STUDIES ON CERTAIN ASPECTS OF THE BIOLOGY OF THE BARRACUDA OF COCHIN REGION

By

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THESIS

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DEDICATED

TO MY PARENTS

DECLARATION

I hereby declare that this thesis entitled STUDIES ON CERTAIN ASPECTS OF THE BIOLOGY OF THE BARRACUDA OF COCHIN REGION is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society

Panangad

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CERTIFICATE

Certified that the thesis entitled STUDIES ON CERTAIN ASPECTS OF THE BIOLOGY OF THE BARRACUDA OF COCHIN REGION is a record of research work done independently by Shri Krishnadas K J under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to him

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INTRODUCTION

I INTRODUCTION

Family Sphyraenidae contains only one genus viz *Sphyraena* Klein 1778 Commonly called the barracudas they are a well defined group enjoying mostly a circumtropical distribution but extending also into the subtropical regions of the Atlantic Indian and Pacific Oceans (Nelson 1984) According to Talwar and Kacker (1984) of the 18 valid species 9 are represented in the waters around the Indian subcontinent

Barracudas are reported to inhabit varying depths from surface to 100 metres The smaller species seldom exceeding two feet in length are generally schooling forms while the larger ones growing upto 10 feet are reported to be solitary and nomadic (De Sylva 1973) The latter are mostly confined to the oceanic regions of the world Their stream lined body indicating swift swimming ability reaching upto 12 mts /Sec (De Sylva 1973) coupled with a large mouth carrying sharp canine like teeth are well suited to a predatory life The larger barracudas are reported to be very ferocious occasionally attacking even human beings Reports also indicate ciguatera poisoning caused by certain barracudas like *Sphyraena barracuda* *S* *jello* and *S* *forsteri* (Fonssagrives and Mericourt 1861 Smith 1947 and Valdes 1980), which is presumed to be associated with their food habits However no such cases of poisoning or attacks on human beings have been reported from the Indian waters

Although India stands fifth in world barracuda production (F A O 1988) the group s contribution to the total exploited fishery resources in India is meagre In 1990 the total barracuda landings in India was 11 125 metric tonnes forming 0 51 percent of the total marine landings of the country (C M F R I 1991) Statewise Kerala s contribution to their fishery is second only to Tamil Nadu However no targeted fishery exists in India for this group and very little is known about the potential resources available

The biology of most spe ies of barracudas has received very little attention The Great barracuda Sphyraena barracuda (Walbaum) is perhaps the only exception whose biology has been investigated in detail by De Sylva (1963) Other major contributions in this line are those by Gudger (1918) Walford (1932) and Williams (1959) Other available publications on this aspect deal essentially on brief species listings and descriptions and notes on their natural history Most taxonomists share the opinion expressed by De Sylva (1963) that there exists two basic problems which permeate the taxonomy of Sphyraenids the great similarity among species and the dearth of museum specimens especially that of the larger species The first drawback has resulted in descriptions which are insufficient to differentiate among most species while the second has encouraged the description of juveniles as new species

Regarding the Indian Ocean barracudas not much comprehensive work on the systematics and life history has been attempted A preliminary review of systematics and ecology of this group in the Indian Ocean and adjacent waters is that of De Sylva (1973) Despite this Rose (1984) has indicated that the validity of at least some of the currently listed Indo-Pacific Sphyraenids requires a reassessment

Not enough information is available on the seasonal and region wise distribution of the coastal species which presently constitute the barracuda fishery of India Information on food and feeding maturation and spawning as well as age and growth of the constituent species is also scanty Of the two major contributors to the barracuda catches in India S jello Cuv and S obtusata (Cuv & Val) the latter species has been subjected to a detailed biological study by Kothare (1973) in Maharashtra waters It is in this context that a systematic redescription of the available Sphyraenids in Cochin region and a study on certain aspects of biology of S jello the commercially more important species have been undertaken for the Master s research in Fishery Biology

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

2 1 Systematics

Besides facilitating the identification of species on the practical side a system of natural classification picturises the phylogenetic relationships of the various groups concerned (Schenk and McMasters 1956) This is quite true in the case of Sphyraenids since this group has been subjected to transfer of systematic position by various taxonomists

Day (1878) placed family Sphyraenidae along with two other families namely Atherinidae and Mugilidae under the group Mugiliformes in the order Acanthopterygii together with all other perch and perch-like fishes Weber and Beaufort (1922) while describing the eight species of Indo Australian barracudas placed the family Sphyraenidae under the order Percesoces at the sub-perciform level Later Berg (1940) in his classic work retained this family under the order Mugiliformes suborder Sphyraenoidei at the subperciform level Families Mugilidae and Atherinidae were kept under the suborder Mugiloidei Munro (1955) Lindberg and Lageza (1969) and Jones and Kumaran (1980) followed Berg (1940) without the subordinal status

Jordan (1923) made some modifications According to him family Sphyraenidae comes under order Percomorphi suborder Percesoces (synonymous with the Mugiliformes of Berg 1940) along with other families Bedotiidae Melanotaeniidae Atherinidae and Mugilidae While working on Sphyraenids De Sylva (1963) followed Jordan s classification

A sea change has been brought about in the classification of teleosts by Greenwood et al (1966) In their classification Berg s order Mugiliformes in part was taken to order Perciformes under super order Acanthopetrygii Also Sphyraenids retained the subordinal status as Sphyraenoidei along with Mugiloidei Family Atherinidae placed under the order Mugiliformes in Berg s system was also elevated to subordinal status as Atherenoidei under order Atheriniformes at the subperciform level

This major shift of Sphyraenids from the subperciform to the perciform level has been widely accepted by subsequent workers Norman (1975) Nelson (1976 1984) Talwar and Kacker (1984) and De Sylva and Williams (1986) closely followed the classification of Greenwood et al (1966) But some authors have made minor modifications at the subordinal level McAllister (1968) and Gosline (1968 1971) placed the families Sphyraenidae and Mugilidae under suborder Mugiloidei order Perciformes Gosline (1968) brought the family Atherinidae also under the suborder Mugiloidei General systematic position of the barracudas according to different authors is given in Table 1

According to De Sylva (1963) the phylogenetic relationships

Table 1 General systematic position of the Barracudas with reference to the order Perciformes

Sub perciform	Perciform
1 Order Acanthopterygii Group Mugiliformes Family Sphyraenidae (Day 1878)	1 Order Perciformes Suborder Sphyraenoidei Family Sphyraenidae (Greenwood et al 1966 Norman 1975 Nelson 1976 1984 Talwar and Kacker 1984 De Sylva and Williams 1986)
2 Order Percesoces Family Sphyraenidae (Weber and Beaufort 1922)	
3 Order Percomorphi Suborder Percesoces (Mugiliformes of Berg 1940) Family Sphyraenidae (Jordan 1923 De Sylva 1963)	2 Order Perciformes Suborder Mugiloidei Family Sphyraenidae (McAllister 1968 Gosline 1968 1971)
4 Order Mugiliformes Suborder Sphyraenoidei Family Sphyraenidae (Berg 1940)	
5 Order Mugiliformes Family Sphyraenidae (Munro 1955 Lindberg and Lageza 1969 Jones and Kumaran 1980)	

of the family Sphyraenidae have been discussed in detail by Bridge (1896) Starks (1899) Dollo (1909) Goodrich (1909) Regan (1912) Ribeiro (1915) Jordan and Hubbs (1919) Frost (1929) Gregory (1933) Hollister (1937) and Gosline (1962)

The living members of the family Sphyraenidae are represented by a single genus Sphyraena Klein 1778 Linnaeus (1758) in Systema Naturae listed the genus Esox L with Esox lucius L as the type Catesby (1771) suggested Umbla as the generic name for the type species Esox barracuda Shaw But Umbla is of doubtful eligibility as being Latin vernacular rather than genus (Jordan 1917- 20)

Most of the workers of the 18th and 19th century proposed the name sphyraena to the genus (Klein 1778 Rose 1793 Bloch and Schneider 1801 Dumeril 1806 Rafinesque 1810 and Swainson 1839) with Esox sphyraena Linnaeus as the type But Plumier (1803) proposed the name Acus with Acus americana Plumier as the type According to Jordan (1917 20) Umbla Catesby 1771 Acus Plumier 1803 and Sphyraena Swainson 1839 are of doubtful eligibility either because of not being binomial or given without type definition or explanation

Fowler (1903) proposed the subgenus Agriosphyraena for a large scaled form with 75 to 87 lateral line scales having a flattened or slightly concave head with barracuda Walbaum 1792 as the type as opposed to the subgenus Sphyraena with more than 100 scales and slightly convex head Smith (1956) subsequently elevated Fowler s subgenus to full generic rank His generic distinctions are however based upon characters such as the number of gill rakers length and placement of fins the shape of preopercle and the number of lateral line scales which appear to be important specific characters (De Sylva 1963) Whitley s (1947) genus Australuzza although proposed for a different species (Sphyraena novaehollandiae Gunther) also appears to be only a case of specific differentiation (De Sylva 1963) Now it looks most appropriate to consider Sphyraena Klein 1778 as the sole generic representative of all the living species of the family Sphyraenidae until a complete revision of the family is undertaken (De Sylva 1963)

Coming to the species level no comprehensive review of the barracudas of the world is available till date Meek and Robert (1884) reviewed the American species while Schultz (1953) confined himself to only the specimens in the U S National museum and used fin lengths as diagnostic characters Smith (1956) followed the same pitfalls for Indian ocean barracudas West African species have been revised by De Sylva (1982) and rare species have been recorded by Fowler (1903) George et al (1970 71) and De Witt et al (1981) Indian ocean species have been recently reviewed by Williams (1959) and De Sylva (1973)

The descriptions by many authors might well apply to any of the 69 nominal species which have been described hitherto Of these about 20 spec es are valid according to De Sylva (1973) and 18 species according to Talwar and Kacker (1984) Some members are circumtropical while many are Indo-Pacific endemics and a few may be confined to island groups a peculiar attribute in any semipelagic family containing species which are often world-wide in distribution

Various reports of occurrence as well as species listings are available from many parts of the world though none is complete giving all the available species from Indian ocean The listing by Talwar and Kacker (1984) based on De Sylva s (1973) work is the most recent and may be the most reliable Of the 46 nominal species listed by De Sylva (1973) as occurring in Indian ocean and adjacent seas only nine are having the identity of valid species Later Rose (1984) included S novaehollandiae also as a valid species representing this family in the Indian ocean and Talwar and Kacker (1984) reported the single record of this species in our region But De Sylva (1973) doubted the validity of this species The valid species that are reported to occur in Indian seas by various authors are listed in Table 2

In the description of species as well as preparation of keys for identification De Sylva (1973) and Talwar and Kacker (1984) have used different characters Meristic characters such as the scale counts and the number of gill rakers (even the absence in certain cases) and the morphometric characters like the fin lengths and their relative positions are found to be of great importance in the taxonomy

Table 2 List of valid species of the family Sphyraenidae in Indian seas

Day (8 8	Webe and Bea or (922	Munro (1955	De Sy a 973	use (984	T war and Kacke (984	De Sy a nd W ams (986)
S ac p nnia Day 876		S acu p nnis Day 18 6	S a p nnis Day 8 6	S u p nnis Day 8 6	S cu p nnis Day 8 6	S u p nni Day 8 6
S ommersoni Cu 829	[2]S p cud B och & S hn 80	[2]S p uda B och 80	S b acuda (Walbaum 1792	S barracuda (Wa b m 1792	S barr cuda (Wa baum 792)	S ba cud (Wa bau 792)
			b eeke Wil ams 959	S pu nam ae Jordan & Sea e 905	[7]S b eeke W m 9 9	S p nam ae o dan & Se o 190
	[3]S angsar B eek 854	[3]S angsa B oek 854	S a uda R ppe 1835	S a cauda R ppo 835	S cauda R ppe 835	S c da R ppe 835
	ors C 829		S Cuv 829	S rs e C 1829	S ors e Cuv 829	S s Cu 829
			S d as es H e & Snodg ass 1903	[9]S gh a Ch dhur 9	[9]S gha a Chaudhur 9	
J o C 829	S Je o C 8 9	S Je o Cu 8 9	S J Cu 829	Je o Cuv 82	S J o Cuv 829	S Je o C 829
S ob usa a Cuv 829	S ob usa C 829	S ob us a Cuv 1829	S ob usa a Cuv 829	S ob usa a Cu 829	S ob us a Cuv 1829	[10]S ch yso aenia K un nge 884
	[4]S al p nni Ogl by 9 0		S genie Klunzinge 870	S gen e Klunz nge 8 0	S g n o Klunzinge 1870	S g e K unz nge 18 0
			[8]S nov ho and ae Gun he 860	S no h and ae Gun h 860	S n aeh a d ae Gun h 860	S no ho and e Gun he 8 0
	[5]S b achygna hus B k 854					
	[6]S japon S h ge 84					

recor d

& yon m b d W b 9 De S (96

& ynon m d R ppe 83 De y (9

P ob b ynonym g ge 8 0 De y a 9

ynonym J 8 S and W ms (986

J da ca JU De and W m (9

8 V d y ub d e y (

S nonym of S d as es le & S o g 903 de De Sy a (9

0 P b b e no m S ob us 829 De Sy va and W am (986

of this group by these authors Morphometric characters have been employed even to the extent of stock variability studies in a species of barracuda S obtusata by Kothare and Bal (1976) Graves and Somero (1982) have used electrophoretic studies as a tool for delineating the interspecific difference of four species of lesser barracudas (S lucasana S argentia S idiastes and S ensis)

2 2 Food and Feeding habits

Not much information is available on this inmportant aspect of biology of barracudas However the highly predatory nature of Sphyraenids is proved beyond doubt De Sylva (1963) described the way in which both young ones and adults of sphyraenids swallow the prey S barracuda is generally a day time feeder while smaller species of barracudas are nocturnal feeders (De Sylva 1973) Pillai (1981) and Somvanshi (1989) also gave hints on feeding habits of barracudas

The literature on the functional morphology of feeding in this family is limited to the osteological details given by Gregory (1933) and the works by Suyehiro (1942) and Yasuda (1960) on S pinguis

Austin and Austin (1971) studied the diet and dietary habits of barracudas Reshetnikov et al (1972) gave an account of the prey-predator relationship in the family Sphyraenide while Blaber (1982) highlighted the significance of predation by S barracuda

Mowbray (1922) Gudger and Charles (1928) De Sylva (1963 1973 & 1982) and Valdes (1980) reported ciguatera poisoning caused by barracudas which is attributed to their feeding habits and ecology

Feeding intensity in relation to breeding in *S obtusata* has been studied by Kothare (1973) and Premalatha and Manojkumar (1990) while a similar account in the case of *S jello* has been given by Premalatha and Manojkumar (1990)

Of all the species of Sphyraenids very few have been studied with a view to understand their food preferences as well as change in the choice of food with seasonal variation and at different phases of the life history Even in such cases the knowledge is often incomplete

Most of the studies on the food of fishes are based on analysis of the contents of the stomach while a few workers have taken into consideration the contents of the entire gut of the captured fish A number of methods have been developed for analysing the stomach contents of fishes and for recording the results of which mention may be made of Pearse (1915) Breder and Crawford (1922) Job (1940) Swinnerton and Worthington (1940) Hynes (1950) and Bhimachar and George (1953)

In all these methods for dietary analysis the objective has been to study either the frequency of occurrence of food items or the bulk The occurrence method is insulated from the quantitative element and the quantitative methods from the occurrence element The Index of preponderance method proposed by Natarajan and Jhingran (1961) eliminates this handicap by taking into consideration the occurrence as well as volume of each of the food items in grading Recently Mohan and Sankaran (1988 a) proposed two new indices Simple resultant index and Weighted resultant index which reflect the relative significance of occurrence as well as volume elements as in the index of preponderance method and also facilitate better graphical interpretations

The various methods of stomach content analysis in fish have been reviewed by Hynes (1950) Pillai (1952) Windell (1971) Windell and Bowen (1978) and Hyslop (1980) However while studying the food habits of barracudas most of the workers have made only a qualitative analysis Chacko (1949) reported the food preference of barracudas in general while Menon (1942) and Rabindranath (1966) studied the stomach contents of S acutipinnis De Sylva (1963) working on S barracuda made interesting observations regarding food items This species in the Losy estuary has been subjected to stomach content analysis by Blaber (1982) Kothare (1973) studied the food preferences of both juveniles and adults of S obtusata while Somvanshi (1989) reported the food of juveniles of this species

A work in this line most relevant to the present area of study is that of Premalatha and Manojkumar (1990) They made investigations on the food items of S obtusata as well as S jello of Cochin area

2 3 Breeding Biology

There is virtually no information on the breeding biology of S jello the species subjected to detailed investigation in the present study except for Manacop (1936) and also notes by Premalatha and Manojkumar (1990) Generalised observations on the spawning of sphyraenids have been made by De Sylva (1973)

No sexual dimorphism in general appearance has so far been reported in any of the sphyraenids and thus it appears that the sexes may be identified by macroscopic examination of the gonads Length-weight relationships of both the sexes have been studied closely by De Sylva (1963) in S barracuda and Kothare (1973) Somvanshi (1989) and Premalatha and Manojkumar (1990) in S obtusata

Studies on maturation and spawning habits of barracudas from Indian waters are meagre Observations on occurrence of ripe females and size at first maturity in the case of S barracuda have been made by Malpas (1926) from Ceylon waters and De Sylva (1963) from Miami Study of condition factor has been made use of to find out the size at first maturity in S obtusata from Bombay waters by Kothare (1973) Somvanshi (1989) and Premalatha and Manojkumar (1990) also gave size at first maturity of this species from Gulf of Mannar and Cochin region respectively Premalatha and Manojkumar (1990) provided similar informations in the case of *S jello* also

Information on spawning of this group is often confined to records of ripe individuals and at rare instances appearance of juveniles has provided clue to delineate the spawning period Such reports are those of Walford (1932) on *S argentia* Williams (1956) on *S barracuda* and Rabindranath (1966) on *S acutipinnis*

Spawning season and periodicity in *S barracuda* has been given by De Sylva (1963) while that of *S obtusata* by Kothare (1973) and Premalatha and Manojkumar (1990) Probably the only information of similar kind available on *S jello* is that of Premalatha and Manojkumar (1990) Occurrence of juveniles of *S jello* has been reported by Venkataramanujam and Ramamoorthy (1974) and Premalatha and Manojkumar (1990)

Note on the ovarian developments in barracudas is made available by Pillai (1981) Observations of De Sylva (1963) in *S barracuda* were indicative of the age and size dependent variation in absolute fecundity Kothare (1973) reported the fecundity range in *S obtusata* while Pillai (1981) gave a generalised fecundity range in barracudas Premalatha and Manojkumar (1990) also reported the absolute fecundity of *S obtusata* and *S jello* from Cochin waters

Length weight relationships in S obtusata have been given by Kothare (1973) Somvanshi (1989) and Premalatha and Manojkumar (1990) De Sylva (1963) discussed this type of relationship in S barracuda and he also compared the exponent with that of a chunky heavy bodied fish (Euthynnus alletteratus) to delineate the contrasting nature of length related weight increment Similar expressions in S jello have been provided by Premalatha and Manojkumar (1990)

MATERIALS AND METHODS

III MATERIALS AND METHODS

Monthly random collections were made for a period of 24 months (November 1988 to October 1990) from the various fish markets in Ernakulam Cochin Fisheries Harbour Integrated Fisheries Project and Fort Cochin Most of the samples were from the landings by the small commercial trawlers operating from Cochin while a few were obtained from the landings at the Integrated Fisheries Project by its larger vessels Therefore the gap between the catch and sampling time was only five to eight hours since the small commercial trawlers return on the same day Three numbers of large specimens of the size range 724 to 943 mm in total length were also obtained from the gill net landings

A total of 141 males and 64 females were subjected to various analyses during the course of study The males ranged in total length from 270 to 943 mm while the females ranged between 322 and 770 mm The specimens were preserved in five percent formalin after incising the abdomen

3 1 Systematics

Three species of barracudas belonging to the genus Sphyraena collected from the marine landings of Cochin region were used for the present study A random sample of 20 numbers each of S jello (222 798 mm in standard length) and S obtusata (171-247 mm SL) and a single specimen of S barracuda (937 mm SL) have been used for redescription

3 1 1 Morphometric characters

Morphometric measurements were made to the nearest millimeter using dividers The measurements are expressed as percentage of standard length (Head length Pre dorsal length Pre-pectoral length Pre pelvic length Pre anal length Inter dorsal space and body depth) head length (Pre orbital Post orbital and Eye diameter) and body depth (caudal peduncle depth)

The different measurements made as illustrated in Fig 1 are

1 Total length (TL) tip of the snout to the tip of the upper caudal lobe
2 Fork length (FL) tip of the snout to the tail fork
3 Standard length (SL) tip of the snout to base of the caudal fin
4 Head length (HL) tip of the snout to the free tip of operculum
5 Pre orbital length tip of the snout to the anterior margin of eye
6 Eye diameter antero-posterior diameter of the eye
7 Post orbital length posterior margin of the eye to the free tip of the operculum
8 Pre dorsal length tip of the snout to the anterior margin of the first dorsal

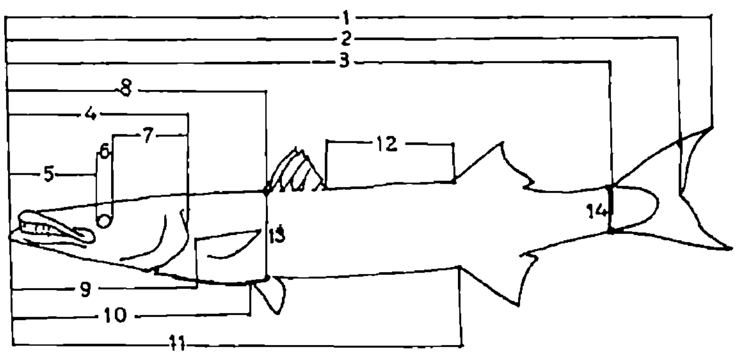


Fig 1 Diagramatic representation of the different morphometric measurements

9 Pre pectoral length tip of the snout to the upper base of pectoral

10 Pre pelvic length tip of the snout to the anterior base of pelvic

11 Pre anal length tip of the snout to the anterior margin of anal fin

12 Inter-dorsal space last spine of the first dorsal to the first spine of the second dorsal

13 Bodydepth maximum depth of the body below the first dorsal spine

14 Caudal peduncle depth depth of caudal peduncle between the base of first and last caudal rays

3 1 2 Meristic counts

Fin ray counts and scale counts on lateral line and lateral triangle were taken

3 1 3 Other characteristics

Numbers and characteristics of jaw and palatine teeth and gill rakers were noted Colour pattern of fresh specimens was also closely examined for the redescription

3 2 Food and Feeding habits

During the course of study 141 males and 64 females of S jello were investigated to understand the food and feeding habits in terms of quality quantity and seasonal changes Of these 57 males and 11 females were of size range upto 400 mm while 80 males and 51 females were of the range between 400 and 500 mm in total length These two size groups (upto 400 mm and 400 500 mm) were dealt with separately all through the analysis so as to study the differences in food preferences if any between these size groups The remaining six fishes (four males and two females) in the size range 501-943 mm were analysed separately for food habits

3 2 1 Feeding habits

To provide supporting evidence for the feeding habits the pattern of jaws mouth and pharyngeal teeth gill rakers and also the relative length of gut (R L G) were studied R L G was obtained using 109 males and 46 females in the total length range of 270 943 mm employig the formula

$$\text{R L G} \quad \frac{\text{length of gut}}{\text{total length of fish}} \times 100$$

3 2 2 Qualitative analysis

Qualitative analysis was done by identifying the food items to the lowest syste iatic level possible depending upon the condition of the food organism based on the extent of digestion

3 2 3 Quantitative analysis

The intensity of feeding was recorded based on the state of distension of the stomachs and the quantity of food contained in them and were accordingly categorised as

E (Empty)		empty stomach
T (Traces)		traces of food in stomach
P (Poor)	-	1/4 full stomach
M (Medium)	-	1/2 full stomach
G (Good)	-	3/4 full stomach
H (Heavy)		full and distended stomach

Stomachs in these conditions were assigned points of 0 5 10 20 30 and 40 respectively Thus Points method (Swinnerton and Worthington 1940 Hynes 1950 Bhimachar and George 1953) was adopted for the quantitative analysis and the various food contents were given points corresponding to their contribution to the total content of each stomach (percentage volume - V_i) Further analysis was done taking into consideration the occurrence of each of the food items in all the specimens observed (percentage occurrence O_i) Combining these two factors the index of preponderence method (Natarajan and Jhingran 1961) was followed in the present study which is given by the formula

$$\text{Index of preponderence (I)} \quad \frac{V_i O_i}{\Sigma V_i O_i} \times 100$$

For better graphical representation of the relative importance of volume and occurrence two new indices namely Simple resultant index (Rs) and Weighted resultant index (Rw) (Mohan and Sankaran 1988 a) were calculated Thus the Simple resultant index was obtained using the formula

$$Rs \quad \frac{(V_1^2 + O_1^2)^{\frac{1}{2}}}{\Sigma (V_1^2 + O_1^2)^{\frac{1}{2}}} \times 100$$

The Weighted resultant index was calculated using the formula

$$Rw \quad \frac{Q\ (V_1^2 + O_1^2)^{\frac{1}{2}}}{\Sigma Q\ (V_1^2 + O_1^2)^{\frac{1}{2}}} \times 100 \quad \text{where } Q \quad \frac{45 - / \theta - 45 /}{45}$$

θ being the angle which is equal to $\tan^{1} (O_1 / V_1)$ These indices were plotted on the Y axis of a graph against the angle (0) on the X axis thus bringing out the relative importance of volume and occurrence of each food item in determining its grade

3 2 4 <u>Gastro somatic index</u>

In order to study the fluctuations in the feeding intensity during different months of an year the gastro somatic index (Ga S I) was calculated as

$$Ga\ S\ I \quad \frac{\text{Weight of the stomach with contents}}{\text{Weight of the fish}} \times 100$$

Ga S I worked out separately for males and females is compared with the gonado somatic index (G S I) for the respective periods so as to correlate the spawning feeding relationship

3 2 5 Prey-Predator length relationship

The total length of the prey was noted whenever intact in order to bring out the prey-predator length relationship

3 3 Breeding Biology

A total of 139 males of the size range 270 to 553 mm and 63 females of the range 322 to 501 mm in total length were used for studying the various aspects of the breeding biology of the species S jello Sex and proper stages of maturity were determined in the fresh condition itself while all further analyses were carried out using formalin preserved specimens

3 3 1 Maturation and Spawning

For classification of the maturity stages a five stage key was used wherein the stages are categorised based on the colour translucency the extent of body cavity occupied by the ovary and also the visibility of ova in it in the case of females In addition to colour of the testis its width nature of margin and softness were also used for this purpose in males

Ova diameter measurements were done on a monocular microscope with 10 x 10 magnification after standardising the calibrations on the ocular micrometer using a stage micrometer The ova were classified at intervals of 75 μ and those below 150 μ were considered as a block (immature stock) in all stages In order to study the differential distribution of ova stocks in the ovary if any ova diameter measurements were taken from the anterior middle and posterior regions of the ripening/ripe ovary A few ovaries in the different stages of maturity were used to study the maturation of ova through these stages Random samples of about 1000 eggs each of pooled subsamples from different regions of the ovary were measured for this purpose Hickling and Rutenberg (1936) Prabhu (1956) Karekar and Bal (1960) Qasim and Qayyum (1961) and Nair and Nair (1983) made use of the ova-diameter data also to understand the spawning frequency of fish species

To delineate the spawning season the monthly percentage occurrence of the mature females (stages III and IV) and also that of the spent/partially spent ones (stage V) were used The data thus obtained were supplemented with a quantitative assessment of the condition of the gonad employing the method of Gonado somatic index G S I has been worked out as

$$G\ S\ I \quad \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100$$

Low values of G S I represent an immature or spawned out condition while high values indicate the ripe populations So this provides scope for delineating the spawning season as shown by sharp decline of the index value in the plot of the average monthly G S I for the whole year

All data pertaining to the maturation and spawning studies are graphically represented to picturise the breeding habit of S jello

3 3 2 Size at first maturity

All the specimens collected were grouped into different length classes with an interval of 50 mm and the percentage occurrence of individuals at maturity stages III and above in each of these classes was noted Data thus obtained were represented graphically to find out the minimum size at first maturity of both males and females

3 3 3 Sex ratio

The sex ratio of random collections made each month for detailed biological studies during the two year period of investigation were calculated and represented graphically to show the fluctuation in the female ratio as against male ratio

3 3 4 Fecundity

For fecundity studies 22 specimens of S jello with ripe ovaries were used The specimens ranged from 400 to 501 mm in total length (334 to 410 mm in standard length) and 259 to 469 gm in weight

Length of the ovaries ranged between 115 and 160 mm and their weights between 8 678 and 26 323 gm Average of the lengths of the two lobes has been taken as the length of the ovary Since fecundity is defined as the total number of mature/naturing eggs present in a ripe ovary all fully yolked eggs were considered for the counts (Hickling and Rutenberg 1936)

Fecundity counts were obtained employing gravimetric method From a weighed ovary a minimum of three subsamples were taken at random Weight of the subsamples ranged between 120 and 199 mg Such samples were counted for the number of mature ova and the average number per subsample worked out for each ovary Then on the basis of the average count average weight of the subsample and the weight of the ovary the total or absolute or individual fecundity was computed using the formula

$$\text{Absolute fecundity} \quad \frac{\text{Weight of the ovary x Average egg count}}{\text{Average weight of subsample}}$$

The ralationships between fecundity and standard length of fish weight of fish length of the ovary and weight of the ovary were also calculated using linear regression

3 3 5 Length weight relationship

A total of 139 males and 63 females were examined for the calculation of length weight relationship Males ranged from 270 to

553 mm in total length (220 to 447 mm in standard length) and 81 to 592 gm in weight In the case of females the range was between 322 and 501 mm in total length (266 and 410 mm in standard length) and 149 and 513 5 gm in weight Length measurements were taken with an accuracy of ± 0 5 mm and weight in a double pan balance with a precision of ± 0 5 gm

The regression equation y A + bx where y log weight (gm) x log length (mm) A log a the constant and b regression coefficient was calculated by the method of least squares This was done separately for both the sexes and the resulting regression coefficients were subjected to analysis of covaria ce[1] to test whether the regression of y on x is significantly different for the two sexes The correlation coefficient (r) for the two variables of length and weight was also found out for the different sexes separately and the same was tested for its significance[2] using t test

1 $$t \quad \frac{/ \; b_1 \;\; b_2 \; /}{\sqrt{\left[\frac{\Sigma Y_1^{\,2} \quad \frac{(\Sigma X_1 Y_1)^2}{\Sigma X_1^{\,2}} + \Sigma Y_2^{\,2} - \frac{(\Sigma X_2 Y_2)^2}{\Sigma X_2^{\,2}}}{n_1 + n_2 \;\; 4}\right]\left[\frac{1}{\Sigma X_1^{\,2}} \quad \frac{1}{\Sigma X_2^{\,2}}\right]}}$$

2 $$t \quad r \sqrt{\frac{n-2}{1-r^2}}$$

3 3 6 <u>Condition factors</u>

The Ponderal index (K) is calculated utilizing length weight data to determine the condition or general well being of the fish The ponderal indices used in this study were obtained from the formula K $\frac{W \times 10^5}{L^3}$ where W is the weight of the fish in gram and L its length in mm (Jhingran 1972)

Relative condition factor (Kn) is given by the formula Kn $\frac{W}{\bar{W}}$ where W is the observed weight and $\bar{W}$ is the empirically calculated weight using the length-weight relationship established ie log W log a + b log L (Le Cren 1951) The average monthly relative condition factor was computed from the individual Kn values

These condition factors were obtained separately for males and females during each year The plots of condition factors (two years pooled data) are used to strengthen the findings on spawning season in the species To assess whether the ponderal index (K) is also influenced by the fat content of the fish in addition to maturation of gonads and presence of undigested food the K value was also calculated using eviscerated weight of the fish in lieu of the weight of whole fish in the formula

RESULTS

IV RESULTS

4 1 Systematics

4 1 1 Systematic position

The latest systematic position of the barracudas as per Nelson (1984) following the classification of Greenwood et al (1966) is as follows

Super order	Acanthopterygii
Order	Perciformes
Sub order	Sphyraenoidei
Family	Sphyraenidae
Genus	Sphyraena Klein

4 1 2 Redescription of the species

The percentage range of various morphometric measurements in relation to the standard length head length and body depth for the three species redescribed are given in Table 3 (the mean values are used in the text)

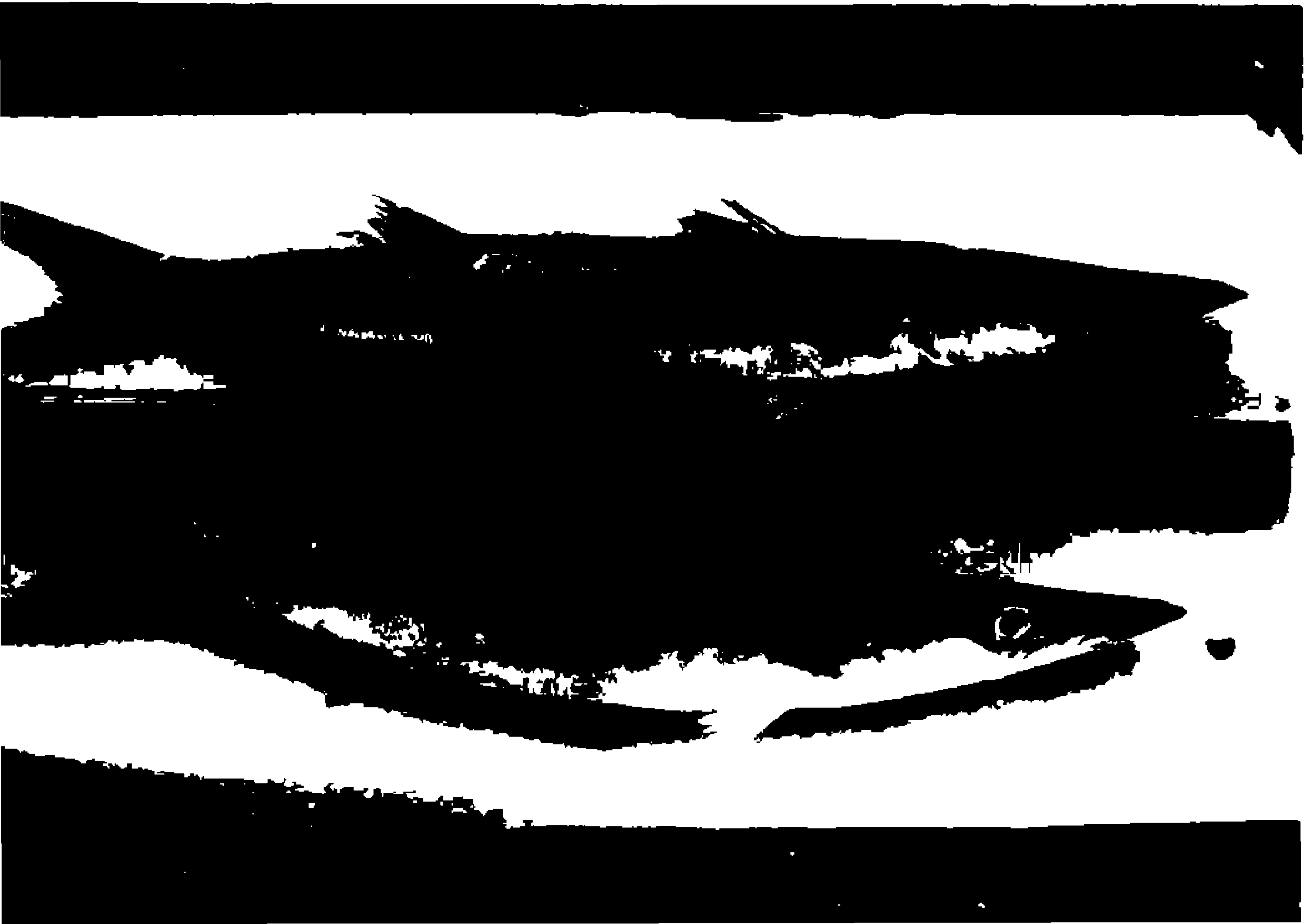
1 Sphyraena jello Cuv (Fig 2)

D V+I 9 A II 8 P 14 V I 5 C 17 LL 126 130 Ltr 17 18/23 24

Table 3 The percentage range of various morphometric measurements in relation to Standard length Head length and Body depth in *S jello* *S obtusata* and *S barracuda* (mean values given in brackets)

Morphometric characters	*S jello* 20 specimens)	*S obtusata* (20 specimens)	*S barracuda* (1 specimen)
As percentage of SL			
1 Head length	29 07 37 03 (3[illegible] 82)	33 52 36 46 (34 62)	30 1
Pre dorsal length	41 10 45 04 43 63)	43 96 46 96 (45 57)	41 2
3 Pre pectoral length	29 07 35 13 (33 08)	32 95 35 94 (34 83)	31 2
4 Pre pelvic length	36 34 42 34 (40 21)	39 77 42 73 (41 11)	36 18
5 Pre anal length	73 31 77 91 (76 22)	72 72 76 61 (74 84)	71 4
6 Inter dorsal space	17 01 24 23 (20 46)	14 36 18 22 (16 22)	21 98
7 Body depth	11 42 16 54 (14 27)	15 [illegible]0 18 92 (16 40)	17 61
As percentage of HL			
8 Pre orbital length	44 44 50 54 (48 68)	43 21 46 8 (44 54)	46 8
9 Post orbital length	33 62 41 38 (37 02	35 62 39 44 (37 48)	41 49
1 Eye diameter	11 64 17 83 (14 43)	17 57 21 62 (19 33)	13 48
As percentage of Body depth			
1 Caudal peduncle depth	40 31 56 52 (46 13)	4 22 55 55 (49 09)	40 0

Fig 2 *Sphyraena jello* Cuv



Body elo g te and so e l at cyli drical Large l ead 32 % of SL) Long pointed snout vith axilla reaching to anterior arg of the e e lo er ja projecting tl out a flesl y t p lou h arg Upper ja itl a single se ies of tiny teeth and t o airs of larg canines in front lo er ja ith larger teeth i a single ro n d teetl ue lo ger tha t ose n o and a s gle st o g at the symphysis h ch fits into the recess on the upper a F sharp canines on the palatine F rst g ll arcl ithout g ll raker (Fig 3)

Pre orbital 48 68% of FL a d post orbit l 37 02% of L Eyes not ery large measur ng 14 43% of L Pre opercle round a opercle th t o soft sp nes

l rst dorsal fin orig n slightly bel ind the orig n of pe cs (Pre dorsal 43 63% of SL and Pre pel c 40 21% of SL) r dor space 20 46% of S Anal origin behind the or g n of secon dorsa (Pre anal 76 22% of SL) l re pectoral 33 08% of SL Body dept 14 2 % of SL and Caudal peduncle depth 46 19% of body dep th Scales e o d small in s ze LI 126 130)

Bod dusky b ack abo e the lateral l and s l ery lo 18 20 dusky cross bars present

str l ut on Indo l acific regi (Weber and Bea for 192

Fig 3 Branchial arches of (A) S jello and (B) S obtusata

GR Gill raker

De Syl a 1973 De Sylva and \ lliams 1986) More com o Arabian sea and Bay of Bengal than to tle south and east n Pac f c De Sylva 1 3)

2 <u>Sphyraena</u> <u>obtusata</u> Cuv & Val) Fig 4)

D \ II 8 A I J P 14 V I 5 C 17 LL 90 91 8 16

Body elongate and slightly compressed Large l ead (34 b % o SL) Lo g po ted s ut with ax lla ot re ing c a te r arg of eye lo ver ja projecting Mouth large upper jav tl a er of inute teeth and t o pa rs of sharp ca ines i fro t a ter r sma pair and posterior large pair) slender teeth on lo er ja th single canine at the symphysis Palatine vith a single ro of a fe sharp teeth follo ved by numerous inute teetl I i st gill arch i h t vo gill rakers one at the angle and a smaller one at the lo ver li b (Fig 3)

Pre orbital 44 54% of HL and Post orbital 37 48% of L Ly very large measuring 19 33% of HL Pre opercle rounded a d operc vith a single soft spine

First dorsal or g n sl ghtly beh nd t e or g n of pelv s I r dorsal 45 57% of SL and Pre pelv c 41 11% of SL) Dorsals no d separated Inter dorsal space 16 22% of SL) Anal orig n almost oppos

Fig 4 Sphyraena obtusata (Cuv & Val)

to that of the second dorsal Pre-pectoral 34 83% of SL and Pre anal 74 84% of SL Body depth 16 40% of SL and Caudal peduncle depth 49 09% of body depth Scales cetenoid large ın size (LL 90 91)

Body greyısh above and sılvery white below Pelvıcs white all other fins with an yellow tinge No cross bars

Dıstrıbutıon Central and Western Indo Pacıfıc regıon (De Sylva & Wıllıams 1986)

3 Sphyraena barracuda (Walbaum) (Fıg 5)

D V +I ı 8 A II 8 P 14 V I 5 C 17 LL 83 Ltr 12/14

Body elongate and slıghtly compressed Head large (30 10% of SL) Long snout wıth maxılla reachıng to the anterıor margın of eye lower jaw projecting

Upper jaw w th a sıngle serıes of small teeth and a paır of canınes ın front Lower jaw also has a sıngle serıes of teeth wıth two sharp canines in front Palatıne wıth large broad teeth whıch gradually reduces ın sıze towards the back of the jaw Fırst gıll arch wıthout any gıll rakers

Pre orbıtal 46 81% of HL and Post orbıtal 41 49% of HL Eyes

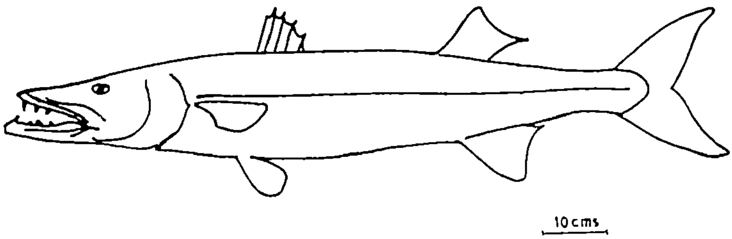


Fig 5 *Sphyraena barracuda* (Walbaum)

comparatively small measuring only 13 48% of HL

First dorsal fin origin behind the origin of pelvics (Pre-dorsal 41 20% of SL and Pre pelvic 36 18% of SL) Dorsals widely separated with Inter-dorsal space 21 98% of SL Anal origin behind the origin of second dorsal Pre-pectoral 31 20% of SL and Pre anal 71 40% of SL Body depth 17 61% of SL and Caudal peduncle depth 40 00% of body depth Scales ctenoid large in size (LL 83)

Body greenish to steel grey above and silvery below with inky blotches on posterior part of the lower side Paired fins white and median fins dark

Distribution Circumtropical in distribution (Talwar and Kacker 1984) According to De Sylva and Williams (1986) the barracudas are seen in all tropical seas except Eastern Pacific

4 2 Food and Feeding Habits

4 2 1 General morphology of alimentary canal

S jello has a large mouth with the lower jaw projecting beyond upper jaw A single series of small triangular teeth is present on the upper jaw (premaxillary) and two pairs of sharp triangular canines in front Palatines also bear long teeth The lower jaw (dentary) carries a single series of traingular teeth much larger than those on the upper jaw and also a strong canine in front which fits into a recess in the upper jaw The size of the teeth in lower jaw increases posteriorwards

Branchial arches are long so that the cavity between the floor of the cranium and floor of the mouth is enlarged facilitating the swallowing habit Gill rakers are totally absent on any of the gill arches But infra and supra-pharyngeal tooth pads are present on the ceratobranchials and pharyngobranchials respectively

Buccal cavity leads into a short muscular oesophagus at the posterior end of which the well defined distensible elongated stomach is seen The pyloric caecae are formed at the junction of the oesophagus and stomach A short straight intestine starts from near the anterior region of stomach runs parallel to it and opens to the outside (Fig 6)

The relative lengths of gut expressed as percentage of total length of the fish for males and females separately are given belo

Males	32 12 3 54
Females	32 77 + 3 64
Pooled data	32 32 + 3 58

4 2 2 <u>Qualitative analysis of the gut contents</u>

Gut content analysis of the random collections during the two

Fig 6 General morphology of alimentary canal of S jello

G	Gonad	L	Liver
H	Heart	PC	Pyloric caecae
I	Intestine	ST	Stomach

year period revealed that the major portion of the food consisted of small pelagic shoaling fishes like sardines anchovies and carangids Occassionally cephalopods were also observed in the diet The gut contents on most occasions were in a semi digested state making detailed taxonomic identification difficult There were just two instances throughout the period of investigation when crustaceans were found in the gut content

The principal fish groups encountered are the anchovies (Anchoviella spp) the scads (Decapterus sp) (Fig 7) and sardines (Sardinella spp) Fish and fish remains were invariably present in the gut irrespective of sex and size during all the months Fish larvae (Leiognathus spp and Secutor sp) were also recorded as forming part of the food content during February of first year

Cuttle fish (Fig 8) appeared in the gut contents of smaller females (less than 400 mm in total length) during December and in bigger ones (400 500 mm in TL) during March and May in the first year In the case of males cuttle fish was recorded in both the size groups in the first year during December and May and only in the bigger size group in the second year in April

Among the six largest specimens (four males and two females) having a size more than 500 mm in total length males (552 943 mm) investigated had empty stomachs The two females (501 mm and 770 mm) had fish as principal gut co tent

Fig 7 Major fish prey encountered in the stomach contents of *S jello*

A *Decapterus* sp

B *Anchoviella* sp

Fig 8 Cephalopod remains encountered in the stomach contents of *S jello*


A
B

4 2 3 Quantitative analysis

The indices of preponderance for the different size groups of males and females for the two year period are given in Table 4a & 4b respectively and illustrated in Fig 9 The graphical representation of the results of the analyses of Simple resultant index (Rs) and Weighted resultant index (Rw) given in Fig 10 brings out the relative significance of volume and occurrence of the different food items Values of these indices and also the index of predonderance (I) are presented in the Table 5 so as to compare the relative importance of various food items The gross picture of the ranking of food items using the three indices remains the same

Invariably the fish and fish remains ranked first irrespective of the size and sex during the two years of study Semi-digested matter ranked second followed by the cephalopods Semi digested matter found in stomachs with fish or fish remains must in all probability be of fish origin But due to their unidentifiable nature they are included under semi-digested matter

Figure 10 clearly brings out the relative importance of volume and occurrence of the different food items Fish and fish remains attain the importance more due to the volume rather than occurrence But semi digested matter attains second importance which can be attributed more to its occurrence than volume In the case of the

Table 4a Indices of preponderance of the food items in males of *S jello*

Size group	Period	Food item	Volume	Occurrence	Percentage volume (Vi)	Percentage occurrence (Oi)	Vi Oi	Index of preponderance (In)
Upto 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	317	24	69 67	51 06	3557 35	77 27
		Crustaceans						
		Cephalopods	38	1	8 35	2 13	17 79	0 39
		Semidigested matter	100	22	21 98	46 81	1028 88	22 35
	Nov 89 to Oct 90	Fish and fish remains	93 5	7	62 33	43 75	2726 92	56 27
		Crustaceans						
		Cephalopods						
		Semidigested matter	56 5	9	37 67	56 25	2118 94	43 73
Above 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	429 8	25	65 62	43 86	2878 09	68 94
		Crustaceans						
		Cephalopods	65	3	9 92	5 26	52 18	1 25
		Semidigested matter	160 2	29	24 46	50 88	1244 52	29 81
	Nov 89 to Oct 90	Fish and fish remains	157	8	74 76	44 44	3322 33	75 07
		Crustaceans						
		Cephalopods	7 5	1	3 57	5 56	19 85	0 45
		Semidigested matter	45 5	9	21 67	50 00	1083 50	24 48

Table 4b Indices of preponderance of the food items in females of S jello

Size group	Period	Food item	Volume	Occurrence	Percentage volume (Vi)	Percentage occurrence (O)	ViO	Index of preponderance (In)
Upto 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	119 2	9	72 24	45 0	3250 80	84 73
		Crustaceans	9	2	5 45	10 0	54 50	1 42
		Cephalopods	17	1	10 30	5 0	51 50	1 34
		Semidigested matter	19 8	8	12 00	40 0	480 00	12 51
	Nov 89 to Oct 90	Fish and fish remains	9	1	90	50	4500 00	90
		Crustaceans						
		Cephalopods						
		Semidigested matter	1	1	10	50	500 00	10
Above 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	314 2	14	73 07	45 16	3299 84	83 51
		Crustaceans						
		Cephalopods	66 8	2	15 53	6 45	100 17	2 53
		Semidigested matter	49	15	11 40	48 39	551 65	13 96
	Nov 89 to Oct 90	Fish and fish remains	108 40	6	80 30	50	4015 00	80 30
		Crustaceans						
		Cephalopods						
		Semidigested matter	26 6	6	19 70	50	985 00	19 70

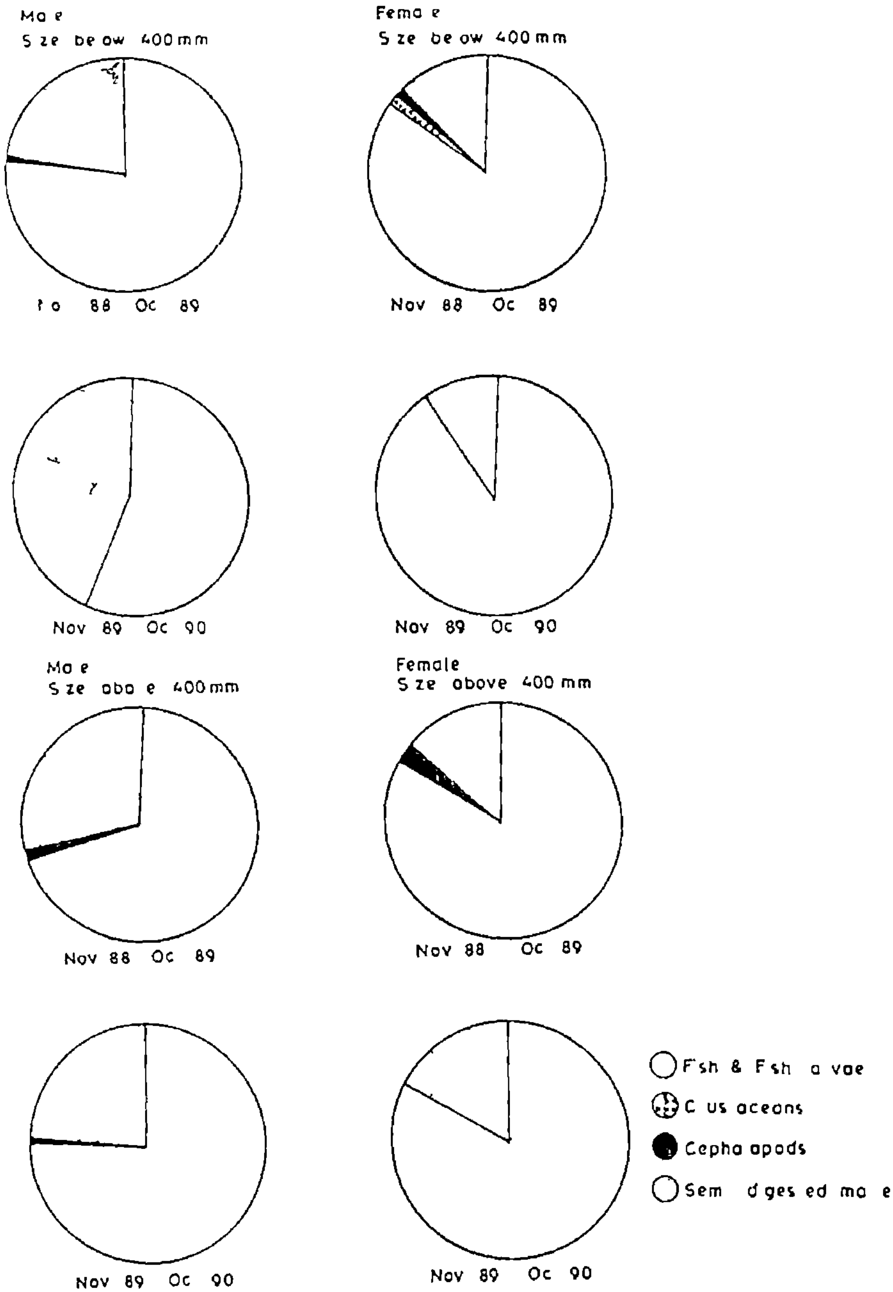


Fig 9 Indices of preponderence of the food tems in two size groups of males and females of S jello

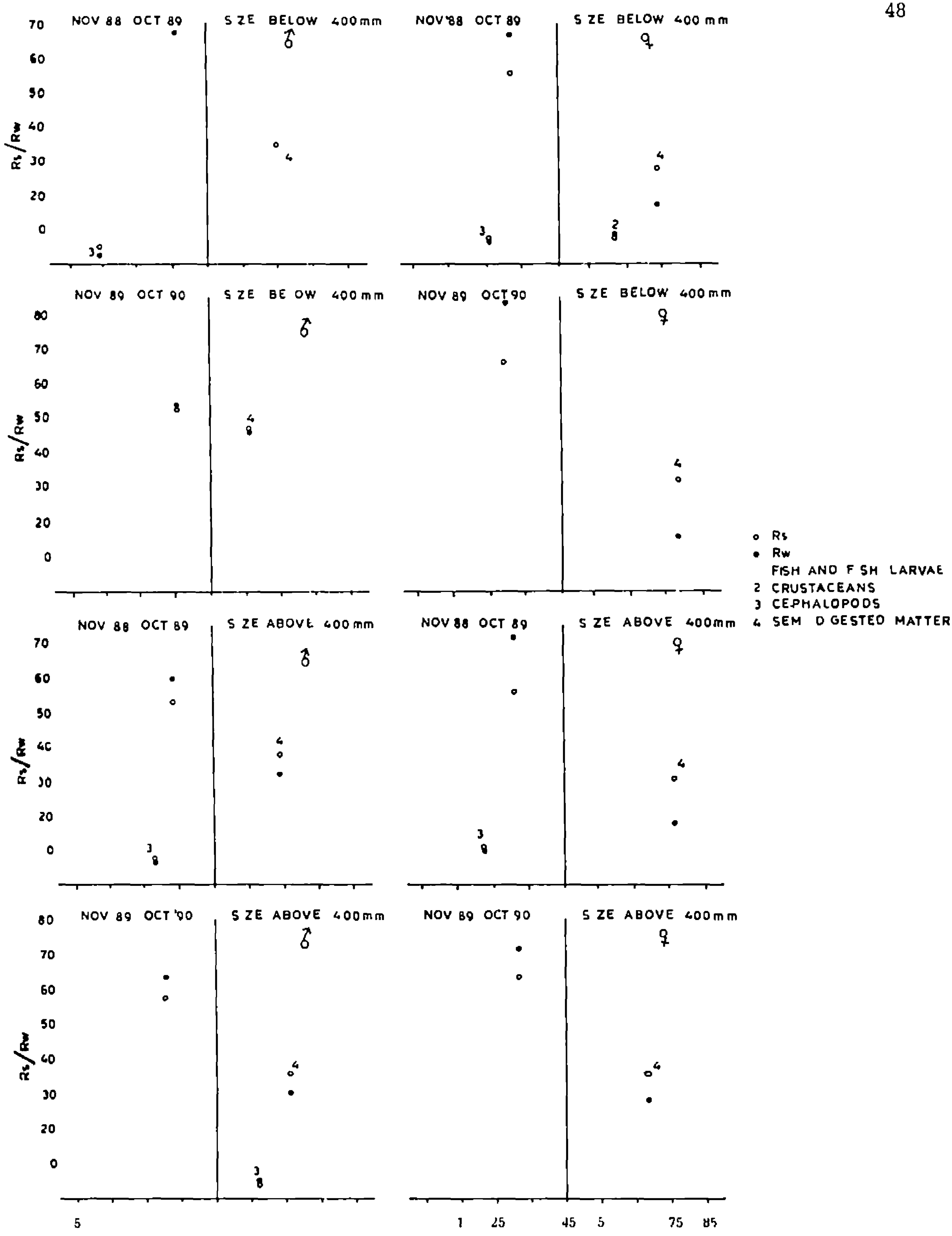


Fig 10 Graphical respresentation of the Simple and Weighted resultant indices of the food items in S jello

Table 5 Simple resultant index (Rs) Weighted resultant index (Rw) and Index of preponderance (In) of the food items in S jello

Size group	Period	Food item	Male			Female		
			Rs	Rw	In	Rs		
Up to 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	58 88	68 81	77 27	56 85	67 23	84 73
		Crustaceans				7 61	8 12	1 4
		Cephalopods	5 88	2 71	0 39	7 65	7 33	1 34
		Semidigested matter	35 25	29 46	22 35	27 89	17 20	1 51
	Nov 89 to Oct 90	Fish and fish remains	52 94	53 91	56 27	66 88	84 0	90 0
		Crustaceans						
		Cephalopods						
		Semidigested matter	47 06	46 09	43 73	33 12	16 0	10 0
Above 400 mm in total length	Nov 88 to Oct 89	Fish and fish remains	53 84	60 20	68 94	56 35	7 06	83 51
		Crustaceans						
		Cephalopods	7 66	7 08	1 75	11 03	10 08	53
		Semidigested matter	38 50	32 72	29 81	32 61	17 87	13 96
	Nov 89 to Oct 90	Fish and fish remains	58 74	64 07	75 07	63 77	72 25	80 30
		Crustaceans						
		Cephalopods	4 46	5 23	0 45			
		Semidigested matter	36 80	30 69	24 48	36 3	27 75	19 70

cephalopods volume is more significant than occurrence except in the males of bigger size group during the second year

4 2 4 Intensity of feeding

Monthly Gastro-somatic index (Ga S I) values calculated separately for males and females are given in Table 6 and illustrated in Fig 11 Inspite of the interruption in the pattern for want of data the plots for the two years give a gross picture In males the peak value of gastrosomatic index occured in November Thereafter it shows a declining trend till February and again increases reaching another peak in May A decrease in the index values is noticed in subsequent months Females also show almost the same trend but differ in the months of peak values being December and March respectively

4 2 5 Prey-predator length relationship

The total length of prey as percentage of the predator length varied between 18 58 and 31 43% based on data obtained from intact prey (Table 7) The mean value is 24 31% An instance of a stomach with a Decapterus sp of length 47 29% of the total length of the predator was also present

Table 6 Monthly Gastro-somatic index (Ga S I) values in <u>S</u> <u>jello</u>

Month	Male		Female	
	Nov 88- Oct 89	Nov 89 Oct 90	Nov 88 Oct 89	Nov 89- Oct 90
NOV	3 38	1 46	2 52	1 29
DEC	2 53	0 94	5 24	0 83
JAN	2 01	0 75		
FEB	0 78	1 19	2 09	0 74
MAR	1 23	-	3 84	
APR	1 77	1 15	2 79	0 74
MAY	3 07	-	2 08	
JUN	1 05	2 23	1 06	0 99
JUL	-	1 10	-	3 04
AUG		-	-	
SEP	2 63	1 66	0 38	1 97
OCT	1 11	1 69	-	1 24

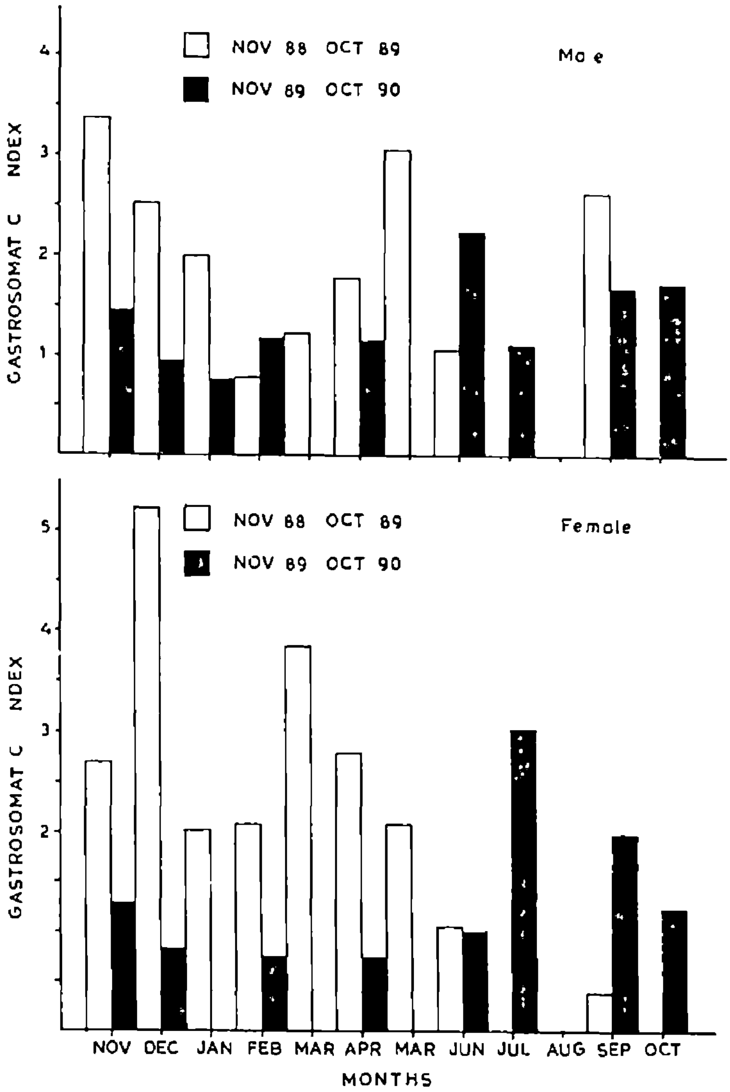


Fig 11 Monthly Gastro somatic index values in males and females of S jello

Table 7 Prey predator length relationship in _S jello_

Total length of predator (mm)	Total length of prey (mn)	Percentage total length of prey
360	85	23 61
355	67	18 87
414	118	28 50
356	111	31 18
419	104	24 82
452	128	28 32
420	132	31 43
372	71	19 07
423	79	18 68
391	88	22 51
465	95	20 43

4 3 Breeding Biology

4 3 1 Classification of maturity stages

It was found convenient to use a five stage key for classification of maturity stages in both males and females of *S jello* These stages could be easily identified by observing the external characteristics of the gonad Microscopic examination was also of help whenever in doubt The five stage key prepared is as follows

Stage I (Immature virgin) -

Female Ovaries in this stage are very small reaching less than or upto 1/3 of the body cavity with almost equal lobes They are transluscent and pinkish in colour Ova are not visible in them Ova diameter below 225 μ the bulk of them (88 0%) below 150 μ No yolked ova are present

Male Testes occupy less than 1/3 of the body cavity They are white in colour and very thin Also the texture is not soft

Stage II (Maturing virgin) -

Female Ovaries reaching about half of the body cavity are with unequal lobes They are pinkish in colour opaque and the ova are visible Yolked ova above 300 μ diameter are also present though mostly below 300 μ

Male Testes also reach half of the body cavity and are slightly broadened with a smooth margin They are whitish in colour

Stage III (Ripening/Spent recovering)

It is difficult to differentiate between first time ripening and spent recovering females and males

Female Ovaries reaching 2/3 of the body cavity with colour turned to slight yellow They are granular in appearance Most of the ova are yolked and have a diameter well above 300 μ

Males Creamy and broad testes Reach 2/3 of the body cavity They have an irregular margin

Stage IV (Ripe)

Female Ovaries occupy the whole body cavity They are deep yellow in colour The ovarian wall is transparent and the ova are clearly visible Conspicuous blood vessels appear all over the ovarian wall Ova mostly in the range of 450 750 μ in diameter

Male Creamy testes are very soft and occupy almost the entire body cavity Testes have highly irregular margin

Stage V (Partially spent/spent)

Female Ovaries with a reduced size reaching to only half the body cavity They are dark pinkish transluscent and flaccid in appearance with scattered atretic mature ova

Male Testes reach half of the body cavity with dull white colour and flabby appearance It is difficult to distinguish between partially spent and spent testes

4 3 2 Size at first maturity

Size at first maturity determined by graphical plot of the data relevant to all mature (Stage III and above) fish examined (Table 8) is given in Fig 12 First mature males appeared in 250 300 mm length class while the first mature females appeared only in the length class 300 350 mm Practically all male fish were found mature on reaching 450 500 mm length class and all female fish on reaching 500 550 mm length class The 50% maturity is plotted in the above figure and it is clear from the figure that the size at first maturity for males is around 360 mm and that for females is around 370 mm

4 3 3 Distribution of ova in the ovary

The distribution of ova stocks in the anterior middle and posterior regions of a ripe ovary are presented in Table 9

Table 8 Percentage occurrence of mature fish with increasing size in S jello

Size class (mm)	Percentage of mature fish	
	Male	Female
250 300	8 1	
301 350	27 4	19 9
351 400	63 0	54 7
401 450	91 3	88 3
451 500	100 0	97 1
501-550	100 0	100 0
above 550	100 0	

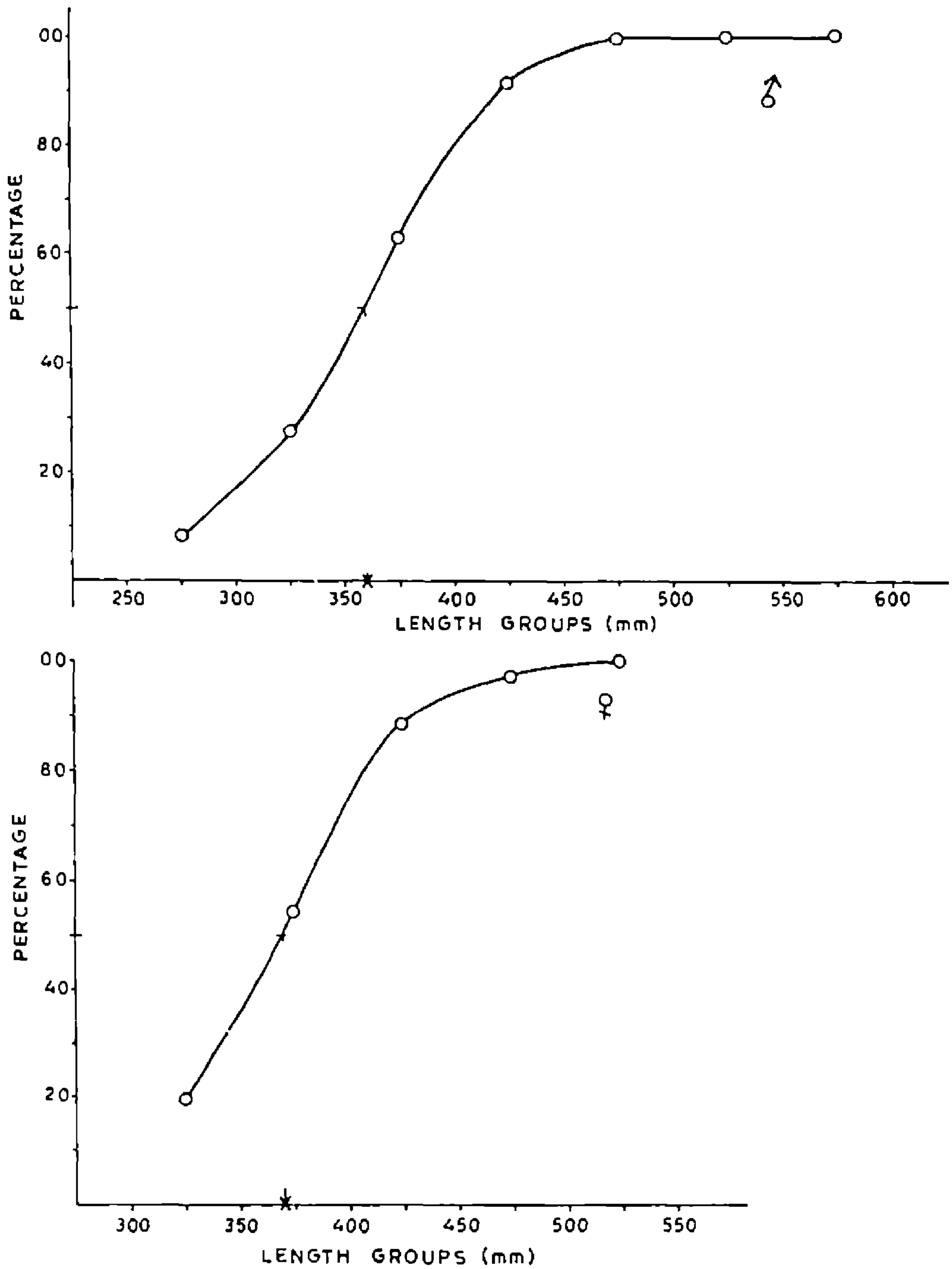


Fig 12 Percentage occurrence of mature fish with increasing size in S jello

and illustrated in Fig 13 It is evident from the figure that the gross picture of the ova stock distribution from the three regions remains almost the same except for the slight variations in the percentage composition of the mode However the ripe mode shifts slightly in the posterior region (600-675 μ) indicating presence of increased numbers of larger ova in this region as compared to the anterior and middle regions It was also noted that ova above 300 μ in diameter are generally yolked

4 3 4 Growth of ova in the ovary

To eliminate the possibility of slight differences in ova stocks distribution betwen the regions of the ovary mixed subsamples were taken for the ova diameter measurements to study the growth of ova in the ovary The percentage frequency of different size classes of ova in the different stages of maturity (five stages) of the ovary (Table 10)) is shown in Fig 14

Apart from the block (88 0%) representing ova below 150 in diameter (in nature stock) the stage I (immature virgin) has ova only in the diameter class of 150-225 μ (12 0%) Coming to the stage II (maturing virgin) the immature stock is reduced to 67 0% and the maturing stock ranges from 150 450 μ the mode being at 150 225 μ class In the stage III (ripening/spent recovering) the picture becomes more clear with a distinct ripe mode at 600 675 μ class In this stage an increasing percentage of occurrence can be seen from

Table 9 Distribution of ova in the ovary (stage III)

Ova diameter * class (μ)	Percentage frequency in different regions		
	Anterior	Middle	Posterior
0 150	28 16	22 92	13 08
150 225	13 25	5 20	3 01
225 300	8 64	6 82	3 62
300 375	4 72	4 40	4 10
375 450	5 20	9 52	11 03
450-525	5 80	11 03	14 03
525-600	15 97	18 19	16 04
600 675	13 50	13 21	25 10
675 750	4 75	8 73	10 00

* Oocytes above 300 μ are yolked

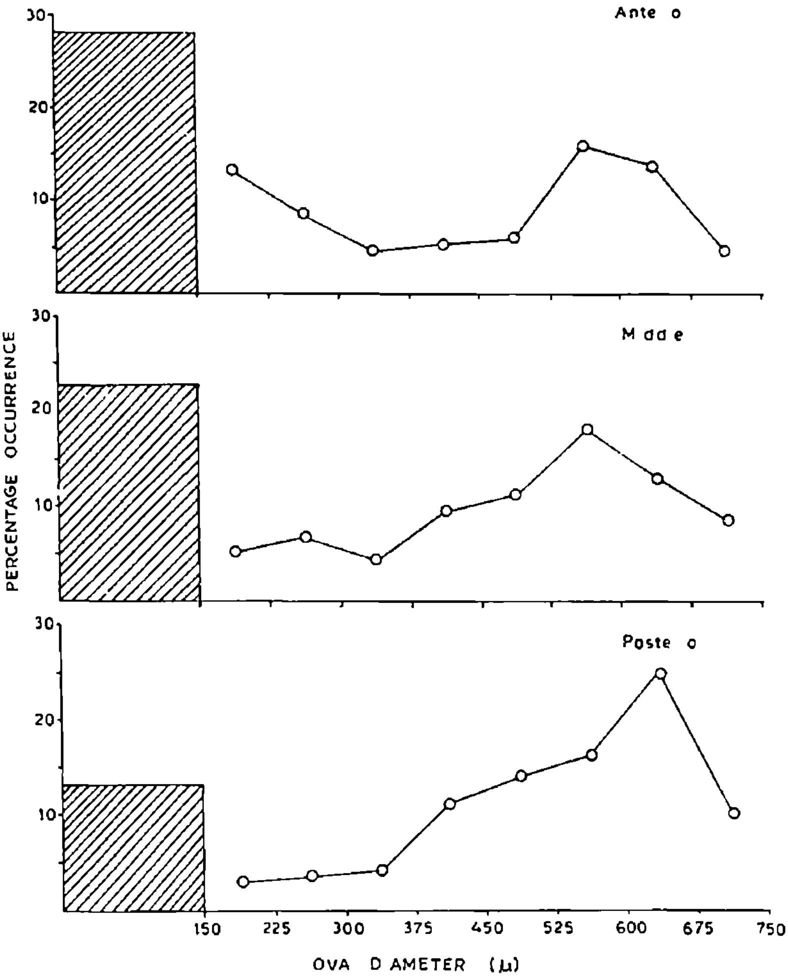


Fıg 13 Dıfferentıal distrıbution of ova stocks ın a rıpe ovary of S jello

Table 10 Frequency of ova diameter classes in different maturity stages

Ova diameter class (μ)	Percentage frequency in different maturity stages				
	I	II	III	IV	V
0 150	87 90	67 32	14 00	11 25	18 50
150-225	12 10	17 43	4 03	2 47	9 18
225-300		8 00	6 20	6 81	7 98
300 375		4 25	5 92	3 06	15 00
375 450		3 01	7 00	6 22	8 01
450 525			11 10	7 76	13 71
525 600			18 80	13 08	6 92
600 675			24 21	25 10	8 84
675 750			8 73	12 32	4 47
750 825				7 78	4 41
825 900				4 12	2 97

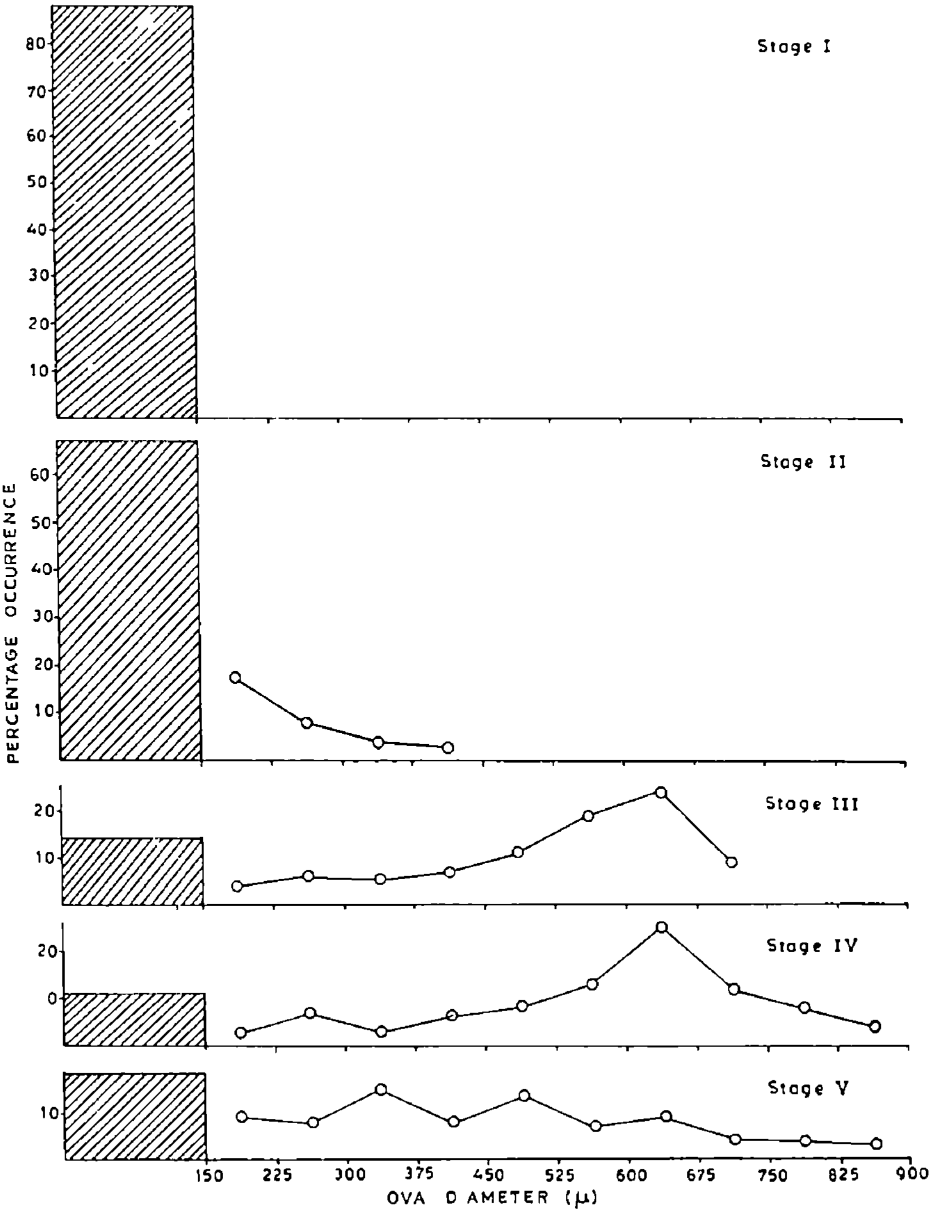


Fig 14 Differential distribution of ova stocks in the five maturity stages in S jello

the lower size class to the higher ones The same ripe mode is represented in the stage IV (ripe) with an increase in the percentage of occurrence of that size class (600 675 μ) A steady decrease in the percentage occurrence of the immature stock of ova (less than 150 μ) with increasing maturity is also evident from the figure Stage V (Partially spent) provides a picture of promiscuous modes but has better percentage of occurrence of the immature stock (new source) and an increased presence of ripening stock being widely spread out (225-600 μ)

4 3 5 Spawning season

The monthly percentage occurrence of mature (stages III and IV) and partially spent/spent (Stage V) females for the two years are presented in Table 11 and illustrated in Fig 15 The gross picture remains the same for the two years of study A steady increase in the percentage of mature individuals can be seen from November onwards reaching the maximum value during May 1989 and June 1990 (absence of sample during May 1990) The spent individuals make thier appearance in the collections from April onwards during both the years During the period May/June to September/October a decreasing trend in the percentage occurrence of mature individuals coupled with a rise in the percentage occurrence of spent individuals can be clearly discerned from the figures

The period of occurrence of spent individuals in the population

Table 11 Percentage occurrence of mature and spent females during different months

Month	Nov 88 Oct 89		Nov 89-Oct 90	
	Percentage occurrence of stage III & IV	Percentage occurrence of stage V	Percentage occurrence of stage III & IV	Percentage occurrence of stage V
NOV	9 80	0 00	17 20	0 00
DEC	17 21	0 00	21 23	0 00
JAN	19 50	0 00	32 41	0 00
FEB	29 43	0 00	31 40	0 00
MAR	36 72	0 00		
APR	48 17	21 25	43 36	8 28
MAY	55 18	34 23	*	*
JUN	34 22	51 90	59 02	36 40
JUL	*		27 73	62 78
AUG	*	*	*	
SEP	21 75	50 48	13 77	68 29
OCT	*	*	14 35	16 07

* No collection

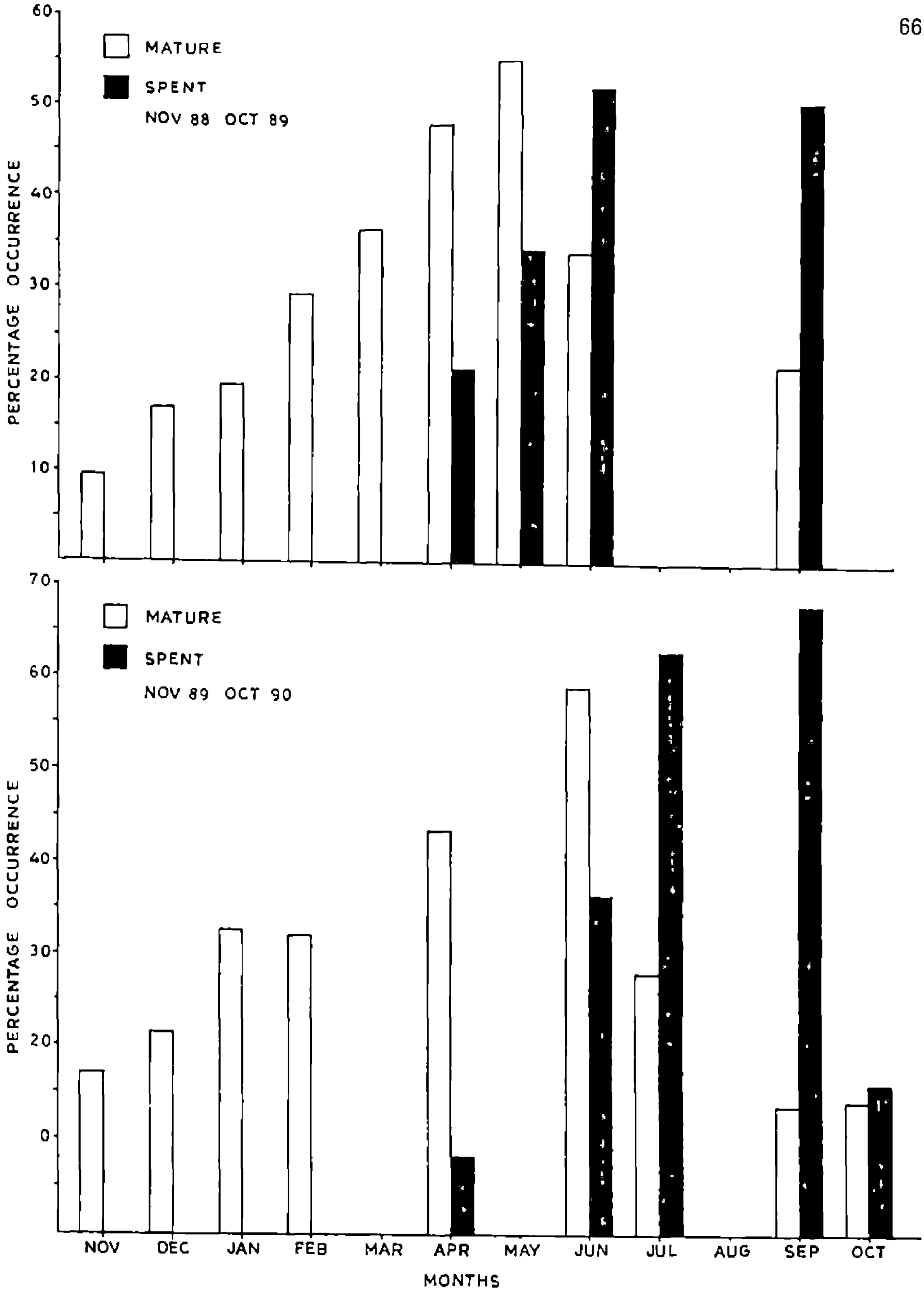


Fig 15 Monthly percentage occurrence of mature and spent females of S jello

during April September/October in the two year period clearly denotes a protracted spawning season for the species Increased spawning activity as denoted by the period of steep fall in the percentage of mature individuals coinciding with the steep increase in spent individuals occurs during June-September

To corroborate the findings on spawning season the data on monthly gonado somatic index (G S I) values (Table 12) are graphically presented in Fig 16 As illustrated in the figure the gonado-somatic index in the case of males attains its peak value during the month of June in both the years which is followed by a steep decline in the subsequent months Thereafter rebuilding starts from September onwards and the increase is almost steady from February till June In the case of females the index fluctuations were not that regular as shown by the graph The peak value was in April with a secondary peak in June for the first year while the peak in the second year occured in June During both the years the rebuilding started from November onwards and was more prominent after January/February Both the sexes are in general shown to have low index values during the period November March

The inference on spawning season is thus strengthened by the plot of monthly gonado somatic index showing a sharp decline after June Absence of spent individuals from November to March coinciding with the low values of gonado-somatic index denotes the period of no spawning activity It can be summarised from the above findings

Table 12 Monthly Gonado somatic index values (G S I) in S jello

Month	Male		Female	
	Nov 88 Oct 89	Nov 89- Oct 90	Nov 88 Oct 89	Nov 89 Oct 90
NOV	0 59	0 79	0 53	0 68
DEC	0 88	0 70	1 75	1 44
JAN	0 88	0 92		1 62
FEB	0 99	0 68	1 62	2 88
MAR	1 25		2 67	
APR	1 61	1 11	4 65	3 12
MAY	1 62		2 85	
JUN	1 77	4 16	3 29	5 01
JUL		2 98		4 53
AUG				
SEP	0 97	0 19	3 70	1 70
OCT	1 47	0 64		1 27

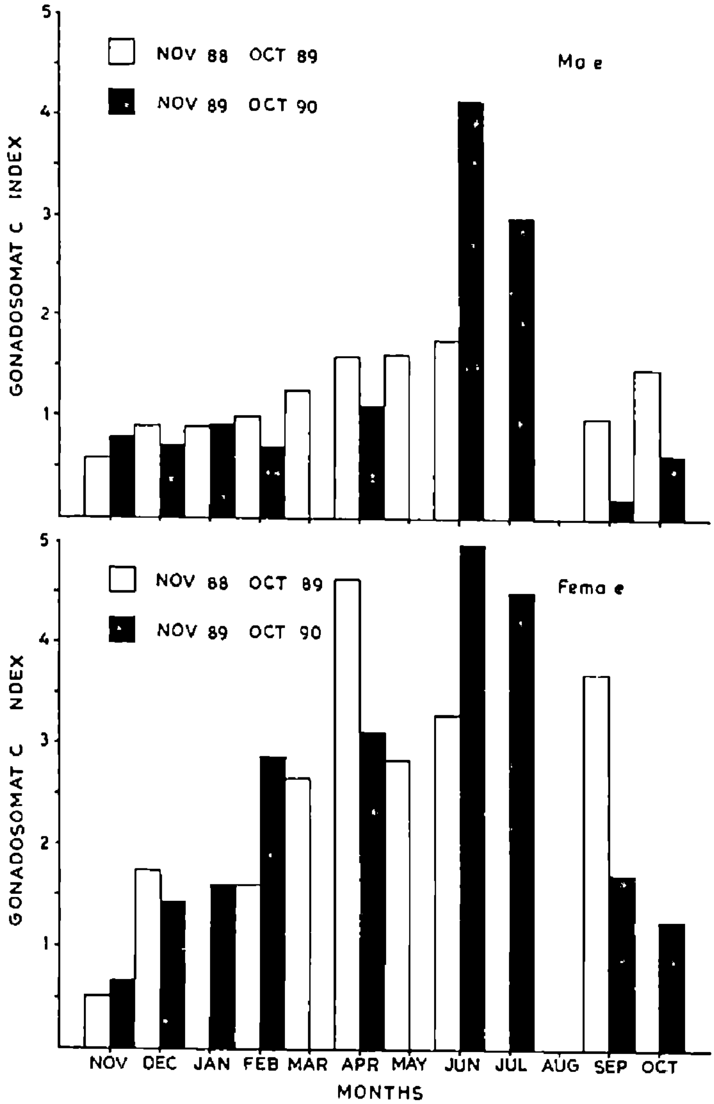


Fig 16 Monthly Gonado somatic index values in S jello

that S jello has a protracted spawning season from April to September/October with increased activity during June to September

4 3 6 Spawning frequency

The results of ova diameter studies are illustrated in Fig 14 The figure shows the presence of only a single distinct mode of ripe eggs with the range in size of the mature ova being more than half the total range in size of the entire intraovarian eggs (Stage IV) This clearly denotes that spawning takes place over an extended period of time with an almost continuous supply of gradually maturing eggs which contribute to the general stock of ripe eggs throughout the spawning season Thus an individual fish may spawn more than once during the protracted spawning season

4 3 7 Sex ratio

Figure 17 shows the sex ratio of the monthly random collections for the two year period (pooled data) Since the ratio of females is plotted against the unit ratio of males it facilitates understanding of the relative abundance of females to the male population Though there are interruptions in the data a gross picture evolves for the two year period In general the females outnumbered the males during the months of May June and July This denotes a female dominance coinciding with spawning activity (data lacking for August in both years)

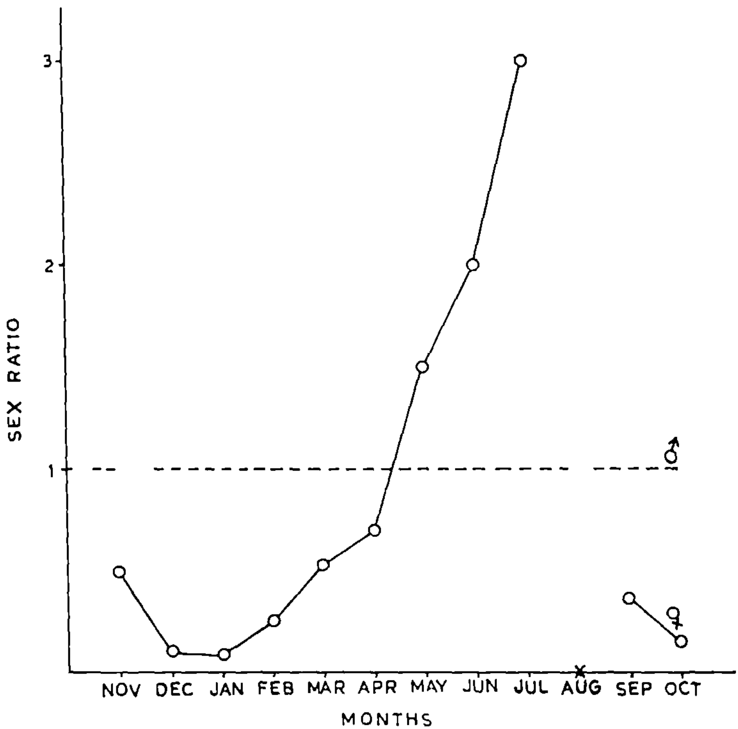


Fig 17 Monthly male to female ratio ın S jello usıng pooled data for the two year perıod

4 3 8 Fecundity

The results of the fecundity counts are given in Table 13 Absolute fecundity ranged from 82 431 to 1 63 533 in the size of 400 to 501 mm standard length The relative fecundity ranged from 2288 to 4215 per cm fish length and from 273 to 383 per gm body weight of the fish

The relationship between fecundity and a) Standard length of fish (mm) b) Weight of fish (gm) c) Length of ovary (mm) and d) Weight of ovary (gm) were found out and are represented in Table 14 and illustrated in Figs 18 21

4 3 9 Spawning Feeding relationship

By comparing the plots of gastro somatic index with gonado-somatic index in Fig 22 (pooled data for the two years) it can be seen that feeding intensity is higher during the post spawning period During the period of increased spawning activity they do not abstain from feeding but the intensity is much reduced

4 3 10 Length weight relationship

Length weight relationships were found out separately for males and females Correlation coefficients (r) for these variables were also calculated for both the sexes and tested for significance The

Table 13 Absolute fecundity and relative fecundity in recruit spawners of S jello

Sl No	Fish Total length (mm)	Fish Standard length (mm)	Weight (gm)	Ovary Length (mm)	Ovary Weight (gm)	Average weight of subsample (mg)	Average egg count	Absolute fecundity	Relative fecundity per cm fish SL	Relative fecundity per gm fish weight
1	01	410	469	136	23 467	181	251	16 195	3356	346
2	471	382	412	148	18 377	126	830	121055	3163	234
3	473	388	427	160	19 178	129	1100	163533	4215	383
4	485	401	420	156	13 112	122	1068	114784	2862	273
5	451	363	404	144	20 240	134	820	123857	3356	30
6	448	368	378	129	12 720	120	1094	115006	3125	304
7	465	382	363 5	126	11 430	128	1276	113942	2983	313
8	490	401	446	138	13 520	124	1353	147521	3679	331
9	435	360	339 5	125	10 000	123	1249	101545	2821	299
10	414	346	259	122	9 691	124	1013	79169	2288	306
11	424	354	308	121	10 899	199	1678	91902	2596	298
12	447	371	336 5	130	8 678	122	1454	103425	2788	307
13	447	371	357 5	138	17 174	131	834	109337	2947	306
14	410	338	294 5	115	10 120	127	1064	84785	2508	288
15	451	373	342	132	11 380	128	1186	105443	2827	308
16	437	351	334	132	13 500	124	899	97875	2788	233
17	450	370	371	132	17 976	129	813	113291	3062	305
18	456	376	390	137	26 323	123	565	12031[illegible]	3216	310
19	400	334	295 5	121	16 608	126	642	84622	2534	286
20	441	353	334 5	130	13 971	122	873	99973	2785	293
21	406	336	288	123	14 006	192	1130	82431	2453	286
22	431	3 2	383 5	1 0	11 800	121	1157	112831	3205	294

Table 14 Relatıonshıp between fecundıty and standard length weıght of fısh length and weıght of ovary

Variant (x)	Constant (a)	Regression Coefficient (b)	Correlatıon Coefficient (r)	t value
Standard length of fısh (mm)	-2 7481	3 0357	0 8745	8 0633 **
Weıght of fish (gm)	1 9038	1 2276	0 9513	13 8008 **
Length of ovary (mm)	1 3592	1 7327	0 8049	6 0659 **
Weıght of ovary (gm)	4 6055	0 3766	0 5681	3 0872 **

** sıgnıfıcant at 1 0% level

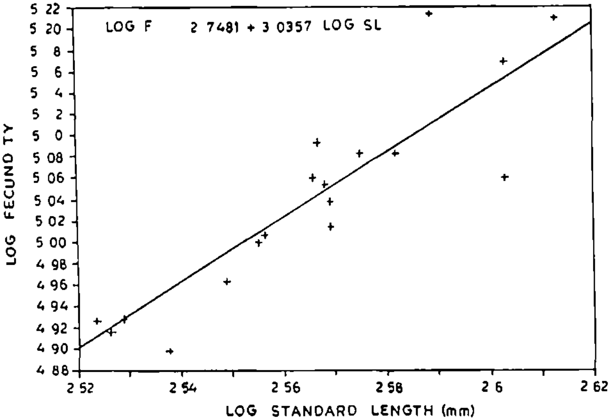


Fig 18 Relationship between fecundity and standard length of fish in S jello

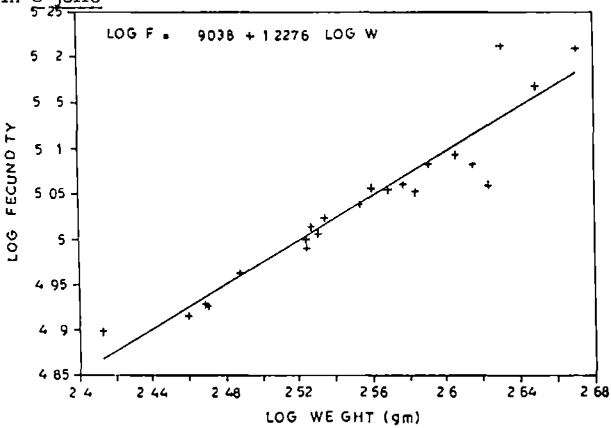


Fig 19 Relationship between fecundity and weight of fish in S jello

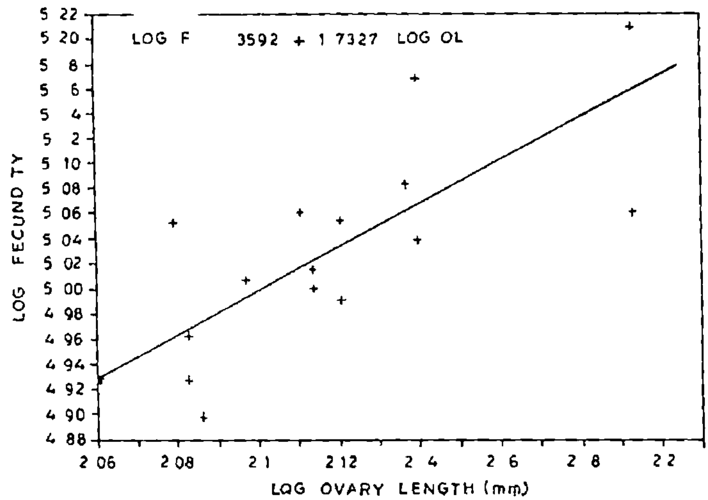


Fig 20 Relationship between fecundity and length of ovary in S jello

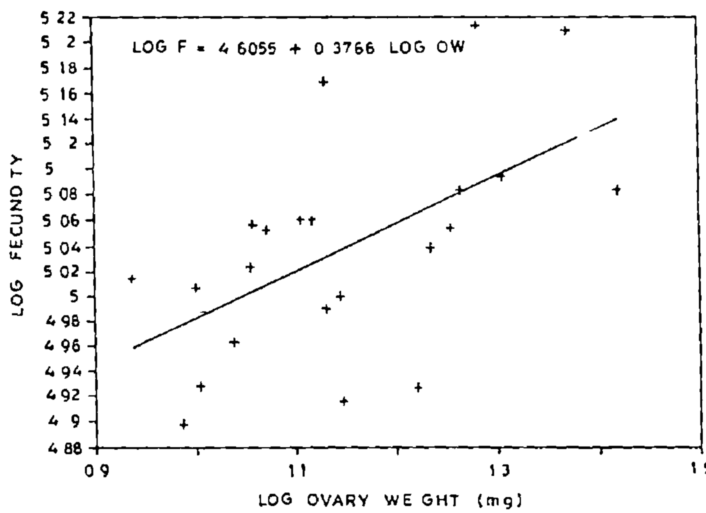


Fig 21 Relationship between fecundity and weight of ovary in S jello

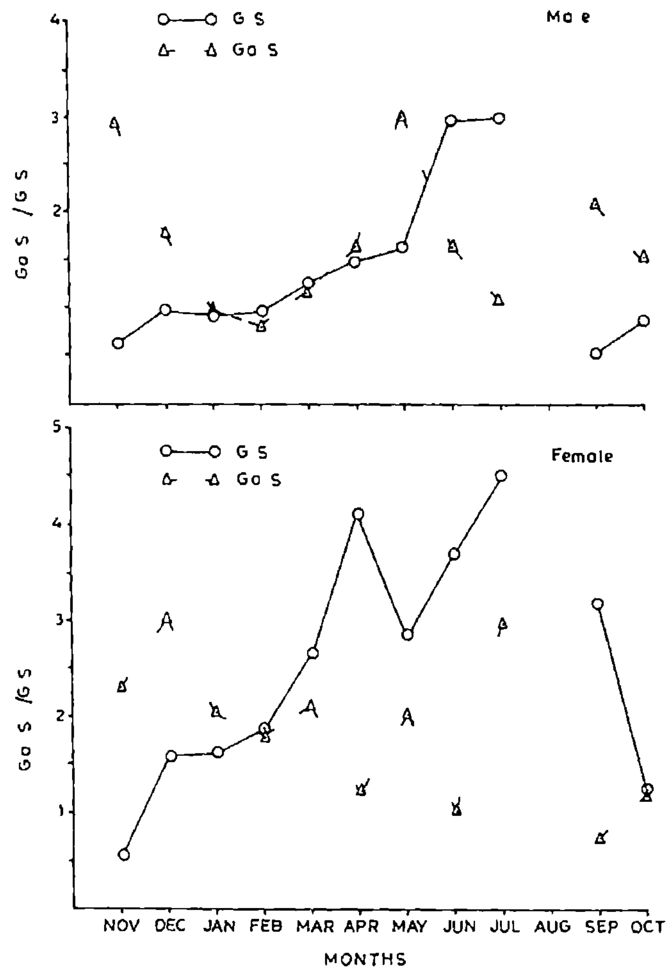


Fig 22 Comparison of monthly Gastro-somatic and Gonado somatic index values for males and females of S jello (pooled data for the two year period)

Male log W -4 4469 + 2 6514 log L

r 0 9556 t 37 9581**

Female log W -3 8308 + 2 4146 log L

r 0 8961 t 15 7682**

where W weight of the fish in gm

L total length of the fish in mm

On comparing the regression coefficients for males and females (b_1 and b_2) the t value obtained was 1 4995 which when compared with the table value of t at 5% level (1 960) showed that the variation between these regression coefficients is not statistically significant Hence the pooled data is used to calculate the length-weight relationship in S jello

log W -4 2751 + 2 5848 log L

r 0 8964 t 28 6004**

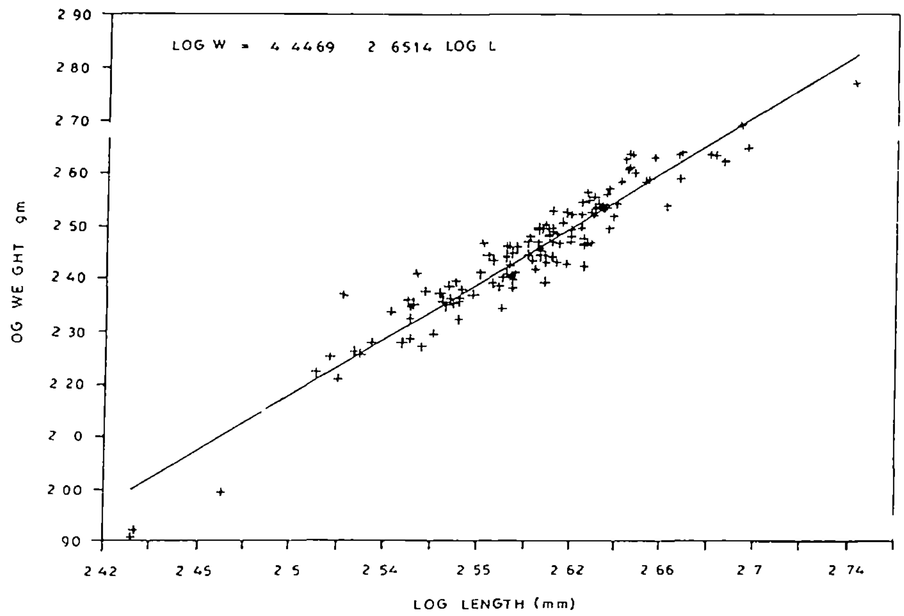
The length-weight equations in this species can be expressed (following the methodology of Mohan and Sankaran 1988 b) as -

Male W 0 00003573 $L^{2\ 6514}_{270-553}$ gm/mm

Female W 0 00014765 $L^{2\ 4146}_{322\ 501}$ gm/mm

Pooled data W 0 00005307 $L^{2\ 5848}_{270-553}$ gm/mm

Graphic representations of these results are shown in Figs 23 24 and 25



I ig 23 Length weight relationship in nales of S jello

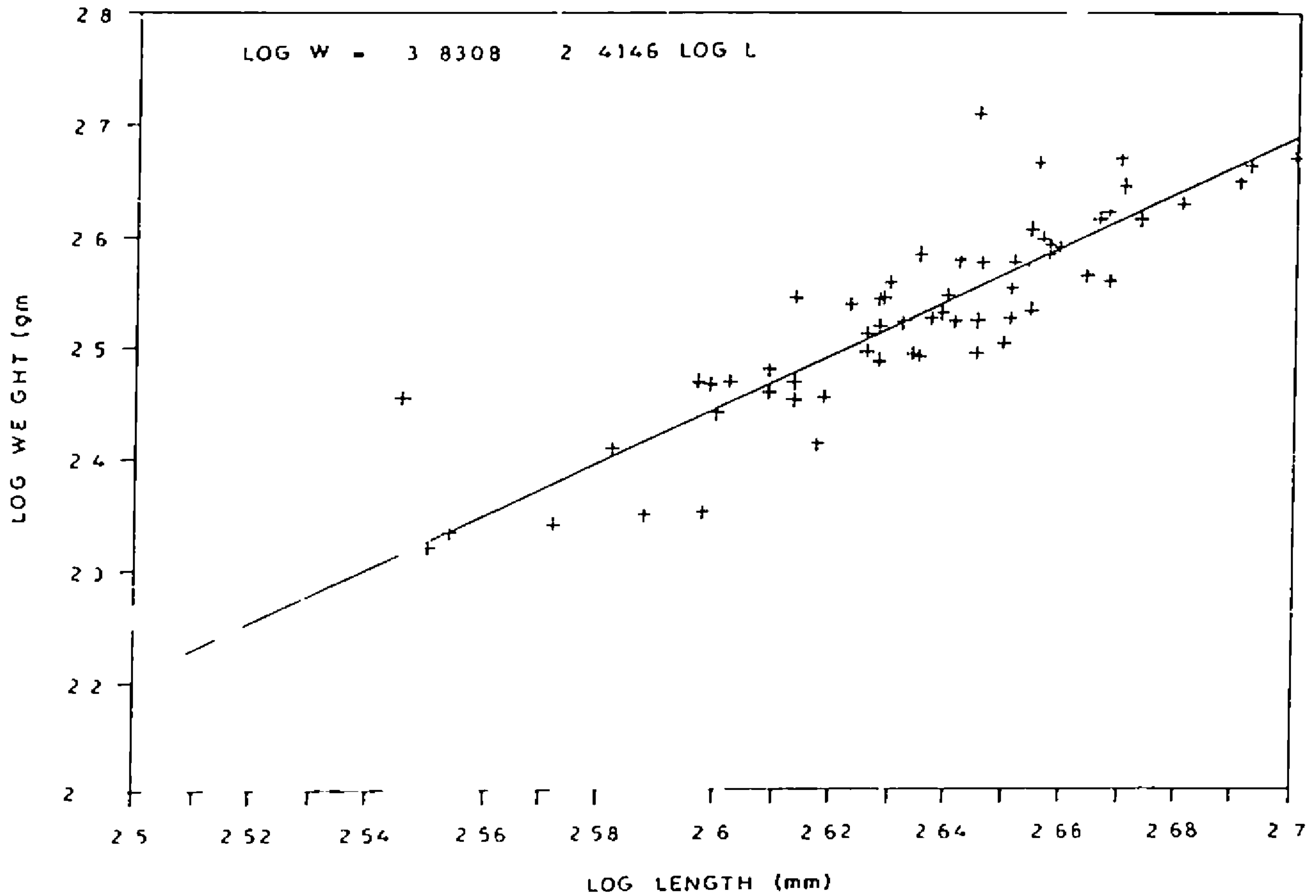


Fig 24 Length weight relationship in females of S. jello

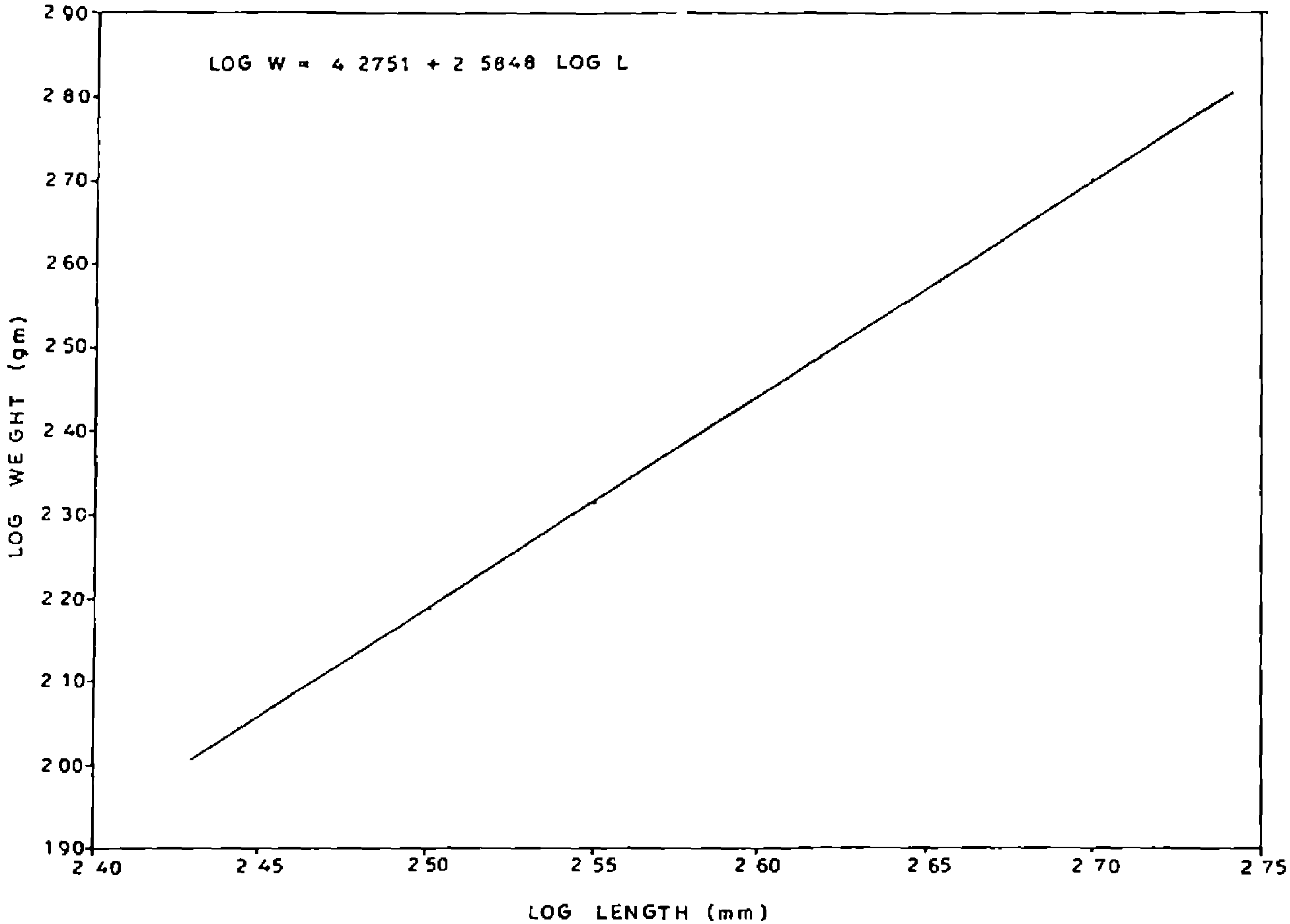


Fig 25 Length weight relationship of the species S jello

4 3 11 Condition factors

The relative condition factor (K_n) worked out separately for the males and females during the two years are given in Table 15 and illustrated in Fig 26 Starting from November till March the relative conditions of males are near unity with slight fluctuations to both sides while from March/April onwards a decreasing trend which is almost steady is seen Relative condition of females also shows a similar trend decreasing from April onwards This pattern of changes more or less depicts the same picture as given by the fluctuations in the gonado somatic index corroborating the findings on spawning activity in the species

In the case of ponderal index (K) also the same kind of variation can be noticed (Fig 26) This is true also for the ponderal index calculated with eviscerated weight (K_{ev}) inferring that the condition is also closely followed by the accumulatio of fat materials in the muscles and other body tissue of the fish thus being a measure of the true well being of the fish

Table 15 Relative condition factor (Kn) Ponderal index (K) and Ponderal index calculated using eviscerated weight (Kev) in S jello

Month	Male			Female		
	Kn	K	Kev	Kn	K	Kev
NOV	1 0292	0 4669	0 4202	1 0429	0 4649	0 4264
DEC	1 0360	0 4615	0 4234	1 0810	0 4895	0 4517
JAN	0 9356	0 4092	0 3863	1 0114	0 4338	0 4065
FEB	1 0194	0 4403	0 4195	1 0557	0 4483	0 4187
MAR	1 0099	0 4488	0 4270	0 9931	0 4305	0 3894
APR	0 9817	0 4288	0 4063	1 0057	0 4186	0 3808
MAY	0 9142	0 4021	0 3733	0 9288	0 3967	0 3646
JUN	0 9682	0 4201	0 3983	0 9405	0 3966	0 3682
JUL	0 8897	0 3681	0 3414	0 9725	0 3853	0 3421
AUG	*	*	*	*	*	
SEP	1 0037	0 4473	0 4257	1 1497	0 4716	0 4412
OCT	1 0352	0 4642	0 4535	1 0109	0 4064	0 3836

Note prepared using pooled data for the two years (Nov 88-Oct 90)

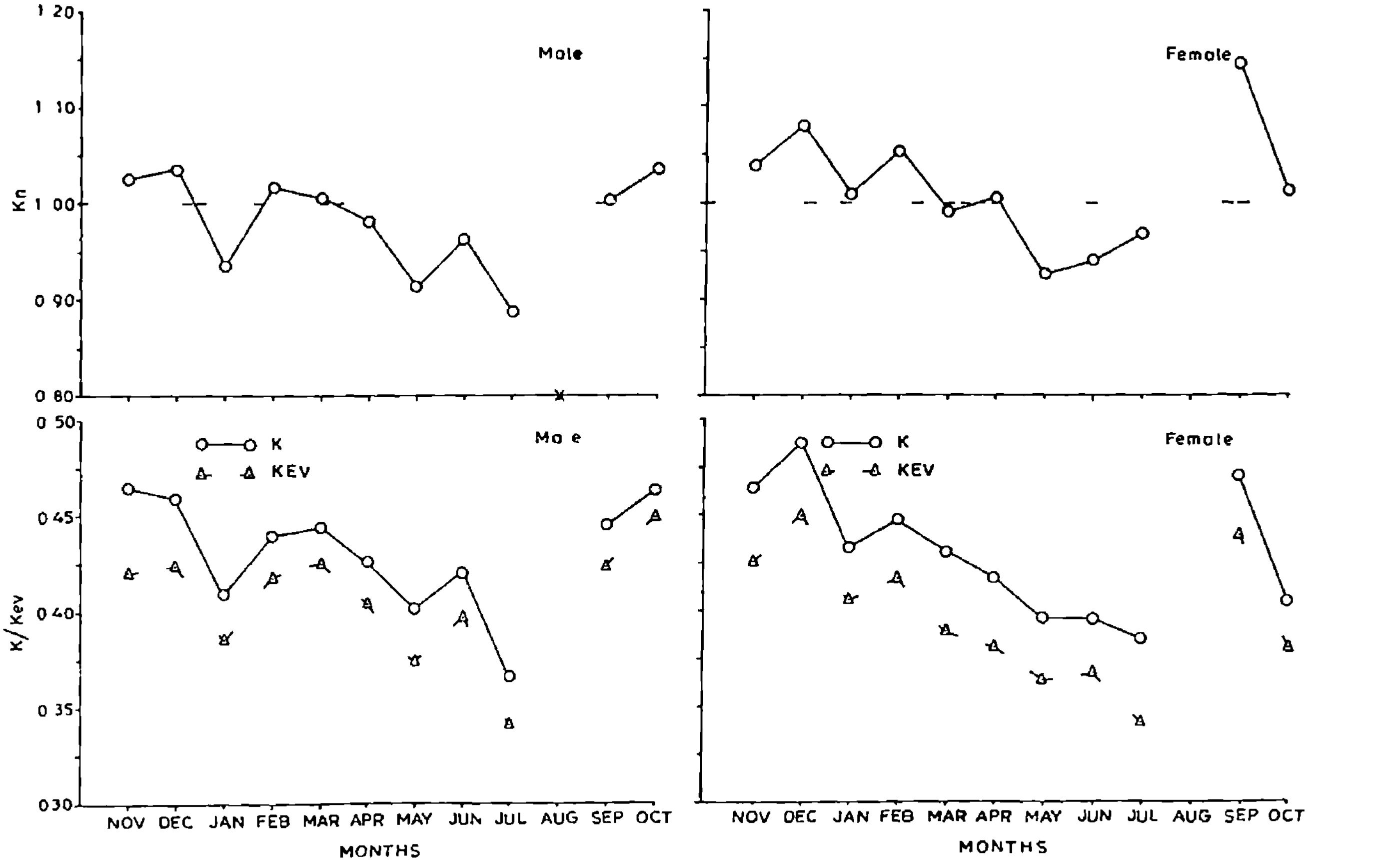


Fig 26 Monthly Relative condition factor (Kn) Ponderal index (K) and Ponderal index using eviscerated weight (Kev) in S jello

DISCUSSION

V DISCUSSION

5 1 Systematics

Specimens of S jello used in the present study have two pairs of large canines on the upper jaw whereas Weber and Beaufort (1922) Abe (1974) and Talwar and Kacker (1984) have described only a single pair of large canines De Sylva (1973) Rose (1984) and De Sylva and Williams (1986) have made no mention of the number of large canines on the upper jaw But in De Sylva and Williams (1986) the photograph of S jello (page 725) clearly shows the presence of two pairs of large canines in the front portion of the upper jaw as seen in the present study S putnamiae Jordan & Seale (S bleekeri Williams) a closely related species is found to have lower jaw with a fleshy point (De Sylva and Williams 1986) But the absence of fleshy tip on the lower jaw of the specimens of S jello used for this study clearly differentiates it from S putnamiae

A solution to the existing controversy on taxonomic proximity or even overlapping of species like S jello Cuv S putnamiae Jordan & Seale (S bleekeri Williams) and S genie Kluzinger needs further studies and clarification Similarly the Indo Pacific S obtusata Cuv S flavicauda Ruppell S pinguis Gunther complex also require further elaborate investigations

5 2 Food and Feeding habits

Despite the scanty information available on the functional morphology of feeding in Sphyraenids the highly predatory nature of feeding in this group has been well established According to Moyle and Cech (1982) the body plan of the barracudas is an interesting compromise between that of the lie in wait predator and that of an active predator Their narrow head-on profile and silvery colouring reduce their visibility to the prey In S jello the two pairs of canines and the series of teeth on the premaxilla together with the palatine canines act against the dentary canine and teeth series for cutting the prey The upper jaw is non-protrusible and according to Nelson (1984) it is a secondary modification in sphyraenids adapting the fish to feeding on large prey This may also help the fish to bite and cut the prey to pieces The infrapharyngeal (ceratobranchials) and suprapharyngeal (pharyngobranchials) bearing small backwardly pointed teeth pads help in swallowing The enlarged cavity between the floor of the cranium and floor of the mouth due to the presence of long branchial arches also facilitiate the swallowing habit

Both young ones and adults of barracudas have been observed to swallow prey either head first or tail first or to grasp the prey at the mid-section fold it and swallow it Also the barracudas are capable of slicing the prey into two or more pieces and swallowing (De Sylva 1963) Pike perch without elongated gill rakers take spiny rayed fish prey head first to prevent spines or opercles from lodging in the buccal cavity and oesophagus (Marshall 1977) Since S jello is devoid of gill rakers soft rayed fishes like anchovies can be swallowed tail first also as seen in some of the stomachs in the present study while spiny rayed prey like Decapterus sp were found taken head first In a few stomachs the fish and cephalopod preys were found as chunks having been cut up into pieces and swallowed

The average relative length of the gut in S jello is found to be 32 32+3 58% Carnivorous predators show a typical relative length of gut which will be less than 50% of the total length (Suyehiro 1942) Muscular oesophagus and well defined distensible stomach are indicative of the predatory habit of this species Muscular oesophagus helps in pushing the prey into the distensible elongated conical stomach which can accomodate large prey Similarity in stomach structure is shown by S pinguis (Suyehiro 1942)

It appears that large solitary adults of barracudas are day time feeders while the smaller fish forming shoaling groups are nocturnal (De Sylva 1973) The report by Somvanshi (1989) that the moving shoals of barracudas are more common at nights also supports this view They are known to herd shoals of other fishes and keep guard in order to prey upon them (Pillai 1981) Their swift swimming ability reaching upto 12 metres per second (De Sylva 1973) is also of great help in this mode of feeding

Bulk of the specimens of S jello in the present study are comparatively small sized fishes forming shoaling groups (270 553 mm) which feed at night They are caught by trawlers during day time and hence the food contents available in the stomachs are usually in advanced stages of digestion and many stomachs examined had semi-digested matter which was beyond qualitative analysis Hence this material is given the status of a food item eventhough the semi-digested matter must be of fish or cephalopod origin Therefore unlike in the case of other food items the importance which semi-digested matter attained in the quantitative analysis can be attributed more to the occurrence than its volume

All the literature available on the qualitative aspect of feeding in sphyraenids show that they are predominantly piscivorous Principal prey groups encountered in the present study are the members of family Engraulidae (Anchoviella spp) Clupeidae (Sardinella spp) and Carangidae (Decapterus sp) which are all pelagic or mid water shoaling groups Fish larvae found in the stomachs of both the sexes during the month of February belonged to the family Leiognathidae a demersal shallow water shoaling group (Leiognathus spp and Secutor sp) The instances of occurrence of cephalopods in the stomach content were during December to May period

The occurrence of these groups in the gut contents is more or less in agreement with the previous reports Legand (1952) observed that in New Caledonia S barracuda and S jello feed upon schools of silver-side (Atherina forskali) and in mangroove habitat both species feed upon mullet (Mugil spp) Inger (1955) collected a gobiid and a percoid (Ambassis sp) from a 400 mm specimen of S jello from Borneo Ah Kow (1950) found anchovies (Stolephorus sp) to be a main food item in the diet of S jello from the Singapore straits other food items taken included squids and larvae of decapod crustaceans According to Premalatha and Manojkumar (1990) the food items of S jello in the Cochin area mainly consists of mackerels horse mackerels clupeids ,lizard fish and cuttle fish.

Chacko (1949) observed bony fishes and molluscs (Sepia) as forming the food of adult barracudas Anchovies were found to be the staple diet of S acutipinnis (Malpas 1926 Menon 1942 Rabindranath 1966) supplemented occassionally by small Loligo sp This is found to be true in the case of S obtusata also (Premalatha and Manojkumar 1990) Juveniles of this species also take bony fishes like Bregmaceros maclellandi Apogon sp Ambassis commersonii Gobies Enrgraulis purava and also copepods cirriped larvae pteropods and a few polyzoans (Kothare 1973 Somvanshi 1989) Lamellibranch and gastropod larvae have been found in the gut contents of the juveniles of S obtusata (Somvanshi 1989) Suyehiro (1942) gave the food of S pinguis as consisting of small crustaceans and young fish

Juveniles of Mugilids Rhabdosargus sp and adults of Ambassis sp are the food items of S barracuda in estuaries (Blaber 1982) On occassions squids were also eaten by S barracuda (Longley and Hildebrand 1941) Atherinids and mysids are the principal food of juveniles of S borealis taken from Delaware estuary and adjacent areas (De Sylva et al 1962)

Estuarine inhabitants like the Atherinids and Mugilids have been reported to form the food contents in S jello from estuarine and mangroove areas (Legand 1952) In the present study since the sample is not from a similar habitat such prey groups were not encountered Also there were just two instances of occurrence of crustaceans - an isopod during November and two prawn juveniles during March of the first year of study These may be occassional food items The fish and cephalopod prey obtained in the present study mainly belong to the inshore pelagic and mid-water shoaling groups denoting the migratory feeding habit of S jello

Size dependent differences in food preference was not clear since almost all the specimens used in the present study were in the same stage of life history namely first maturing adults (270 553 mm) But there have been reports of difference in diet with age and growth (Austin and Austin 1971) Premalatha and Manojkumar (1990) noticed a predominance of anchovies over the other pelagic fishes in the stomachs of smaller individuals of S jello De Sylva (1963) observed that in general sphyraenids which do not attain a large size feed mainly on small schooling fishes and cephalopods whereas the large species of sphyraenids which tend to be solitary feed upon larger fishes which are essentially non-schooling in nature

S barracuda and S jello are the species which may be predominantly or even exclusively involved in ciguatera poisoning (De Sylva 1973) Bio-accumulation of dinoflagellate toxins by marine organisms is the principal cause of ciguatera poisoning (De Sylva 1982) Looking at the prey and their feeding habits Valdes (1980) proposed that parrot fishes (Fam Scaridae) surgeon fishes (Fam Acanthuridae) and some tetradontiforn fishes are transmitters of the ichthyosarcotoxin The above mentioned fish prey species have not been reported in the gut contents of S jello (Premalatha and Manojkumar 1990) and S obtusata (Kothare 1973 Somvanshi 1989 Premalatha and Manojkumar 1990) the two common species of barracudas in our region In the pressent study on S jello also they were not encountered in the stomach

Males and females of S jello neither showed any marked difference in the food contents nor in the pattern of changes in the intensity of feeding

Except for a single instance of prey of size 47 29% of the total length of predator mostly the size of the prey ranged from 18 68% to 31 43% (Average 24 31%) of the total length of predator in the present study Beebe and Tee-Van (1928) noted a parrot fish (Scarus croicensis) of size 27 5% a Chloroscombrus chrysurus of size 20 0% and a specimen of Ocyurus chrysurus of size 10 04% in stomachs of S barracuda from Haiti Reviewing the biology of percids Collette et al (1977) stated that the prey size rarely exceeds half the length of the predator and is usually considerably less However the impact of a large predator like S jello on the population of commercially important small sized shoaling pelagic and mid-water fish species like anchovies sardines and scads is worth a detailed study

5 3 Breeding Biology

In general the spawning in Sphyraenids occurs over deep water at the edge of continental shelf The eggs drift inshore where they develop in mangroves sea grass beds or other sheltered areas After varying periods in inshore waters the fish move offshore and become semi-migratory over deep waters or along the slope of continental shelf (De Sylva 1973)

In the present study the size at first maturity of males and females of S jello is found to be around 360 mm and 370 mm respectively (350-400 mm size class) Premalatha and Manojkumar (1990) also found that specimens of S jello above 400 mm collected within a depth range upto 50 metres off Cochin were with maturing gonads

Ripe females of S barracuda from Ceylon measured 350 410 mm in fork length (Malpas 1926) In Miami most of the females of this species were found to mature during the fourth year of life at a length of about 660 mm while males during the second year at a fork length of 500 mm Also the females ripe at a later date than the males (De Sylva 1963)

Kothare (1973) gave the size at first maturity of both the sexes of S obtusata in Bombay waters as to be in the 161 180 mm size group At Gulf of Mannar the minimum size at first maturity for the species is 180 mm (Somvanshi 1989) According to Premalatha and Manojkumar (1990) the species in Cochin waters mature during the second year of life at a size of 200 mm

In the present study S jello in Cochin waters is found to have a protracted spawning season extending from April till September/October with increased activity during June-September According to Premalatha and Manojkumar (1990) gonad development in this species starts from November/December onwards and subsequently third and fourth stages occur in January/February They also reported that maturing specimens of S jello are found from March onwards in Cochin waters A prolonged spawning season from April to July has been observed by them for the species In agreement with this the specimens collected by them during August/September from deeper waters were all in spent condition with empty stomach It may be due to the fact that the spawned individuals have migrated to deeper waters In the present study spawning activity is clearly noticed till Spetember during both the years

Venkataramanujam and Ramamoorthy (1974) reported occurrence of juveniles of S jello ranging from 22 to 27 mm size in the inshore waters of East coast in September November period Young ones of this species have been caught from Cochin area during May-June months in pelagic trawls (Premalatha and Manojkumar 1990) All these relevant observations confirm the present findings on the spawning season of S jello

Unlike S jello mature specimens of S acutipinnis are found to occur along the Travancore coast from September onwards with commonest availability during December-March period (Rabindranath 1966) Ripe individuals of S barracuda occur in East African waters during September-May (Williams 1956) De Sylva (1963) found no peak time of spawning in males of this species and observed July as the peak spawning period for females with secondary peaks in May and September He suggested an almost continuous supply of gradually maturing eggs which contribute to the general stock of eggs throughout the spawning season and hence an extended spawning season for S barracuda S obtusata also is reported to have a protracted spawning period commencing in October and lasting till February/March (Kothare 1973 Premalatha and Manojkumar 1990)

In the present study based on the distribution of ova stocks individuals of S jello were found to release eggs more than once during an extended period of spawning This finding is also corroborated by the presence of partially spent ovaries during the spawning season Thus the protracted spawning season in S jello is supported by an asynchronous breeding population According to supporting this view

In the present study ripe transluscent eggs in recruit spawners of S jello ranged from 0 6 to 0 75 mm in diameter with an oil globule of 0 2 mm size The egg diameter of this species has been given as 0 9 mm with an oil globule of 0 3 mm size by Premalatha and Manojkumar (1990) probably for the 1300 mm fish In S barracuda ripe transluscent eggs measure 0 74 0 81 mm (De Sylva 1963) and in S argentia 1 02 mm (Barnhart 1927) to 1 14 to 1 6 mm (Walford 1932 Orton 1955) in diameter

Premalatha and Manojkumar (1990) found that S jello feed actively even during the spawning period However in the present study it is seen that during increased spawning activity the intensity of feeding is less when compared to the post spawning period In S obtusata higher percentage occurrence of empty stomachs and lower volumes of food consumed are noticed during breeding season (Kothare 1973 Premalatha and Manojkumar 1990)

Studies on length weight relationships show that significant positive correlation exists between these two variables But comparison of regression coefficients for both sexes reveals that the length dependent weight increment in males and females of S jello do not show statistically significant difference and hence a common expression is also derived for the species Somvanshi (1989) gave only a single expression for S obtusata Kothare (1973) observed no significant difference between the exponents for both sexes of this species and De Sylva (1963) also gave no appreciable difference in the case of S barracuda However Premalatha and Manojkumar (1990) reported difference indicating differential growth in males and females of S obtusata De Sylva (1963) has mentioned that in S barracuda the males are heavier than females at the same length as can also be seen in the present study

In the present study the fluctuations in the ponderal index and also the relative condition factor are indicative of the spawning activity in S jello Relative condition factor values are clearly below 1 during the spawning period for both males and females closely following the spawning activity Since only minor deviations from unity occur in the case of relative condition factor in this species the factor can be said to furnish a sensitive index of the spawning cycle

Qasim (1957) suggested that the waxing and waning of the condition factor can probably be due to the building up or loss of reserves of fish In order to meet the high energy needs of breeding time the body reserves may be utilized thus showing a decline in the condition during spawning period as seen in the present study

Bhatnagar and Karamchandani (1970) and Jhingran (1972) studied the condition factor using eviscerated weight of the fish Present

Pillai (1981) ovarian developments indicated that barracudas may spawn more than once in a season Walford (1932) in S argentia De Sylva (1963) in S barracuda and Kothare (1973) in S obtusata have made similar observations

Female dominance in the population during the periods of increased spawning activity is shown by S jello in the present study In S barracuda prespawning migration of males is observed causing marked changes in the sex ratio in favour of the females (De Sylva 1963)

In the present study absolute fecundity of S jello ranged between 82 431 and 1 63 533 in the case of first maturing individuals (Size range of 334 to 410 mm in SL) Premalatha and Manojkumar (1990) obtained an absolute fecundity of 9 77 000 for S jello (1300 mm) Kothare (1973) reported a fecundity range of 30 175 to 1 01 152 in S obtusata while Premalatha and Manojkumar (1990) noted the fecundity of a 310 mm individual as 2 80 800 De Sylva (1963) obtained a fecundity of 5 60 000 for a 895 mm forklength specimen and 6 70 000 for a 1011 mm forklength specimen of S barracuda

Pillai (1981) reported that in barracudas the number of eggs released increases with age and size ranging from an estimated 42 000 for the first time spawner to over 4 84 000 for older fish Fecundity in S jello is found to have positive correlation with the length of the fish weight of the fish and also length and weight of the ovary study shows that the pattern of fluctuations in the ponderal index is similar in respect of the whole as well as eviscerated fish the difference being only that of magnitude This points that even in the eviscerated fish fluctuations in index values occur thus providing a measure of the true well being of the fish

SUMMARY

VI SUMMARY

1 Morphometric measurements meristic counts teeth pattern structure of gill rakers and colour pattern of 20 specimens each of *Sphyraena jello* Cuv (271-943 mm total length) and *S obtusata* (Cuv & Val) (209-296 mm TL) and a single specimen of *S barracuda* (Walbaum) (1100 mm TL) were used for the systematic redescription

2 *S jello* commercially the most important species was subjected to detailed analyses for the study of food and feeding habits breeding biology length weight relationship and condition cycles

3 Monthly random sampling was done for a two year period (November 1988 to October 1990) from various collection centres in and around Cochin A total number of 141 males (270-943 mm TL) and 64 females (322-770 mm TL) were subjected to analyses

4 The jaw mouth and pharyngeal teeth pattern the structure of gill rakers and relative length of gut were studied to elucidate the feeding habits The findings revealed the predatory nature of feeding in this species

5 The stomach contents were subjected to qualitative and quantitative analyses Index of preponderence method and two new indices Simple resultant index and Weighted resultant index were made use of for quantitative analysis

6 S jello is found to be predominantly piscivorous feeding on small-sized pelagic shoaling fishes like sardines and anchovies and mid-water shoaling groups like scads and silverbellies The instances of occurrence of cephalopods in the stomach content were also noticed during December to May period

7 Fluctuations in feeding intensity of males and females were studied separately using Gastro-somatic index values It showed an almost similar gross trend in the intensity of feeding with minor differences in the months of peak values

8 The prey predator length relationship was studied It was found that the prey size ranged from 18 68 to 31 43% of predator length (average 24 31%) a trend similar to many other piscivores

9 A five stage key was used for classification of maturity stages The size at first maturity for males and females were found to be 360 and 370 mm respectively (350 400 mm length class)

10 The monthly percentage occurrence of the mature and spent/partially spent females and the monthly gonado somatic index values were made use of to delineate the spawning season S jello in Cochin region was found to have a protracted spawning season spanning from April to September/October with increased activity during June to September

11 The ova diameter studies showed that individuals of S jello spawn more than once during the extended spawning season

12 Sex ratio studies indicated a female dominance coinciding with spawning activity

13 Absolute fecundity of recruit spawners of S jello ranged between 82 431 and 1 63 533 (400-501 mm in TL) Fecundity showed a positive linear relationship with the length of fish weight of fish length of ovary and weight of ovary

14 Feeding intensity was found to be higher during post spawning period and lower during the period of increased spawning

15 Length weight relationships were found out separately for males and females and the regression values were compared statistically The length dependent weight increment showed no significant difference between the sexes and hence a single expression for lenght-weight relationship for the species was calculated as log W 4 2751 + 2 5848 log L

16 The graphs of relative condition factor as well as ponderal index were used to strengthen the findings on spawning season The ponderal index was also calculated using eviscerated weight of the fish Fluctuations in the relative condition factor closely followed the spawning cycle the value being very close to 1 Ponderal index calculated with eviscerated weight of fish provided an index of true well being of the fish

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STUDIES ON CERTAIN ASPECTS OF THE BIOLOGY OF THE BARRACUDA OF COCHIN REGION

By

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ABSTRACT OF A THESIS

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ABSTRACT

A systematic redescription of the three species viz Sphyraena jello Cuv S obtusata (Cuv & Val) and S barracuda (Walbaum) available in the Cochin region has been done The food and feeding habits breeding biology length weight relationship and condition cylces of S jello the commercially most important species of the region have been studied in detail

A total of 141 males (270 943 mm TL) and 64 females (322-770 mm TL) collected during Nov 88 to Oct 90 were subjected to various investigations like qualitative and quantitative assessment of stomach content feeding intensity prey-predator length relationship feeding habits quantification of maturity stages size at first maturity spawning season and spawning frequency sex ratio spawning potential length weight relationship and condition and relative condition cycles using standard methods

S jello is found to be a typical predator and a predominant piscivore The species mostly feeds on small pelagic and mid-water shoaling fishes like clupeids anchovies scads and silverbellies occassionally consuming cephalopods The total length of the prey rangfed from 18 68 to 31 43% of the predator length

The size at first maturity is found to be 360 mm for males and 370 mm for females (350-400 mm length class) The species exhibits a prolonged spawning season in the Cochin region spanning from April

September/October with increased activity during June to September Individuals of S jello spawn more than once during this prolonged spawning season Female dominance in the population was noticed during May to July coinciding with spawning activity The absolute fecundity of recruit spawners of S jello ranged between 82 431 and 1 63 533 (400 501 mm TL) The intensity of feeding was lower during the period of increased spawning activity and higher during post-spawning period

The length-weight relationship worked out for the species is log W -4 2751 + 2 5848 log L the relationship showing no significant difference between the sexes The relative condition cycle closely followed the spawning cycle the values being close to 1 Condition factor calculated using eviscerated weight of fish provided an index of true well being of the fish

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