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Annelida Community Structure in the Gorgan Bay, Southeast of Caspian Sea, Iran - A Case Study

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Abstract: Annelida communities of the Gorgan Bay at the southeast of the Caspian Sea were studied in relation to the environmental conditions at 15 stations in June 2005. A total of 2946 individuals belonged to three families and four species were identified. Among them the polychaete, *Streblospio gynobranchiata* was the dominant species with 64.80 of the total population. The maximum density observed was 4382 (station 1) while the minimum density observed was 411 (station 6). It seems the diversity and density of annelid decreased during last decade so that the maximum diversity, richness and evenness were obtained, 1.00, 0.70 and 0.92, respectively and no species of Hirudinea was observed. There was also not significant correlation between environmental conditions, density and ecological indices (H', D and J) and it seems that the annelida communities was controlled by other factors like pollution and predators pressure. Also, multivariate analysis separated differences of density among stations.

Key words: Biodiversity · Community structure · Annelida · Goran Bay · Caspian Sea · Iran

INTRODUCTION

The Caspian Sea is the largest landlocked water body on the earth, containing 40% of the earth's continental water mass [1]. Structurally, it is divided to three different parts that; the southern part is the deepest 1025 meter and has the most salinity (12-13 ppt). Because of long-term geographical isolation and independent evolution, great parts of its fauna are endemic [2]. Nowadays, biological invasions [3], oil extraction, petroleum production [4] and rural and agricultural wastewater are the main problems for the living animals in this Sea [5].

Annelida have low biodiversity in the Caspian Sea so that less than twenty species have been recorded. Although density and distribution of them have been affected by various physical and chemical conditions (depth, currents, seasons, sediment grain size and organic matter contents), grazing pressure by sturgeon fishes is the most important factor that can control the biomass and diversity of macrofauna in this sea [6] So that in the diet of these fishes, annelida are one of the most abundant food items [4, 7] and it seems after the invasion of *Mnemiopsis leidyi,* abundance of them increased [8].

Gorgan Bay is the most important natural ecosystem in the south part of the Caspian Sea (Iranian border) so that it is nursery area for a lot of juvenile fishes and very good place for breeding and wintering of water birds. Also, the north part of it is suitable for mariculture and there are some cage cultures in this part. Few studies have described the benthic fauna of the south Caspian Sea [9-11] especially in Iranian border [12-14]. Nowadays unfortunately, heavy metals [15], microbial pollutions [16, 17] and rural and agricultural wastewater are increasing in this bay so that it is not suitable for swimming [16].

Annelida can be used as bio indicator for environmental monitoring programs [18] so, the aims of this project were; studying on some environmental conditions and studying on biodiversity and community structure of annelida related to these conditions. These results can help us to manage and conserve this bay for future.

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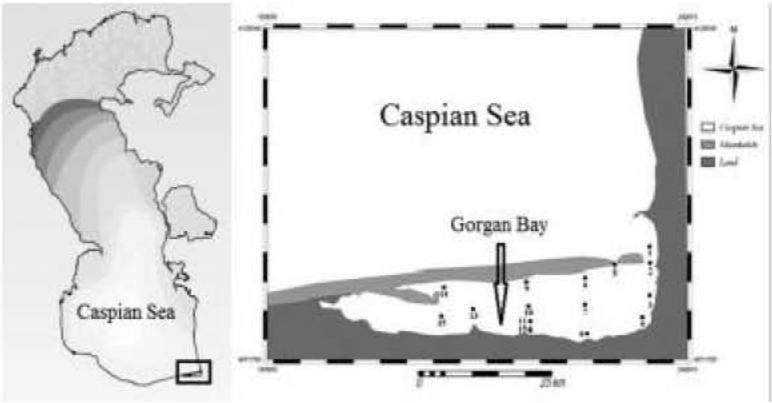

Fig. 1: Location of the sampling sites on the Gorgan Bay - south east of the Caspian Sea.

MATERIALS AND METHODES

Study Area: Gorgan bay is located in the southeast coast of the Caspian Sea along the Iranian border. Its area is around 400 Km^2 with the maximum length of 70 Km. Big part of this bay has low depth (less than 2 meter) especially in the west part and the maximum depth is 5 meter. Characteristics of the water column in this bay are partly similar to the Caspian Sea but it is influenced by some rivers that come into it. The Qarahsoo River (east part) and a branch of Neka River (west part) are important fresh water source in this bay.

Data Collection: Sampling was carried out in 15 stations throughout Gorgan Bay in June 2005 (Fig. 1). At each station for the biological study, three replicate samples were collected using Van Veen grab [19]. In the field, the contents of each grab were stored in the separate plastic containers. In the laboratory, sediment of each container is gently sieved by 0.5 mm mesh and the retained material is fixed in 4% buffered formalin and stained with Rose Bengal. Then, annelida were separated, identified and counted under stereomicroscope. Another replicate sediment samples were taken at each station to measure the percentage of the total organic matter (TOM) and the sediment grain size by Van Veen grab. The surface sediment (4 cm) was sub-sampled and stored in cleaned plastic containers. Total organic matter was determined by loss weight on ignition (4 hours at 550°C) after drying (24 hours at 90 °C) to constant weight [20]. Grain size analysis was performed using a Particle Size Analyser in the Iranian National Institute for Oceanography and the sediment fractions (sand, silt and clay) were reported as percentages and defined according to the Wentworth scale. Physicochemical data (depth, temperature, salinity and dissolved oxygen) of the water column were obtained using a CTD at each station and the data of near 30 cm depth above the sediment were used for the analysis [21].

Annelida community structure was described by univariate analyses based on the following parameters: density, species number (S), diversity (as Shannon-wiener's, H'), richness (As margalef's, D) and evenness (as Pielou's, J) per square meter. Prior to the analysis, data were tested for the normality (using Shapiro-Wilk) and the homogeneity of variance (using Levene's test). Whenever data were normal and homogen, one-way analysis of variance (ANOVA) was used to test the differences among the biological parameters (density, diversity, richness and evenness). Tukey's test ($P<0.05$) was used to assess the significant differences among the stations. The relationship between the density and the ecological indices (H', D and J) with all the environmental conditions was estimated using a Pearson's rank correlation coefficient ($P<0.05$). The frequency of the occurrence (F %) of the species was calculated according to Arasaki *et al*. [22]. Based on, the species were classified as constant (F>50%), Common (10%= F= 50%) and rare (F<10%).

Principal components analysis (PCA) was used to investigate the variations in the environmental conditions (transformed data to Log x+1) over the stations and to determine which variables had the most difference among the stations. Density's transformed data (Log x+1) were used for the classification and the ordination. Similarity was calculated using the Bray-Curtis coefficient. Non-metric multidimensional scaling (nMDS) was used to analyze the changes of annelida communities. Species with one individual were eliminated for these analyses [21].

RESULTS

Environmental Conditions: Environmental conditions are given in table 1. It is neccesory to mention that stations 11, 12 and 15 were coverd with fresh water plants mainly with *Potamogeton* sp. Depth ranged from 0.62 meter at station 11 to 4.12 meter at station 7. Sediment total organic matter were varied between 15.68 % at station 5 and 3.60 % at station 14. The highest value of TOM was observed near the station 5. The higher value at staions 15, 12 and 11 is refelected to the fresh water plants at these stations. Maximum and minimum water temperatures were observed at station 7 and 1, respectively. The salinity was varied among stations, so that the maximum salinity was obtained at station 13 and the minimum was observed at station 15. Accrording to the salinity value, it seems the current in the bay is counterclockwise. Dissolved oxygen ranged from 8.26 mgl^{-1} at staion 8 and 5.16 mgl^{-1} at station 7. According to the grain size, station 14 had the coarsest sediment while station 4 showed the finest sediment.

Results of the PCA with the abiotic data showed that the first two axes explained 72.20% of the total variance. The first component (PC1) explained 42.75% of variance and was negatively loaded by sand and positively loaded by TOM, silt and clay. The second component (PC2) explained 29.95% of variance and was negatively loaded by TOM and positively loaded by depth and salinity (Fig. 2).

Community Structure: A total of 2946 individuals belonged to 3 families and 4 species were identified. Except unknown Tubificid species, the others were constant in the bay (Table 2). Two species of them belonged to polychaete and they were numerically dominated group and *Streblospio gynobranchiata,* was the dominant species with 64.80% of total individuals so that it observed in all of stations and it had highest density value of the total annelid (Fig. 3). Also, there was not any species of Hirudinea in the study area. Significant difference in density was observed among stations (Table 3). According Tukey's test, maximum density was obtained at station 1 while minimum was observed at station 6. There was significant difference just in diversity among stations. Maximum values of diversity were obtained at stations 10 (1.00) and 9 (0.96) and minimum was obtained at station 2 (0.15). There was not significant correlation between all environmental conditions, density and ecological indices (Table 4).

Table 1: Environmental characteristics of the sampled sites

Station No	Depth (meter)	TOM (%)	Temperature (°C)	Salinity (ppm)	Oxygen dissolved (ml^{-1})	Sand	Silt	Clay
S 1	3.65	5.79	23.95	11.96	5.55	20.42	42.02	37.56
S 2	3.07	4.52	24.74	11.01	5.44	11.85	52.8	35.35
S 3	2.24	7.53	25.41	10.80	5.38	0.79	65.46	33.75
S 4	1.46	6.60	25.91	10.88	5.34	0.66	66.66	32.68
S 5	1.50	15.68	26.55	11.31	5.26	18.22	31.16	50.62
S 6	2.87	8.03	26.74	11.38	5.24	8.48	45.06	46.46
S 7	4.12	8.37	27.48	11.67	5.16	0.44	40.52	59.04
S 8	2.35	5.29	27.27	7.63	8.26	34.42	24.07	41.51
S 9	1.54	8.78	25.22	11.35	5.38	26.90	28.36	44.74
S 10	1.05	12.25	26.20	11.33	5.30	4.88	39.46	55.66
S 11	0.62	10.32	26.47	5.18	5.25	58.71	13.54	27.75
S 12	0.76	9.91	27.38	5.37	7.54	17.39	45.85	36.76
S 13	0.77	8.57	25.54	12.40	5.32	65.10	11.28	23.62
S 14	0.65	3.60	26.91	11.67	5.22	89.62	3.88	6.50
S 15	1.53	14.76	25.38	4.95	8.02	1.37	37.58	61.05

Table 2: List of taxa identified and frequency of occurrence during this study

Family	Genus	Species	F %
Nereididae	Nereis	Nereis diversicolor	71.11
Spionidae	Streblospio	Streblospio gynobranchiata	100
Tubificidae	Tubificoides	Tubificoides fraseri	68.89
Tubificidae	Unknown	unknown	20

Table 3: Density, species number (S), diversity (H′), evenness (J) and richness (D) during this study.

Stations	Density	S	H'	J	D
S 1	4382.35±1752.35 [a]	4	0.60±0.01 [abc]	0.63±0.31	0.41±0.21
S 2	1803.82±975.58 [abc]	3	0.15±0.25 [c]	0.17±0.30	0.20±0.36
S 3	1696.17±1427.35 [abc]	2	0.33±0.27 [abc]	0.73±0.21	0.28±0.08
S 4	3255.00±2234.41 [abc]	3	0.34±0.27 [abc]	0.57±0.17	0.36±0.08
S 5	1764.70±60.88 [abc]	3	0.77±0.13 [abc]	0.73±0.09	0.49±0.04
S 6	411.76±235.29 [c]	3	0.43±0.50 [abc]	0.85±0.16	0.37±0.39
S 7	656.76±244.70 [bc]	2	0.25±0.08 [bc]	0.65±0.05	0.33±0.05
S 8	3460.88±817.60 [ab]	4	0.86±0.21 [abc]	0.60±0.12	0.63±0.03
S 9	2313.82±700.00 [abc]	4	1.00±0.22 [a]	0.69±0.14	0.70±0.05
S 10	3921.47±573.52 [b]	4	0.96±0.07 [ab]	0.79±0.08	0.48±0.13
S 11	2411.76±1017.64 [abc]	3	0.37±0.26 [abc]	0.57±0.16	0.39±0.15
S 12	774.41±67.64 [bc]	3	0.42±0.16 [abc]	0.61±0.19	0.50±0.17
S 13	431.47±495.88 [c]	2	0.18±0.20 [c]	0.77±0.21	0.26±0.25
S 14	715.58±420.29 [bc]	3	0.64±.024 [abc]	0.64±0.16	0.67±0.13
S 15	882.35±420.58 [bc]	2	0.61±0.08 [abc]	0.92±0.08	0.30±0.06

Upper case letter (subscripted): variation among stations

Table 4: Pearson's rank correlation coefficient between density of annelid and environmental Conditions.

	Tom	Depth	Temp	Salinity	Oxygen	Sand	Silt	Clay
Density	-0.113	0.106	-0.367	0.067	0.005	-0.188	0.179	0.063

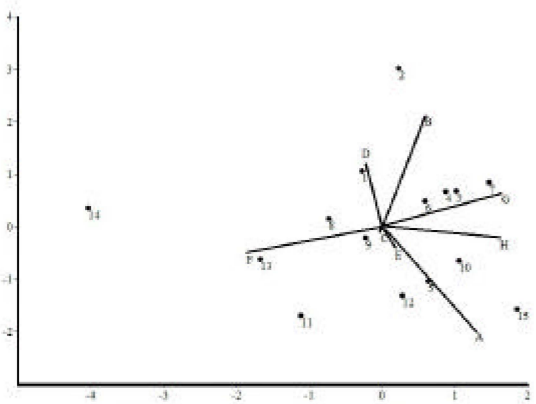

Fig. 2: Principal component analysis spatial presentation of stations based on environmental data. A: TOM, B: depth, C: temperature, D: salinity, E: oxygen, F: sand, G: silt, H: clay

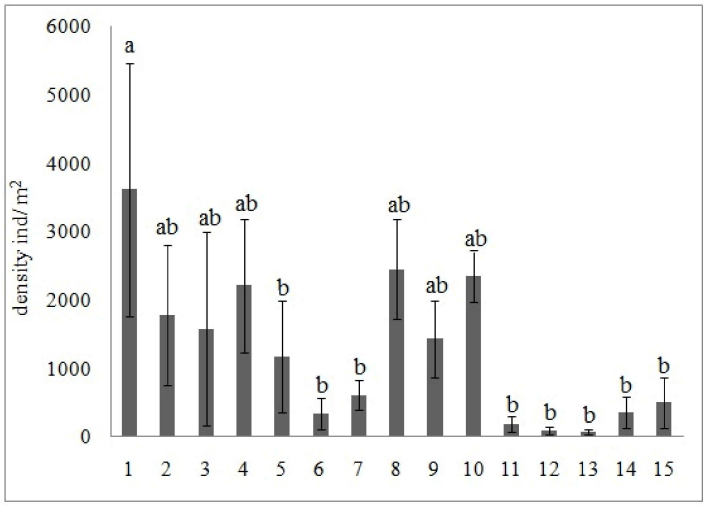

Fig. 3: Mean density of dominant species (*S. gynobranchiata*) at all stations.

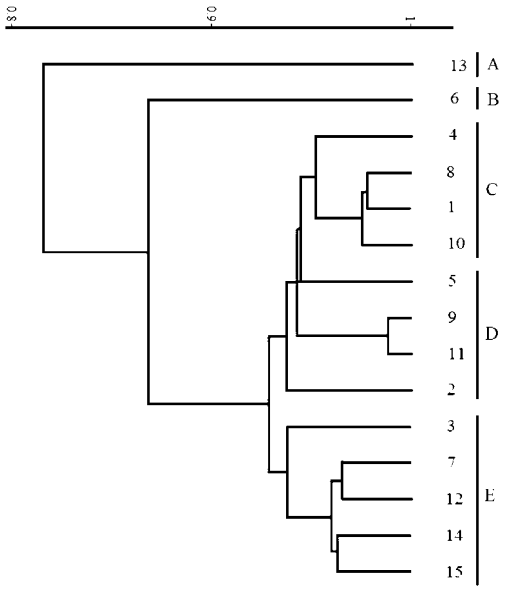

Fig. 4: Similarity among stations using the Bray-Curtis coefficient.

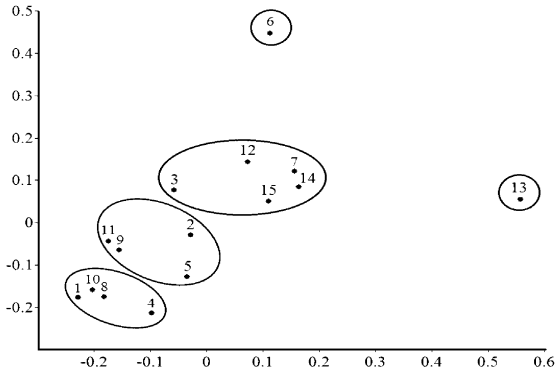

Fig. 5: Non-metric multidimensional scaling plot of annelida communities among the stations.

Multivariate Analysis: The Bray-Curtis analysis separated five groups of stations (Fig. 4). A comprised one station and the density of it were obtained 431 ind/m^2. B joined 1 station and the density of it was obtained 411 ind/m^2. C was formed by 4 stations that this group had the highest density value, 3255-4382 ind/m^2. D was formed by 4 stations and the density of them was obtained 1764-2411 ind/m^2. Finally, E comprised 5 stations and the density of them was obtained 656-1696 ind/m^2.

The MDS ordination plot for the complete data is shown in figure (5). According to this analysis, the stations were separated into 5 distinct groups and these groups are very similar to those generated with the Bray-Curtis coefficient. Stress value was obtained 0.08.

DISCUSSION

Annelida are one of the biggest macrofauna groups in marine ecosystems but less than twenty species have been reported in the Caspian Sea [3, 9, 10, 23, 24]. In this study, four species of them were obtained. Similar results were observed in the Gorgan Bay [12, 13] and Noor caost-southern Caspian Sea [8, 14]. Also, Malinovskaja *et al*. [25] and Parr *et al*. [11] showed 10 species of them in the northern and the southern Caspian Sea, respectively.

Previous studies showed five species of polychaete in the south Caspian Sea and Gorgan bay [11, 12, 14, 26] but two species were observed in the present study. The endemic polychaetes (*Hypania invalida*; *Hypniola kowalewskii* and *Manayunkia caspica*), which had been observed before in Gorgan bay, disappeared in this study and *Streblospio gynobranchiata* was replaced instead of them. Being disappeared the mentioned species may be related to the invasion of *S. gynobranchiatac* and *Tubificoides fraseri* in this sea so that they won in the competition for food and habitat or related to the pollution of this bay [15-17] because *H. invalida* was observed in another study in 2010 at Mazandaran province - south Caspian Sea (unpublished). In the present study two species of oligochaeta were observed and similar result was reported by Taheri and Yazdani, [14] at Noor coast while six species of oligochaeta were reported in the south Caspian Sea [11] but no oligochaeta species was observed in Dagestan region [27]. Furthermore, in the Northern part of the Caspian Sea three species [25] and in the Southern part one species [11, 8] of Hirudinea were reported but no species of them was obtained in the present study. Similar result was reported by Taheri *et al*., Bandany *et al*. and Taheri and Foshtomi [12-14]. It is necessary to note that different parts of the Caspian Sea have different structures of macrofauna communities so that at a special area, it is possible some species to be disappeared for some time and after that to be appeared again [24] and also fish grazing pressure [6] and reproduction cycle can be the main reasons of it.

Totally, in comparison to the other seas, the biodiversity of the Caspian is low. It is 2.5 times lower than the Black Sea and 5 times lower than the Barents Sea [28]. Probably the main reason for this is: i) low salinity (maximum 13 ppt) so that for the true freshwater species, this salinity is too high but for the marine origin species, this is too low. Maybe during the past decades, when Volga - Don Canal (opened 1952) connected the Caspian Sea and the sea of Azov to each other, some none indigenous benthic species arrived to the Caspian Sea but

because of different salinity regimes in the Caspian Sea, they could not settle and make population though there are many empty ecological niches in this sea. Therefore, this condition is just favourable for the brackish water species originating from both marine and freshwater [29]. ii) The long geographical isolation of the Caspian Sea from the Black sea (open seas) about 5-6 million years ago what was the adequate time for the evaluation of a unique and diverse fauna [28] so that great parts of its fauna are endemic [2].

The results of the previous studies in Gorgan bay indicated that salinity was more than (16 ppt) the adjustment area of the Caspian Sea specialty in the western part [30] but according to the present study, the salinity was different in different areas and ranged 4.95-12.40 ppt. Minimum of it was observed in the south western and the south part because a branch of Neka River has recently been inserted into the Gorgan bay from this part. Unfortunately, this fresh water could insert pollution into the bay and change the western part ecosystem so that the maximum salinity was obtained 12.40 at this part and some stations with the lowest salinity such as 8, 11, 12 and 15 completly were coverd by fresh water plants mainly with *Potamogeton* sp. Also larva of freshwater insect was observed at these parts. Besides, higher value of the TOM content of sediment was observed in this part. Because of this unstable condition, minimum density of annelida was obtaine in these areas. It is neccessory to say that previous studies showed that maximum TOM in this bay were 7.8% [12] while in present study, the highest level was obtained 15.68% at station 5, where there are some cage culture very closed to this station in the right side. In general, reasons of increasing value of TOM can be invaded of *Mnemiopsis leidyi* into this sea or eutrophication as result of sewage of agricultur [31]. Dissolved oxygen near the bottem of the sediment is a good indicatore to show organic pollution and hypoxia condition. Although in present study the percentage of TOM was high in some stations, dissolved oxygen values were between 5.16 - 8.26 mgl^{-1} and it can show that mineralization of total organic matter can be done well. Also, with PCA, stations were separated according to the environmental conditions so that the first component (PC1) explained 42.75% of variance and was negatively loaded by sand and positively by TOM, silt and clay. The second component (PC2) explained 29.95% of variance and was negatively loaded by TOM and positively by depth and salinity. Although different environmental factors were investigated in present study, there were not significant correlation between them, density and ecological indices (H', D and J) and it seems that the other factors can be determine the annelida assemblages.

In the current study, maximum (4382) and minimum (431) densities were obtained at station 1 and 13, respectively. Station 1 is located outside and near the mouth the Gorgan Bay and the highest density may be related to better environmental condition outside the bay. The highest density (6051) of polychaeta was observed in summer at Gorgan bay [12] and at the Noor coast highest density (10548) of macrofauna was obtained in winter [14]. *S. gynobranchiata* was dominant species during this study and maximum density of it was obtained 3617. Similar results were obtained at the Noor coast (10311) and Gorgan bay (4077) [12-14] but in present study density of it was obtained less than the previous studies.

Maximum species number (4), diversity (1.00), evenness (0.92) and richness (0.70) were obtained very low. Similar results were reported in the Gorgan Bay about polychaeta [12, 13] and in southern Caspian Sea at Noor coast [14]. The value of these indices could be related to the small number of annelid species and existence of *S. gynobranchiata* as the dominant species with very high density in each season.

According to the density, the multivariate analyses indicated five different groups. Groups B and A had the lowest density while the highest density was observed in group C. The environmental conditions in these groups were to some extent similar.

In conclusion, the present results show that this bay has not favourable environment for annelida development and suggest that their assemblages are controlled by unpredictable and complex factors like pollution, predator's pressure, seasons and reproduction capacity of each species.

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