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Biodiversity of Deep Sea Prawns in the Upper Continental Slope of Arabian Sea, off Kerala (South West India): A Comparison Between Depths and Years

S. R. Radhika Rajasree[1,*]

[1] Sathyabama University, Centre for Ocean Research, NIOT-SU Collaborative Research Centre, Chennai, 600119, Tamilnadu, India.

* Corresponding Author: Tel.: +91.044 24501270-5066; Fax: +91.044 24501270;
E-mail: radhiin@gmail.com

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Abstract

Univariate diversity indices and multivariate cluster analysis were performed in order to evaluate the year wise and depth wise bio diversity of deep sea prawns between 150-650 m in the upper continental slope of Arabian Sea, off Kerala, South India. Data were collected from both exploratory surveys as well as commercial deep sea -to fishery off Kerala coast between latitudes 7°N to 13°N. Biodiversity and species assemblage are discussed considering the different environmental characters as well as deep sea fishing intensity. Analysis of biodiversity indices of deep sea prawns off Kerala during different months of 2000-01 and 2001-02 revealed that the biodiversity indices were high at 150-250 and 251-350 m whereas in higher depth zones of 351-450, 451-550 and 551-650 m, the diversity is gradually declining. The species richness was also found maximum at relatively lower depth zones of 251-350 m in contrast to the low values registered in higher depths. The results showed the variation in species diversity, abundance and evenness of deep sea prawns observed at various depth zones might be due to the combined effect of both nature of substratum and the prevailing water temperature, besides the impacts of deep sea trawling operations.

Keywords: Deep sea prawns, bio diversity indices, species richness.

Kerela'da (Güneybatı Hindistan) Umman Denizi Kıtasal Avcılık Bölgesinde Derin Deniz Karidesi Biyoçeşitliliğinin Derinlik ve Yıllara Göre Değişimi

Özet

Güney Hindistanda yer alan Kerala bölgesinde Umman Denizi üst kıtasal kıyılarında, 150-650 m arasında derin deniz karidesinin biyoçeşitliliğini değerlendirmek üzere; yıllara ve derinliğe göre tek değişkenli çeşitlilik indeksleri ve çok değişkenli kümeleme analizi yapılmıştır. Veriler Kerela Eyaleti kıyılarında 7-13°N kuzey enlemleri arasında derin deniz bölgesinde hem araştırma sörveylerinde, hem de ticari avcılıktan toplanmıştır. Biyoçeşitlilik ve türlerin durumu farklı çevresel karakterlerin yanısıra derin deniz balıkçılığı yoğunluğu da göz önüne alınarak tartışılmıştır. Biyolojik çeşitlilik indekslerinin analizleri 2000-01 ve 2001-02 yıllarının farklı ayları boyunca Kerela'da derin deniz karidesinin, 150-250 ve 251-350 m'de biyoçeşitlilik indekslerinin daha yüksek olduğunu ortaya çıkarmıştır. Buna karşın 351-450, 451-550 ve 551-650 m'lik yüksek derinlik bölgelerinde çeşitlilik kademeli olarak azalmaktadır. Daha yüksek derinliklerde tür zenginliğinin de düşük değerlerde kaydedilmesinin aksine 251-350 m gibi daha az derin bölgelerde maksimum tür çeşitliliği olduğu bulunmuştur. Sonuçlar, derin deniz trol avcılığının etkisi dışında, dipteki doğal yapısının ve hakim su sıcaklığının kombine etkisine göre çeşitli derinlik bölgelerinde gözlemlenen derin deniz karidesinin tür çeşitliliğinin, kabul edilebilir etkisini göstermiştir.

Anahtar Kelimeler: Derin deniz karidesi, biyoçeşitlilik indeksleri, türlerin zenginliği.

Introduction

The Arabian Sea is a contiguous basin of Indian Ocean, delimited eastwards and southwards by the Arabian and Indian coasts and it articulates Red Sea through Gulf of Aden, Persian Gulf through Gulf of Oman and Bay of Bengal through Palk Strait. Such a geographical position results in a complex hydrography owing to the presence of different water masses. The deep-water region of Arabian Sea is characterized by certain physical and hydrographic features, which are significantly different from the conventional trawling grounds of the inshore regions (Suseelan, 1985). Knowledge on the distribution and abundance of deep sea fauna in the Arabian basin comes mostly from the Indian continent where systematic surveys of the deep sea organisms have been carried out ever since 1958 (John and Kurian, 1959; Kurian, 1964, 1965; George and Rao, 1966; Rao and Suseelan, 1967; Suseelan, 1985).

The rich and diversified deep sea crustacean fauna and their general distribution pattern in the Arabian Sea had been studied during the past four decades (Mohamed and Suseelan, 1973; Suseelan, 1974; Suseelan *et al*., 1989a, 1989b). The discovery on the availability of commercially exploitable deep sea prawns by these surveys during the recent past have offered tremendous scope for the onset of commercial deep sea fishery to enhance production of crustaceans in Arabian sea off Kerala (S. India). However, the concept of commercial deep sea prawn exploitation became a reality only quite recently and contributed immensely to the exploited fishery resource of Kerala. Analysis of exploited fishery data of deep sea prawns since 2001 showed wide dwindling in the catch rates and the respective contribution of various species to the fishery (Rajasree, 2005).

Benthic communities usually have a long life cycle and stable community structure and therefore can often be used as a monitoring index for pollution (Leppakoski, 1975). In addition, deep sea community are also considered as biological indicators for assessing marine water quality because the organisms are mostly sessile and affected by factors causing environment pollution (Trong, 1996). As members of epifauna, these crustaceans have much higher mobility than do members of the infauna. Therefore, whenever there are environmental changes, these communities suddenly respond either with their disappearance, suspending recruitment at species level, or with a quicker response by the movement of individuals both in and out of an area (Chou *et al*., 1999). Effect of fishing on ecosystem structure and processes have been studied by a number of researchers from different parts of the world, notably by Jennings and Kaiser (1988), Farina *et al*. (1997), Chou *et al*. (1999), Hall (1999), Trong *et al*. (2000) and D'Onghia *et al*. (2002) .In spite of the fact that the hydrographic features and the fishing intensity can affect the distribution and abundance respectively of many species and thereby influencing the diversity in marine ecosystems, such effects on the species diversity and species richness have never been the topic of research in the deeper waters off Indian coast. Therefore, in the present study, an attempt is made in this direction with reference to deep sea prawns off the coast of Kerala with the following objectives. To calculate bio diversity indices of deep sea prawns off Kerala with a view to examine the change in community structure, if any, based on the taxonomic relatedness. To assess the depth wise and year wise species abundance, richness and evenness. To work out similarity index among the populations from month wise analysis.

Materials and Methods

The data for the study were collected from commercial deep sea trawlers operated at 150-650 m off Kerala from September 2000 to August 2002. Data on the deep sea prawn catch and effort were collected at weekly intervals from six major harbours of Kerala viz. Sakthikulangara, Neendakara, Cochin, Munambum, Beypore, and Puthiyappa and 4 minor harbours viz. Thottapally, Murikkumpadam, Ponnani and Mopla Bay spread along 6 districts of Kerala (Figure 1). Besides, the data on deep sea prawn resources and hydrographic parameters were also collected on board FORV Sagar Sampada during her

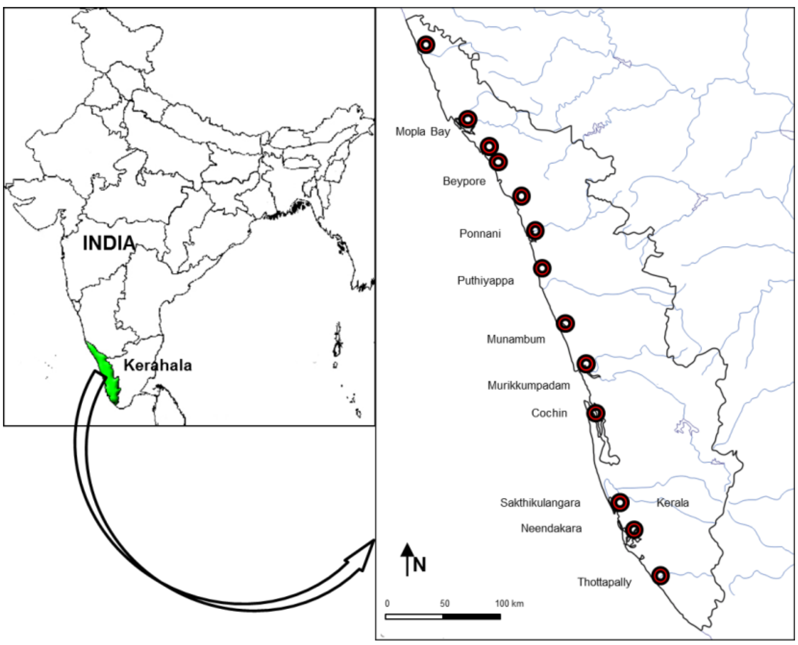

Figure 1. Study area, map of Kerahala showing important fishing harbours.

experimental trawl fishing cruise surveys no. 174, 183, 189, 191, 196 and 197 carried out at depths varying from 100-750 m in the latitudes 7°N and 13°N and longitudes 71'E and 77'E. For depth wise substrate characteristic studies, soil samples were collected using grab sampler from latitude 7°N to 13°N between 100 and 600 m depth. The samples were stored in sealed polythene containers at 40°C until arrival of the laboratory. The samples were then separated into particle sizes by wet sieving using 20 µm nylon sieves. Substrate analysis tests were carried out following Brown (1990). Species level identification of the deep sea prawns were done following Alcock (1901). The data of individual species was expressed as numbers. Once the species was identified, their respective numbers were analyzed for diversity indices at various depths using the PRIMER-5 (Plymouth Routine in Multivariate Ecological Research) tool pack. Species diversity was computed using the following Univariate ecological indices (Ludwig and Reynolds, 1988).

a) Shannon –Wiener diversity index (H'):

$$H' = -\sum_{i=1}^{s} pi\,(\log 2\ pi) \text{ or } -\sum n_i/N\,(\log 2\ n_i/N)$$

where pi is equivalent with ni/N; ni : the number of individuals in ith species. N: total number of individuals.

b) Evenness Index:

$$J' = H' / \text{Log}(S)$$

where H' measured Shannon –Wiener index, S: total number of species, J' : evenness.

c) Margalef's species richness index :

$$d = (S - 1) / \text{Log}e\ N$$

where d: richness index, S: total number of species, N: total number of individuals.

Similarities of deep sea prawn resources at five depth zones were worked out using multivariate analysis in the PRIMER package (Carr, 1997). Before multivariate analysis, deep sea prawn numbers were fourth-root-transformed, and the Bray –Curtis similarity measure was used to compute the similarity matrix. The abundance of each deep sea prawn species in terms of their number at 5 depths was calculated using hierarchical agglomerative clustering using the unweighted pair group mean arithmetic linking method (UPGMA). To test the significance one and two way ANOVA was employed following Snedecor and Cochran (1967).

Results

Substrate Characteristics

Substrate characteristics in the survey area of FORV Sagar Sampada are described in detail (Table1). It may be seen that fine sand and mud constitute the major components of bottom sediments up to 300 m where good trawlable grounds exist especially beyond 125 m. In the lat. 9-10°N, beyond 300 m depth, occasional rocky and muddy bottoms were encountered. Lat. 8-9°N which covers the famous Quilon bank is found to provide a good trawling ground at all depths with fine sandy and muddy bottom except for some rocky patches at 300-400 m depths. The bottom substrata between in lat. 10 and 13°N were found to be either sandy or muddy or have a combination of both.

Hydrographic Parameters

The salinity between the latitudes 7°N and 13°N showed a slight increase with an increase of depth and ranged between 34 and 36‰ from 200 to 500 m. The temperature showed a steady decline with increase of depths which varied from 15.3°C at 150 m to 9.9°C at 700 m whereas the dissolved oxygen level also showed an inverse relationship with depth, which ranged from 0.13 to 0.04 ml/L between 150 m and 700 m (Table 2).

Species Composition

Fifteen species of deep sea prawns belonging to 5 family and 10 genera were recorded in the depth zones 150-550 m off Kerala coast in Arabian Sea. The higher abundance of pandalids was observed at 250-

Table 1. Depth wise substrate characteristics in the sea bed between latitudes 8°N -13°N

Latitude	Depth (m)				
Zones	100-200	200-300	300-400	400-500	500-600
Latitude 8°N	sandy	sandy	sandy/muddy	sandy/muddy	muddy
Latitude 9°N	sandy	muddy	sandy/muddy/rock	muddy	muddy
Latitude 10°N	sandy	muddy	muddy/rock	muddy/rock	sandy/muddy
Latitude 11°N	sandy	muddy	muddy	muddy/rock	sandy/muddy
Latitude 12°N	sandy	muddy	muddy	muddy	sandy/muddy
Latitude 13°N	muddy	muddy	muddy	muddy	sandy/muddy

Table 2. Depth wise average hydrographic parameters of six cruises in latitudes 7°N- 13°N

Depth (m)	Temperature (°C)	Salinity (‰)	Dissolved Oxygen (ml/L)
50	21	34.2	0.59
100	17.43	34.91	0.54
150	15.27	34.68	0.53
200	13.86	35.1	0.59
250	12.85	35.18	0.48
300	11.81	35.12	0.28
350	11.58	35.3	0.27
400	11.41	35.74	0.25
450	11.24	35.68	0.21
500	11.11	36.01	0.21
550	10.55	36.07	0.28
600	10.1	35.98	0.25
650	9.72	36.21	0.25
700	9.19	36.04	0.21
800	8.96	36.01	0.20

Table 3. Species composition of deep sea prawns collected from150-550 m depth zones of study area

Family	Species	Vertical Distributional range (m)
Pandalidae	*Heterocarpus gibbosus*	250-350
	Heterocarpus woodmasoni	250-300
	Heterocarpus laevigatus	250-300
	Parapandalus spinipes	150-250
	Plesonika ensis	250-350
	Plesonika martia	250-350
	Plesionika alcocki	250-350
Aristeidae	*Aristeus alcocki*	350-550
Solenoceridae	*Solenocera hextii*	150-250
Oplophoridae	*Acanthephyra sanguinea*	350-550
	Acanthephyra armata	350-550
	Oplophorus typus	250-350
Penaeidae	*Peneopsis jerryi*	150-250
	P. investigatoris	150-250
	Metapenaeus andamanensis	150-250

Table 4. Ecological indices of deep sea prawns off Kerala between latitudes 7°N and 13°N

Month	2000-01			2001-02		
	Loge (H')	Species richness index (d)	Pielous evenness index (J')	Loge (H')	Species richness index (d)	Pielous even-Ness index (J')
August	-	-	-	0.189	0.268	0.272
September	1.530	0.818	0.736	1.608	0.982	0.732
October	1.703	0.933	0.819	1.921	1.163	0.834
November	1.607	1.145	0.698	1.843	1.255	0.768
December	2.309	1.422	0.929	1.977	1.332	0.824
January	2.335	1.388	0.940	1.720	1.412	0.692
February	2.136	1.127	0.927	2.035	1.269	0.884
March	2.017	1.220	0.841	1.806	0.914	0.868
April	1.811	0.864	0.871	1.801	1.207	0.782

350 m except for *Parapandalus spinipes* which showed preponderance at 150-250 m depth along with penaeid prawns (Table 3). Among the deep sea prawns caught, *Parapandalus spinipes* appeared as the most dominant species in the total catch whereas *Heterocarpus gibbosus* and *H.woodmasoni* occupied 2nd and 3rd position each in the total catches.

Year Wise Variation in Diversity Indices

Table 4 shows the ecological indices of Shannon diversity (H'), species richness (d) and evenness (J') of deep sea prawns in the study area. The Shannon diversity was high in January (2.34) while it was lowest during September (1.53). On the other hand, the species richness varied from 0.818 in September to 1.422 in December while the evenness values were in the range 0.73 in September and 0.94 in January. An increasing trend in the H′ values were observed from November to December touching as high as 2.31 in December and thereafter it gradually declined, however, no such definite trend could be discernible during 2001-02. Generally, the diversity indices showed a decline during the second year, and the highest H′ and J′ were recorded in February with 2.03 and 0.88 respectively while high species richness value was observed during January .Results of ANOVA showed that there exists significant variation ($P<0.001$) in the community structure between the first and second years .

The multivariate analysis showed a clear pattern linked to seasons highlighting the similarities in the distribution and abundance of populations during 2000 to 2002 (Figure 2). Maximum similarity was observed between the population of October 2001 and November 2001 followed by December 2000 and January 2001.

Depth Wise Variation in Diversity

Depth wise variation in diversity indices of deep sea prawns during 2000-02 is depicted in Figure 3. The H′ was found to be highest at 251-350 m during both the years and a decline was perceptible in the contiguous higher depths. Results of ANOVA showed significant variation ($P<0.01$) between H′ values among various depth zones for both the years .The species richness was also found to be highest at 251-350 m depth zones, however, a gradual declining trend was pronounced with an increase in depth (Figure 4).

Diversity Indices at 151-250 m

The Shannon diversity showed significant increase in species abundance from November to February during the first year while no such definite trend could be discernible during the second year of study (Figure 5). The H′ showed a slight decrease when compared to the previous year showing a peak in March (1.784), on the other hand species richness showed a sharp increase in March with 1.17. Maximum evenness was observed during October (0.932). Results of analysis of variance showed that there was significant difference ($P<0.001$) between the seasons. Results of multivariate analysis showed maximum similarity in species abundance between the population in November 2000 and April 2001 (95.33%) (Figure 6). In the second year also the trend was same in November and April with 99.64% similarity between the above two months (Figure 7).

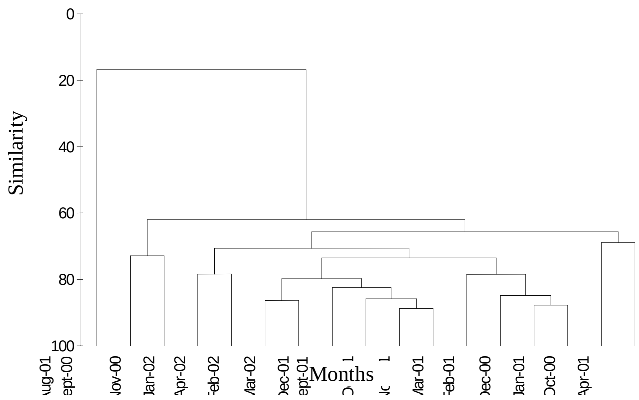

Figure 2. Dendrogram of year wise similarity index (in percentage) of deep sea prawns off Kerala between latitudes 7°N and 13°N during 2000-02.

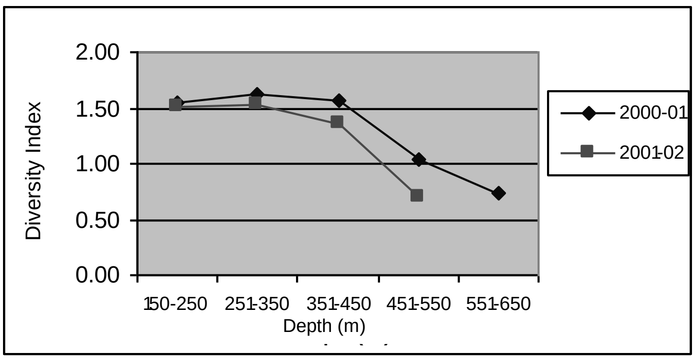

Figure 3. Depth wise indices of deep sea prawns of Arabian Sea.

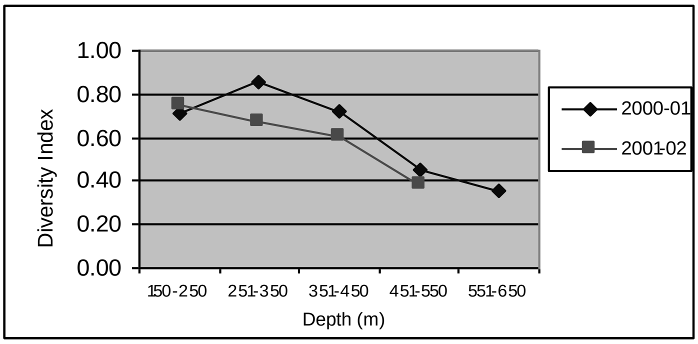

Figure 4. Depth wise species richness of deep sea prawns of Arabian Sea.

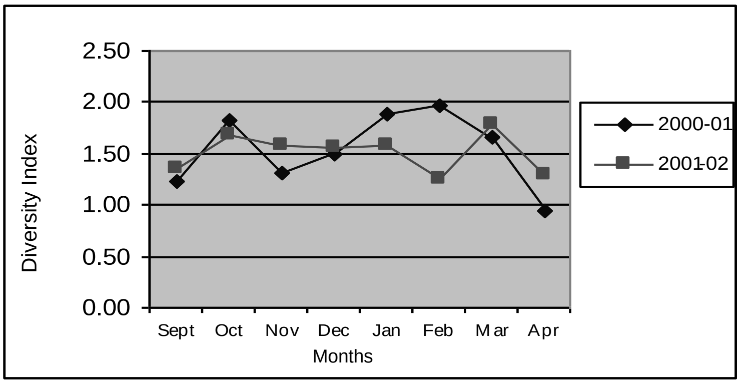

Figure.5. Depth wise diversity indices of deep sea prawns at 151-250 m.

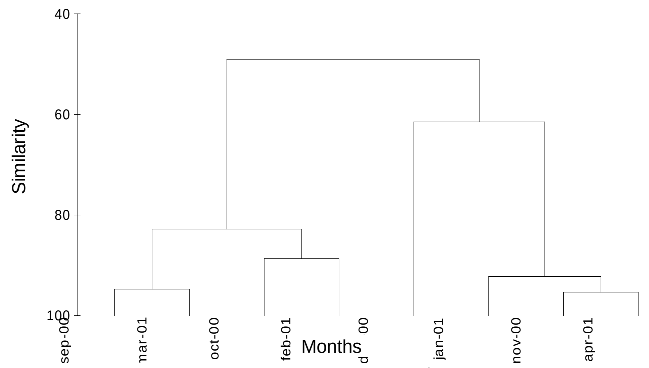

Figure 6. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 151- 250m during 2000-01.

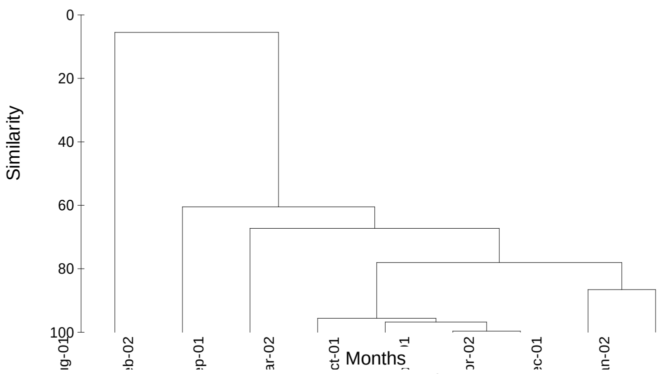

Figure 7. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 151- 250m during 2001-02.

Diversity Indices at 251-350 m

During 2000-01, the diversity index was high in February while the richness and evenness were maximum during October and December with 1.51 and 0.99 respectively (Figure 8). Where as in the second year both the H′ and d declined sharply, showing the peak value in March and December while J′ remained almost constant, showing high value in March. There exist significant variation between the populations during the two years (P<0.001).

Results of cluster analysis showed maximum similarity between the population of January 2001 and February 2001 (99.57%) in species abundance while it was between October 2002 and March 2002 during the second year (98.45%) (Figures 9 and 10).

Diversity Indices at 351-450 m

All the three indices were found highest at 351-450 m from 2000 to 2001. In December, registering 2.00, 0.90 and 0.90 respectively for H′, d, J′. In 2001-02 H′and d were highest during October with 1.706 and 1.205 respectively while highest evenness value was observed in September (0.974). Shannon diversity index showed an increasing trend from November to March during the first year, in contrast, a decreasing trend was discernible during the same months during the second year. The difference was

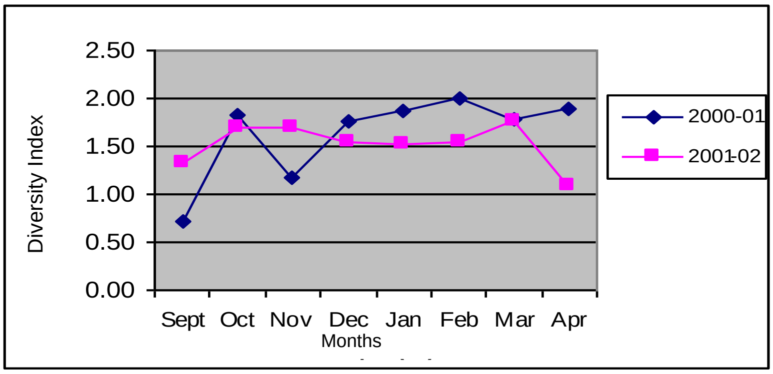

Figure 8. Depth wise diversity indices of deep sea prawns at 251-350 m.

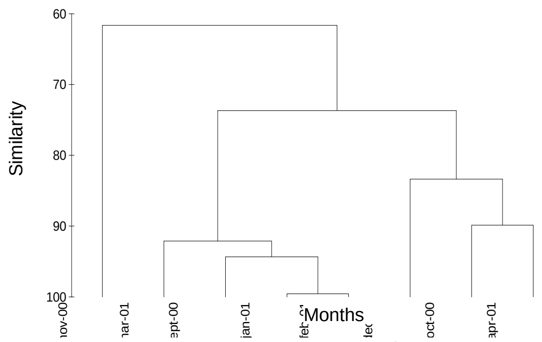

Figure 9. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 251-350 m during 2000-01.

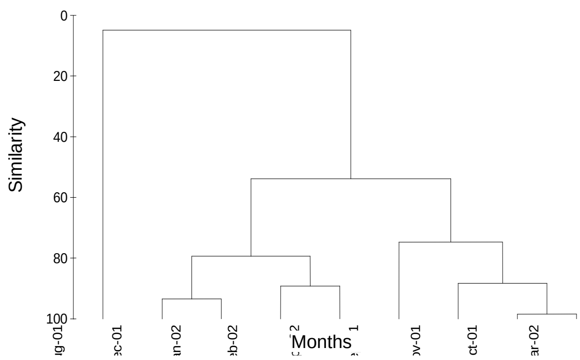

Figure 10. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 251-350 m during 2001-02.

found to be statistically significant (P<0.05).

Results of multivariate analysis showed maximum similarity in the species abundance between the population of November 2000 and March 2001(99.60%) while the similarity was high between November 2001 and December 2001 during 2001-02 at 350-450 m (97.11%) (Figures 11 and 12).

Diversity Indices at 451-550 m

The diversity indices at 451-550 m were maximum during December with 1.525, 0.897 and 0.737 for H´, d, J´ respectively. During the second year, the diversity indices showed a declining trend and the maximum H´ (1.44) and d (0.599) were attained in November while the J´ was high in December (0.907). H´ showed a gradual increasing trend until December and thereafter showed a decline up to February and further it increased. During the second year, there was a steady increase until November and thereafter it declined (Figure 13).

The cluster analysis showed maximum similarity between population of September 2001 and February 2001 during the preceding year while in the succeeding year the similarity was high between March 2002 and April 2002 in the populations of deep sea prawns.

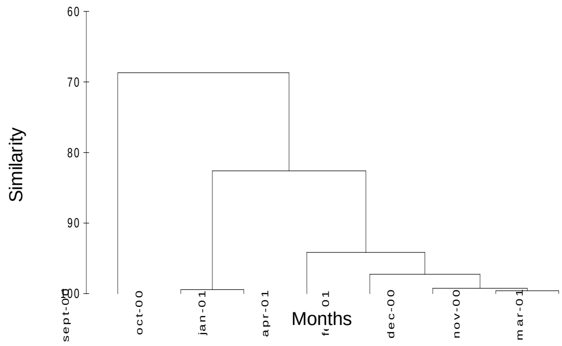

Figure 11. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 351-450 m during 2000-01.

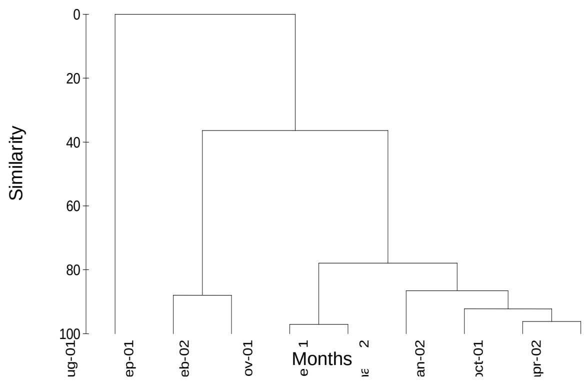

Figure 12. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 351-450 m during 2001-02.

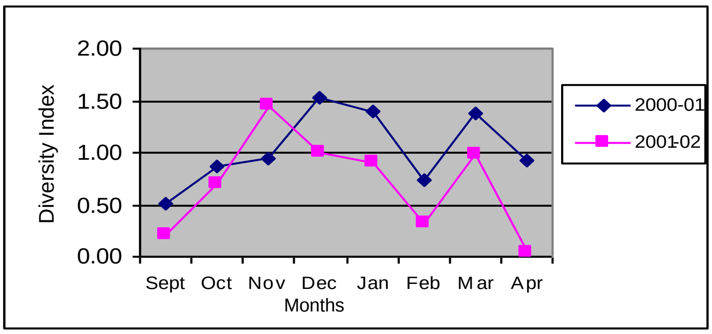

Figure 13. Depth wise diversity indices of deep sea prawns at 451-550 m.

Diversity Indices at 551-650 m

Shannon diversity was observed to be high in November while the species richness and evenness were high during October and January. H' showed an increase from October to February with peak in January (Figure 14). Results of multivariate analysis showed maximum similarity between the populations of November 2000 and April 2001 (97.80%) (Figure 15).

Discussion

In the present study, a pioneer attempt was made to work out the biodiversity indices of deep sea prawns in the continental slope of Arabian Sea. The depth wise and month wise species diversity, species richness and evenness in the deep sea prawn population were computed using univariate analysis whereas multivariate analysis was employed in order to assess the similarities exist in the distribution and abundance of populations during different months of 2000-01 and 2001-02.

Results of the bio diversity indices of deep sea prawn species inhabiting at various depth zones off Kerala coast during 2000-01 showed that it was high at 151-250 m and 251-350 m whereas at higher depths of 351-450 m, 451-550 m and 551-650 m, the diversity showed a gradually declining tendency. The species richness was also found to be relatively high at lower depth zones of 251-350 m, against the low values registered at higher depths. During 2001-02 also, similar findings were made with high diversity as well as species richness at 251-350 m while it was lowest at 451-550 m thus showing that diversity as well as species richness are showing inverse relationship with depth. It appears that the depth profoundly influences the assemblage structures of deep sea prawns. Clarke *et al*. (1993) opined that community structure would change with an increase of water depth and the present finding is complementary to the above statement. The structure of decapod crustacean assemblages on the continental regions in different geographic area are largely determined by spatial differences in environmental and oceanographic conditions, and particularly, by depth, bottom type and characteristics of the water masses (Abelló *et al*., 1988; Markle *et al*., 1988; Basford *et al*., 1989; Olaso, 1990; Macpherson, 1991; Cartes and Sardá, 1993; Sardá *et al*., 1994).

Off the Kerala coast, there is a marked deep sea faunal zonation along the bathymetric gradient. The distribution and abundance patterns of deep sea prawns off Kerala showed strong agreement with those reported in earlier studies (Mohamed and Suseelan, 1973; Suseelan, 1985) who had also reported that there is a reduction in species diversity as well as richness commensurate with increase of depth. Besides depth, the spatial structure of the shelf and upper slope of crustacean assemblages is well

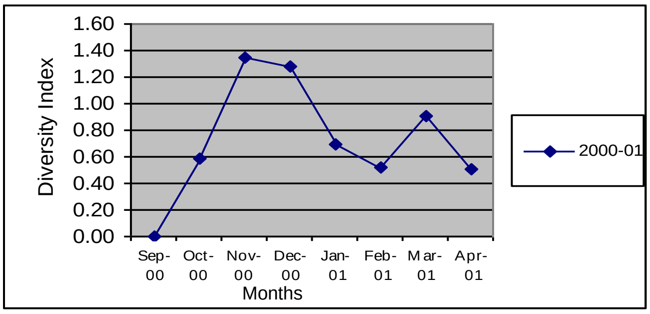

Figure 14. Depth wise diversity indices of deep sea prawns at 551-650 m.

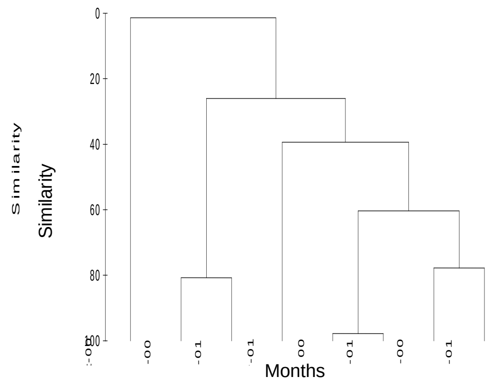

Figure 15. Dendrogram of depth wise similarity index (in percentage) of deep sea prawns at 551-650 m during 2001-02.

related to sediment granulometry (Bianchi, 1992; Setubal, 1992). Other habitat parameters such as character of bottom substratum, fishing disturbances, flow of various water bodies, salinity and oil spills etc. can also significantly change community structure (Wu, 1982). The variation encountered in the species diversity and species richness of deep sea prawns among various depth zones and seasons in the present study might possibly be due to the differences noticed in the bottom substratum as well as hydrographic factors at different depths. As the salinity do not shows severe change among the depth zones studied, it can reasonably be presumed that this parameter may not have been any significant influence on the species diversity. A strong correlation, however, is exist between the richness and diversity of deep sea prawns and the existing hydrographic parameters, by and large by water temperature, which exhibits strong variation with respect to depth zones. The relatively cooler water temperature coupled with fine muddy substrate provide the most congenial habitat for the pandalid prawns between the latitudes 8 to 9°N in Quilon Bank (Suseelan, 1985), where the species richness and diversity at 251-350 m was very high when compared to other zones. The penaeid prawns such as *Penaeopsis jerryi*, *M.andamanensis* and *Solenocera hextii* appear to be showing strong preference towards slightly higher water temperature and a substrate demarcated by mixture of sand and mud as evidenced from their distribution within 250 m. John and Kurien (1959) investigated on the influence of bottom temperature and the type of substratum on the distribution of *Penaeopsis philippi* along the south west coast of India and reported that there exists a positive correlation among temperature, optimum depth and soil composition in the distribution of this species off Kerala coast.

Several attempts have been made to study the effect of temperature on the distribution and abundance deep sea crustaceans. Smidt (1967) reported that *Pandalus borealis* fishery was constantly high in the warmer waters of Greenland whereas instability in temperature results in the fluctuations of species abundance. Rasmussen (1967) and Squires (1968) observed a positive correlation between the temperature and abundance of *P.borealis* from the Norwegian and Newfoundland waters. According to Dow (1967), seawater temperature, which ranged between 0^oC and 16^oC and soft muddy bottom, had profoundly influenced the species richness of the shrimp population than any other factors. Thompson (1967) also reported similar views in the abundance of *Hymenopenaeus robustus* , which showed highest concentration in the isothermal layer between 250-450 m depths. According to Sharma and Murty (1973), the isothermal layer and gradient of temperature play a decisive role in the distribution of prawns off south west coast of India while Suseelan (1985) pointed out that the deep sea prawns dwelling in the deeper waters are more sensitive to environmental factors than the littoral species. The species richness and abundance of deep sea prawns in certain months observed in the present study might be due to the large scale periodic migration of the prawns across the various depth zones, probably influenced by the slight change in water temperatures as opined by Silas (1969) and Suseelan (1985).

Interestingly, the diversity index H′ in the lower depth zones was glaringly high where intensive deep sea trawl fishing was in vogue. Though the deep sea fishing has started quite recently in south west coast of India, there are possibilities of its impact on the deep sea prawn species diversity in Arabian Sea besides causing changes in sea bottom ecology. According to Murawski (2000) the great H′ values registered in Italian waters is caused by heavy exploitation of prawns which in turn caused an increase in evenness and *interalia* diversity. Present findings strongly corroborates with the above observation, wherein a glaringly high evenness values were observed during the second year irrespective of depth zones or months. The low H′ reckoned invariably observed in deeper waters might be due to clear dominance of one (*A. alcocki*) or few species (*A. sanguinea*, *A. armata*) and also due to the relatively low intensity of trawl fishing. The trawl fishing impact will be more on the deep sea prawns which are less resilient than to their counter parts of coastal waters even though the commercial exploitation started only since 1999.

Though the present results are still preliminary, however, it will serve as a baseline and pioneer database relating to variations in the species diversity, abundance and evenness of deep sea prawns of various depths off Kerala in Arabian Sea. It is also indicative of showing the combined influence of soil type and water temperature as well; probably throw some light on the immediate impacts of deep sea trawling operations on biodiversity. Further data collection and analysis are required to evaluate the role of each process and to what extent these parameters interact.

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