

Holocene Benthonic Foraminifera from the Shelf Sediments of Kerala Coast

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Of the 32 species of benthic foraminifera recovered here some show definite Indo-Pacific affinity. Ecological parameters which govern this off-shore region are considered. Several species show similarities with those found in the Neogene while the occurrence of *Hyalinea balthica* found in the present material and which marks the Pliocene-Pleistocene boundary in Italy is known to be a cool to cold water indicator. Earlier it was reported (Setty 1972) that *Globigerina pachyderma* (Ehrenburg) a cool to cold water planktonic species also occurs in this region. A few other species present in the sediment at this depth are considered to be transported fauna. However, they all show a geologic range from Miocene to Recent.

Introduction

Based on a study of the planktonic foraminifera of a few surface samples collected by the author at 9°N and 78°E at 89 m depth aboard 'INS KISTNA' three important conclusions were arrived at, - (1) some of the planktonic species have a geologic range from Miocene to late Pleistocene and Recent (2) that *Globigerina hexagona* and *Globobulimina conglomerata*, which disappeared from the Atlantic nearly 50,000 to one million years ago, are being seen to be living today in the Arabian Sea, and (3) *Globigerina pachyderma* (Ehrenberg) which is considered to be a polar, cold water species is found in an otherwise tropical environment with typical warm water species (Setty, 1972).

The purpose of the present study is to present a detailed but brief account of the various benthonic foraminiferal species contained in the sediments of the above region (9°N 78°E). 32 species belonging to 17 families and 23 genera are identified and a

short account of the important characteristics of each species is recorded. Some species are found to be abundant and the paleoecological interpretations are chiefly based on them, though, the relevant characteristics of importance of other minor species are also taken into account. It is a well-known fact that benthic foraminifera represent an important, if not the primary, means of interpreting ancient marine environments.

Systematics of the 32 species identified and illustrated is given below. Synonymies and description of species are intended to be brief and pertinent and not exhaustive.

Family : Lagenidae

Genus : *Robulus* Montfort 1808

Robulus calcar (Linne)

1923 *Robulus calcar* (Linn'e) Cushman, Bandy-U. *S. Geol. Surv. Prof. Paper* 274, p. 197, pl. 30, fig. 11.

Test planispiral, bilaterally symmetricai, involute, glassy surface, aperture radiate.

Occurs in Gulf of Mexico and Carribean region. Recent.

Family : Nodosariidae Ehrenberg 1838

Genus : *Dentalina* d'Orbigny 1826
Dentalina badensis d'Orbigny

1952 *Dentalina badensis* d'Orbigny, Todd
U. S. Geol. Survey Prof Paper 241,
p. 12, pl. 2, fig. 8.

It is rather a large slender specimen as described by d'Orbigny from the Miocene of the Vienna basin. Also from the Recent.

Dentalina communis d'Orbigny

1964 *Dentalina communis* d'Orbigny, LeRoy-
U. S. Geol. Survey Prof. Paper 454-F, p. F23, pl. 15, fig. 28.

Wall calcareous, finely perforate uniserial, radiate aperture, round in transverse section. Miocene to Recent.

Genus : *Lagenonodosaria* Silvestri 1900

Lagenonodosaria scalaris (Batsch)

Plate 1, fig. 1

1964 *Lagenonodosaria scalaris* (Batsch)
LeRoy-*U. S. Geol. Survey Prof. Paper* 454-F, p. F27, pl. 15, fig. 20, 29.

Test typically nodosarian, chambers in a straight linear series, aperture terminal with neck having strong, riblike feature. Recent.

Family : Textulariidae Ehrenberg 1838

Genus : *Textularia* DeFrance 1824

Textularia Sacasensis Lalicker & McCulloch
Plate 1, fig. 2

1964 *Textularia sacasensis* Lalicker and
McCulloch, Smith-*U. S. Geol. Survey Prof. Paper* 429-B, p. B28, pl. 1, fig. 5a-b.
This specimen is distinguished by its subacute lobed periphery. Recorded from the western Pacific region. Occurs at depth ranging from 50 m. Recent.

Family : Eponididae Hofker 1951

Genus : *Eponides* Montfort 1808

Eponides dupret ciervoensis Cushman and Simonsen.

1960 *Eponides dupret ciervoensis* Cushman and Simonsen-*U. S. Geol. Survey Prof. Paper* 260-X, p. 239, pl. 260, fig. 7.

This subspecies was described and recorded from the Tumey formation of Atwill, California. It has 5 chambers in the final whorl, wall smooth, punctuate, and delicate; umbilicus closed. Miocene to Recent.

Eponides subornatus (Cushman)

Plate 1, fig. 3-4

1964 *Eponides subornatus* (Cushman) LeRoy-
U. S. Geol. Survey Prof. Paper 454-F, p. F38, pl. 7, figs. 27-29.

Test trochoid, biconvex, perforate, umbilical area closed, aperture a low opening between the periphery and umbilical region. Occurs in the Pacific and the Indian Ocean. Miocene to Recent.

Poroeponides cribrarepandus Asano and Uchio

1957 *Poroeponides cribrarepandus* Asano and Uchio-*U. S. Geol. Survey Prof. Paper* 280-H, p. 290, pl. 93, fig. 9.

Test trochoid, biconvex, umbilical area open, aperture in the adult chambers with numerous rounded openings in the ventral face. Recent.

Pseudoeponides umbonatus (Reuss)

1964 *Pseudoeponides umbonatus* (Reuss)
LeRoy-*U. S. Geol. Survey Prof. Paper* 454-F, p. F39, pl. 7, figs. 33-38.

Occurs in Miocene to Recent sediments of Southern Okinawa.

Family : Elphidiidae Galloway 1933

Genus : *Elphidium* Montfort 1808

Elphidium fax barbawarese Nicol

Plate 1, fig. 5

1964 *Elphidium fax barbavense* Nicol,
LeRoy-U. S. Geol. Survey Prof.
Paper 454-F, p. F28, pl. 10, figs. 1-2.

This is a subspecies; occasionally occurs even
in Pacific and Okinawa Region. Miocene to
Recent.

Family : Cibicididae Cushman 1927

Genus : *Hyalinea* Hofker 1951

Hyalinea balthica (Schroeter)

Plate 1, fig. 6-7.

1964 *Hyalinea balthica* (Schroeter) LeRoy-
U. S. Geol. Survey Prof. Paper 454-F,
p. F44, pl. 9, figs. 34-36.

1967 *Hyalinea balthica* (Schroeter) Matoba
Tohoku Univ. Sci. Rep. vol. 38, No. 2,
p. 235, pl. 28, fig. 2.

1971 *Hyalinea balthica* (Schroeter) Bock-
Micropaleontology, p. 187, pl. 4, figs.
7, 8.

Commonly recorded in late Tertiary
and Recent sediments of Southern Pacific.
The Pliocene - Pleistocene boundary is
defined on the basis of the first appearance
of this species in the sections of Le Castella,
Calabria, southern Italy. However, Ericson,
Ewing and Wollin (1953) consider the first
appearance of *H. balthica* to be valid only
locally i. e. Mediterranean. *H. balthica* is
considered to be a cool water to cold water
indicator but Akers (in Bock, 1971) has
found this species consistently abundant in
the Gulf Coast region.

Genus *Cibicides* Montfort 1808

Cibicides refulgens Montfort

Plate 1, fig. 8-9

1960 *Cibicides refulgens* Todd and Low -
U. S. Geol. Survey Prof. Paper 260-X
p. 852, pl. 262, fig. 14.

It is a small conical form; about seven
chambers visible on the dorsal side. The
conical ventral side shows pearly lustre.
Occurs upto 400 m depth. Miocene to
Recent.

Family : Miliolidae Ehrenberg 1839

Genus : *Quinqueloculina* d'Orbigny 1826

Quinqueloculina akneriona d'Orbigny

Plate 1, fig. 10

1960 *Quinqueloculina akneriona* d'Orbigny,
Todd and Low-U. S. Geol. Survey
Prof. Paper 260-X, p. 821, pl. 261,
fig. 6.

This species was first described from Wiener
Becken (Vienna Basin) of Miocene; however
it is also widely seen in the Recent sedi-
ments. Also found in cores of Eocene age
and ranges from Eocene to Recent.

Quinqueloculina ferussaci d'Orbigny

1957 *Quinqueloculina ferussaci* Todd-U. S.
Geol. Survey Prof. Paper 280-E, p.
286, pl. 86, fig. 6.

Quinqueloculine test with ribbed vertical
surface and simple toothed aperture. Recent.

Genus *Triloculina* d'Orbigny 1828

Triloculina tricarinata d'Orbigny

1964 *Triloculina tricarinata* d'Orbigny,
LeRoy - U. S. Geol. Survey Prof.
Paper 454-F, p. F20, pl. 3, figs 32, 33.

Test triloculine, common in upper Miocene
Pliocene of Okinawa. Recent.

Genus *Spiroloculina* d'Orbigny 1826

Spiroloculina communis Cushman and Todd

1944 *Spiroloculina communis* Cushman and
Todd - Cushman Found. Foram Res.
Paper 11, p. 63, pl. 9, figs 4,5; 7,8.

Typically spiroloculine test. Pliocene to
Recent.

Genus *Austrotrillina* Parr 1942

Austrotrillina striata Todd and Post

Plate 1, fig. 11-12

1957 *Triloculina labiosa* (d'Orbigny) Todd
- U. S. Geol. Survey Prof. Paper
280-E-J, p. 286, pl. 87, fig. 16.

1960 *Austrotrillina striata* Todd and Post -
U. S. Geol. Survey Prof. Paper 260-X,
p. 825, pl. 261, fig. 22.

This species is very similar to that of Chattian age (Upper Oligocene) of Middle East, which is regarded as an intermediate stage between *A. paucialveolata* (Grimsdale) from the lower Oligocene and *A. howchini* which occurs in the Agitanian and Burdigalian (Miocene); thus it is considered as a transitional form. It is found abundantly today at 1855-2000 ft. near Enwitok, Bikini and nearby Marshal Islands of the Pacific. Miocene to Recent.

Family: Robertinidae Reuss 1850

Genus: *Cushmanella* Palmer and Bermudez 1936

Cushmanella primitiva Cushman and McCulloch

Plate 1, fig. 13-14

1964 *Cushmanella primitiva* Smith - U. S. Geol. Survey Prof. Paper 429-B, p. B41, pl. 3, fig. 9.

Characterised by a double set of chambers, nearly planispiral, supplementary chambers visible on both sides of the test; secondary apertures consist of secondary interiomarginal, equatorial apertures and complicated tube like openings on side of the test; primary structure being axial. Recent. Occurs at 40-140 m depth.

Family: Polymorphinidae d'Orbigny 1839

Genus: *Cuttulina* d'Orbigny 1839

Cuttulina pacifica (Cushman and Ozawa) Plate 1, fig. 15

1964 *Cuttulina pacifica* (Cushman and Ozawa) LeRoy - U. S. Geol. Survey Prof. Paper 454-F, p. F27, pl. 11, figs. 23, 26.

Wall calcareous, finely perforate, radiate, aperture and entirely quinqueloculine. Miocene to Recent.

Family: Discorbidae Ehrenberg 1838

Genus: *Cancris* Montfort

Cancris carmanensis Natland

1964 *Cancris carmanensis* Natland Smith - U. S. Geol. Survey Prof. Paper 429-B, p. B45, pl. 5, fig. 6.

This specimen is very similar to *Valvulnerta oblonga* d'Orbigny, but differs in being broader, with inflated chambers and typical of the genus *Cancris* in its character of the last chamber. Recent.

Cancris sagra (d'Orbigny)

1964 *Cancris sagra* (d'Orbigny) Smith - U. S. Geol. Survey Prof. Paper 429-B, p. B45, pl. 5, fig. 1a-c.

Test trochoid, biconvex, compressed, chambers rapidly enlarging, aperture narrow. Occurs at 40-1600 m depth. Recent.

Genus: *Neoconorbina* *Neoconorbina* Hofkar 1951.

Neoconorbina tabernacularis (Brady)

1884 *Discorbina tabernacularis* Brady - Challenger Rept. Zool. vol. 9, p. 648

1960 *Neoconorbina tabernacularis* (Brady), Todd and Low - U. S. Geol. Survey Prof. Paper 260-X, P. 837, pl. 262, fig. 6.

Distinguished by its high conical test and radial costae from the tip of the spire. Miocene to Recent.

Neoconorbina pacifica LeRoy
Plate 1, fig. 16

1964 *Neoconorbina pacifica* LeRoy - U. S. Geol. Survey Prof. Paper 454-F, p. F36, pl. 4, figs. 26-28.

Test nearly circular, more curved dorsally, five chambers in last whorl, ventral surface slightly depressed and curved, wall coarsely punctuate, aperture basal. This species is similar to *Neoconorbina* (*Discorbis*) *australis* (Parr) but ventrally somewhat convex. Miocene to Recent.

Family: Bulivinitidae Cushman 1929

Genus: *Bulivina* d'Orbigny 1839

1957 *Bolivina ligularia* Schwager - U. S. Geol. Survey Prof. Paper 280-F-J, p. 290, pl. 89, fig. 17.

Test calcareous, biserial, perforate, aperture with internal tooth plate and loop-shaped, transverse section elliptical or slightly compressed. Miocene of Recent.

Bolivina robusta (Brady)

1884 *Bolivina robusta* Brady - Challenger Rept. Zool. vol. 9, p. 421, pl. 53, fig. 7-9.

This specimen is very similar to Brady's figures specimen. Widely recorded from late Tertiary and Recent deposits of the Indo-Pacific region; common in the Recent Pacific of Japan.

Family : Loxostomatidae Loeblich and Tappan 1952

Genus : *Loxostomum* Ehrenberg 1854
Loxostomum limbatum (Brady)
Plate 1, fig. 17

1957 *Loxostomum limbatum* (Brady), Todd - U. S. Geol. Survey Prof. Paper 280-EJ, p. 290 (table) pl. 89, fig. 22.

Biserial tending to become uniserial, aperture interior marginal in biserial stage but terminal in uniserial state. Miocene to Recent.

Loxostomum okinawensis LeRoy

1964 *Loxostomum okinawensis* LeRoy - U. S. Geol. Survey Prof. Paper 454 -F, p. 33, pl. 2, fig. 17, 18.

Test elongate five times as long as wide, twisted; gradually increasing in width, periphery broadly rounded, distinct chambers, wall coarsely punctate, aperture comma-shaped and elongated. Similar to *L. capitata* (Cushman) described from Recent of Fiji but differs in being twisted and perforated.

Family : Buliminidae Jones 1875

Genus : *Bulimina* d'Orbigny 1826

Bulimina denudata Cushman and Parker

Plate 1, fig. 18

1955 *Bulimina denudata* Cushman and Parker, Walton - Jour. Paleon. p. 1003, vol. 29, pl. 102, fig. 8.

Test triserial, elongate spiral, chambers inflated, aperture loopshaped. The specimen shows a well-developed overhang at the base of the chambers and well-developed spines. Recent.

Family : Soritidae Ehrenberg 1839

Genus : *Peneroplis* Montfort 1808

Peneroplis pertusus (Forskal)

Plate 1, fig. 19

1964 *Peneroplis pertusus* (Forskal), LeRoy - U. S. Geol. Survey Prof. Paper 454-F, p. F28, pl. 5, fig. 5.

Test planispiral; young close coiled, involute; adult variously shaped, partially uncoiled; chambers undivided, aperture at base of apertural face, simple. Recent.

Subfamily : Nummulitinae de Blainville 1825

Genus : *Operculina* d'Orbigny 1828

Operculina complanata (DeFrance)

1953 *Operculina complanata* (DeFrance) subsp. *Japonica* (Hanzawa), Carter - Jour. Paleon. p. 241, vol. 27, No. 2 pl. 33, figs. 1-12; pl. 34, figs. 7, 8.

Individual specimens diverse externally, test complanate, ovate, periphery well marked, sutures limbate, beaded, chambers numerous, central portion raised boss or with papillae, *O. complanata* distinguished by its well developed keel, distinct spiral and septal sutures, and evolute coiling. Occurs in the Recent sediments of Japan sea, Pacific and also Indian Ocean.

Subfamily Cyclogyrinae Loeblich and Tappan 1961

Genus : *Cornuspira* Schultze 1854

Cornuspira involvens (Reuss)

1964 *Cornuspira involvens* Reuss, LeRoy-
U. S. Geol. Survey Prof. Paper 454-F,
p. F21, pl. 1, figs. 8, 9.

Specimen deeply depressed and showing considerable variation in the degree of inflation of the evolute tube. Recent.

Family : *Uvigerinidae*, Haeckel 1894

Genus : *Uvigerina* d'Orbigny 1826

Uvigerina bellula Bandy

Plate 1, fig. 20

1956 *Uvigerina bellula* Bandy-U. S. Geol.
Survey Prof. Paper 274-G, p. 199, pl.
31, fig. 13.

Test small elongate, fusiform, assuming a very loose triserial arrangement in late part, wall finely perforate, early part somewhat hispid, aperture terminal, round with a neck. Similar to *U. laevis* (Ehrenberg), reported from Gulf of Mexico. (Phlegar and Parker 1951, p. 18).

Environmental Analysis

The physical and chemical factors which are known to determine the distribution of foraminifera are depth, temperature, salinity, and oxygen content of the bottom water; organic content or the debris, and the nature and kind of the sediment. Thus, the abundance and morphology of foraminiferal species vary with the depth of water. Generally speaking, it is considered that the dead specimens of a species are found where living specimens also occur; however, depth range of dead tests extends to greater depths than for the living ones. This is most probably due to the downslope drift of the dead tests before their final entombment in the sediment.

According to McGlasson, (1959, p. 21) certain species prefer sediments grain size,

Bulimina denudata and *Bolivina acuminata* are common in the sediments with median diameter ~~less than 0.125 mm.~~ less than 0.125 mm. This view apparently agrees with our present material but the author feels that much work on these lines will be required before such definite conclusions are drawn. Similarly, Hendrix (1958) inferred from his study of Miocene and Pliocene deposits of Southern California that the shell thickness decreases with the decrease in grain size of the sediment. But, it is observed that the test thickness varies widely between different species within the same sample, while the wall thickness within the specimens of the same species remains constant.

Discussion

Most of the specimens found in the shelf sediments here are well preserved, and similar to those reported from other regions of the Pacific. Most of the species are cosmopolitan. The family Miliolidae is dominant both in number and diversity. *Peneroplis pertusus*, and *Operculina complanata* stand out prominently in size for the smaller foraminifera.

Foraminifera occurring at this depth (89 m), in this region, may be considered as those which are not subjected to seasonal variations and thereby not disturbed very much from the ecological factors that govern this region. The temperature variation at this depth may be small and the variation in salinity may be slight and oxygen content lower than in shallower zones, but the nitrogen content as a result of degradation of organic matter is greater. Therefore, it is noticed that the foraminifera of this shelf region generally show rounded peripheries. The fauna contains many species that have been recorded in the late Tertiary and Recent deposits of other areas of the South and Central Pacific region. Thus, some of them show Indo-Pacific affinity. Species

of a species

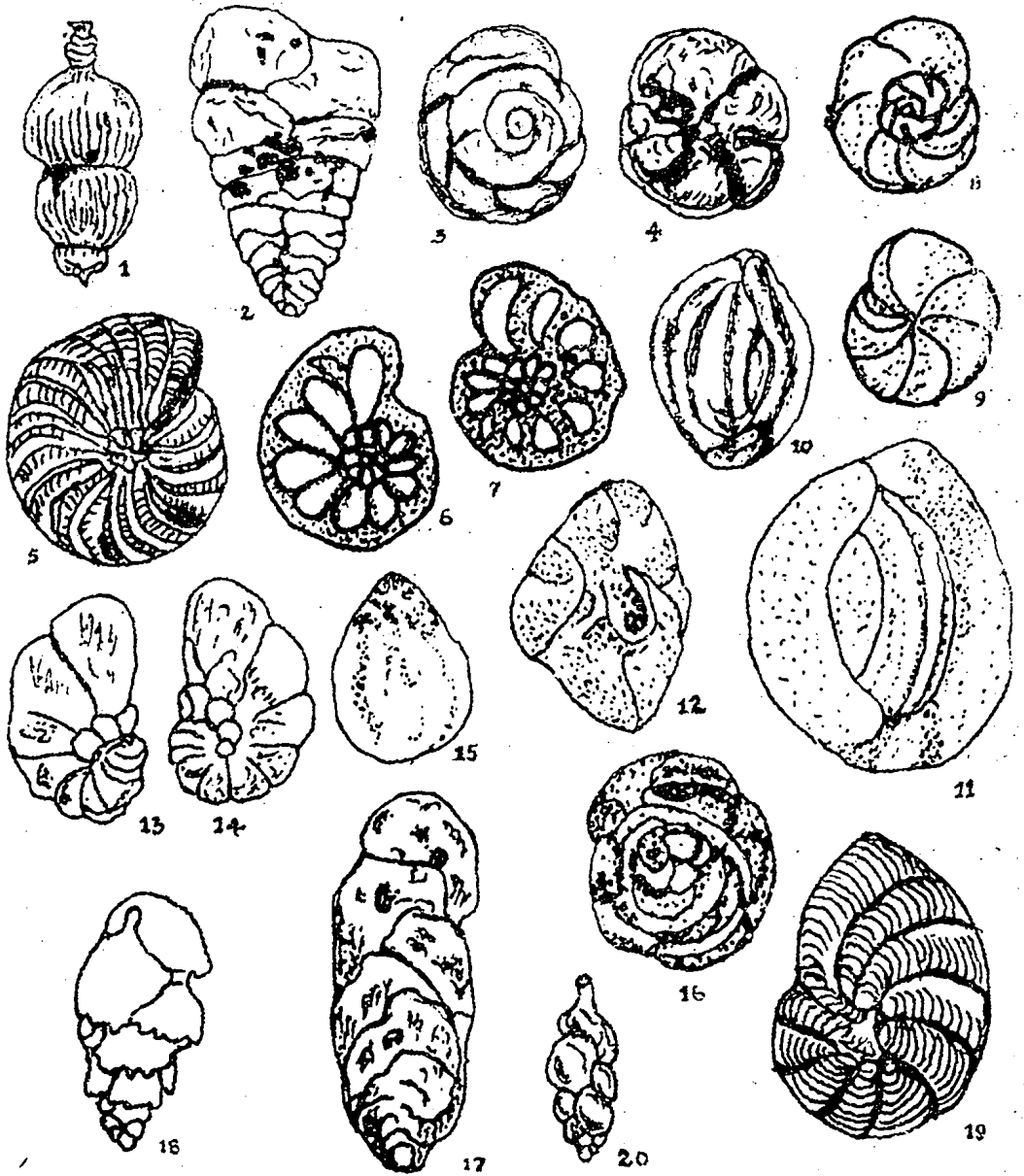


Fig. 1. *Lagenodosuria scalaris* Silvestri, hypotype x 35. Fig. 2. *Textularia secasensis* Lalicker & McCulloch, hypotype x 45. Fig. 3-4. *Epoides subornatus* Cushman, hypotype 3 - dorsal view, 4 - ventral view x 35. Fig. 5. *Elphidium fax barbarense* Nicol, hypotype x 45. Fig. 6-7. *Hyalinea balthica* Schroeter, hypotype, 6 - dorsal view, 7 - ventral view x 75. Fig. 8-9. *Cibicides resurgens* Montfort, hypotype, 8 - dorsal view, 9 - ventral view x 75. Fig. 10. *Quinqueloculina akneriana* d'Orbigny, x 40. Fig. 11-12. *Austrotrillina striata* Todd & Post, hypotype, 11 - dorsal view, 12 - apertural view x 40. Fig. 13-14. *Cushmanella primitiva* Cushman & McCulloch, hypotype, 13 - dorsal view, 14 - ventral view x 75. Fig. 15. *Guttulina pacifica* Cushman & Ozawa, hypotype x 35. Fig. 16. *Neoconorbina pacifica* LeRoy, hypotype x 64. Fig. 17. *Loxostomum limbatum* Brady, hypotype, x 35. Fig. 18. *Bulimina denudata* Cushman & Parker, hypotype, x 45. Fig. 19. *Peneroplis pertusus* Forskal, hypotype x 40. Fig. 20. *Uvigerina bellula* Bandy, hypotype x 115.

like *Eponides subornatus*, *Lagenonodosaria seclaria*, *Quinqueloculina akneriana*, *Robulus calcar*, *Spiroloculina communis*, and *Triloculina triloculata* are noticed from the Miocene strata of Okinawa. It is significant to note that *Q. akneriana* is stated to be present in the core samples of Eocene rocks also (Todd and Low, 1960).

The Pliocene-Pleistocene boundary in Italy is defined on the basis of the first appearance of *Hyadina balthica* which is found in the present material. Though it is an indicator of cool water to cold water, like the planktonic form *Globigerina pachyderma* (Ehrenberg) it is found in this region also, (Setty, 1972). Akers (in Bock, 1971) found *H. balthica* abundantly in the warm waters of the Gulf of Mexico. However, LeRoy (1964, p. F6-F9) records the occurrence of *H. balthica* in the Shimzato member of the Shimjiri formation (of either late Miocene or Pliocene) and also in Chinen Sand member of Pliocene of Southern Okinawa.

Robulus calcar, *Uvigerina bellula*, *Cibicides* sp., *Caneris sagra*, *Bullmina denudata*, and *Bolivina* sp., are characteristic of off-shore region and of depths ranging from 30 to nearly 800 m; however, species like *Quinqueloculina akneriana*, *Ephidium fax barbarense*, *Textularia secasensis* which are characteristic of near-shore area, ranging in depths from 3 to 30 m (and not specific of this depth) occur here, hence they are considered to be a transported fauna.

As is known, planktonic foraminifera increase in number and percentage with the progressive increase in depth and also in distance offshore. Thus, their percentage rises sharply from nearly 30-40 per cent to 60-70 per cent seaward across the edge of the shelf. This is noticed in terms of the increased number of species and also in the diversity of genera. Faunal affinities are more easily recognised in the planktonic element of a faunal assemblage than in the benthonic element, because benthonic species, by their very nature, present significant information about their habitat than their geologic age.

Planktonic species are found to be in almost equal number as the benthonics in all the samples examined and the occurrence of characteristic species from these sediments are reported earlier (Setty, 1972). Accordingly, they also show a geologic range from Miocene to Recent.

Ammonia beccart which has a world-wide distribution is found to be absent in the samples examined. Its apparent disappearance may either be considered as accidental, or due to some change in environment which was unfavourable to it.

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