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Some ecological indices of the Caspian Sea Amphipoda at different depths in Guilan offshore

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Abstracts: In the present study, some ecological factors were studied for Amphipoda at different depths. The Shannon, Margalef, and Hill indices were used to determine the species diversity, richness and evenness, respectively. In addition, the association and niche overlap values were estimated. Indices of species richness and diversity were highest at 50 and 100m depths, respectively. The ordination of depths show that the highest dissimilarity was at 20m depth and the lowest dissimilarity at 100 meter. Results of interspecific association and specific overlap of species show that only a few species could have similar ecological requirements. Results show that *Paraniphargoides derzhavini* with *Niphargoides grimmi* and, *Stenogammarus compersus* with *Amathilina cristata* had low associations. *Corophium spinulosum* with *Corophium nobile* and *Stenogammarus compersus* with *Paraniphargoides derzhavini*, however, had high associations.

Keywords: Amphipoda, Diversity, Interspecific association, Caspian Sea, Iran

Introduction

In the Caspian Sea, amphipoda is one of the most diverse groups, after molluscs. From all recorded amphipoda, 69 species were endemic, one species was related to Mediterranean fauna and four species were related to the North Arctic fauna (Kasymov, 1994). According to Pjatakova and Tarasov (1996), 72 species of amphipoda represented in the Caspian Sea. They described systematic and ecological parameters of some of those species.

Mordukhai-Bolotovskoi (1979) recorded more than 74 amphipod species in the Caspian Sea. Study by Stock *et al.* (1998) on Iranian waters of the Caspian Sea added four species to the lost of amphipoda of the Caspian Sea, including two new species and two new geographical records. Distribution and abundance of amphipoda species were studied in the Iranian coast of the Caspian Sea by Mirzajani & Kiabi (2000). Their study showed that the density of amphipoda increased with increase in depths, from three species at the shore to 11 species at 100 meter depth.

Using some indices including richness, diversity, evenness, association and niche overlap are particularly useful in ecological studies when a series is being compared (Clifford & Stephenson, 1975). Species having similar patterns of resource usage may be thought of as having a high degree of overlap, while those species with dissimilar usage patterns are considered to have a low degree of overlap (Smith, 1984). In theory, niche overlaps are considered as the possible determinants of species diversity and community structure (Petraitis, 1985). Species diversity includes the number of species in the community, and the evenness shows how the individuals are distributed among any species (Krebs, 1989).

Study by Thurston (2000) on benthic Gammaridea in the deep sea showed that diversity of benthic gammaridean amphipods and bathymetric ranges of more frequently collected species varied widely.

In this study some ecological factors of species of amphipoda of the Caspian Sea were studied in relation to different depths in order to use Mirzajani & Kiabi

(2000) data. The ecological indices were richness, diversity, evenness, association and niche overlap of the species.

Material and Methods

Sampling was conducted, seasonally, from autumn 1995 to summer. The amphipoda samples were taken from 10, 20, 50, 100 meter depths at nine perpendicular transects to the shore. Study area was southwest of the Caspian Sea from Astara (38° 27' N, 48° 53' E) to Noshahr (36° 40' N 51° 30' E), mostly in Guilan province (Fig. 1). Van Veen grab with 0.1m^2 size was used for bottom sampling. Specimens were removed using 0.25mm hair sieve and fixed with 4 % formalin. All specimens were identified, by the late professor J.H. Stock from Zoological Museum of Amsterdam.

Ecological indices, such as species diversity, richness and association were determined for amphipoda at different depths. The Shannon, Margalef, and Hill indices were used for species diversity, richness and evenness, respectively (Ludwig & Reynolds, 1988).

The indices were determined, separately, for different depths and different seasons. The total number of species and their abundance at each depth were used for calculation of indices for different seasons. At each transect in different seasons, total number of species as well as their abundance were calculated and averaged in order to determine the diversity indices at each transect. Statistical analysis such as One Way Anova as well as LSD were used to test the significance of differences between indices at different depths. The indices of Jaccard, Ochiai, and Dice were used for species association that is based on neglecting conjoint absences of species (Ludwig & Reynolds, 1988; Clifford & Stephenson, 1975).

Presence and absence of each species at each station was only considered annually (4 seasons combined). This procedure was actually selected to facilitate the interpretation of the data. In this way the effects of season is omitted. The software programs Spdivers.bas and Spassoci.bas (Ludwig & Reynolds, 1988) were used. The Spovrlap.bas was used to compute values of GO and SO. The complete overlap of the species, and the hypothesis that the specific overlaps of any pair of amphipoda species are complete also were tested. The Bray-Curtis polar ordination was used to determine the sampling depths.

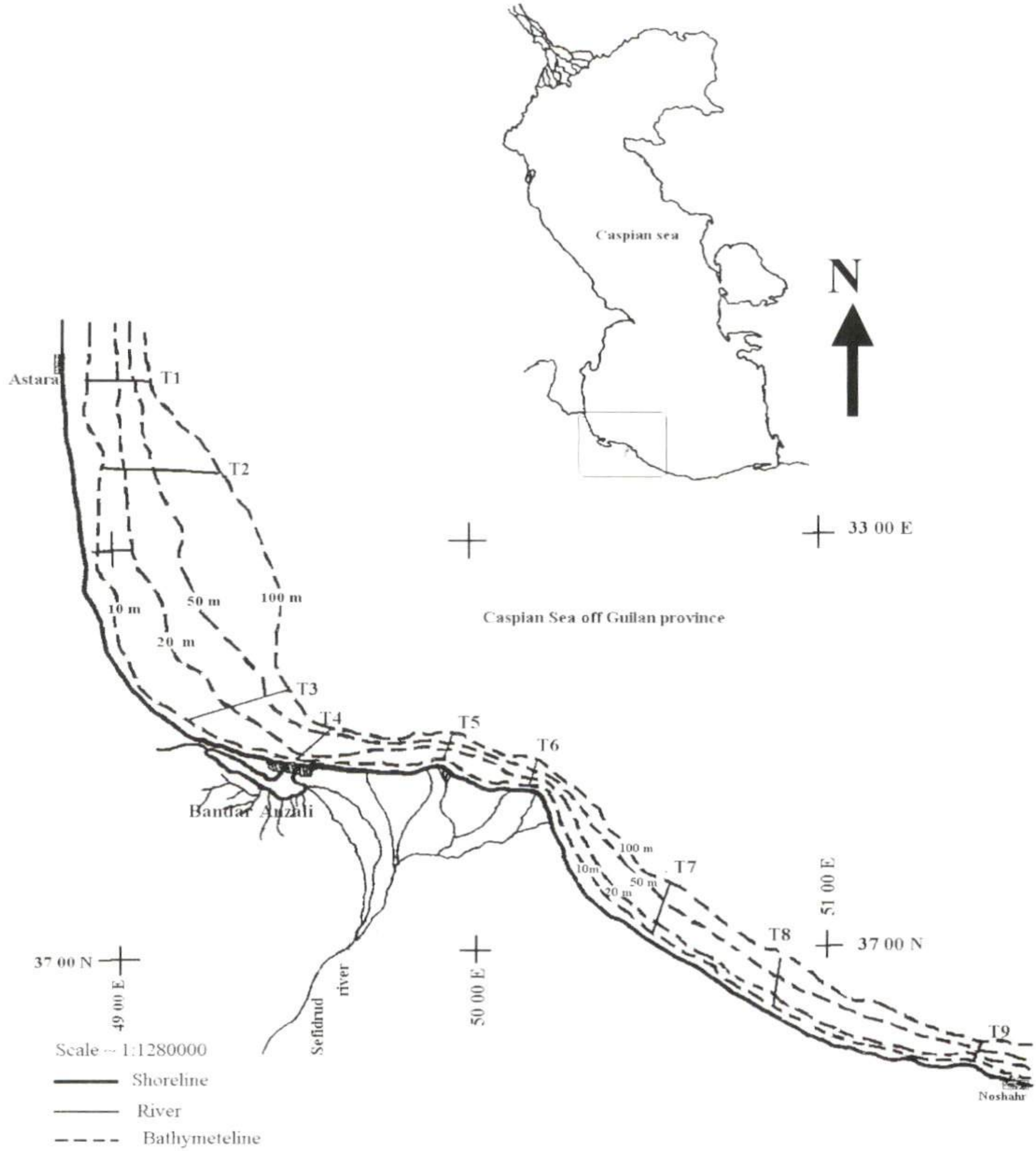

Figure 1: Sampling sites along the southwest coast of the Caspian Sea

Results

Observed species proportion at different depths (Table 1) show that 100 and 20 meter depths had the highest and lowest number of species, respectively.

Table 1: Observed amphipoda species proportion (%) in the southwest of the Caspian sea at different depths from nine transects, combined

Species	Species proportion at different depths (%)			
	10 m	**20 m**	**50 m**	**100 m**
Paraniphargoides derzhavini (Pjatakova, 1962)	43.9	37.5	18.7	
Niphargoides grimmi (Sars, 1896)	4.76	9.52	42.86	42.86
Stenogammarus compressus (Sars, 1894)	64.29	35.71		
Derzhavinella cava (Stock *et al*., 1998)			90	10
Amathillina cristata (Sars, 1894)			57.14	42.86
Gmelinopsis sp. (Sars, 1896	10		50	40
Corophium spinulosum (Sars, 1895	4.5	27.3	40.9	27.3
Corophium nobile (Sars, 1895		6.25	56.25	37.5
Corophium chelicorne (Sars, 1895			75	25
Caspicola knipovitschi (Derzhavin, 1944)			100	
Pandorites podoceroides (Sars, 1895)	14.29		28.57	57.14
Chaetogammarus pauxillus (Sars, 1896)				100
Monoporeia microphthalma (Sars, 1896)				100
Niphargogammarus borodini (Sars, 1897)	100			
Axelboeckia spinosa (Sars, 1894)				100

The species richness at 100 meter and 50 meter depths ranked first and second respectively, while those values at 10 meter and 20 meter were not clear cut (Fig. 2). Species richness at 10 meter, however, was lower than that at 20 meter depth. Species richness at 20 meter depth was higher in three seasons (Fig. 2). Differences between species richness at 100 meter and 50 meter depth with that at other depths were statistically significant ($F=27.65$, $P<0.01$).

The species evenness at 50 meter was low and differences between species evenness in that depths was not statistically significant ($F=3.54$, $P>0.01$). Species diversity at different depths was the same as species richness, which ranked first and second at 100 and 50 meter, respectively (Fig. 3). Differences diversity at 100 meter with other depths was statistically significant ($F=26.16$, $P<0.01$).

Arrangement of depths based on abundance of amphipoda showed that the 50 meter depth was close to 100 meter depth but a far distance from 10 and 20 meter depths was observed. The 50 meter depth had the most cumulative similarity with other depths, this depth had the most dissimilarity with 20 meter depth and had a less dissimilarity with 100 meter (Table 2).

Table 2: Percent dissimilarity matrix and cumulative dissimilarity of amphipoda for different depths

Depth	10 m	20 m	50 m	100 m
10 m		43.43	99.31	97.75
20 m			99.64	98.72
50 m				78.89
Cumulative dissimilarity	240.48	241.76	277.83	275.36

Fluctuations of index diversity of species, richness and evenness at different transects are shown in Fig. 4. The highest richness and second lowest evenness were found in transect 3 with high species diversity. On the other hand, transect 5 had least richness and most evenness while species diversity was low. In transects 7 and 8; the highest species diversity were observed which seems to be as a result of high species richness and evenness (Fig. 4).

Statistical analysis showed the significant interspecific association indices for all pairs of species in table 3 ($x^2 = 3.84$, df =1, $P<0.05$).

According to table 3 the *Paraniphargoides derzhavini* with *Niphargoides grimmi* and *stenogammarus compersus* with *Amathilina cristata* had negative association, while these values for *Corophium spinulosum* with *Corophium nobile* or *Stenogammarus compersus* with *Paraniphargoides derzhavini* were positive.

The general overlap between the 15 species in sampling sites was low (GO=0.55), with V=8474.318 (Table 4), higher than the critical value of chi-square=58.11 (df = 42, $P<0.05$) indicating that the general niche overlap hypothesis was rejected for all of species.

Table 5 shows the specific niche overlap for amphipoda species. Species had complete niche overlap that their test statistics were lower than the critical value of 7.82 (df=3, P<0.05). According to table 3 and 5, *A. cristata* with *N. grimmi*, *D. cava* with *C. spinulosum* and *C. knipovitchi* with *D. cava* had a complete niche overlap.

Table 3: Accepted interspecific association between pair of amphipoda species

Pair of species	Chi-square Value	Association type[1]	Association Indices[2]		
			Ochiai	Dice	Jaccard
P. derzhavini & N. grimmi	8.691	-	0.273	0.270	0.156
P. derzhavini & S. compersus	8.691	+	0.710	0.710	0.550
P. derzhavini & Gmelinopsis sp.	6.653	-	0.079	0.077	0.04
P. derzhavini & C. nobile	7.701	-	0.188	0.188	0.103
N. grimmi & S. compersus	15.546	-	0.169	0.167	0.091
N. grimmi & D. cava	9.890	+	0.69	0.645	0.475
N. grimmi & A. cristat	6.207	+	0.577	0.5	0.333
N. grimmi & Gmelinopsis sp.	9.890	+	0.69	0.645	0.475
N. grimmi & C. nobile	14.86	+	0.818	0.811	0.682
S. compersus & D. cava	9.89	-	0.0	0.0	0.0
S. compersus & A. cristata	6.207	-	0.0	0.0	0.0
S. compersus & Gmelinopsis sp.	5.713	-	0.082	0.08	0.042
S. compersus & C. pinulosum	6.361	-	0.323	0.316	0.188
S. compersus & C. nobile	20.571	-	0.0	0.0	0.0
D. cava & A. cristata	8.253	+	0.598	0.588	0.417
D. cava & Gmelinopsis sp.	7.166	+	0.6	0.6	0.429
D. cava & C. spinulosum	7.826	+	0.659	0.606	0.435
D. cava & C. nobile	17.308	+	0.791	0.769	0.625
D. cava & C. knipovitschi	8.509	+	0.548	0.462	0.3
A. cristata & Gmelinopsis sp.	22.593	+	0.837	0.824	0.7
A. cristata & C. nobile	10.862	+	0.661	0.609	0.438
Gmelinopsis sp. & C. nobile	11.638	+	0.712	0.692	0.529
C. spinulosum & C. nobile	9.959	+	0.730	0.718	0.560
C. nobile & C. chelicorne	5.625	+	0.5	0.4	0.25

[1] The sign indicates direction of the species association

[2] Indices measure provide the degree of association

Table 4 : The general and specific overlap for 15 amphipoda species

Species number	Go	Gmin	Gadj	V	Df
15	0.55	0.181	0.451	8474.318	42

Table 5: Specific niche overlap of Amphipoda species (with complete overlap) in the southwest of the Caspian Sea

Pair of amphipoda species	Specific niche overlap	Test statistic value
Species *C. knipovitchi* onto *C. spinulosumi*	0.995	0.313
Species *C. knipovitchi* onto *C. nobile*	0.961	2.412
Species *A. cristata* onto *N. grimmi*	0.975	5.051
Species *C. chelicorne* onto *P. podoceroides*	0.954	4.306
Species *A. spinosa* onto *N. grimmi*	0.511	1.342
Species *N. borodini* onto *S. compersus*	0.862	2.086
Species *D. cava* onto *C. spinulosum*	0.998	0.716
Species *C. kinipovitchi* onto *D. cava*	0.991	7.541
Species *C. chelicorne* onto *A. cristata*	0.919	7.762
Species *A. spinosa* onto *A. cristata*	0.614	0.976
Species *A. spinosa* onto *Gmelinopsis sp.*	0.238	2.870
Species *A. spinosa* onto *C. nobile*	0.036	6.668
Species *A. spinosa* onto *C. chelicorne*	0.804	0.435
Species *A. spinosa* onto *P. podoceroides*	0.840	0.348
Species *C. pauxillus* onto *M. microphetalma*	0.994	0.980
Species *C. pauxillus* onto *A. spinosa*	1	0
Species *A. spinosa* onto *C. pauxillus*	1	0
Species *A. spinosa* onto *M. microphetalma*	0.994	0.012

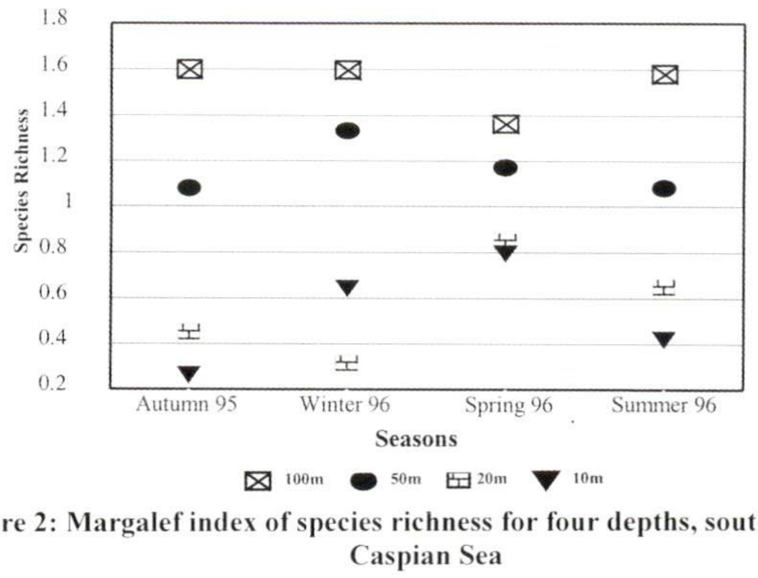

Figure 2: Margalef index of species richness for four depths, southwest of the Caspian Sea

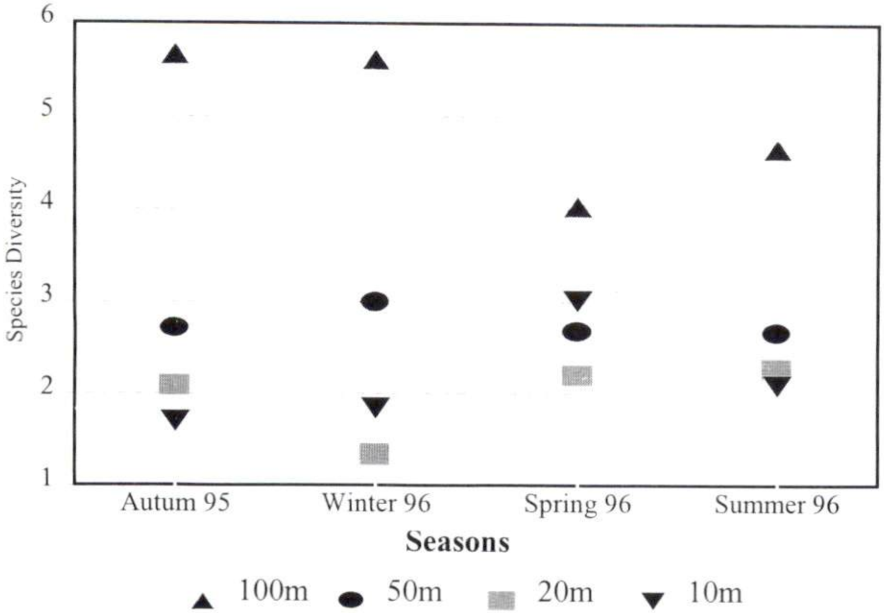

Figure 3: Shannon index of species diversity of amphipoda for four depths, southwest of the Caspian Sea

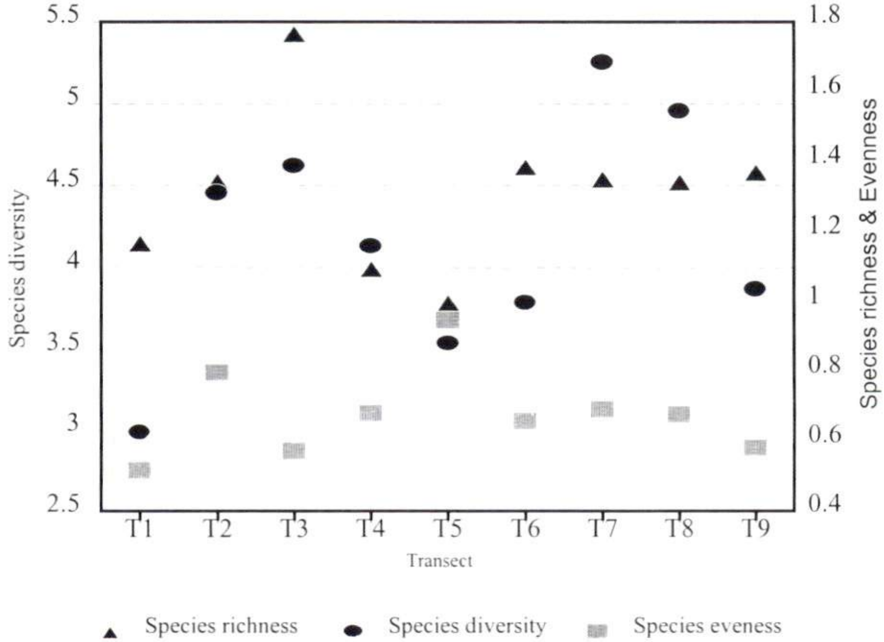

Figure 4: Variations of species diversity, richness and evenness of amphipoda at different transects, southwest of the Caspian Sea

Discussion

During the results of the present study, in different depths, aboundance and distribution of variety of species were observed. Study by Thurston (2000) showed that diversity of benthic gammaridean amphipods was highest in shallow water while, 82.2% of marine species had been recorded from the continental shelf and numbers decrease rapidly with increasing depth. Most species are confined to a single depth zone with 80.9% of all species only on the continental shelf, the choice of depth zones correspond roughly with the physical and environmental features of the continental margins and deep-sea floor (Thurston, 2000).

Based on the results, the species diversity and richness were higher in 100 and 50 meter depths than those at 10 and 20 meter depths, during different season. The evenness, however, showed little variations at different depths. Wanda *et al.* (2000) discribed that the amphipod fauna showed a decreasing trend, in terms of species abundance and diversity, with increasing depth in all seasons. This indicated the presence of distinct environmental conditions between the upper and lower circumlittoral zones of Heraklion Bay.

Wanda *et al.* (2000), also, revealed that the mean values of species richness and diversity index per sampling period at each depth exhibited little variation among the stations along the bathymetric gradient (with the lowest values at the deepest station), while the range of seasonal variation appeared to be almost constant at different depths.

Seasonal variability, as observed in this study, was less evident with increasing depth, most likely as a response to the prevalence of more stable environmental conditions than that at the continental shelf edge of Heraklion Bay (Wanda *et al.*, 2000). According to Michael (1990) the species diversity seems to increase as the community, becomes more stable, on the other hand, based on the study by Valerio-Berardo *et al.* (2000) the outer shelf has a more stable and uniform bottom water profile. This allows maintenance of a more diversified and stable community that exhibits no variation in its diversity and evenness values.

In this study the least richness was across Sefidrud river estuary, probably because of the river's influences on the indices. The environmental stability for the present study, however, remains to be determined. Study of the substrate characteristics in Guilan's offshore indicated that the depths of 50 and 10 meter had the most and the least organic matters, respectively, the most organic matters were observed at deeper stations, almost at all regions. All depths composed of the same grain size, and sediment compositions were mostly silt (Mirzajani *et al.*, 2003). On the other hand, Kasymov & Bagirov (1977) and Zahmatkesh (1993) observed higher amphipoda abundances of the Caspian Sea in the silty and sandy-silty sediments, that prevail in deeper bottoms. Wanda *et al.* (2000) noted the relation between the sediment texture and diversity, too. Although, they concluded that the establishment of a thermocline at approximately 70m depth most probably accounted for the decreasing bathymetric end in the amphipoda community. In the Caspian Sea, the thermocline establishment was reported at about 30 meter depths, for limited time from July to October (Bagheri & Kideys, 2002). That might be the effect of stable environment at 50 and 100 meter throughout the year. The similarites between species distribution and polar ordination at 50 and 100m depths have been showed in the present study, while according to Ludwig and Reynolds (1988) and Karami (1994) the distances between depths reflect their general similarity and the relation to the underlying environment gradients.

As survey on benthic community of the area of the present study during 1992-93 (Mirzajani, 1998) and 1996-97 (Mirzajani & Ghaninezhad, in press) showed the highest benthos biomass in depths deeper than 50 meter at Sefidrud river estuary region.

The tube dwellers amphipoda *Corophium spinulosum* and *Corophium nobile* dominated at 50 and 100 meter depths while the burrowers amphipoda *Stenogammarus compersus* and *Paraniphargoides derzhavini* dominated in 10 and 20 meter depths. In a study by Valerio-Berardo *et al.* (2000) low values of diversity were found at the inner shelf association at autumn and winter periods when the amphipod fauna was dominated by burrowers. Intermediate diversity values were presented by the outer shelf association, which was dominated by epifaunal and infaunal tube dwellers, and was characterized by an environmental stability all year around. Smith (1984) noted that there is a dependence of the lower bound of Go on sample size and the number of species considered, also he recommendes the Go should be adjusted to account for this dependence on sample size.

According to the present study some species had complete niche overlaps, therefore they might have the same requirements in the studied stations, since according to Ludwig & Reynolds (1988) and Karami (1994), the associations and niche overlaps, are studied to identify the species that have same ecological requirements. Also base on Smith (1984) measures of niche overlap are commonly used to summarize data on resource use by many species.

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