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Distribution and biology of the deep sea fish *Psenopsis cyanea* (Alcock) inhabiting continental slope of the west coast of India

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Abstract

Psenopsis cyanea (Alcock, 1980) was found to be one of the most dominant species in the deep-sea catches of FORV *Sagar Sampada* from the west coast of India. This paper encompasses the geographical and vertical distribution, abundance, feeding, spawning biology and length-weight relationships of *P. cyanea* collected from FORV *Sagar Sampada* and commercial boats operated along the continental slope of the south west coast of India. Spatially it was found abundant at lat. 11° to 12° N and vertically at 201-300 and 301 - 400 m depth zones. Females dominated irrespective of seasons or depth. It exhibits a seasonally synchronized reproduction due to the presence of mature adults during the late pre monsoon and early monsoon which is confirmed by the recruitment of the juveniles during late monsoon. Prawns were found to be the principal food item followed by fishes. 'b' values showed negative deviation from the isometric growth with increase of depth as 3.3039 and 1.7933 in the depth zones 201-300 m and 301-400 m respectively. The length range of the exploited stock varied from 13.6 to 21.6 cm with a distinct mode at 16.6-17 cm both in male and female followed by 16.1-16.5 cm in female and 17.6-18 cm in male. The major part of the harvested stock belonged to 15 to 19 cm length group which appeared as the commercial size group of this species.

Introduction

The exploited marine fisheries of India had been stagnating around 2.7 million tons (Anon, 2001) against the total potential marine fish wealth of 3.9 million tonnes of Indian EEZ (Sudersan *et al.* 1989). Further improvement in the landings can only be possible by targeting the harvest of the under and unexploited resources, especially in depths beyond 100m. Gravely (1929), Silas (1969); Joseph and John (1986); Nair and Joseph (1986); Sudarsan and Somvanshi (1988); James and Pillai, (1990); Panicker *et al.* (1993); Khan *et al.* (1996); Philip *et al.* (1984); Sivakami *et al.* (1996 & 1998) and Venu and Kurup (2002) reported the existence of fairly rich grounds of deep-sea fishery resources in the EEZ of India.

As part of the stock assessment studies conducted in deep sea fishes in the EEZ of west coast of India, the abundance of *Psenopsis cyanea* was found in some depth zones of this part. This species showed a discontinuous distribution in the east and west coasts of India, off Socotra and the mouth of the Gulf of Aden (Fischer and Bianchi, 1984). Preliminary reports on *P. cyanea* from Indian EEZ are those of

Sivakami *et al.*(1996), Prasad and Nair (1973) and Khan *et al.* (1996). The present paper encompasses the distribution and catch per unit of effort, biology and length-weight relationship of *P. cyanea* inhabiting 200 m depth and beyond in the south west coast of India.

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Material and methods

Data were collected during the fishing surveys conducted during 1999 June to 2001 August by FORV *Sagar Sampada* (Dept. of Ocean Development) and from the commercial boats operated beyond 200m along south west coast of India based at Cochin, Munambam and Sakthikulangara fishing harbours of Kerala during November 2000 - February 2002. The upper continental slope region of lat.7° -12°N was surveyed during Cruise Nos. 174, 183, 189, 196 and 197 of FORV *Sagar Sampada.* The cruises 196, 174 and 197 carried out in June, July and August respectively represented monsoon period while cruise no. 183 in April represented pre-monsoon whereas 189 was in October-November representing post monsoon. 38m High Speed Demersal Trawl II and 45.6m Expo - model Demersal Trawl were used for fishing in above cruises at a depth of 200 to 750 m. Fishing was done at 95 stations and the total catch and species composition and effort expended were recorded at each fishing station. Latitude wise and depth-wise distribution and abundance of deep-sea finfish resources were assessed after grouping the stations covered in each cruise into 5 depth zones of 201-300 (Zone I), 301-400 (Zone II), 401-500 (Zone III), 501-600 (Zone IV) and 600 and above (Zone V) following Khan *et al.* (1996) and catch per unit of effort at different latitudes was estimated following Sivakami(1990). Estimation of catch and catch per unit effort was done following Venu and Kurup (2002). The catches from the deep sea fishing trawlers landed at Kochi, Munambam and Sakthikulangara fishing harbours were regularly observed from September 2000 to February 2002 at weekly intervals. Total deep sea trawlers landed on the date of observation was enumerated and the selection of units for detailed observation was done following Alagaraja (1983). From the selected units, the craft and gear details were recorded, the landing of *P. cyanea* was assessed and length and weight were also measured on an assorted sample. The details of fishing ground, number of haul and duration of each haul, quantity of discarded catch on board, endurance, etc were collected from the crews. Random samples were also collected from the landings for detailed examination on the biology.

Specimens were also obtained from individual hauls from different fishing grounds by keeping samples in plastic tubs entrusted with the crew operated from Munambam harbour. Informaton regard-

ing depth of operation, name of the fishing ground and the geographical position, etc, were also made available through the pretested questionnaire supplied to the crew. The average landing per boat was thus computed and with the help of data so generated, the monthly landing from each harbour was worked out following Kurup (2001). The landings thus estimated was further apportioned fishing ground wise based on the details collected from the crew. 435 specimens ranging in size 8.3 to 19.0 cm TL and 11.7 to 66.3 g weight were analysed for food and feeding habits, sex ratio and stage of maturity and length-weight relationships. Total length (from the tip of the snout to the tip of the upper caudal lobe to the nearest mm) and weight (nearest to 0.1g) of both sexes were taken separately. Length weight relationship is expressed by the formula $W = aL^b$ (Le Cren, 1951). Fullness of stomachs and the amount of food present were observed by visual examination and they were graded as full, 3/4 full, 1/2 full, 1/4 full, trace and empty to assess the intensity of feeding. Occurrence of each item was expressed as percentage of total number of stomachs examined. In order to determine the maturity stages, general appearance of ovary like fullness in the ventral cavity, size, shape and colour were taken into consideration. The five-stage classification was used to determine the maturity stages (Qasim, 1973).

Results and discussion

Distribution and abundance

The latitutde wise catch and catch rate of *P. cyanea* is shown in Table 1. Based on the results it appears that this species is having a wide range of distribution in the southwest coast of India. It occurred in the entire area (lat. 8° to 15°N) with an exception only at 12°-13° N. The geographical pattern of distribution revealed that 11° to 12° N lat is most productive area when compared to the other latitudes with a catch rate of 140 kg/hr. Highest catch of *P. cyanea* obtained in a single haul was 2270 kg of juveniles fishes in the length range 11-13 cm from a depth of 76 m at 10°39′ N in August followed by 600 kg in the same cruise at a depth of 115 m at lat. 11°14′N. The higher value registered in lat. 10°-11° N was on account of accidential entrapment of a catch of 2270 kg of juveniles of *P. cyanea* (Table 1). At lat. 8° to 9° and 9° to 10° N, this species was moderately represented with catch rates of 28 and 32 kg/hr respectively.

The range of vertical distribution varied from 60-448 m (Table 1). Juveniles less than 13 cm were found distributed in the depths below 200 m with a very high catch rate of 802 kg/hr. High catch of 2270 kg was obtained during the monsoon period. In the depth range 201-300 m, this species could be recorded in 12 trawling stations with a catch rate of 31kg/hr. At depth 301-400 m, it was encountered from 16 stations with a catch rate of 28 kg/hr. Whereas in depth zone 401-500 m, it was found only at two stations with a catch rate of 4 kg/hr. The present observation is at variance with that of Khan *et al.* (1996) who reported that *P. cyanea* showed peak abundance in depth zone 301-400 m and moderate in 101

Table 1 *Seasonal variations in the catch(Kg) and catch rate of Psenopsis cyanea along the south west coast of India*

Lat.	Long.	Depth	Effort (hr)	Catch (Kg)	C/E (kg/hr)	Total Catch	%
			Pre-monsoon				
08°37′00	75°39′00	320	1.00	17	17.00	40	42.5
08°40′00	75°32′00	305	0.92	6	6.55	179	3.4
08°52′00	75°50′00	330	1.00	15	15.00	37	40.5
09°00′00	75°48′00	330	1.00	18	18.00	72	25.0
10°23′00	75°28′00	300	1.00	15	15.00	250	6.0
14°33′00	73°08′00	263	1.00	3	3.00	7	42.9
Total			**5.92**	**74**	**12.51**	**585**	**12.6**
			Monsoon				
09°37′236	75°52′616	70	1.08	1	0.93	75	1.3
09°19′00	75°47′00	315	1.50	282	188.00	304	92.8
09°28′00	75°42′00	330	1.92	13	6.78	123	10.6
09°38′00	75°36′00	330	1.42	3	2.12	134	2.2
10°29′801	75°38′396	60	0.75	0	0.13	10	1.0
10°39′13	75°18′99	391	1.50	10	6.67	138	7.2
10°39′449	75°28′459	76	1.00	2270	2270.00	2500	90.8
10°39′50	75°18′50	320	1.25	6	4.80	18	33.3
10°56′39	75°07′99	340	1.00	15	15.00	110	13.6
11°06′00	74°59′00	448	0.75	6	8.00	27	22.2
11°14′028	74°57′99	115	0.75	600	800.00	700	85.7
11°44′216	74°31′421	230	0.50	50	100.00	310	16.1
11°44′646	74°31′438	228	0.58	26	44.57	230	11.3
11°45′132	74°31′489	232	1.00	30	30.00	160	18.8
11°45′924	74°30′466	219	0.75	45	60.00	212	21.2
11°46′125	74°30′437	230	0.75	50	66.67	270	18.5
14°52′00	73°07′00	250	1.67	18	10.80	54	33.3
14°58′90	27°57′90	440	1.00	1	0.50	8	6.5
Total			**19.16**	**3426**	**178.76**	**5383**	**63.6**
			Post-monsoon				
08°42′46	75°39′724	300	1.00	85	85.00	6100	1.4
08°42′567	75°43′723	332	0.75	12	16.00	417	2.9
09°04′073	75°50′937	330	0.83	5	6.36	40	13.3
09°05′87	75°41′85	350	1.00	12	12.00	55	21.9
09°11′225	75°51′509	285	1.00	3	3.00	34	8.7
11°20′091	74°49′871	240	0.83	23	27.60	1085	2.1
14°00′063	73°16′141	273	0.92	20	21.82	135	14.9
14°32′368	73°08′533	276	1.00	37	37.00	55	67.9
14°54′243	72°59′983	252	0.33	10	28.50	20	48.7
Total			**8.67**	**219**	**25.25**	**7972**	**2.7**

- 200 m and 201-300 m. According to Sivakami (1990) deep-sea fishes like *Psenopsis* spp. *Chlorophthalmus* spp. *Priacanthus* spp., *Cubiceps* spp., *Neoepinnula* spp., and *Trichiurus auriga* are having immense potential along the south west zone in the depth range 151-398 m. Prasad and Nair (1973) reported a high abundance of deep-sea fishes viz. *C. agassizi, N. orientalis, P. cyanea* and *C. natalensis* in the upper continental slope (180-450 m depth zone) in the India EEZ.

A comparison of various seasons revealed that highest abundance of this species was recorded during monsoon season (178 kg/hr) followed by post monsoon (25 kg/hr) while it was least in pre monsoon (12 kg/hr). The aggregation of juveniles of this species at depth> 150 m in the area 9° to 12° N lat. during the monsoon (Table 1) is worth reporting. Month wise catches of *P. cyanea* from different deep sea fishing grounds off Kerala quantified from the commercial boats of three fishing harbours of Kerala during 2000-01 and 2001-02 are given in Table 2. Three fishing grounds could be demarcated off Kerala such as Kollam, Alapuzha and Cochin based on the appearance of *P. cyanea* in the landings from the commercial trawlers operated targeting deep sea prawns. Off Kollam, the landing varied from 788 kg in February to 2052 kg in November in the depths 250-300 m during 2000-01 while in 2001-02 a reduction in the landing from the same depths could be discernible. Whereas from off Cochin, during 2000-01, the landing varied from 496 kg in March to 1252 kg in November. A decline in the landing was noticed from this ground during 2001-02. The availability of this species along Alapuzha ground was found very insignificant in both the years (Table 2).

Size groups of the exploited stock

The length range of the exploited stock varied from 13.6 to 23.5 cm. The sex wise length frequency distribution of the harvested population is shown in Fig. 1. In both male and female, the length class 16.6-17 cm appeared as the model class followed by 17.6-18 cm in male and 16.1-16.5 cm in female as the second modal classes. Major portion of the landing belonged to 15-19cm length class.

Sex ratio

Out of 435 specimens, 223 were females and 212 males (51% & 49%). Females dominated in all the seasons and in most of the length groups observed. This is at variance with the observations of Khan *et al.* (1996) who reported that males showed predominance in the catches along the southeastern Arabian Sea. Length related Chi square analysis showed that the sex ratio was not

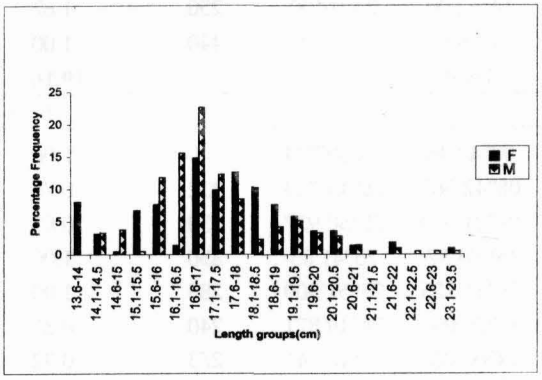

Fig. 1. *Length frequency distribution of Psenopsis cyanea exploited from the west coast of India*

Table 2 *Month wise landings of Psenopsis cyanea from commercial trawls operated along the Kerala coast during 2000-01 & 2001-02*

	Off Cochin			Off Kollam			Off Alappuzha		
Month	Catch (kg)	Effort (hr)	C/E (kg/hr)	Catch (kg)	Effort (hr)	C/E (kg/hr)	Catch (kg)	Effort (hr)	C/E (kg/hr)
Nov	2227	810	3.1	2052	1140	1.8	216	180	1.2
Dec	1253	540	2.3	828	720	1.2	110	120	0.9
Jan	1098	360	3.1	1094	480	2.3	nil	nil	nil
Feb	1392	320	4.4	798	600	1.3	66	40	1.7
Mar	497	240	2.1	1155	420	2.8	nil	nil	nil
	6767	2270	3.0	5927	3360	1.8	392	340	1.2
					2001-02				
Nov	1413	432	3.3	1008	576	1.8	nil	252	nil
Dec	630	420	1.5	864	720	1.2	nil	60	nil
Jan	1012	400	2.5	630	600	1.1	125	160	0.8
Feb	266	216	1.2	357	243	15	nil	nil	nil
	3320	1468	2.3	28959	2139	1.3	125	472	0.3

significantly different in all the three seasons (Table 3). Female : male ratio during pre-monsoon showed significant difference ($p<0.05$) from expected 1 : 1 ratio only in the length groups 13.5 and 17.5 ($x^2 = 5.00$ and 6.40 respectively). In monsoon, three length groups showed significant difference in the sex ratio. While it was significantly different only in a single length group in the post monsoon. The overall female : male ratio was not significantly different from the expected 1 : 1 ratio.

Maturation and spawning

Presence of maturity stages I to V could be discernible in February, March and April with a preponderance of stage IV (43%). Whereas Khan *et al.* (1996) reported 34% mature females of *P. cyanea* during December and January at depth 100-400m from the southeastern Arabian Sea. Stages III and II collectively represented 21%, whereas the immature and ripe fishes were represented in lesser percentage (7%). While in June, July and August, most of the females were found to be in advanced stages of maturity. 50% of the females analysed during these months from the trawl catches were found to be in the ripe stage. Spent females present in the catches constituted 33%. During October, November, December and January, stages I to IV could only be seen with a distinct predominance of 49% of stage II. (Fig. 2).

Unripe and maturing fishes were found mostly in the pre monsoon and post monsoon months. It would thus appear that the spawning season of of the *P. cyanea* coincided strongly with monsoon season. Large quantities of juveniles in the length 10-13 cm were caught in the trawl nets

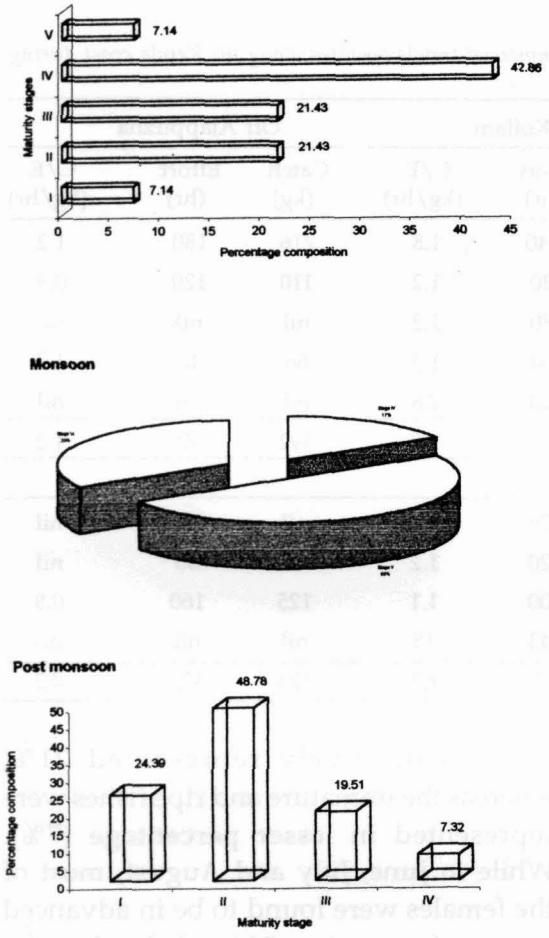

Fig. 2 *Percentage composition of maturity stages of Psenopsis cyanea*

during August from the shallower depths in the 10° - 12° N lat. This would also suggests that the species exhibits a seasonally synchronized reproduction with the presence of mature adults during the late pre monsoon and early monsoon and it is confirmed by the recruitment of the juveniles during late monsoon. Also the feeding intensity of the females was very less during pre monsoon and monsoon when compared to the post monsoon months. Dighe (1977) reported low feeding activity during the spawning season in *Saurida*

Table 3. *Length group wise sex ratio of Psenopsis cyanea during different seasons*

Pre-monsoon			
Length group (cm)	No. of fish	Ratio (M.F)	*Remarks
13.5	20	1:3	S
14.5	15	1:2	NS
15.5	25	1:1.5	NS
16.5	65	1:0.63	NS
17.5	10	1:0	S
Total	135	1:1.25	NS
Monsoon			
14.5	6	1:0.2	NS
15.5	12	:1	NS
16.5	13	1:0.08	S
17.5	19	1:0.46	NS
18.5	32	1:4.3	S
19.5	15	1:4	S
20.5	11	1:2.67	NS
Total	108	1:1.43	NS
Post -monsoon			
15.50	8	1:1	NS
16.50	25	1:0.32	S
17.50	47	1:1.04	NS
18.50	33	1:1.75	NS
19.50	40	1:0.90	NS
20.50	17	1:0.89	NS
21.50	10	1:0.43	NS
22.50	8	1:33	NS
23.50	4	1:1	NS
Total	108	1:1.08	NS

S- Significant
NS-Not Significant

tumbil. Similar observations were also made by Das and Mishra (1990).

Occurence of juveniles in the shallower area indicates that either it spawns in the shelf water below 150 m or there is a possibility of the migration of juveniles from the deeper waters to inshore regions. This species could be encountered from depths

below 200 m only during the monsoon season and there was total absence of adults at these regions during all other seasons. It may therefore, be inferred that the adults may be either migrating towards the shelf waters for spawning or the fingerlings and juveniles are undertaking migration into the shelf waters as these regions are endowed with relatively high productivity and favourable abiotic and biotic factors which offer better survival of the eggs and juveniles.

Food and feeding

P. cyanea is a carnivore and feeds primarily on benthic and epibenthic organisms like fishes and shrimps, with dominance of the latter. Since most of the food items found inside the stomachs were in advanced conditions of digestion, the complete identification of the gut contents was found difficult. The food items so identified included mostly juveniles of *Aristeus* spp., *Heterocarpus* spp., etc. while the myctophids dominated the fish components in the diet.

Season wise food composition is shown in Table 6. During pre-monsoon season, the digested matter accounted for 100% in females while in males semi-digested shrimp comprised of 81% followed by digested matter (19%). Semi-digested shrimps (58%) and digested matter (66%) dominated in the females and males respectively during monsoon. In post-monsoon, the digested matter (52%) showed dominance in females and in males, semi-digested shrimps and digested matter showed almost equal dominance with 37% and 36% respectively. No significant difference could be seen in food preference of fishes inhabiting different depth zones.

The percentage composition of stomachs with different degree of fullness showed that most of the stomachs in male as well as female fishes, irrespective of depth and seasons, were empty (Table 5). This may be due to the regurgitation. The stomachs of female fishes examined were empty during pre-monsoon season. In males, feeding intensity was found to be slightly high when compared to the females. During monsoon, about 80% of stomachs of males and females were empty, 8.2% of the stomachs in females were found to be 3/4 full followed by 6.8% with trace quantity of food items. Whereas in males 1/4 full condition showed dominance (8%) followed by 1/2 full (5%). The feeding intensity of females was found to be high when compared to males in this season with 61% of stomachs having food inside.

Table 4 *Percentage occurrence of food items of Psenopsis cyanea*

Food items	Per monsoon (%)		Monsoon (%)		Post monsoon (%)	
	Female	Male	Female	Male	Female	Male
Semidigested shrimp	0	81	58	11	16	37
Semidigested fish	0	0	28	23	32	27
Digested matter	100	19	14	66	52	36

Table 5. *Season wise feeding intensity of Psenopsis cyanea*

Stomach condition	Per monsoon (%)		Monsoon (%)		Post monsoon (%)	
	Female	Male	Female	Male	Female	Male
Full	0	11.11	0.7	2.7	13.41	10
$^3/_4$ Full	0	0	8.2	0	7.31	1.2
$^1/_2$ Full	0	0	1.2	5	14.63	7.8
$^1/_4$ Full	0	11.11	3.1	8	7.31	3.3
Trace	2	0	6.8	2.3	18.29	4.4
Empty	98	77.78	80	82	39.05	73.3

While in males, 73% of the stomachs were empty.

Length-weight relationships

The logarithmic regression equations arrived at in respect of length-weight relationships for male and female of *P. cyanea* (Figs. 3 & 4) at two depth zones are as follows:

Male and Female combined (depth 201-300m) (Fig. 3)

log w = -2.3689 + 3.3039 log l

Female log w = -2.1047 + 3.0929 log l

Male log w = -2.5334 + 3.4372 log l

Male and Female combined (depth 301 - 400 m) (Fig. 4)

log w = -0.5015 + 1.7933 log l

Female log w = -0.8306 + 2.0591 log l

Male log w = -0.13329 + 1.8012 log l

The results of the logarithmic regression showed that the 'b' value of male and female shows an inverse relationship with increase in depth. The slope value greater than 3.0 denotes the stoutness of fish when it increases in length and a value less than this indicates that fish becomes more slender (Grover and Juliano, 1976). Khan *et al.* (1996) observed that females are a little heavier than males with 'b' values of

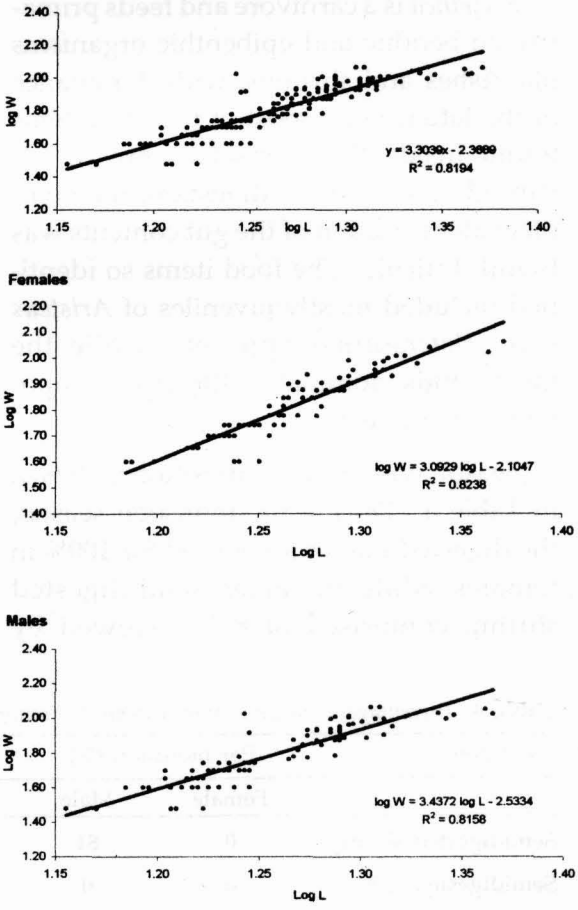

Fig. 3 *LWR of Psenopsis cyanea (depth 201-300 m)*

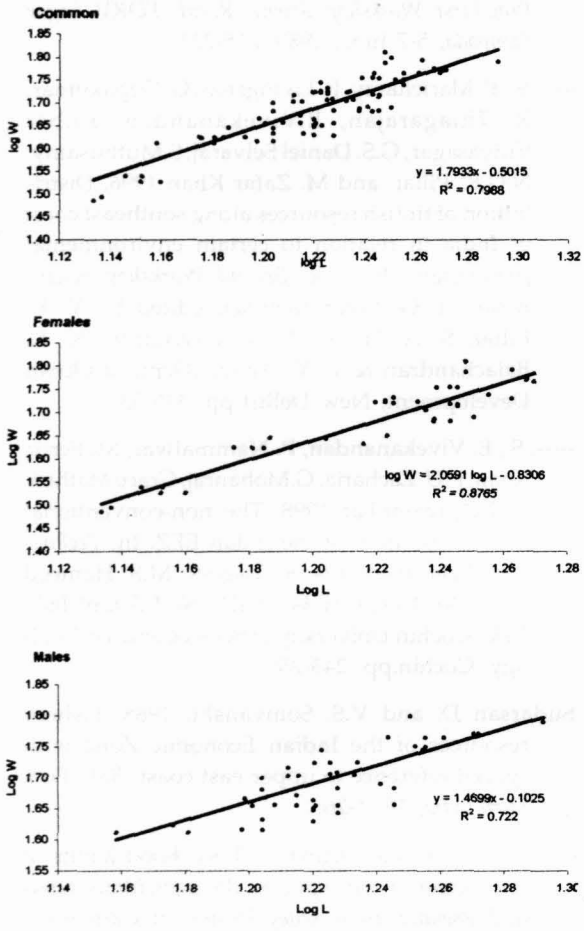

Fig. 4. *LWR of Psenopsis cyanea (depth 301-400 m)*

3.76 and 3.37 respectively. In the present study, the exponential value for females from the depth zone 201-300 m was 3.0929, which indicates that the growth is isometric, whe-reas in males the b value was 3.4372, which denotes that males follow more than the cube law. But the 'b' values of female and male fishes in the depth zone 201-400m showed decreasing trend when compared to 201-300 m depth zone. It would thus appear that in the shallower depth zones, the fish grows isometrically compared to deeper zones.

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