FORAMINIFERA FROM BOTTOM SEDIMENTS OF LAKE MARYUT AND LAKE MANZALAH, EGYPT

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covered with sandy-silty-clay. The dominant type of sediment in the lake is sand-silt-clay. The average median diameter of the sediments of lake Manzalah is 85.6 microns and the majority of sediments are badly sorted.

MATERIAL AND METHOD OF STUDY

Sediments were collected from the bottom of the two lakes using a Petersen grab sampler from 32 positions in Lake Maryût (Fig. 1) and 46 in Lake Manzalah (Fig. 2), covering the whole area of the two lakes. Samples were subjected to mechanical analysis following the routine technique of Krumbein and Pettijohn (1938). Six fractions resulting from the mechanical analysis were chosen, namely > 2, $2 - 1$, $1 - \frac{1}{2}$, $\frac{1}{2} - \frac{1}{4}$, $\frac{1}{4} - \frac{1}{8}$ and $\frac{1}{8} - \frac{1}{16}$ mm. The first three fractions proved to be devoid of foraminifera, whereas the other three fractions were examined microscopically. Each sample was usually sprayed many times on a squared slide in order to find out the approximate frequency of the different foraminiferal genera. From the study of the hydrography and chemistry of Lake Maryût (Wahby; 1961) and that of Lake Manzalah (El-Wakeel and Wahby, 1969b) it was found that each lake is identified ecologically into zones. Accordingly, it was found reasonable to examine the foraminifera of each zone separately and then correlation is established between the different zones in order to throw light on the effect of the ecological factors on the foraminifera of each lake.

Foraminifera of Lake Maryût :

Lake Maryût could be divided into five subdivisions by means of roads, drains and other factors. Each subdivision comprises a number of samples as follows :

Zone	I	:	samples	1 and 2
,,	II	:	,,	3 to 20
,,	III	:	,,	20 - 24
,,	IV	:	,,	25 - 28
,,	V	:	,,	29 - 32

The first zone is identified from the second by being subjected directly to sewage pollution and situated in the north eastern part of the proper lake. The *second zone forms the rest of the main body of the lake and lies nearly in the central* north western part of the lake. It is separated from the Mediterranean by a sandy ridge. The third zone is situated in the western part of the lake, while the fourth zone lies in the southern part. The fifth zone is an elongated strip in the southrrn side of the lake, south to the desert road.

The foraminferal content in the sediments of lake Maryût is mainly comopsed of the genus *Ammonia*. The genera *Elphidium* and *Triloculina* which are marine forms; are present in single specimens in few samples. Said (1955) identified the forms *Streblus beccarii* (Linné) and its variety *Streblus beccarii parkinsoniana* from Lake Maryût (Streblus = Ammonia). He considered these Mediterranean species transported artificially into the lake through the transplantation of fish there,

TABLE 1.—TENTATIVE DISTRIBUTION OF FORAMINIFERAL GENERA AND OSTRACODS IN THE BOTTOM SEDIMENTS OF LAKE MARYUT.

Zone	Sample No.	Fraction	Foraminiferal Genera			Ostracoda
			Ammonia	Elphidium	Triloculina	
I	M 1	$< \frac{1}{16}$	++			+++
	2	$< \frac{1}{16}$	++			+++
II	3	4	+			+++
		5	++			+++
		6	++			+++
	4	4	+			+++
		5	++			+++
		6	+++			+++
	5	4	++			+++
		5	+++			+++
		6	+++			+++
	6	4	++			+++
		5	+++			+++
		6	+++			+++
	7	4				+++
		5	++			+++
		6	+++			+++
	8	4				+++
		5	+++			+++
		6	+++			+++
	9	$> \frac{1}{16}$	++ (small sized)			+++
	10	4	+			+++
		5	+++			+++
		6	+++			+++

TABLE 1 (*contd.*)

Zone	Sample No.	Fraction	Foraminiferal Genera			Ostracoda
			Ammonia	Elphidium	Triloculina	
	11	4	++			+++
		5	+++			+++
		6	+++			+++
	12	4	+	o		+++
		5	+++			+++
		6	+++			+++
	13	4	+			+++
		5	+++			+++
		6	+++			+++
	14	4	+			+++
		5	+++	o		+++
		6	+++			+++
11	15	4	+			+++
		5	+++			+++
		6	+++			+++
	16	4	+			+++
		5	+++		o	+++
		6	+++			+++
	17	4	+			+++
		5	+++			+++
		6	+++			+++
	18	4	+			+++
		5	+++			+++
		6	+++			+++
	19	4	+			+++
		5	+++			+++
		6	+++			+++
	20	4	+			+++
		5	+++			+++
		6	+++	o		+++

TABLE 1 (*contd.*)

Zone	Sample No.	Fraction	Foraminiferal Genera			Ostracoda
			Ammonia	Elphidium	Triloculina	
	21	4	+	(Due to the abundance of rooted plants and plant remains, foraminifera appear less)		+++
		5	++			+++
		6	+			+++
	22	4				+++
		5	+			+++
III		6	+			+++
	23	4	+			+++
		5	++			+++
		6	+			+++
	24	4	+			+++
		5	+++	o		+++
		6	+++			+++
	25	>1/16				+ full of plants
	26	>1/16				+
	27	4		(calcarious shell fragments dominant)		+++
IV		5	++			+++
		6	+			++
	28	4		(calcarious shell fragments with a decrease in ammonia and ostracods)		+++
		5	++			+++
		6	+			+
	29	4	++			+++
		5	+++			+++
V		6	++	o		+++
	30	4	+			+++
		5	+++			+++
		6	++			+++

TABLE 1 (*contd.*)

Zone	Sample No.	Fraction	Foraminiferal Genera			Ostracoda
			Ammonia	Elphidium	Triloculina	
V	31	4	++	(rich in calcarious shell fragments)		+++
		5	+++			+++
		6	++			++
	32	4	++			
		5	+++			
		6	++			

Frequency Symbols :

o	Single
+	Rare
++	Frequent
+++	Flood

It seems that the transportation of marine fishes (mullets) into the lake, in addition to the previous flooding of the lake with sea water introduced marine forms into the lake, but those forms did not survive. *Ostracods* are represented by flooding frequencies in nearly all samples (Fig. 3). Table 1. represents a tentative distribution of foraminiferal genera and Ostracods in the different zones.

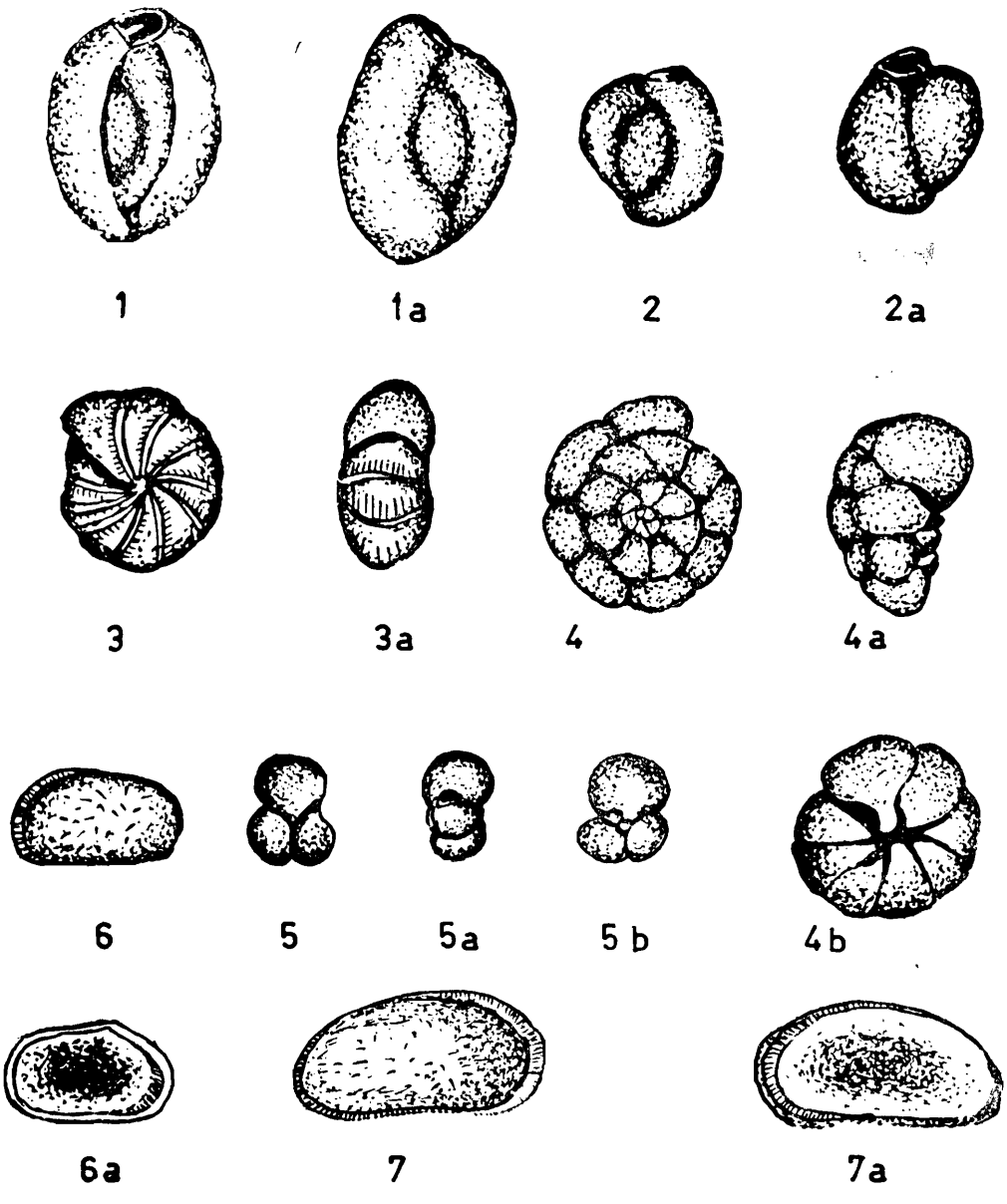
From table 1 it is quite obvious that the foraminifera are uniform allover the five zones of lake Maryût. Genus *Ammonia* is flooding in fractions 5 and 6 ($\frac{1}{4}$ - $\frac{1}{8}$ & $\frac{1}{8}$ - $\frac{1}{16}$ mm.) only, while it is rare or absent in fraction 4 ($\frac{1}{2}$ - $\frac{1}{4}$ mm.). This is an indication of the small size of this genus in Lake Maryût. The same genus proved to be small and of less frequency in samples rich in plant remains. The presence of marine genera as *Elphidium* and *Triloculina* in very few numbers may be due to transportation with fish from the sea to the lake or probably may be descendents of marine forms which survived in the lake since its last connection with the sea. Ostracods are flooding in all the semples, but decrease in number in samples rich in calcareous shell fragments.

Foraminifera of Lake Manzalah :

Lake Manzalah can be differentiated into six zones according to variation in the ecological factors. Each zone contains a number of samples as follows :

Zone	I	: Samples	2, 3, 4, 5, 6, 7 & 8
,,	II	: ,,	1, 9, 10, 15, 16, 17 & 18
,,	III	: ,,	11, 12, 13, 14, 19, 20 & 21
,,	IV	: ,,	22, 23, 24, 29, 30, 31, 32, 33, 34 & 35
,,	V	: ,,	25, 26, 27, 28, 36, 37, 38, 39 & 40
,,	VI	: ,,	41, 42, 43, 44, 45 & 46

The first zone occupies the south eastern part of the lake which is subjected to the direct effect of drainage water coming from the south eastern and south western directions. The secord zone lies north to zone I and is away from the direct effect of drainage water. Zone III is situated at the extreme north east of the lake where the lake has connections with both the Mediterranean through El Gamil opening and the Suez Canal through El-Kabouti Canal. Zone IV occupies nearly the central part of the lake and is not affected directly by drainage water. The fifth zone lies on the western part of the lake and is affected by fresh waters coming from the south west and the west. Zone VI lies in the extreme north western part and its northern borders are occasionally washed by the Mediterranean Sea water. The foraminiferal content of Lake Manalah is represented by the benthonic genera *Ammonia, Quinqueloculina, Triloculina, Elphidium, Orbulina, Robulus, Cibicides, Discorbis,* and the planktonic genus *Globigerina.* Ostracods are present in abundance in all samples (Fig. 3). The approximate frequency of these genera is given in table 2.



1.—*Quinqueloculina* sp.
1*a*.—*Quinqu loculina* sp., another view.
2.—*Triloculina* sp.
2*a*.—*Triloculina* sp., another view.
3.—*Elphidium* sp.
3*a*.—*Elphidium* sp., apertural view.
4.—*Ammonia beccarii* (Linnaeus), dorsal view.
4*a*.—*Ammonia beccarii* (Linnaeus), side view.
4*b*.—*Ammonia beccarii* (Linnaeus), ventral view.
5.—*Globigerina* sp., ventral view.
5*a*.—*Globigerina* sp., side view.
5*b*.—*Globigerina* sp., dorsal view.
6.—Shell of an ostracod, external view.
6*a*.—Shell of the same ostracod, internal view.
7.—Shell of another species of ostracod external view.
7*a*.—Shell of the same ostracod, internal view.

Fig. 3

TABLE 2.—TENTATIVE DISTRIBUTION OF FORAMINIFERAL GENERA AND OSTRACODS IN THE BOTTOMS SEDIMENTS OF LAKE MANZALAH

Zone	Sample No.	Fractions	Foraminiferal Genera									Ostracoda
			Ammonia	Quinqueloculina	Triloculina	Elphidium	Globigerina	Orbulina	Robulus	Cibicides	Discorbis	
I	2	½ — 1/16	+++	+			+		o			+++
	3	½ — 1/16	+++	+								+++
	4	½ — 1/16	+++			+						+++
	5	½ — 1/16	+++									+++
	6	½ — 1/16	++									+++
	7	½ — 1/16	+++			+						+++
	8	½ — 1/16	+++									+++
II	1	½ — 1/16	+++			+					+	+++
	9	½ — 1/16	+++	+		+					+	+++

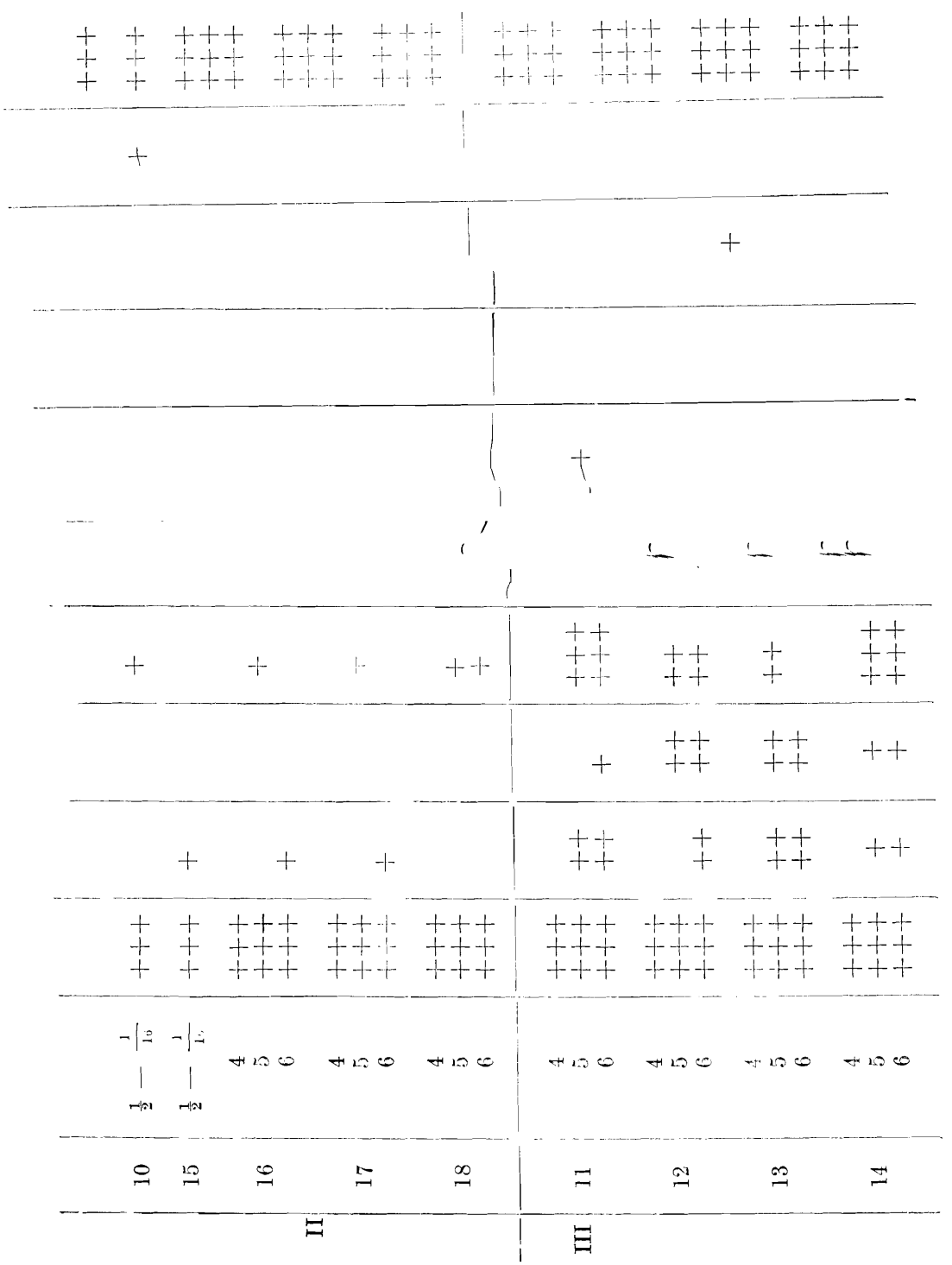

10
15
16
17
18
11
12
13
14
II
III
4 5 6
1/3 — 1/10
1/2 — 1/15

TABLE 2. (*Cont.*)

Zone	Sample No.	Fractions	Foraminiferal Genera									Ostracoda
			Ammonia	Quinqueloculina	Triloculina	Elphidium	Globigerina	Orbulina	Robulus	Cibicides	Discorbis	
	19	4	++			+++						+++
		5	+++	++		+++	+					+++
		6	+++	++		+++	+					+++
	20	4	+									+++
		5	+++	+	+	+++	o					+++
		6	+++	+	+	+++	o					+++
	21	> 1/16	+++			+++						+++
IV	22	4	+++									+++
		5	+++			+						+++
		6	+++			+						+++
	23	4	+++									+++
		5	+++			+						+++
		6	+++			+						+++
	24	> 1/16	+++			+						+++

IV	29	4	+++								+++
		5	+++	o		+					+++
		6	+++	o		+					+++
	30	> $\frac{1}{16}$	+++								+++
	31	4	++								+++
		5	+++	+	+	+					+++
		6	+++	++	++						+++
	32	> $\frac{1}{16}$	+++			++					+++
	33	4	+++								+++
		5	+++	+	+	++					+++
		6	+++	++	++	++					+++
	34	4	+++								+++
		5	+++	+	+	++					+++
		6	+++	++	++						+++
	35	4	++								+++
		5	+++		o						+++
		6	+++			+					+++
V	25	4	+++								+++
		5	+++	+	+	+					+++
		6	+++	+	+	+					+++
	26	4	+++			+					+++
		5	+++	+	+	+					+++
		6	+++	+++	++	++					+++

TABLE 2. (*Cont.*)

Zone	Sample No.	Fractions	Foraminiferal Genera: Ammonia	Quinqueloculina	Triloculina	Elphidium	Globigerina	Orbulina	Robulus	Cibicides	Discorbis	Ostracoda
V	27	4	+++									+++
		5	+++			++						+++
		6	+++		+							+++
	28	$>\frac{1}{16}$	+++									+++
	36	4	+++			+						+++
		5	+++			+						+++
		6	+++			+++						+++
	37	4	+++			+						+++
		5	+++	+		++						+++
		6	+++			++						+++
	38	$>\frac{1}{16}$	+++			+						+++
	39	4	+++									+++
		5	+++		+							+++
		6	+++		+	++						+++

	40	> 1/16	+++									+++
		4	+++									+++
	41	5	+++	++	++	++						+++
		6	+++	++	++	++						+++
VI	42	> 1/16	+		o							+
		4	+									+++
	43	5	+++		+							+++
		6	+++	+	++							+++
		4	+									+++
	44	5	+									
		6	+									
	45	> 1/16	++									++
		4	++									++
	46	5	++									++
		6	+									++

Frequency Symbols :

o Single
+ Rare
++ Frequent
+++ Flood

The foraminiferal genera of each zone are discussed here separately.

Zone I : *Ammonia* and ostracods are flooding, but *Quinqueloculina, Elphidium* and *Globigerina* are rare. A single specimen of *Robulus* is found.

Zone II : *Ammonia* and ostracods are flooding, whereas *Quinqueloculina, Elphidium* and *Discorbis* are rare.

Zone III : *Ammonia*, ostracods flooding; *Quinqueloculina, Triloculina*, and *Elphidium* are flooding in fract . 5 and 6 ($\frac{1}{4}$ - $\frac{1}{8}$ & $\frac{1}{8}$ - $\frac{1}{16}$mm.) only. *Globigerina* and *Cibicides* are represented by rare frequencies.

Zone IV : *Ammonia* and ostracods flooding; *Quinqueloculina, Triloculina*, and *Elphidium* are present in frequent, rare and even single frequencies in fractions 5 and 6. It is obvious that these three genera are fewer in number than in zone III.

Zone V : *Ammonia* and ostracods flood; *Quniqueloculina, Triloculina* and *Elphidium* are frequent and rare in fractions 5 and 6 and they are still represented by less frequencies than in zone IV.

Zone VI : *Ammonia* and Ostracods flood; *Quinqueloculina, Triloculina* and *Elphidium* are frequent in fractions 5 and 6. The last genus is found in sample No. 41 only. Samples 42, 44 and 46 are sandy and are generally poor in foraminifera.

From the foregoing foraminiferal distribution in the different zones of Lake Manzalah, we may conclude that:

1.—Genus *Ammonia* is met with as a flooding form in all samples and all fractions (all sizes). The species of this genus can stand different salinities (Phleger, 1960). Bradshow (1957) cultured *Streblus beccarii* (Linné) var. *tepida* Cushman in the laboratory and found that this variety can grow in salinities ranging between 7‰ and 67‰. It is noticeable that the range of salinity of Lake Manzalah lies between 2‰ in zone I to over 30‰ in zone III. This explains the flooding of Ammonia in the different zones of the lake.

2.—The genera *Quinqueloculina, Triloculina, Elphidium* and *Globigerina* represent a marine foraminiferal assemblage (Phleger, 1960). The distribution and approximate frequencies of these genera in the different zones of Lake Manzalah is a clear indication of their tendency to survive and flourish in salinities close to that of sea water. Thus the zones which are in direct connection with the sea such as zone III are characterised by high populations of these genera. This phenomenon shows gradual changes when passing from high to low salinities as from zone III to IV and V, where a gradual decrease in the frequency of these forms can be traced. In the meantime, zone I characterised by low salinity (2‰) is devoid of this marine assemblage. The same forms are found in zone VI but in a lower frequency, where there is no direct connection with the sea, but sea watee invades this zone occasionally during times of rough sea. On the other hand, thr effect of fresh water inlets on zone I and zone V is reflected in the absence or low frequency of the marine assemblage in both zones.

3.—Ostracods as a group of Crustacea occur as marine and nonmarine forms (Glaessner, 1948). Marine forms live in shallow neritic enviroments, while non-marine forms are found in lakes, ponds and streams (Jones, 1956). Ostracods are flourishing in Lake Manzalah as marine and non marine forms. It seems that the environment of Lake Manzalah is favourable for the life of these forms and this is reflected on their flood in all samples and all sizes.

Correlation of foraminiferal contents of Lake Maryût and Lake Manzalah:

The study carried out on the foraminifera in the sediments of Lake Maryût and Lake Manzalah is quite interesting when its distribution is correlated with the ecological conditions. Comparison between the foraminiferal assemblages in both lakes leads to the following facts:

1.—Lake Maryût has a uniform assemblage of foraminifera, where no variations in the different zones could be traced. The lake being disconnected with the sea, its environment is unique. On the other hand, Lake Manzalah has a direct connection with the sea and other fresh water supplies. Consequently, the salinity of the lake water varies from one zone to another which is reflected on the variation in the foraminiferal content in the six zones of the lake. Marine forms enter the lake and survive into it near the lake-sea connection but become less and less in areas where fresh water dominates. The introduction of both sea water and fresh water into the lake induces a sort of circulation, refreshing its water all the time.

2.—Lake Maryût is very poor or nearly devoid of marine forms where no sea water is introduced into this lake. On the other hand, marine foraminifera are better represented in Lake Manzalah especially in zones with salinity close to that of sea water.

3.—Lake Manzalah is more rich in foraminiferal population than Lake Maryût. The latter is enclosed and receives drainage water besides the plant remains and abundant organic matter. Such conditions hinder the life of foraminiferal forms, except those which can overcome these unfavourable conditions. The evironmental conditions in Lake Manzalah are more favourable for life due to the circulation of water coming from both the sea and fresh water and consequently, the lake is more rich in foraminiferal population than Lake Maryût. It is also noticeable that the size of forms in Lake Manzalah is much greater than for those of Lake Maryût. Such remark is more clear if we compare fraction 4 ($\frac{1}{2} - \frac{1}{4}$ mm.) of samples from Lake Manzalah and Lake Maryut. The variation in size of forms in both lakes is another proof for the difference in environmental conditions where that of Lake Manzalah is more suitable for foraminifera than Lake Maryût.

SUMMARY

The foraminifera present in the bottom sediments of Lake Maryût and Lake Manzalah were identified generically and their relative frequency is represented. The two lakes were devided into different zones according to hydrographical conditions and the foraminiferal forms of each zone were examined separately where correlation was established between the different zones and between the two lakes. Lake Maryût has a uniform assemblege of foraminifera where no variations in the different zones could be traced. In Lake Manzalah, the salinity which varies

from one zone to another is reflected on the variation of the foraminiferal content in the different zones of the lake. Lake Maryût is very poor or nearly devoid of marine forms whereas in lake Manzalah marine foraminifera are better represented. The environmental conditions are more favourable for life in Lake Manzalahand. consequently, the lake is more rich in foraminiferal population than lake Mar yût It is also noticeable that the size of forms in Lake Manzalah is much greater than for those of Lake Maryût.

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