

Effect of Hydrographic Conditions on the Ecology of Benthic Foraminifera in Two Different Hypersaline Lagoons, Eastern Red Sea Coast, Kingdom of Saudi Arabia

Mohammad Saleh B. Hariri

*Marine Biology Dept., Faculty of Marine Sciences,
King Abdulaziz University, Jeddah, Saudi Arabia*

Abstract. Abundance and distribution of benthic foraminifera have been investigated in the bottom sediments of Shuaiba and Sharm al-Kharrar lagoons, located south and north of Jeddah, respectively. The environmental factors that control the ecology of the benthonic foraminifera in these lagoons are also discussed. The identified benthic faunal assemblages in these two hypersaline lagoons show significant variations. It was found that the suborder Rotaliids (*e.g. Amphistegina* sp. and *Elphidium* sp.) occur more predominantly than suborder Miliolids in the bottom sediments of Sharm Al-kharrar lagoon; results also indicated that the suborder Miliolids dominate the Rotaliids in Shuaiba lagoon. The distribution pattern of benthic foraminifera in the two studied lagoons was mainly controlled by environmental factors such as water depth, intensity of light, texture of the sediments and dilution by fresh water.

Introduction

Little is known about the occurrence and distribution of benthic foraminifera in the hypersaline lagoon sediments along the Red Sea coastal stretches. The environmental conditions of the marine environment are the limiting factors in the occurrence and abundance of benthonic foraminifera. Murray (1973) mentioned that a species may be

able to survive in an environment in which it is unable to reproduce if any factor exceeds the tolerance level.

In this paper an attempt is made to define the criteria by which the recent benthic foraminiferal frequency distribution and species abundance may be used to differentiate carbonate sediments in two different hypersaline lagoons such as Shuaiba lagoon south of Jeddah and Sharm al Kharrar lagoon north of Jeddah. The effect of hydrographic conditions on the distribution patterns of benthic foraminiferal assemblages in these two lagoons have been also investigated.

Many studies have been carried out on the recent foraminifera in the western coast of Saudi Arabia (Bahafzallah, 1979; Bahafzallah and El-Askary, 1981; Yusuf, 1984; Abou Ouf *et al.*, 1988; Abou Ouf, 1992 (a, b); and Gheith & Abou Ouf, 1996). Most of these studies dealt with the abundance and distribution of benthic foraminifera and their relation to temperature, salinity, substrate and nutrients. This paper aims to establish a correlation scheme between the distributional pattern of benthic foraminifera and their ecological factors in these two lagoons.

Materials and Methods

Fifteen bottom sediment samples were collected from the Sharm El Kharrar and Shuaiba lagoons using a grab sampler (seven samples were collected from El Kharrar and eight samples were collected from Shuaiba). The collected samples were spread on paper sheet and allowed to dry in air then disaggregated and a known weight of each sample was washed by water to remove the soluble salts and dried at 80°C then the dry samples were sieved through a standard set of sieves with mesh openings of 1, 0.5, 0.25, 0.125, 0.063 mm. Microfossils analyses were applied on 1 gram of sediment chosen from the 0.5 mm fraction where benthic foraminiferal species are abundant and suitable for counting many species as they are present (Gheith and Abou Ouf, 1996). The most common species in each sample was identified under the binocular microscope and the percentages of each species and genera were determined and presented in graphs.

Physiography of the Studied Lagoons

The Saudi coastal stretch along the Red Sea extends nearly 1932 km with numerous coastal lagoons, locally some of them known as Sharms. Their origins were discussed by many authors (*e.g.* Rabaa, 1988; Head, 1987; Braithwaite, 1987; and Brown *et al.*, 1989). They were formed by erosion in the pluvial Pleistocene and drowned by post glacial sea level rises during the Holocene. The Red Sea coastal lagoons of Saudi Arabia had suffered little attention compared to those of the Arabian Gulf (El-Sayed, 1987; Behairy *et al.*, 1991; El-Abd and Awad, 1991; Abou Ouf & El-Shater, 1993; Al-Washmi, 1999; and Gheith, 2000). The present study deals mainly with the sharm Al-Khrrar and Shuaiba lagoons. Their main physiographic characters will be discussed below.

Sharm Al-Kharrar Lagoon

The Sharm Al-Kharrar lagoon lies in the coastal plain northwest of Rabigh between latitude 22° 45' and 23° 00' N and longitude 39° 00' and 38° 45' E (Fig. 1). It has length of 17 km long with an average width of 3km. The lagoon water depth ranges from 2 to 14 m. It is connected to the adjacent Red Sea through a narrow channel located at northwestern side. The southern and eastern parts of the lagoon are bounded by extensive intertidal and supratidal flats (sabkha). Mangrove (*Avicennia*) stands are common specially around the lagoon islands. In general, the lagoon is bordered by the Tertiary rocks forming mountains parallel to the Red Sea coast. In the south-southeast of the lagoon, several ephemeral streams occasionally feed the lagoon with fresh waters. The Red Sea waters enter the lagoon twice a day and subject to dilution by the incoming fresh water from the wadis during flooding period (Al-Washmi and Rasul, 2003). Tidal range at the lagoon is very low (20-30 cm). Sediment textures consist of mud, gravelly sand and sandy mud. Mud is dominant in the southern half and along the southeast fringes of the lagoon. Sediment composition is mainly of biogenic origin.

Shuaiba Lagoon

The Shuaiba lagoon, a representative hypersaline lagoon, lies on the Red Sea coastal plain 90 km south of Jeddah. It is located between latitude 39° 26' and 39° 32' N and longitudes 20° 42' and 20° 51' E (Fig.

2). It breaks the continuity of the Pleistocene coral reef complex and connects with the sea by a narrow tidal channel. The Shuaiba Lagoon consists of two restricted lagoons with average length of 20 km and width of 5 km. They are separated from the Red Sea by coral reefs barrier covered with sand dunes. This natural condition protects the lagoon from strong waves, therefore many mangroves are able to survive and develop. The lagoon is veneered with sediments of biogenic, aeolian and/or of evaporitic origin. Sediment texture ranges between gravel and mud, where sand is the dominant size fraction (Al-Washmi, 2003). The lagoon has an average depth of 2m and is characterized by strong dry climate leading to the formation of coastal sabkha especially in the southern and eastern parts of the lagoon (Gheith, 2000). Rainfall is very rare and seasonal, usually occurs during the winter months. The atmospheric temperature above the lagoon is very high, allowing the plant *Avicennia* to develop. Average temperature ranges between 35.3°C in July and 23.6°C in February. The measured pH equals 7.7 in July and 6.5 in February. Tides are very low ranging from 6-9 cm in February to 17 cm in July. The tide is generally affected by winds which drift the sea water towards the land.

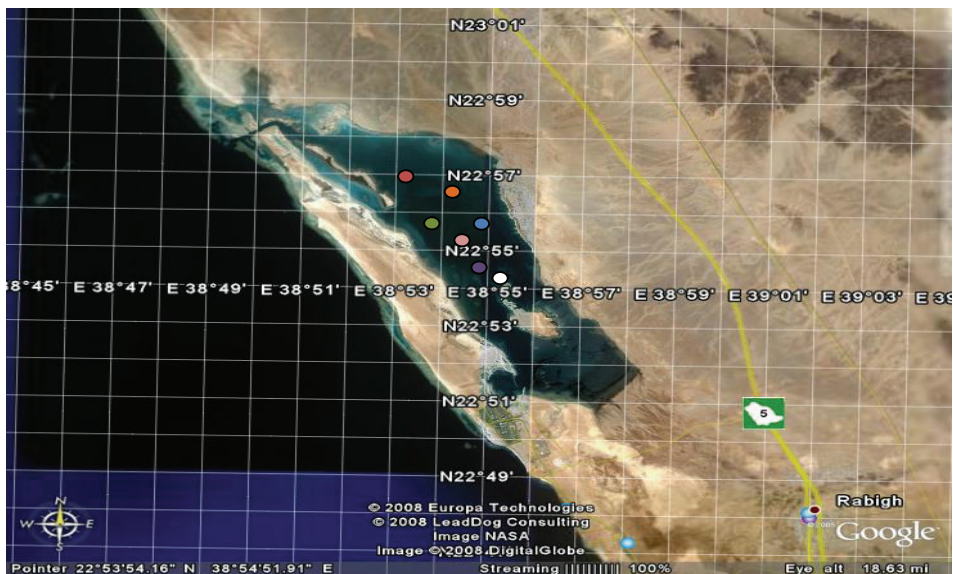


Fig. 1. Location map of Al-Kharrar lagoon located at the northwestern side of Rabigh city. Colored circles indicate the location of samples. Seven samples were collected from the bottom sediments of the lagoon.

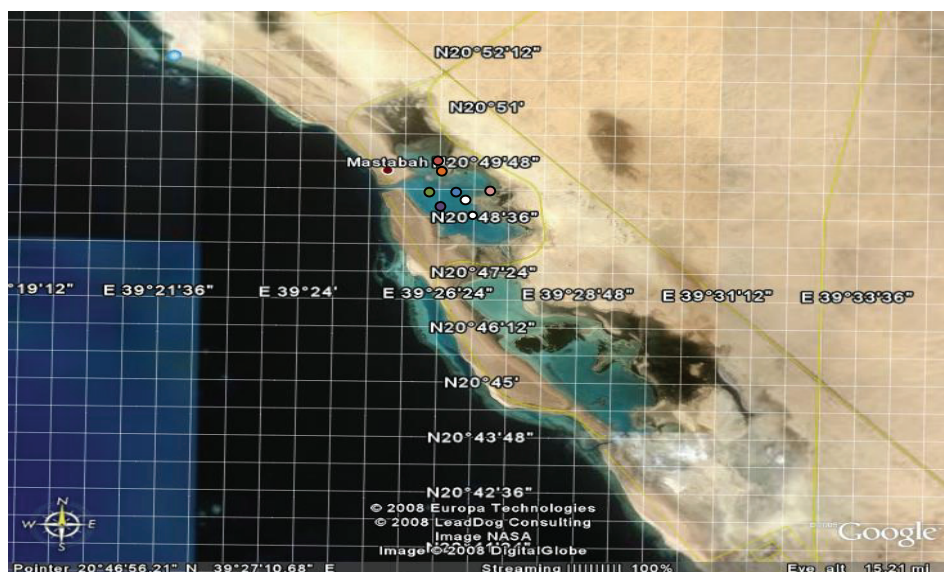


Fig. 2. Location map of Shuaiba lagoon located south of Jeddah city. Colored circles indicate the location of samples. Eight samples were collected from the bottom of sediment of the lagoon.

Results and Discussion

The most common benthic foraminiferal assemblage identified in both Shuaiba and Sharm Al-Kharrar lagoons are represented mainly by Miliolina and Rotaliina suborders. The Rotaliina assemblage includes the following species; *Elphidium* sp., *Ammonia beccarii*, *Amphistegina* sp. and *Calcarina calcar*. While the Miliolina assemblage is represented mainly by *Spiroloculina*, *Quinqueloculina*, *Triloculina*, *Peneroplis planatus* and *Sorites*.

The abundance and distribution of benthic foraminiferal species and genera present in the studied recent bottom sediments of the Shuaiba and Sharm al-Kharrar lagoons are summarized in Tables 1&2. Their distribution patterns are shown in Fig. 2&3.

In general, the Rotaliina assemblage is more abundant in the Sharm Al-Kharrar lagoon than of the Miliolina assemblage, while the Miliolids assemblage dominates the Rotaliids in the Shuaiba Lagoon. This is probably related to differences in the Lagoons water depths. Depth has effective influence on the light that reaches the bottom communities. Therefore, the abundance of Rotaliids in Sharm al-Kharrar can be

attributed to the water depth as a control. These findings were also indicated by Hottinger (1977).

Table 1. Frequency percentages of the benthic foraminiferal species in Shuaiba lagoon sediment.

Sample number	Foraminiferal species										
	<i>Triloculina</i>	<i>Peneroplis</i>	<i>Spiroloculina</i>	<i>Sorites</i>	<i>Quinqueloculina</i>	<i>Elphidium</i>	<i>Ammonia beccarii</i>	<i>Amphistegina</i>	<i>Calcarina calcarata</i>	Total Miliolina %	Total Rotalina %
1	0	0	0	15.1	15.3	46.1	16	0	7.5	30.4	69.5
2	0	9.3	6.9	18.6	9.3	37.3	18.6	0	0	44.1	55.9
3	0	9.1	12.1	18.2	12.1	27.3	9.1	0	12.1	51.5	48.5
4	5.8	11.9	6.8	48.7	5.8	5.8	6.8	0	8.4	79	21
5	16.6	0	0	66.8	0	16.6	0	0	0	83.4	16.6
6	0	9	7.6	45.6	7.6	19.5	10.8	0	0	69.7	30.3
7	6.1	6.1	12	18.1	12	36.7	9.0	0	0	53.4	46.6
8	0	12.1	3.03	42.5	3.03	25.2	4.04	6.06	4.04	60.7	39.3

Table 2. Frequency percentages of the benthic foraminiferal species identified in Sharm Al-Kharrar lagoon sediments.

Sample number	Foraminiferal species								
	<i>Triloculina</i>	<i>Peneroplis planatus</i>	<i>Spiroloculina</i>	<i>Sorites</i>	<i>Elphidium</i>	<i>Ammonia beccarii</i>	<i>Amphistegina</i>	Miliolina %	Rotalina %
1	0	28.6	0	14.2	28.6	0	28.6	42.8	57.2
2	0	24.64	10.14	0	34.29	4.35	26.59	30.7	69.2
3	4.77	11.1	6.3	12.7	34.92	0	30.3	34.8	65.2
4	3.19	24.8	9.6	3.19	30.43	0	29.1	40.5	59.5
5	6.77	13.6	5.4	6.77	37.3	6.77	23.4	32.5	67.5
6	0	20	6	40	22	0	12	66	34
7	5	24	12	8	37	0	14	51	49

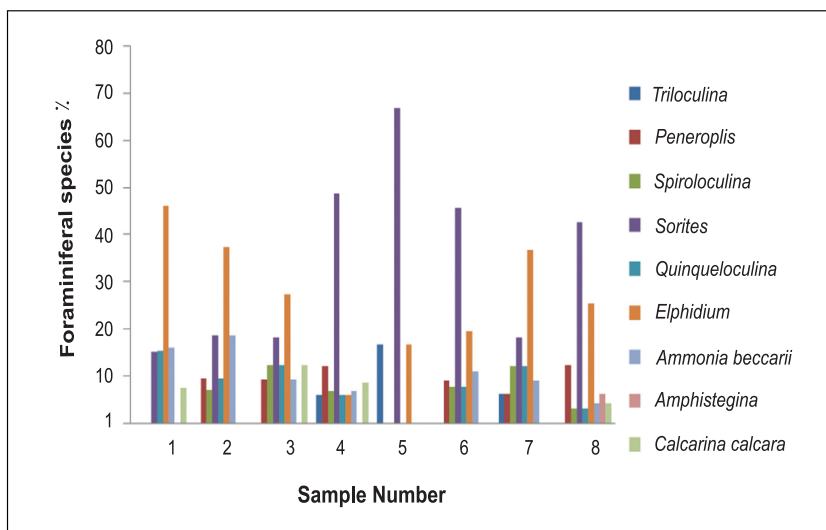


Fig. 3. Histograms showing the frequency distribution of benthic foraminiferal species in the Shuaiba lagoon.

The foraminiferal species identified in the two studied lagoons show significant variations. The dominant foraminiferal species in Sharm Al-Kharrar Lagoon are represented mainly by *Elphidium* sp., *Amphistegina* sp. and *peneroplis planatus*. Yusuf (1984) found that *Elphidium* spp occur in the area north of Jeddah only at water depths less than 20m. The *Amphistegina* sp. also dominates particularly in muddy sediments. The other species constitute only a minor proportion. The distribution pattern of benthic foraminifera in the Shuaiba Lagoon shows high frequency of *Sorites* species. The present study shows that *Sorites* sp. occurs abundantly in the coarser fraction of the sediments. Abou Ouf (1996) found that *Rotaliina* species increase with increasing mean grain size of sediments while *Miliolina* species increase with decreasing mean grain size. The ecological data for selected genera of recent foraminifera was given by Murray (1973). He mentioned that *Quinqueloculina*, *Triloculina*, *Ammonia* and *Elphidium* have affinity towards hypersaline lagoon environment. Mean size is another factor affecting the abundance of foraminifera in the sediments. Gheith and Abou Ouf (1996) mentioned that *Sorites* are the dominant genus in the coarser fraction (1mm size), while *Elphidium* and *Triloculina* are abundant in the finest fraction (0.125mm size).

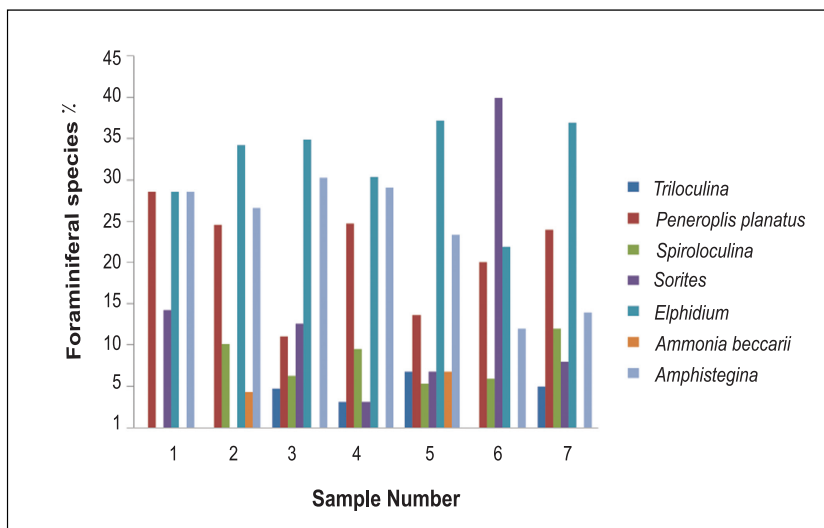


Fig. 4. Histograms showing the frequency distribution of benthic foraminiferal species in the Sharm al-Kharrar lagoon.

Conclusion

The distribution pattern of benthic foraminifera in the two studied lagoon bottom sediments is mainly controlled by the water depth, light, sediment texture and salinity of the lagoon waters. It was found that the suborder Rotaliids occur more abundantly than Milioids in Sharm al-Kharrar bottom sediments where *Amphistegina* and *Elphidium* species dominate. This is related to the occurrence of high content of mud fraction and great depth. While the Shuaiba Lagoon sediments show that Miliolids occur more abundantly than Rotaliids where *Sorites* and *Elphidium* dominate. The different hydrographical conditions between the two studied lagoons could be responsible for the variations and abundances of the benthic foraminiferal species.

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تأثير الظروف الهيدروجرافية على بيئة الفورامينفرا القاعية فى ملاحظتين مختلفتين، السهل الساحلى الشرقى للبحر الأحمر، المملكة العربية السعودية

محمد صالح بكر حيرى

قسم الأحياء البحرية، كلية علوم البحار، جامعة الملك عبدالعزيز،

جدة- المملكة العربية السعودية

المستخلص. دراسة وفرة وتوزيع الفورامينفرا القاعية فى رواسب القاع لكل من ملاحه الشعبيه جنوب جدة وملاحه الخرار فى الشمال من أجل الحصول على معلومات مفيدة عن بيئة تواجد الأحافير القاعية. إن تجمعات الأحافير القاعية التى تم تعريفها فى رواسب قاع الملاحظتين عكست اختلافات مميزة.

ولقد وجد أن رتبة الروتالينا تسود عن رتبة المليولينا بالأخص فى رواسب قاع لاجون شرم الخرار، حيث يسود جنس الأمفيستجينا. بينما تسود رتبة المليولينا فى رواسب قاع لاجون الشعبيه.

إن نموذج التوزيع للأحافير القاعية فى اللاجونين يتأثر أساسا بعمق الماء، شدة الإضاءة، نسيج الرواسب والتخفيف بالماء العذب.