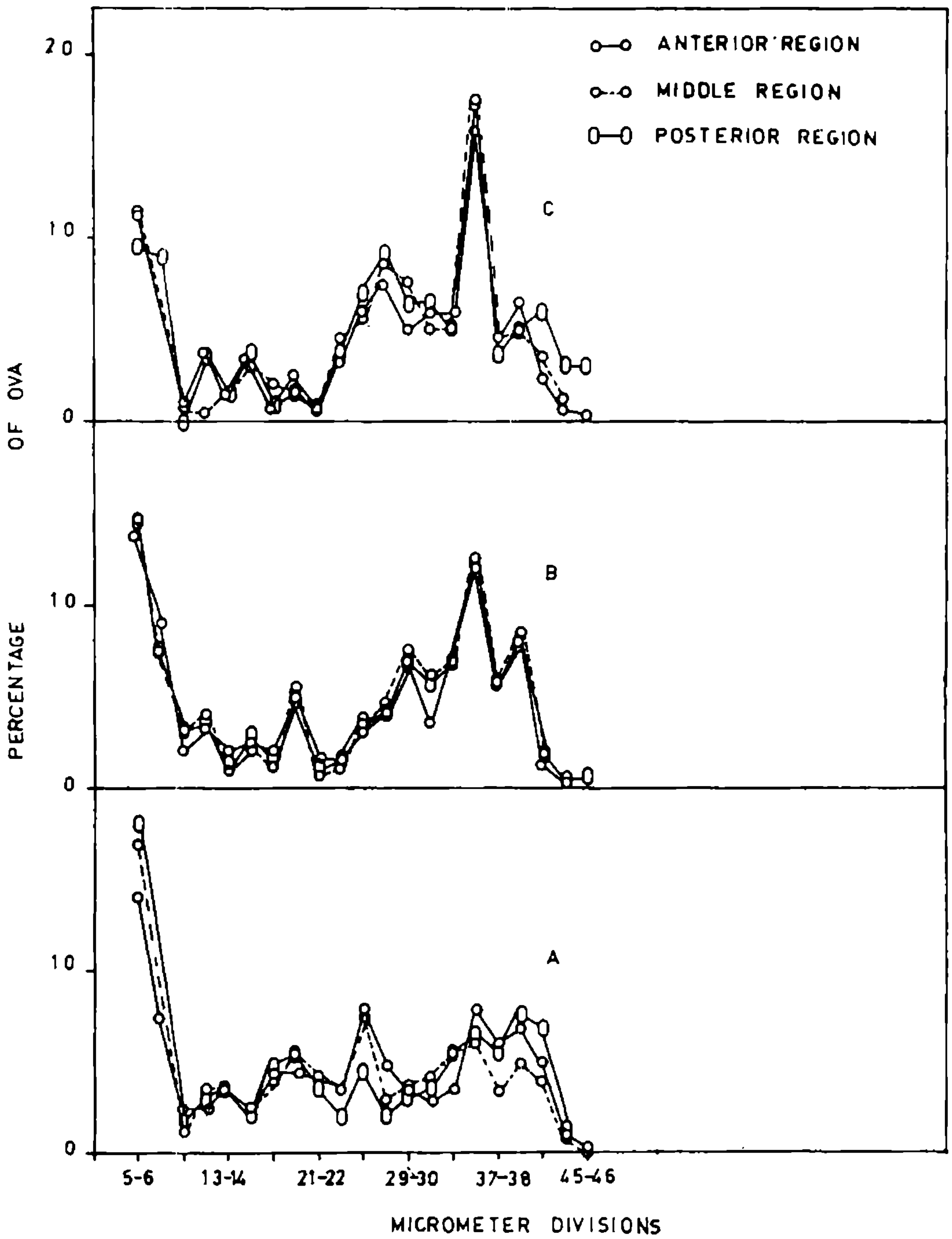


Figure 6 Ova-diameter frequency polygon of the anterior, middle and posterior regions of mature ovaries of J. sina of A-13.6, B-14.7 and C-16.2 cm in total length.

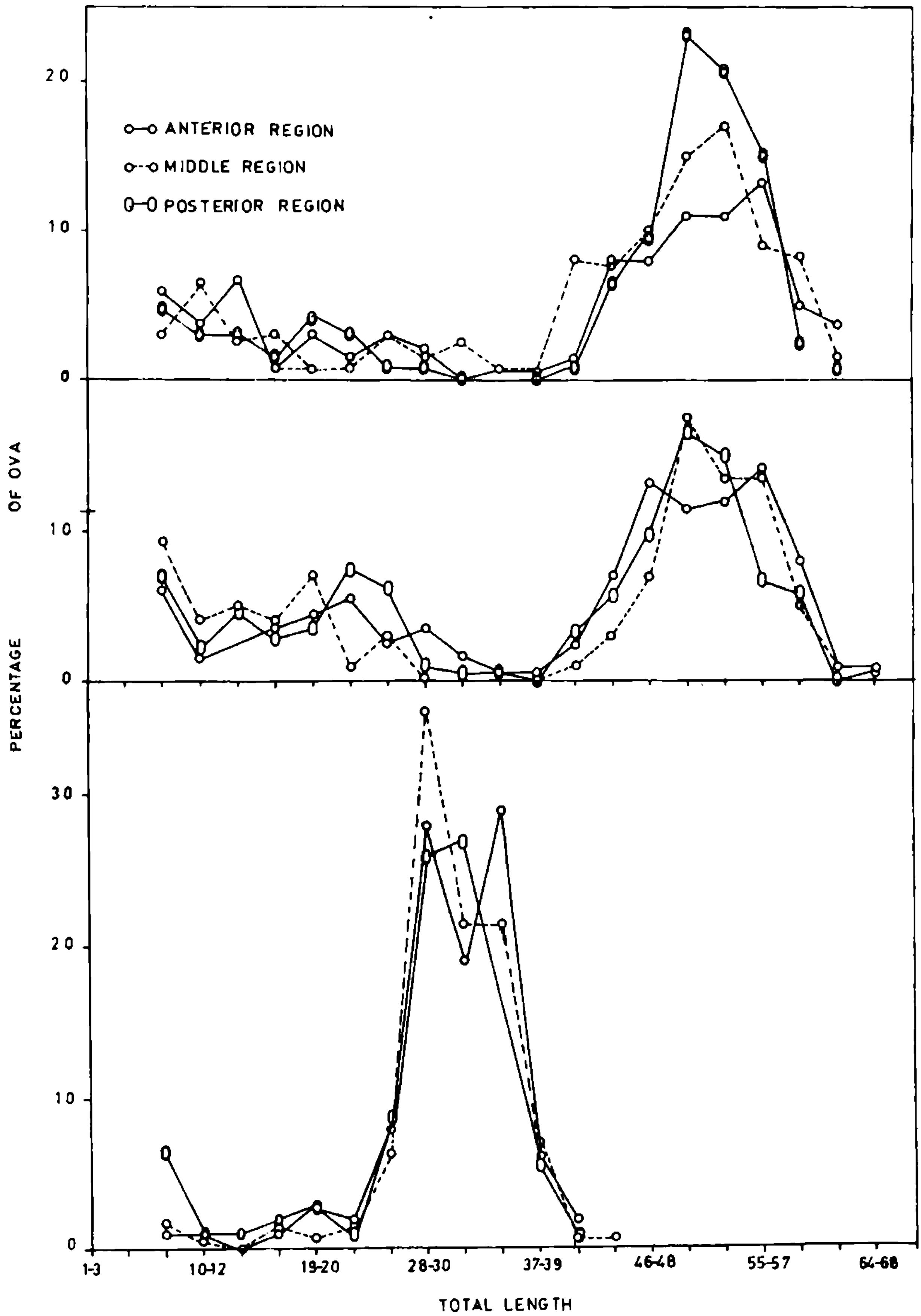


Figure 7 Ova-diameter frequency polygon of the anterior, middle and posterior regions of mature ovaries of O. ruber of A-24.4, B-28.3 and C-30.6 cm in total length.

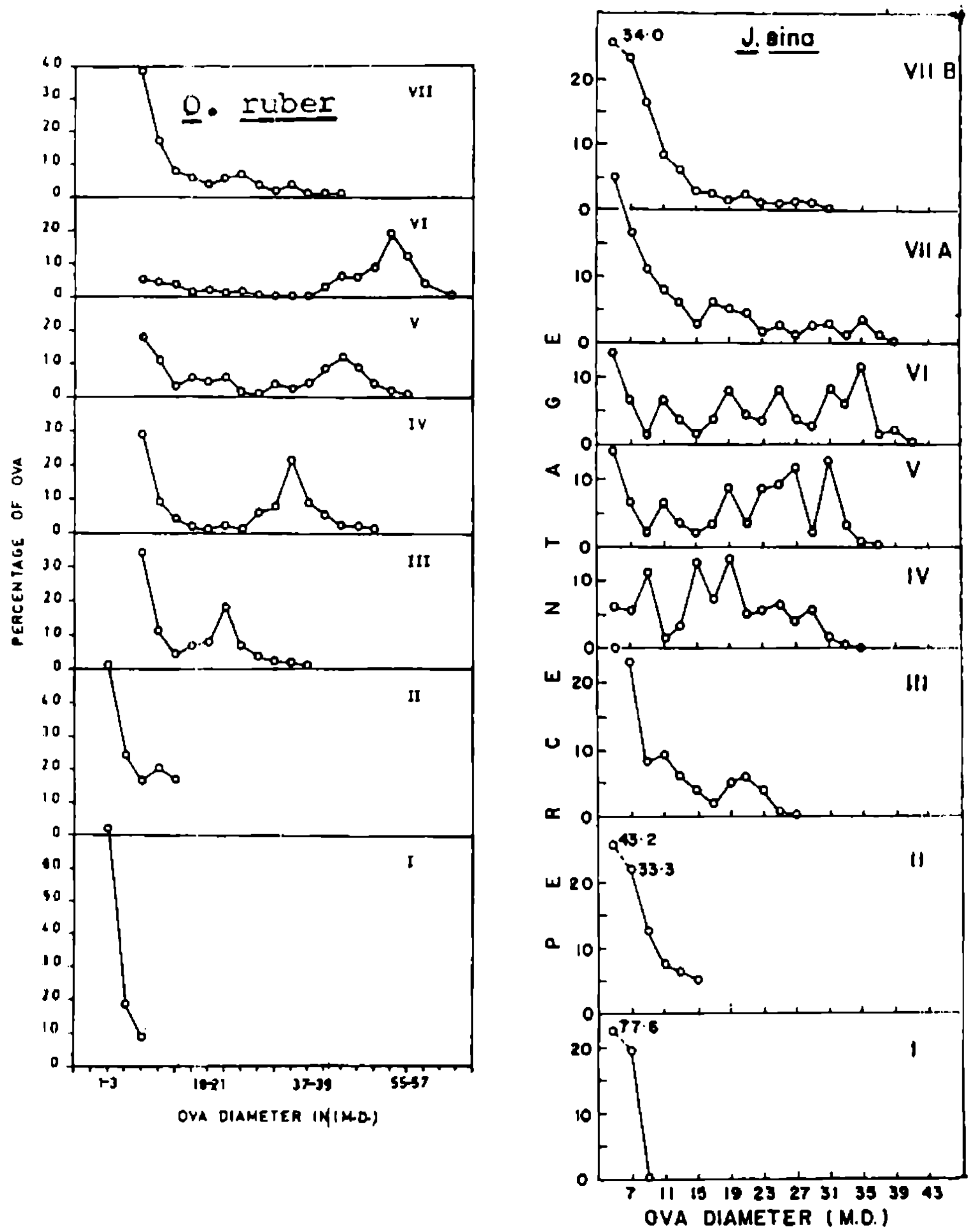


Figure 8 Ova-diameter frequency of J. sina from stages I to VII B and O. ruber from I to VII.

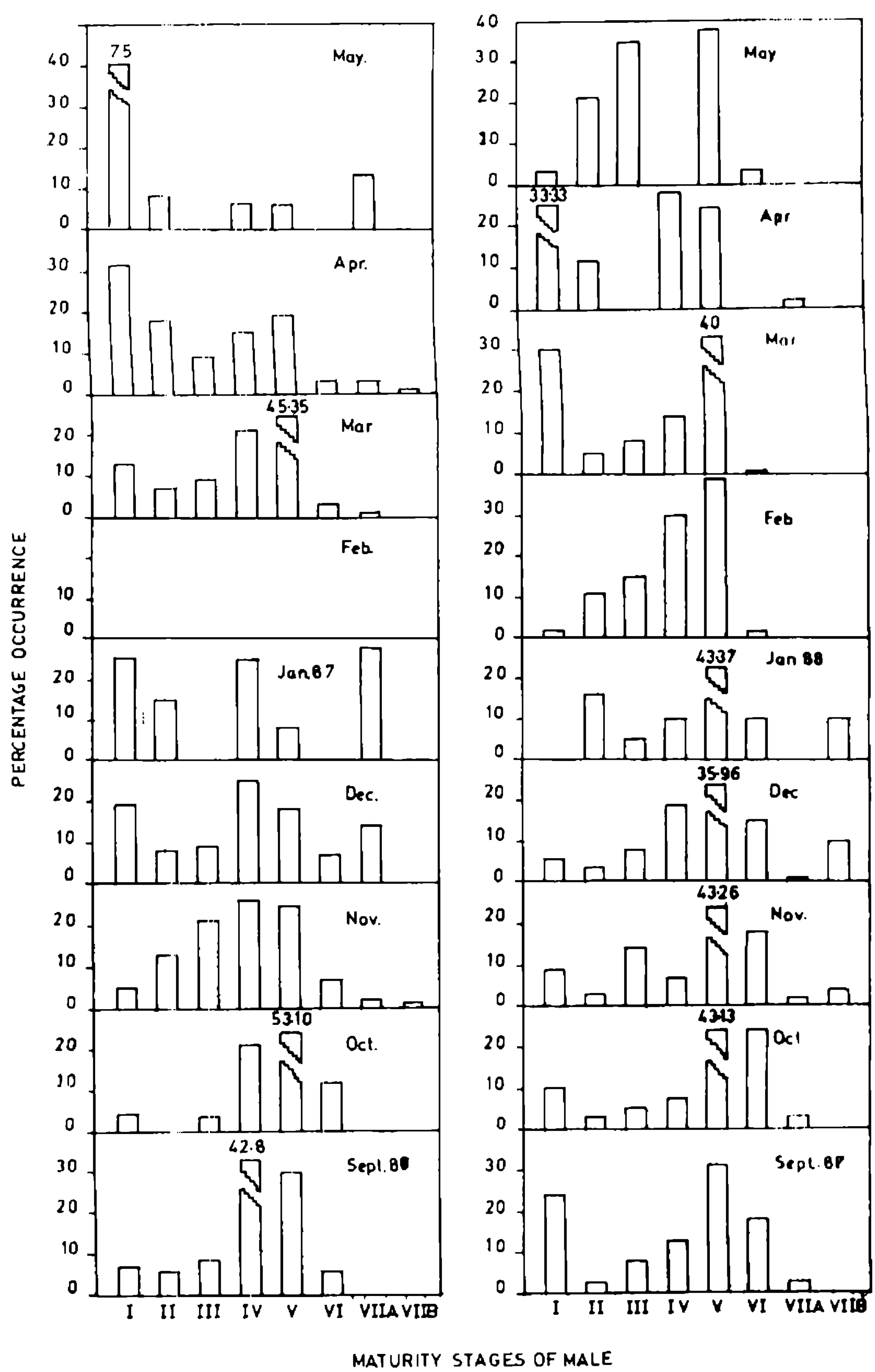


Figure 9 Monthwise percentage occurrence of different stages of maturity of *J. sina* males during 1986-88.

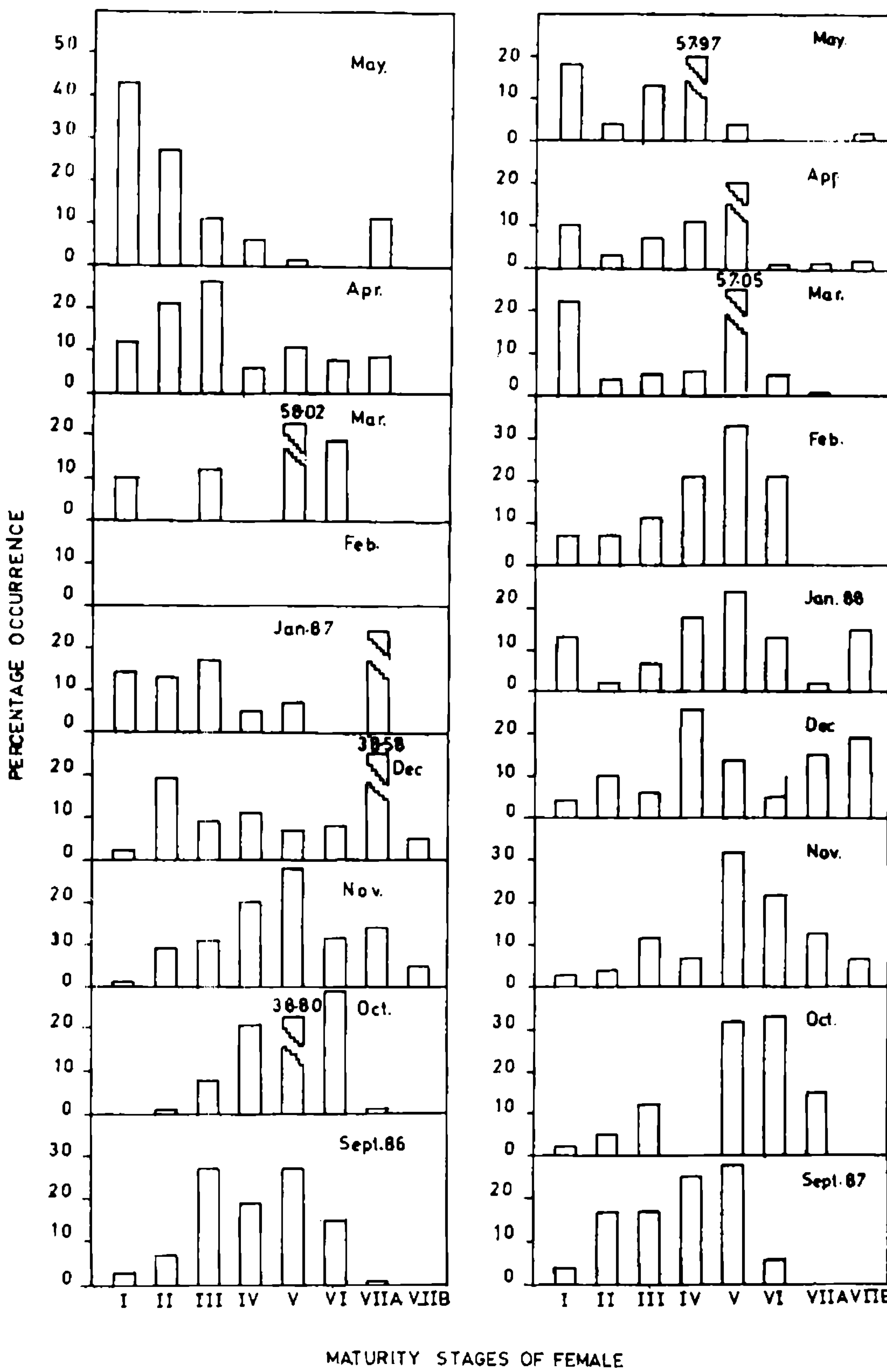


Figure 10 Monthwise percentage occurrence of different stages of maturity of *J. sina* females during 1986-88.

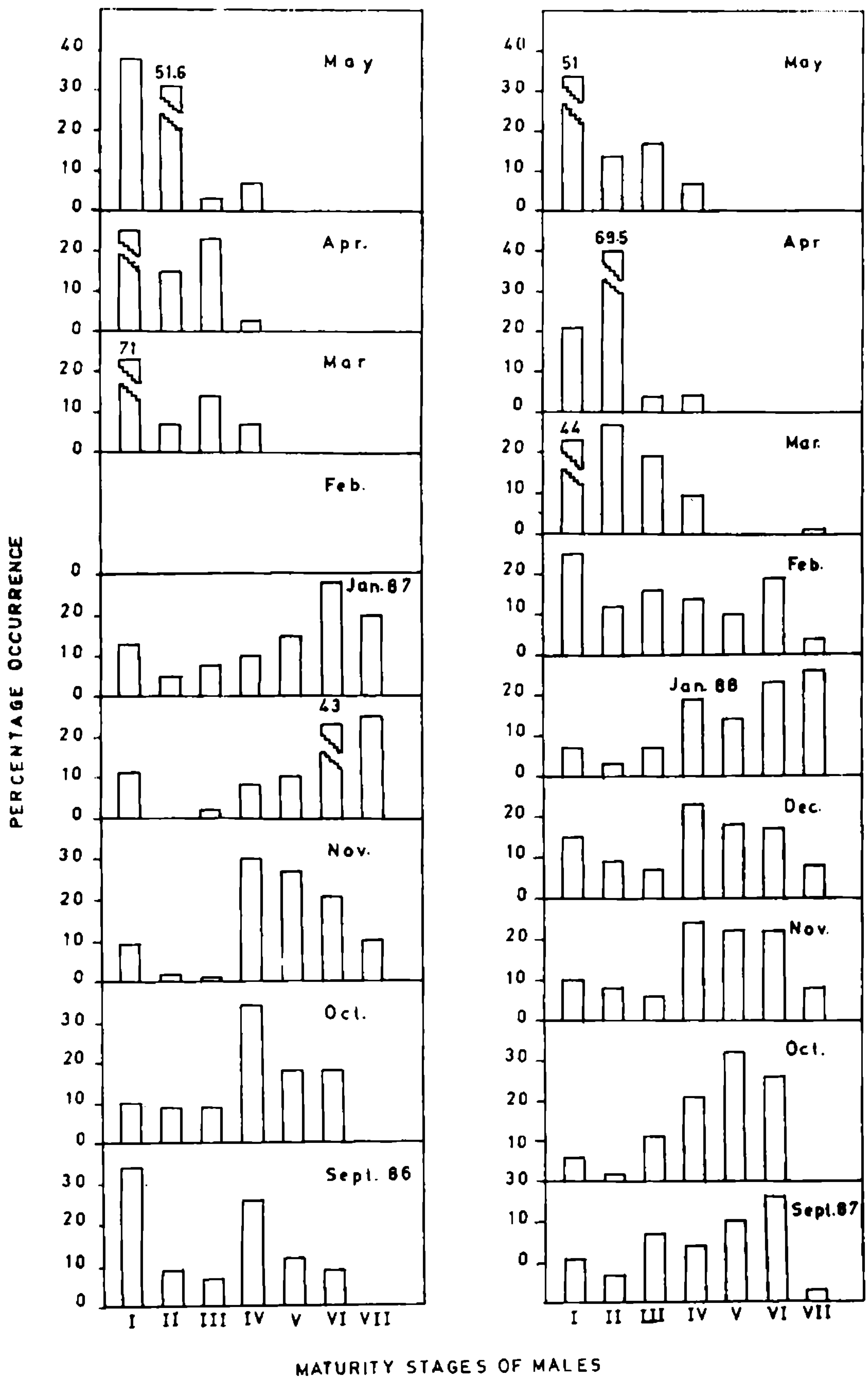


Figure 11 : Monthwise percentage occurrence of different stages of maturity of *O. ruber* males during 1986-88.

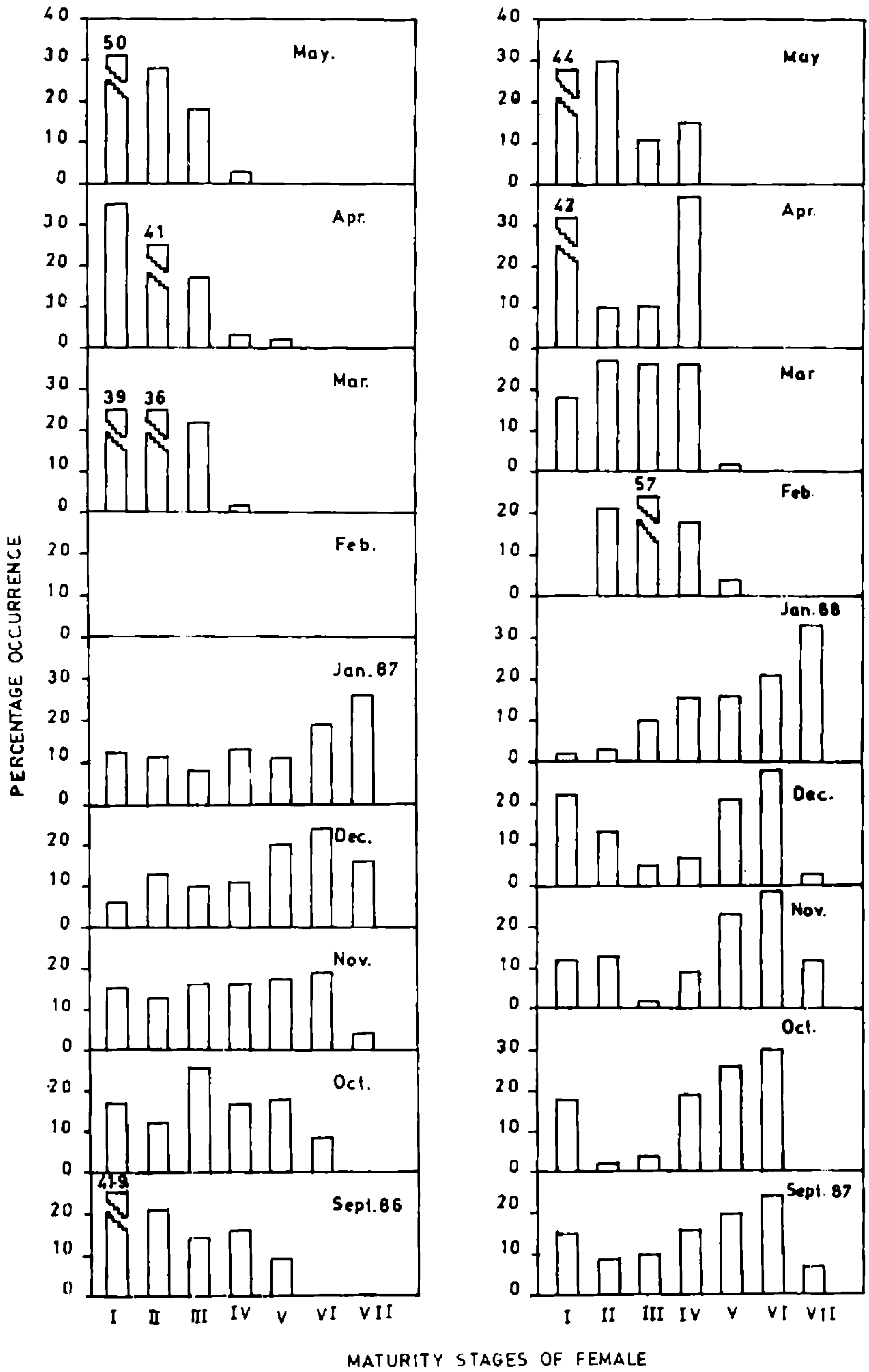


Figure 12 Monthwise percentage occurrence of different stages of maturity of O. ruber females during 1986-88.

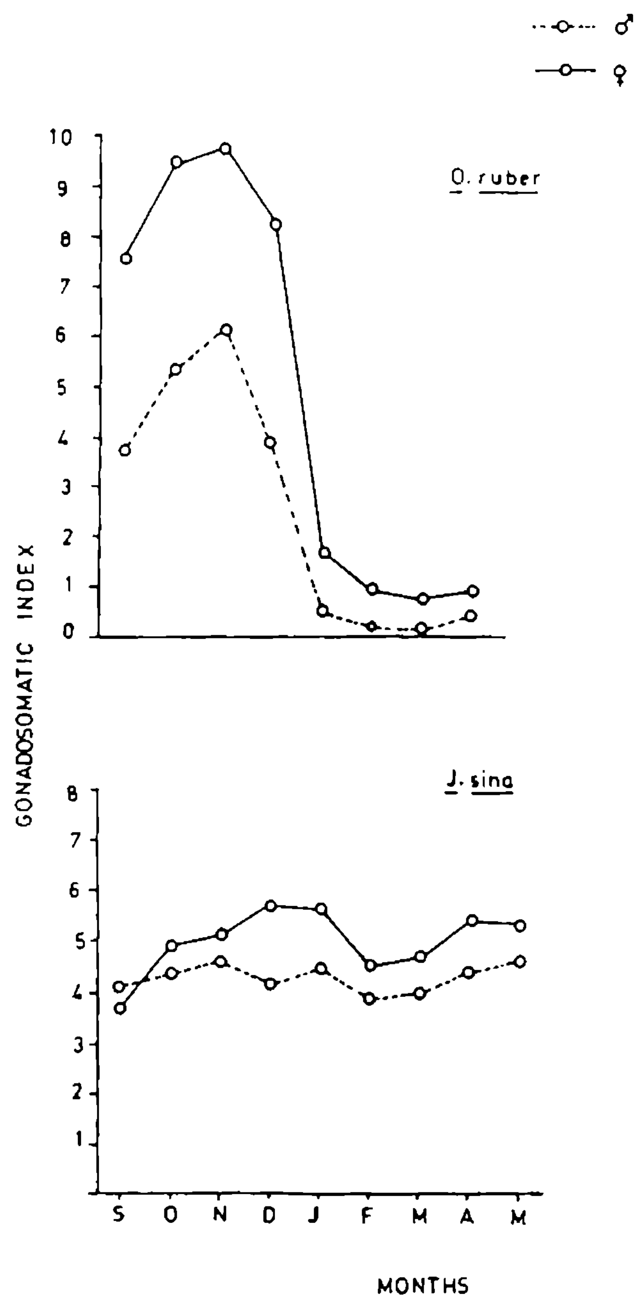


Figure 13 Gonado-somatic indices during different months in *J. sina* and *O. ruber*.

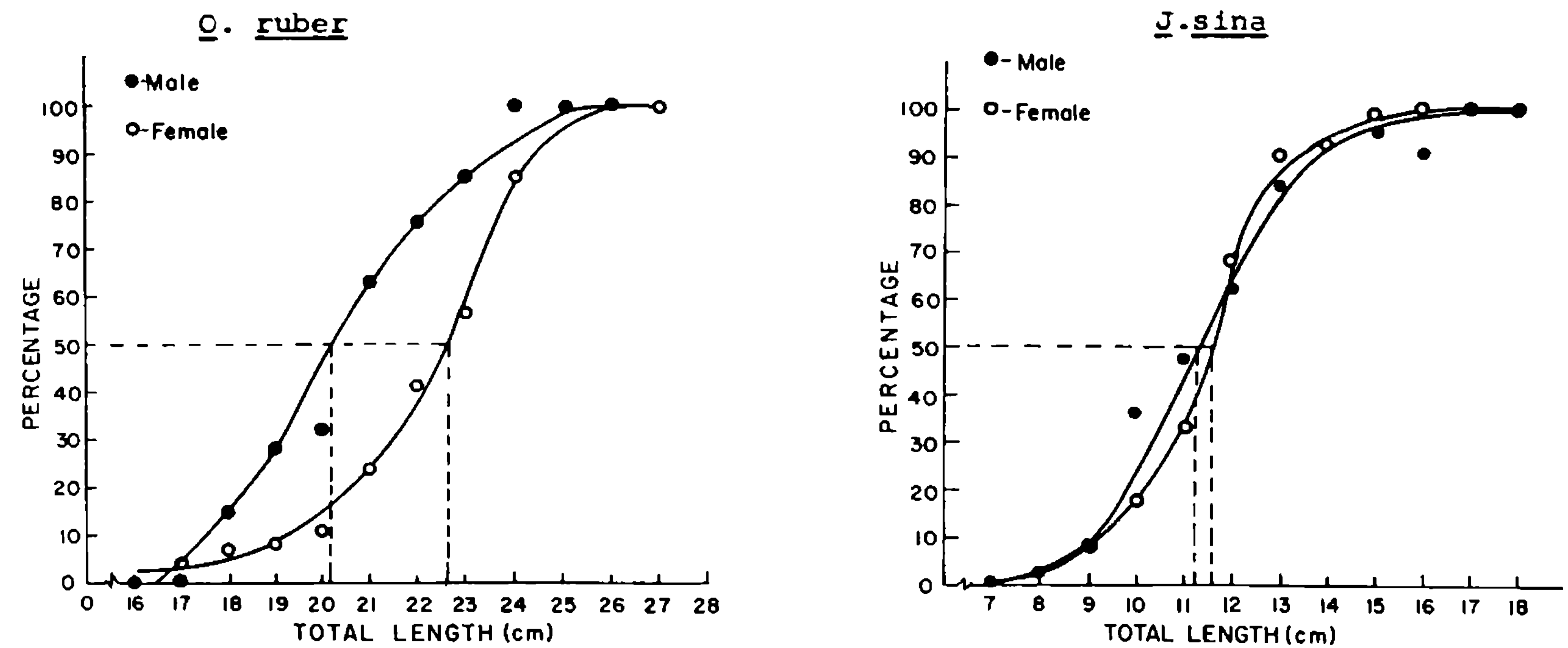
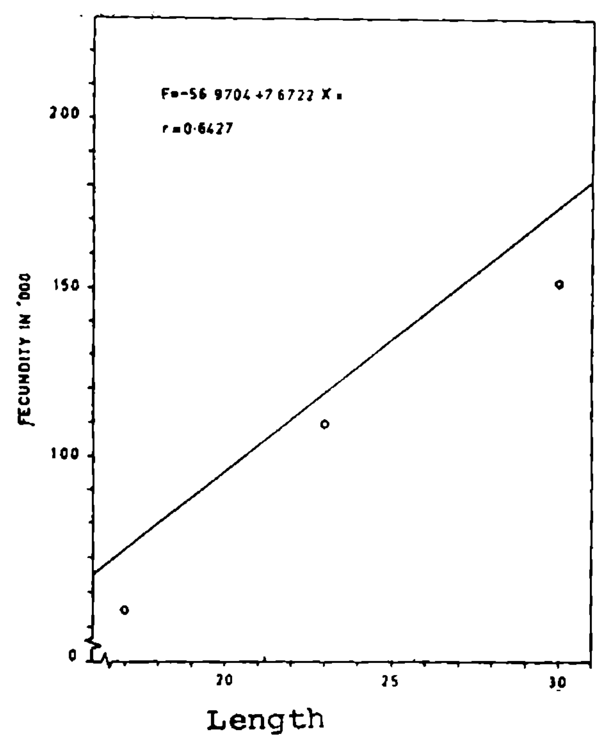


Figure 14 Size at first maturity of males and females of J. sina and O. ruber during 1986-88.



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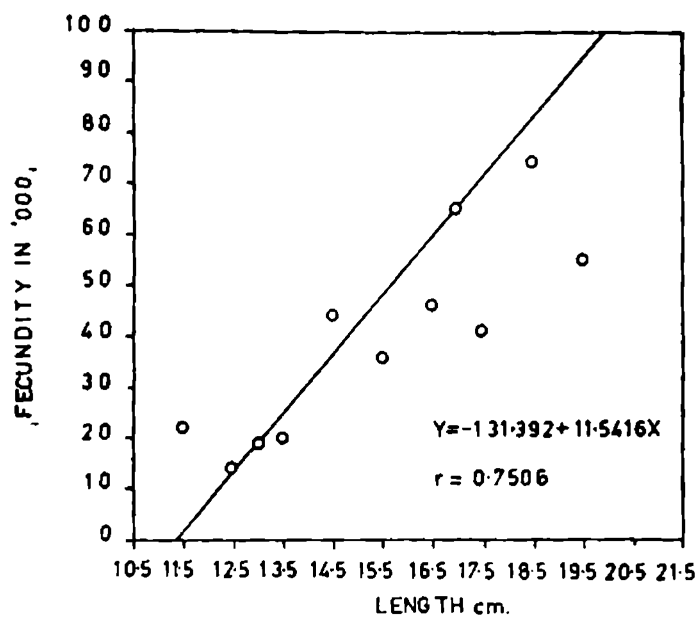

J. sina

Figure 15 Relation between fecundity and length of fish in the case of J. sina and O. ruber.

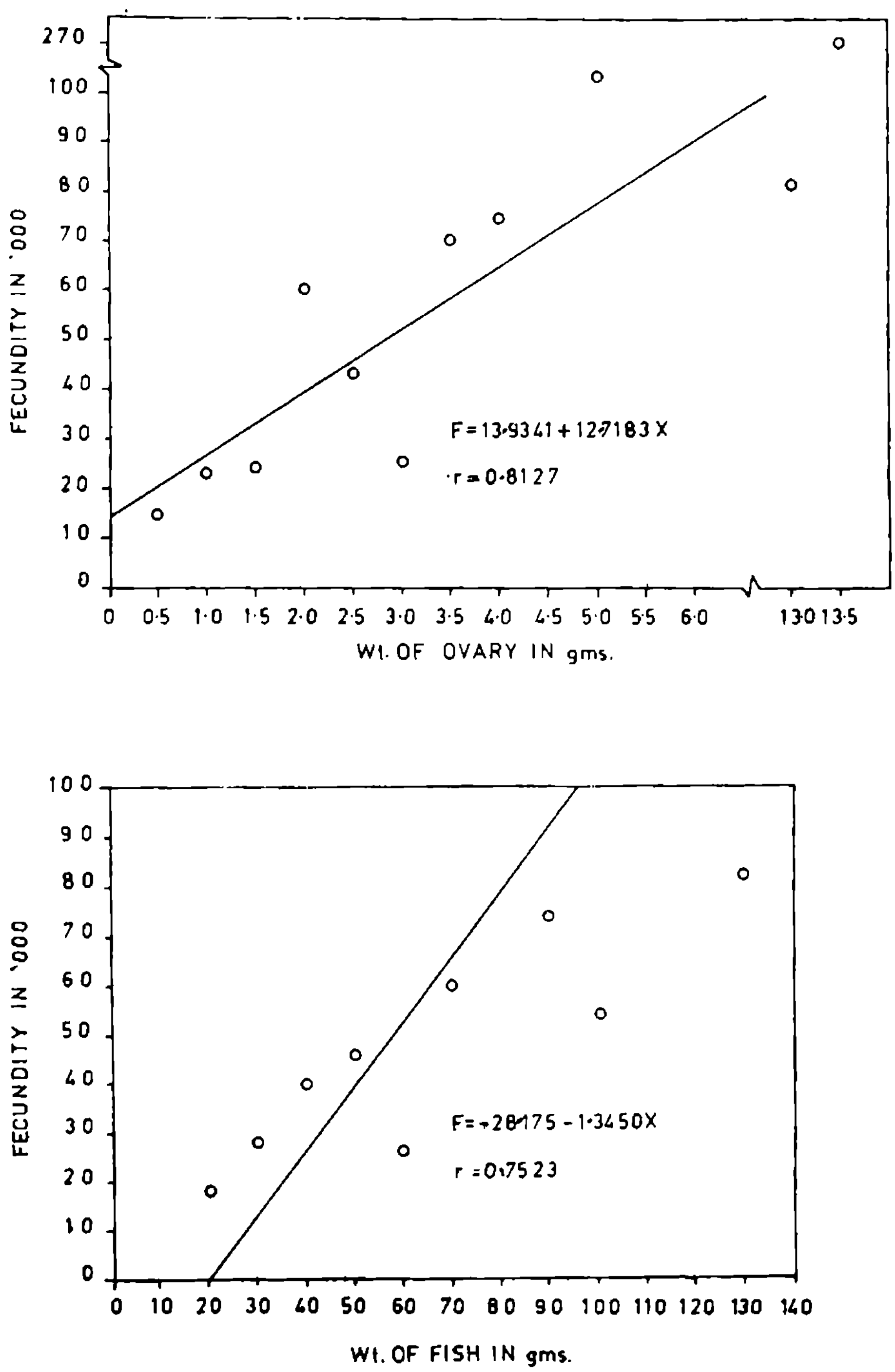

Figure 16 Relations between fecundity and weight of ovary and weight of fish in *J. sina*.

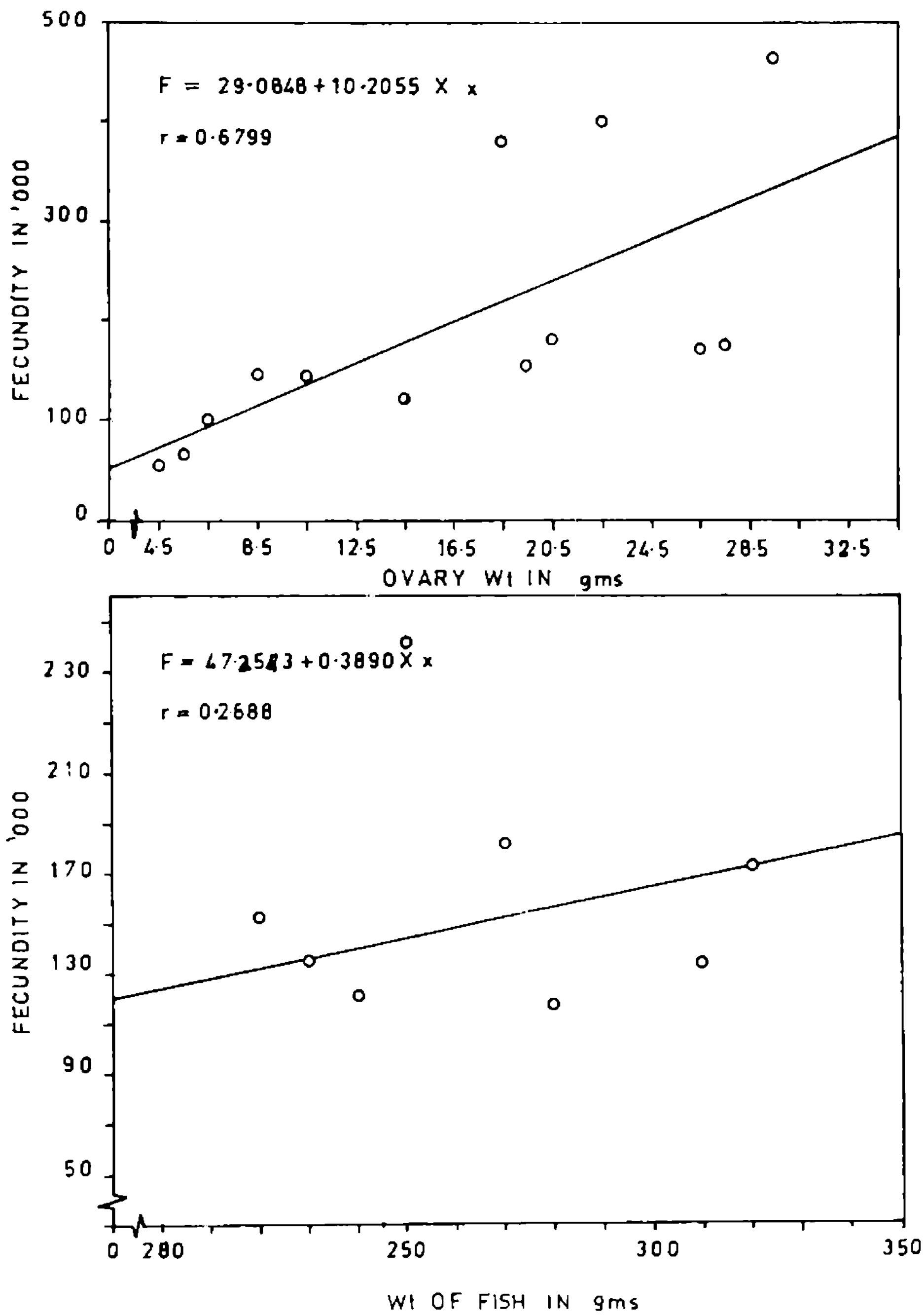

Figure 17 : Relations between fecundity and weight of ovary and weight of fish in O. ruber.

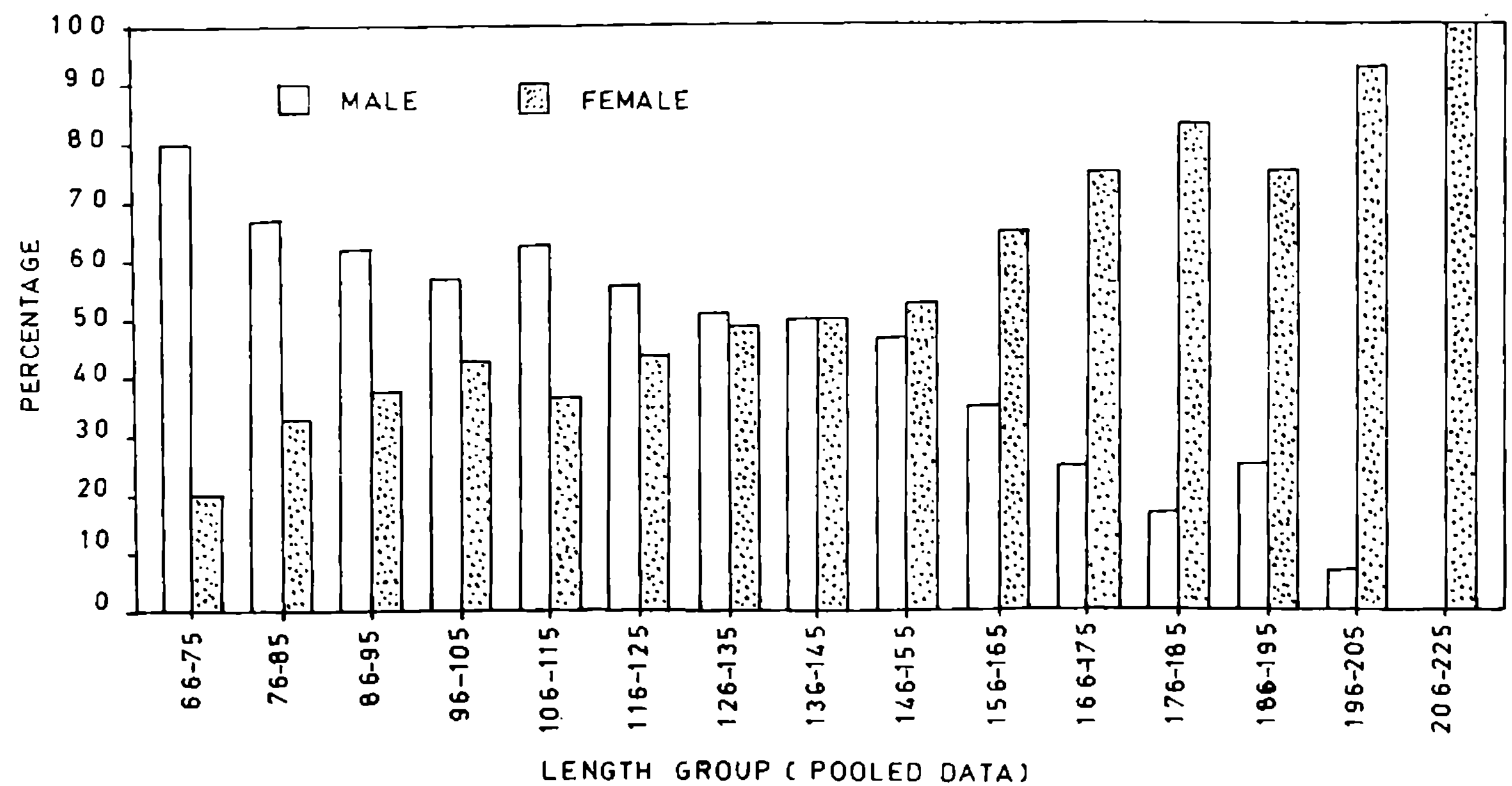

Figure 18 Lengthwise males and females in percentages in *J. sina*.

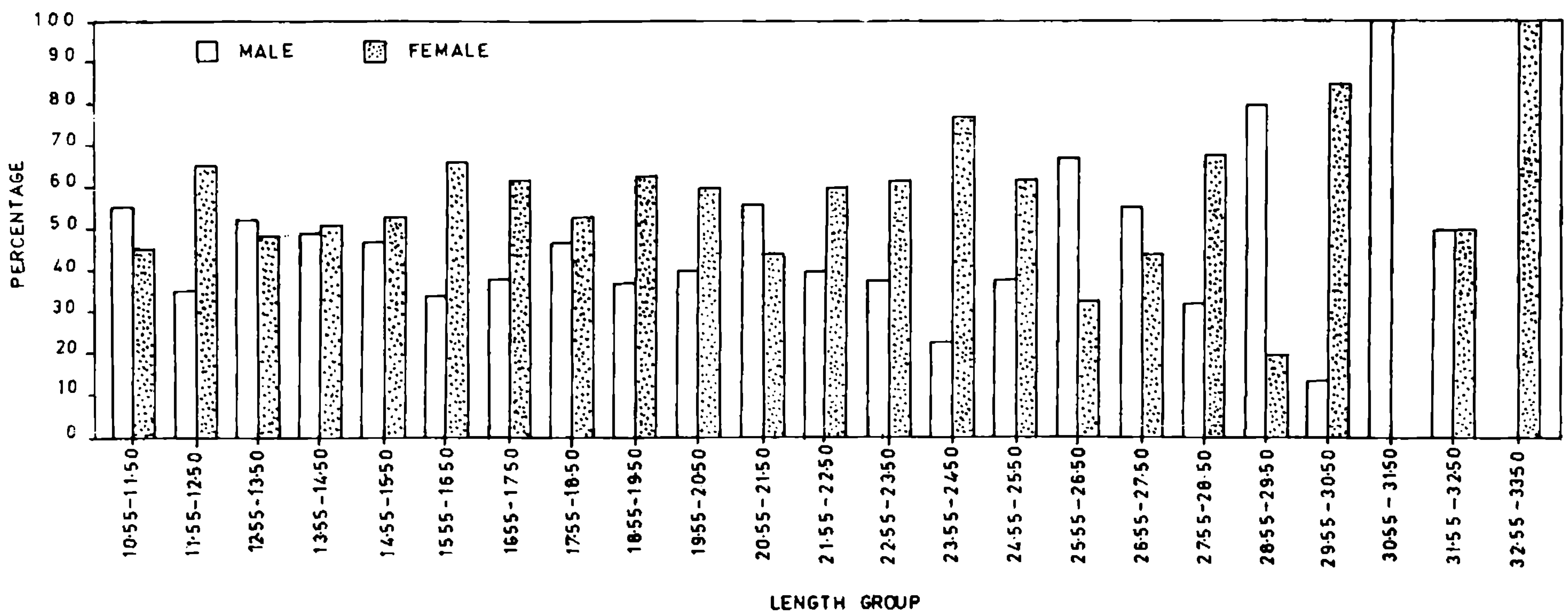

Figure 19   Lengthwise males and females in percentage in *O. ruber*.

Table 10 Aspects of reproductive biology of different sciaenid species.

Sr. No.	Species	Method applied	Length at first maturity in cm.	Spawning habit	Spawning season	Fecundity	Author & place
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Johnius glaucus	Occurrence of ripe and spent gonads.	11.0	Twice a year	March to May and Sept. to November	-	Jacob(1948), Calicut.
2.	Johnious carutta	Occurrence of ripe and spent gonads.	10.0	Twice a year	March to May and Sept. to November	-	Jacob(1948), Calicut.
		Ova diameter	-	Once a year, short duration.	March to April.	-	Rao, T. Appa(1967), Waltair.
		Ova diameter	15.0	Once a year but prolonged.	January to June.	-	Murty(1979), Kakinada.
3.	Johnius Coitor	Occurrence of ripe and spent gonads.	-	Once a year and short duration.	July	-	Jacob(1948), Calicut.

Contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4.	<u>Johnius dussumieri</u>	Ova diameter	16.0	Once a year	July to August	93,678 to 2,95,643	Savant (1963), Bombay.
		Ova diameter and ponderal index	16.0	Twice a year	Dec. to Jan. and June to September	1,42,005 to 2,22,988	Devadoss (1969), Bombay.
5.	<u>Johnieops sina</u>	Ova diameter	11.5	Twice a year, prolonged	Nov. to Feb. and April to May	12,744 to 1,51,697	Nair (1980), Calicut.
6.	<u>Johnieops vogleri</u>	Ova diameter	15.9	Twice a year, short duration	June to July and Oct. to November	26,028 to 5,81,295	Muthiah (1982), Bombay.
7.	<u>Nibea coiber</u>	Gonado-somatic index	-	Once a year, slight prolonged	May to August	27,500 to 3,56,304	Rajan (1964), Chilka lake
8.	<u>Otolithes ruber</u>	Occurrence of ripe and spent gonads	14.0	Once a year	May to August	-	Jacob (1948), Calicut.
		Ova diameter	-	Once a year	July to October	-	Vaidya (1960), Bombay.

Contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Ova diameter	19.5	Once a year, slight prolonged	July to October	44,621 to 1,79,659	Devadoss (1969), Bombay.
		Ova diameter	-	Once a year	-	43,810 to 1,70,130	Pillai (1983), Port Novo
9.	<u>Otolithes cuvieri</u>	Occurrence of ripe and spent gonads	12.0	Once a year	April to July	-	Jacob (1948), Calicut.
		Ova diameter	-	Once a year, slight prolonged	October to January	-	Annigeri (1963), Manglore.
10.	<u>Protonibea diacanthus</u>	Occurrence of ripe & spent gonads	-	Once a year	September	62,50,000	Jacob (1948),
		Ova diameter	85.0	Once a year	June to September	17,43,010 to 68,63,638	Rao, K. V. S. (1963), Bombay.
11.	<u>Otolithoides pama</u>	Ova diameter	-	Throughout the year	Jan. to December	-	Pantulu, Jones (1951), Hoogly estuary.

Contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
12.	<u>Pennahia macrophthalmus</u>	Post-larval occurrance	-	Once a year	June to October	-	John (1951), Madras.
		Ova diameter	17.0	Once a year	Dec. to March	-	Rao, T. Appa (1967), Waltair.
		Gonado-somatic index	-	Once a year	Feb. to March	-	Mohan (1977), Mandapam.
		Ova diameter	13.5	Once a year	Feb. to April	13,405 to 44,167	Mohan (1977), Mandapam.
		Ova diameter	13.4	Once a year	Sept. to October	11,423 to 79,835	Gandhi (1982), Port Novo.
13.	<u>Johnieops osseus</u>	Ova diameter	11.5	Throughout the year	All month	46,585	Baragi (1980), Manglore.

Table 11 : Key to the maturity stages in females and males of *J. sina*

Maturity Stages	State of Maturity	Nature and extent of ovary in the body cavity	Appearance of ova under microscope	Range of ova diameter in mm	Nature and extent of testes in the body cavity
(1)	(2)	(3)	(4)	(5)	(6)
I.	Immature	Ovary white creamy in colour, thread like extending upto 1/4th of body cavity. Ova not visible to the naked eyes	Small, yolkless transparent with a clear nucleus	0.013 to 0.117	Thin, thread like white in colour, occupying less than 1/4th length of the body cavity
II.	Early Maturing	Ovary yellow-red in colour, occupying 1/4th to 1/2 in the body cavity, ova not visible to the naked eye	Small in size, yolk formation just started around nucleus	0.117 to 0.195	Small, flattened white in colour, extending upto 1/3rd to 1/4th the length of the body cavity.
III.	Late Maturing	Ovary cylindrical, creamy red in colour, occupying 1/2 to 2/3rd in the body cavity	Slightly larger size, yolk deposition around nucleus	0.195 to 0.390	White in colour, occupying 1/2 the length of body cavity.
IV.	Mature	Ovary increased in size, yellowish or creamy red in colour occupying the 2/3rd length of body cavity	Medium sized opaque ova	0.390 to 0.455	White in colour, occupying 3/4th of body cavity.

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(1)	(2)	(3)	(4)	(5)	(6)
V.	Ripe	Yellowish or creamy red in colour, blood vessels seen on dorsal side. Ovary occupied 3/4th to 4/5th in body cavity. Ova seen prominently.	Large sized, mature, highly opaque ova.	0.455 to 0.480	White in colour occupying whole body cavity.
VI.	Spawning	Ovary reddish white in colour, occupying the whole body cavity. Ova seen prominently through ovary wall.	Large size ova with oil globule.	0.480 to 0.533	White in colour, occupying whole body cavity.
VII.A.	Partially spent	Ovary reddish in colour, slightly flabby occupying slightly less than the full length of the body cavity.	Ova with yolk deposition fully or partially.	-	White in colour, smaller than the previous one in size, occupying 4/5th body testes collapsed, occupying 2/3rd to 1/3 the length of body cavity.
VII.B.	Fully spent	Ovary loose, shrunken with blood shot.	nuerous small ova, few yolked bigger ones in reabsorbing condition.	-	Testes collapased, occupying 2/3rd to 1/3rd the length of body cavity.

Table 12 Key to the maturity stages in females and males of _O. ruber._

Maturity Stages	State of Maturity	Nature and extent of ovary in the body cavity	Appearance of ova under microscope	Range of ova diameter in mm	Nature and extent of testes in the body cavity
(1)	(2)	(3)	(4)	(5)	(6)
I.	Immature	Ovary thin, thread like, pale creamy in colour, extending 1/4th the length of the body cavity. Ova not visible to the naked eyes.	Small, yolkless, transparent with prominent nucleus	0.0113 to 0.120	Thin, pale white in colour exten-ding upto less than 1/3rd length of body cavity.
II.	Early Maturing	Ovary small, tubular fills 1/3rd to 1/2 body cavity, ova not visible to the naked eyes.	Transparent ova, yolk formation just commenced around nucleus.	0.120 to 0.195	Tubular, pale white in colour extending 1/3rd of body cavity.
III.	Late Maturing	Ovary large tube like, pink creamy to yellow in colour, occupying 1/2 of body cavity.	Ova larger than earlier stages, nucleus partly or completely hidden by yolk.	0.200 to 0.355	White in colour, occupying 1/2 the length of body cavity.

Contd...

(1)	(2)	(3)	(4)	(5)	(6)
IV.	Mature	Ovary creamy to yellow in colour, extending to 2/3rd or more than length of body cavity, ova seen easily blood vessels appeared on dorsal side.	Ova large, opaque, nucleus not seen	0.355 to 0.500	Whitish in colour, larger in diameter, not perfectly tubular, occupying 3/4th of body cavity.
V.	Ripe	Ovary reddish in colour, sometimes creamy reddish, extending more than 3/4th of body cavity, blood vessels prominent, ova seen prominently.	Ova large, highly opaque.	0.500 to 0.660	Whitish in colour, occupying 4/5th of body cavity.
VI.	Spawning	Ovary reddish or creamy reddish in colour, extending the whole body cavity, ova seen through ovarian wall.	Ova largest in size, ripe, yolk vacuolated with oil globule.	0.660 to 0.820	Whitish in colour, filled the entire body cavity.
VII.	Spent	Ovary blood-shot, shrunk, flaccid.	Few large ova, some in degenerating stage, numerous immature ova.	-	Shrunken, occupying 3/4th or less the length of body cavity.

Table 13 Frequency of spawning observed by different methods.

Sr. No.	Methods	Observations	
		J. sina	*O. ruber*
1)	Ova-diameter frequency polygon Fig.8	Multimodal frequency, modes not sharply differentiated from one another	Single mode of mature ova, distinctly separated from others.
2)	Percentage occurrence of mature fishes Fig.9,10,11,12	Mature fishes occurred throughout the year	Mature fishes occurred during September to January.
3)	Kn values Fig. 24	Values varied within a narrow range throughout the year	Values were high during September to November.
4)	GSI values Fig. 13	Indices varied within a narrow range	Indices were high during September to November.
5)	Conclusion	Spawning protracted. Breeds almost throughout the year	Spawning restricted. Breeds at a definite period and within a short interval of time.

composition in *J. sina* in each cm. length group during 1986–88

L in cm mid value	No.of fish exami-ned	No. of sexes Male	Female	% of sexes Male	Female	Ratio Male:Fema-le	Chi-square value	d.f.	Remarks
7.0	35	28	7	80.00	20.00	1:0.25	12.6000	1	**
8.0	123	83	40	67.48	32.52	1:0.48	15.0325	1	**
9.0	159	98	61	61.63	38.37	1:0.62	8.6100	1	**
10.0	221	127	94	57.47	42.53	1:0.74	4.9276	1	**
11.0	409	257	152	62.84	37.16	1:0.59	26.9559	1	**
12.0	636	354	282	55.60	44.34	1:0.80	8.1509	1	**
13.0	804	413	391	51.37	48.63	1:0.95	0.6020	1	N.S.
14.0	665	334	331	50.23	49.77	1:0.99	0.0135	1	N.S.
15.0	582	275	307	47.25	52.75	1:1.12	1.7595	1	N.S.
16.0	457	159	298	34.79	65.21	1:1.87	42.2779	1	**
17.0	236	58	178	24.58	75.42	1:3.07	61.0169	1	**
18.0	99	17	82	17.17	82.83	1:4.82	42.6768	1	**
19.0	52	13	39	25.00	75.00	1:3.00	13.0000	1	**
20.0	15	1	14	6.67	93.33	1:13.99	11.2667	1	**
21.0	7	-	7	00.00	100.00	-	-	-	-
22.0	1	1	-	100.00	00.00				
23.0	2	-	2	00.00	100.00				
24.0	1	-	1	00.00	100.00				
Total	4504	2218	2286	49.25	50.75	1:1.0306	1.02	1	N.S

* Significant at 5% level.

** Significant at 1% level.

Table 15 : Sex composition in *O. ruber* in each cm length group during 1986–88

Length in cm mid value	No. of fish examined	No. of sexes		% of sexes		Ratio	Chi-square value	d. f.	Remakrs
		Male	Female	Male	Female	Male:Female			
11.0	56	31	25	55.35	44.65	1:0.8065	0.6429	1	N.S.
12.0	60	21	39	35.00	65.00	1:1.8511	5.4000	1	*
13.0	128	67	61	52.34	47.66	1:0.9105	0.2813	1	N.S.
14.0	153	75	78	49.02	50.98	1:1.0400	0.0588	1	N.S.
15.0	283	134	149	47.35	52.65	1:1.1119	0.7950	1	N.S.
16.0	310	105	205	33.87	66.13	1:1.9524	32.2580	1	**
17.0	262	99	163	37.78	62.22	1:1.6465	15.6336	1	**
18.0	261	123	138	47.12	52.88	1:1.1219	0.8621	1	N.S.
19.0	176	66	110	37.50	62.50	1:1.6667	11.0000	1	**
20.0	149	59	90	39.60	60.40	1:1.5254	6.4497	1	*
21.0	115	64	51	55.65	44.35	1:0.7969	1.4696	1	N.S.
22.0	76	30	46	39.47	60.63	1:1.5333	3.3684	1	N.S.
23.0	45	17	28	33.77	62.27	1:1.6470	2.6886	1	N.S.
24.0	22	5	17	22.73	77.27	1:3.4000	6.5455	1	*
25.0	13	5	8	38.46	61.54	1:1.6000	0.6923	1	N.S.
26.0	24	16	8	66.67	33.33	1:0.5000	2.6666	1	N.S.
27.0	34	19	15	55.88	44.12	1:0.7894	0.4706	1	N.S.
28.0	19	6	13	31.58	68.42	1:2.1667	2.5789	1	N.S.
29.0	10	8	2	80.00	20.00	1:0.2500	3.6000	1	N.S.
30.0	14	2	12	14.29	85.71	1:6.0000	7.1418	1	**
31.0	4	4	0	100.00	00.00	-	-	-	-
32.0	4	2	2	50.00	50.00	1:1.0000	0.0000	1	N.S.
33.0	2	0	2	00.00	100.00	-	-	-	-
TOTAL	2220	958	1262	43.15	56.85	1:1.3173	41.6288	1	**

Table 16 Monthwise sex ratio in *J. sina* during 1986–87 and 1987–88

Months	No. of fish examined	No. of sexes		% of sexes		Sex ratio Male:Female	Chi-square value	d.f.	Remarks
		Male	Female	Male	Female				
Sept.86	561	264	297	47.05	52.95	1:1.12	1.9492	1	N.S.
Oct.86	247	113	134	45.75	54.25	1:1.18	1.7854	1	N.S.
Nov.86	662	355	307	53.63	46.37	1:0.86	3.4804	1	N.S.
Dec.86	489	292	197	59.71	40.29	1:0.67	18.4560	1	**
Jan.87	221	121	100	54.75	45.25	1:0.83	1.9955	1	N.S.
Feb.87	+								
March 87	253	172	81	67.98	30.02	1:0.47	32.7312	1	**
April 87	429	255	174	59.44	40.56	1:0.68	15.2937	1	**
May 87	130	64	66	49.23	50.77	1:1.03	0.0308	1	N.S.
Total	2992	1636	1356	54.68	45.32	1:0.8288	26.2022	1	**
Sept.87	85	38	47	44.70	65.30	1:1.23	0.9529	1	N.S.
Oct. 87	265	102	163	38.49	61.51	1:1.60	14.0415	1	**
Nov. 87	261	104	157	39.85	60.15	1:1.51	10.7624	1	**
Dec. 87	222	89	133	40.09	59.91	1:1.49	8.7207	1	**
Jan. 88	64	19	45	29.69	70.31	1:2.36	10.5625	1	**
Feb. 88	113	46	67	40.70	59.30	1:1.46	3.9026	1	*
March 88	261	105	156	40.23	59.77	1:1.48	9.9655	1	**
April 88	140	45	95	32.14	67.86	1:2.11	17.8571	1	**
May 88	103	34	69	33.00	67.00	1:2.03	11.8932	1	**
Total	1512	582	930	38.49	61.51	1:1.59	80.0952	1	**
nd Total	4504	2218	2286	49.25	50.75	1:1.0306	1.02	1	N.S.

+ No collection could be made the author was away to Coci for consult ith hi

Table 17 Monthwise sex ratio in *O. ruber* during 1986-87 and 1987-88

Months	No. of fish examined	No. of sexes		% of sexes		Sex ratio Male:Female	Chi-square value	d. f.	Remarks
		Male	Female	Male	Female				
Sept.86	120	88	32	73.33	26.67	1:0.3636	26.1313	1	**
Oct. 86	146	63	83	43.15	56.85	1:1.3175	2.7397	1	N.S.
Nov. 86	203	105	98	51.72	48.28	1:0.9333	0.2414	1	N.S.
Dec. 86	153	62	91	40.52	59.48	1:1.4677	5.4967	1	*
Jan. 87	176	78	98	44.32	55.68	1:1.2564	2.2727	1	N.S.
Feb. 87									
March87	38	8	30	21.05	78.95	1:3.7500	12.7368	1	**
April87	136	43	93	31.62	68.38	1:2.1628	18.3823	1	**
May 87	60	16	44	26.67	73.33	1:2.7500	13.0667	1	**
Total	1032	463	569	44.86	55.14	1:1.2289	10.8876	1	**
Sept.87	211	83	128	39.34	60.66	1:1.5422	9.5972	1	**
Oct. 87	173	49	124	28.32	71.68	1:2.5306	32.5144	1	**
Nov. 87	229	72	157	31.44	68.56	1:2.1806	31.5502	1	**
Dec. 87	121	66	55	54.55	45.45	1:0.8333	1.0000	1	N.S.
Jan. 88	154	42	112	27.27	72.73	1:2.6667	31.8182	1	**
Feb. 88	90	65	25	72.22	27.78	1:0.3846	17.7777	1	**
March88	115	66	49	57.39	42.61	1:0.7424	2.5130	1	N.S.
April88	29	11	18	37.93	62.07	1:1.6364	1.6696	1	N.S.
May 88	66	41	25	62.12	37.88	1:0.6097	3.8788	1	**
Total	1188	495	693	41.67	58.33	1:1.4000	33.0000	1	**
Grand Total	2220	958	1262	43.15	56.85	1:1.3173	41.6288	1	**

CHAPTER -III AGE AND GROWTH

Length-weight relationship

Introduction

Length-weight relationship expressed in mathematical terms has many practical applications in fishery biology. The relationship derived from length-weight measurements is used to obtain one of the measurements when the other is known. It is also useful in studying the condition, "well being" of the fish in the population by calculating the condition factor (K) or relative condition factor (Kn) (Le Cren, 1951) and to determine it's changes with age, sex, season etc.

Material and Methods

The samples of J. sina and O. ruber were collected from the commercial trawl catches landed at Mirkarwada fisheries harbour, Ratnagiri, from September 86 to May 87 and September 87 to May 88 periods. The samples were kept in deep freezer on the same day evening. Next day morning, the fish were thawed under running tap water and water drained out completely by keeping the samples in seive. These samples were used for all biological studies. Total length and weight were measured upto mm and 0.5 g respectively.

The methods suggested by Le Cren (1951) were adopted to compute length-weight relationship and relative condition factor for two species separately. Computations were made for male and female separately. The length-weight relationship always be represented by $W = a\ L^b$, where W and L are weights and lengths of fish respectively and 'a' and 'b' are two constants (initial growth index and exponent, the regression respectively). A logarithmic transformation gives the straight line relationship as,

$$\text{Log } W = \text{Log } a + b \times \text{Log } L$$

Le Cren's (1951) relative condition factor (Kn) was calculated using the formula,

$$Kn = W/\bar{W}$$

Where, 'W' is the observed weight and $\bar{W}$ is then calculated weight of the fish.

Analysis of covariance test was applied to test the identicality of regression lines, equality of slopes of males and females relationships (Snedecor and Cochran, 1980). This was used to find out whether the males and females could be pooled together for a common relationship or not. Computations were done for two species separately.

Results

1706 specimens of J. sina (male 662, Female-1044) and 666 of O.ruber (male 318, Female 348) were utilized for length-weight estimation. The computed values of length-weight relationships are given in Table 18 Highly significant coefficient correlations have been observed in each relationship.

Test on identicality of straight lines was applied to find out whether the data of male and female could be pooled together to have a common relationship for all or not. This test helps to know whether these two lines are identical to each other or otherwise. If the test is not significant, then the straight lines are identical and also indicates the equality in values of 'b' and 'a' of lines. It means, two lines are parallel to each other and originate from a single point, that is it is the only one line for two relationships. In such case a common relationship can be found out. If the straight lines are not identical the values of 'b' or 'a' or both are not equal. It shows that those two lines are not parallel to each other because of different origins (a) or different angles of inclination (b) or both. Here a common relation is not applicable but it is essential to find out the reason, whether it is because of 'b' or 'a' or both different values. For this the same test (F test) is applicable here. If the test for two slopes proves to be not significant, then the 'b' values of two lines are equal and obviously the difference is due to different values of 'a'. If the test is significant then the values of 'b' are different. Then onwards the F test was applied to test 'a' values.

In *J. sina*, the test on identicality of strainght lines and for slopes for male and female were not significant at 5% level of significance (F_1 = 0.2748, d.f. 1,1702, F_2 = 6.4351, d.f. 1,1703 respectively, Table 19). Similarly in *O. ruber* also those values were not significant at 5% level of significance (F_1 = 0.3634, d.f. 1,662, F_2 = 4.9977, d.f. 1,663 respectively, Table 20). Hence for both the species, the data of male and female pooled together for the common length-weight relationshps for each species separately (Table 18).

Relative condition factor

As per Hickling (1945) & Qasim (1957), the Kn values decrease with increase in size and due to development of gonads to maturity in fishes. In *J. sina*, the lowest Kn values observed were at 11.0 cm for male and 12.0 cm for female (Fig.23) and in *O. ruber* at 21.0 cm and 23.0 cm for males and female respectively indicating their lengths at first maturity (Fig.23). These inferences were further supported by the reproductive studies (percentage of occurrance of mature fishes, Fig.14).

Fig. 24 showed the seasonal variations in 'Kn' values from September to May for both the species. In case of J. sina, 'Kn' values of both the sexes fluctuated within a narrow range. Observations on food and feeding habit showed that this species was poorly fed (Table 2). Actively fed adults were less in percentages. Also no regular periodicity in the intensity of feeding has been observed (Fig. 3). So it cleared that the food did not have any relation for variations in the weight of the species. Similarly from September, to May most of the fishes were in mature stages. Ovaries and testes were found in IV, V and VI stages of maturity throughout the period of observation (Fig. 9,10) No large changes in development of gonads have been noticed during September to May and moreover this species is a protracted spawner. All these factors were responsible for very less varations in 'Kn' values.

In case of O. ruber 'Kn' values were high during October from there onwards it decreased upto April and increased slightly in May. It showed that the spawning took place during October to January. This species is also poorly fed with less percentages of actively fed fishes (Table 3). So it's food did not have any effect on its weight and hence the development of reproductive organs was responsible for variations in 'Kn' values.

Discussion

The weight of a fish increases approximately by cube of it's length, since length is a linear measure and weight a measure of volume. The value of 'b' is normally found to be '3' for an ideal fish, provided the form and specific gravity of the fish remained constant throughout the life. Allen (1938)has showed the value of 'b' for an ideal fish which maintained constant shape was '3'. However the change in morphology due to increase in age, 'b' value departs substantially from '3'. So Le Cren (1951) stated that a more general parabolic equation of the form $W = aL^b$ would serve better than the cubic formula. Also according to Hille (1936) and Martin (1949) the value of 'b', the exponent in parabolic equation usually lies between 2.5 to 4.0. Beverton and Holt (1957) have stated that the values of 'a' and 'b' may vary within wide limits for every similar data. They also stated that isometri growth in adult fishes were rare. The 'b' value in <u>Thyrsites atum</u> (Blackburn, 1960) is below 3.0, in <u>Sardinella longiceps</u> from Calicut waters varied from 2.5 to 3.0 for indeterminate, immature and mature (Antony Raja, 1967). The value of 'a' will depend upon the fatness, being high in fat fishes and low in thin fishes (Brown, 1957).

In the present studies, 'b' values in _J. sina_, for male and female were 3.3045 and 3.2792 respectively and similarly in _O. ruber_, they were 3.0395 and 3.0887 respectively as above. Test on identicality of stragith lines showed that the straight lines of both species were identical and hence data of each species pooled together for a common relationship.

In case of _Johnius (Johnieops) dussumieri_ from Kakinada, 'b' values were 2.8816 for male and 3.0649 for female (Murty, 1979). The analysis of covariance showed no significant difference between these two values, hence a common relationship was estimated and 'b' value was 2.7634. Similarly in case of _Johnius carutta_ from Kakinada, the 'b' values were 3.2258 for male and 3.2457 for female which were not significantly different and common relationship was calculated and 'b' was 3.2334 (Murty, 1979). Baragi (1980) studied the length-weight relationship for _Johnius osseus_ from Manglore and Malpe. 'b' values were, for Mangalore, male = 3.1479, female = 3.1877; for Malpe, male = 3.0468, female = 3.1071. He didn't find any significant differences between sexes of species collected from different places. Therefore common relationship was estimated (b = 3.1540). Muthaiah (1982) has calculated the 'b' value for _Johnieops vogleri_ from Bombay waters as 3.2866 for male and 3.2808 for females. Appa Rao (1982) found the 'b' values for

Pennahia macrophthalmus from Waltair and those were 2.8380 for males and 2.8684 for females which were less then '3'. Vivekanandan (1985) estimated the length-weight relationship for *Johnius carutta* from Madras and 'b' values were 2.7501 for females and 2.8159 for males. Those values were different from those obtained for the same species from Kakinada by Murty (1979). Vivekanandan found not significant test by analysis of covariance and hence a common relationship was estimated where 'b' was 2.7990.

The aforesaid works on Sciaenids showed that 'b' values were not significantly different within the sexes and even between the same species collected from two different places (Baragi, 1980). For *Johnius carutta* from Kakinada (Murty, 1979) and from Madras (Vivekanandan, 1985), 'b' values were different but were not tested for combined relationship. But in *J. sina* and *O. ruber* the tests for identicality of straight lines were not significant for male and female. The variation of the observed weight from the expected weight of individual fish gives information about its fatness, general well being or gonad development of fish. Those variations have been studied by calculating condition factor (Hile, 1936; Thompson, 1945). The period of inflexion in the curve showing diminution of 'Kn' with increasing length is the length at which the fish attained the size at first sexual maturity (Hickling, 1945; Qasim 1957 and Morrow, 1951).

As stated above, in case of *J. sina*, 'Kn' values decreased to 0.96 at 11.0 cm and to 0.94 at 12.0 cm in male and female respectively (Fig. 23). Afterwards the values rose to 1.04 in the case of male and to 1.02 in the case of female at 14.0 cm length for both the sexes. Similarly monthwise 'Kn' values showed fluctuations within a narrow range (Fig.24). Nair (1977) noticed the lengths at first maturity for male 12.5 cm and for female 11.5 cm by 'Kn' values for *J. sina* from Calicut. Hickling (1945) found high and low 'Kn' values before and after spawning of *Sardina pilchardus* and also depend upon food intake. Similarly Le Cren (1951) also noticed relation between relative condition and gonad weight of *Perca fluviatilis*. But in *J. sina* high or low 'Kn' values were not noticed throughout the year. It showed that development of gonads was a continuous process throughtout the year. No wide variations were observe in the 'Kn' values of fish. Also this fish was poorly fed (Table 2).indicating no effect on 'kn' values on account of poor food intake and irregularity in the intensity of feeding. If the gonads would have been developed fully and the fish spawned once and completely coming back to resting stage, then definitely 'Kn' values might have been changed widely. It showed that this species spawns for a longer period of times.

In the case of *O. ruber*, the lengths at first maturity were 21.0 cm for male and 23.0 cm for females. Also high 'Kn' values have been noticed during September to October and then onwards declined upto April indicating spawning during October to January. Here this fish also poorly fed and hence the possibility of food intake influencing 'Kn' values could not be ascertained. In *Johnius* (*Johnieops*) *dussumieri* and *Johnius carutta*, 'Kn' values varied with development in gonads and spawning (Murty, 1979). In *Johnieops vogleri*, the 'Kn' values were high in December because of high intake of food in that month (Muthiah, 1982). In the case of *Johnieops osseus*, Baragi (1980) found monthly variations in its 'Kn' values and he pointed out that maturity and spawning were not be the factors responsible. Blackburn (1960), James (1967) and Nair (1983) pointed out that sexual cycle and food intake were not the factors responsible for high or low 'Kn' values.

Growth of fish may vary with envirormental factors and physical state of the fish (Brown,1957). The aforesaid studies showed that minor or wide variation in 'Kn' values may be related to the reproductive cycle and to some extent with feeding.

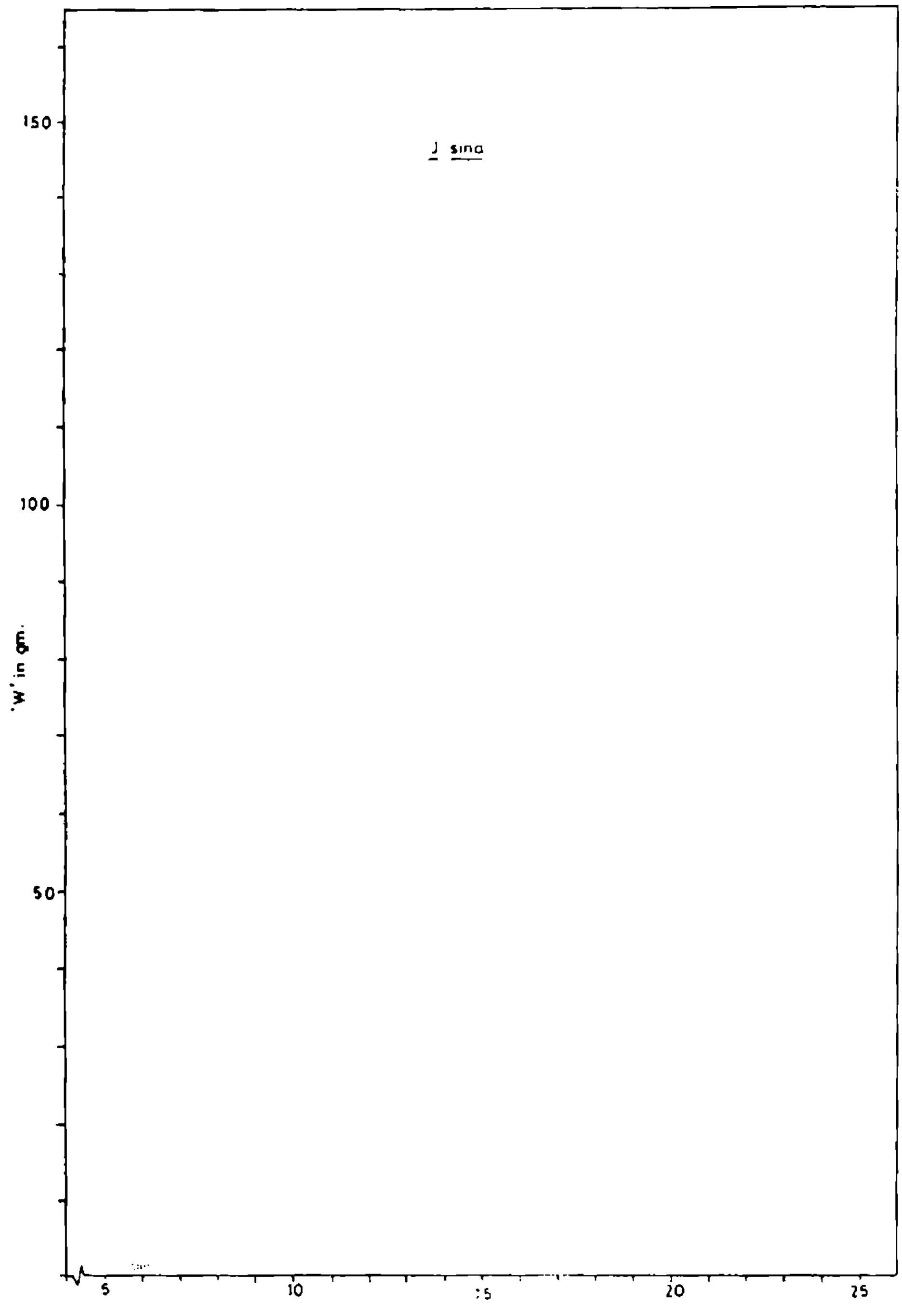


Figure 20 : Length-weight relationship in *J. sina*.

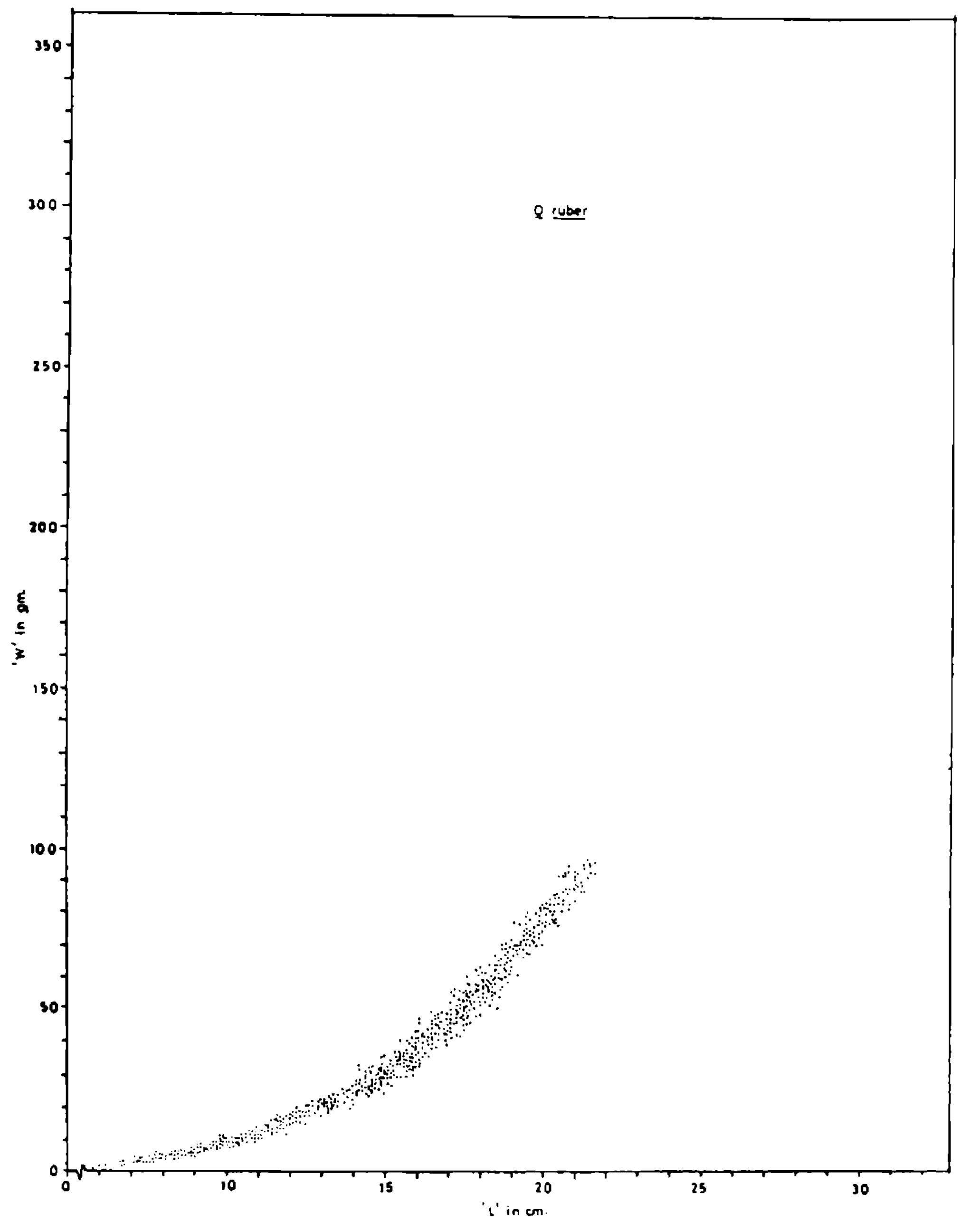


Figure 21 : Length-weight relationship in O. ruber.

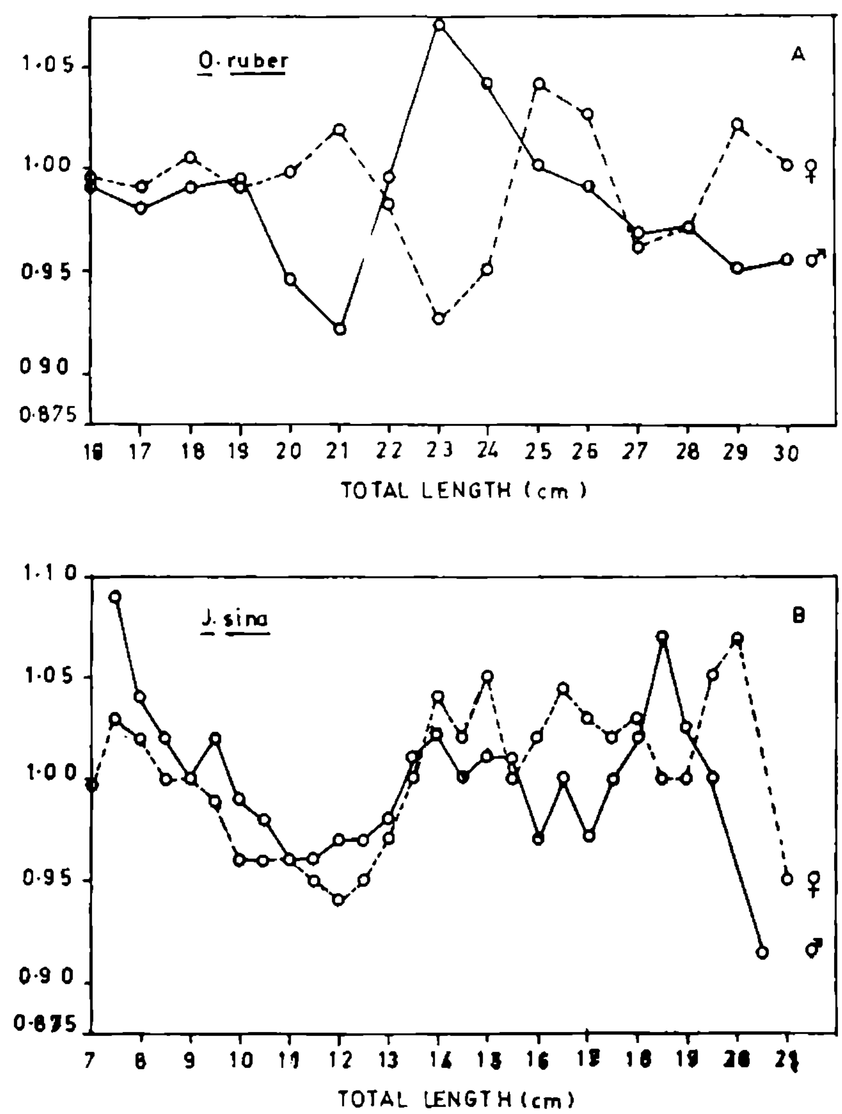


Figure 23 Mean 'Kn' values for various lengths of J. sina and O. ruber.

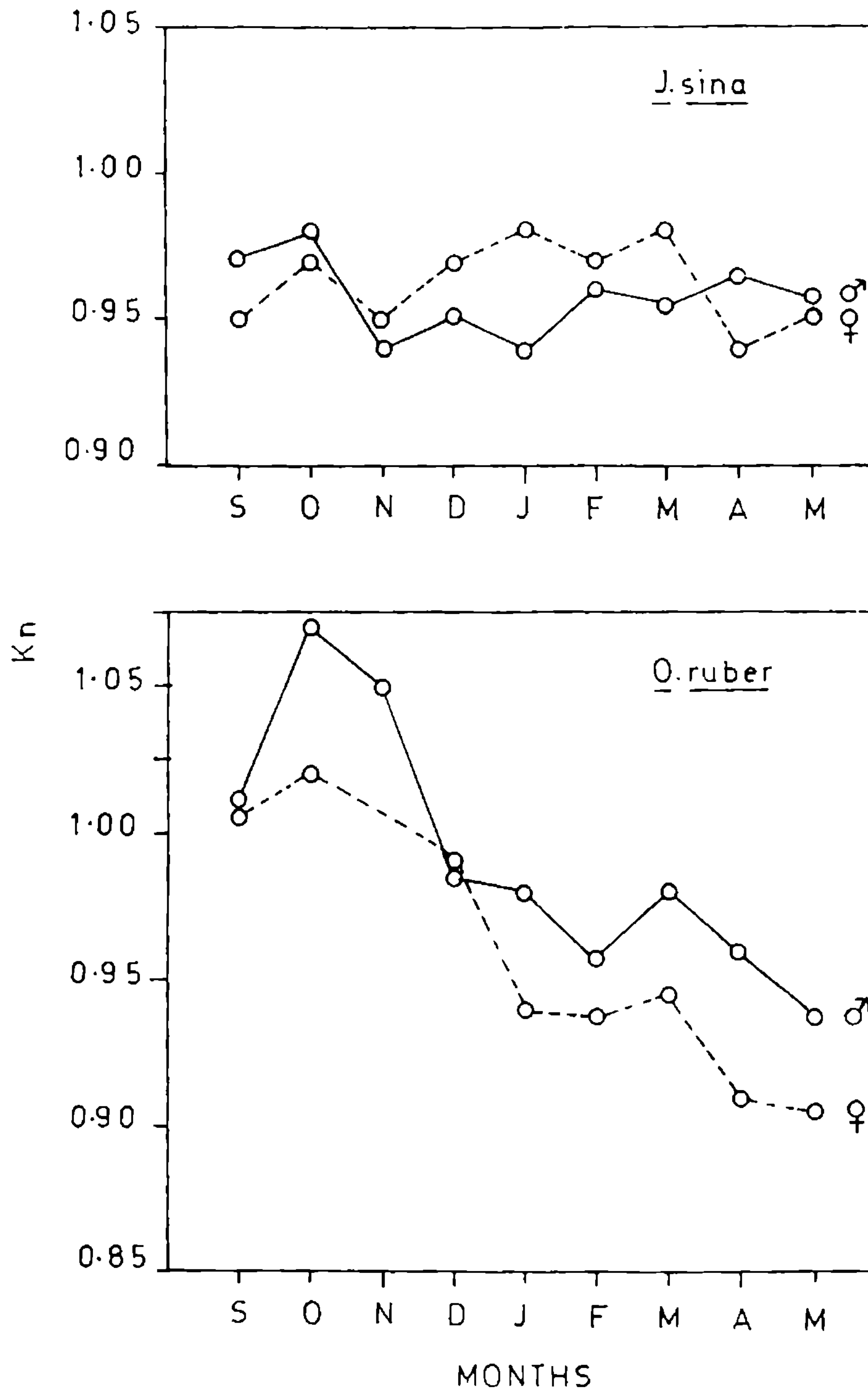


Figure 24 . Month wise 'Kn' values in J.sina and O.ruber.

Table - 18 Length-weight relationship of *J. sina* and *O. ruber* (Length in cm & weight in gms)

Species	Sex	Length-weight relationship: Log W= Log a + b x Log L (Log in ln)	Length-weight relationship: $W = aL^b$	n	r
J. sina	Male	Log W = − 5.2985 + 3.3045 X Log L	$W = 0.004999 \times L^{3.3045}$	662	0.9713
	Female	Log W = − 5.2065 + 3.2792 X Log L	$W = 0.005481 \times L^{3.2792}$	1044	0.9975
	Male + Female	Log W = − 5.2525 + 3.3071 X Log L	$W = 0.005234 \times L^{3.3071}$	1706	0.9986
O. ruber	Male	Log W = − 4.7508 + 3.0395 X Log L	$W = 0.008645 \times L^{3.0395}$	318	0.9905
	Female	Log W = − 5.3805 + 3.0887 X Log L	$W = 0.004605 \times L^{3.0887}$	348	0.9914
	Male + Female	Log W = − 4.9689 + 3.1313 X Log L	$W = 0.006950 \times L^{3.0940}$	666	0.9936

Table 19: Comparition of regression lines, male and female of *J. sina* by ANOCOVA

		d.f.	x^2	y^2	xy	Reg. Coef.	Deviation from Regression d.f.	S. S.	M. S.
	Within								
1.	Male	661	8.4950	98.3404	28.0718	3.3045	660	5.5769	
2.	Female	1043	17.1414	201.0332	56.2103	3.2792	1042	16.7077	
3.							1702	22.2846	0.0131
4.	Pooled	1704	25.6364	299.3736	84.2821	3.2876	1703	22.2882	0.0131
5.			Difference between slopes				1	0.0036	0.0036
6.	Between		1.3591	18.2481	4.9950				
7.	Total	1705	26.9955	317.6217	89.2771	3.3071	1704	22.3725	
			Between adjusted mean				1	0.0843	0.0843

Comparision of slopes $F_1 = 0.0036/0.0131 = 0.2748$ (d.f. = 1,1702) N.S.

Comparision of elevations $F_2 = 0.0843/0.0131 = 6.4351$ (d.f. = 1,1703) N.S.

Table value for d.f. 1,1703 (1702) at 5% level of significance = 7.88

Table 20 : Comparition of regression lines, male and female of *O. ruber* by ANOCOVA

		d.f.	x^2	y^2	xy	Reg. Coef.	Deviation from Regression d.f.	S. S.	M. S.
	Within								
1.	Male	317	13.9370	142.4998	42.3608	3.0395	316	13.7463	
2.	Female	347	12.0812	130.1417	37.3154	3.0887	346	14.8850	
3.							662	28.6313	0.0432
4.	Pooled	664	26.0182	272.6415	79.6762	3.0623	663	28.6470	0.0432
5.	Difference between slopes						1	0.0157	0.0157
6.	Between	1	0.7538	18.7322	4.1566				
7.	Total	665	26.7720	285.1483	82.8328	3.0940	664	28.8629	
	Between adjusted mean						1	0.2159	0.2159

Comparision of slopes $F_1 = 0.0157/0.0432 = 0.3634$ (d.f. = 1,662) N.S.

Comparision of elevations :$F_2 = 0.2159/0.0432 = 4.9977$ (d.f. = 1,663) N.S.

Table value for d.f. 1, 663 (662) at 5% level of significance = 7.88

Age and growth

The knowledge of the age structure of fish population from year to year helps to furnish mortality and survival rates of various year classes and also the success of yearly recruitment. This indicates the need for such studies in the management of exploited fish stock. Analysis of size and age data of fish gives estimates of growth rate of fish and also explains the role played by various strength of year classes in the fluctuations of the fishery. The determination of maximum sustainable yield is based on growth (Beverton and Holt, 1957). The rational exploitation of the fishery depends on adequate information of these vital rates for which accurate assessment of age is essential.

Studies on age and growth of few species of sciaenids from Indian waters have been studied (Table 21). Narayankutty (1961) studied the scales of Otolithoides biauritus but didn't assign the age for growth marks. Age and growth of Johnius dussumieri have been studied by using length frequency method from Bombay (Savant, 1963). Nibea coiber has been studied by Rajan (1964) from Chilka lake for estimation of age and growth where he applied length frequency method. Venkat Subba Rao (1966) with the help of length frequency method, otoliths and scales, estimated age and growth of Protonibea diacantus from Bombay. The same species has been studied by Sreenivas Rao (1968) from the same place where he used length-frequency method and scale observation. Jayprakash (1973, 1977) observed the vertebra, length frequency and scale of Otolithoides biauritus from Bombay for estimation of age and growth. By length-frequency method, age and growth studies were carried out on Pennahia macrophthalmus from Mandapam (Mohan, 1977), Johnieops vogleri from Bombay (Muthiah,1982) Johnius carutta from Madras (Vivekanandan, 1985). Nair (1974) studied the length-frequency and growth marks on scales of J. sina from Calicut region for estimation of age and growth. Details regarding the age and growth of O. ruber from Indian waters have not been studied so far.

Methods for determining age and growth of fishes are (1) length-frequency method (2) growth checks on hard parts (3) by rearing the fish in pond or aquarium and (4) mark - recapture method. Last two methods were not considered since the species are delicate and the procedures are lengthy. Hence length-frequency method and studies of growth checks on hard parts were considered in this chapter.

Length-frequency method   Analysis of length frequency data by Petersen's method (1929) enables in determining the average size of a fish at different ages.

"With 'Petersen's method', assumptions are made as to the time interval separating the various peaks of one length frequency sample, these peaks being assumed to represent distinct age groups." (Pauly, 1983). Probability paper is useful for separating the different age groups (Harding, 1949; Cassie, 1954). Modes should be wide apart and overlapping of successive age distribution should be minimum. Due to continuous spawning or high growth rate or because of both reasons, modes overlap and becomes difficult to separate them. But first one or two modes will be clear and those should be selected to get the idea of ages. Petersen's method is most useful for the fishes which spawn once in a year at a particular period. Fishes which spawn continuously age distributions overlap and become difficult to separate them.

Growth checks on hard parts   Characteristic marks in hard parts which appear at regular intervals during growth of fish in temperate waters are frequently used as indicators of age. Scales, otoliths and opercular bones are commonly used for age determination, though vertebrae, cleithra, finrays etc. are also used (Bagenal, 1974).

Growth checks are formed during alternate periods of faster growth and slower growth or no growth at all. Various environmental and or internal influences also reflect the growth marks (Simkiss, 1974 ; Dilton, 1974).

During favourable temperature conditions and obundant food supply the fish grows fast and obviously the hard structure grows fast forming a broad and uniform band of growth. During unfavourable conditions, low diet, fasting, spawning, etc. the growth of fish slows down and naturally narrow growth layers are laid down very close to each other producing a narrow but dark band. These broad and narrow bands form a single growth-check in a season or year. Environmental conditions and physiology of the fish are responsible for the formation of growth checks. If the seasonal temperature differences are greater, the annual marks will be more clear. So in temperate regions growth checks are more distinct (Bagenal et al, 1978). Hence in temperate countries, the age determination of fish by counting the periodic markings in the skeletal structures is well established. It has become accepted routine in many fishery investigations.

The stable environment and continuous breeding habits of many tropical species lead to marks being laid down at any time of the year and in many number (Weatherley, 1972). However, in tropical waters otolith, scales etc. have been used for age determination by many workers (Nair, 1949; Seshappa and Bhimachar, 1951, 1954, 1955; Pillay, 1954; Radhakrishnan, 1954, 1957; Sarojini, 1957; Jhingran, 1957; Seshappa, 1958; Balan, 1959; Kutty, 1961; Rao, 1961;

1966,68). In India many workers have tried to use growth checks on hard parts but have found it difficult in fixing the periodicity of growth check formation.

Validation of the method Graham (1929), Van Oosten (1929) and De Bont (1967) listed the following five criteria for validation of growth checks -

1) Scales or bones must remain identical throughout the life of fish.
2) Growth of the scale or bone must be proportional to the overall growth of the fish.
3) A regular increase in body size must correlate with increased number of growth checks.
4) Growth check must be formed yearly or during specific periods of a year.
5) Back-calculated lengths should agree with emprical lengths.

Back-calculation The reading of scales and other structures for back-calculation of past lengths for age is a common technique suggested by many authors (De Bont, 1967; Tesch, 1968; Weatherley, 1972). The method suggested by Zamachaev, 1941; Le Cren, 1947; Koops, 1959; Penaz and Tesch, 1970; Reay, 1972; Tesch, 1977; has been utilised for this study.

1) Radius was measured from the mid-point that is nucleus to the anterior median margin of scale or otolith with the help of occular micrometer under microscope.

2) Radius to each growth check was measured in micrometer division along the same line as in (1).

3) Graph for fish length against scale radius was plotted. Back calculations are based on the relationship between fish-length and scale radius. The following formulae are suggested for different relationships between scale and radius.

a) Linear and passing through the origin,

$$Ln = \frac{Sn}{S} X \quad L \tag{1}$$

(Lea's formula, 1910)

b) Linear but not passing through the origin,

$$Ln - a = \frac{Sn}{S} \quad (1 - a) \tag{2}$$

(Fraser, 1916; Lee, 1920)

c) Curved (Slope increasing)

$$\bar{S}n = \frac{\bar{S}Sn}{S} \tag{3}$$

(Ricker and Lagler, 1942)

d) S - shaped

$$Log\ L = log\ a + b\ (log\ S) \tag{4}$$

(Hile, 1941)

Where, Ln = length of fish when annulus 'n' was formed.

L = length of the fish when scale sample was obtained.

Sn = radius of annulus 'n' at fish length Ln.

S = total scale radius.

a = intercept.

b = regression.

$\bar{S}n$ = adjusted distance to the nth annulus.

$\bar{S}$ = average scale radius for a fish of the observed length.

Materials and methods

Details about material is given in length-weight chapter.

Measurement of length : Total lengths of specimens from the tip of the snout to the largest caudal ray, corrected to the nearest milimeter was taken on measuring board.

Length-frequency The data were grouped at the class interval of 0.5 cm for J. sina and 1.0 cm for O. ruber irrespective of the sex for the day. The numbers were raised for that day for two species separately and daily raised figures added for a month and again raised for that month. Such monthly frequency data were converted in percentage frequencies and represented graphically Interpretation of growth rates is based on the shifting of monthly modes in the length-frequency distribution.

The progression of modes could not be traced through out the period of study by length frequency. Hence in order to dissect out the probable modes representing various year classes, the modes were grouped in sets of three by permutation and combination and the validity of mode as year classes was tested by using the formula -

$$L_{t+1} = L_{\infty} \left(1 - e^{-K} \right) + e^{-K} \times L_t \quad \ldots\ldots\ldots\ldots(5)$$

Where, L_{∞} = asymptotic length.

L_t = length at time t

L_{t+1} = length at time t+1

K = coefficient of growth, a constant.

t_0 = age at zero length.

e = 2.718, a constant.

It is a derivative of Von Bertalanffy's formula

$$L_t = L_{\infty} \left(1 - e^{-K(t - t_0)} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Equation '5' is nothing but a Ford-Walfort plot forming a simple equation of Y = a+bX

$$\text{Where, } a = L\infty\,(1-\bar{e}^{K}) \tag{7}$$

$$b = \bar{e}^{K} \tag{8}$$

$$X = L_t$$

$$\therefore b = \bar{e}^{K}$$

$$\cdot\ \text{Log}_e b = -K$$

$$\cdot\ -\log_e b = K \tag{9}$$

and

$$\cdot\ a = L\infty\,(1-\bar{e}^{K})$$

$$L\infty = a/1-b \tag{10}$$

From the above sets of modes, a set or sets or modes were selected those had given $L\infty$ closer to the maximum length cited in the literature (Table 22). While selecting the modes, care was taken that the differences between successive modes were of decreasing order. For estimation of growth parameters, this set was used.

Collection, preparation and mounting of otoliths and scales For the observation, sagittae, the largest of the three pairs of otoliths were used. There are many methods for extracting the otoliths from the fish (Chugunova, 1963; Buckman, 1929; Bagenal and Tesch, 1978).

Otoliths (sagittae) are situated in the otic capsule in the fish head. Gills were removed and lower part of the cranium was exposed and otic capsules were seen (Chugunova, 1963). These otic capsules were cut open and sagittae were taken out by forceps. The otoliths were washed in fresh water by rubbing them between two fingers. Otoliths were dried and stored in paper envelopes writing the date, serial number, length, weight and sex of the fish.

For observations, the otoliths were rubbed from both sides on carborundum stone till it turned into thin slice. Such thin sections were observed under dissecting microscope, immersing them into water against dark background (Bagenal, 1978).

In both species, the scales from different regions of fish body were taken and the region from which least variations were observed in the scales, was fixed. From that region only scales were taken for the observations. The scales 5 to 6 in numbers from the fixed region on each side were held with the help of forceps and pulled out in backward direction, fish head to tail direction (Chugunova, 1963). The scales were washed in fresh water by rubbing them with fingers, dried and stored in paper folds. Date, serial number, species, length, weight and sex were noted. For observations, these scales were held between two slides firmly and observed under microscope. The growth check was considered to be at the outer border of the closely spaced ridges. Secondary, false marks were carefully observed and true marks were considered. True marks are distinct and continuous encircling the nucleus. False marks are less distinct and less continuous than the true marks.

Results

Length frequency analysis

Data on length were callected during September 86 to May 1987 and September 87 to May 88. A total of 5690 specimens of _J. sina_ (3654 during 1986-87 and 2036 during 1987-88) ranging from 4.7 to 23.5 cm were observed. In case of _O. ruber_ total 2025 specimens (1009 during 1986-87 and 1016 during 1987-88) ranging from 4.5 to 32.5 cm were observed. The percentage frequencies are graphically represented in Fig. 25 and 26 for _J. sina_ and _O. ruber_ respectively.

J. sina

From the length-frequency graph (Fig. 25), it was observed that the juvenile fis s recruited in the fishery almost in all months. It could be inferred that the species is a protracted spawner, spawns mostly throughout the year. Because of continuous recruitment, modes were overlapping and some modes did not show any continuation with modes of previous or next months. This fishery mainly consisted of younger group and older groups were represented by very few numbers. The progression of modes could not be traced throughout the period of study. However, in initial stages few modes of the same cohort could be traceable.

From the data many modes were found which are as follows, 7.0, 7.5, 8.0, 9.0, 9.5, 10.0, 10.5, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.5, 19.5. From the above modes, the modes were grouped in sets of three and $L\infty$ were estimated using formula 5 for each set. Two sets of modes, one with 7.5, 12.5 and 16.5 and other one with 8.0, 11.5 and 14.5 gave $L\infty$ = 32.5 cm which was nearer to the recorded maximum length 30.0 cm cited in the literature (Munro, 1955; Day, 1981 ; FAO, 1984). The calculations were as follows.

Modes in a set (cm)	L_t(cm)	L_{t+1}(cm)
7.5	7.5	12.5
12.5	12.5	16.5
16.5		

using the equation 5,

$$L_{t+1} = L\infty\,(1-\bar{e}^{K}) + L_t \times \bar{e}^{K}$$

$$12.5 = \quad a \quad +7.5 \times b \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

$$16.5 = \quad a \quad +12.5 X b \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Solving these two simultaneous equations (11) and (12) 'a' and 'b' were estimated as follows

$b = 0.8000$ and $a = 6.5$

hence $L\infty = a/1-b = 32.5$ cm ....(13)

and $K = -\log_e b = 0.2231$ ....(14)

For caluculation of life span (T) of J. sina following formula was used

$$T = t\text{-}to = \frac{1}{K} \log_e \left(1 - \frac{L_t}{L\infty}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

where, T = life span.

t = age at maximum length

to = age at zero length

L_t = maximum length attained by fish which is slightly smaller than estimated $L\infty$ by 0.5 cm.

$L\infty$ = asymptotic length attained by fish (estimated)

Here, L_t and $L\infty$ were the same lengths but for the purpose of calculation, L_t was taken slightly less than $L\infty$ normally by substracting class interval (0.5 cm). Hence estimated $L\infty$ was 32.5 cm and L_t, 32.0 cm. If both values were equal then the value of life span would have been infinite.

$$T = \gamma 0.2231 \quad \log_e \left(1 - \frac{32.0}{32.5}\right) = 19 \text{ units of time} \quad ....(16)$$

(Unit of time may be month , quarter of a year, six month or a year etc.).

Similarly another set of modes used for estimation of growth parameters and compared with the parameters obtained from the previous set of modes. Those two sets gave the same value for $L\infty$, So average of the two sets of modes was taken for a single set (Table 22). It was observed that the $L\infty$ (31.8 cm) estimated from the average values of modes of two sets was very closer to the recorded maximum length (30.0 cm) of the species (Munro, 1955; Day, 1981; FAO, 1984). This average value was taken for further calculations.

O. ruber :

For this species also, from length-frequency graph (Fig.26) various sets of modes were observed. Using the same method applied for J. sina, different parameters were estimated. Four sets of modes were observed which gave different values for $L\infty$ but closer to the observed maximum length (75.0cm)given in the literature (Munro, 1955 Day, 1981 FAO, 1984). The values for K, T and M remained unchanged for all sets and even for the average of four sets of modes. Hence average of four sets of modes was taken for common estimation (Table 23).

Observations on hard parts: Scale –

Criteria for obtaining reliable determination of age and growth from scales were met (Van Oosten, 1929; De Bont, 1967). Those were as follows :-

1) Scales were identical and found in all sizes of fish examined in both species.

2) The regressions of lengths on scale radii were calculated for two species and the relationships were (Fig.27, 28),

J. sina; T.L. = 2.1075 + 0.2579 X S ....(18)

(r = 0.9967; n = 430)

O. ruber; T.L. = 0.0845 + 0.6099 X S ....(19)

(r = 0.9939; n = 407)

Where, T.L. = Total length of the fish in cm.

S = scale radius in m.d.

Regressions of total lengths on scale radii showed linear relationship indicating that the growth of scale and fish were proportional to each other.

3) It was clear from the Table 26,27that as the length of fish increased the number of growth rings also increased.

4) The criterion that growth check must be formed yearly (or biyearly or quarterly or monthly) and at the same time of the year could not be proved. Minimum mean marginal length helps in finding the period of ring formation. After formation of growth mark or ring, the scale grows as the growth of fish continues further. This forms a margin to the last growth mark or ring. Minimum marginal length indicates that the ring has formed recently and if margin is more then ring formed before some months and not recently. In J. sina no clear mean marginal lengths were observed. The first growth mark was observed in fishes of 9.00 cm in length (Table 28). The lengths at first maturity were 11.2 and 11.6 cm. for male and female respectively (Fig. 14). It is a protracted spawner. So the formation of first ring and the successive rings could not be related with it's maturity and spawning. Similarly in O. ruber, first growth ring was observed at 18.9 cm. length (Table 29), the lengths at first maturity were 20.6 and 23.0 cm. in male and female respectively (Fig. 14). Population of O. ruber spawns from November to December (Fig.12,13). Hence, period of formation of first ring and then onwards successive rings could not be related to it's maturity or spawning activities. Also these species are poorly fed throughout the year (Table 2,3) Seasonal variations in food intake is responsible for ring formation but in these species food item was not the criterion responsible for ring formation.

5) From the Table 28,29, it could be concluded that the back-calculated lengths agreed reasonably with empirical lengths in two species. Since older specimens were landed rarely, so very few observations could be made on larger specimens.

The asymptotic length obtained from scale studies: Back-calculated lengths based on scale studies, were used for calculation of age and growth of both species as per Michael (1977) and Mercer (1978). The Walford lines (Walford, 1946) were plotted for J. sina and O. ruber (Fig. 29). and those were,

J. sina; $Y = 7.0309 + 0.7355\ X$ $(r = 0.9762)$. (20)

O. ruber; $Y = 13.1584 + 0.8124\ X$ $(r = 0.9866)$ (21)

From the constants of above equations (20, 21), the values for $L\infty$ and K were estimated, those were,

J. sina; $L\infty = 26.9$ cm.; $K = 0.5859$ ....(22)

O. ruber $L\infty = 69.9$ cm.; $K = 0.4184$ ....(23)

In both species, the values of $L\infty$ were less than the observed maximum values as cited in earlier paragraphs. Also, the time of ring formation and nature of ring (annual or biannual) could not be determined. But the sets of modes from length frequency gave $L\infty$ nearer to the observed maximum ones, So for estimation of other parameters (growth parameters, mortality, life span, etc.), the appropriate set of modes selected from length-frequency only were considered, since they proved to be more reliable than the scale analysis.

Otolith

32 otoliths of J. sina and 44 of O. ruber were tried to study the length at various growth checks. Growth markings were not clearly visible. Most of the rings were diffused ones and continuous upto the otolith margin. These observations couldn't help in fixing the lengths at various growth markings. Hence otoliths were not considered for the study of age and growth of these two species.

Fixing age

A fish grows rapidly in it's early period of life and later it's growth slowsdown so as to reach to it's asymptotic length finally. In other words, after a definite time, the size of the fish reaches to it's maximum size (asymptotic size) in it's life. At this stage the growth rate is nil. But it's growth rate in it's last few years of life is very low. Hence a fish attains maximum size in it's early period of life due to higher growth rate and then onwards, the difference being not much, it takes much time to attain asymptotic size. The rate at which it grows and time required to attain asymptotic size are estimated by a coefficient of growth factor (K). If K is high then the fish reaches to it's asymptotic size in a short period of time as compared to that which has low K values.

Thus life span of a fish depends upon K value. If K value is low, then more time will be required for a fish to attain an asymptotic size than a fish having high K value.

Life span of _J. sina_ and _O. ruber_ were estimated using the following equation.

$$T = {}^{1}\!/K \log_e(1 - L_t/L\infty)$$

The estimated life spans of _J. sina_ and _O. ruber_ were 21 and 38 units of time period.

Longevity

As mentioned in the earlier paragraph the life span of _J. sina_ is 21 time units. Considering the $L\infty$ (31.8 cm) and K value (0.1942) of this fish, it may be safely assumed that each time unit is quarterly and the life span is about 5 years. Similarly in case of _O. ruber_, with $L\infty$ (76.5 cm) and K (0.1335) each time unit may be considered as quarterly and total of it's life span to be about 9-10 years. The earlier works on age and growth of sciaenid species have also arrived more or less at the same conclusions. Table 21 indicates the details of the work carried out by different authors on sciaenids in Indian waters.

It is worth noting from the table referred above that for *Johnius carutta* with $L\infty$ = 26.0 cm, Vivekanandan (1985) indicated the age of this fish to be more than three years. In case of *J. sina,* $L\infty$ is about 32.0 cm and it's age estimated as 5 years in this study may be acceptable. Other works in this table also support this view. Mohan (1977) stated that age of *Pennahia macrophthalmus* was more than $2\frac{1}{2}$ years and it's $L\infty$ was 32.0 cm. The age of *Johnieops vogleri* is more than three years whose $L\infty$ is 29.0 cm. (Muthiah, 1982). Nair (1974) has studied age and growth of *J. sina* and noted it's age to be more than three years. However in his case sizes at first year, second year and third year were 13.5, 16.5 and 18.5 cm. respectively. Growth in the second and third years appears to be small as compared to the first year. In the present study the sizes attained at first, second and third years were 18.38, 25.64 and 29.0 cm. This growth is more or less similar to that of *J. vogleri* studied by Muthiah (1982). So considering the above, the life span of *J. sina* may be safely taken as 5 years.

In case of *O. ruber* also, similar argument may lead to the conclusion that it's life span is about. 10 years.

Discussion

In fishes which spawn in a short and restricted period of a year, the length frequency shows distinct modes. These modes represent different year classes. Such frequency distribution helps in fixing monthly and annual growth rates of respective year classes. If the growth is slow, it is not easy to follow the progression of modes from month to month and if spawning is prolonged and continuous, the length frequency distribution will not give proper indication of year classes. It leads to difficulties while tracing the growth accurately through different months. And this is exactly what has happened with regard to the growth study in most fishes from Indian waters (Qasim, 1973).

In protracted spawners, due to peak spawning seasons as in J. sina, some clear modes are seen in the beginning few months and in others they overlap or merge into each other. Length frequency distribution of J. sina did not help for age and growth studies. Hence, the modes which were clearly observed in few months were put into groups of three modes. Such sets of modes were used to estimate $L\infty$ using the equation 5, which is a derivative of Von Bertalanffy's growth equation. This method was adopted for both the species. The estimated $L\infty$s (31.8 cm.

of <u>J. sina</u> and 76.5 cm. of <u>O. ruber</u>) were closer to the recorded maximum lengths in literature (30.0 cm. of <u>J. sina</u> and 75.0 cm. of <u>O. ruber</u> by Munro, 1955; Day, 1981 and FAO, 1984). Estimated values seemed to be slightly higher than the recorded ones. Lengths need not be the same since there are chances for fishes to grow beyond the recorded lengths.

Average of modes of the sets givining L_∞ closer to maximum lengths recorded, were 7.75, 12.0 and 15.5 cm. and 12.5, 20 .5 and 27.5 cm. for <u>J. sina</u> and <u>O. ruber</u> respectively. The longivities were estimated and those are 21 and 38 units of time. Each unit of time was fixed as quarterly. From the available data, it is clear that the life span of most of the tropical fishes is short and seldom exceeds 2 - 3 years (Qasim, 1973). In big sized fishes, the life span is 7 to 10 years (Table 21). From above it is clear that the life span of small size sciaenid, <u>J. sina</u> is 5 years and medium sized <u>O. ruber</u> is 10 years which are well agreeable.

From above, in <u>J. sina</u>, lengths at the end of first second and third years were 18.38, 25.54 and 28.99 cm. which are higher than the lengths fixed by Nair (1974) as 13.5, 16.5 and 18.5 cm. for three years. He has also observed the number of rings in scales but neither explained the nature of those rings nor fixed the time of ring formation.

There are different opinions regarding the causative factor for the formation of rings in the scale of fish. Rao (1966) pointed out that low feeding in case of juveniles and spawning in adults of Pseudosciaena diacanthus, were the causative factors for ring formation. But he is of opinion that fast growth in juveniles and after spawning may be responsible. Kutty (1961) stated that low feeding and low temperature were probable causes in Otolithoides brunneus. Jayprakash (1976) claimed that low temperature, high salinity and upwelling were seemed to be causative factors but he has not considered it's low feeding intensity during the months of ring formation. According to Seshappa and Bhimachar (1951, 1954, and 1955) ring formation in Malabar sole, Cynoglossus semifasciatus is associated with starvation and monsoon conditions. Seshappa (1958 and 1969) pointed out that the rings in Rastrelliger kanagurta were formed because of strain caused by growth, ripening of gonad and spawning activity. In Johnieops vogleri (Muthiah 1982) rings were formed due to low feeding intensity, spawning and monsoon.

In J. sina, time for formation of ring could not be fixed. This species is a protracted spawner and poorly fed almost in all months, hence these two factors will not be responsible for formation of rings. In O. ruber, time of ring formation could not be fixed, since it is also a poorly fed and though spawning takes place once in a year more than one ring were observed in a year. So formation of ring could not be related with above factors. According to Qasim (1973), if more than one growth mark are formed during the course of one year, then the back-calculations are subjected to error. Besides these problems, L_∞ estimated from scale analysis are 26.9 and 69.9 cm. for J. sina and O. ruber respectively which are less than the recorded maximum length by workers. Considering all these points, the length frequency analyses were considered for further studies, since they are found to be more reliable than scale studies.

Regarding the otoliths of both species, no clear zonations of dark and light bands were observed and hence not considered for this study.

For estimation of different lengths at various ages, the known values of modes were inserted in equation 5 and the length for the next time period was calculated by solving simultaneous equations. Here the asymptotic lengths estimated for both the species from the appropriate set of modes were used in above equation.

The present study has shown that maximum length attained by J. sina is 31.8 cm. and that by O. ruber is 76.5 cm. Their life spans are 5 years and 10 years respectively. These findings are well agreeable when compared with the available data (Table 21). Being tropical waters and short life spans, these species grow fast in early period of their lives and mature before they become one year old. This has been supported by the literature on sciaenids (Table 21 and Ross, 1984).

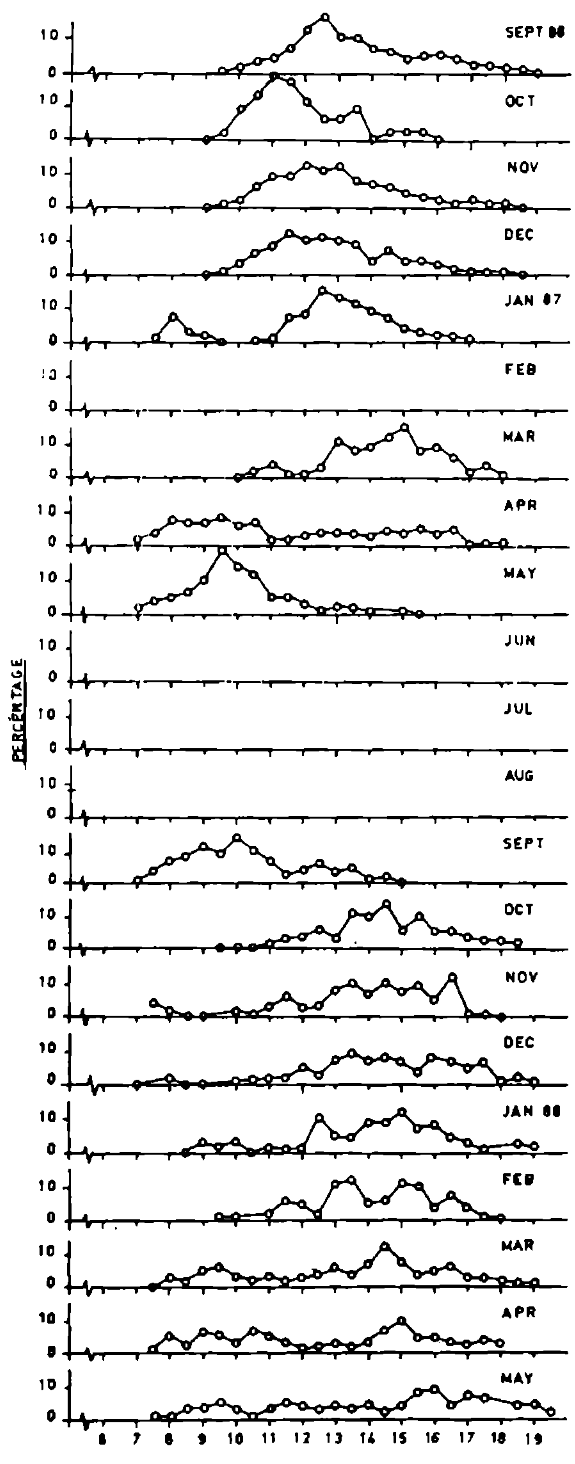


Figure 25 Length frequency distribution of J. sina.

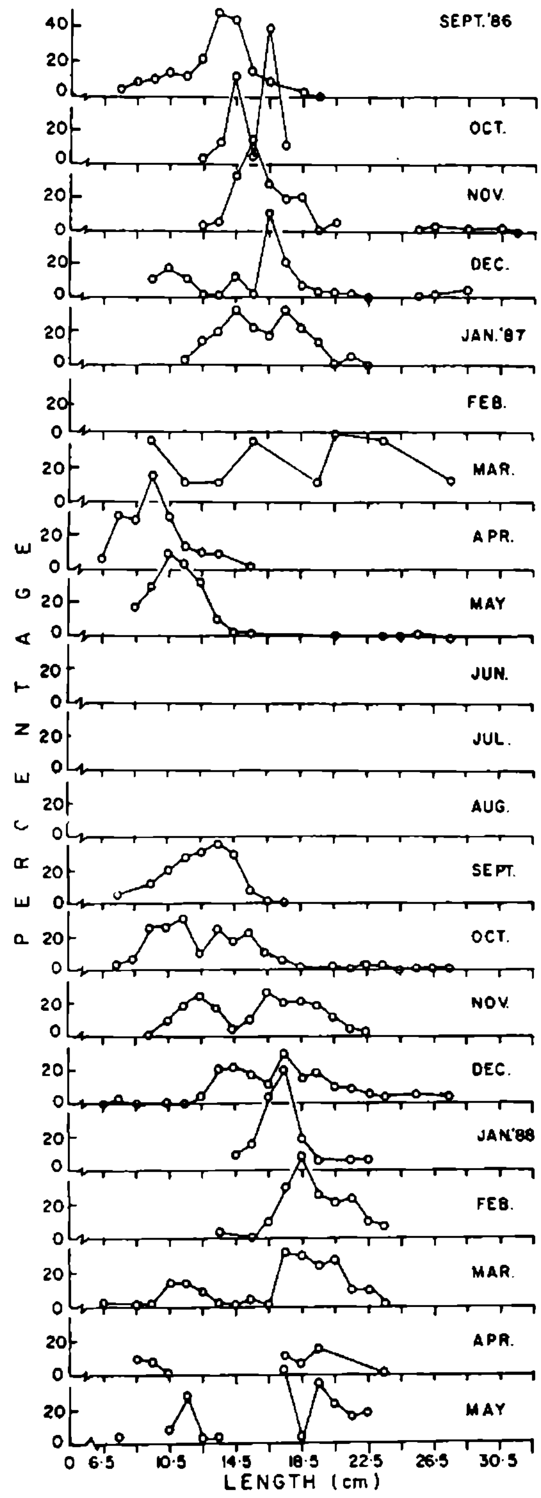


Figure 26 Length frequency distribution of O. ruber.

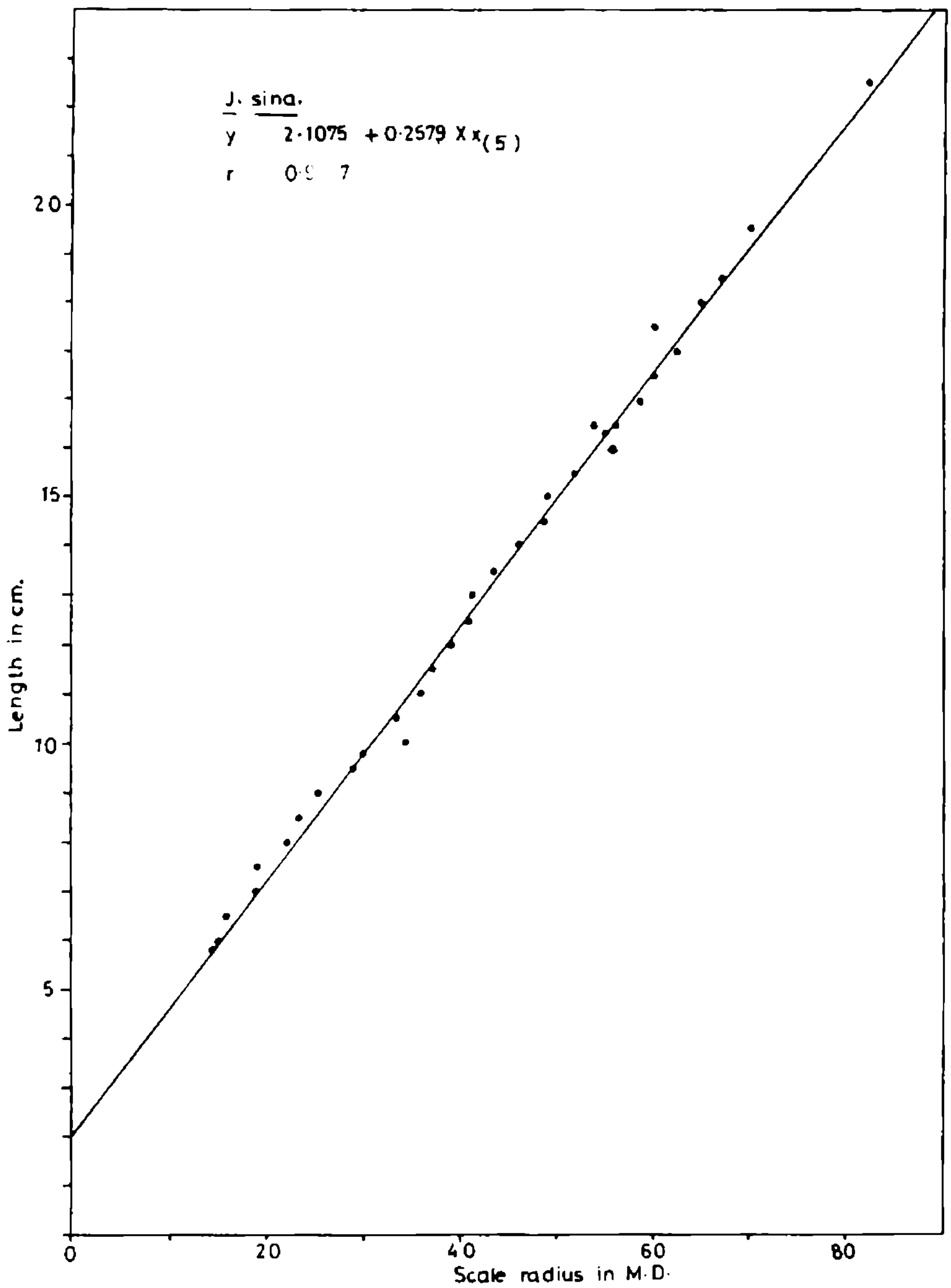


Figure 27 Length: scale relationship for J. sina (Length - T.L. in cm).

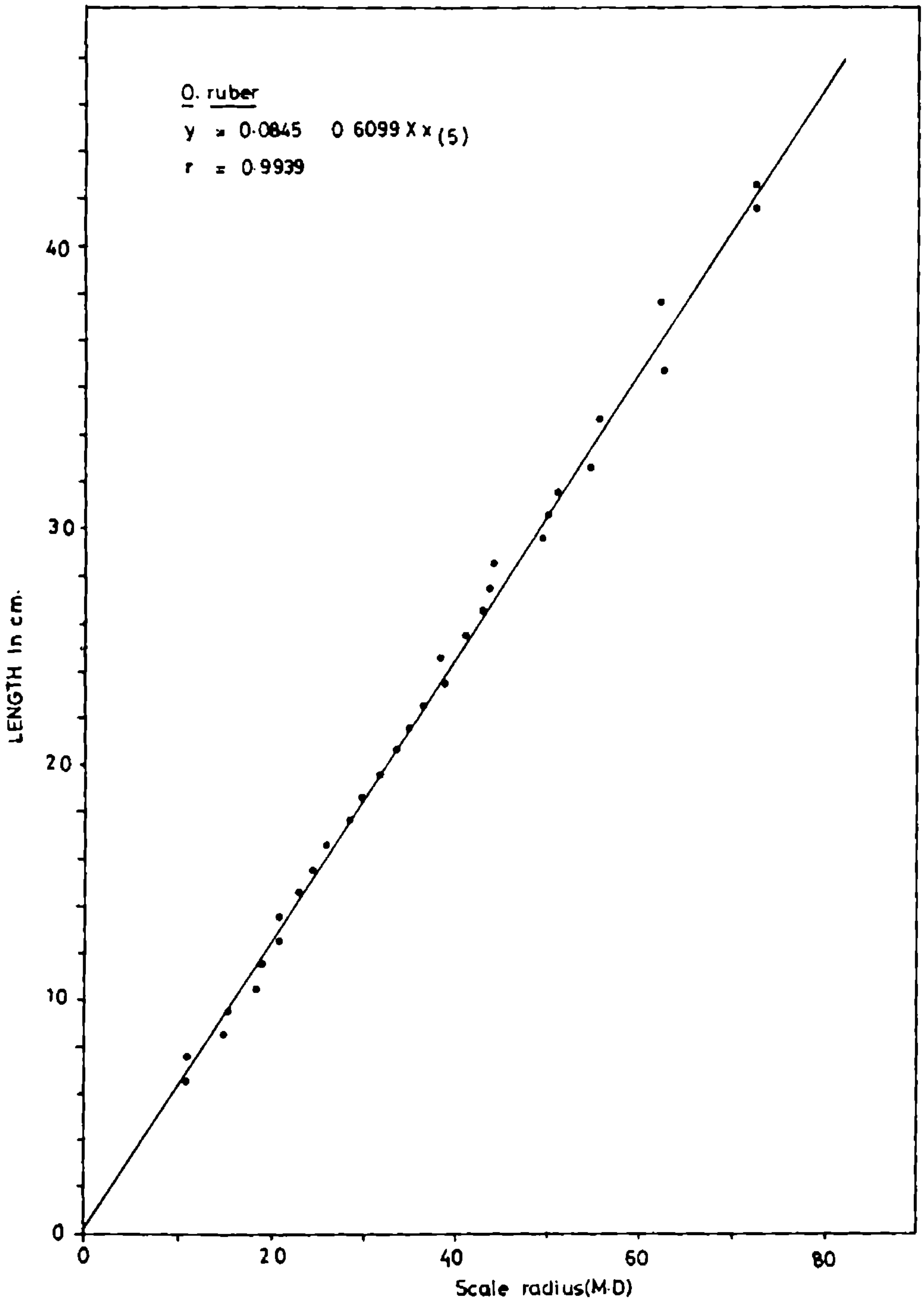


Figure 28 : Length scale relationship for O. ruber (Length - T.L. in cm).

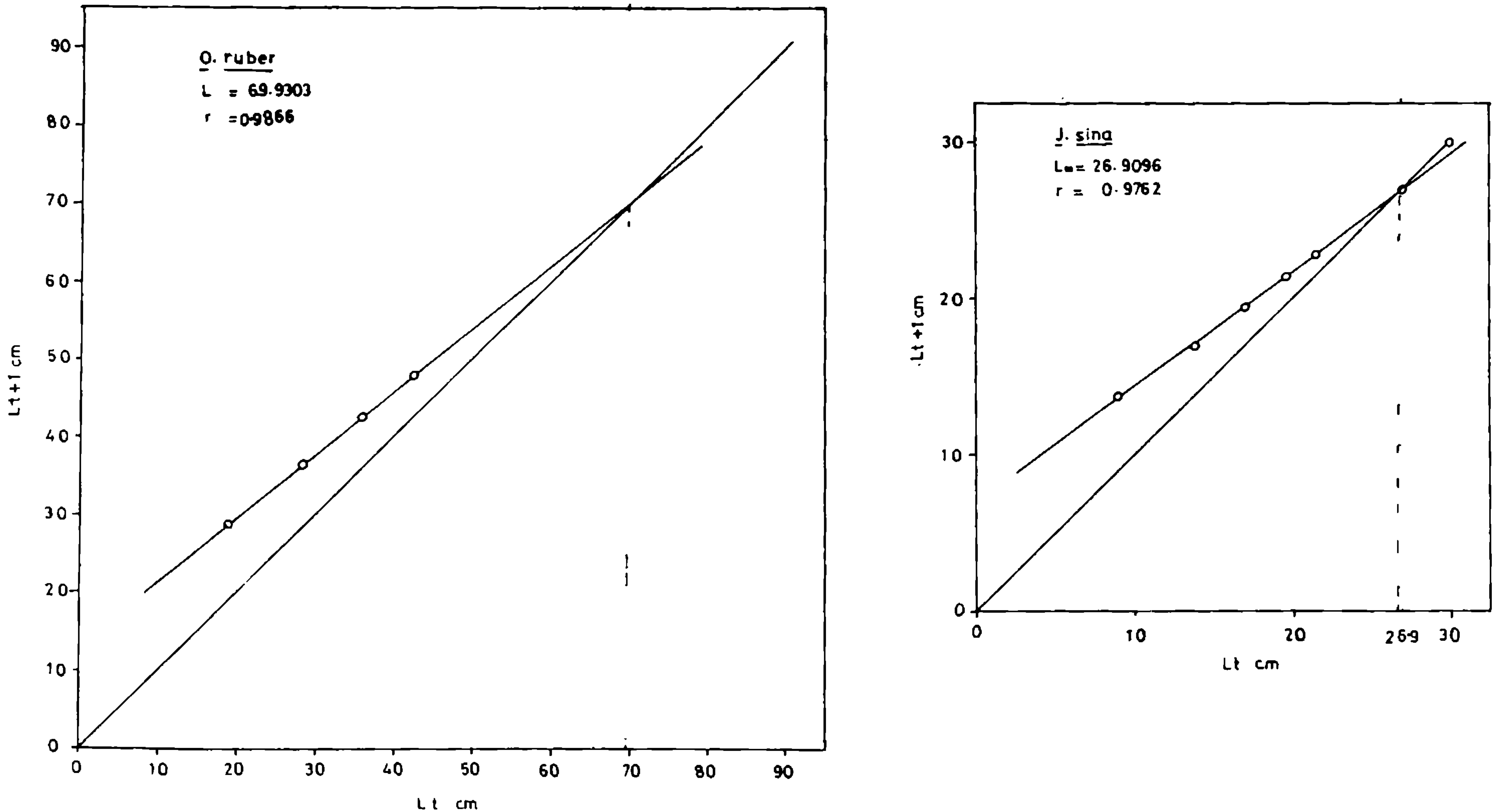


Figure 29 Ford - Walford plot for _J. sina_ and _O. ruber_ based on scale analyses.

Table 21 Age and growth of some sciaenids from Indian waters.

Sr. No.	Species	Method used	Maximum age in years	Maximum length in cm.	Length at ages in cm.	Place	Author
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	*Johnius dussumieri*	Length frequency	3	25.0	11.5(1),19.5(2)	Bombay	Savant (1963)
2.	*Nibea coiber*	Length frequency	5	69.7	12.6(0),25.1(1) 37.3(2),49.2(3) 60.5(4),68.1(5)	Chilka lake	Rajan (1964)
3.	*Johnieops sina*	Length frequency and scale	3	21.5	13.5(1),16.5(2), 18.5(3)	Calicut	Nair (1974)
4.	*Johnieops vogleri*	Length frequency	3	29.0	15.8(1),24.0(2) 28.0(3)	Bombay	Muthiah (1982)
5.	*Johnius carutta*	Length frequency	3	25.9	10.5(1),18.5(2) 22.3(3)	Madras	Vivekanandan(1985)
6.	*Pennahia macrophthalmus*	Length frequency	2½	32.0	13.1(1),19.5(2) 20.7(2½)	Mandapam	Mohan (1977)

Contd....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
7.	*Otolithoides biurites*	Scale	12	149.0	41.8(1),60.2(2) 74.1(3),83.0(4) 108.0(5),127.0 (6),135.0(7), 136.0(8),138.5 (9), 142.0(10), 148.2(11),149.0 (12)	Bombay	Kutty (1961)
		Vertebra	4	Not given	42.6(1),61.2(2)	Bombay	Jayprakash (1973)
		Length prequency	4	Not given	40.7(1),60.0(2), 80.0(3),95.5(4),	Bombay	Jayprakash (1977)
		Scale	4	-"-	40.7(1),57.8(2), 75.6(3),91.3(4)	Bombay	Jayprakash (1977)
8.	*Protonibea dicanthus*	Length frequency	7	117.5	42.6(1),61.9(2), 77.9(3),89.7(4), 98.3(5),104.7 (6),109.3(7), 112.7(8)	Bombay	Venkata-subba Rao (1963)
		Otolith	5	117.5	44.0(1),68.0(2), 83.0(3),92.0(4), 97.0(5)	Bombay	Venkata-subba Rao (1966)
		Scale	8	117.5	42.0(1),64.0(2), 80.4(3),90.4(4), 98.0(5),104.9 (6),109.9(7), 114.0( )	Bombay	Venkata-subba Rao (1966)

Contd.....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Length frequency	7	127.0	44.0(1),60.9(2), 76.9(3),90.3(4), 100.1(5),105.7 (6),115.2(7)	Bombay	Sreeni-vasa Rao (1968)
		Scale	7	127.0	40.0(1),64.2(2), 80.5(3),90.3(4), 101.0(5),105.7 (6)	Bombay	Sreeni-vasa Rao (1968)
9.	*Nibea chui*	Length frequency	4	75.0	26.0(1),41.0(2), 51.0(3),61.0(4)	Chilka lake	Devadoss (M.S.)

Table 22 Set of modes used for estimation of L∞, in *J. sina*.

Sr. No.	Set of modes(cm) M1	M2	M3	L∞ cm	Sr. No.	Set of modes(cm) M1	M2	M3	L∞ cm
1.	7.0	9.5	11.5	19.5	20.	9.0	13.5	16.5	22.5
2.	7.0	11.5	13.0	13.7	21.	9.5	11.5	13.0	17.5
3.	7.0	11.5	13.5	15.1	22.	9.5	14.5	17.5	22.0
4.	7.0	11.5	14.0	17.1	23.	10.5	13.0	15.0	23.0
5.	7.0	11.5	14.5	20.4	24.	11.5	13.0	13.5	13.7
6.	7.0	11.5	15.0	27.2	25.	11.5	13.5	15.0	19.5
7.	7.5	10.0	12.0	20.0	26.	12.0	13.5	14.0	14.2
8.	7.5	12.0	15.0	21.0	27.	12.0	13.5	14.5	16.5
9.	7.5	12.5	15.0	17.5	28.	13.5	15.0	15.5	15.7
10.	7.5	12.5	16.5	32.5	29.	14.0	16.5	19.5	1.5
11.	8.0	11.5	13.0	14.0	30.	14.5	16.5	17.0	17.0
12.	8.0	11.5	14.5	32.5	31.	14.5	16.5	17.5	12.5
13.	8.0	12.0	14.5	18.6	32.	14.5	17.5	19.5	13.5
14.	8.0	12.0	15.0	24.0	33.	15.0	16.5	17.0	17.25
15.	8.0	13.0	16.5	24.7	34.	15.0	16.5	17.5	19.5
16.	9.0	11.5	13.0	15.3	35.	15.0	17.5	18.5	19.2
17.	9.0	11.5	13.5	21.5	36.	15.0	17.5	20.5	2.5
18.	9.0	13.0	15.0	17.0	37.	16.5	18.5	19.5	20.5
19.	9.0	13.0	17.5	23.0					

Table 23 Set of modes used for estimation of L∞ in *O. ruber*

Sr. No.	Set of modes (cm) M1	M2	M3	L∞ cm
1.	6.5	13.5	19.5	55.4
2.	6.5	14.5	21.5	70.5
3.	6.5	16.5	25.5	106.5
4.	7.5	15.5	22.5	71.5
5.	7.5	17.5	26.5	107.5
6.	8.5	12.5	15.5	24.5
7.	8.5	14.5	19.5	44.5
8.	8.5	15.5	21.5	39.5
9.	8.5	16.5	22.5	40.5
10.	9.5	18.5	26.5	90.5
11.	9.5	19.5	26.5	42.3
12.	9.5	19.5	28.5	109.5
13.	10.5	18.5	25.5	74.5
14.	10.5	18.5	26.5	9.0
15.	10.5	18.5	28.5	21.5
16.	10.5	19.5	26.5	50.9
17.	10.5	20.5	26.5	37.6
18.	10.5	20.5	28.5	60.5
19.	10.5	20.5	29.5	110.5
20.	10.5	21.5	30.5	70.9
21.	11.5	19.5	26.5	75.5
22.	11.5	20.5	28.5	92.5
23.	12.5	19.5	25.5	61.4
24.	13.5	19.5	25.5	61.5
25.	13.5	20.5	26.5	62.5
26.	13.5	21.5	26.5	34.5
27.	13.5	21.5	28.5	77.5
28.	14.5	22.5	29.5	78.5

Table 24 Average of modes based on selected set of modes and estimated values of various parameters.

Species	Average length in cm.			Values of parameters			
	M1	M2	M3	$L\infty$	K	T	M
J. sina	7.75	12.0	15.5	31.8	0.1942	21	0.2152
O. ruber	12.5	20.5	27.5	76.5	0.1335	38	0.1212

Table 25 Lengths at various ages based on first three modes.

Age in year	Age in units of time	Length at ages in cm. *J. sina*	*O. ruber*
0	1	7.75	12.5
	2	12.0	20.5
	3	15.5	27.5
1	4	18.38	33.63
	5	20.76	38.98
	6	22.71	43.67
	7	24.32	47.78
2	8	25.64	51.37
	9	26.74	54.51
	10	27.64	57.26
	11	28.38	59.66
3	12	28.99	61.77
	13	29.49	63.61
	14	29.90	65.22
	15	30.24	66.63
4	16	30.52	67.86
	17	30.75	68.94
	18	30.94	69.89
	19	31.10	70.71
5	20	31.22	71.44

(In both species, first three lengths for first three units of time were taken from length-frequency analysis and next lengths for further units of time were estimated from earlier first three lengths).

Table 26 : Observation of rings in scale of *J. sina.*

Length (cm.)	No. of fish observed	Rings observed in fishes						
		0	1	2	3	4	5	6
7.0	5	4	1					
7.5	7	5	2					
8.0	9	4	5					
8.5	10	7	3					
9.0	6	3	3					
9.5	5	2	3					
10.0	8	2	6					
10.5	4	2	2					
11.0	12	5	7					
11.5	7	1	6					
12.0	11	1	10					
12.5	20	7	11	2				
13.0	27	8	6	13				
13.5	23	7	0	16				
14.0	19	5	0	14				
14.5	26	2	0	24				
15.0	33	3	0	26	4			
15.5	30	2	0	28	0			
16.0	37	1	0	28	8			
16.5	32	1	0	26	5			
17.0	31	0	0	6	25			
17.5	45	0	0	0	42	3		
18.0	23	0	0	0	23	0		
18.5	15	0	0	0	8	7		
19.0	16	0	0	0	12	4		
19.5	10	0	0	0	4	6		
20.0	0	0	0	0	0	0		
20.5	9	0	0	0	0	9		
21.5	1	0	0	0	0	0	1	
23.5	1	0	0	0	0	0	0	1
	482	72	65	183	131	29	1	1

Table 27 Observation of rings in scale of *O. ruber*

Length (cm.)	No. of fish observed	Rings observed in fishes					
		0	1	2	3	4	5
12.5	16	16					
13.5	18	18					
14.5	21	17	4				
15.5	62	37	25				
16.5	78	31	47				
17.5	70	26	44				
18.5	59	21	38				
19.5	48	6	42				
20.5	53	7	46				
21.5	43	2	41				
22.5	19	0	19				
23.5	9	0	9				
24.5	3	0	2	1			
25.5	8	0	1	7			
26.5	13	0	0	13			
27.5	11	0	0	11			
28.5	10	0	0	10			
29.5	6	0	0	6			
30.5	8	0	0	8			
31.5	2	0	0	2			
32.5	0	0	0	0			
34.5	2	0	0	0	2		
36.5	1	0	0	0	1		
39.5	1	0	0	0	1		
43.5	1	0	0	0	0	1	
44.5	1	0	0	0	0	1	
51.5	1	0	0	0	0	0	1
	530	147	318	58	4	2	1

Table 28 : Mean back-calculated lengths (T.L. in cm.) of *J. sina* from scales.

Age ?	No. of fish exa-min-ed	Mean length at capture cm.	Mean back-calculated length at successive rings in cm.					
			I	II	III	IV	V	VI
1	65	8.9	7.33					
2	183	10.8	9.33	13.87				
3	131	15.7	9.8	13.86	16.83			
4	29	20.8	8.5	14.25	17.59	19.43		
5	1	Samples not	9.5	13.52	16.90	19.34	20.92	
6	1	suffi-cient	9.2	14.36	16.78	19.49	21.90	22.88
Total	410	Weig-ted mean	9.09	13.89	16.97	19.42	21.41	22.88
Growth increment			9.09	4.8	3.08	2.45	1.99	1.47

? = Age may be yearly, six monthly, quarterly or monthly.

Table 29 Mean back-calculated lengths (T.L. in cm.) of *O. ruber* from scales.

Age ?	No. of fish examined	Mean length at capture cm.	Mean back-calculated length at successive rings in cm. I	II	III	IV	V
1	318	19.1	18.91				
2	58	27.9	18.83	24.48			
3	4	Samples not sufficient	19.09	28.06	36.81		
4	2		17.86	28.86	34.99	42.15	
5	1		20.22	28.12	37.63	43.67	47.82
Total	381	Weighted mean	18.90	28.46	36.40	42.66	47.82
Growth increment			18.90	9.56	7.94	6.28	5.16

? = Age may be yearly, six monthly, quarterly or monthly.

Table 30 Number of growth checks and corrosponding lenghts - 1) observed 2) back-calculated 3) length-frequency analysis.

J. sina

Range of fish length cm.	Assigned ages ?	No.of growth rings	Mean length at capture cm.	Back-calcu-led length cm	Length from length frequency cm.
7.0-12.0	0	0	8.9	-	7.75
7.0-13.0	1	1	10.8	9.09	12.0
12.5-17.0	2	2	15.65	13.89	15.5
15.0-19.0	3	3	20.86	16.97	Overlapping of modes
18.0 Onwards	4	4	Not sufficient samples	19.42	
	5	5		21.41	
	6	6		22.88	

O. ruber

-18.5	0	0	9.0	-	12.5
14.5-25.5	1	1	19.02	18.9	20.5
24.5-31-5	2	2	27.9	28.46	27.5
30.0 Onwards	3	3	Not sufficient samples	36.40	Overlapping of modes
Not sufficient samples	4	4		42.66	
	5	5		47.82	

? = Age may be year, six months, quarter of a year or month.

CHAPTER -IV POPULATION DYNAMICS AND MANAGEMENT

Fishery is an activity concerned with fish. Fish stocks are affected by fishery independent and fishery dependent factors. Fishery independent factors such as salinity, temperature etc. are not easily controllable. However, when these vary within the allowable margins, the stocks are not affected by them. When fishery is in stable or an equalibrium condition, stocks are affected by fishery dependent factors, such as method of exploitation, intensity of effort, mesh size. These factors are controllable. Hence under normal conditions, stocks can be exploited in such a way as to yield at MSY levels. Information regarding fish stocks and the effect of fishing on them help in taking managerial decisions. Factors such as fishing mortality (F) and size at first capture (Lc) are needed for this purpose.

In the present study, Beverton and Holt's yield per recruit model (Y/R) is used and effect of various changes in length at first caputure (Lc) and exploitation rate (E=F/Z) have been studied. Length at first capture (Lc) is the length of fish at which 50% fishes escape through the gear. Exploitation rate (E=F/Z) is a derived measure calculated from instantaneous fishing mortality (F) and instantaneous total mortality (Z). Beverton and Holt's model gives yield but per recruit basis. So it is called yield per recruit. Materials and methods are given below.

Material and Methods:

Fishing area : From Ganapatipule, north of Ratnagiri ($17^{O}13'30''$ N, $73^{O}14'50''$ E) to Pawas south of Ratnagiri ($16^{O}53'10''$ N, $73^{O}15'25''$ E) and from shore to westward upto 50 m depth was the fishing area (Fig. 1).

Craft : The wooden trawlers 12 to 16 m in length operated off Ratnagiri were considered for sampling.

Gear The above trawlers were using the following trawl net.

1) Two seam trawl net
2) Twine used - garfil
3) Thickness of twine - 1.25 mm.
4) Length of head rope - 20 m.
5) Length of foot rope - 22 m.
6) Floats 12 to 14 in numbers, diameter - 15 cm. metal aluminium.
7) Iron chain for foot rope - 10 mm, 80 kg.
8) Otter board (a pair) - 60 kg. each.
9) Codend mesh size - 12 to 15 mm.

Selection of a day for observation Landings at Mirkarwada Fisheries harbour were observed on alternate days in each month for two years during September to May. One day out of two first fishing days in a week was selected randomly and then followed alternate days.

Time of observation Regular landings at fisheries harbour take place in between 4,00 p.m. and 8.00 p.m. during which period landings were observed.

Selection of units : Number of trawlers to be expected to land was ascertained by making local enquiries on the day of observation. For selection of units systematic random sampling procedure was followed (Alagraja, 1984).

If units were 15 or less, then all units were observed. Regularly more than 50 trawlers used to land their catches. In such circumstances the selection of units was done as follows. The number of units expected to land were divided by ten and groups of units were formed. The number of units may not be exactly in multiple of tens. In such cases, the last of the exact multiples of ten in the number of expected units was taken. For example, if 67 is the number of expected units, then the last exact multiple of ten in the number is 60 and the sampling interval for selection of units is 60/10 = 6. From the first six units, one unit was selected randomly and the rest systematically keeping the interval of 6. Suppose 4th unit was selected randomly, then the systematically selected ones were 4th, 10th, 16th and so on till the 67th. By this way the units selected were in between 10 and 12.

Observation of Units The fishermen used to sort out the multispecies catch into groupwise fishes (like ribbon fish, catfish, elasmobranchs, sciaenids) and put them into separate baskets on board. The catches were landed in baskets each of which contained approximately 25 - 26 kg. of fish. Number of baskets varied from one unit to other and from one day to other. For each selected unit, number of baskets were counted for different groups of fishes and converted into total weights for each group of fish. Thus groupwise fish landings in kg. were noted for each unit. Such observations were made for 10-12 number of selected units. Those were used in estimating the total landings for groupwise, unitwise and groupwise for all units landed. Total number of units which landed the catch on that day was noted as effort.

The fish caught by the trawlers off Ratnagiri upto 50 m depth were landed at Mirkarwada fisheries harbour from where samples were collected on the same day of observation of units for study purposes. For this out of observed units two units were selected randomly. From each selected unit one basket containing sciaenids was selected randomly. The selected basket was shaken for well mixing of the sciaenid species and one to two kg. of fish sample was taken from the basket. While sampling ut at most care was taken to make the sample more representative of the day's catch. This was followed for the second unit. Two samples were stored together in deep freezer overnight.

Raising the observed landings for a day The group-wise landings for each unit were recorded. Those groupwise landings were added together and groupwise total of observed units raised for that day as follows.

$$\text{Total landings of a fish group for a day of observation. (kg.)} = \text{Total landings of a fish group observed (kg.)} \times \frac{\text{Total number of units landed the catch on that day}}{\text{Number of units observed on that day.}}$$

Raising the catch for a month The above estimated groupwise landings were pooled for a month and raised for that month as follows.

$$\text{Total landings of a group of fish for a month (kg.)} = \text{Sum of daily estimated landings of a group of fish for a month (kg.)} \times \frac{\text{Number of fishing days in the month}}{\text{Number of fishing days observed in the month}}$$

Raising samples to total catch in number by length groups : The sample stored in deep freezer was thawed, washed and water drained out completely. This sample was weighed and J. sina and O. ruber sorted out and weighed. Numbers of J. sina and O. ruber were counted Their lengths (T.L.) were measured in cm. The following steps were followed for raising the number by length groups for a month.

$$\text{Total wt. of } \textit{J. sina} \text{ landed on the day of observation (kg.)} = \text{Total wt. of } \textit{J. sina} \text{ in the sample (kg)} \times \frac{\text{Total estimated landings of sciaenid for that day (kg)}}{\text{Total wt. of the sciaenid sample (kg) taken on that day.}}$$

$$\text{Total number of } \underline{J.\ sina} \text{ landed on the day of observation (kg)} = \text{Total number of } \underline{J.\ sina} \text{ in the sample} \times \frac{\text{Total estimated wt. of } \underline{J.\ sina} \text{ landed on that day (kg)}}{\text{Wt. of } \underline{J.\ sina} \text{ in the sample (kg) taken on that day.}}$$

$$\text{Total number of } \underline{J.\ sina} \text{ of a particular length group landed on the day of observation} = \text{Number of } \underline{J.\ sina} \text{ of a particular length in the sample} \times \frac{\text{Total estimated number of } \underline{J.\ sina} \text{ landed on that day}}{\text{Total number of } \underline{J.\ sina} \text{ in the sample taken on that day.}}$$

Thus the length-frequencies of both the species were raised to the total by the above methods. The length-frequencies (estimated) were pooled for a month and raised for the month as follows-

$$\text{Total Number of } \underline{J.\ sina} \text{ of a particular length group landed during a month} = \text{Total estimated number of } \underline{J.\ sina} \text{ in a particular length group during the observation days in the month} \times \frac{\text{Number of fishing days in the month}}{\text{Number of fishing days observed in the month.}}$$

Thus length-frequencies of both species were raised for a month for all length groups.

Catch-effort data

Method of collecting catch data for a day and raising for the month are given in the earlier paragraphs. Regarding effort, while collecting the catch data, number of boats to be landed on that day was ascertained. Effort was raised for a month by following way.

$$\text{Total effort for a month} = \text{Total number of fishing days in that month} \times \frac{\text{Number of units operated on the days of observations in that month}}{\text{Total number of days observed in that month.}}$$

Growth parameters Estimates of $L\infty$, $W\infty$ and K have been obtained in the chapter, Age and Growth. (Table 24).

Length at first capture The first prominent mode observed of the length frequency was taken as the length at first capture (Lc) in this thesis.

Length at recruitment When there was a mode prior to the mode of length at first capture, then it was taken as the length at recruitment.

Length at first maturity: This aspect has been studied in the chapter, Reproductive Biology (Fig. 14).

Longevity This aspect has been delt with in the chapter Age and Growth (Table 24).

Natural mortality Natural mortality was estimated by applying the method of Sekharan (1975). The concept is that if fish is allowed to live throughout it's life and exposed to natural mortality then at the end, 99% of a cohort dies. $\frac{N_T}{N_0} = e^{-MT} = 0.01$

$$\therefore M_{1}\% = -\frac{I}{T} \; Ln\ (0.01)$$

Where, $M_1\%$ = natural mortality corrosponding to 1% survival

T = longevity of fish.

Total mortality : Using length frequency data (Table 35 to 39) and following the method of Alagaraja (1984) estimates of 'Z' for two years for two species have been obtained. That portion of the length frequency distribution which resembled the right limb of catch curve alone was considered for estimation of 'Z'.

Relative yield per recruit : The values obtained from above were used and Beverton and Holt's relative yield per recruit values have been obtained using the Lotus software available at C.M.F.R.I. Different values were obtained for various levels of E and Lc.

Fishing mortality It was obtained by substracting natural mortality from total mortality (F=Z-M).

Results :

The estimates on $L\infty$ and K have already been obtained in the previous chapter. The asymptotic weights expected to be attained by *J. sina* and *O. ruber* were estimated as 487 gm. and 4687 gm. respectively using the formula $W\infty = a \times L^{b}\infty$. The sizes at first capture (Lc) of *J. sina* and *O. ruber* were 14.0 and 17.5 cm. The sizes at first capture for *J. sina* during 1986-87 and 1987-88 were 12.5 and 14.0 cm. These values were obtained from the length frequency table as follows-

First three point moving averages have been taken from the frequencies for those two years to smoothen the distribution.

In the smoothened distribution the segment that could be taken for estimating Z using the method of Alagaraja (1984), from 12.5 to 22.5 cm. covers the size ranges from 12.5 to 21.0 cm. during 1986-87 and from 15.0 to 22.5 cm. in 1987-88. This segment was taken for estimating total mortality rate (Z) since, it satisfied their requirements of the right segment of catch curve. Hence for the present study 14.0 cm was taken as Lc, the size at first capture. Similarly in the case of O. ruber, the segments of selection for estimating Z started from 16.5 and 18.5 cm. in the year 1986-87 and 1987-88 respectively were taken and Lc was determined as 17.5 cm.

The size at recruitment was taken as size at which the mode appeared prior to Lc. The case of J. sina, respective sizes at Lr were 7.5 and 9.0 cm. during the two years respectively and in the case of O. ruber they were 11.5 cm in both the years. Hence Lr for J. sina was taken as 8.0 cm and for O. ruber 11.5 cm. The Table (31) gives the estimates of all parameters required for arriving at yield per recruit for these species. The table also contains the estimates of exploitation ratio (E) and the values of 'F' and other related values such as $Lc/L\infty$, Lr/Lc, etc.

Fishing mortality rates ($\bar{Z}$) were estimated for two years for each species by using Alagaraja's method (1984). Length-wise individual values which were beyond 95% confidence limit were omitted from estimation fo $\bar{Z}$ values. Including all the values, estimated $\bar{Z}$ values for two years together were 2.0180 $\pm$ 2(0.3836) and 3.4073 $\pm$ 2(0.4549) for *J. sina* and *O. ruber* respectively. Excluding the values which were beyond 95% confidence limit, average values were estimated as 1.7432 and 3.5752 for *J. sina* and *O. ruber* respectively. These values were within the $\dot{Z} \pm 2(SD)$ values estimated by considering all the values. Therefore, the average $\bar{Z}$ values, 1.7432 and 3.5752 for *J. sina* and *O. ruber* were taken safely for further analysis.

Yield per recruit analysis : Yield, effort curves indicated in the Figures (30-45) for these two species gave the relative yield per recruit values only. In order to arrive at the actual yield per recruit values, their relative yield per recruit values have to be multiplied by Woo X $e^{-M(tc-tr)}$. The raising factor for *J. sina* and *O. ruber* have been estimated as 353 and 4284 respectively as given in the Table (31).

J. sina The relative yield per recruit curve and relative biomass per recruit curve at the present rate of exploitation with Lc/L∞ = 0.44 and M/K = 1.10, have been obtained using the Lotus software available at C.M.F.R.I. (Fig.30-38). The exploitation rate (E = F/Z) was estimated 0.88 which is very high indicating very high fishing intensity. From the above Table (31), the estimates of M = 0.22 and F = 1.53. From these two values it is clear that F is more than seven times of M. This fact has been clearly brought out in the Figure(34) where the present level of exploitation falls to the right side of the level for exploiting maximum yield. The level at which the maximum Y/R could be obtained is indicated in the Table (42) as E max. In this case E max is 0.62 which is far below the present level of exploitation (0.88). In order to obtain maximum sustainable yield (MSY) at the present level of size at first capture (Lc), the level of exploitation should be less than present level of exploitation. In other words, the instanteneous fishing mortality rate should be brought down to 0.36 This value may be denoted as F max $\left[= \frac{M \times E\ max}{1 - E\ max}\right]$. In order to obtain MSY, it is clear that a reduction of 76% in the effort is needed $\left[= \frac{1.53 - 0.36}{1.53} \times 100\right]$ The relative yield per recruit at E max is 0.0725. Hence Y/R at E max is 25.6 gms (0.0725 X 353).

In order to find out whether change in mesh size in other words change in values of Lc will lead to higher MSY, the estimates of relative Y/R for different $Lc/L\infty$ were obtained and given in Figures and Tables. For the lower values of Lc the relative Y/R values at respective E max were less than the present relative Y/R at the corrosponding E max of 0.617. (Fig 30-38 Table 42, 44). It is clear from the observations that it is not worth reducing the mesh size.

The higher values of Lc indicated higher yields per recruits (Fig. 30 - 38 Table 42, 44). This clearly suggests that mesh size can be increased to higher levels in order to reap higher MSY.

The size at first maturity for *J. sina* has been estimated just below 12 cm. in the earlier chapter. The Lc, the size at first capture for this species has been taken as 14.0 cm. which is above the size at first maturity. Hence existing mesh size does not appear to be harmful to the fishery. However reduction in the intensity of fishing in other words the number of fishing units may be reduced by 76% as indicated above to maximise the yield.

Similar results are available when the estimates on relative biomass per recruit (B'/R) considered (Fig. 30 to 38 and 39 to 45). In that B'/R values at E max does not vary much.

O. ruber :

The present exploitation rate 'E' has been estimated at 0.97. It appears to be extremely high indicating the effort pressure put on this stock of *O.ruber* off Ratnagiri is highly intensive. The Y'/R obtained using the Beverton Holt model (1956) with the aid of computer Lotus software available at C.M.F.R.I. presented in Tables 43 and Figures 39 - 45 for different values of Lcs as in the case of *J. sina*. These include Tables and Figures for different values of Lcs. For the present level of exploitation E max was found to be equal to 0.50 which is for below than the present level of E (0.97). This clearly indicates a reduction of effort by about 96 % is required to obtain MSY. The instantaneous fishing mortality rate F (3.4540) is about 28 times of instantaneous natural mortality rate (0.1212). This reflects the level of intensity of fishing effort on the stock of *O. ruber* at different levels of Lc. At the present level of exploitation, E = 0.97 the Y/R is 54.2 gms against the 311 gm for at E max 0.50, In order to find out whether changes in mesh size in other words changes in size at first capture have any effect on MSY, estimates on Y'/R have been obtained (Table 43, 44 Fig. 39 to 45).

In this case also for lesser values of Lc, the MSY values were less than that for present Lc value indicating reduction in mesh size leads to reduction in the Y/R (Table 43).

When values of Lcs are increased the corrosponding Y'/R values also increased. Hence increase in mesh size is favourable in this case. The size at first maturity of this fish was estimated at about 20.0 cm. whereas the size at first capture was found to be 17.5 cm. which is less than the size at first maturity. Hence in the case of *O. ruber* mesh size has to be increased not only to reap higher Y /R but also to allow the stock to spawn once atleast before being captured.

Discussion.

It may be noted that in the case of *J. sina*, the size at first capture is higher than the size at first maturity. This indicates present mesh size does not appear to be harmful to this fishery. However, increase in mesh size leads to increase in Y/R as mentioned earlier. In *O. ruber*, the size at first capture is less than the size at first maturity. Hence, it is imperative that mesh size has to be increased so that size at first maturity is always less than or at least equals size at first capture.

Figure 30 to 45 and Table 42 to44 show that the present levels of effort are high indicating that the two species are under high exploitation rate. For obtaining maximum Y/R for present mesh size, the effort are to be reduced by 76% and by 96 % for J. sina and O. ruber respectively. As compared to that of J. sina, higher reduction in units of fishing effort is therefore required in the case of O. ruber for obtaining maximum Y/R.

Though Y/R attains maximum when $Lc/L\infty$ is 0.75 for both species, the corrosponding exploitation ratios were almost nearer to 1.0 which is unrealistic (Table 44). By reducing the effort and by increasing mesh size, there is ample scope to increase yield for this fishery. Increase in mesh size to 30mm will go a long way to yield more landings in future and also their stocks will not be affected by fishing.

Having this in view, it is suggested for the increase of codend mesh size and if possible in reduction in number of units exploiting the fishery. In terms of Socio-economics, though reduction in number of units may not be acceptable, it is worth trying to impose mesh size regulation so that the codend mesh size is considerably increased.

Shrimp trawlers are mainly used for catching prawns in Ratnagiri waters. During trawling demersal fishes are also caught along with prawns. There is no different gear presently used for catching demersal fishes. As such present trawl fishery has not only affected sciaenid stock but also other fish stocks. In order to arrive at a suitable codend mesh size to exploit all these groups a seperate study is required.

From the above studies, it is clear that sciaenids were found not to be the only target species for trawl fishery. Hence, while deciding the suitable level of effort and codend mesh size for the trawls for any group exploited by them, consideration for at least the major groups exploited by the trawls, is to be given. Thus while deciding the suitable level of effort (F) and codend mesh size (Lc), these points are to be born in mind. As mentioned earlier, reduction in effort though may not be advisable in socio-economic point of view, codend mesh size may effectively be regulated so that ultimate beneficiary would be fishermen themselves. Hence increase in the codend mesh size at least to 30mm is worth attempting.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0105471	.919139	0.55	.0688594	.258410
0.10	.0203606	.840485	0.60	.0690845	.211244
0.15	.0294015	.764176	0.65	.0681757	168376
0.20	.0376290	.690364	0.70	.0661433	.130018
0.25	.0450006	.619207	0.75	.0630272	.096361
0.30	.0514733	.550877	0.80	.0589086	.067548
0.35	.0570031	.485556	0.85	.0539271	.043649
0.40	.0615467	.423440	0.90	.0482997	.024615
0.45	.0650621	.364732	0.95	.0423438	.010222
0.50	.0675107	.309648	1.00	.0364888	.000000

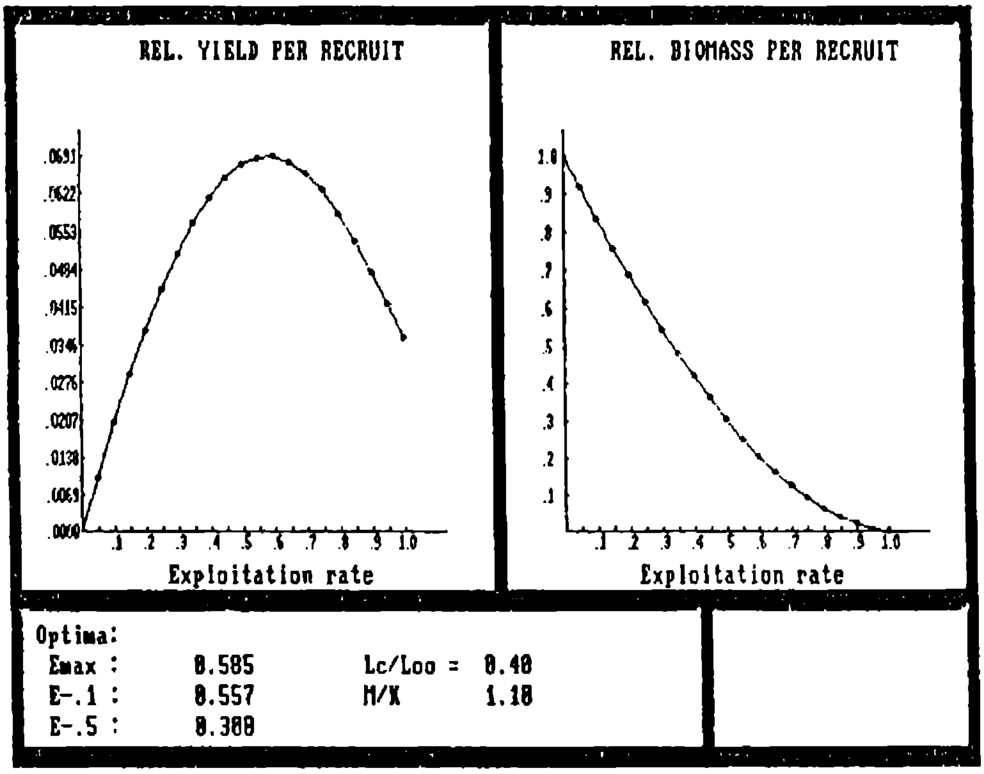


Figure 30 Relative yield per recruit and relative biomas per recruit values in J. sina for Lc/Loo = 0.40.

E	Y /R	B /R	E	Y /R	B /R
0.05	.0105208	.919777	0.55	.0693755	.261971
0.10	.0203253	.841706	0.60	.0699719	.214641
0.15	0293750	.765924	0.65	.0692465	.171566
0.20	.0376294	.692577	0.70	.06 4049	1[illegible]
0.25	.0450468	.621821	0.	.0644818	.0[illegible]8900
0.30	.0515842	.553827	0.80	.0605505	06[illegible]653
0.35	.0571980	488772	0.85	.0557401	.04[illegible]261
0.40	.0618446	.426848	0.90	.0502546	025[illegible]
0.45	.0654918	368257	0.95	.0443952	010751
0.50	.0680702	.313211	1.00	.0385745	.000000

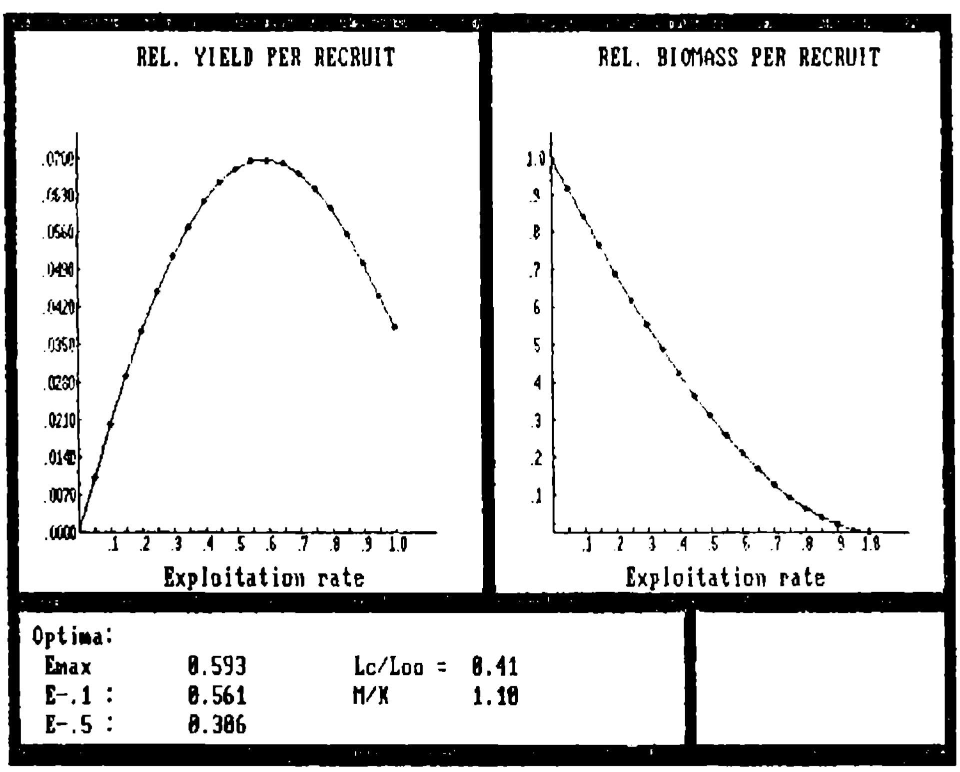
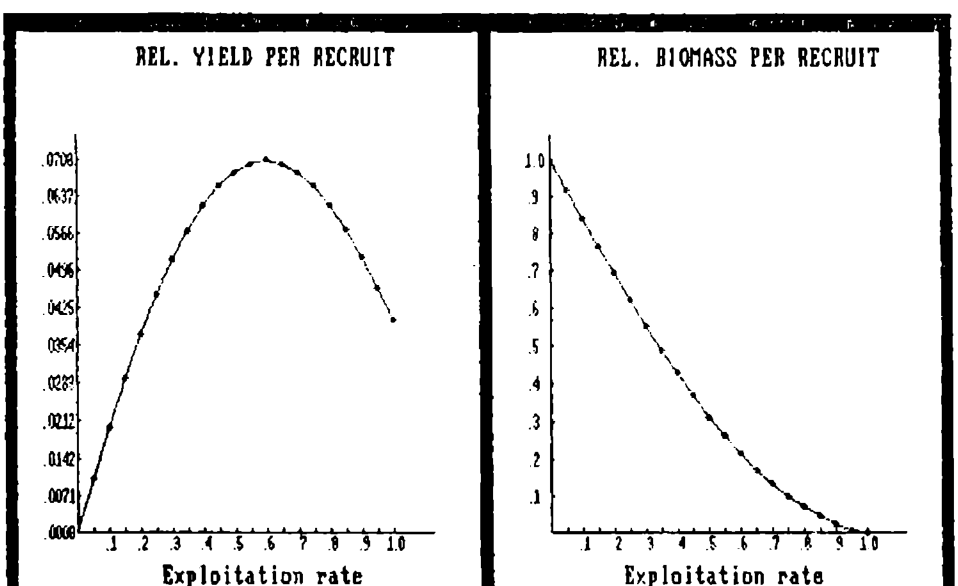


Figure 31 Relative yield per recruit and relative biomass per recruit values in *J. sina* for Lc/L∞ = 0.41.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0104920	.920413	0.55	.0702717	
0.10	.0202849	.842924	0.60	.0708100	[illegible]
0.15	.0293409	.767667	0.65	.0702990	[illegible]
0.20	.0376200	.694785	[illegible]	.0686510	[illegible]
0.25	.0450809	.624433	[illegible]	.0659244	[illegible]
0.30	.0516809	.556774	0.80	.0621054	[illegible]
0.35	.0573767	.491986	0.85	.0575532	[illegible]
0.40	.0621248	.430257	0.90	.0522107	[illegible]
0.45	.0658826	.371786	0.95	.0464671	[illegible]
0.50	.0686100	.316781	1.00	.0406939	.000000



Optima:			
Emax	0.601	Lc/Loo =	0.42
E-.1	0.571	M/K	1.10
E-.5 :	0.384		

Figure 32 Relative yield per recruit and relative biomass per recruit values for J. sina for Lc/L∞ = 0.42.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0104605	.921047	0.55	.0709461	.269002
0.10	.0202397	.844139	0.60	.0716865	.221474
0.15	.0292909	.769406	0.65	.0713311	.177996
0.20	.0376001	.696990	0.70	.0698785	.138786
0.25	.0451021	.627040	0.75	.0673520	.104041
0.30	.0517626	.559719	0.80	.0638103	.073928
0.35	.0575384	.495199	0.85	.0593628	.048547
0.40	.0623861	.433667	0.90	.0541881	.027902
0.45	.0662630	.375317	0.75	.0485553	.011843
0.50	.0691286	.320357	1.00	.0428429	.000000

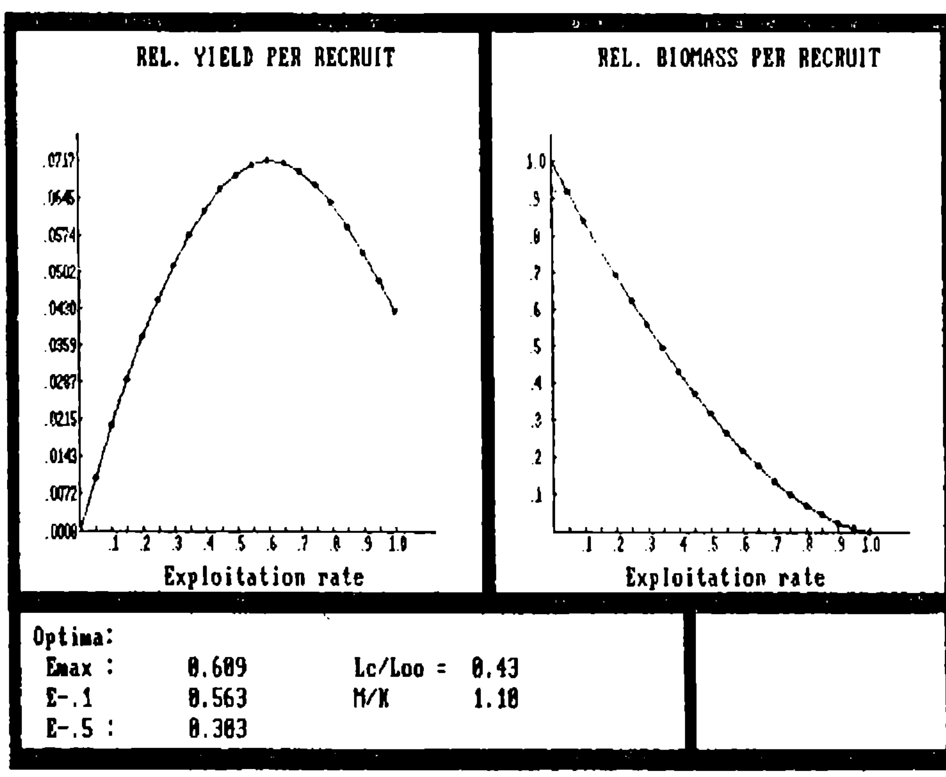


Figure 33 : Relative yield per recruit and relative biomass per recruit values for J. sina for Lc/Loo = 0.43.

E	/R	B'/R	E	/R	B'/R
0.05	.0104261	.921679	0.55	.0715968	.272550
0.10	.0201879	.845350	0.60	.0725091	.224907
0.15	.0272485	.771141	0.65	0723402	.1812[illegible]
0.20	.0375692	.699189	0.70	.0710849	.14174[illegible]
0.25	.0451097	.629642	0.75	.0687614	.106641
0.30	.0518202	.562659	0.80	.0654216	.076096
0.35	.0576818	.498409	0.85	.0611653	.050220
0.40	.0626272	.437076	0.90	.0561587	.0290[illegible]
0.45	.0666217	.378851	0.95	.0506555	.012404
0.50	.0696240	.323938	1.00	.0450168	.000000

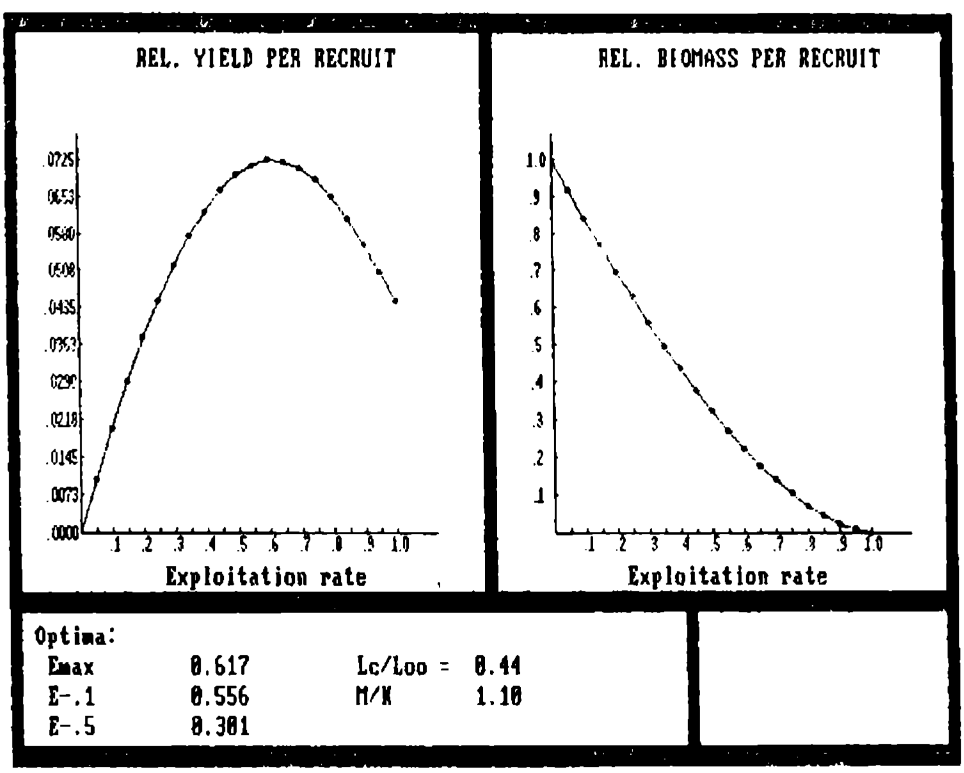


Figure 34 Relative yield per recruit and relative biomass per recruit values for *J. sina* for Lc/L∞ 0.44.

E	Y´/R	B´/R	E	Y´/R	B´/R
0.05	.0103889	.922308	0.55	.0722218	.27610
0.10	.0201300	.846556	0.60	.0733050	.220350
0.15	.0291874	.772869	0.65	.0733238	.184481
0.20	.0375268	.701301	0.70	.0722672	.144716
0.25	.0451031	.632237	0.75	.0701494	.109259
0.30	.0518769	.565593	0.80	.0670157	.078283
0.35	.0578059	.501615	0.85	.0629566	.051912
0.40	.0628469	.440482	0.90	.0581264	.030178
0.45	.0669570	.382383	0.95	.0527635	.012976
0.50	.0700947	.327520	1.00	.0472113	.000000

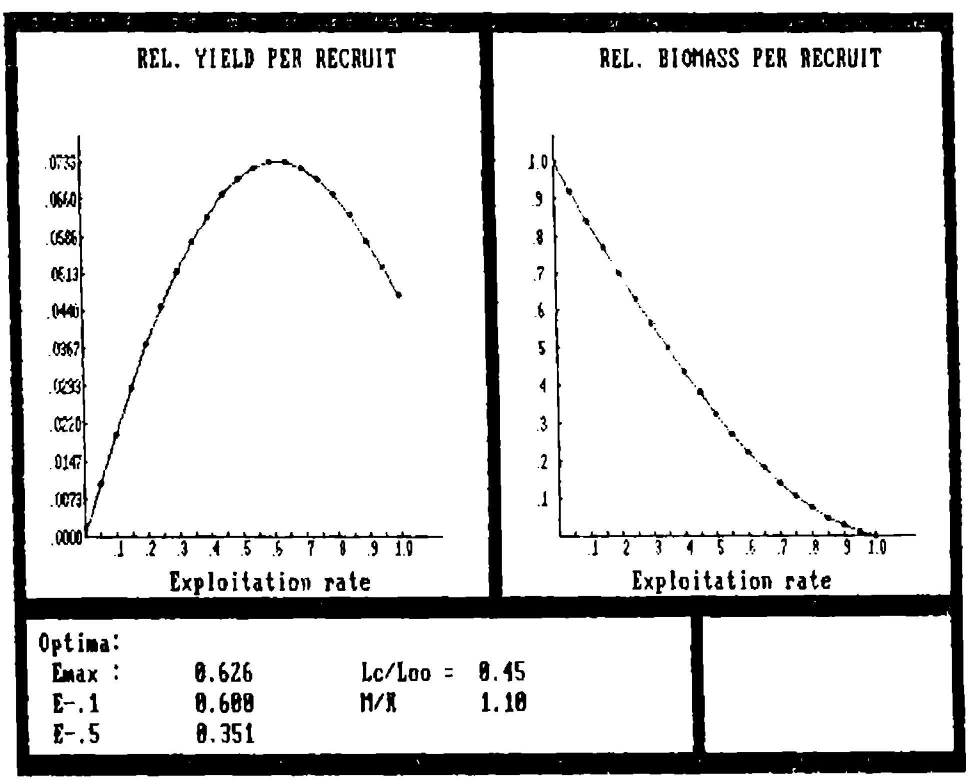


Figure 35 Relative yield per recruit and relative biomass per recruit values for *J. sina* for Lc/L∞ = 0.45.

E	/R	B'/R	E	Y /R	B /R
0.05	.0103486	.922935	0	.0728189	.279660
0.10	.0200675	.847758	0.60	.0740741	[illegible]1799
0.15	.029121	.774592	0.65	.0742792	197741
0.20	.0374772	.703567	0.70	.07[illegible]	14770
0.25	.0450814	.634826	0.75	.0715129	111822
0.30	.0519079	.568521	0.80	.068[illegible]	080488
0.35	.0577096	501815	0.85	.0647331	05[illegible]1
0.40	.0630438	443884	0.90	.0600870	031[illegible]8
0.45	.0672674	.385915	0.95	.0548744	.01[illegible]7
0.50	.0705388	331104	1.00	.0494215	000000

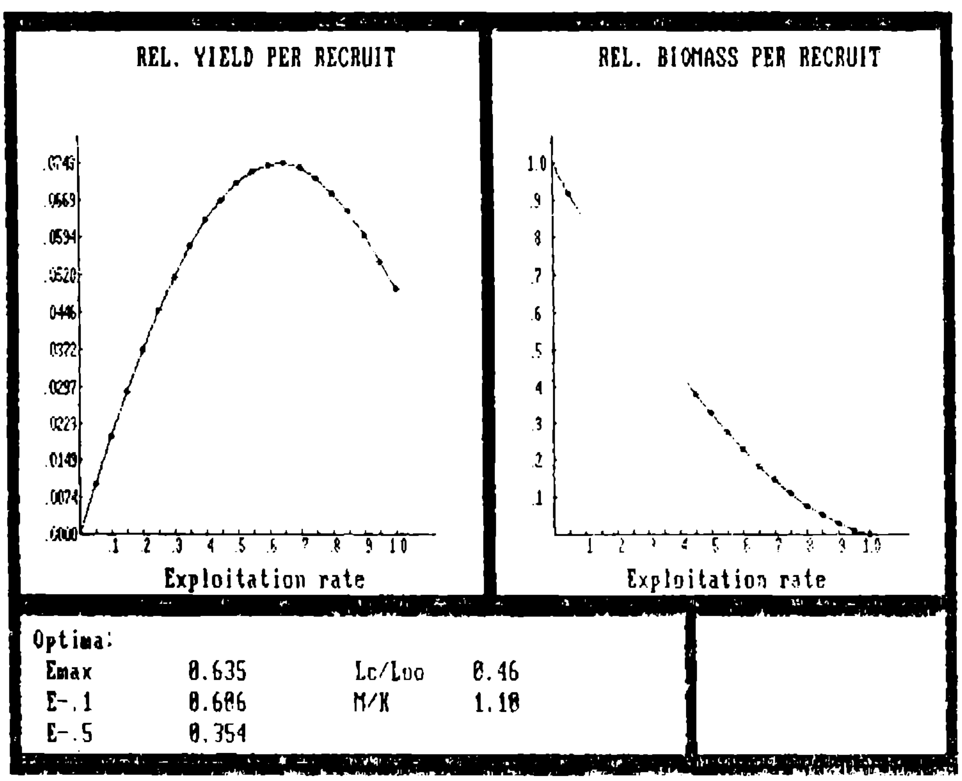


Figure 36 Relative yield per recruit and relative biomass per recruit values for J. sina for Lc/L∞ = 0.46

E	Y'/R	B'/R	E	Y'/R	B'/R
Ø.Ø5	Ø1Ø3Ø51	.923559	Ø.55	Ø733862	28322Ø
Ø.1Ø	.Ø199978	.848955	Ø.6Ø	.Ø748116	.235254
Ø.15	.Ø29Ø433	7763Ø8	Ø.65	.Ø752Ø37	191ØØ9
Ø.2Ø	.Ø374Ø49	7Ø5745	Ø 7Ø	.Ø745479	15Ø7Ø2
Ø.25	.Ø45Ø439	6374Ø7	Ø.75	.Ø728485	114541
Ø.3Ø	.Ø5192Ø1	.571442	Ø 8Ø	.Ø7Ø1383	.Ø827Ø9
Ø.35	.Ø579918	.5Ø8ØØ9	Ø.85	.Ø664904	.Ø55347
Ø.4Ø	.Ø632165	447282	Ø.9Ø	.Ø62Ø36Ø	.Ø32513
Ø.45	.Ø675514	.389443	Ø.95	.Ø569838	Ø14147
Ø.5Ø	.Ø7Ø9545	334688	1 ØØ	.Ø518424	.ØØØØØØ

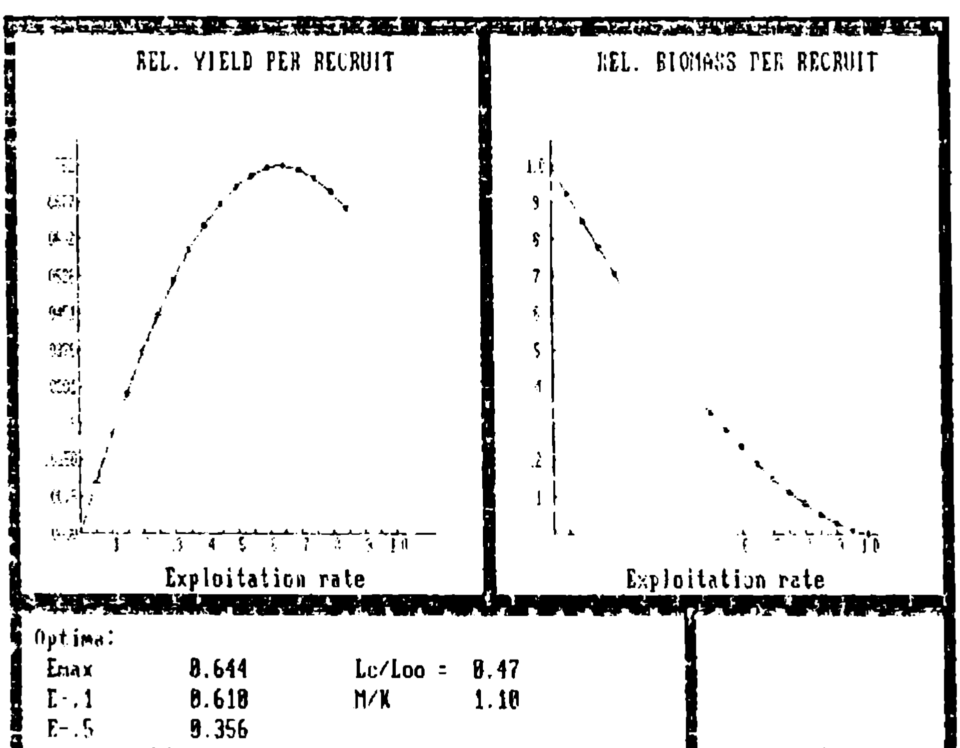


Figure 37 : Relative yield per recruit and relative biomass per recruit values for J. sina for Lc/Loo = 0.47.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0102582	.924180	0.55	.0739214	.286781
0.10	.0199214	.850146	0.60	.0755160	.238714
0.15	.0289555	.778016	0.65	.0760947	194285
0.20	.0373242	.707915	0.70	.0756401	.153711
0.25	.0449898	.639979	0.75	.0741527	.117202
0.30	.0519125	.574353	0.80	.0716591	.084946
0.35	.0580512	.511195	0.85	.0682245	.057088
0.40	.0633636	.450673	0.90	.0639688	.033702
0.45	.0678072	.392967	0.95	.0590864	.014746
0.50	.0713398	.338269	1.00	.0538686	.000000

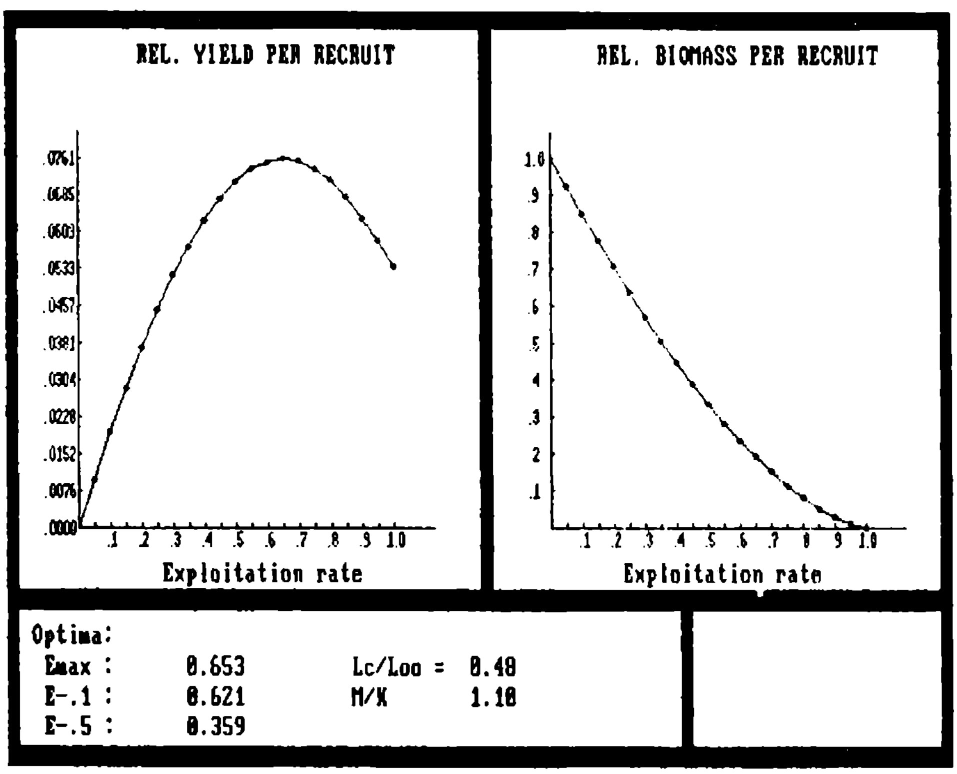


Figure 38 : Relative yield per recruit and relative biomass per recruit values for J. sina for Lc/Loo = 0.48-

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0132095	.910276	0.55	.0688033	.204171
0.10	.0252239	.823358	0.60	.0655091	.158396
0.15	.0359782	.739437	0.65	.0605727	.118295
0.20	.0454054	.658721	0.70	.0541152	.084116
0.25	.0534372	.581432	0.75	.0463510	.056037
0.30	.0600054	.507810	0.80	.0376227	.034113
0.35	.0650434	.438109	0.85	.0284464	.018207
0.40	.0684891	.372603	0.90	.0195552	.007881
0.45	.0702883	.311578	0.95	.0119056	.002273
0.50	.0704000	.255333	1.00	.0065304	.000000

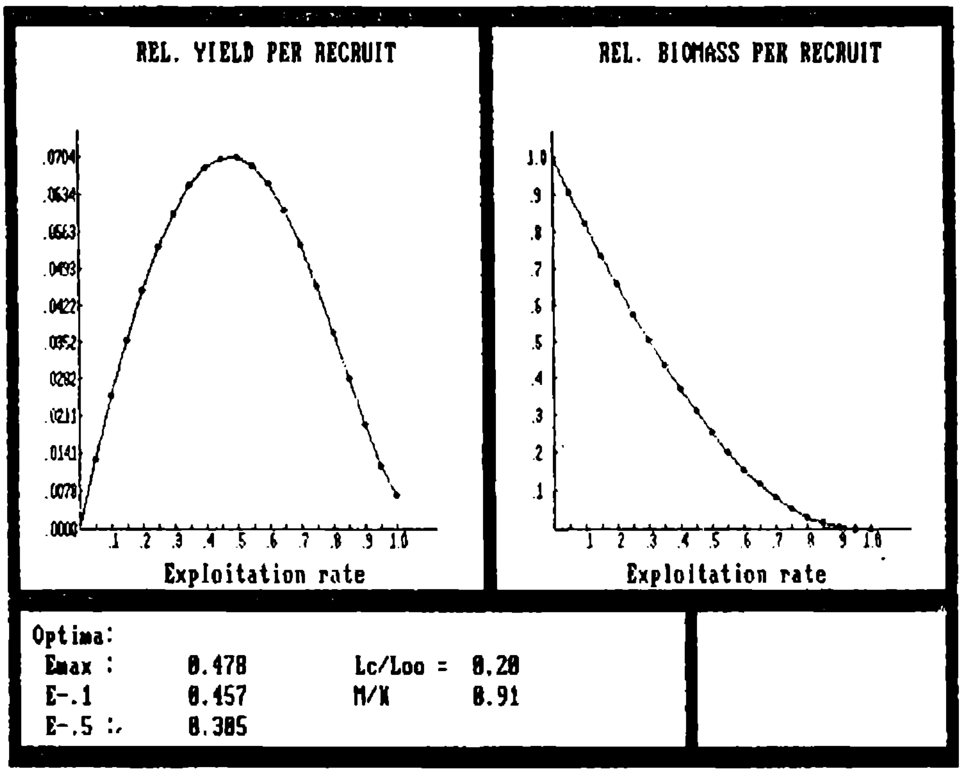


Figure 39 : Relative yield per recruit and relative biomass per recruit values for O. ruber for Lc/L∞ = 0.20.

E	Y'/R	B'/R	E	Y /R	B'/R
0.05	.0132132	.910798	0.55	.0696741	.206815
0.10	.0252471	.824354	0.60	.0665224	.160893
0.15	.0360368	740856	0.65	.0617237	120578
0.20	.0455155	.660509	0.70	.0553907	.086123
0.25	.0536147	583523	0.75	.0477259	.057716
0.30	.0602660	.510163	0.80	.0390576	.035425
0.35	.0654022	.440654	0.85	.0298844	.019173
0.40	.0689602	.375275	0.90	.0209190	.008433
0.45	.0708839	.314310	0.95	.0131026	.002502
0.50	.0711298	.258055	1.00	.0074737	000000

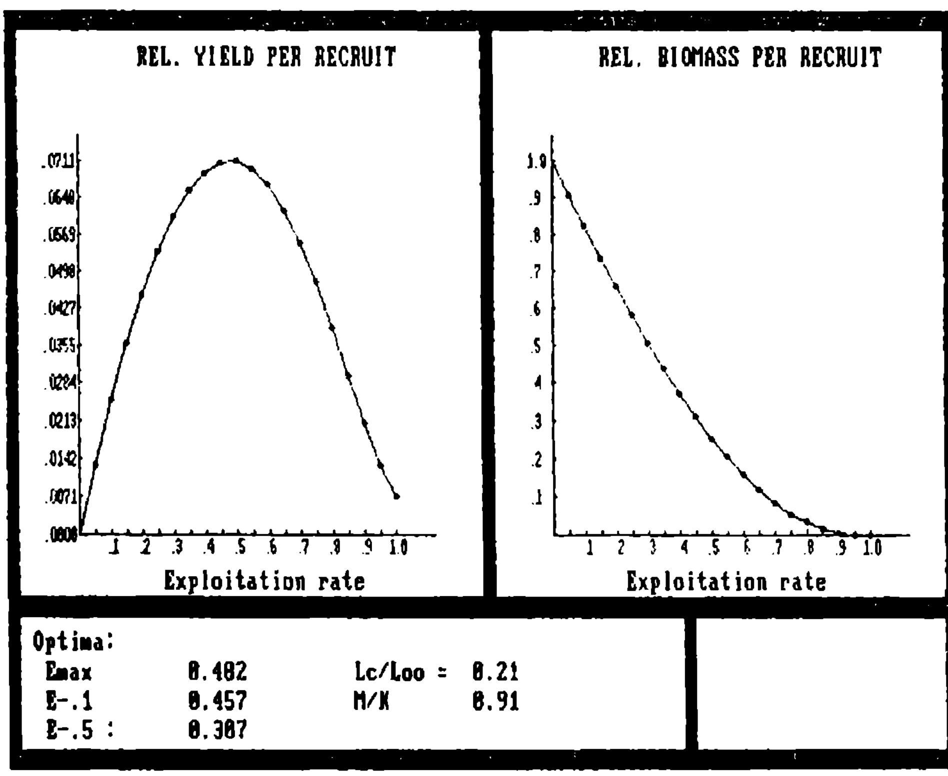


Figure 40 : Relative yield per recruit and relative biomass per recruit values for O. ruber for Lc/L∞ = 0.21.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0132164	.911325	0.55	.0705545	.209498
0.10	.0252693	.825358	0.60	.0675493	.163431
0.15	.0360943	.742287	0.65	.0628935	.122904
0.20	.0456244	.662313	0.70	.0566907	.088174
0.25	.0537914	.585653	0.75	.0491326	.059437
0.30	.0605264	.512540	0.80	.0405330	.036775
0.35	.0657618	.443226	0.85	.0313719	.020092
0.40	.0694333	.377977	0.90	.0223429	.009010
0.45	.0714834	.317074	0.95	.0143700	.002745
0.50	.0718662	.260814	1.00	.0084941	.000000

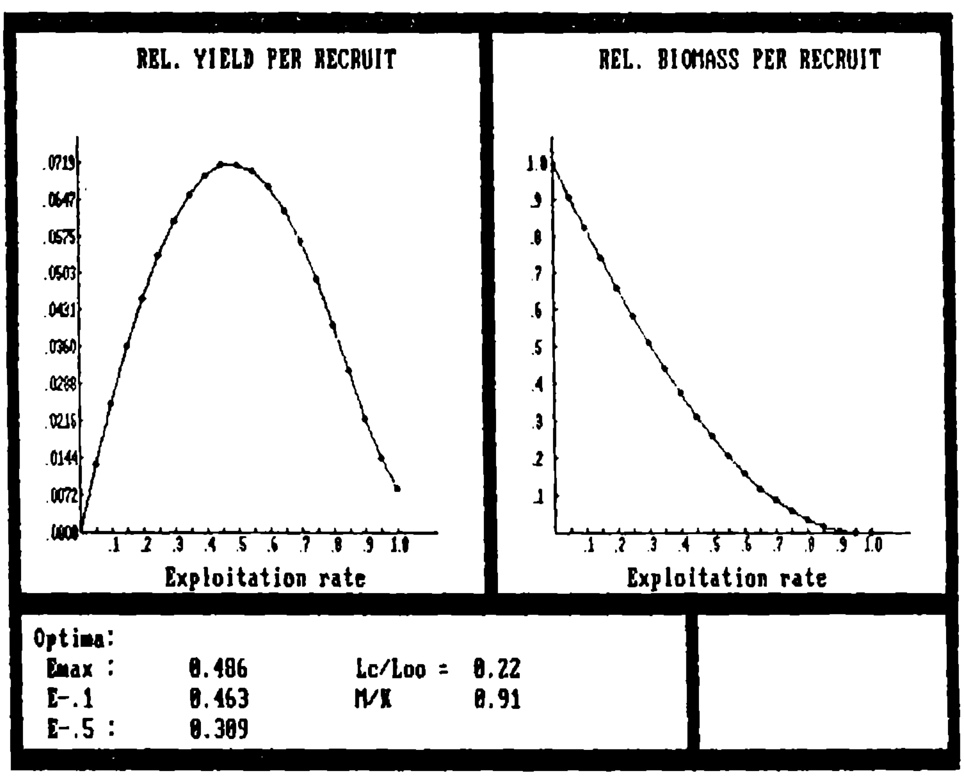


Figure 41 Relative yield per recruit and relative biomass per recruit values for O. ruber Lc/Loo = 0.22.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0132190	.911854	0.55	.0714430	.212221
0.10	.0252905	.826368	0.60	.0685891	.166011
0.15	.0361504	.743727	0.65	.0640808	.125273
0.20	.0457320	.664130	0.70	.0500146	.090268
0.25	.0539669	.587790	0.75	.0505704	.061200
0.30	.0607863	.514938	0.80	.0420470	.038164
0.35	.0661216	.445822	0.85	.0329092	.021084
0.40	.0699079	.380707	0.90	.0238272	.009612
0.45	.0720862	.319871	0.95	.0157080	.003002
0.50	.0726083	.263609	1.00	.0095924	.000000

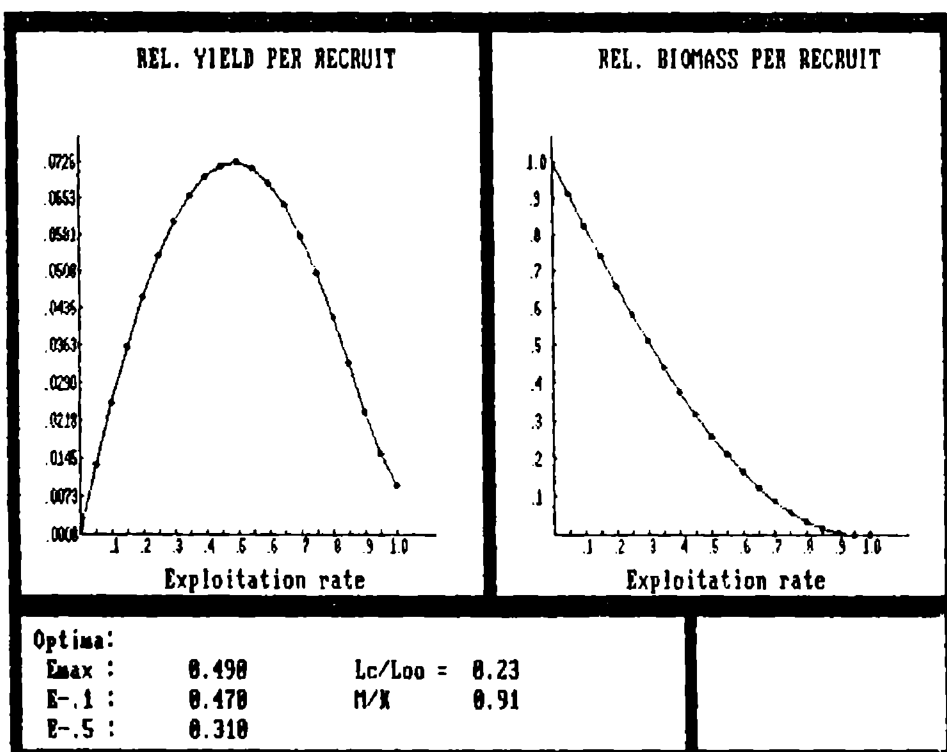


Figure 42 : Relative yield per recruit and relative biomass per recruit for O. ruber for Lc/Loo = 0.23.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0132209	.912386	0.55	.0723411	.214980
0.10	.0253105	.827385	0.60	.0696407	.168630
0.15	.0362050	.745178	0.65	.0652851	127683
0.20	.0458379	.665960	0.70	.0593611	.092404
0.25	.0541409	.589944	0.75	.0520381	.063003
0.30	.0610449	.517357	0.80	.0436013	.039592
0.35	.0664812	.448444	0.85	.0344950	.022110
0.40	.0703836	.383466	0.90	.0253712	.010239
0.45	.0726918	.322700	0.95	0171167	.003272
0.50	.0733554	.266438	1.00	.0107699	.000000

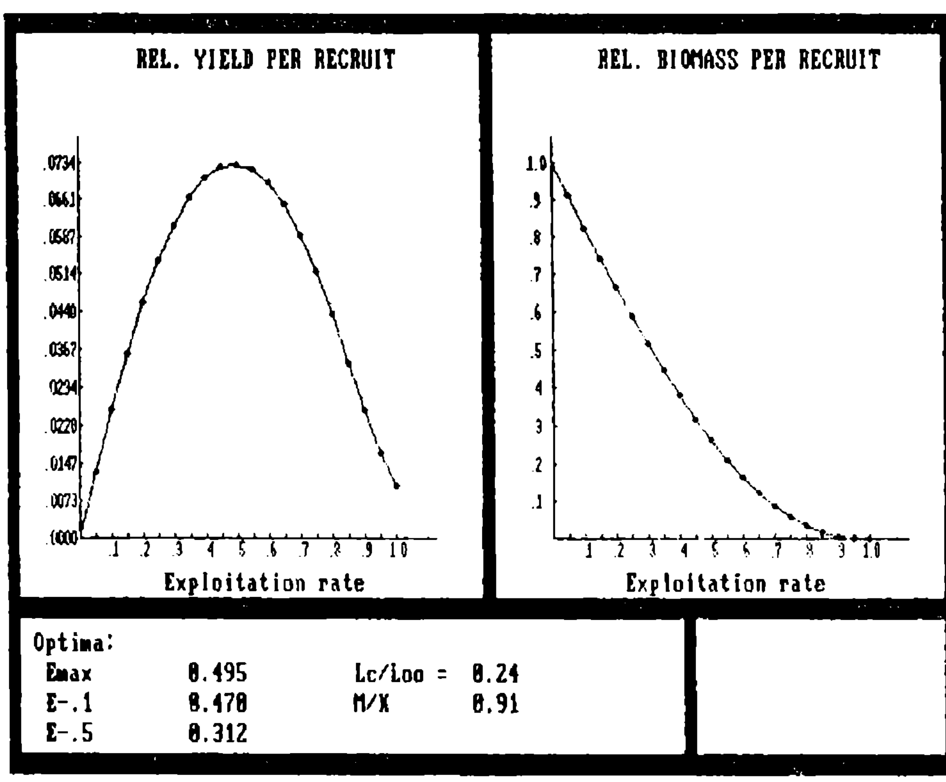


Figure 43 Relative yield per recruit and relative biomass per recruit values for _O. ruber_ for Lc/L∞ = 0.24.

E	Y /R	B'/R	E	/R	B /R
0.05	.0132021	912922	0.55	.0732456	.217777
0.10	.0253292	.828408	0.60	.0707035	.171789
0.15	.0362578	.746638	0.65	.0665051	.130134
0.20	.0459418	.667804	0.70	.0607294	.094581
0.25	.0543130	.592115	0.75	.0535350	.064840
0.30	.0613020	.519795	0.80	.0451924	.041057
0.35	.0668398	.451088	0.85	.0361285	.023169
0.40	.0708595	.386251	0.90	.0269742	010891
0.45	.0732992	.325559	0.95	.0185962	003557
0.50	.0741068	.269302	1.00	.0120272	.000000

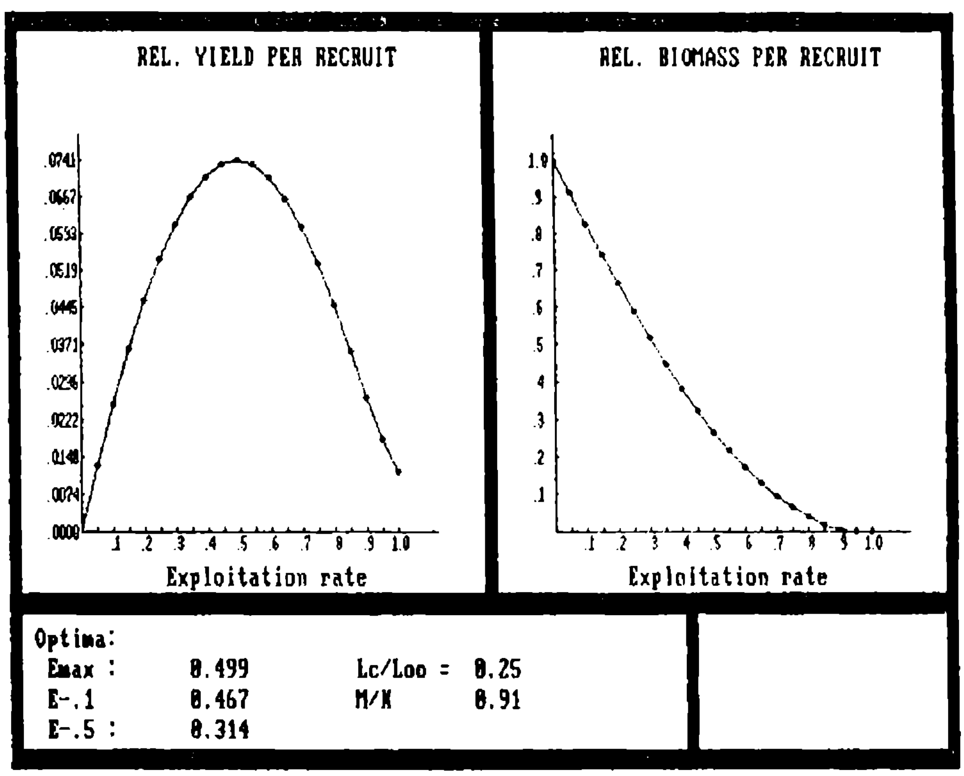


Figure 44 : Relative yield per recruit and relative biomass per recruit values for O. ruber Lc/L∞ = 0.25.

E	Y'/R	B'/R	E	Y'/R	B'/R
0.05	.0132224	.913460	0.55	.0741565	.220610
0.10	.0253464	.829437	0.60	.0717763	.173986
0.15	.0363087	.748107	0.65	.0677398	.132625
0.20	.0460435	.669659	0.70	.0621184	.096799
0.25	.0544828	.594301	0.75	.0550596	.066732
0.30	.0615572	.522253	0.80	.0468203	.042560
0.35	.0671972	.453755	0.85	0378090	.024260
0.40	.0713351	.389063	0.90	.0286357	.011569
0.45	.0739080	.328448	0.95	.0201458	.003855
0.50	.0748616	.272198	1.00	.0133646	.000000

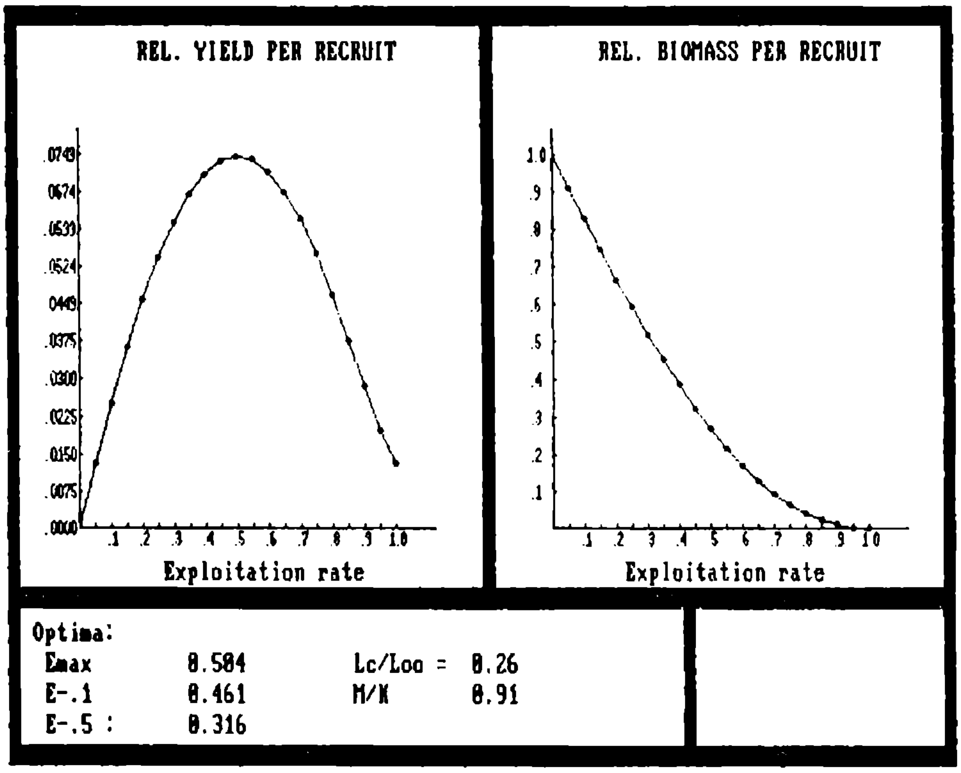


Figure 45 Relative yield per recruit and relative biomass per recruit for O. ruber for Lc/L∞ = 0.26.

Table 31 Estimates of parameters and other values required for Y'/R analysis.

Parameters/ Values	Species: *J. sina*	Species: *O. ruber*
L_∞ (cm)	31.8	76.5
W_∞ (g)	487.017	4678.241
K	0.1942	0.1335
M	0.2152	0.1212
M/K	1.1025	0.9079
T (Time Units)	21	38
Z	1.7432	3.5752
F	1.5280	3.4540
Lc (cm)	14.0	17.5
E = F/Z	0.8765	0.9661
$t_c - t_n$	1.4951	0.7259
Lc/L_∞	0.4402	0.2288
Lr/L_∞	0.2516	0.1503
$W_\infty e^{-M(tc-tn)}$ (Raising factor for relative Y/R) Y/R in gms.	353	4284
Lr (cm)	8.0	11.5

Table 32 : Length-wise estimated landings of *J. sina* in numbers with three point moving averages for 1986-87.

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
1.	5.0	3118	
2.	5.5	182	7986
3.	6.0	20660	11128
4.	6.5	12542	22162
5.	7.0	33284	38366
6.	7.5	69274	88542
7.	8.0	163070	122488
8.	8.5	135122	153286
9.	9.0	161666	186932
10.	9.5	264010	223010
11.	10.0	243356	295167
12.	10.5	378136	334705
13.	11.0	382625	416945
14.	11.5	490076	461595
15.	12.0	512086	531628
16.	12.5	592722	578869
17.	13.0	631799	575666
18.	13.5	502278	505294
19.	14.0	381607	425346
20.	14.5	391955	362055

Contd...

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
21.	15.0	312605	309775
22.	15.5	224767	243437
23.	16.0	192939	188013
24.	16.5	146333	140749
25.	17.0	82976	98448
26.	17.5	66036	62885
27.	18.0	39644	42490
28.	18.5	21790	23774
29.	19.0	9888	13342
30.	19.5	8348	9108
31.	20.0	9090	7433
32.	20.5	4861	4650
33.	21.0	0	2104
34.	21.5	1542	-

(Bracketed portion used for z estimation).

Table 33 Length-wise estimated landings of *J. sina* in numbers with three point moving averages for 1987-88.

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
1.	6.5	27204	-
2.	7.0	48643	74649
3.	7.5	148102	165401
4.	8.0	299460	227597
5.	8.5	235230	337424
6.	9.0	477583	385807
7.	9.5	444609	457565
8.	10.0	450503	411726
9.	10.5	340068	407303
10.	11.0	431339	416808
11.	11.5	479017	444574
12.	12.0	423367	488591
13.	12.5	563391	594344
14.	13.0	796274	731890
15.	13.5	836007	802252
16.	14.0	774475	875863
17.	14.5	1017107	956364
18.	15.0	1077447	975417
19.	15.5	831697	887621
20.	16.0	753719	789303

Contd..

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
21.	16.5	782494	658124
22.	17.0	438160	539002
23.	17.5	396353	322955
24.	18.0	134353	249758
25.	18.5	218568	169597
26.	19.0	155871	157089
27.	19.5	96829	98020
28.	20.0	41362	88283
29.	20.5	126659	56336
30.	21.0	988	45021
31.	21.5	7416	3130
32.	22.0	988	2801
33.	22.5	0	329
34.	23.0	0	10012
35.	23.5	30038	-

(Bracketed portion used for Z estimation).

Table 34 Length-wise estimated landings of O. ruber in numbers with three point moving averages for 1986-87.

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
1.	5.5	790	-
2.	6.5	0	1800
3.	7.5	4611	10813
4.	8.5	27829	30932
5.	9.5	60357	66776
6.	10.5	112144	100183
7.	11.5	128049	116989
8.	12.5	110775	116099
9.	13.5	109474	107958
10.	14.5	103626	130686
11.	15.5	178960	161662
12.	16.5	202400	176543
13.	17.5	148270	156647
14.	18.5	119271	119288
15.	19.5	[illegible]323	80817
16.	20.5	32859	49183
17.	21.5	24368	23952
18.	22.5	14629	14864
19.	23.5	5595	8519
20.	24.5	5333	4142
21.	25.5	1500	6072
22.	26.5	11383	8544
23.	27.5	12749	8928
24.	28.5	2652	8607
25.	29.5	10421	4357
26.	30.5	0	6714
27.	31.5	9721	4290
28.	32.5	3149	-

(Bracketed portion used for Z estimation).

Table 35 Length-wise estimated landings of *O. ruber* in numbers with three point moving averages for 1987-88.

Sr. No.	Length (Mid value in cm)	Number of fishes	Moving averages
1.	5.5	4166	-
2.	6.5	11644	18595
3.	7.5	39975	28590
4.	8.5	34153	54400
5.	9.5	89073	119984
6.	10.5	236727	199976
7.	11.5	274128	256906
8.	12.5	259864	279720
9.	13.5	305169	267946
10.	14.5	238805	259045
11.	15.5	233163	303009
12.	16.5	437060	502282
13.	17.5	836624	670171
14.	18.5	736831	687089
15.	19.5	487812	542350
16.	20.5	402407	408728
17.	21.5	335967	326644
18.	22.5	241559	220894
19.	23.5	85157	109773
20.	24.5	2603	37085
21.	25.5	23497	18673
22.	26.5	29919	27886
23.	27.5	30244	21450
24.	28.5	4188	21833
25.	29.5	31068	20458
26.	30.5	26120	27330
27.	31.5	24804	-

(Bracketed portion used for Z estimation).

Table 36 Estimation of 'Z' for *J. sina* from bracketed portions for the year 1986-87.

L_∞ = 31.8 cm and K = 0.1942

L_t	$L_\infty - L_t$	Log ($L_\infty - L_t$)	Their difference A	C_t	Log C_t	Their difference B	B/A	Z
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12.5	19.3	1.2855		578869	5.7626			
			0.0114			0.0024	0.2105	0.0409
13.0	18.8	1.2741		575666	5.7602			
			0.0116			0.0567	4.8879	0.9492
13.5	18.3	1.2625		505294	5.7035			
			0.0121			0.0748	6.1818	1.2005
14.0	17.8	1.2504		425346	5.6287			
			0.0123			0.0699	0.0123	1.1036
14.5	17.3	1.2380		362055	5.5588			
			0.0127			0.0678	5.3386	1.0367
15.0	16.8	1.2253		309775	5.4910			
			0.0131			0.1046	7.9847	1.5506
15.5	16.3	1.2122		243437	5.3864			
			0.0136			0.1122	8.2500	1.6021
16.0	15.8	1.1986		188013	5.2742			
			0.0139			0.1258	9.0503	1.7576
16.5	15.3	1.1847		140749	5.1484			
			0.0145			0.1552	10.7034	2.0786

Contd....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
17.0	14.8	1.1702		98448	4.9932			
			0.0149			0.1947	13.0671	2.5376
17.5	14.3	1.1553		62885	4.7985			
			0.0154			0.1702	11.0519	2.1462
18.0	13.8	1.1399		42490	4.6283			
			0.0161			0.2522	15.6644	3.0420
18.5	13.3	1.1238		23774	4.3761			
			0.0166			0.2509	15.1144	2.9352
19.0	12.8	1.1072		13342	4.1252			
			0.0173			0.1658	9.5825	1.8609
19.5	12.3	1.0899		9108	3.9594			
			0.0180			0.0882	4.9020	0.9520
20.0	11.8	1.0719		7433	3.8711			
			0.0189			0.2036	10.7725	2.0920
20.5	11.3	1.0530		4650	3.6675			
			0.0196			0.3445	17.5765	3.4134
21.0	10.8	1.0334		2104	3.3230			

Table 37 Estimation of 'Z' for *J. sina* from bracketed portions for the year 1987-88.

$L\infty$ = 31.8 cm and K = 0.1942

L_t	$L\infty - L_t$	Log $(L\infty-L_t)$	Their difference A	C_t	Log C_t	Their difference B	B/A	Z
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
15.0	16.8	1.2253		975417	5.9892			
			0.0131			0.0410	3.1297	0.6078
15.5	16.3	1.2122		887621	5.9482			
			0.0136			0.0510	3.7500	0.7282
16.0	15.8	1.1986		789303	5.8972			
			0.0139			0.0789	5.6763	1.1023
16.5	15.3	1.1847		658124	5.8183			
			0.0144			0.0867	6.0208	1.1692
17.0	14.8	1.1703		539002	5.7316			
			0.0150			0.2225	14.8333	2.8806
17.5	14.3	1.1553		322955	5.5091			
			0.0154			0.1116	7.2467	1.4073
18.0	13.8	1.1399		249758	5.3975			
			0.0161			0.1681	10.4410	2.0276
18.5	13.3	1.1238		169597	5.2294			
			0.0166			0.0333	2.0060	0.3896

Contd.....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19.0	12.8	1.1072		157089	5.1961			
			0.0173			0.2048	11.8382	2.2989
19.5	12.3	1.0899		98020	4.9913			
			0.0180			0.0454	2.5222	0.4898
20.0	11.8	1.0719		88283	4.9459			
			0.0189			0.1951	10.3227	2.0047
20.5	11.3	1.0530		56336	4.7508			
			0.0196			0.0974	4.9694	0.9650
21.0	10.8	1.0334		45021	4.6534			
			0.0206			1.1579	56.2087	10.9157
21.5	10.3	1.0128		3130	3.4955			
			0.0216			0.0482	2.2315	0.4333
22.0	9.8	0.9912		2801	3.4473			
			0.0227			0.9301	40.9736	7.9571
22.5	9.3	0.9685		329	2.5172			

Table 38 Estimation of 'Z' for *O. ruber* from bracketed portions for the year 1986-87.

$L_\infty = 76.5$ and $K = 0.1335$.

L_t	$L_\infty - L_t$	Log $(L_\infty - L_t)$	Their difference A	C_t	Log C_t	Their difference B	B/A	Z
16.5	60.0	1.7781		176543	5.2468			
			0.0073			0.0519	7.1096	0.9491
17.5	59.0	1.7708		156647	5.1949			
			0.0074			0.1183	15.9886	2.1342
18.5	58.0	1.7634		119288	5.0766			
			0.0075			0.1691	22.5467	3.0100
19.5	57.0	1.7559		80817	4.9075			
			0.0077			0.2157	28.0130	3.7397
20.5	56.0	1.7482		49183	4.6918			
			0.0078			0.3125	40.0641	5.3486
21.5	55.0	1.7404		23952	4.3793			
			0.0080			0.2072	25.9000	3.4576
22.5	54.0	1.7324		14864	4.1721			
			0.0081			0.2417	29.8395	3.9836
23.5	53.0	1.7243		8519	3.9304			
			0.0083			0.3132	37.7349	5.0376
24.5	52.0	1.7160		4142	3.6172			

Table 39 : Estimation of 'Z' for *O. ruber* from bracketed portions for the year 1987-88.

$L_\infty = 76.5$ and $K = 0.1335$.

L_t	$L_\infty - L_t$	Log $(L_\infty - L_t)$	Their difference A	C_t	Log C_t	Their difference B	B/A	Z
18.5	58.0	1.7634		687089	5.8370			
			0.0075			0.1027	13.6933	1.8281
19.5	57.0	1.7559		542350	5.7343			
			0.0077			0.1229	15.9610	2.1308
20.5	56.0	1.7482		408728	5.6114			
			0.0079			0.0973	12.3165	1.6442
21.5	55.0	1.7403		326644	5.5141			
			0.0079			0.1699	21.5063	2.8711
22.5	54.0	1.7324		220894	5.3442			
			0.0081			0.3037	37.4938	5.4575
23.5	53.0	1.7243		109773	5.0405			
			0.0083			0.4713	56.7831	7.5805
24.5	52.0	1.7160		37085	4.5692			
			0.0085			0.2980	35.0588	4.6803
25.5	51.0	1.7075		18673	4.2712			

Table 40 Monthwise catch effort data of *J. sina* and *O. ruber* during 1986 - 87.

Month	*J. sina* Catch in Numbers	*J. sina* Catch in Weight-Kg.	*O. ruber* Catch in Number	*O. ruber* Catch in Weight-Kg.	Effort
Sept. 86	272502	7482	104819	2942	487
Oct.	274856	4959	17544	618	139
Nov.	1695885	41942	469385	24364	1642
Dec.	857935	22492	119059	5164	754
Jan. 87	1351721	[illegible]429	309704	13234	1739
Feb.	+				
March	710334	28282	19201	1197	1408
April	387959	10964	157822	1461	1099
May	942576	13316	333704	25172	845

(+ No sampling).

Table 41 Monthwise catch effort data of *J. sina* and *O. ruber* during 1987 - 88.

Month	*J. sina* Catch in Numbers	*J. sina* Catch in Weight-Kg.	*O. ruber* Catch in Numbers	*O. ruber* Catch in Weight-Kg.	Effort
Sept. 87	996000	18720	571074	12804	601
Oct.	325817	13364	210326	6494	674
Nov.	1378068	47776	769527	38592	1791
Dec.	1115642	45476	639476	46531	2272
Jan. 88	2033395	92040	726063	45461	2080
Feb.	1966366	78762	1333738	95558	2797
March	1898511	62268	712220	44334	2346
April	1995475	61487	252104	25496	1615
May	1176048	44038	248198	15757	1017

Table.42 Y/R , E max, F max, reduction in F etc. at different levels of $Lc/L\infty$ in case of *J. sina*

	Parameters/values	Different values of $Lc/L\infty$ 0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.48
1.	E max for MSY	0.5650	0.5930	0.6010	0.6090	0.6200	0.6260	0.6350	0.6440	0.6530
2.	(Y/R)' at E max	0.0690	0.0700	0.0708	0.0716	0.0725	0.0733	.0740	0.0752	0.0761
3.	Y/R at E max (gm)	24.4	24.7	25.0	25.3	25.6	25.9	26.2	26.5	26.9
4.	(Y/R)' at present E	0.0510	0.0530	0.0549	0.0567	0.0587	0.0605	0.0624	0.0643	0.0661
5.	Y/R at present E (gm)	18.0	18.7	19.4	20.0	20.7	21.4	22.0	22.7	23.3
6.	F max for MSY	0.31	0.32	0.33	0.34	0.36	0.37	0.38	0.40	0.41
7.	Reduction in % in the present units of effort to obtain MSY	80	79	78	78	76 Present fishery	76	75	74	73

Table 43 Y/R, E max, reduction in F etc at different levels of Lc/L∞ in case of *O. ruber*

	Parameters/Values	Different values of Lc/L∞						
		0.20	0.21	0.22	0.23	0.24	0.25	0.26
1.	E max for MSY	0.4780	0.4820	0.4860	0.4900	0.4950	0.4990	0.5040
2.	(Y/R)' at E max	0.0703	0.0711	0.0717	0.0726	0.0731	0.0741	0.0748
3.	Y/R at E max (gms)	301.2	304.1	307.1	311.0	314.4	317.4	320.4
4.	(Y/R)' at present E	0.0092	0.0103	0.0114	0.0126	0.0139	0.0153	0.0168
5.	Y/R at present E (gms)	39.4	44.0	48.8	54.2	59.7	65.6	71.8
6.	F max for MSY	0.1110	0.1128	0.1146	0.1164	0.1188	0.1207	0.1231
7.	Reduction in % in the units of effort to obtain MSY	97	97	97	96 Present fishery	96	96	96

SUMMARY

Sciaenids are landed in large quantities at Ratnagiri fish landing centre and it is consumed by many people covering all strata of the society. It plays an important role in economy of fisherman. Species, *Johnieops sina* (Cuvier) and *Otolithes ruber* (Schneider) are landed in major quantities. Hence these two species are selected for studies for biostatistical evaluation and management of the fishery. The significant findings of this work are as follows.

Food and Feeding habits:

1) Both species are carnivorous feeding mainly on teleosts and crustaceans.
2) They feed on organisms in midwater and lower region of the sea.
3) Their food components are based on their habitats, juveniles remain near sea bottom hence their food contains the organisms from the lower level of sea including sea bed and adults migrate to all strata of water column hence their food included organisms on wide range.
4) Change in food with size was observed. Juveniles preferred crustaceans and as they grow in size they shifted their feeding preference teleosts which gradually became major food item of adults.

5) In the case of J. sina, percentages of poorly fed juveniles were high and percentages of poorly fed adults and with empty stomaches were higher than other types of feeding intensities. In the case of O. ruber, the percentages of actively fed juveniles were highest and percentages of adults with empty stomachs were higher than other types of intensities.

6) No regular periodicity in different intensities of feeding were observed throughout the year in both species.

7) Teleosts formed the major food item in both the species; penaeid prawns, Acetes spp. and squilla were the second important food item while polychaetes, molluscs, crabs and miscellaneous constituted minor food item in both species.

8) No regularity in indices of food items except that of teleost, was observed during different seasons.

9) Spawning activity or gonad development could not be related with high or low intake of food since high percentages of poorly fed adults were observed throughout theperiod of studies in both species.

Reproductive biology.

J. sina :

1) In ova diameter frequency polygon multimodes were not seperated from each other indicating prolonged spawning with two peak spawning seasons, September to January and March to May.

2) Mature fishes were observed throughout the year.

3) Lengths at first maturity were 11.2 and 11.6cm. for males and females respectively by percentage of occurrence of mature fishes method and 11.0 and 12.0cm by Kn values.

4) GSI values varied within narrow range in different months (3.7 to 5.7) indicating continuous spawning.

5) Kn values varied with narrow range strengthening the earlier statement regarding the prolonged spawning.

6) Fecundity ranged from 12,500 to 2,71,000 in various length groups (12.0 to 20.6 cm).

7) Significant correlation coefficient (r) between fecundity and length of fish, fecundity and weight of fish and fecundity and weight of ovary have been observed (0.7506, 0.7523 and 0.8127 respectively).

8) Sex ratio varied in different months but the pooled data did not differ from 1:1 ratio.

9) In juveniles, Chi-square values were significant since males were outnumbered the females. In mature groups for the length groups below 15.0 cm, Chi-square values were not significant. However in those above 15.0 cm. females were dominant.

O. ruber

1) This species individually spawns once in a year within a restricted period but population as such spawns from

September to January.

2) The lengths at first maturity were 20.2 and 22.6 cm. for males and females respectively by percentage occurrence of mature fishes method and by relative condition method those were 21.0 and 23.0 cm.for males and females respectively.

3) High GSI values were observed during September to January and low in other months indicating restricted spawning period.

4) Kn values were also high in above period supporting the previous statement.

5) Fecundity varied from 54,600 to 4,40,000 for size range from 16.7 to 32.7 cm.

6) The correlation coefficient (r) between fecundity and length of fish and fecundity and weight of ovary were significant (0.6427 and 0.6799 respectively) but between fecundity and weight of fish it was poor (0.2688).

7) Monthly sex ratioes were significant, except in December 1986 and 1987 which might be because of peak spawning period.

8) In the pooled data females were dominant.

9) In immature groups sex ratioes were significant and in mature groups those were not significant.

Age and growth

a) Length - weight relationship.

1) In both the species, *J. sina* and *O. ruber* the length - weight relationships showed parabolic form.

2) The coefficient correlations for the length - weight relationships for male and female were highly significant for both the species.

3) Tests on identicality of straight lines were not significant female and male in each species and hence common relationship was obtained for each species.

4) Lengths at first maturity estimated from Kn values were as follows

   J. sina male = 11.0 cm, female = 12.0 cm;

   O. ruber male = 21.0 cm, female = 23.0 cm.

5) In *J. sina*, monthly 'Kn' values varied within a narrow range indicating prolonged spawning.

6) In *O. ruber*, high 'Kn' values observed during September to October and low values in other months indicating restricted period of spawning.

7) In both the species, food intake was not the main criteria for varations in 'Kn' values, since majority of them were found to be poorly fed.

b) Age and growth.

1) Length-frequency analyses were found to be more reliable for the study of age and growth.

2) The asymptotic lengths were 31.8 and 76.5 cm. for *J. sina*

and *O. ruber* respectively.

3) The lengths attained by the *J. sina* at the end of first, second, third, fourth and fifth years were 18.38, 25.64, 28.91, 30.52 and 31.22 cm. respectively and by *O. ruber* 33.63, 51.37, 61.77, 67.86 and 71.44 cm. respectively.

4) Growth rates were fast in their first year in both species.

5) The longevities of *J. sina* and *O. ruber* were found to be 5 and 10 years respectively.

6) Estimated K values(coefficient of growth) were estimated as 0.1942 and 0.1335 for *J. sina* and *O. ruber* respectively.

7) The maximum attainable weights were estimated as 487 and 4678 gms. for *J. sina* and *O. ruber* respectively.

Population dynamics and Management

J. sina

1) Length at first capture (Lc) : 14.0 cm.

2) Lengths at recruitment : 8.0 cm.

3) Present rate of exploitation was found to be high (0.88) indicating very high fishing intensity.

4) Instantaneous fishing mortality rate (F = 1.53) was seven times of instantaneous natural mortality (M = 0.22).

5) Maximum Y/R obtained at E max (0.62) was far below the present level of exploitation (0.88).

6) In order to obtain MSY at the present level of size at firs capture (Lc), the level of exploitation should be less than present level of exploitation the instantaneous fishing

mortality rate should be brought down to 0.36 by reducing the present effort by 76%.

7) Relative yield per recruit at E max was 0.725, hence Y/R at E max was 25.6 gms.

8) Increase in mesh size indicated higher MSY.

9) Size at first capture (Lc) was higher than the size at first maturity. Hence existing mesh size was found to be not harmful to the fishery. However reduction in number of fishing units was found to be favourable to obtain MSY.

O. ruber

1) Length at first capture : 17.5 cm.

2) Length at recruitment 11.5 cm.

3) Present rate of exploitation (E) was estimated as 0.97 indicating high instantaneous fishing mortality (3.45).

4) E max was found to be 0.50 which was far below the present level of exploitation (0.97).

5) Reduction in effort by about 96% was required to obtain MSY.

6) Instantaneous fishing mortality rate (F = 3.45) was about 28 times of instantaneous natural mortality rate (0.12).

7) Relative yield per recruit at E max was 0.073, hence Y/R at E max was 311.0 gm.

8) Increase in mesh size was found to be favourable to increase Y/R.

9) Size at first capture (17.5 cm) is less than the size at first maturity (21.0 cm). Hence mesh size has to be increased

not only to reap high Y/R but also to allow the stock to spawn once at least before being captured.

General Conclusion

In terms of socio-economics, reduction in number of fishing units may not be acceptable but increase in codend mesh size may be enforceable. Codend mesh size may be increased to at least 30mm.

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