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Research Article

Identification and distribution of benthic foraminifera in coastal waters of the Persian Gulf (Bushehr Province)

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Abstract

Benthic foraminifera in coastal sediments of the Persian Gulf were studied at four stations in summer and winter (August and February 2017), to identify and determine the species diversity. Sedimentary specimens were collected by a corer down to the depth of 5cm and by the diver down to the depths of 3, 5 and 10m at every station and transferred to the laboratory after being fixed (by 5% formalin solution). In this study, 10 species belonging to 8 genera and 5 families were identified. The highest abundance of the species is related to family Rotaliidae. *Ammonia beccari* and *Qunqueloculina bicostata* were dominant species in the region.The environmental factors including depth, temperature, dissolved oxygen, salinity, water pH, electrical conductivity and total dissolved solid using CTD and total organic matter concentration and sediment particle diameter were measured. The results of PCA test showed that temperature, salinity and dissolved oxygen have an effect on the density of the foraminiferal communities. Also the study results showed that sediment particles (sand / silt + clay, sand / silt, sand and calcium carbonate) are important in determining species densities.

Keywords: Foraminifera, Identification, Distribution, Bushehr Province, Persian Gulf

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Introduction

Foraminifera are a group of animals belongs to the kingdom protista. Foraminifera are unicellular creatures which are of a simple structure in the primitive forms and a relatively more complicated structure in the developed forms. Just as amoeba, the body of foraminifera is made up of a cell with cytoplasm and nucleus (Ashoori and Najjarzadeh, 2002).

Foraminifera have an important role in the food chain of aquatic ecosystems and are involved in the transfer of energy to higher levels. The shells of these creatures precipitate after death and participate in the formation of sedimentary rocks(Wu and Shin, 1997). With increasing latitude and depth , the diversity of species of foraminifera is reduced (Fairbridge *et al*., 1979).

The foraminifera are capable to move slowly in environment. Their movement is controlled by the stretching and pushing mechanism of their pseudopods at a speed of several millimeters per hour (Dimiza *et al*., 2016).

The Persian Gulf is between 30 and 24 degrees north to 56 and 48 degrees east of the Greenwich meridian (Khaledi, 2000). Studies conducted in recent years in the Persian Gulf and the Sea of Oman including the study of the continental shelf of the Sea of Oman (Moghaddasi *et al*., 2009a) 52 species, the region of Busher (Mirdar *et al*., 2004) 29 species, the coasts of Qeshm Island (Sohrabi-Mollayousefi *et al*., 2010) 9 species, the region of Assaluyeh (Mooraki *et al*., 2013a) 15 species, and northwest Persian Gulf (Nabavi *et al*., 2014) 93 specieswere identified and introduced in the waters of the Persian Gulf. Due to the great extent of Persian Gulf, there is a scattered research on the identification of benthic foraminifera in different Gulf coastlines, but a comprehensive study has not been carried out on this area along the coastline of Persian Gulf. The present research was to identify benthic foraminifera and to determine the importance in the study of changes in the ecosystem caused by various environmental factors.

Materials and methods

Sediment sampling was carried out in coastal waters of northern Coasts of the Persian Gulf in four stations including Assaluyeh, Kangan, Bushehr and Deylam at three depths of 3, 5 and 10m in summer (August) and winter (February) in 2017 (Fig. 1). Three transects perpendicular to the sea were taken .Samples were collected by a diver used corer at each station and fixed with 5% formalin solution. Electron images were obtained for species identification. . Identification keys were used such as Leoblich and Tappan (1964), Cushman (1969), Leoblich and Tappan (1988), and MOOPAM (1999). The relative abundanceof foraminiferal species at all depths were determined by counting with SEMduring both seasons. Table 1 shows the geographical coordinates.

In this study, some of the most important abiotic factors of sedimentary environment, including depth, water

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temperature, salinity, dissolved oxygen concentration, and seawater pH in the vicinity of the bed surface at each station and the type of bed sediment aggregation, percent of total organic matter and calcium carbonate assay were also measured to investigate the relationship between the extent of these factors and the structure of the biomass. Non-biological factors were measured by CTD and recorded at the sampling stations . nMDS test of foraminiferaand PCA test of environmental factors and substrate particles were conducted.

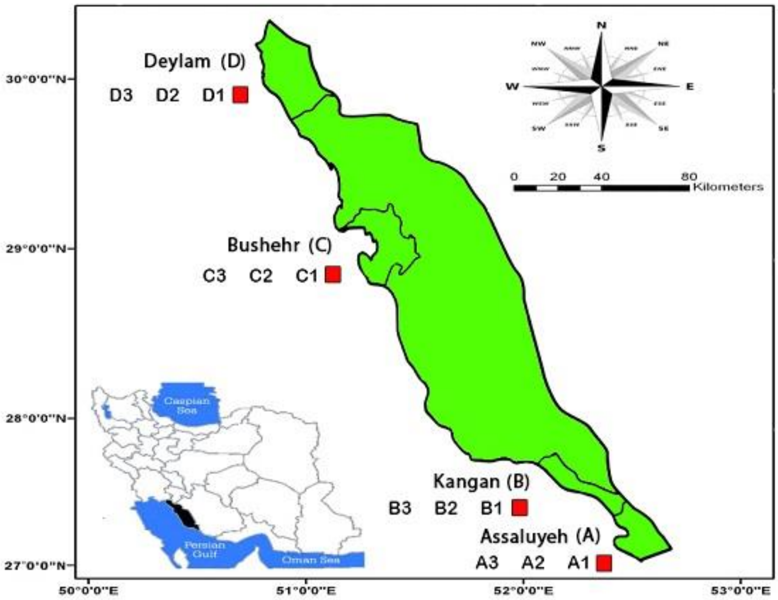

Figure 1: Map of sampling stations in the Persian Gulf (2017).

Table 1: Geographical coordinates of sampling stations (2017).

Station	Transect	Longitude (N)	Latitude (E)	(meter)Depth
A (Assaluyeh)	A1	27° : 27′ : 32/8″	52° : 37′ : 77/5″	3
	A2	27° : 27′ : 19/7″	52° : 37′ : 57/1″	5
	A3	27° : 26′ : 85/6″	52° : 37′ : 23/1″	10
B (kangan)	B1	27° : 50′ : 35/8″	52° : 01′ 75/7″	3
	B2	27° : 50′ : 29/2″	52° : 01′ : 69/6″	5
	B3	27° : 49′ : 57/3″	52° : 01′ : 53/7″	10
C (Bushehr)	C1	8° : 48′ : 37/4″	50° : 55′ : 65/6″	3
	C2	28° : 48′ : 14/ 7″	50° : 55′ : 54/9″	5
	C3	28° : 47′ : 88/7″	50° : 55′ : 42/9″	10
D (Deylam)	D1	30° : 03′ : 37/3″	50° : 07′ : 95/2″	3
	D2	30° : 02′ : 79/8″	50° : 06′ : 91/0″	5
	D3	30° : 02′ : 34/0″	50° : 05′ : 50/5″	10

Comparison of environmental factors between sampling stations was performed using one-way ANOVA and correlation between environmental factors with diversity and density of foraminifera, using Pearson correlation test. Excel 2016 and IBM SPSS Statistics 20 were used to design and

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draw charts. Percentage of biocenose to taphocenose foraminifera was measured at different stations in both seasons.

Results

In this study, 10 species belonging to eight genera and five families were identified. *Ammonia beccarii* was observed in all stations and family Rotaliidae had the most diversity among the identified families. Scanning Electron Microscope (SEM) images and classification of the identified species are presented in Table 2 and Fig. 2.

Table 2: Classification of identified benthic foraminifera in the Persian Gulf (2017).

Family	Genus	Species
Rotaliidae	*Ammonia* *Elphidium* *Asterorotalia*	*A. beccarii* *E. excavatum* *A. dentata*
Peneroplidae	*Peneroplis*	*P. planatus*
Hauerinidae	*Qunqueloculina*	*Q. bicostata* *Q. seminulum* *Qunqueloculina* sp.
Spirolosulinidae	*Spiroloculina* *Adelosina*	*S. communis* *Adelosina* sp.
Textulariidae	*Textularia*	*Textularia* sp.

Results of this study, including different depths, the seasons and species in the summer and winter are shown in Tables 3 and 4. In the two seasons, Kangan station had the highest percentage of benthic foraminifera. The lowest abundant is related to the Bushehr station in summer and Deylam station in winter.

Ammonia beccari and *Qunqueloculina bicostata* were the most abundant at most stations. *Qunqueloculina seminulum*, *Peneroplis Planatus* and *Elphidium excavatum* were not observed at Bushehr station in both seasons. The environmental factors are shown in Tables 5 and 6.

The results of sediment samples showed that the highest percentage of sand weight was at the Kangan station at the depth of 5m. The highest percentage of clay weight was observed at Deylam station at the depth of 10 m. On the other hand, the highest weight percentage of silt was measured in Asaluyeh and Kangan at the depth of 10m. The highest weight percentage of sand / silt ratio was obtained at the depth of 5m in Kangan Station and the highest percentage of sand weight / silt and clay were measured in Kangan station at the depth of 5 m (Table 7).

To find out the environmental characteristics of the bed, calcium carbonate content was measured at each station. The minimum mean calcium carbonate content at 3 m depth was 11.76 (%) at Asaluyeh station and its maximum was 40.26 (%) at 10 m depth at Deylam station.

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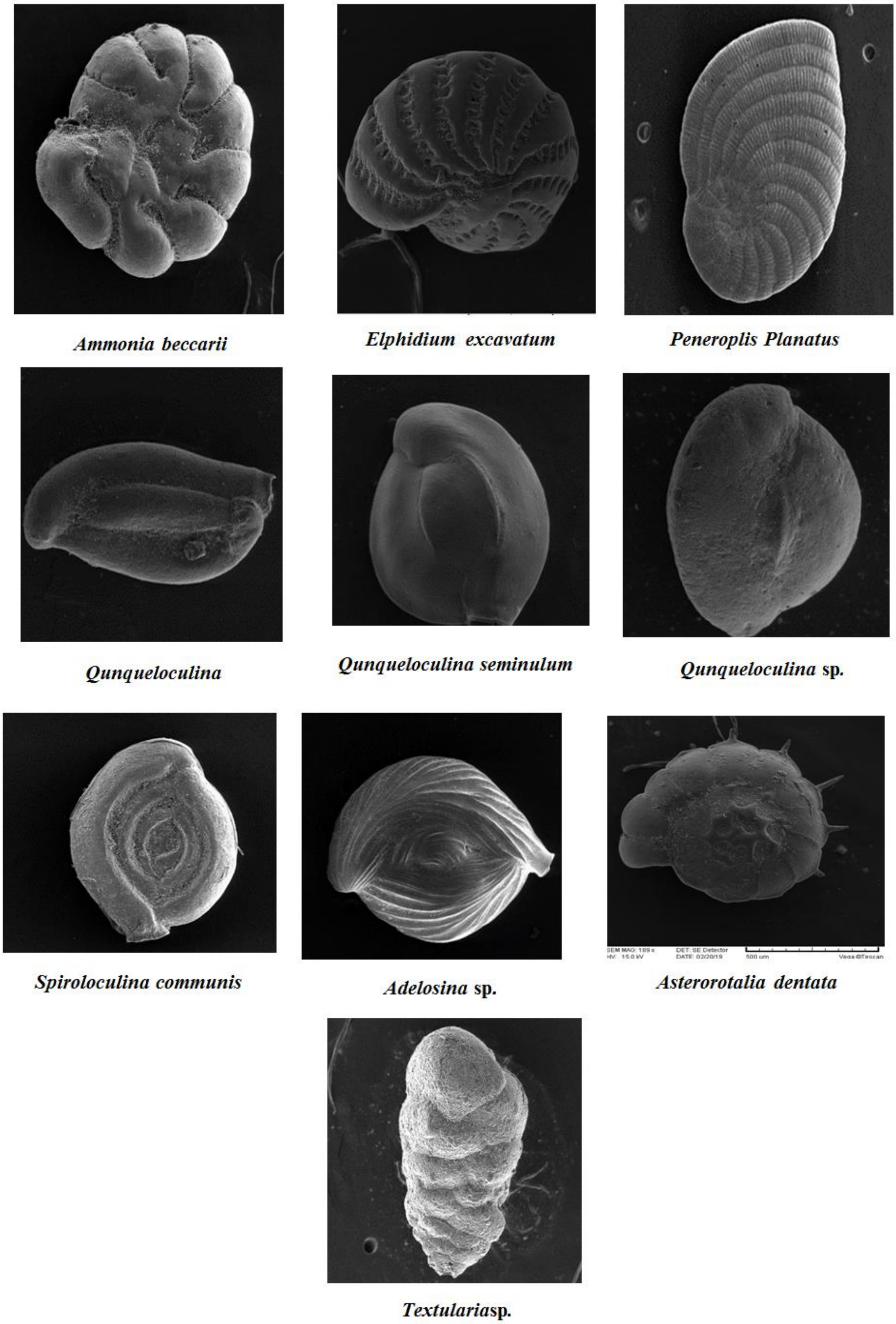

Figure 2: Scanning Electron Microscope (SEM) images of benthic foraminifera in the Persian Gulf (2017) (500mm).

Table 3: Relative abundance of benthic foraminifera in summer (N/cm^2), Persian Gulf (2017).

Name of the Species	Summer (2017)											
	(Assaluyeh) A			(Kangan) B			(Bushehr) C			(Deylam) D		
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Ammonia beccarii	20.52	20.52	26.75	9.05	15.56	4.95	8.06	1.69	1.98	10.61	38.92	4.38
Elphidium excavatum	2.83	0	0	1.55	0	0	0	0	0	0	0	0
Asterorotalia dentata	0.84	2.97	0	0	8.20	0	9.2	0	3.68	0	0	0
Peneroplis Planatus	0	0	0	0	0	0	0	0	0	0	0	0
Qunqueloculina bicostata	6.93	2.68	36.23	12.59	116.91	17.12	5.09	0.99	1.27	6.22	15.56	1.69
Qunqueloculina sp.	1.27	1.069	27.6	2.68	48.83	17.55	2.12	0	0	0	0	0
Qunqueloculina seminulum	1.27	1.98	35.10	3.82	49.25	1.69	0	0	0	0	0	5
Adelosina sp.	12.31	2.12	14.29	12.59	26.32	7.92	4.95	0	0.28	20.52	7.92	2.26
Spiroloculina communis	14.29	3.39	11.04	16.27	44.16	0	5.94	0	2.26	25.19	18.96	4.95
Textularia sp.	2.97	1.27	5.94	8.77	18.11	21.51	8.06	2.12	0	0	3.68	0

Table 4: Relative abundance of benthic foraminifera in winter (N/cm^2), Persian Gulf (2017).

Name of the Species	Winter (2017)											
	(Assaluyeh) A			(Kangan) B			(Bushehr) C			(Deylam) D		
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
Ammonia beccarii	16.7	29.72	10.61	16.98	138.71	106.15	0.70	7.92	15.56	2.68	1.69	1.13
Elphidium excavatum	7.5	7.92	4.38	12.03	17.69	48.83	0	0	0	0	0	0
Asterorotalia dentata	0	0	0	1.13	3.96	6.36	0	0	1.69	0	0	0
Peneroplis Planatus	0	0	0	0	1.13	0.42	0	0	0	0	0	0
Qunqueloculina bicostata	2.4	6.51	119.6	191.08	205.23	232.83	2.54	3.53	12.59	4.95	15.71	0.70
Qunqueloculina sp.	0	0.42	12.59	49.82	36.51	41.75	0	0	0	0	0	0
Qunqueloculina seminulum	1.55	2.54	16.277	36.09	79.97	37.5	0	0	0	1.41	1.13	0
Adelosina sp.	3.82	0	24.2	26.75	31.84	48.83	0	0	0	0	0	0
Spiroloculina communis	0	8.91	7.64	27.6	36.23	51.66	0	3.68	8.91	0	10.61	2.97
Textularia sp.	0	0.42	1.55	2.83	6.36	20.52	0	0	0	0	0	0

Table 5: Environmental factors at stations during the sampling period, Persian Gulf (summer).

station	Station No.	Depth (m)	Temperature (°C)	pH	Salinity (ppt)	EC (µ mho/cm)	Dissolved Oxygen (ppm)	TDS (Mg/l)
Assaluyeh	A1	3	35.49± 0.36 [cd]	7.66 ± 0.2 [bcd]	29.89 ± 0.6 [k]	62100±40[o]	5.49±0.34[j]	40976±44.5[p]
	A2	5	35.34 ± 0.59 [cd]	7.5 ± 0.4 [cd]	30.25 ± 0.5 [k]	62040±20[p]	5.43±0.3 [j]	40947±27.5[g]
	A3	10	39.05 ± 0.55 [a]	7.51 ± 0.3[cd]	30.70 ± 0.5[k]	62000±25[p]	4.36 ±0.3 [k]	40929±16.37[p]
Kangan	B1	3	35.93 ± 0.57 [bc]	8.61 ±0.45 [a]	34.8 ± 0.5 [hi]	60120±15[t]	6.76 ±0.15 [g]	39666±37.5[p]
	B2	5	35.43 ± 0.33 [cd]	8.45 ±0.4 [a]	34.43 ± 0.3 [j]	66900±36.05[e]	6.46 ±0.4[gh]	44182±40[d]
	B3	10	35.17 ± 0.5 [cd]	8.34 ± 0.41 [a]	32.94 ± 0.8 [j]	61710±32.7[q]	5.43 ±0.35 [j]	40690±42.25[p]
Bushehr	C1	3	35.3 ± 0.28 [c]	8.35 ± 0.3 [a]	36.23 ± 0.6 [efg]	67760±35[bc]	6.23 ±0.15 [hi]	44712±40[g]
	C2	5	35.1 ± 0.57 [cd]	8.48 ± 0.41 [a]	36.1 ± 0.8[efg]	65505±21.7 [f]	6.17 ±0.13 [hi]	43206±27.5[k]
	C3	10	36.86 ± 0.29[b]	7.43 ±0.39 [d]	35. 62 ± 0.5[fgn]	65510±5[f]	6. 43 ±0.23 [gh]	43228±20[k]
Deylam	D1	3	34.2 ± 0.28 [d]	8.54 ±0.26 [a]	37.2 ± 0.4 [cde]	69000±10[a]	7. 34 ±0.16[ef]	45624±65[d]
	D2	5	34.98 ± 0.37 [cd]	8.17 ±0.15 [abc]	37.26 ± 0.5 [cde]	63000±30[l]	7.7 ±0.1 [de]	41582±80[o]
	D3	10	34.98 ± 0.36 [cd]	7.52 ±0.36 [cd]	36.63 ±0.5 [defg]	67300±18.92[d]	7.63 ±0.15 [def]	44409±52.84[h]

Table 6: Environmental factors at stations during the sampling period, Persian Gulf (winter).

station	Station No.	Depth (m)	Temperature (°C)	pH	Salinity (ppt)	EC (µ mho/cm)	DO (ppm)	TDS (Mg/L)
Asaluyeh	A1	3	22.24± 0.59 [e]	8.75 ± 0.5 [e]	36.6± 0.7 [defg]	65400±20[g]	6.54±0.32[gh]	45120±21.07[e]
	A2	5	22.21 ± 0.47 [e]	6.59 ± 0.4 [e]	35.5 ±0 [ghi]	65400±10[g]	6.43±0.3[gh]	45130±21.07[g]
	A3	10	20.34 ± 0.17 [e]	7.4 ± 0.4[cd]	37.07 ± 0.8 [cde]	62350±15[m]	5.83 ±0.3[ij]	43000±20 [i]
Kangan	B1	3	20.50 ± 0. 29 [f]	8.25 ±0.4 [a]	36.8 ± 0. 7 [def]	64260±35[j]	7.66 ±0.2[def]	44310±20[p]
	B2	5	19.83 ± 0.32 [f]	8.63 ±0.4 [a]	37.03 ± 0.7 [cde]	65200±20[h]	8.5 ±0.2[ab]	44310±20[i]
	B3	10	18.4± 0.38 [f]	8.37 ± 0.4 [a]	37± 0.8 [cde]	61510±21.7[r]	7.93 ±0.15[cd]	44970±40[f]
Bushehr	C1	3	19.7 ± 0.28 [g]	8.29 ± 0.37 [ab]	37.77 ± 0.4 [cd]	67800±45.8[bc]	7.45 ±0.27[ef]	42440±30[m]
	C2	5	20.16 ± 0.28 [f]	8.52 ± 0.44 [a]	38.08 ± 0.38 [bc]	60900±20 [s]	7.24 ±0.14 [f]	46820±23[a]
	C3	10	18.76 ± 0.37[f]	8.75 ±0.29 [a]	76.76 ± 0.65[cde]	64200±17.55[k]	7. 73 ±0.15 [de]	42000±50[m]
Deylam	D1	3	18.27 ± 0. 28 [g]	8.37 ±0.25 [a]	39.13 ± 0. 9 [ab]	62300±20[n]	8. 23 ±0.15[bc]	45740±48[c]
	D2	5	18.5 ± 0.9 [g]	8.57 ±0.15 [a]	39.28 ± 0.9 [a]	64900±17. 99[i]	8.4 ±0.2 [ab]	44740±58.10[g]
	D3	10	16.76 ± 0.5 [h]	8.37 ±0.20 [a]	37.34 ± 0.5 [cde]	67750±10[c]	8.37 ±0.20 [a]	46730±70[b]

The percentages of calcium carbonate in different stations are shown in Table 8.

To investigate the effect of season factors (summer and winter), area (Asaluyeh, Kangan,Bushehr and Deylam) and depth (3 m, 5 m and 10 m) on the structure and composition of foraminifera species by three-way ANOVA test (3 -way permutational MANOVA) was used. Main test results showed that season and station had significant effect on foraminiferal species composition (p<0.05) but no significant effect on depth composition for foraminiferal species (p>0.05). Pairwise test comparisons revealed significant differences in species composition between the summer and winter seasons as well as significant differences between Asaluyeh/ Kangan, Asaluyeh/ Bushehr, Asaluyeh/ Deylam, Kangan/ Bushehr, Kangan/ Deylam and no significant difference between the two Bushehr/ Deylam areas.The permutational MANOVA - significant differences in species composition and population structure of foraminiferal communities in different seasons, stations and depths are shown in Table 9.

Table 7: Weight percentage of sediment particles by droplets at stations, Persian Gulf (2017).

station	Station No.	Depth (m)	Sand	Clay	Silt	sand/silt	sand/silt+clay
	A1	3	58	23	19	3.05	1.38
Asaluyeh	A2	5	88	11	1	88	7.33
	A3	10	28	37	35	0.8	0.38
	B1	3	64	13	23	2.78	1.77
Kangan	B2	5	89	10	1	89	8.09
	B3	10	42	23	35	1.2	0.72
	C1	3	35	33	32	1.09	0.53
Bushehr	C2	5	28	39	33	0.84	0.38
	C3	10	33	39	28	1.17	0.49
	D1	3	33	33	34	0.97	0.49
Deylam	D2	5	30	37	33	0.9	0.42
	D3	10	28	41	31	0.90	0.38

Table 8: Percentages of calcium carbonate in different stations (2017).

station	Station No.	Depth (m)	Calcium carbonat (%)
	A1	3	11.76
Asaluyeh	A2	5	31.65
	A3	10	13.96
	B1	3	19.13
Kangan	B2	5	16.76
	B3	10	17.13
	C1	3	26.69
Bushehr	C2	5	13.76
	C3	10	23.24
	D1	3	23.45
Deylam	D2	5	29.48
	D3	10	40.26

Results of PCA test in the study areas showed that temperature, salinity and dissolved oxygen are the main environmental factors affecting the density of foraminifer’s species. The eigenvalues for axes 1, 2, 3, and 4 are 0.94, 0.18, 0.13, and 0.009%, respectively. The total variance was 76%. This chart investigates the impact of physical and chemical effects on the biological community (Fig. 3).

Fig. 3 shows the position of foraminiferal species in relation to environmental factors. Lines that are taller and closer to the axes, they have the greatest impact on the biological community.So, for example, with increasing salinity, Ambe increases. The solid arrow shows environmental variables including temperature, salinity, pH, total organic matter, electrical conductivity, total soluble

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solids and dissolved oxygen, and the hollow lines are the foraminiferal species. Larger arrows closer to the x and y-axis indicate the greatest impact of environmental parameters on species density.

Table 9: Permutational MANOVA - significant differences in species composition and population structure of foraminiferal communities in different seasons, stations and depths, 2017.

Factor	df	MS	Pseudo F	P (perm)
season	1	1778	6.04	0.01*
station	3	4010	13.62	0.0005*
depth	2	217	0.73	0.6
		(Pairwise comparisons)		
Season			**t-value**	**P (perm)**
Summer/winter			2.45	0.015*
Depth			**t-value**	**P (perm)**
5-3			0.13	0.3
5-3			0.52	0.6
10-5			0.7	0.4
Station			**t-value**	**P (perm)**
Kangan/asaluyeh			3.29	0.05*
Bushehr/asaluyeh			3.83	0.03*
Deylam/asaluyeh			3.90	0.04*
Bushehr/kangan			3.66	0.03*
Deylam/kangan			6.8	0.02*
Deylam/bushehr			1.35	0.2

*Significant difference at 5% level

According to PCA diagrams, temperature, salinity, and dissolved oxygen have the most significant effect on the *Amonia beccari*, *Quinqueloculina bicostata* and *Quinqueloculina seminulumso*. As the salinity and dissolved oxygen increased, we saw an increase in density, However increasing temperature reduced density of foraminifera. Increasing the electrical conductivity and total soluble solids had the greatest effect on reducing the density of three species *Textularia* sp., *Asterorotalia dentata* and *Adelosina* sp. (Fig. 3).

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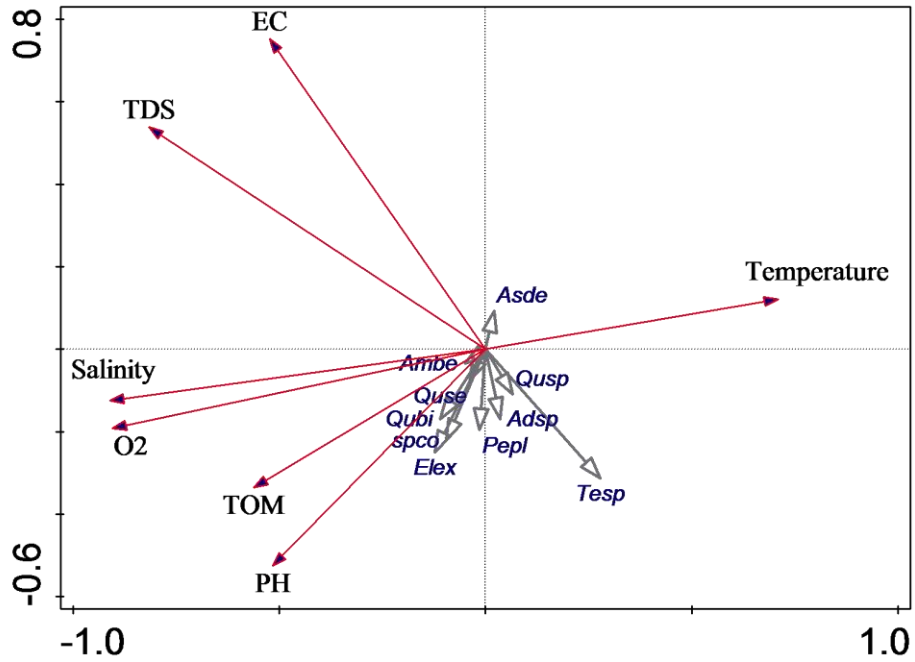

Figure 3: The position of foraminiferal species in relation to environmental factors, (2017). Species identification key: Ambe: *Amonia beccari*, Elex: *Elphidium excavatum*, Pepl: *Peneroplis planatus*, Qubi: *Quinqueloculina bicostata*, Qusp: *Quinqueloculina* sp., Quse: *Quinqueloculina seminulum*, Adsp: *Adelosina* sp., spco: *Spiroloculina communis*, Tesp: *Textularia* sp., Asde: *Asterorotalia dentata*.

Results of PCA test in the study area showed that sediment particles (sand/ silt + clay, sand/ silt, sand, atman index and calcium carbonate) are the main factors affecting the density of foraminiferal species (Fig. 4). The eigenvalues for axes 1, 2, 3, and 4 are 0.85, 0.07, 0.004, and 0.002%, respectively. The amount of variance is 94%.

The diagram shows the position of foraminiferal species in relation to sedimentation factors. The solid arrow shows sediment variables including sand/ silt + clay; sand/ silt, sand, calcium carbonate, silt, clay, silt, carbonate and silicate phases, and hollow lines are foraminiferal species. Larger and closer arrows to the x and y-axes indicate the greatest influence of sediment parameters on species density.

According to PCA diagrams, the foraminifera species, especially *Asterorotalia dentata*, *Amonia beccari*, *Spiroloculina communis*, *Quinqueloculina bicostataand*, *Quinqueloculina seminulum* had the most impact on sand/ silt + clay, sand/ silt, sand, Atman and carbonate indices. Their density increases with increasing amount of sand/ silt + clay, sand/ silt and sand and decreases with increasing concentration of Atman and calcium carbonate (Fig. 4).

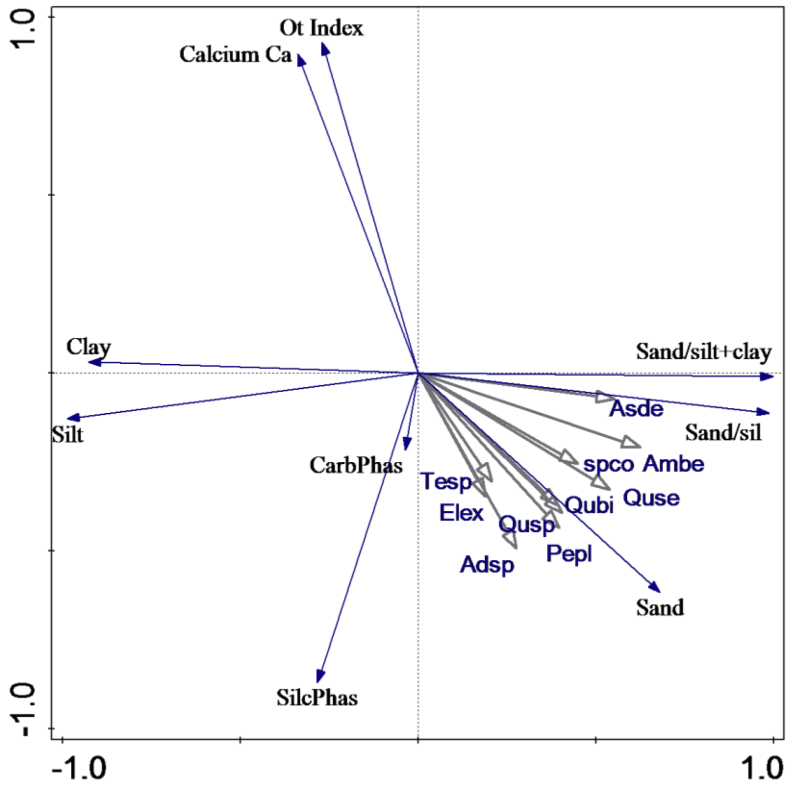

Figure 4: The position of foraminiferal species in relation to sedimentation factors, (2017). Species identification key: Ambe: *Amonia beccari*, Elex: *Elphidium excavatum*, Pepl: *Peneroplis planatus*, Qubi: *Quinqueloculina bicostata*, Qusp: *Quinqueloculina* sp., Quse: *Quinqueloculina seminulum*, Adsp: *Adelosina* sp., spco: *Spiroloculina communis*, Tesp: *Textularia* sp., Asde: *Asterorotalia dentate*.

Discussion

Benthic foraminifera are among the most important and abundant microbenthos in aquatic environments. The results of the present study in Bushehr province showed that the foraminifera was present at all stations in both seasons, but their diversity and density was different in various stations and depths. The abundance of foraminifera was higher in summer than in winter.

The results of PCA test in the study area showed that temperature, salinity and dissolved oxygen are the main environmental factors affecting the density of foraminiferal species. The main test results showed that season and station influenced the composition of foraminiferal species ($p<0.05$). However, the effect of depth on foraminiferal species composition was not significant ($p>0.05$). Pairwise test showed significant differences in species composition between the two seasons, i.e. summer and winter as well as significant differences between Asaluyeh/ Kangan, Asaluyeh/ Bushehr, Asaluyeh/ Deylam, Kangan/ Bushehr, Kangan/ Deylam areas and no significant difference between the two Bushehr/ Deylam.

Due to the close physical relationship between the macrobenthoses and the surrounding sediments, strong correlation patterns between the sedimentary particles and the macrobenthoses are observed (Chapman and Tolhurst, 2007; Anderson, 2008). However, numerous studies have been reported poor correlations between macrofauna and sedimentary particles (Wu and Shin, 1997; Barnes and Villiers, 2000) and the reason for such factors are as hunting and predation (Hines *et al*., 1997), physical disturbances (Thrush and Dayton, 2002), infection (Gray, 1992), and factors influencing colonization (Wu and Shin, 1997; Lundquist *et al*., 2006). The difference of sedimentary particles is of crucial importance in the way of macrobenthoses because their feeding strategy (Zhuang and Wang, 2004) and larval seating on the bed (McLachlan *et al*., 1995) depend on the type of sedimentary particles.

In the present PCA study, silt-clay and sand (long and near-axis arrows) are the first two factors affecting the density of the most abundant macrobenthos in the stations. Most of the differences between the characteristics of the sedimentary environment at the sampling stations are related to the results of the sediment identification section as well as the topographic location of the study stations . Therefore, at Kangan Station, it has the highest percentage of clay, silt and sand, and as a result, the foraminiferal density is high at this station in summer.

The results showed that the species *Ammonia beccarii*, *Qunqueloculina bicostata* and *Spiroloculina communis* are the dominant species of the study area. *A. beccarii* was the dominant species in the summer, and it is the most abundant species in the world, and has been introduced in previous studies in the Persian Gulf as the most abundant species in the study area (Mostafawi, 2003). This could be due to the high resistance of this species to the harsh and stressfull environments . *A. beccarii* had the highest abundance at Kangan Station in the summer and less abundant in other stations. This species has been observed in the Persian Gulf (Mooraki *et al*., 2013, 2018) and in the northern and southern of the Oman Sea (Moghaddasi *et al*., 2009b). It has been observed in the east of Qeshm Island by Ashkpour *et al*. (2016) and in Kish Island by Sohrabi Molla Yousefi *et al*. (2011).

The most abundant species of the present study was *Qunqueloculina bicostata* at Kangan Station in winter. The genus *Qunqueloculina* has the most species diversity and high abundance in winter at the Kangan station, but it was not observed at Bushehr Station in both seasons. This genus was observed in previous studies in the Persian Gulf by Mooraki *et al*. (2018) in Hormuz Island, Moghaddasi *et al*. (2009b) in the Oman Sea, Eskandari *et al*. (2008) on the northern and eastern coasts of Kish Island, and Sohrabi Molla Yousefi *et al*. (2008) in the islands of Kish and

Qeshm. It is one of the index species of Persian Gulf and Oman Sea.

Peneroplis Planatus was seen only in Kangan station in winter. This species has been observed in the study by Sohrabi Molla Yusefi *et al.* (2007) as well as by Eskandari *et al*. (2008) around Kish Island, which could be due to environmental adaptation to the climatic conditions of Kish Island, as a result of the similarity of the climate and environmental conditions of Kish Island with our study areas.In addition, the genus *Peneroplis* hasbeen reported in Mooraki *et al*. (2013b) in Naiband and Haleh area as well as in Qeshm Island (Ashkpur *et al*., 2016).

Spiroloculina communis species was not observed at 3 meter depth in winter but was observed at other depths. Depth is one of the most important factors affecting the distribution pattern and demographic structure of benthic foraminifera (Mostafawi, 2003). *Qunqueloculina* sp. , *Adelosina* sp. and *Textularia* sp. were exclusively related to the Kangan and Assalouye stations in the winter. Species of *Elphidium excavatum*, *Asterorotalia dentata*, *Peneroplis Planatus* and *Qunqueloculina* sp. have not been observed at Deylam station in both seasons, and their presence may be due to certain environmental conditions that are not observed at the intended station. *Asterorotalia dentate* was observed sparsely at three stations in the summer and two ones in the winter.

Genous *Spiroloculina*, which has been reported only in a few previous studies in the Persian Gulf (Mooraki *et al*. 2018), was abundant in all stations in both summer and winter. Also, the *Adelosina* sp was observed at all stations studied in both seasons, in addition to Bushehr and Deylam.

Peneroplis planatus was observed only in winter at the Kangan station , so this can be considered as the index species of Kangan station.

Considering the combination of benthic foraminifera communities in the Persian Gulf, the Hauerinidae family is the most abundant at Asaluyeh and Bushehr stations in summer and winter, nonexistent or very limited at other stations.

It can be concluded that species diversity of the foraminifera is lower in our stations than other regions of the Persian Gulf, which could be due to the absence of the habitats characteristics required by foraminifera. Investigation of foraminifera is recommended in more stations and higher depths in the Persian Gulf in order to obtain more accurate relation between density and environmental variations in the region.

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