

Foraminifera of the Pliocene of South-Eastern Australia

By W. J. Parr, F.R.M.S.

Introduction.

In a recent paper by the late Professor W. Howchin and the present writer (6) on the geological features and foraminiferal fauna of the Metropolitan Abattoirs Bore, Adelaide, reference is made to the position of the Kalimnan of Victoria in relation to the beds in the vicinity of Adelaide to which Howchin (4) applied the name of "Adelaidean."

The term "Kalimnan" is a local stage name given by Hall and Pritchard (1) in 1902 to the marine Tertiary beds exposed at Jemmy's Point, near Kalimna (the type locality for the Kalimnan), Muddy Creek (the upper beds), Beaumaris (the upper beds), and elsewhere. The Kalimnan is now regarded as Lower Pliocene. The Adelaidean beds consist of fossiliferous marine deposits of a sandy facies occurring in borings in a limited area along the western and north-eastern sides of the City of Adelaide. They have been referred by Hall and Pritchard (1) to the Kalimnan and by Mrs. N. H. Ludbrook (7) to the Lower Pliocene. Tate (8) regarded them as intermediate in age between the Limestone Creek (Werrikoian of Hall and Pritchard = Upper Pliocene or Lower Pleistocene) beds and those at Jemmy's Point. Howchin (3) advanced the view that these deposits were of Upper Pliocene age and has been supported in this by the writer (1). Chapman (1) agreed with Howchin's opinion that the Adelaidean beds were younger than Kalimnan but did not give a closer estimate of their age.

The palaeontological evidence used by the authors named, other than Howchin and Parr, in considering the ages of the Kalimnan and the Adelaidean, has been supplied by the larger fossils. With the exception of Howchin's paper (2), published as long ago as 1889, on the foraminifera of Muddy Creek, the foraminifera occurring in the surface exposures of the Kalimnan, including those of the type locality, have not been described. In view of the use now being made of the smaller foraminifera in problems of correlation, the following notes on the foraminifera of the Kalimnan of Victoria have been prepared. They represent the results of the examination of a representative series of samples from Jemmy's Point and the Hamilton district. A comparative table setting out the species occurring at the several localities and their known time ranges in the Australian region is given, together with similar details in regard to those recorded by Howchin (5) and by Howchin and Parr (6) from the Adelaidean of the Cowandilla and Abattoirs Bores respectively. Howchin's determinations in his Cowandilla paper have been revised and the names of two of the species from the Abattoirs Bore have been amended. Notes are also given on the new and distinctive forms.

The material from Jemmy's Point has been collected by the Director of the Geological Survey, Mr. W. Baragwanath, and by Mr. J. Easton, also of the Mines Department, while the three samples from the Hamilton district are of the writer's own collecting. It may be noted that one of the latter is from a new locality for the Kalimnan, viz., on the west side of the Grange Burn, overlying the *Lepidocyclina* limestone, opposite Henty's. The foraminifera of the upper beds at Beaumaris have not been included as a separate paper on these is in the course of preparation.

The types of all new species, and examples of the species recorded from Jemmy's Point, have been deposited in the Mines Department Museum.

DESCRIPTION OF MATERIAL.

Jemmy's Point, near Kalimna.

The material varies from brown, finely-sandy marl, rich in Kalimnan species of mollusca, to brown, more sandy marl, frequently with calcareous concretions, but without larger fossils. The only smaller organisms which are common, other than foraminifera, are ostracoda. There are occasional bryozoans and echinoidal (spatangoid) spines. As the foraminifera occur throughout the section, separate lists of those from each sample have not been prepared.

Small gully on west side of Grange Burn, from thin layer of marl, overlying *Lepidocyclina* limestone, opposite Henty's.

Light brown marl. The residues after washing include fragments of mollusca and bryozoans, with some fine quartz sand. The foraminifera are all small forms, *Rotalia beccarii* being predominant. The absence of miliolines and the large species such as *Discorbis dimidiatus* and (?) *Epistomaria poly-stomelloides*, which are common at Forsyth's and McDonald's, is noteworthy.

Forsyth's, Grange Burn.

Greyish marl, with abundant Kalimnan mollusca. The residues after washing consist of finely comminuted organic fragments (broken siliceous sponge spicules common) and a small proportion of minute, sub-angular quartz grains.

McDonald's, Muddy Creek.

Brown sandy marl, with abundant Kalimnan mollusca. The residues after washing consist of comminuted, worn, organic material, of coarser grade than at Forsyth's, with a small proportion of quartz grains, some of which are wind polished. The foraminifera are often much worn.

TABLE SHOWING DISTRIBUTION OF FORAMINIFERA IN KALIMNAN OF VICTORIA AND ADELAIDEAN OF SOUTH AUSTRALIA.

(v.c., very common; c., common; f., frequent; r., rare; v.r., very rare; x, occurs.)

Species with Range from Miocene to Recent in Australia.

	Kalimnan.				Adelaidean.	
	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Spirillina inaequalis</i> Brady	v.r.	..	..
<i>Lenticulina gibba</i> (d'Orb.)	f.	..	..	..	..
<i>Dentalina consobrina</i> d'Orb.	v.r.	..	..	..	..
<i>D. inornata</i> d'Orb. ..	v.r.	v.r.	..	..	..	..
<i>D. obliqua</i> (Linné)	v.r.	..
<i>Lagena acuticosta</i> Reuss	v.r.	..	..	..
<i>L. striata</i> (d'Orb.)	c.	f.	..	..	..
<i>L. sulcata</i> (W. and J.)	f.	..	..	..	..
<i>L. hexagona</i> (Will.) ..	v.r.	..	..	..	..	..
<i>L. elongata</i> (Ehr.)	f.	..	..	..	..
<i>L. distoma</i> P. and J.	f.	..	v.r.	..	..
<i>L. marginata</i> (W. and B.)	c.	v.r.	..	..	..
<i>L. orbignyana</i> (Seg.)	f.	..	..	..	..
<i>Gutulina problema</i> d'Orb.	f.	f.	f.	v.r.	x.
<i>G. regina</i> (B., P., and J.)	f.	x.
<i>Sigmoidella elegantissima</i> (P. and J.)	f.	..	f.	x.
<i>S. kagaensis</i> C. and O. ..	v.r.	..	c.	e.	f.	x.
<i>Virgulina schreibersiana</i> Czjzek	f.	..	..	..	..
<i>Cassidulina laevigata</i> d'Orb.	f.	..	..	..	..
<i>C. subglobosa</i> Brady	f.	..	..	..	..
<i>Discorbis globularis</i> (d'Orb.)	v.r.	..
<i>D. australis</i> Parr	c.	f.	..	..	..
<i>D. haliotis</i> (H.-A. and E.)	v.r.	..	..	..
<i>D. margaritifera</i> (H.-A. and E.)	f.	..	..	..	..
<i>Eponides repandus</i> (F. and M.)
<i>Rotalia beccarii</i> (Linné)	c.	v.c.	c.	v.c.	x.
<i>Cancris auricula</i> (F. and M.)	c.	..	..	..	..
<i>Cibicides lobatulus</i> (W. and J.)	f.	..	..	f.	x.
<i>Gypsina globulus</i> (Reuss)	f.	f.	v.r.	..
<i>Globigerina bulloides</i> d'Orb.	f.	v.r.	f.	..	..
<i>Orbulina universa</i> d'Orb.	f.	..	..	..	..
<i>Elphidium crispum</i> (Linné)	f.	..	..	..	x.
<i>E. macellum</i> (F. and M.)	f.	c.	f.	..	x.
<i>Cornuspira involvens</i> (Reuss) ..	v.r.	..	v.r.	..	..	..
<i>Nubecularia lucifuga</i> Defrance	c.	..
<i>Quinqueloculina seminulum</i> (Linné)	c.	f.	f.	f.	x.
<i>Q. vulgaris</i> d'Orb.	f.	c.	f.	f.	..
<i>Spiroloculina antillarum</i> d'Orb.	f.	f.	..
<i>Triloculina tricarinata</i> d'Orb.	f.	..	f.	f.	x.
<i>T. trigonula</i> (Lam.)	c.	e.	..	x.
<i>T. oblonga</i> (Montagu)	x.
<i>Pyrgo cf. bulloides</i> (d'Orb.)	v.r.	..	f.	..
<i>P. depressa</i> (d'Orb.)	f.	..	..	..
<i>Marginopora vertebralis</i> Blainville	f.	x.
Total number—44 ..	24	9	23	12	16	13

Species known only from Miocene and Kalimnan.

	Kalimnan.				Adelaidean.	
	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Astrononion australe</i> Cushman and Edw.	f.	r.	..	r.	..	..
<i>Triloculina schreiberiana</i> d'Orb.	..	..	f.	..	..	..*
Total number—2	1	1	1	1	..	..

*Occurs living, West Indies.

Species known only from Miocene and Adelaidean.

	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Nodobacularella cultrata</i> H. and P.	v.r.	..

Species known only from Kalimnan, Adelaidean, and Recent Australian Seas.

	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Guttulina yabei</i> C. and O.	..	v.r.	..	..	..	x.
<i>Discorbis dimidiatus</i> (J. and P.)	..	..	c.	f.	r.	x.
<i>D. mira</i> Cushman	..	..	c.	f.	..	x.
<i>Epistomaria polystomelloides</i> (P. and J.)	..	..	c.	e.	f.	x.
<i>Elphidium advenum</i> (Cushman)	f.	r.	..	..	f.	..
<i>Polystomellina clathrata</i> (Brady)	..	c.	c.	c.	f.	x.
<i>Quinqueloculina agglutinans</i> d'Orb.	v.r.	..	..	..	r.	..
<i>Q. ammophila</i> Parr	..	c.	..	c.	r.	..
<i>Q. lamareckiana</i> d'Orb.	..	..	..	c.	r.	..
<i>Massilina lapidigera</i> (H. and P.)	..	f.	..	v.r.	r.	x.
<i>Triloculina cultrata</i> (Brady)	..	r.	..	..	v.r.	..
<i>Clavulina multicamerata</i> Chapman	..	..	..	f.	v.r.	r.
Total number—12	6	3	7	7	10	7

Species and Varieties known only from the Kalimnan and Recent Australian Seas.

	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Planularia patens</i> (Brady)	v.r.	..	v.r.	..	..	..
<i>Vaginulina vertebralis</i> Parr	v.r.	v.r.	..	..	..	..
<i>Nodosaria vertebralis</i> (Batsch)	..	..	v.r.	v.r.	..	..
<i>Lagena squamosa</i> (Montagu)	f.	r.	..	..	..	..
<i>L. lucida</i> (Will.)	v.r.	..	r.	..	..	..
<i>L. perlucida</i> (Montagu)	f.	r.	v.r.	..	..	..
<i>Guttulina seguenziana</i> (Brady)	v.r.	r.	..	..	..	..
<i>Polymorphina howchini</i> C. and O.	..	..	v.r.	f.	..	..
<i>Buliminella elegantissima</i> (d'Orb.)	..	..	v.r.	..	..	..
<i>Virgulina pauciloculata</i> Brady	r.	..	..	..	..	..
<i>Bolivina alata</i> (Seguenza)	..	f.	..	..	..	..
<i>B. compacta</i> Sidebottom	..	r.	..	..	..	..
<i>Rectobolivina bifrons</i> (Brady), var. <i>striatula</i> (Cushman)	c.	c.	r.	v.r.	..	..
<i>Pavonina flabelliformis</i> d'Orb.	..	v.r.	v.r.	..	..	..
<i>Urigerina cf. pigma</i> d'Orb.	f.	..	..	..	..	..
<i>Discorbis australensis</i> H.-A. and E.	..	..	..	f.	f.	..
<i>D. opercularis</i> (d'Orb.)	..	..	..	..	r.	..
<i>D. involutus</i> (Sidebottom)	..	..	..	..	v.r.	..
<i>Cancris philippinensis</i> (Cushman)	f.	c.	c.	c.	r.	..
<i>Anomalina nonionoides</i> Parr	..	v.r.	..	..	..	..
<i>Planulina bioncava</i> (J. and P.)	..	v.r.	r.	f.	..	..
<i>Amphistegina radiata</i> (F. and M.)	..	..	..	..	r.	..
<i>Elphidium imperatrix</i> (Brady)	..	c.	..	f.	c.	..
<i>Quinqueloculina laevigata</i> d'Orb.	..	c.	..	..	..	..
<i>Q. costata</i> d'Orb.	..	v.r.	..	c.	r.	..
<i>Spiroloculina limbata</i> d'Orb.	..	..	..	c.	v.r.	..
<i>Triloculina insignis</i> (Brady)	..	..	..	r.	..	..
Total number—27	15	8	16	12	..	..

Features of this analysis are:—

- (1) The number of species with a range of from Miocene to Recent in Australia found in the Kalimnan (38 out of 90, or 42%) and Adelaidean (20 out of 49, or 41%).
- (2) The number of species still living in Australian seas—77 out of 90, or 86%, in the Kalimnan, and 45 out of 49, or 92%, in the Adelaidean.
- (3) The species (27) common to the Kalimnan and Adelaidean are all living forms.
- (4) The extremely small number of species previously known only from the Miocene—Kalimnan (2 out of 90 or 2%), and Adelaidean (1 out of 49, or 2%).
- (5) The number of species restricted to the Kalimnan (11 out of 90, or 12%). The corresponding figures for the Adelaidean are 3 out of 49, or 6%.

Species and Varieties known only from Adelaidean and Recent Australian Seas.

	Kalimnan.				Adelaidean.	
	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Elphidium rotatum</i> H. and P.	r.	x.
<i>Nubecularia lucifuga</i> Defr., var. <i>lapidea</i> Wiesner	f.	..
<i>Quinqueloculina bosciiana</i> d'Orb.	r.	..
<i>Q. polygona</i> d'Orb.	c.	x.
<i>Q. limbata</i> d'Orb.	r.	..*
<i>Hauerina ornatisissima</i> (Karrer)	v.r.	v.r.
<i>Flintina triquetra</i> (Brady)	v.c.	..
<i>Peneroplis pertusus</i> (Forsk.)	c.	..
<i>Sorites marginalis</i> (Lamarck)	r.	..
<i>Amphisorus hemprichii</i> Ehr.	r.	..
<i>Clavulina pacifica</i> Cushman	r.	..
<i>C. difformis</i> Brady	v.r.	..
<i>Cribrobulimina polystoma</i> (P. and J.)	x.
Total number—13	12	4

* Occurs living, Red Sea and Adriatic.

Species and Varieties restricted to the Kalimnan.

	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Guttulina regina</i> (B., P., and J.), var. <i>crassicostrata</i> C. and O.	v.r.	..	..	..	..	..
<i>Glandulina kalimnensis</i> , sp. nov.	c.	c.	c.	f.	..	..
<i>Pseudopolymorphina victoriensis</i> , sp. nov.	r.	..	..	..	..	..
<i>Bulimina echinata</i> d'Orb.	f.	..	..	..	..	†
<i>Siphonodosaria australis</i> , sp. nov.	f.	..	..	..	..	..
<i>Rotalia hamiltonensis</i> , sp. nov.	..	..	f.	c.	..	..
<i>Planulina kalimnensis</i> , sp. nov.	f.	c.	c.	v.r.	..	..
<i>Nonion victoriense</i> Cushman	v.c.	..	..	..	..	..
<i>Elphidium pseudonodosum</i> Cushman	..	f.	f.	c.	..	..
<i>Flintina intermedia</i> (Howchin)	c.	..	c.	..	..	..
<i>Fabularia howchini</i> Schlumberger	..	..	..	r.	..	..
Total number—11	8	3	5	6	..	..

† Occurs in Pliocene of Italy.

Species restricted to the Adelaidean.

	Jemmy's Point.	West of Henty's	Forsyth's.	McDonald's.	Abattoirs Bore.	Cowandilla Bore.
<i>Discorbis cycloclypeus</i> H. and P.	f.	..
<i>Elphidium adalaidense</i> H. and P.	f.	x. ‡
<i>Quinqueloculina adalaidensis</i> H. and P.	f.	..
Total number—3	3	1

‡ Occurs doubtfully in Miocene of South Australia.

SUMMARY.

Number of Species with Range.	Kalimnan.	Adelaidean.	Total.
Miocene to Recent in Australia	38	20	44
Miocene and Kalimnan	2	..	2
Miocene and Adelaidean	..	1	1
Kalimnan, Adelaidean, and Recent Australian	12	12	12
Kalimnan and Recent Australian	27	..	27
Adelaidean and Recent Australian	..	13	13
Kalimnan only	11	..	11
Adelaidean only	..	3	3
Grand Total	90	49	113

- (6) The considerable number of species at Jemmy's Point, and to a lesser extent in the Hamilton district, now found living on the east coast of Australia as far south as the eastern part of Bass Strait. At Forsyth's and McDonald's, there is a warmer water element, evidenced by the presence of (?) *Epistomaria polystomelloides* and *Amphistegina radiata* (at McDonald's only).
- (7) The presence in the Adelaidean of a number of genera of the Peneroplidae (*Marginopora*, *Amphisorus*, and *Sorites*) usually found living in shallow water in tropical and sub-tropical seas, in association with typical Flindersian foraminifera such as *Flintina triquetra*, *Cribrobulimina polystoma*, and *Nubecularia lucifuga*, var. *lapidea*. *Marginopora* and *Amphisorus* are, however, very common in the Pleistocene of South Australia and it would accordingly appear that similar temperatures and conditions prevailed during the formation of the Adelaidean beds and those of the Pleistocene.

Notes on some of the Species.

FAMILY NODOSARIIDAE.

Genus PLANULARIA DeFrance, 1824.

PLANULARIA PATENS (Brady).

Fig. 1.

Vaginulina patens Brady, 1884, Chall. Rept. Zool., vol. ix, p. 533, pl. lxxvii, figs. 15, 16. Parr, 1932, Proc. Roy. Soc. Vic., vol. xlv (n.s.), pt. 2, p. 221.

V. costata Chapman (*non Planularia costata* Cornuel), 1909, Journ. Quek. Micr. Club, ser. 2, vol. x (for 1907), p. 130, pl. ix, fig. 10. Sidebottom, 1918, J. R. M. S., p. 139, pl. v, figs. 4, 5.

Brady described this species from off the Philippines, 95 fms., and recorded it also from off Raine Island, 155 fms. The records by Chapman and myself are from Victorian shore sands. While Chapman's figure represents a specimen of very similar form to those figured by Brady, the species as it occurs in Bass Strait, in the Tertiary of Victoria, and also in some examples from off Raine Island, has usually a broader, subovate test, due to the strong outward curvature of the later chambers. In addition to the examples recorded from the Kalimnan at Jemmy's Point, I have others from the upper beds at Beaumaris and from the Post-tertiary of Bore No. 5, Parish of Wannaeue, 177-187 ft.

Genus VAGINULINA d'Orbigny, 1826.

VAGINULINA VERTEBRALIS Parr.

Vaginulina vertebralis Parr, 1932, Proc. Roy. Soc. Vic., vol. xlv (n.s.), pt. 2, p. 221, pl. xxii, fig. 42.

There are two examples. This species was described by the writer as a Recent form from shore sand, Torquay, Vic., and recorded at the same time as a fossil from the Post-tertiary of Victoria at Boneo (Bore No. 5, Parish of Wannaeue, 177-187 ft.) and from the Lower Pliocene of Beaumaris. These are the only records of its occurrence.

FAMILY POLYMORPHINIDAE.

Genus GUTTULINA d'Orbigny, 1839.

GUTTULINA REGINA (Brady, Parker, and Jones), var.

CRASSICOSTATA Cushman and Ozawa.

Fig. 2.

Guttulina regina (B., P., & J.), var. *crassicostata* Cushman and Ozawa, 1930, Proc. U.S. Nat. Mus., vol. lxxvii, Art. 6, p. 35, pl. xi, figs. 5 a-c. Parr and Collins, 1937, Proc. Roy. Soc. Vic., vol. 1 (n.s.), pt. 1, p. 194, pl. xii, fig. 6.

This coarsely-costate form of the well-known Recent Australian species, *G. regina*, has hitherto been known only from the Lower Pliocene (Kalimnan) of Beaumaris. There is one example from Jemmy's Point.

GUTTULINA SEGUENZANA (Brady).

Fig. 3.

Polymorphina sequenzana Brady, 1884, Chall. Rept. Zool., vol. ix, p. 567, pl. lxxii, figs. 16, 17.

Guttulina sequenzana. Parr and Collins, 1937, Proc. Roy. Soc. Vic., vol. 1 (n.s.), pt. 1, p. 196, pl. xii, figs. 10 a and c.

There are several examples. This is a rare Eastern Australian species, which has not been previously recorded as a fossil. It occurs also in the upper beds at Beaumaris.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928.

PSEUDOPOLYMORPHINA VICTORIENSIS, sp. nov.

Figs. 4 a, b.

Test about three times as long as broad, somewhat compressed, bluntly pointed at each end; chambers elongate and inflated, only slightly embracing, arranged at first in a quinqueloculine series occupying about one-third of the length of the test, chambers in the remainder of the test biserially arranged, few in number; sutures well depressed, distinct; wall smooth; aperture radiate. Length of holotype (from

Jemmy's Point), 1.4 mm.; breadth, 0.44 mm.; thickness, 0.4 mm.

This species occurs rarely at Jemmy's Point and I have other examples from the upper beds at Beaumaris. Its nearest relative appears to be *P. tasmanica* Parr and Collins, from the Lower Miocene of Table Cape, Tas., but it may be distinguished from the latter species by its proportionately longer test and the greater development of the early guttuline series of chambers.

Genus POLYMORPHINA d'Orbigny, 1826.

POLYMORPHINA HOWCHINI Cushman and Ozawa.

Polymorphina compressa (*pars*) Brady (*non P. compressa* d'Orbigny), 1884, Chall. Rept. Zool., vol. ix, p. 565, pl. lxxii, figs. 9, 10.

P. howchini Cushman and Ozawa, 1930, Proc. U.S. Nat. Mus., vol. lxxvii, Art. 6, p. 121, pl. xxxi, fig. 9. Parr and Collins, 1937, Proc. Roy. Soc. Vic., vol. 1 (n.s.), pt. 1, p. 202, pl. xiv, fig. 8.

This is a large, broad, flattened species ornamented with numerous fine longitudinal costae. In the Kalimnan of Victoria, it is known only from McDonald's, from whence it was described, and Forsyth's, in the Hamilton district. It is still living in Bass Strait.

Genus GLANDULINA d'Orbigny, 1826.

GLANDULINA KALIMNENSIS, sp. nov.

Figs. 5, 6.

Test long for the genus, subcylindrical, the length from two to (generally) four times the diameter; chambers increasing more quickly in length than in breadth as added, very slightly inflated, in the microspheric form at first arranged in a short triserial series, the remainder of the chambers uniserial, in the megalospheric form the chambers are uniserial throughout; sutures distinct, slightly depressed in the later part of the test, wall smooth, translucent; aperture radiate. Length up to 1.6 mm.; diameter to 0.44 mm.

Holotype from marl overlying *Lepidocyclina* limestone, west side of Grange Burn, opposite Henty's.

This very distinct form is one of the most characteristic species of the Kalimnan, occurring in all of the samples examined, and I have it also from the upper beds at Beaumaris. It does not resemble any previously-described species, but may be compared with the specimen figured by A. C. Collins and myself (Proc. Roy. Soc. Vic., vol. 1 (n.s.), pt. 1, 1937, p. 197, pl. xiv, fig. 5) as *Pyrulina fusiformis* (Roemer), from the Miocene of Grice's Creek, Vic.

FAMILY BULIMINIDAE.

Genus BULIMINA d'Orbigny, 1826.

BULIMINA ECHINATA d'Orbigny.

Fig. 7.

Bulimina echinata d'Orbigny, 1826, Ann. Sci. Nat., vol. vii, p. 269, No. 5. Fornasini, 1901, Boll. Soc. Geol. Ital., vol. xx, p. 176, text-fig. 2. Cushman and Parker, 1938, Contr. Cushman Lab., vol. xiv, p. 54, pl. ix, figs. 3, 4.

This species has not been previously recorded from the Australian region, but is represented in the Jemmy's Point material by a number of examples which agree closely with Cushman and Parker's figures of examples from the type locality, Coroncina, in Northern Italy, where it occurs in beds of Pliocene age.

Genus VIRGULINA d'Orbigny, 1826.

VIRGULINA SCHREIBERSIANA Czjzek.

Fig. 8.

Virgulina schreibersiana Czjzek, 1848, Haidinger's Nat. Abhand., vol. ii, p. 147, pl. xiii, figs. 18-21. Cushman, 1937, Cushman Lab. Spl. Publ. No. 9, p. 13, pl. ii, figs. 11-20.

There are two typical examples from Jemmy's Point. This species was described from the Miocene of the Vienna Basin

and Cushman states it occurs as a living form in the Indo-Pacific off the Philippines and southward to Fiji. I have Recent specimens from shore sand at Barwon Heads, Vic., collected by Mr. W. Baragwanath.

VIRGULINA PAUCILOCOLATA Brady.

Fig. 9.

Virgulina pauciloculata Brady, 1884, Chall. Rept. Zool., vol. ix, p. 414, pl. lii, figs. 4, 5. Cushman, 1937, Cushman. Lab. Spl. Publ. No. 9, p. 25, pl. iv, figs. 4-6.

There are five examples from Jemmy's Point. This species was described from Humboldt Bay, Papua, 37 fms., and is typically a shallow water, tropical Indo-Pacific form. It has not been previously found fossil.

Genus BOLIVINA d'Orbigny, 1839.

BOLIVINA COMPACTA Sidebottom.

Fig. 10.

Bolivina robusta Brady, var. *compacta* Sidebottom, 1905, Mem. Proc. Manchester Lit. Philos. Soc., vol. xlix, No. 5, p. 15, pl. iii, fig. 7.

B. compacta, Cushman, 1937, Cushman. Lab. Spl. Publ. No. 9, p. 135, pl. xvii, figs. 22-24.

This species was described from the eastern Mediterranean and is widely distributed in the tropical Pacific, usually occurring in shallow water. It has not been previously met with as a fossil. There are several typical examples from Jemmy's Point.

BOLIVINA ALATA (Seguenza).

Fig. 11.

Vulvulina alata Seguenza, 1862, Atti Accad. Gioenia Sci. Nat. ser. 2, vol. xviii, p. 115, pl. ii, figs. 5, 5 a.

Bolivina alata, Cushman, 1937, Cushman. Lab. Spl. Publ. No. 9, p. 106, pl. xiii, figs. 3-11.

The only specimens are from Jemmy's Point. This is the first record of this species from the Tertiary of Australia. It occurs living off Gabo Island in water of moderate depth and elsewhere on the east coast of Australia. The types were from the Pleistocene of Sicily.

Genus RECTOBOLIVINA Cushman, 1927.

RECTOBOLIVINA BIFRONS (Brady), var. STRIATULA (Cushman).

Figs. 12, 13.

Siphogenerina bifrons (Brady), var. *striatula* Cushman, 1917, Proc. U.S. Nat. Mus., vol. li, p. 662; 1921, Bull. 100, U.S. Nat. Mus., vol. iv, p. 278, pl. lvi, fig. 4.

Rectobolivina bifrons (Brady), var. *striatula*, Cushman, 1937, Cushman. Lab. Spl. Publ. No. 9, p. 205, pl. xxiii, figs. 17, 18.

This occurs in all of the samples and also in the upper beds at Beaumaris. It was originally described from off the Philippines and has been recorded by Cushman from off New Zealand. According to Cushman, it differs from *R. bifrons* in having the surface with numerous longitudinal striations, rather more elongate, and with the central indented portion deeper and more defined. Judging by Recent examples from off Raine Island, Torres Strait, and the Kalimnan specimens, the median depression is often extremely slight and is occasionally absent. Specimens from Jemmy's Point, mounted in glycerine, show the internal tube characteristic of *Rectobolivina*.

Genus UVIGERINA d'Orbigny, 1826.

UVIGERINA sp. cf. PIGMEA d'Orbigny.

Fig. 14.

There are about twenty examples of a species of *Uvigerina* from Jemmy's Point, but, because of the unsatisfactory position of the costate species of this genus, it has not been possible to identify them with any degree of certainty. *U.*

pigmea has been used for many such forms, but Dr. Cushman's figures (Contr. Cushman. Lab., vol. vi, 1930, p. 62, pl. ix, figs. 14-20) of topotype specimens of this species from the Pliocene of Coroneina, Italy, show that few of the records of *U. pigmea* relate to that species. The test of *U. pigmea* is elongate and all but the last one or two chambers have rather sharp longitudinal costae. The remaining chambers lose the costae and become nearly smooth, but have numerous short spines. The apertural end has a distinct neck, long and slender, ending in a distinct lip. The Victorian specimens are similar in general form, but are costate throughout, the costae sometimes becoming prickly on the last one or two chambers. The apertural neck is, however, short and with a comparatively large lip.

Genus SIPHONODOSARIA A. Silvestri, 1924.

SIPHONODOSARIA AUSTRALIS, sp. nov.

Figs. 15, 16.

Test elongate, slender, gently curved; chambers distinct, increasing gradually in diameter and proportionately more in length as added, slightly pyriform in the adult, with the greatest breadth towards the base, well inflated; sutures distinct, depressed, somewhat limbate; surface of test faintly hispid and also ornamented with indistinct broken low costae or warty protuberances arranged longitudinally; aperture terminal, semi-elliptical, at the end of a short neck with a phialine lip. Length of holotype, 3 mm.; diameter, 0.22 mm.

Holotype from Jemmy's Point.

This genus has not been recorded previously from the Australian region. The species is distinct from any other with which I am acquainted. It occurs fairly frequently at Jemmy's Point, but has not been met with elsewhere.

FAMILY ROTALIIDAE.

Genus DISCORBIS Lamarek, 1804.

DISCORBIS HALIOTIS (Heron-Allen and Earland).

Discorbina haliotis Heron-Allen and Earland, 1924, J. R. M. S., p. 173, pl. xiii, figs. 99-101.

This is a peculiar ear-shaped form, the only previous record of which is from the Lower Miocene of Batesford. The Kalimnan example is from McDonald's, on Muddy Creek. The species also occurs in the lower beds (of Lower Miocene age) at Clifton Bank, on Muddy Creek, and I have Recent specimens from shore sand, Barwon Heads, Vic., and shallow water, Geraldton Harbor, W.A.

DISCORBIS AUSTRALENSIS Heron-Allen and Earland.

Discorbina pileolus Brady (non *Valvulina pileolus* d'Orbigny). 1884, Chall. Rept. Zool., vol. ix, p. 649, pl. lxxxix, figs. 2-4.

Discorbis australensis Heron-Allen and Earland, 1932, Discovery Repts., vol. iv, p. 416.

This species is common in shallow water on the coasts of Victoria and New South Wales, but is generally known as *D. pileolus*. Brady has given excellent figures of specimens from Port Elizabeth, Algoa Bay, and Port Jackson. Heron-Allen and Earland, in their work (*op. cit.*) on the foraminifera of the ice-free area of the Falkland Islands and adjacent seas, recognized that Brady's form was not d'Orbigny's *Valvulina pileolus* and renamed it *Discorbis australensis*. They did not designate a type and I accordingly select the specimen represented by Brady's figure 3 as the holotype of the species. This was from "Challenger" Station 163B, Port Jackson, depth 2-10 fms.

DISCORBIS MARGARITIFERUS (Heron-Allen and Earland).

Discorbina margaritifera Heron-Allen and Earland, 1924, J. R. M. S., p. 167, pl. xi, figs. 71-73.

Discorbis margaritifera, Parr, 1932, Proc. Roy. Soc. Vic., vol. xlv (n.s.), pt. 2, p. 226, pl. xxi, figs. 26 a-c.

This species was described from the Lower Miocene of Batesford, near Geelong, and has been recorded by the writer as a living form from Point Lonsdale. Typical examples have been met with in the Kalimnan at two localities in the Hamilton district.

Genus ROTALIA Lamarck, 1804.

ROTALIA HAMILTONENSIS, sp. nov.

Figs. 17 a-c.

Calcarina rarispina Howchin (*non* Deshayes), 1889, Trans. Roy. Soc. Sth. Aust., vol. xii, p. 15.

Test trochoid, biconvex, the dorsal side usually less convex than the ventral, periphery subacute, frequently with three or four short, stout, radial spines, each situated at the forward end of a chamber, umbilical area almost invariably closed with a plug of varying size; chambers usually 7 in the last-formed whorl, increasing gradually in size as added, not inflated; sutures on the dorsal side oblique, limbate, flush or rarely raised, radial and much depressed on the ventral side; wall comparatively thick, smooth or ornamented with bead-like projections of varying size; aperture a small arched slit on the ventral side, nearer the umbilical area than the periphery. Diameter up to 0.9 mm.; thickness to 0.4 mm.

Holotype from McDonald's, Muddy Creek.

This species was recorded by Howchin from the upper beds at Muddy Creek under the name of *Calcarina rarispina* d'Orbigny, although, according to Sherborn's Index, Deshayes was the author (in Lyell, Principles of Geology, vol. iii, 1833, p. 251, pl. iv, figs. 9-11). Judging by the figures given of *C. rarispina* (from the Eocene of France) in Lyell's Elements of Geology (1865), text-figs. 265 a-c, on page 301, it is close to the present species, but has six chambers to a whorl and the marginal spines are placed in the centre and not at the forward end of each chamber. *Rotalia calcar* (d'Orb.) is also near *R. hamiltonensis*, but has a larger number of chambers to a whorl. *R. hamiltonensis* is fairly common at McDonald's and Forsyth's, in the Hamilton district, and also occurs in the upper beds at Beaumaris.

Genus CANCRIS Montfort, 1808.

CANCRIS PHILIPPINENSIS (Cushman).

Figs. 18 a-c.

Pulvinulina hauerii (*pars*) Brady (*non* *Rotalina hauerii* d'Orbigny), 1884, Chall. Rept. Zool., vol. ix, p. 690, pl. cvi, fig. 7 (*non* fig. 6).

P. philippinensis Cushman, 1921, Bull. 100, U.S. Nat. Mus., vol. iv, p. 331, pl. lviii, figs. 2 a-c.

This species was described from off the Philippines, in 170 fms. Brady's figured specimen was from Ki Islands, southwest of Papua, in 129 fms. While it does not appear to have been recorded by any other author since Cushman described it, it is a common form on the east coast of Australia, its range extending from Torres Strait ("Challenger" Stn. 185, off Raine Island, 155 fms.) to Bass Strait, where it occurs off Barwon Heads, Vic. It does not occur in the Tertiary of Victoria in beds older than the Kalimnan. It was met with in all of the samples and I have numerous examples from the upper beds at Beaumaris.

Genus PLANULINA d'Orbigny, 1826.

PLANULINA KALIMNENSIS, sp. nov.

Figs. 19 a-c.

Test trochoid, compressed, biconvex, the ventral side less convex than the dorsal and frequently slightly evolute and umbonate, periphery subacute, with a limbate margin except in the last two or three chambers, sometimes slightly lobulate; chambers distinct, generally 8 or 9 in the adult whorl, gradually and uniformly increasing in size as added, very little inflated; sutures distinct, thickened, occasionally slightly depressed, gently recurved, the amount of curvature being greater on the dorsal side; wall fairly thin and distinctly perforate; aperture a narrow slit with a distinct lip, at the base of the last-formed chamber, extending to the dorsal side for a short distance along the inner margin of the chamber. Diameter up to 0.8 mm.; thickness to 0.26 mm.

Holotype from Jemmy's Point.

This is one of the characteristic species of the Kalimnan, occurring in all of the samples. It is also found in the upper beds at Beaumaris. The only species resembling it appears to be *P. taylorensis* (Carsey), from the Upper Cretaceous of Texas, U.S.A. This is a much larger form, with an almost complanate test, umbonate on both sides, and with the spiral suture strongly depressed.

Genus AMPHISTEGINA d'Orbigny, 1826.

AMPHISTEGINA RADIATA (Fichtel and Moll).

Nautilus radiatus Fichtel and Moll, 1798, Test. Micr., p. 58, pl. viii, figs. 8 a-d.

Amphistegina radiata, Cushman, 1924, Carn. Inst. Wash. Publ. 342, p. 49, pl. xvii, figs. 1, 2.

There are two examples from McDonald's, on Muddy Creek, each measuring 1.2 mm. in diameter. This species is typically a tropical Indo-Pacific form, but has been recorded by F. Chapman and myself from the Great Australian Bight. The species of *Amphistegina* occurring in the Miocene of Victoria is a different form, which is close to, if not identical with, *A. hauerina* d'Orbigny, from the Miocene of the Vienna Basin.

FAMILY NUMMULITIDAE.

Genus NONION Montfort, 1808.

NONION VICTORIENSE Cushman.

Fig. 20.

Nonion victoriense Cushman, 1936, Contr. Cushman. Lab. vol. xii, p. 67, pl. xii, figs. 10 a, b.

This species has been recently described by Dr. Cushman from material sent by the writer from the Lower Pliocene (Kalimnan), east of Lake Bunga, Gippsland. It occurs also at Jemmy's Point, where it is extremely common in the upper part of the cliff section.

Genus ELPHIDIUM Montfort, 1808.

ELPHIDIUM PSEUDONODOSUM Cushman.

Fig. 21.

Elphidium pseudonodosum Cushman, 1936, Contr. Cushman. Lab., vol. xii, p. 82, pl. xiv, figs. 9 a, b (*E. australe* in description of plate).

The type locality for this species is Forsyth's, on the Grange Burn, the specimens described by Dr. Cushman being collected by the writer. It appears to have a limited distribution, as it has not been found elsewhere than in the Kalimnan of the Hamilton district.

ELPHIDIUM IMPERATRIX (Brady).

Fig. 22.

Polystomella imperatrix Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi (n.s.), p. 66; 1884, Chall. Rept. Zool., vol. ix, p. 738, pl. ex, figs. 13-15. Howchin, 1889, Trans. Roy. Soc. Sth. Aust., vol. xii, p. 16.

This very striking species is of common occurrence in the Kalimnan of Victoria. As figured by Brady, the periphery carries several stout radiating spines, but both Recent and fossil examples are frequently spineless. Howchin also noted this in relation to the specimens he examined from the upper beds at Muddy Creek, suggesting that they probably represented a varietal or intermediate form. Brady's records were from Port Jackson, N.S.W., and Storm Bay, Tasmania. Judging by my own experience, it is confined to shallow water in Bass Strait and off the coasts of New South Wales and Tasmania, where it occurs in depths of up to 100 fms.

Genus POLYSTOMELLINA Yabe and Hanzawa, 1923.

POLYSTOMELLINA CLATHRATA (Brady).

Rotalia clathrata Brady, 1884, Chall. Rept. Zool., vol. ix, p. 709, pl. cvii, figs. 8, 9. Howchin, 1889, Trans. Roy. Soc. Sth. Aust., vol. xii, p. 15.

Polystomellina howchini Howchin and Parr (*non* *Rotalia howchini* Chapman, Parr, and Collins), 1938, Trans. Roy. Soc. Sth. Aust., vol. lxii, pt. 2, p. 300.

According to Brady, this species was only met with by the "Challenger" in the South Pacific, where its range extends from the west coast of Patagonia to Bass Strait. It is particularly common in New Zealand waters. Examples are plentiful in the Kalimnan of Victoria. At Jemmy's Point, it exhibits a greater range of variation in the character of the ornament

than is met with in Recent specimens. The surface is frequently finely reticulate and some examples have the periphery bordered with short radial spines. As has already been noted, *Elphidium imperatrix* may also occur with the margin spinous or smooth.

In the paper by Howchin and myself on the Abattoirs Bore, *P. howchini* was recorded from the Upper Pliocene (Adelaidean). I have re-examined the specimens and find them to be *P. clathrata*. *P. howchini* is a smaller thicker species of the same group as *P. clathrata*, but is confined to the Miocene of Victoria and South Australia.

FAMILY MILIOLIDAE.

Genus MASSILINA Schlumberger, 1893.

MASSILINA LAPIDIGERA (Howchin and Parr).

Fig. 23.

Spiroloculina lapidigera Howchin and Parr, 1938, Trans. Roy. Soc. Sth. Aust., vol. lxii, pt. 2, p. 294, pl. xv, fig. 10.

This species was described from the Upper Pliocene (Adelaidean) of the Cowandilla (Government) Bore, Adelaide, at 420 ft., and referred to the genus *Spiroloculina*. As many of the very fine specimens occurring at Jemmy's Point showed the early chambers to be arranged in a distinct quinqueloculine series, I have re-examined the holotype which had been mounted by Howchin in a sealed cell with other examples of the species and now place it in the genus *Massilina*. The quinqueloculine stage is not always clearly visible, but is then indicated by the depressed centre of the test being slightly convex on one side and concave on the other.

Genus FLINTINA Cushman, 1921.

FLINTINA INTERMEDIA (Howchin).

Figs. 24 a, b.

Hauerina intermedia Howchin, 1889, Trans. Roy. Soc. Sth. Aust., vol. xii, p. 4, pl. i, figs. 6 a, b.

This is probably the most characteristic species of the Kalimnan of Victoria and a valuable "marker," since it does not appear to be confined to beds of the one facies, occurring in every sample of material examined with the exception of that from the marl overlying the limestone on the west side of the Grange Burn. I also have examples from the upper beds at Beaumaris. *F. intermedia* was described by Howchin from the upper beds at Muddy Creek as *Hauerina*. This genus is now used only for those forms with the early chambers quinqueloculine, the later chambers more or less in one plane and more than two to a coil, and a cribrate aperture. In the present species, the test in the earliest stages is triloculine, the remaining chambers being in the one plane. The first whorl frequently consists of only two chambers; in the adult whorl there are typically three, although in the figured specimen there are three and a half. The aperture has a large plate-like tooth. These are the characters of the genus *Flintina*, to which the species is accordingly now referred.

Genus FABULARIA Defrance, 1820.

FABULARIA HOWCHINI Schlumberger.

Fig. 25.

Fabularia howchini Schlumberger, 1891, Trans. Roy. Soc. Sth. Aust., vol. xiv, pt. 2, p. 346, pl. xiii, figs. 5-8; text figs. 1-3.

This species was described from the upper beds at Muddy Creek. While the exact locality was not stated by Schlumberger or Howchin, it was that here named McDonald's, to which *F. howchini* is confined. The occurrence of the genus *Fabularia* in the Lower Pliocene of Australia is noteworthy, as all other records of the genus are from the Eocene.

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EXPLANATION OF THE PLATE.

- Fig. 1. *Planularia patens* (Brady). Jemmy's Point. × 78.
- Fig. 2. *Guttulina regina* (Brady, Parker, and Jones), var. *crassicosata* Cushman and Ozawa. Jemmy's Point. × 39.
- Fig. 3. *G. seguenzana* (Brady). Jemmy's Point. × 31.
- Fig. 4, a, b. *Pseudopolymorphina victoriensis*, sp. nov. Holotype. Jemmy's Point. a, side view; b, edge view. × 36.
- Figs. 5, 6. *Glandulina kalimnensis*, sp. nov. 5. Holotype. Marl overlying *Lepidocyclina* limestone, west side of Grange Burn, opposite Henty's. 6. Megalospheric example from Forsyth's, Grange Burn. Both × 23.
- Fig. 7. *Bulimina echinata* d'Orb. Jemmy's Point. × 68.
- Fig. 8. *Virgulina schreibersiana* Czjzek. Jemmy's Point. × 39.
- Fig. 9. *V. pauciloculata* Brady. Jemmy's Point. × 78.
- Fig. 10. *Bolivina compacta* Sidebottom. Jemmy's Point. × 78.
- Fig. 11. *B. alata* (Seguenza). Jemmy's Point. × 39.
- Figs. 12, 13. *Rectobolivina bifrons* (Brady), var. *striatula* (Cushman). Marl overlying *Lepidocyclina* limestone, west side of Grange Burn, opposite Henty's. 12. Megalospheric example. 13. Microspheric specimen. Both × 39.
- Fig. 14. *Uvigerina* sp. cf. *pigmea* d'Orb. Jemmy's Point. × 50.
- Figs. 15, 16. *Siphonodosaria australis*, sp. nov. Jemmy's Point. 15. Holotype. × 33. 16. Apertural view of another specimen. × 50.
- Fig. 17 a-c. *Rotalia hamiltonensis*, sp. nov. Holotype. Forsyth's, Grange Burn. a, dorsal view; b, ventral view; c, edge view. All × 39.
- Fig. 18 a-c. *Cancris philippinensis* (Cushman). Marl overlying *Lepidocyclina* limestone, west side of Grange Burn, opposite Henty's. a, dorsal view; b, ventral view; c, edge view. All × 39.
- Fig. 19 a-c. *Planulina kalimnensis*, sp. nov. Holotype. Jemmy's Point. a, dorsal view; b, ventral view; c, edge view. All × 39.
- Fig. 20. *Nonion victoriense* Cushman. Jemmy's Point. × 36.
- Fig. 21. *Elphidium pseudonodosum* Cushman. McDonald's, Muddy Creek. × 23.
- Fig. 22. *E. imperatrix* (Brady). Jemmy's Point. × 34.
- Fig. 23. *Massilina lapidigera* (Howchin and Parr). Jemmy's Point. × 16.
- Fig. 24 a, b. *Flintina intermedia* (Howchin). McDonald's, Muddy Creek. a, side view; b, apertural view. × 13.
- Fig. 25. *Fabularia howchini* Schlumberger. McDonald's, Muddy Creek. Worn specimen showing portion of longitudinal ridges subdividing partially eroded last chamber. × 16.

