SOME NEOGENE AND RECENT MARINE OSTRACODS FROM
SABAH, MALAYSIA

THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE
FACULTY OF SCIENCE,
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by

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SAMPLES FROM THE NEogene AND RECENT MARINE OSTRACODS FROM SABAH, MALAYSIA:
A thesis submitted for the degree of Doctor of Philosophy in
the Faculty of Science, University of Leicester by Manzoor Hasan.

ABSTRACT

Samples from the Neogene and Recent of Sabah, Malaysia,
have yielded 43 cladocopine, platycopine and podocopine ostracod
genera which are recorded and variously described. The genera
Polycope, Cytherelloidea and Atjehella are described in detail
and contain a total of 27 new species.

Polycope is recorded from this part of the world for the
first time. Newly discovered morphological structures suggest
that shell ornament may be a valuable aid (to soft parts) in
the taxonomy of the genus. The functional significance of many
ornamental features of the shell is probably as strengthening
devices.

Morphology of the marginal pore canals is particularly
useful in distinguishing the originally monotypic Atjehella.

The existing view, based on foraminifera (Whittaker &
Hodgkinson, 1979), that the Pliocene Togopi Formation of Sabah
was deposited in shallow marine conditions (inner shelf to
littoral) is substantiated by its ostracod fauna.

At specific level the ostracod assemblages of the Pliocene
Togopi Formation and Recent of Darvel Bay, Sabah are new; a
comparison of the ostracod fauna of Sabah to known ostracod faunas
from the Indian Ocean and adjacent areas (e.g. Western Australia,
Java-Sumatra, Burma, Western India and the Persian Gulf) reveals
a pattern of discrete faunal areas within a broadly defined Indo-
Pacific faunal province.
IN MEMORY OF

THE LATE PROFESSOR P.C. SYLVESTER-BRADLEY,
THIS THESIS IS HUMBLY DEDICATED.
ACKNOWLEDGMENTS

I would like to express my sincere thanks to everyone who has helped me in any way with my research.

I am especially indebted to the late Professor P. C. Sylvester-Bradley, to Dr. John D. Hudson and to Dr. David J. Siveter of the Department of Geology, University of Leicester for their supervision and encouragement.

My thanks are due to Dr. R. H. Bate and Dr. J. E. Whittaker of the British Museum (Natural History) for their great help in obtaining samples from the British Museum.

I owe a debt of gratitude to my colleague Dr. John Athersuch for invaluable discussions on many occasions.

My thanks go to Dr. J. Boxshall for access to the ostracod collection in the Zoology Department of the British Museum (N.H.).

I am most grateful to my former teacher Dr. Peter Marks for his assistance and gracious hospitality during my visit to the Geological Institute of the University of Utrecht, Holland. I am also particularly indebted to Dr. A. J. Keij for his hospitality and stimulating discussion during my visit to the Shell Petroleum's research centre in Rijswijk, Holland.

I would like to thank the departmental technical staff of Leicester University, particularly Mr. George L. C. McTurk for taking the scanning electron micrographs and for his great amiability throughout my work in this university.

Professor N. S. Haile of the University of Malaya kindly provided me with information and several important publications
on the Malaysian region. Herr Helmut Schmitz and Fraulein Elisabeth Blaschka were of great help in translating German papers into English.

Thanks to the relevant authorities of Leicester University for providing some financial support.

Finally, I would like to thank the staff of the Central Photographic Unit of Leicester University for copying plates.
In this thesis the plates illustrating the species of *Polycope*, *Cyperelloidea* and *Atjehella* have been made according to the format of the *Stereo-Atlas of Ostracod Shells*, but since the Atlas size is larger than this volume, each plate has been cut in half and presented on consecutive pages.
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CHAPTER I

INTRODUCTION

Purpose of the present study

Works on ostracods from Indonesian-Malaysian region are not plentiful. Pyan (1916, Pliocene of Timor) was the first to describe ostracods from the region. Other workers are Doeglas (1931, Neogene of NE Kalimanta, Borneo), Le Roy (1941, Neogene of Sumatra), Kingma (1948, Neogene of North Sumatra and Java), Keij (1964, Neogene of Malaysian Borneo). More recently Keij (December, 1979) has published on the Neogene to Holocene genus Atjehella.

Since little work has been done there was the possibility of finding something new and worthwhile from the ostracod studies in these regions. Recent material from Darvel Bay, Sabah, Malaysia was made available by the British Museum (Nat. Hist.). The late Professor P. C. Sylvester-Bradley suggested the study.

The Pliocene Togopi Formation of eastern Sabah has been investigated by Whittaker and Hodgkinson (1979) for foraminifera. Since the Togopi River section is adjacent to Darvel Bay, Togopi ostracod material has been added to the present study in the hope of relating the palaeontology to the Recent ostracod fauna of the region. Togopi material was also made available by the British Museum (Nat. Hist.).

From the ostracod assemblages, three genera (Polycope, Atjehella and Cytherelloidea) were chosen for detailed study. The reason for choosing Polycope was that it yielded nineteen new species and no other genus found in the assemblages showed
Fig. 1 Location of the study area and the stratigraphy of the eastern part of the Dent Peninsula, Sabah (after Whittaker & Hodgkinson 1979).
so much species diversity. Moreover, it is the first study of the genus from the region. Atjehella was chosen because Kingma's (1948) genus is morphologically unusual and was monospecific until December 1979 when Dr. A. J. Keij introduced five new species into the literature. Cytherelloidea is a platycop e whose very highly ornate representatives are particularly characteristic of South East Asia.

The present work further includes a comparative study to establish the nature of the faunal affinities of the ostracod assemblages with the context of known Indo-Pacific ostracod faunas.

**Source of material**

The Recent Darvel Bay material from Sabah, Malaysia was collected by HMS Dampier in 1961, 1962, 1963 and 1965 and was deposited in the British Museum (Nat. Hist., London). Altogether 75 bottom samples from Darvel Bay (see Appendix A, figs. 3 and 4) were processed and studied at Leicester University.

In 1961 Dr. N. S. Haile collected 18 samples from the type area of the Togopi Formation. Eight of these samples were made available for this study from the Togopi River section (fig. 2).
The British Museum (NH) samples studied are:

- NB 9456/9457
- NB 9454
- NB 9452
- NB 9460
- NB 9450
- NB 9449
- NB 9447
- NB 9446

A review of previous work

There is no record of any previous ostracod studies from Darvel Bay, Sabah, Malaysia or from the Togopi Formation of the Dent Peninsula, Sabah, Malaysia.

However, previous work on ostracods in the Indonesian-Malaysian region has been done by Payan (1916), Doeglas (1931), Le Roy (1939, 1941), Kingma (1948), Van den Bold (1950, Recent of Sumatra, Indonesia) and Keij (1964). Keij's other work was published in 1954 and deals with ostracods from Manila (Philippines). Most recently Keij (December, 1979) has described five new species of Atjehella from the Indo-westpacific region. Of all these works Kingma's (1948) contribution is the most important; in this work he described six new genera, including
Fig. 2 Map of the upper Togopi River Section, eastern Dent Peninsula, Sabah, showing the location of samples (after Whittaker & Hodgkinson 1979).
the genus *Atiheella*.

After Brady's (1869) description of the species *Cytherella cingulata* ( = *Cytherelloidea cingulata* (Brady) ) from Hong Kong, Le Roy (1941) published the first major paper on *Cytherelloidea* from the East Indies. Keij (1964) later published a paper on *Cytherelloidea* from the Indo-Malaysian region.

**Terminology**

Ostracod terminology used here is primarily that of Sylvester-Bradley and Benson (1971) and in some cases Moore (1961).

A new term is proposed for a prominent volcano-like surface structure present in *Polycope*. The term coined is *vulcanus* (*P. vulcanus* plate B, fig. 1), plural (*vulcani*). Derivation of the word is from Latin *vulcanus*, meaning volcanic. Volcani are described from the following species of *Polycope*:

*Polycope carticula* sp. nov.
*P. olivosa* sp. nov.
*P. peltata* sp. nov.
*P. vulcana* sp. nov.

**Repository**

All the type and other figured specimens have been deposited in the British Museum (Nat. Hist.), London, and their registered numbers are cited in the plate explanations.
Map based on the Admiralty chart No. 1680

FIG 3. Map of Darvel Bay Sabah Showing the location of Samples
Fig. 4 Texture of sediments in Darvel Bay, Sabah.

- Clay
- Silt
- Fine sand
Methods

75 wet samples from Darvel Bay were processed by the author; an outline of the methods used in the preparation of samples and specimens is given below.

Most of the samples were washed in hot water and passed through a 200-mesh (aperture: 75 microns) sieve. The residue left on the sieve was dried at 100°C. In cases where the clay samples were plastic, a weak solution of hydrogen peroxide was used. The sediment was then washed in hot water.

The processed samples were sprinkled onto a black tray and examined under a Zeiss 'Stereo-II' binocular microscope. By using a moistened 'O' squirrel hair brush the specimens were removed and placed in cardboard slides.

The preparation of specimens for the Scanning Electron Microscope (S.E.M. hereafter) investigation involved cleaning individual specimens thoroughly in water and immersion in acetone.

The specimens were then mounted on rivet-shaped S.E.M. aluminium stubs using 'Kodaf lat' adhesive. A very thin coating of Kodaf lat was given for a smooth background to the specimen.

Thermal evaporation was used in coating specimens with aluminium in a N.G.N. 12" coating unit, with a planetary specimen holder.

After coating, the specimens were photographed at 0° and 10° on the S.E.M., so that stereoscopic pairs could be made.

Most of the scanning electron microscopy was done on the International Scientific Instruments' 60 model (ISI-60), but some was carried out using the Cambridge Instruments 'Stereoscan Mk II'. Both instruments are at the University of Leicester.
The length of each specimen has been recorded by using a Zeiss 'Stereo-II' binocular microscope fitted with a calibrated eyepiece graticule.

Transmitted light microscopy: The marginal pore canal systems of Atjehella species were examined in transmitted light. Specimens immersed in glycerine, were viewed under a Zeiss photo-microscope. The photographs were taken using Pan-X 35 mm. monochrome film.

The Togopi Formation material was received from the British Museum (N.H.) in processed condition and only ostracods were found in it. Whittaker & Hodgkinson (1979) have mentioned that "the dry clay samples were disaggregated by boiling in a weak solution of hydrogen peroxide. The sediment was washed through a series of sieves, the finest being 200 mesh (aperture : 75 microns), and dried". They also mentioned that the friable limestones (NB 9446 and NB 9448) were crushed and washed.
CHAPTER II

BIOSTRATIGRAPHY OF THE TOGOPI FORMATION

Stratigraphy of the Dent Group

The Dent Group of the eastern Dent Peninsula, Sabah comprises in ascending order, the Sebahat, Ganduman and Togopi Formations. The Dent Group has a thickness of 14000 ft. (4300 m) comprising a mainly marine sequence of predominantly clastic sediments with subordinate limestones. It unconformably overlies the Miocene Segama Group.

The Sebahat Formation is estimated by Haile, Wong & Nuttall (1965, p.74) to be over 7500 ft. thick. The Ganduman Formation has a thickness of 5000 ft. The Togopi Formation is itself overlain with slight unconformity by about 100 ft. of Quaternary terrace and Recent river alluvium (fig. 1). Structurally the area consists of a broad anticlinal uplift, trending ENE, down the centre of the peninsula, off which the three formations dip gently in a more or less conformable sequence.

Haile, Wong and Nuttall (1965, p.80) recorded that the Togopi Formation consists of loosely cemented reef-limestone, calcareous sandstone, clay and marl, with a well preserved, rich fauna of molluscs, echinoids, foraminifera and corals.

The Togopi Formation has a curved outcrop 2 to 3 miles wide, convex to the east, extending from Tambisan Island in the north to Sungai Merah in the South, in the extreme eastern part of the Dent Peninsula. The type locality and section is in the Togopi River, and few exposures are known elsewhere. The formation has a shallow dip (usually under 10 degrees) towards the north-east, east and south-east, around the nose of the Sebahat Anticline.
Palaeoecology and age of the Togopi Formation

Whittaker and Hodgkinson (1979) described 119 benthic and six planktonic foraminifera species. Of the 119 benthic foraminifera species, the following 15 now extinct species have been found in the Togopi Formation:

- **Nummulites** cf. *amplicuneatus*
- **Nummulites** tamanensis
- **Amphistegina** cf. *wanneriana*
- **Asterorotalia** inspinosa
- **Brizalina** amygdalaesformis *iokiensis*
- **Cellanthus** adelaidensis
- **Ammonia** togopiensis sp. nov.
- **Cribroronion** tikutoensis
- **Pseudeponides** japonicus
- **Pseudorotalia** catilliformis
- **Bolivina** sabahensis sp. nov.*
- **Cellanthus** biperforatus sp. nov.*
- **Cellanthus** hailei sp. nov.*
- **Cribroelphidium** dentense sp. nov.*
- **Textilina** subrectangularis sp. nov.*

*Species known only from the Togopi Formation (presumed extinct).

Whittaker and Hodgkinson have analysed their finding in detail in order to establish a correct picture on the palaeoecology and age of the Togopi Formation. Several of the above-mentioned, extinct foraminifera species are found to be of great importance, such as **Nummulites tamanensis** (its only previous record is from the Miocene of Trinidad). **Amphistegina** cf. *wanneriana* has been previously reported only from the Pliocene of Ceram and Soemba,
Indonesia. Whittaker & Hodgkinson observed further that *Brizalina amygdaelectris iokiensis*, *Asterorotalia inspinosa* and *Gellanthus adelaidensis* occur in the Togopi Formation with some frequency. These species have all been described often by other workers, and do not appear to have been found in post-Pliocene sediments.

Whittaker & Hodgkinson mention that they applied a biometric method to species of *Operculina ammonoides* (Schroter) and *Nummulites cf. ampicuneatus* (Cole), and both were determined to belong to the Upper Pliocene. These results may be good evidence that sample NB 9452, if not the whole of the Formation, is of that age.

On the basis of their study, Whittaker & Hodgkinson concluded that the Togopi Formation was deposited under shallow marine conditions (inner shelf to littoral). They have reassessed the age of the Togopi Formation to be mainly Pliocene although its upper part could perhaps be slightly younger.

The Pliocene Togopi ostracods *Cytherelloidea cingulata* (Brady), *Cytherelloidea curvata* sp. nov. and *Cytherelloidea sabahensis* Keij all dwell in shallow marine waters at the present day.

Keij (1964) observed that *Cytherelloidea cingulata* (Brady) is found in the inner and middle neritic bottom samples of the Borneo offshore material; which is also found in the shallow waters of Darvel Bay. He further noted the distribution of *Cytherelloidea sabahensis* in waters from 54-113 metres depth off Sabah — between Big Bonanza Shoal and Pulau Mangalum.

Regarding the genus *Atjehella*, Keij (1979) has mentioned that the present day species of this genus are found in the inner
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**Fig. 5**  The distribution of foraminifera species (extinct) and Cytherelloides species in successive samples from the Togopi Formation. Sample numbers are arranged in ascending stratigraphical order, left to right. (Foraminifera data from Whittaker & Hodgkinson, 1979.)
shelf bottoms between the coastline and approximately 100 metres depth.

All these findings on the above-mentioned *Cytherelloidea* species and the genus *Atjehella* thus substantiate the view of Whittaker and Hodgkinson (1979) regarding the depth conditions (inner shelf to littoral) of formation of the Togopi Formation.

Figures 5 and 6 show the distribution of foraminifera (extinct species) with *Cytherelloidea* and *Atjehella* species during the Pliocene 'Togopi time'.

The species *Cytherelloidea cordata* sp. nov., *Cytherelloidea curvata* sp. nov., *Atjehella apoxeia* sp. nov. and *Atjehella reticulata* sp. nov. although only found in the Togopi Formation, should not be used as stratigraphic markers for the time being. More work in the Neogene and Recent of adjacent areas of the Indo-Malaysian region is necessary to determine the range of the four species. However, it is to be noted that these new species have not been found in the Recent of Darvel Bay.
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Fig.6 The distribution of foraminifera species (extinct) and Atjehella species in successive samples from the Togopi Formation. Sample numbers are arranged in ascending stratigraphical order, left to right. (Foraminifera data from Whittaker & Hodgkinson, 1979.)
CHAPTER III

GENERAL SYSTEMATICS OF THE SABAH OSTRACOD FAUNA

1) The taxonomic position of ostracods from the Togopi Formation and Darvel Bay:

ORDER PODOCOPIDA G.W. Mueller, 1894

Suborder CLADOCOPA Sars, 1866  
Family Polycopidae Sars, 1866  
Genus Polycope Sars, 1866  
P. spp. (see chapter IV)

Suborder PLATYCPA Sars, 1866

Family Cytherellidae Sars, 1866

Genus Cytherella Jones, 1849  
C. semitalis Brady, 1868 (DB Pl. 8, figs. 3-4)  
C. spp. A, B, C (TF Pl. 12, figs. 1-4; DB Pl. 8, figs. 1-2)

Genus Cytherelloidea Alexander, 1929  
C. spp. (see chapter V)

Suborder PODOCOPA Sars, 1866

Family Cyprididae Baird, 1850

Genus Paracypris Sars, 1866  
P. cf. zealndica (Brady, 1880) (DB Pl. 15, figs. 1-2)

Genus Phlyctenophora Brady, 1880  
P. cf. zealndica Brady, 1880 (TF Pl. 22, figs. 1-2; DB Pl. 16, figs. 1-2)

Family Cytheridae Baird, 1850

Genus Atjehella Kingma, 1948  
A. spp. (see chapter VI)

Genus Bythoceratina Hornibrook, 1952  
B. spp. A, B (TF Pl. 7, figs. 1-2; DB Pl. 4, figs. 1-2)

Genus Bythocythere Sars, 1866
Genus *Cushmanidea* Blake, 1933

*C.* sp. (TF Pl. 11, figs. 1-2)

Genus *Cyprideis* Jones, 1857

*C.* sp. (DB Pl. 7, figs. 1-2)

Genus *Clithrocytheridea* Stephenson, 1936

*C.* *spinulosa* (Brady, 1868) (DB Pl. 5, figs. 3-4)

Genus *Cythere* Mueller, 1785

*C'cribriformis* Brady, 1866 (TF Pl. 11, figs. 3-4; DB Pl. 7, figs. 3-4)

Genus *Hemicytheridea* Kingma, 1948

*H.* *reticulata* Kingma, 1948 (TF Pl. 14, figs. 1-2; DB Pl. 10, figs. 3-4)

Genus *Hemikrithe* van den Bold, 1950

*H.* sp. (DB Pl. 11, figs. 1-2)

Genus *Neocytheretta* van Morkhoven, 1963

*N.* sp. (TF Pl. 19, figs. 1-2)

*N.* *snelli* (Kingma, 1948) (DB Pl. 14, figs. 1-2)

Genus *Neomonoceratina* Kingma, 1948

*N.* *columbiformis* Kingma, 1948 (TF Pl. 19, figs. 3-4)

*N.* cf. *entomon* (Brady, 1890) (TF Pl. 20, figs. 1-2)

*N.* *koenigswaldei* Keij, 1954 (TF Pl. 20, figs. 3-4)

*N.* spp. A, B (TF Pl. 21, figs. 1-2; DB Pl. 14, figs. 3-4)

Genus *Paracytheridea* Mueller, 1894

*P.* *remanei* Hartmann, 1964 (TF Pl. 21, figs. 3-4)

*P.* cf. *remanei* Hartmann, 1964 (DB Pl. 15, figs. 3-4)

Genus *Uroleberis* Treibel 1958

*U.* sp. (TF Pl. 23, figs. 3-4; DB Pl. 18, figs. 1-2)

Family Bairdiidae Sars, 1868

'Bairdia' spp. A, B, C, D, E, F, G, H, I (TF Pls. 2-5; DB Pls. 2-3)

Family Cytheruridae Mueller, 1894

Genus *Cytheropteron* Sars, 1866

*C.* spp. A, B, C (TF Pl. 13, figs. 1-2; DB Pl. 9, figs. 3-4, Pl. 10, figs. 1-2)
Genus **Cytherura** Sars, 1866

* C. sp. (DB Pl. 9, figs. 1-2)

**Family Loxoconchidae** Sars, 1925

Genus **Loxoconcha** Sars, 1866

* L. spp. A, B (TF Pl. 16, figs. 1-2; DB Pl. 12)

Genus **Loxoconchella** Triebel, 1954

* L. anomala (Brady) (TF Pl. 16, figs. 3-4)
* L. spp. A, B (TF Pl. 17, figs. 1-2; DB Pl. 12, figs. 2-3)

Genus **Loxocormiculum** Benson & Coleman, 1963

* L. sp. (DB Pl. 13, figs. 1-2)

**Family Trachyleberididae** Sylvester-Bradley, 1948

Genus **Actinocythereis** Puri, 1953

* A. cf. *scutigera* (Brady, 1868) (TF Pl. 1, figs. 1-2; DB Pl. 1, figs. 1-2)

Genus **Alocopocythere** Siddiqui, 1971

* A. reticulata indoaustralica* Hartmann, 1978 (TF Pl. 1, figs. 3-4; DB Pl. 1, figs. 3-4)

Genus **Brachycythere** Alexander, 1933

* B. spp. A, B (TF Pl. 6, figs. 1-4)

Genus **Carinocythereis** Ruggieri, 1956

* C. spp. (TF Pl. 9, figs. 1-4; DB Pl. 5, figs. 3-4)

Genus **Chrysoocythere** Ruggieri, 1961

* C. sp. (TF Pl. 10, figs. 3-4)

Genus **Falsocythere** Ruggieri 1972

* F. sp. (TF Pl. 13, figs. 3-4)

Genus **Keijella** Ruggieri, 1967

* K. sp. (TF Pl. 14, figs. 3-4; DB Pl. 11, figs. 3-4)

Genus **Lankacythere** Bhatia & Kumar, 1979

* L. sp. (TF Pl. 15, figs. 1-4)
Genus *Ruggiera* Keij, 1957
R. sp. (DB Pl. 17, figs. 1-2)

Genus *Trachyleberis* Brady, 1898
T. sp. (DB Pl. 17, figs. 3-4)

Family Hemicytheridae Puri, 1953

Genus *Aurila* Pokorny, 1955
A. sp. (TP Pl. 2, figs. 1-2)

Genus *Bradleya* Hornibrook, 1952
B. sp. (DB Pl. 3, figs. 3-4)

Genus *Caudites* Coryell & Fields, 1937
C. sp. (DB Pl. 6, figs. 1-2)
C. cf. javana Kingma, 1948 (TP Pl. 10, figs. 1-2)

Genus *Mutilus* Neviani, 1928
M. spp. A, B, C (TP Pls. 17-18; DB Pl. 13, figs. 3-4)

Genus *Pseudocycthereis* Skogsberg, 1928
P. sp. (DB Pl. 16, figs. 3-4)

Genus *Quadracythere* Hornibrook, 1952
Q. sp. (TP Pl. 22, figs. 3-4)

Family Leptocytheridae Hanai, 1957

Genus *Callistocythere* Ruggieri, 1953
C. spp. A, B (TP Pl. 8, figs. 1-4)

Genus *Leptocythere* Sars, 1928
L. sp. (TP Pl. 15, figs. 3-4)

Genus *Tanella* Kingma, 1948
T. sp. (TP Pl. 23, figs. 1-2)
2) **Main morphological characteristics of the Sabah ostracod genera**:

The following represents an outline of the taxonomic position and general morphological characteristics (modified mainly after Moore, 1961 and Morkhoven, 1963) of all but three of the ostracod genera recorded from the Sabah samples. It is not intended to be a formal diagnosis of each, the strict delimitation of which would require further studies outside the scope of the present work. *Polycone, Cytherelloidea* and *Atjehella* are discussed in more detail in other chapters of the thesis.

**Family Cytherellidae**

**Genus Cytherella**:

The shape is elongate-ovate. Widest posteriorly. Anterior end usually evenly rounded. Valves either smooth or punctate and ridges are missing. Central muscle scars typically 'feather'-shaped.

**Family Cyprididae**

**Genus Paracypris**:

Valve elongate, wedge-shaped, tapering to pointed posterior. Large anterior and posterior vestibula present. Rounded sparsely scattered subdued puncta on the shell surface.

**Genus Phlyctenophora**:


**Family Cytheridae**

**Genus Bythoceratina**:

Dorsal and ventral margins of the valve are subparallel.
Posterior end is provided with a subdorsal caudal process. Valve bearing a sharp ventrolateral spine in the posterior half. Median region carinate. The valve surface is punctate. Hinge is merodont and crenulate. Five adductor muscle scars forming an arcuate group with a sixth scar above them.

Genus Bythocythere:

Dorsal and ventral margins of the valve are subparallel. Valve surface is punctate and subdued carinae are present. Median hinge element is smooth. An arcuate group of five adductor muscle-scar is present.

Genus Cushmanidea:

Valve rounded at both ends. Ventral margin concave. Shell surface ornamented with rounded to elongate fossae with papillate muri. Inner lamella widest anteriorly. Hinge merodont with elongate anterior groove in the left valve which accommodates the elongate corresponding tooth of the right valve.

Genus Cyprideis:


Genus Clithrocytheridea:

Dorsal and ventral margin of the valve nearly straight and converging towards the posterior end. Valve surface coarsely punctate. Mid-anterior and antero-ventral margins dentate.
Merodont hinge; all elements are crenulate, the terminal elements more coarsely so than the median element. Eye spot absent.

Genus Cythere:

Valve elongate, ornamented with "basket-like ponticulate tegmen bearing conjunctive spines and ingrowing spines edging fossae". Inner lamella widest anteriorly. Hinge merodont. Adductor muscle scars in a row of four, with crescent shaped antennal scar in front of uppermost adductor and oval mandibular scar in front of lower adductor.

Genus Hemicytheridea:

In lateral view the valves are elongate in outline. Postero-dorsal cardinal angle prominent. Anterior end broader than posterior. Heavily, reticulate throughout with rounded and elliptical fossae. Inner lamella moderately wide anteriorly. Hinge amphidont.

Genus Hemikrithe:

Valves elongate. Anterior end evenly rounded. Dorsal margin nearly straight, converging posteriorly. Valve surface covered with subrounded to elliptical fossae. Inner lamella very broad at anterior. Inner margin and line of concrescence coincide everywhere except in the central-anterior region where the line of concrescence makes a conspicuous loop towards the outer margin. Hinge is merodont. Eye spot absent.

Genus Neocytheretta:

Valve in lateral view elongate-ovate. Anterior end broadly
rounded. Marginal border ridged and standing vertically. In the posterior half the valves have irregular tubercles arranged approximately into three horizontal lines. The upper row projects over the dorsal margin. A prominent subcentral tubercle is present. Inner lamella very wide throughout; the course of inner margin very irregular. Hinge amphidont. A vertical row of four adductor muscle scar and a subcircular frontal scar are present. They are situated in the internal subcentral depression. Eye spot prominent.

Genus Neomonoceratina:

Dorsal margin of the valve straight, ventral outline somewhat variable. Posterior end of the valve with prominent caudal process which is situated above the middle. Pronounced vertical subcentral sulcus on the valve divide it into two inflated parts. Fossil pattern rectangular to subrounded. Hinge amphidont (schizodont-type) with split anterior teeth, middle element crenulate.

Genus Paracytheridea:

Valve elongate with rounded anterior and pointed posterior extremities. Carinate ala strongly developed. Surface heavily ornamented with tubercles. Fossil pattern irregular and the surface is foveolate. Inner lamella moderately wide. The median hinge element is crenulated.

Genus Uroleberis:

Valve with strongly convex dorsal margin. Posterior end with a caudal process. Anterior end rounded. Surface of the valve covered with rounded to elliptical puncta. Hinge merodont.
In the right valve terminal teeth are crenulate; toothlets are highest distally. Shallow eye pit on inside; externally the eye spot is weakly developed. Muscle scars in a vertical row of four with a curved antennal scar in front.

Family Bairdiidae

Valve ovate to subhexagonal in lateral view. Surface smooth or punctate. Right valve hinge a simple bar with dorsal groove, left valve hinge an incised groove with dorsal shelf and ventroterminal triangular sloping platforms. Adductor muscle-scar pattern characteristically composed of 8-10 scars. Hinge element simple, consisting of a straight groove in the left valve into which fits the dorsal edge of the right one.

Family Cytheruridae

Genus Cythereopteron:

Valve with caudal process and lateral wing-like expansions are present. Surface of the valve smooth to punctate. Inner lamella moderately wide at anterior. Hinge is merodont, median hinge element crenulate. The hinge is relatively strongly developed and curved. Eye spot is absent; the animal has no eyes (Morkoven, 1963).

Genus Cytherura:

Valve oblong-reniform in lateral view. The anterior end broadly rounded, the posterior end drawn out into a weak caudal process. Valve surface covered with fine raised lines. In the mid-anterior region some rounded fossae are present. Inner lamella is narrow.
Family Loxoconchidae

Genus Loxoconcha:
  Valve rhomboidal, anterior end rounded. Surface punctate. Puncta arranged in more or less concentric rows. The inner lamella wide anteriorly. Hinge amphidont. Four adductor muscle scars in a row. A frontal scar is also present. A low eye spot is present.

Genus Loxoconchella:
  Valve subrhomboidal in lateral view with distinct blunt caudal process above the middle. Surface smooth but with sparsely distributed fine pits of normal pore canals. Muscle scar in a row of four adductors and a frontal scar. Hinge adont. Eye spot very low.

Genus Loxocorniculum:

Family Trachyleberididae

Genus Actinocythereis:
  Valve subrectangular; anterior margin more rounded than the posterior. Three subparallel rows of spines on the valve surface. Hinge amphidont.

Genus Aloocopocythere:
  Valve sub-ovate; anterior region more broad than the posterior
region. Surface sculptured by subrounded fossae. Fossae enlarge towards the anterior periphery. Mural pores are visible. Sub-central tubercle present. Anterior and posterior cardinal angles well developed. Hinge amphidont.

Genus **Brachycythere**:


Genus **Carinocythereis**:

Valve subrectangular in lateral view. Dorsal and ventral margins nearly straight but slightly converging towards the posterior end. Anterior end broadly rounded. Shell surface heavily ornamented with longitudinal ridges, small tubercles, spines and reticulations. Anterior and posterior vestibules well developed. Four adductor muscle scars in a vertical row with a frontal curved muscle scar. Eye spot prominent. Hinge amphidont.

Genus **Chrysocythere**:

Valve elongate and highest at the anterior cardinal angle. Dorsal and ventral margin converging posteriorly. Anterior end rounded. Shell surface with rounded to subrounded puncta and longitudinal subdued ridges are present. Marginal denticulations at anterior and posterior margins. Eye tubercle present. Numerous normal pore canals are seen from the internal side of the valve. Hinge amphidont.
Genus *Keijella* :

Valve oblong-ovate. Surface ornamented with rounded to elongate pits which diminish in the anterior part. In the postero-ventral margin pronounced spine is seen. Central muscle scars with a vertical row of four adductors and a frontal scar. Terminal hinge elements elongate.

Genus *Lankacythere* :

Valve subquadrate; dorsal margin undulating. Anterior margin broadly and obliquely rounded. Surface ornamented with rounded to subrounded deep fossae. An ear-shaped ridge on the postero-ventral side which slightly overhangs the postero-ventral margin. Anterior and posterior margins dentate. A vertical row of four adductor muscle scars and a big frontal scar are present.

Genus *Ruggieria* :

Valve elongate-ovate and ornamented with longitudinal ridges. Pitted surface reticulations are less in the anterior region. Carina is continuous in the ventral part. Anterior and posterior margins bear spines. A vertical row of four adductor muscle scars and a frontal scar are present. Hinge amphidont.

Genus *Trachyleberis* :

Valve subrectangular in outline, tapering posteriorly. Anterior end rounded. Shell surface bears mamillate spines, some are bifurcated. Small tubercles are also present. The central muscle scar area has four adductors and a frontal V-shaped scar. These scars are all situated in a depression
on the internal surface of the valve. Hinge is amphidont.

Family Hemicytheridae

Genus *Aurila*:

Genus *Bradleya*:
Valve subrectangular in outline with longitudinal ridges. Subcentral tubercle present but not well developed. Of all the ridges, ventral ridge is most strongly developed. Surface ornamented with dense puncta. Eye tubercle is situated just below the anterior cardinal angle.

Genus *Caudites*:
Valve elongate, anterior end rounded; posterior end drawn out ventrally. Prominent dorsal cardinal angles. Ridges run longitudinally on the valve surface. Caudal process is strongly developed. Eye tubercle lie below the anterior cardinal angle. Inner lamella of moderate width. Hinge is amphidont.

Genus *Mutilus*:
Valve subquadrate. Anterior end broadly rounded, posterior end with a postero-ventral caudal prolongation. Surface covered with densely populated puncta. Inner lamella of medium width. Hinge amphidont. Eye spot is weakly developed.
Genus *Pseudocythereis*:

Valve ovate, surface entirely covered with reticulation consisting of small elongate pits arranged more or less in concentric rows. Anterior end broader than posterior and bear small spines. The central muscle scars consist of a row of four vertical scars and a frontal scar. Inner lamella of moderate width. Hinge amphidont; median hinge amphidont; median hinge element crenulated. Eye spot present.

Genus *Quadracythere*:

Valve subquadrate with posterodorsal and postero-ventral projecting ornamental ridges. Anterior end broadly rounded, posterior end with a postero-ventral caudal process. Shell surface ornamented with rounded to subrounded puncta. Inner lamella of medium width. Hinge amphidont; posterior tooth in right valve is weakly lobed.

Family *Leptocytheridae*

Genus *Callistocythere*:

Valve elongate, Anterior end slightly broader than posterior. Posterodorsal cardinal angle prominent. Maximum height equal to about half the length, in anterior end. Anterior end more broadly rounded than the posterior. Surface reticulate with peripheral ridges. Inner lamella wide in anterior region. Eye spot very weakly developed. Hinge amphidont.

Genus *Leptocythere*:

Valve elongate. Broadly rounded anterior end. Rounded to elliptical fossae well developed. A concentric reticulation
pattern is present in the antero-dorsal region. Small caudal process is developed at the postero-ventral region. Inner lamella widest anteriorly and posteroventrally. Anterior vestibulum is well developed. Hinge is amphidont. The anteromedian hinge element consists of a single tooth.

Genus Tanella:


INDETERMINATE GENERA

Genus A (family Trachyleberididae):

Genus A (Togopi Formation Pl. 24, figs. 1-2) is unique in having irregular shaped fossae and thick muri. Postero-dorsal region bears small tubercles. The anterior periphery bears several deep puncta. It has some affinity with Allocoptocythere in the general shape and the arrangement of the puncta in anterior region.

Genus B (family Cytheridae):

Genus B (Togopi Formation Pl. 24, figs. 3-4) has closer affinity with the genus Occultocythereis but differs in the absence of an eye tubercle and surface reticulation pattern. The reticulate fossae of Genus B have ingrowing spines. It
probably represents a new genus.

Genus C (family Cytheruridae):

Genus C (Darvel Bay Pl. 18, figs. 3-4) has some affinity with the genus Cytheropteron but it has a weakly developed eye spot. In Cytheropteron no eye spot is developed because "the animal has no eyes" (Morkhoven, 1963). Furthermore Genus C has irregularly dentate anterior and posterior margins and lacks a caudal process, it is probably a new genus.

Genus D (family Trachyleberididae):

Genus D (Darvel Bay Pl. 19, figs. 1-2) is unique in its arrangement of fossal pattern. It has one set of longitudinal arrangement of fossae in the median to anterior region. The other set has vertical arrangement of fossae in the posterior region. This genus has some morphological similarity with Ruggieria.

Genus E (family Cytheridae):

Genus E (Darvel Bay Pl. 19, figs. 3-4) has close resemblance with the genus Pterygocythereis but differs in not having an eye spot. Also the muscle scar pattern is different from Pterygocythereis, in which there are four adductors with a frontal scar; but in the Genus E some seven muscle scar spots are visible in the central muscle scar region. The Sabah material probably represents a new genus.
Ostracods from the Togopi Formation:

Explanation of Plate 1

Fig. 1 Actinocythereis sp. c.f. A. scutigera (Brady),
right valve, ext. lat. (OS10204) (x75)

Fig. 2 Actinocythereis sp. c.f. A. scutigera (Brady),
right valve, int. lat. (OS10204) (x76)

Fig. 3 Alocopocythere reticulata indoaustralica Hartmann,
right valve, ext. lat. (OS10157) (x95)

Fig. 4 Alocopocythere reticulata indoaustralica Hartmann,
right valve, int. lat. (OS10157) (x96)
Ostracods from the Togopi Formation:

Explanation of Plate 2

Fig. 1 *Aurila* sp., right valve, ext. lat. (OS10158) (x125)

Fig. 2 *Aurila* sp., right valve, int. lat. (OS10158) (x128)

Fig. 3 'Bairdia' sp. A, right valve, ext. lat. (OS10159) (x75)

Fig. 4 'Bairdia' sp. A, right valve, int. lat. (OS10159) (x75)
Ostracods from the Togopi Formation:

Explanation of Plate 3

Fig. 1 'Bairdia' sp. B, left valve, ext. lat.  
(OS10160) (x95)

Fig. 2 'Bairdia' sp. B left valve, int. lat.  
(OS10160) (x92)

Fig. 3 'Bairdia' sp. C, left valve, ext. lat.  
(OS10161) (x81)

Fig. 4 'Bairdia' sp. C, left valve, int. lat.  
(OS10161) (x81)
Ostracods from the Togopi Formation:

Explanation of Plate 4

Fig. 1 'Bairdia' sp. D, right valve, ext. lat.  
(OS10162) (x81)

Fig. 2 'Bairdia' sp. D, right valve, int. lat.  
(OS10162) (x83)

Fig. 3 'Bairdia' sp. E, right valve, ext. lat.  
(OS10163) (x48)

Fig. 4 'Bairdia' sp. E, right valve, int. lat.  
(OS10163) (x48)
Ostracods from the Togopi Formation:

Explanation of Plate 5

Fig. 1 'Bairdia' sp. P, left valve, ext. lat.
(OS10164) (x47)

Fig. 2 'Bairdia' sp. P, left valve, int. lat.
(OS10164) (x47)

Fig. 3 'Bairdia' sp. G, right valve, ext. lat.
(OS10165) (x132)

Fig. 4 'Bairdia' sp. G, right valve, int. lat.
(OS10165) (x134)
Ostracods from the Togopi Formation:

Explanation of Plate 6

Fig. 1 *Brachycythere* sp. A, left valve, ext. lat.  
(OS10166) (x116)

Fig. 2 *Brachycythere* sp. A, left valve, int. lat.  
(OS10166) (x115)

Fig. 3 *Brachycythere* sp. B, left valve, ext. lat.  
(OS10167) (x110)

Fig. 4 *Brachycythere* sp. B, left valve, int. lat.  
(OS10167) (x115)
Ostracods from the Togopi Formation:

Explanation of Plate 7

Fig. 1 **Bythoceratina** sp. A, right valve, ext. lat.  
(OS10168) (x140)

Fig. 2 **Bythoceratina** sp. A, right valve, int. lat.  
(OS10168) (x140)

Fig. 3 **Bythocythere** sp. A, left valve, ext. lat.  
(OS10169) (x119)

Fig. 4 **Bythocythere** sp. A, left valve, int. lat.  
(OS10169) (x123)
Ostracods from the Togopi Formation:

Explanation of Plate 8

Fig. 1 Callistocythere sp. A, left valve, ext. lat.
(OS10170) (x166)

Fig. 2 Callistocythere sp. A, left valve, int. lat.
(OS10170) (x164)

Fig. 3 Callistocythere sp. B, left valve, ext. lat.
(OS10171) (x109)

Fig. 4 Callistocythere sp. B, left valve, int. lat.
(OS10171) (x109)
Ostracods from the Togopi Formation:

Explanation of Plate 9

Fig. 1 Carinocythereis sp. A, right valve, ext. lat.  
(OS10172) (x99)

Fig. 2 Carinocythereis sp. A, right valve, int. lat.  
(OS10172) (x101)

Fig. 3 Carinocythereis sp. B, left valve, ext. lat.  
(OS10173) (x155)

Fig. 4 Carinocythereis sp. B, left valve, int. lat.  
(OS10173) (x157)
Ostracods from the Togopi Formation:

Explanations of Plate 10

Fig. 1 Caudites cf. C. javana Kingma, right valve, ext. lat. (OS10174) (x138)

Fig. 2 Caudites cf. C javana Kingma, right valve, int. lat. (OS10174) (x136)

Fig. 3 Chrysocythere sp., right valve, ext. lat. (OS10175) (x115)

Fig. 4 Chrysocythere sp., right valve, int. lat. (OS10175) (x116)
Ostracods from the Togopi Formation:

Explanation of Plate 11

Fig. 1 *Cushmanidea* sp. , left valve, ext. lat.
(OS10176) (x118)

Fig. 2 *Cushmanidea* sp., left valve, int. lat.
(OS10176) (x116)

Fig. 3 'Cythere' *cribiformis* Brady, right valve,
ext. lat. (OS10177) (x107)

Fig. 4 'Cythere' *cribiformis* Brady, right valve,
int. lat. (OS10177) (x115)
Ostracods from the Togopi Formation:

Explanation of Plate 12

Fig. 1 *Cytherella* sp. A, right valve, ext. lat.
(OS10178) (x147)

Fig. 2 *Cytherella* sp. A, right valve, int. lat.
(OS10178) (x149)

Fig. 3 *Cytherella* sp. B, right valve, ext. lat.
(OS10179) (x124)

Fig. 4 *Cytherella* sp. B, right valve, int. lat.
(OS10179) (x123)
Ostracods from the Togopi Formation:

Explanation of Plate 13

Fig. 1 Cytheropteron sp. A, right valve, ext. lat.
(0S10180) (x164)

Fig. 2 Cytheropteron sp. A, right valve, int. lat.
(0S10180) (x164)

Fig. 3 Palsocythere sp., left valve, ext. lat.
(0S10181) (x136)

Fig. 4 Palsocythere sp., left valve, int. lat.
(0S10181) (x138)
Ostracods from the Togopi Formation:

Explanation of Plate 14

Fig. 1 *Hemicytheridea reticulata* Kingma, right valve, ext. lat. (OS10182) (x103)

Fig. 2 *Hemicytheridea reticulata* Kingma, right valve, int. lat. (OS10182) (x101)

Fig. 3 *Keijella* sp., left valve, ext. lat. (OS10183) (x91)

Fig. 4 *Keijella* sp., left valve, int. lat. (OS10183) (x92)
Ostracods from the Togopi Formation:

Explanation of Plate 15

**Fig. 1** *Lankacythere* sp., right valve, ext. lat.
(OS10184) (x99)

**Fig. 2** *Lankacythere* sp., right valve, int. lat.
(OS10184) (x98)

**Fig. 3** *Leptocythere* sp., left valve, ext. lat.
(OS10185) (x97)

**Fig. 4** *Leptocythere* sp., left valve, int. lat.
(OS10185) (x99)
Ostracods from the Togopi Formation:

Explanation of Plate 16

Fig. 1 *Loxoconcha* sp. A, left valve, ext. lat.  
(0S10186) (x140)

Fig. 2 *Loxoconcha* sp. A, left valve, int. lat.  
(0S10186) (x140)

Fig. 3 *Loxoconchella anomala* (Brady), right valve,  
ext. lat. (0S10187) (x128)

Fig. 4 *Loxoconchella anomala* (Brady), right valve,  
int. lat. (0S10187) (x126)
Ostracods from the Togopi Formation:

Explanation of Plate 17

Fig. 1  *Loxoconchella* sp. A, left valve, ext. lat.  
(OS10188) (x134)

Fig. 2  *Loxoconchella* sp. A, left valve, int. lat.  
(OS10188) (x138)

Fig. 3  *Mutilus* sp. A, right valve, ext. lat.  
(OS10189) (x134)

Fig. 4  *Mutilus* sp. A, right valve, int. lat.  
(OS10189) (x134)
Ostracods from the Togopi Formation:

Explanation of Plate 18

Fig. 1 *Mutilus* sp. B, right valve, ext. lat.
(OS10190) (x105)

Fig. 2 *Mutilus* sp. B, right valve, int. lat.
(OS10190) (x104)

Fig. 3 *Mutilus* sp. C, left valve, ext. lat.
(OS10191) (x110)

Fig. 4 *Mutilus* sp. C, left valve, int. lat.
(OS10191) (x110)
Ostracods from the Togopi Formation:

Explanation of Plate 19

Fig. 1 Neocytheretta sp., left valve, ext. lat.  
(OS10192) (x111)

Fig. 2 Neocytheretta sp., left valve, int. lat.  
(OS10192) (x113)

Fig. 3 Neomonoceratina columbiformis Kingma, right valve,  
ext. lat. (OS10193) (x147)

Fig. 4 Neomonoceratina columbiformis Kingma, right valve,  
int. lat. (OS10193) (x149)
Ostracods from the Togopi Formation:

Explanation of Plate 20

Fig. 1 *Neomonoceratina cf. N. entomon* (Brady),
right valve, ext. lat. (OS10194) (x98)

Fig. 2 *Neomonoceratina cf. N. entomon* (Brady),
right valve, int. lat. (OS10194) (x95)

Fig. 3 *Neomonoceratina koenigswaldi* Keij, left valve,
ext. lat. (OS10195) (x128)

Fig. 4 *Neomonoceratina koenigswaldi* Keij, left valve,
int. lat. (OS10195) (x126)
Ostracods from the Togopi Formation:

Explanation of Plate 21

Fig. 1  *Neomonoceratina* sp. A, left valve, ext. lat.  
       (OS10196) (x132)

Fig. 2  *Neomonoceratina* sp. A, left valve, int. lat.  
       (OS10196) (x134)

Fig. 3  *Paracytheridea remanei* Hartmann, right valve,  
       ext. lat. (OS10197) (x130)

Fig. 4  *Paracytheridea remanei* Hartmann, right valve,  
       int. lat. (OS10197) (x128)
Ostracods from the Togopi Formation:

Explanation of Plate 22

Fig. 1  *Phlyctenophora* cf. *P. zealandica* Brady,
left valve, ext. lat. (OS10198) (x70)

Fig. 2  *Phlyctenophora* cf. *P. zealandica* Brady,
left valve, int. lat. (OS10198) (x69)

Fig. 3  *Quadracythere* sp., right valve, ext. lat.
(OS10199) (x124)

Fig. 4  *Quadracythere* sp., right valve, int. lat.
(OS10199) (x123)
Ostracods from the Togopi Formation:

Explanation of Plate 23

Fig. 1 *Tanella* sp., right valve, ext. lat.  
(OS10200) (x86)

Fig. 2 *Tanella* sp., right valve, int. lat.  
(OS10200) (x84)

Fig. 3 *Uroleberis* sp., right valve, ext. lat.  
(OS10201) (x145)

Fig. 4 *Uroleberis* sp., right valve, int. lat.  
(OS10201) (x143)
Ostracods from the Togopi Formation:

Explanation of Plate 24

Fig. 1 Indet. Genus A sp., right valve, ext. lat.  
(0S10202) (x139)

Fig. 2 Indet. Genus A sp., right valve, int. lat.  
(0S10202) (x138)

Fig. 3 Indet. Genus B sp., right valve, ext. lat.  
(0S10203) (x134)

Fig. 4 Indet. Genus B sp., right valve, int. lat.  
(0S10203) (x134)
Ostracods from Darvel Bay:

Explanation of Plate 1

Fig. 1 *Actinocythereis* cf. *A. scutigera* (Brady),
left valve, ext. lat. (OS10205) (x72)

Fig. 2 *Actinocythereis* cf. *A. scutigera* (Brady),
left valve, int. lat. (OS10205) (x71)

Fig. 3 *Alocopocythere reticulata indoaustralica* Hartmann,
left valve, ext. lat. (OS10206) (x88)

Fig. 4 *Alocopocythere reticulata indoaustralica* Hartmann,
left valve, int. lat. (OS10206) (x87)
Ostracods from Darvel Bay:

Explanation of Plate 2

Fig. 1 'Bairdia' sp. E, right valve, ext. lat.  
(OS10207) (x58)

Fig. 2 'Bairdia' sp. E, right valve, int. lat.  
(OS10207) (x60)

Fig. 3 'Bairdia' sp. H, right valve, ext. lat.  
(OS10208) (x134)

Fig. 4 'Bairdia' sp. H, right valve, int. lat.  
(OS10208) (x136)
Ostracods from Darvel Bay:

Explanation of Plate 3

Fig. 1 'Bairdia' sp. I, left valve, ext. lat.
(OS10209) (x77)

Fig. 2 'Bairdia' sp. I, left valve, int. lat.
(OS10209) (x78)

Fig. 3 Bradleya sp., left valve, ext. lat.
(OS10210) (x134)

Fig. 4 Bradleya sp., left valve, int. lat.
(OS10210) (x132)
Ostracods from Darvel Bay:

Explanation of Plate 4

Fig. 1  *Bythoceratina* sp. B, right valve, ext. lat.  
(OS10211) (x93)

Fig. 2  *Bythoceratina* sp. B, right valve, int. lat.  
(OS10211) (x92)

Fig. 3  *Bythocythere* sp. B, left valve, ext. lat.  
(OS10212) (x113)

Fig. 4  *Bythocythere* sp. B, left valve, int. lat.  
(OS10212) (x115)
Ostracods from Darvel Bay:

Explanation of Plate 5

Fig. 1 *Bythocythere* sp. C, right valve, ext. lat.
(OS10213) (x184)

Fig. 2 *Bythocythere* sp. C, right valve, int. lat.
(OS10213) (x179)

Fig. 3 *Carinocythereis* sp.C, left valve, ext. lat.
(OS10214) (x159)

Fig. 4 *Carinocythereis* sp. C, left valve, int. lat.
(OS10214) (x157)
Ostracods from Darvel Bay:

Explanation of Plate 6

Fig. 1 *Caudites* sp., car., ext. lat.
(OS10215) (x123)

Fig. 2 *Caudites* sp., car., ext. dors.
(OS10215) (x123)

Fig. 3 *Clithrocytheridea spinulosa* (Brady), left valve,
ext. lat. (OS10216) (x130)

Fig. 4 *Clithrocytheridea spinulosa* (Brady), left valve,
int. lat. (OS10216) (x128)
Ostracods from Darvel Bay:

Explanation of Plate 7

Fig. 1 *Cyprideis* sp., right valve, ext. lat.
(0S10217) (x166)

Fig. 2 *Cyprideis* sp., right valve, int. lat.
(0S10217) (x168)

Fig. 3 'Cythere' *cribriformis* Brady, right valve,
ext. lat. (0S10218) (x92)

Fig. 4 'Cythere' *cribriformis* Brady, right valve,
int. lat. (0S10216) (x91)
Ostracods from Darvel Bay:

Explanation of Plate 8

Fig. 1  *Cytherella* sp. C, right valve, ext. lat.
      (OS10219) (x105)

Fig. 2  *Cytherella* sp. C, right valve, int. lat.
      (OS10219) (x107)

Fig. 3  *Cytherella* semitalis Brady, right valve, ext. lat.
      (OS10220) (x106)

Fig. 4  *Cytherella* semitalis Brady, right valve, int. lat.
      (OS10220) (x107)
Ostracods from Darvel Bay:

Explanation of Plate 9

Fig. 1 *Cytherura* sp., right valve, ext. lat.
(0S10221) (x128)

Fig. 2 *Cytherura* sp., right valve, int. lat.
(0S10221) (x128)

Fig. 3 *Cytheropteron* sp. B, right valve, ext. lat.
(0S10222) (x138)

Fig. 4 *Cytheropteron* sp. B, right valve, int. lat.
(0S10222) (x140)
Ostracods from Darvel Bay:

Explanation of Plate 10

Fig. 1  *Cytheropteron* sp. C, left valve, ext. lat.  
       (OS10223) (x119)

Fig. 2  *Cytheropteron* sp. C, left valve, int. lat.  
       (OS10223) (x117)

Fig. 3  *Hemicytheridea reticulata* Kingma, right valve,  
       ext. lat. (OS10224) (x98)

Fig. 4  *Hemicytheridea reticulata* Kingma, right valve,  
       int. lat. (OS10224) (x98)
Ostracods from Darvel Bay:

Explanation of Plate 11

Fig. 1 Hemikrithe sp., left valve, ext. lat.  
(OS10225) (x134)

Fig. 2 Hemikrithe sp., left valve, int. lat.  
(OS10225) (x136)

Fig. 3 Keijella sp., left valve, ext. lat.  
(OS10226) (x93)

Fig. 4 Keijella sp., left valve, int. lat.  
(OS10226) (x95)
Ostracods from Darvel Bay:

Explanation of Plate 12

Fig. 1 *Loxoconcha* sp. B, left valve, ext. lat.
(The specimen was lost after the SEM micrograph was taken) (x147)

Fig. 2 *Loxoconchella* sp. B, right valve, ext. lat.
(OS10227) (x159)

Fig. 3 *Loxoconchella* sp. B, right valve, int. lat.
(OS10227) (x155)
Ostracods from Darvel Bay:

Explanation of Plate 13

Fig. 1  *Loxocomiculum* sp., right valve, ext. lat.
       (OS10228) (x179)

Fig. 2  *Loxocomiculum* sp., right valve, int. lat.
       (OS10228) (x184)

Fig. 3  *Mutilus* sp. A, left valve, ext. lat.
       (OS10229) (x155)

Fig. 4  *Mutilus* sp. A, left valve, int. lat.
       (OS10229) (x157)
Ostracods from Darvel Bay:

Explanation of Plate 14

Fig. 1 *Neocytheretta snelli* (Kingma), left valve, ext. lat. (OS10230) (x104)

Fig. 2 *Neocytheretta snelli* (Kingma), left valve, int. lat. (OS10230) (x105)

Fig. 3 *Neomonoceratina* sp. B, left valve, ext. lat. (OS10231) (x126)

Fig. 4 *Neomonoceratina* sp. B, left valve, int. lat. (OS10231) (x124)
Ostracods from Darvel Bay:

Explanation of Plate 15

Fig. 1  *Paracypris* cf. *P. zealandica* (Brady), right valve, ext. lat. (OS10232) (x57)

Fig. 2  *Paracypris* cf. *P. zealandica* (Brady), right valve, int. lat. (OS10232) (x56)

Fig. 3  *Paracytheridea* cf. *P. remanei* Hartmann, left valve, ext. lat. (OS10233) (x109)

Fig. 4  *Paracytheridea* cf. *P. remanei* Hartmann, left valve, int. lat. (OS10233) (x112)
Ostracods from Darvel Bay:

Explanation of Plate 16

Fig. 1 *Phlyctenophora* cf. *P. zealandica* Brady, left valve, ext. lat. (OS10234) (x65)

Fig. 2 *Phlyctenophora* cf. *P. zealandica* Brady, left valve, int. lat. (OS10234) (x66)

Fig. 3 *Pseudocythereis* sp., left valve, ext. lat. (OS10235) (x120)

Fig. 4 *Pseudocythereis* sp., left valve, int. lat. (OS10235) (x120)
Ostracods from Darvel Bay:

Explanation of Plate 17

Fig. 1  *Ruggieria* sp., right valve, ext. lat.
       (OS10236) (x100)

Fig. 2  *Ruggieria* sp., right valve, int. lat.
       (OS10236) (x101)

Fig. 3  *Trachyleberis* sp., right valve, ext. lat.
       (OS10237) (x95)

Fig. 4  *Trachyleberis* sp., right valve, int. lat.
       (OS10237) (x96)
Ostracods from Darvel Bay:

Explanation of Plate 18

Fig. 1 *Uroleberis* sp., right valve, ext. lat.

(0S10238) (x134)

Fig. 2 *Uroleberis* sp., right valve, int. lat.

(0S10238) (x134)

Fig. 3 Indet. Genus C sp., left valve,

ext. lat. (0S10239) (x132)

Fig. 4 Indet. Genus C. sp., left valve,

int. lat. (0S10239) (x134)
Ostracods from Darvel Bay:

Explanation of Plate 19

Fig. 1 Indet. Genus D sp., right valve, 
ext. lat. (OS10240) (x111)

Fig. 2 Indet. Genus D sp., right valve, 
int. lat. (OS10240) (x110)

Fig. 3 Indet. Genus E sp., left valve, ext. lat. 
(OS10241) (x97)

Fig. 4 Indet. Genus E sp., left valve, int. lat. 
(OS10241) (x96)
CHAPTER IV

The genus Polycopé Sars, 1866

The identity of the type-species and the genus:

The genus Polycopé was proposed by G. O. Sars in 1866 and was based on P. orbicularis Sars from the Recent off Norway.

In order to study the type-species P. orbicularis Sars, 1866, relevant material was borrowed from Oslo Museum by Dr. John Athersuch (then at Leicester University). Unfortunately the material was poorly preserved and no recognisable specimens were found in the collection (Dr. Athersuch, personal communication). It was then thought that a neotype of Polycopé orbicularis should be chosen from Scandinavian waters. Dr. David Siveter personally tried at several sources to get Scandinavian material for the purpose but unfortunately without success. For the time being the desirable revision of Polycopé orbicularis, including the selection of a neotype, can not be undertaken; the morphological nature of the genus is, however, not in doubt.

In an attempt to locate Polycopé orbicularis material in the zoological collection of the British Museum (Natural History), Norwegian material collected in 1878 was examined by the present author by SEM but was found to be a different species of Polycopé. The description and illustration of this congeneric material from Norway is included in this thesis for the purpose of general interest.

Polycopé is the type genus of the family Polycopidae. The
other genera, erected primarily on the basis of soft parts, belonging to the family Polycopidae are Polycopsis Sars, 1923; Parapolycope Klie, 1936 and Metapolycope Kornicker & Van Morkhoven, 1976. These genera have only a few known species. Metapolycope has quite a different muscle-scar pattern from Polycope. In Metapolycope the central adductor muscle-scars are composed of nine individual scars forming one-half of a rosette. Polycopsis is closest to Polycope but differs by not having inflated shells.

On the bases of the inflated nature of the shells and three central adductor muscle-scar pattern all the species belonging to the family Polycopidae found in Darvel Bay are assigned to Polycope.

Occurrence of Polycope:

The genus is exclusively marine and is found at all depths. Polycope has been found in abundance in the coastal waters in Europe, but this abundance may be the result of the relatively large number of studies made in this region. Fossil Polycope species recorded from the Pleistocene (Brady, Crosskey & Robertson, 1874), Cretaceous (Bate, 1969) and Jurassic (Apostolescu, 1959 and Blake, 1876) include Polycope orbicularis (Pleistocene; Great Britain), Polycope fungosa Bate (Cretaceous; Great Britain), Polycope decorata Apostolescu (Liassic; France), Polycope cerasia Blake (Liassic; Great Britain).

In addition to the earlier descriptions of some Recent Polycope species, such as P. punctata Sars, 1870, P. dispar G. S. Mueller, 1894, P. areolata Sars, 1923, P. clathrata Sars, 1923, and P. difficulis Klie, 1936 other workers who have
described Recent species of *Polycope* in some detail include: Hartmann, G., 1954 (off the coast of Brazil); Kornicker, L. S., 1959 (from the Bahamas); Barbeito-Gonzalez, P. J., 1971 (from Naxos, Greece); Sissingh, W., 1972 (from South Aegean Island Arc.); Bonaduce, G., Ciampo, G. and Masoli, M., 1975 (from the Adriatic Sea) and Breman, E., 1976 (from the Adriatic Sea. All the species described by these workers are from the Western hemisphere. No previous record of any *Polycope* from the Indo-Malaysian region has been found.

Sabah *Polycope* (a) Informal groupings based on ornament:

From the study of Darvel Bay *Polycope* species several groups of *Polycope* can be recognized on the basis of ornamentation:

**Group A - Punctate:**

- *Polycope* *caverna* sp. nov.
- *P. foraminosa* sp. nov.

**Group B - Reticulate:**

- *Polycope* *regina* sp. nov.
- *P. retia* sp. nov.
- *P. spongia* sp. nov.
- *P. transenna* sp. nov.

**Group C - Heavily carinate:**

- *Polycope* *burostrata* sp. nov.
- *P. clivosa* sp. nov.
- *P. lacinia* sp. nov.
- *P. lacunis* sp. nov.
P. lira sp. nov.
P. monilia sp. nov.
P. vulcana sp. nov.

Group D - Carinate and reticulate:

Polycope arenula sp. nov.
P. carticula sp. nov.
P. choane sp. nov.
P. fistula sp. nov.
P. peltata sp. nov.
P. rama sp. nov.

*Polycope* species described from the western hemisphere in general are less ornamented and mainly have punctate and rather weakly developed reticulate pattern of ornamentations. Heavily carinate, carinate and reticulate species of *Polycope* are more characteristic of the Sabah material. With additional study based on soft parts, these informal groupings may form the basis of formal subgenera.

(b) Observations on the functional significance of ornament in *Polycope*:

Scanning electron microscopy has revealed several undescribed external surface features in some *Polycope* species. In *P. vulcana* sp. nov., prominent growth of volcano-like structures occurs (Pl. A, fig. 3; Pl. B, fig. 1). In *P. regina* sp. nov., between the postero-dorsal and mid-posterior regions "flower-bud"-like growths can be observed (Pl. A, fig. 3); their position and growth is consistent in many valves.

*Polycope lira* sp. nov. shows a slightly deflexed, lirate
posterior spine (Pl. B, fig. 3); the ridges on this spine have the appearance of being thrown up by a plough. Similar lirate structures have been observed on the rostrum of _P. burostrata_ sp. nov. (Pl. D, fig. 3), a species which has, in addition, strutted carinae (Pl. D, figs. 1-2). In _P. lacinia_ sp. nov., the rostrum has a unique, thin, flap-like feature (Pl. A, fig. 2) which is supported by the heavier rostral growth. Grill-like second-order reticulation has been observed in _P. carticula_ sp. nov. (Pl. D, figs. 2-3). _P. fistula_ sp. nov. is distinctive; a broken carina has revealed a tunnel-like structure inside (Pl. B, figs. 1-2). Body fluid passing through these tubes could have been a device for resisting any externally induced stress.

Perhaps in _P. fistula_ sp. nov. the carinae are supporting a dome-like shell structure, as strengthening mechanisms (Pl. A, fig. 1). This ostracod structure may be related to known engineering principles as shown by Benson (1975, p. 39, fig. 19). In this structure it is "assumed that the material used has much less tensile strength than compressive strength" (Benson, 1975, p.39).

The function of the vulcanus structure in several species of _Polycope_ is presumed to be defensive, serving to ward off minute predators, or perhaps to extend sensory setae.

The lirate structures in _Polycope lira_ and _Polycope burostrata_ and the strutted carinae in _P. burostrata_ are examples of "design solutions" (Benson, 1974, p. 56) for increasing the strength or stability in their shells. The lirate structures in the spine of _P. lira_ (Pl. B, fig. 3) and in the rostrum of _P. burostrata_ (Pl. D, figs. 1-2) have given increasing strength
to the projecting spine and rostrum (respectively) in the form of supporting beams. In *P. burostrata* the struts are acting like supporting columns for the carinae.

It is probable that certain other surface features have a functional significance. Examples include rimmed pores in *P. monilia* (Pl. B, fig. 1), dendritic and anastomosing ridges in *P. choane* (Pl. A, figs. 1-2); grill-like second-order reticulation in *P. carticula* and a flap-like feature supported by a heavier rostral growth in *P. lacinia*. However it is not clear, in all cases, what the significance may be. The primary role of these features is believed to be as strengthening mechanisms.

Benson (1974, p. 53) has noted that "the ostracode carapace has an inherent pattern of shell-forming cells combined with a sensory nerve pattern". The shells of most of the species of *Polycope* in Darvel Bay are highly ornate and the ornament may be genetically controlled.

(c) Abundance of *Polycope* in Sabah:

The abundance of *Polycope* in the Recent sediments of Darvel Bay and its absence in the Pliocene Togopi Formation is somewhat puzzling. *Polycope* in the Scandinavian waters were found to live on sandy bottoms covered with a thin layer of silt (Sars, 1923). In the Mediterranean area the genus has been found in silt, fine sand and medium sand substrates (Bonaduce, Ciampo & Masoli, 1975). In Darvel Bay *Polycope* has been found both in silt and clay substrates. Haile, Wong and Nuttall (1965, p. 80) recorded a limey facies for the Togopi Formation consisting of "loosely cemented reef limestone, calcareous sandstone, clay and
It is probable that the species of *Polycope* which are living today in the Darvel Bay area have a preference for a non-limey facies. However, Komicker (1959) described *Polycope bahamaensis* from a "substrate consisting of rock covered by 2 feet of calcareous sand supporting patchy growths of Thalassia grass and alga Laurencia".

It may also be noted in connection with the absence of *Polycope* in the Togopi Formation that shells of many *Polycope* species are not strongly calcified, and for this reason they are not readily preserved.

Naming of the *Polycope* species from Sabah:

In this thesis all Darvel Bay *Polycope* species have been given new names. Even in a few cases where there is only one valve, because the specimen in question is morphologically so distinct it is felt confident that such specimens should be treated under new names rather than open nomenclature.

**Systematic descriptions**

Suborder Cladocopida [nom. correct. Sylvester-Bradley 1961]

Family Polycopidae Sars, 1866

Genus *Polycope* Sars, 1866

Type-species: *Polycope orbicularis* Sars, 1866

General Generic description (modified after Van Morkhoven, 1963):

Valves are ovoid to sub-circular and usually thinly calcified. Anterior rostrum is generally absent; if present it
may be weakly or strongly developed. The dorsal margin has an obtuse angle, and nearly straight short hinge-line. The hinge is adont.

A group of three individual muscle-scars form the main adductor muscle-scar area, and sometimes as many as five to six small spots have been observed above this adductor muscle-scar area (A study of the soft parts of those species bearing extra spots may reveal the nature of their origin).

Occasionally on the exterior lateral surface, a central depression with three spots marks the position of the main muscle-scars.

Normal pore-canals occur in all species and are of simple type; ducts reach the valve surface approximately at right angles. In some (Sabah) species several ornate features have been observed peripheral to the exterior terminals of normal pores. These form papillated loop-like pores (P. lacuntis sp. nov.), rimmed pores (P. monilia sp. nov.) and rimmed funnel pores (P. choane sp. nov.). In P. transenna sp. nov. normal pores have been surrounded by loop-like feature.

Eye spots are absent. Valves are subequal, the right valve is larger than the left. No sexual dimorphism has been observed.

Normally the marginal zone of the inner lamella is very narrow but in Polycope choane sp. nov. it has been found to be rather wide ventrally. The inner margin and line of concrescence diverge throughout. A few species are observed to have a prominent posterior external spine.

The ontogenic stages of Polycope:

There have been no ontogenetic studies of Polycope and because of the general lack of preadult valves the Sabah material did not lend itself to such treatment.
ON POLYCOPE ARENULA sp. nov.
by Manzoor Hasan
(University of Leicester, England)

Polycope arenula sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10128; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°38.5′N, long. 118°39.6′E; Recent.

Derivation of name: Latin, arenula, grain of sand; suggested by the sandy appearance of sola and muri caused by dense papillation.


Specimen OS10128 (holotype) was collected at 34 fathoms by HMS Dampier in 1965.

Diagnosis: Species of Polycope with rounded to subrounded fossae where the sola and muri are papillate. Several small spine-like projections are scattered over the postero-dorsal margin.

Remarks: Valve oval. Line of maximum length passes through the region of muscle-scar and line of maximum height lies just anterior to mid-length. Hinge line and the antero-dorsal margin forms a wide angle. Anterior process is protrusive. Immediately behind the smaller projections one prominent posterior spine is featured on the mid-posterior region. Muscle-scar outline is typical of the genus. Hinge is short.

Both the sola and muri are papillate in Polycope arenula.
sp. nov. and the nature of peripheral carinae is subdued, thus differentiating P. arenula sp. nov. from P. lira sp. nov. In addition, the stout, ridged spine at the mid-posterior region of P. lira is lacking in P. arenula.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope arenula sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10128, 317 μm long); fig. 2, RV, int. lat. (OS10128); fig. 3, RV, post. median to mid. post. region showing dense papillation on sola, muri and spines (holotype OS10128).

Scale A (100 μm; x 208), fig. 1; (100 μm; x 217), fig. 2; scale B (15 μm; x 832).
Polycope arenula sp. nov.

Explanation of Plate B

Fig. 1, RV, mid. post. region showing the prominent posterior spine (holotype OS10128); fig. 2, mid. vent. region showing subdued peripheral papillate carinae and the rounded to subrounded fossae (holotype OS10128); fig. 3, RV, the hinge (holotype OS10128).

Scale A (15 \mu m; x 808), fig. 1; scale B (15 \mu m; x 884), fig. 2; scale C (50 \mu m; x 393), fig. 3.
Polycope burostrata sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10125; LV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, bu, prefix meaning large and rostratus, beaked; suggested by the very prominent rostrum.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10125 (LV: Pl. A, fig. 2; Pl. B, fig. 1; Pl. C, fig. 3); OS10126 (LV: Pl. A, fig. 1; Pl. B, fig. 2; Pl. D, figs. 1-3).

Specimen OS10126 is from lat. 04°38.5'N, long. 118°39.6'E, collected at 34 fathoms; OS10125 (holotype) was collected at 40 fathoms. Both figured specimens are from Darvel Bay, Malaysia, collected in 1965 by HMS Dampier.

Diagnosis: Species of Polycope having four major carinae with struts. A stout and prominent rostrum with ridges and well formed rostral notch.

Remarks: Valve oval. Lines of maximum length and height pass through the mid-point. Basically rounded fossae and muri more or less uniformly developed over the shell surface. Carina on the antero-ventral to mid-anterior margin is widest. Hinge line and muscle-scar are typical of the genus. Carinae are strengthened throughout by strut-like supporting ridges. The large rostrum has a number of ridges.

In P. burostrata sp. nov. the trends of carinae are variable; in some they are subparallel (Pl. A, fig. 2) and in others they are oblique to the ventral margin (Pl. A, fig. 1).
The minor carina in the postero-ventral region can be continuous (Pl. A, fig. 2) and in others it can be discontinuous (Pl. A, fig. 1).

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
**Polycope burostrata** sp. nov.

Explanation of Plate A

Fig. 1, LV, ext. lat. (OS10126, 317 μm long);

fig. 2, LV, ext. lat. (holotype OS10125, 341 μm long).

Scale A (100 μm; x 221), fig. 1; scale B (100 μm; x 205), fig. 2.
**Polycpe burostrata** sp. nov.

**Explanation of Plate B**

Fig. 1, LV, int. lat. (holotype OS10125, 341 μm long); fig. 2, LV, dorsomedian to median region showing basically rounded fossae and excavate carinae (OS10126).

Scale A (100 μm; x 205), fig. 1; scale B (50 μm; x 421), fig. 2.
Polycpe burostrata sp. nov.

Explanation of Plate C

Figs. 1-2, LV, mid. vent. region showing carinae with supporting struts, and rounded fossae (holotype OS10125); fig. 3, LV, anterior oblique (holotype OS10125).

Scale A (20 /µm; x 769), fig. 1; scale B (10 /µm; x 1589), fig. 2; scale C (100 /µm; x 205), fig. 3.
Polycope burostrata sp. nov.

Explanation of Plate D

Figs. 1-2, LV, mid. ant. region showing the rostrum and strutted carinae (OS10126); fig. 3, LV, mid. ant. region showing the large rostrum with ridges (OS10126).

Scale A (30/μm; x 368), fig. 1; scale B (30/μm; x 663), fig. 2; scale C (30/μm; x 884), fig. 3.
Polycope carticula sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10107; LV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, carticula, gridiron; suggested by the grill-like second-order reticulation pattern on some fossae.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10107 (LV: Pl. A, figs. 2, 3; Pl. C, figs. 1-3; Pl. D, figs. 1-3); OS10108 (RV: Pl. A, fig. 1; Pl. B, fig. 3); OS10109 (LV: Pl. B, fig. 1).

All the specimens are Recent from Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; collected by HMS Dampier in 1965 at 40 fathoms.

Diagnosis: Shell bearing basically polygonal fossae. Second-order reticulation in fossae shows net-like and 'grill-like' patterns.

Remarks: Valve oval. The shell surface is covered by polygonal or irregularly shaped fossae. Second-order reticulation on the sola are generally net-like but many fossae bear a 'grill-like' pattern.

Marginal carina is well developed and widens distally to make an undercut carina. An inner, lateral, U-shaped carina is also present. In the mid-dorsal area this terminates at a vulcanus, the mouth of which is abundantly spined. Mid-posterior region has a pair of vulcani. Denticles are
present from mid-anterior to mid-ventral region.

Maximum height of the valve passes in front of the mid-length. Antero-dorsal marginal slope is steep.

Muscle-scar is typical of the genus. Hinge line and antero-dorsal margin forms a wide-angle.

Distribution: Known only from Recent, Darvel Bay, Malaysia.
Polycope carticula sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (OS10108, 268 μm long);
fig. 2, LV, ext. lat. (holotype OS10107, 268 μm long); fig. 3, LV, musc. sc. location as seen from external side of the shell (holotype OS10107).
Scale A (75 μm; x 205), fig. 1; scale B (75 μm; x 231), fig. 2; scale C (10 μm; x 1845), fig. 3.
Polycope carticula sp. nov.

Explanation of Plate B

Fig. 1, LV, int. lat. (OS10109, 268 µm long);
fig. 2, RV, int. lat. (OS10108); fig. 3, RV, int. musc. sc. (OS10108).

Scale A (75 µm; x 220), fig. 1; scale B (75 µm; x 227), fig. 2; scale C (15 µm; x 1089), fig. 3.
Polycope carticula sp. nov.

Explanation of Plate C

Figs. 1-2, LV, dorso-median region showing net-like and 'grill-like' second order reticulation pattern (holotype OS10107); fig. 3, LV, dorso-median region showing abundantly spined vulcanus (holotype OS10107).

Scale A (15 /um; x 1055), fig. 1; scale B (15 /um; x 977), fig. 2; scale C (5 /um; x 2541), fig. 3.
Polycope carticula sp. nov.

Explanation of Plate D

Fig. 1, LV, ext. median region showing the net-like reticulation pattern and the location of musc. sc. area (holotype OS10107); figs. 2-3, LV, dorso-median region with views of the 'grill-like' second-order reticulation pattern (holotype OS10107).

Scale A (15 μm; x 900), fig. 1; scale B (5 μm; x 2310), fig. 2; scale C (3 μm; x 5659), fig. 3.
Polycope caverna sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10131; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°38.5'N, long. 118°39.6'E; Recent.

Derivation of name: Latin, caverna, hollow; suggested by the dominant hollow spine.


Specimen OS10131 (holotype) was collected at 34 fathoms by HMS Dampier in 1965.

Diagnosis: Shell surface is covered by rounded or subrounded puncta. Antero-ventral to mid-ventral margins and mid-posterior region bear delicate carinae. A single stout, hollow spine is present on the postero-median region.

Remarks: Valve oval. Peripheral carina distinctly developed. Delicate ridges are also present on the posterior region. Anterior process bears a subdued rostrum. Line of maximum height lies anterior to the mid-length. Line of maximum length passes through the centrally located muscle-scar region. Normal pores, as seen from the internal view of the valve, are arranged more or less in concentric fashion throughout. Muscle-scar is typical of the genus. Hinge is short.

This new species differs from Polycope foraminosa sp. nov.
primarily in having a stout, hollow spine on the postero-median region.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope caverna sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10131, 561 μm long), fig. 2, RV, int. lat. (holotype OS10131);
fig. 3, RV, int. musc. sc. (holotype OS10131).

Scale A (150 μm; x 124), fig. 1; (150 μm; x 126),
fig. 2; scale B (25 μm; x 529), fig. 3.
Polycope caverna sp. nov.

Explanations of Plate B

Figs. 1-2, RV, post. med. region showing the hollow spine (holotype OS10131); fig. 3, RV, ext. median region showing the location of musc. sc. area and rounded to subrounded puncta (holotype OS10131).
Scale A (10 μm; x 1190), fig. 1; scale B (10 μm; x 1016), fig. 2; scale C (25 μm; x 434), fig. 3.
Polycupe choane sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10112; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°43.8′N, long. 118°32.7′E; Recent.

Derivation of name: Greek, choane, funnel-shaped hollow; suggested by the presence of funnel pores on the shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10112 (RV: Pl. A, fig. 1; Pl. B, figs. 1-3; Pl. C, figs. 1, 2; Pl. D, figs. 1-3); OS10113 (LV: Pl. A, fig. 1; Pl. C, fig. 3).

Specimen OS10112 (holotype) is from 222 ft., collected in 1962. Specimen OS10113 is from lat. 04°40.6′N, long. 118°35.3′E, from 35 fathoms, collected in 1965. Both figured specimens are Recent, from Darvel Bay, Malaysia, collected by HMS Dampier.

Diagnosis: Species of Polycupe with ornament consisting of delicate dendritic and anastomosing ridges which form characteristic scale-like pattern in the ventral region. Well developed funnel pores are scattered on the shell surface.

Remarks: Valve ovoid. Line of maximum length passes through the region of the muscle-scar. Line of maximum height lies anterior to the mid-length. Funnel pores are rimmed and each pore has a single aperture. However, one specimen (the holotype) has a double-pore in the mid-dorsal region; it is elongate with two apertures separated by a dividing wall.
Anterior process is well defined and protrusive. Hinge region is short and narrow. Muscle-scar is typical of the genus.

The inner lamella in *Polycope choane* sp. nov. is unique in being distinctly wide ventrally.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope choane sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10112, 439 μm long); fig. 2, LV, ext. lat. (OS10113, 390 μm long).

Scale A (100 μm; x 159), fig. 1; scale B (100 μm; x 189), fig. 2.
Polycope choane sp. nov.

Explanation of Plate B

Fig. 1, RV, int. lat. (holotype OS10112); figs. 2-3, RV, int. lat. musc. sc. (holotype OS10112).
Scale A (100 µm; x 166), fig. 1; scale B (25 µm; x 332), fig. 2; scale C (25 µm; x 664), fig. 3.
Polycope choane sp. nov.

Explanation of Plate C

Fig. 1, RV, rimmed funnel pore (holotype OS10112); fig. 2, RV (OS10112) and fig. 3, LV (OS10113) showing identical funnel pore positions in the mid-anterior regions.

Scale A (3 μm; x 5329), fig. 1; scale B (10 μm; x 914), fig. 2; scale C (10 μm; x 945), fig. 3.
Polycophe choane sp. nov.

Explanation of Plate D

Fig. 1, RV, post. vent. region showing scale-like pattern (holotype OS10112); figs. 2-3, RV, mid. dorsal region showing elongate double-pore (holotype OS10112).

Scale A (25 μm; x 664), fig. 1; scale B (5 μm; x 3232), fig. 2; scale C (25 μm; x 375), fig. 3.
Polycope clivosa sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10114; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, clivosus, hilly; suggested by the hilly appearance of the isolated carinae on the shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10114 (RV: Pl. A, figs. 1, 3; Pl. B, fig. 3); OS10115 (LV: Pl. A, fig. 2); OS10116 (RV: Pl. B, figs. 1, 2).

Both specimens OS10114 and OS10115 are from the type locality, collected at 40 fathoms in 1965; specimen OS10116 is from lat. 04°56.90'N, long. 118°14.00'E, collected at 114 ft. in 1961. All figured specimens are Recent, from Darvel Bay, Malaysia, collected by HMS Dampier.

Diagnosis: Species of Polycope with a continuous, peripheral carina from mid-dorsal to postero-ventral margin which has irregularly spaced pores; other carinae are shorter, irregularly shaped and randomly distributed forming isolated hillocks-like feature on the shell surface. Prominent, protrusive anterior margin.

Remarks: Lines of maximum length and maximum height pass through the mid-point. Prominent vulcanae are located in the postero-dorsal and mid-posterior region. Muri smooth; surfaces of carinae are papillate. The shell is thick. Hinge margin and the central muscle-scar are typical of the
genus. Dorsally above the central muscle-scar region 5 - 6 additional, rounded spots or pits are present. *Polycope clivosa* sp. nov. resembles *Polycope vulcana* sp. nov. in having several vulcani but differs from it in having a prominent, protrusive anterior margin. Also the irregularly spaced pores along the peripheral carina are lacking in *P. vulcana*.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
**Polycopelivosa** sp. nov.

**Explanation of Plate A**

Fig. 1, RV, ext. lat. (holotype OS10114, 317 /μm long); fig. 2, LV, ext. lat. (OS10115, 292 /μm long); fig. 3, RV, median and post. median region showing isolated hillocks-like feature (holotype OS10114).

Scale A (75 /μm; x 195), fig. 1; scale B (75 /μm; x 216), fig. 2; scale C (25 /μm; x 674), fig. 3.
Polycone clivosa sp. nov.

Explanation of Plate B

Fig. 1, RV, int. lat. (OS10116, 341 /μm long);
fig. 2, RV, int. musc. sc. (OS10116); fig. 3,
RV, int. musc. sc. (holotype OS10114).

Scale A (75 /μm; x 196), fig. 1; scale B (30 /μm;
x 380), fig. 2; scale C (45 /μm; x 320), fig. 3.
Polycope fistula sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10110; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, fistula, tube; suggested by the tube-like carina.


The holotype is from 40 fathoms, collected in 1965 by HMS Dampier.

Diagnosis: A tubular carina having an approximately circular pattern runs along the periphery except for the postero-dorsal marginal region. Several tubercles are present on the postero-dorsal valve edge. The sola are densely foveolate.

Remarks: Valve oval. Anterior rostrum prominent, situated in between antero-dorsal and mid-anterior region. On the outer edge of the mid-posterior area one complete spine is present and above this a base of another possible spine is also seen. The line of maximum height passes through the antero-median region. Mural pores are visible. The location of the muscle-scar can be easily identified on the external surface of the valve. Internally the muscle-scar is typical of the genus. Hinge is situated
between mid-dorsal and postero-dorsal margin.

This is a unique Polycome species where breakage of carinae has revealed their hollow, tubular nature.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycopa fistula sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10110, 390 μm long); fig. 2, RV, the spine on the outer edge of the mid-posterior area (holotype OS10110);
fig. 3, RV, int. lat. (holotype OS10110, 390 μm long).

Scale A (100 μm; x 179), fig. 1; scale B (10 μm; x 1288), fig. 2; scale C (100 μm; x 177), fig. 3.
**Polycope fistula** sp. nov.

**Explanation of Plate B**

Fig. 1, RV, postero-dorsally the inner carina is broken revealing the tunnel-like structure (holotype OS10110); fig. 2, RV, shows the densely foveolate sola and the breakage of mural wall shows another tunnel-type feature (holotype OS10110); fig. 3, RV, in the antero-median region the breakage of tubular carina shows its continuity with the pore canal system (holotype OS10110).

Scale A (10 μm; x 1201), fig. 1; scale B (10 μm; 1342), fig. 2; scale C (15 μm; x 633), fig. 3.
Polycope foraminosa sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10132; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°44.5'N, long. 118°30.0'E; Recent.

Derivation of name: Latin, foraminosus, full of holes; suggested by the puncta distributed over most of the shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10132 (RV: Pl. A, figs. 1, 2; Pl. B, fig. 1); OS10133 (LV: Pl. A, fig. 2; Pl. B, figs. 2, 3).

Specimen OS10132 (holotype) was collected from a depth of 34 fathoms; OS10133 is from lat. 04°40.2'N, long. 118°44.0'E, collected from 40 fathoms. Both figured specimens are from Darvel Bay, Malaysia, collected by HMS Dampier in 1965.

Diagnosis: Rounded or subrounded puncta uniformly cover most of the shell surface. On the mid-ventral margin several delicate carinae branch, each to form a Y-shaped pattern; the stem of the Y is directed away from the margin.

Remarks: Valve oval. Peripheral carina distinctly developed.

Anterior process bears a subdued rostrum. Line of maximum height lies anterior to the mid-length. Line of maximum length passes through the centrally located muscle-scar region. Several delicate carinae are present on the peripheral region. Muscle-scar is typical of the genus. Hinge is short.
Polycpe foraminosa sp. nov. differs from P. caverna sp. nov. in not having a mid-posterior hollow spine on the shell surface.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycpe foraminosa sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10132, 414 µm long); fig. 2, LV, ext. lat. (OS10133, 414 µm long); fig. 3, RV, ext. median region showing impression of the musc. sc. (holotype OS10132).

Scale A (100 µm; x 171), fig. 1; (100 µm; x 164), fig. 2; scale B (10 µm; x 1026), fig. 3.
Polycopé foraminosa sp. nov.

Explanation of Plate B

Fig. 1, RV, mid. vent. margin showing delicate Y-shaped carina (holotype OS10132); fig. 2, LV, int. musc. sc. (OS10133); fig. 3, LV, int. lat. (OS10133).

Scale A (15 μm; x 1026), fig. 1; scale B (15 μm x 659), fig. 2; scale C (100 μm; x 169), fig. 3.
Polycopelacinia sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10134; LV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, lacinia, flap; suggested by the flap-like rostrum.


Specimen OS10134 (holotype) was collected in 1965 from depth of 40 fathoms by HMS Dampier.

Diagnosis: Species of Polycopelacina with a broad, thin, flap-like rostrum. Three more or less continuous, excavate carinae on the shell surface, which are interconnected in the antero-dorsal and mid-anterior regions.

Remarks: Valve oval. Lines of maximum length and maximum height pass through the mid-point. Rounded to subrounded fossae with papillate muri. Carina on the peripheral margin is widest.

Polycopelacinia sp. nov. differs from Polycopelacina burostrata in not having carina with struts. Also the flap-like structure in the rostrum of P. lacinia is unique to that Polycopelacina species.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope lacinia sp. nov.

Explanation of Plate A

Fig. 1, LV, ext. lat. (holotype OS10134, 317 μm long); fig. 2, LV, flap-like structure in the rostrum (holotype OS10134); fig. 3, LV, dorso-median to vent. median region showing some discontinuity in the carinae (holotype OS10134).

Scale A (100 μm; x 224), fig. 1; scale B (25 μm; x 634), fig. 2; scale C (30 μm; x 336), fig. 3.
Polycpe lacinia sp. nov.

Explanation of Plate B

Fig. 1, LV, ant. med. region showing rounded to subrounded fossae with papillate muri (holotype OS10134); fig. 2, LV, median region showing heart-shaped carina (holotype OS10134); fig. 3, LV, mid. post. region showing excavate carinae (holotype OS10134).

Scale A (20 μm; x 672), fig. 1; (20 μm; x 672), fig. 2; (20 μm; x 672), fig. 3.
Polycope lacuntis sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10122; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, lacuntis, a pastry; suggested by the fancied resemblance of the shell ornament to a kind of pastry.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10122 (RV: Pl. A, figs. 1, 3; Pl. B, figs. 1-3); OS10123 (LV: Pl. A, fig. 2).

Both figured specimens are from the type locality at 40 fathoms, collected in 1965 by HMS Dampier.

Diagnosis: Species of Polycope with papillate, undercut, U-shaped carinae which bear papillate, loop-like pores.

Remarks: Valves oval, shell thick. Lines of maximum length and maximum height pass through the mid-point. Ventral to mid-anterior margin is denticulate. The U-shaped carinae on the shell surface have irregularly spaced, loop-like pores adjacent to their axes. The short hinge line and the antero-dorsal margin form a wide angle. Location of the central muscle-scar is visible externally. Internally the pattern of the central muscle-scar is typical of the genus. In addition, 5-6 pits are visible dorsally.

Polycope lacuntis sp. nov. differs from Polycope monilia
sp. nov. in having papillate undercut carinae with loop-like pores. Furthermore, *P. lacunis* has much less reticulation between major carinae than *P. monilia*.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope lacunis sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10122, 341 /um long); fig. 2, LV, ext. lat. (OS10123, 317 /um long); fig. 3, RV, ext. median region showing the location of the central musc. sc. (holotype OS10122).

Scale A (100 /um; x 185), fig. 1; (100 /um; x 198), fig. 2; scale B (25 /um; x 713), fig. 3.
Polycopla lacunata sp. nov.

Explanation of Plate B

Fig. 1, RV, ventro-median region showing double-looped-pore (holotype OS10122); fig. 2, RV, ventro-median to mid-vent. region showing loop-like pores from the axes of the carinae (holotype OS10122); fig. 3, RV, int. lat. (holotype OS10122).

Scale A (5 /um; x 2257), fig. 1; scale B (25 /um; x 390), fig. 2; scale C (100 /um; x 167), fig. 3.
**Polycope lira** sp. nov.

**Holotype**: Brit. Mus. (Nat. Hist.) no. OS10127; LV.

**Type locality**: Darvel Bay, Malaysia, lat. 04°38.5'N, long. 118°39.6'E; Recent.

**Derivation of name**: Latin, *lira*, ridge thrown up by the plough; suggested by the fancied resemblance of the surface appearance of the posterior spine.

**Figured specimen**: Brit. Mus. (Nat. Hist.) no. OS10127 (LV:
Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

Specimen OS10127 (holotype) was collected in 1965 at 34 fathoms by HMS Dampier.

**Diagnosis**: Species of *Polycope* with shell surface covered by fossae with papillate muri. A stout, slightly deflexed, ridged spine is situated at the mid-posterior region.

**Remarks**: Valve oval. Lines of maximum length and maximum height pass through the region of muscle-scar. Besides the well developed and rather irregular peripheral carina, several other less prominent discontinuous carinae are present on the shell surface. Fossae rounded. Hinge line and antero-dorsal margin forms a wide angle. Muscle-scar is typical of the genus and impression of the muscle-scar is visible externally. Hinge margin well developed.

The ridged (lirate) spine found in *Polycope lira* sp. nov. is unique among *Polycope* species.

**Distribution**: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycpe lira sp. nov.

Explanation of Plate A

Fig. 1, LV, ext. lat. (holotype OS10127, 317/μm long); fig. 2, LV, int. lat. (holotype OS10127).

Scale A (100/μm; x 205), fig. 1; (100/μm; x 195), fig. 2.
**Polycope lira** sp. nov.

**Explanation of Plate B**

Fig. 1, LV, dorsomedian to ventromedian region showing the location of musc. sc. and the papillate muri (holotype OS10127); fig. 2, LV, mid. post. to post. vent. region showing discontinuous carinae and the slightly deflexed spine (holotype OS10127); fig. 3, LV, mid. post. region showing the lirate spine (holotype OS10127).

Scale A (25 μm; x 615), fig. 1; scale B (25 μm; x 566), fig. 2; scale C (15 μm; x 1153), fig. 3.
Polycope monilia sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10121; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, monilis, necklace; suggested by the fancied resemblance of the carina to a necklace.


The specimen was collected from 40 fathoms by HMS Dampier in 1965.

Diagnosis: Species of Polycope having a marginal carina with denticles and an inner excavate carina with apophyses.

Remarks: Valve oval. Lines of maximum length and height pass through the mid-point. Midanterior to ventral margin denticulate. Two carinae are present on the shell surface. Apophytic growths from the inner carina lead to rimmed pores. The hinge line and the anterodorsal margin form a wide angle. The central muscle-scar region is typical of the genus. Above the central muscle-scars, 5 other pits are visible dorsally. The hinge area is typical of the genus.

Polycope monilia sp. nov. differs from P. lacunis sp. nov. in having excavate carinae.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope monilia sp. nov.

Explanatio of Plate A

Fig. 1, RV, ext. lat. (holotype OS10121, 317 μm long); fig. 2, RV, int. lat. (holotype OS10121); fig. 3, RV, ext. median region showing the location of musc. sc. area (holotype OS10121).

Scale A (100 μm; x 189), fig. 1; (100 μm; x 198), fig. 2; scale B (25 μm; x 630), fig. 3.
**Polycope monilia** sp. nov.

**Explanation of Plate B**

Fig. 1, RV, papillate, rimmed pore on the ant. vent. region (holotype OS10121); fig. 2, RV, ant. vent. region showing apophytic growths from the carina leading to rimmed pores (holotype OS10121); fig. 3, RV, int. musc. sc. (holotype OS10121).

Scale A (5 μm; x 3591), fig. 1; scale B (25 μm; x 756), fig. 2; scale C (10 μm; x 1310), fig. 3.
**Polycpe peltata** sp. nov.

**Holotype**: Brit. Mus. (Nat. Hist.) no. OS10119; LV.

**Type locality**: Darvel Bay, Malaysia, lat. 04°40.2’N, long. 118°44.0’E; Recent.

**Derivation of name**: Latin, *peltatus*, shield-shaped; suggested by the shield-shaped appearance given to the shell by the inner carina.

**Figured specimens**: Brit. Mus. (Nat. Hist.) nos. OS10119 (LV: Pl. A, figs. 2, 3; Pl. B, figs. 1-3); OS10120 (RV: Pl. A, fig. 1).

Specimen OS10119 (holotype) was collected at a depth of 40 fathoms. The specimen OS10120 is from lat. 04°38.5 N, long. 118°39.6’E, was collected at a depth of 34 fathoms. Both the figured specimens are Recent, from Darvel Bay, Malaysia, collected in 1965 by HMS Dampier.

**Diagnosis**: Species of *Polycpe* with papillate excavate carinae.

The inner carina, which rises well above the level of the muri which define the ground pattern reticulation, is prominently developed, as are posteriorly located vulcani.

**Remarks**: Valve oval. Lines of maximum length and maximum height pass through the mid-point. Peripheral carina well developed with irregularly spaced pores. The inner carina is discontinuous with a gap in the antero-median region. Mid-anterior to ventral margin denticulate. Hinge is typical of
the genus. In the internal view above the typical central muscle-scar pattern, 5-6 additional pits are present.

In *P. peltata* sp. nov. the minor carinae in the median region show variable branching patterns (Pl. A, figs. 1, 2).

The shield-like (of coat of arms) appearance of the inner carina of *Polycope peltata* sp. nov. is unique within *Polycope*.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope peltata sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (0S10120, 243 μm long);
fig. 2, LV, ext. lat. (holotype 0S10119, 268 μm long); fig. 3, LV, antero-vent. region showing marginal denticles (holotype 0S10119).

Scale A (75 μm; x 259), fig. 1; (75 μm; x 239), fig. 2; scale B (25 μm; x 576), fig. 3.
Polycope peltata sp. nov.

Explanation of Plate B

Fig. 1, LV, antero vent. region showing densely papillate muri (holotype OS10119); fig. 2, LV, int. mus. sc. (holotype OS10119); fig. 3, LV, int. lat. (holotype OS10119).

Scale A (15/um; x 1242), fig. 1; scale B (25/um; x 604), fig. 2; scale C (75/um; x 227), fig. 3.
Polycope rama sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10124; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, ramus, branching; suggested by the irregular branching of muri.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10124 (RV: Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

The holotype was collected at 40 fathoms by HMS Dampier in 1965.

Diagnosis: Species of Polycope having two major carinae and irregularly shaped fossae with ramifying muri.

Remarks: Valve oval. Lines of maximum length and maximum height pass through the mid-point. Mid-anterior to ventral margin denticulate. Anterior process slightly protrusive. The well defined hinge line and the antero-dorsal margin form a wide angle. The central muscle-scar region is typical of the genus. Dorsally above the central muscle-scar region 5 pits are visible.

In addition to the two prominent carinae there are two other minor carinae running anteriorly from the mid-posterior region and having a tendency to branch, giving a tree-like appearance.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycopera rama sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10124, 317 \( \mu m \) long); fig. 2, RV, int. lat. (holotype OS10124).

Scale A (100 \( \mu m \) x 208), fig. 1; (100 \( \mu m \); x 205), fig. 2.
Polycope rama sp. nov.

**Explanation of Plate B**

Fig. 1, RV, ext. median region showing the location of musc. sc. area (holotype OS10124); fig. 2, RV, dorsomedian to ventromedian region showing irregularly shaped fossae with ramifying muri (holotype OS10124); fig. 3, RV, int. musc. sc. (holotype OS10124).

Scale A (10 μm x 1733), fig. 1; scale B (25 μm x 641), fig. 2; scale C (25 μm x 428), fig. 3.
Polycope regina sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10100; LV.

Type locality: Darvel Bay, Malaysia, lat. 04°38.5'N, long. 118°39.6'E; Recent.

Derivation of name: Latin, regina, queen; suggested by the fancied imagination that it is the beauty queen among Polycope.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10100 (LV: Pl. A, figs. 2, 3; Pl. B, figs. 1, 2); OS10101 (RV: Pl. B, fig. 1); OS10102 (RV: Pl. B, fig. 3).

Specimen OS10100 is from the type locality; OS10101 is from lat. 04°44.5'N, long. 118°30.0'E; both from 34 fathoms, collected in 1965. OS10102 is from lat. 04°51.6'N, long. 118°28.2'E, at 186 ft., collected in 1962. All figured specimens are Recent, from Darvel Bay, Malaysia, collected by HMS Dampier.

Diagnosis: Species of Polycope having distinctly developed polygonal fossae with excavate muri. Fossae bear second order reticulations. A small almost obscure rostral incisure is present at the antero-dorsal margin.

Remarks: The second order reticulation inside the fossae is basically polygonal, sometimes showing a radial pattern, or showing a minor 'axial' carina along the centre of elongate fossae. The dorsal margin is strongly curved. In lateral
view the ventral margin of the hinge extends ventrally slightly, obscuring part of the valve interior.

*Polycope regina* sp. nov. differs from *Polycope spongia* sp. nov. in having more complex fossae, especially the elongated ones bearing minor 'axial' carina.

In *P. regina* sp. nov., between the postero-dorsal and mid-posterior regions the growth of a "flower-bud"-like structure with four nodes (Pl. A, fig. 3) is variable; in some it is poorly developed and in others it is strongly developed.

**Distribution**: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope regina sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (OS10101, 487 /µm long);
fig. 2, LV, ext. lat. (holotype OS10100, 463 /µm long); fig. 3, LV, postero-dorsal region showing a minor axial carina along the centre of elongate fossa (holotype OS10100).

Scale A (150 /µm; x 129), fig. 1; scale B (150 /µm; x 136), fig. 2; scale C (25 /µm; x 512), fig. 3.
Polycope regina sp. nov.

Explanation of Plate B

Fig. 1, LV, int. lat. (holotype OS10100, 463 μm long); fig. 2, LV, int. lat. musc. sc. (holotype OS10100); fig. 3, RV, int. lat. (OS10102, 439 μm long).

Scale A (150 μm; x 136), fig. 1; scale B (15 μm; x 625), fig. 2; scale C (150 μm; x 141), fig. 3.
**Polycupe retia** sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10111; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, retia, net; suggested by the net-like second-order reticulation.


The holotype was collected in 1965 by HMS Dampier at 40 fathoms.


Remarks: Valve oval. The angle between the hinge line and antero-dorsal margin is behind the mid-point of the valve. Anterior margin protruded. Several intramural pores are present. Between mid-dorsal and antero-dorsal area a 'looped pore' occurs. A few sola bear pores. Central muscle-scar pattern is typical of the genus.

*P. retia* sp. nov. differs from *P. regina* sp. nov. in the nature of reticulation pattern, by not having elongated fossae which bear minor axial carina. Also the dorsal margin of *P. regina* is strongly curved, whereas in *P. retia* it is angular.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycype retia sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10111, 365 μm long); fig. 2, RV, int. lat. (holotype OS10111); fig. 3, RV, int. lat. musc. sc. (holotype OS10111).

Scale A (75 μm; x 172), fig. 1; scale B (75 μm; x 170), fig. 2; scale C (50 μm x 255), fig. 3.
**Polycope retia** sp. nov.

**Explanation of Plate B**

Fig. 1, RV, showing polygonal fossae with net-like second-order reticulation (holotype OS10111); figs. 2-3, RV, showing a 'looped pore' inbetween mid-dorsal and antero-dorsal region (holotype OS10111). Scale A (25 μm; x 416), fig. 1; scale B (20 μm; x 624), fig. 2; scale C (5 μm; x 3324), fig. 3.
**Polycope spongia** sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10105; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, *spongia*, sponge; suggested by the spongy appearance of the second-order reticulation.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10105 (RV: Pl. A, figs. 1, 3; Pl. B, figs. 1-3); OS10106 (LV: Pl. A, fig. 2).

The holotype and the other figured specimen are both Recent from Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; collected by HMS Dampier in 1965 at 40 fathoms.

Diagnosis: Species of *Polycope* with thick shell and rostrum. Generally rectangular fossae with fine second-order reticulation of sponge-like appearance.

Remarks: Valve oval. Greatest length of the valve passes through the mid-height. Anterior region protruded, culminating in a slightly curved rostrum. The sola bear delicate, very fine second-order reticulation. Besides the marginal carina, three other main carinae are present. Possal patterns are visible on the interior side of the shell. Muscle-scar is typical of the genus.

This new species differs from *P. transenna* sp. nov. in having a thick shell, with well defined carinae and basically
rectangular fossae. Furthermore, the distinctive second-order reticulation as seen in *P. spongia* is absent in *P. transsenna*.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycope spongia sp. nov.

Explanation of Plate A

Fig. 1, RV, ext. lat. (holotype OS10105, 341/μm long); fig. 2, LV, ext. lat. (OS10106, 341/μm long); fig. 3, RV, outline of the musc. sc. as seen from the external side of the valve (holotype OS10105).

Scale A (100/μm; x 179), fig. 1; scale B (100/μm; x 167), fig. 2; scale C (25/μm; x 537), fig. 3.
Polycope spongia sp. nov.

Explanation of Plate B

Fig. 1, RV, ventro-median region showing mainly rectangular fossae (holotype OS10105); figs. 2-3, RV, ant. med. region showing sola bearing second order reticulation (holotype OS10105); fig. 4, RV, int. lat. (holotype OS10105).

Scale A (20/μm; x 680), fig. 1; scale B (10/μm; x 1002), fig. 2; scale C (5/μm; x 1969), fig. 3; scale D (75/μm; x 202), fig. 4.
Polycope transenna sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10103; LV.

Type locality: Darvel Bay, Malaysia, lat. 04°46.5′N, long. 118°24.2′E; Recent.

Derivation of name: Latin, transenna, a trap; suggested by the fancied resemblance of the normal pore and surrounding loop-like feature.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10103 (LV: Pl. A, fig. 2; Pl. B, figs. 1-3); OS10104 (RV: Pl. A, fig. 1).

Specimens OS10103 and OS10104 are from Darvel Bay, Malaysia, lat. 04°46.5′N, long. 118°24.2′E; both Recent, from 180 ft., collected in 1962 by HMS Dampier.

Diagnosis: Species of Polycope in which on some sola apophytic growths of muri form loop-like features surrounding pores. Rostral incisure small and slightly curved.

Remarks: Valve oval. Maximum height occurs just behind the antero-median region. Polygonal fossae cover almost entire valve surface; second order reticulation is irregularly and very weakly developed. Several intramural pores are present. Outline of fossal pattern is visible on the inner surface of the valve. In lateral view the hinge slightly overhangs ventrally. P. transenna is easily distinguished by the distinctive morphology of its muri.

The number of sola bearing apophytic growths of muri is
variable in *P. transenna* sp. nov.; in some, it may be
less than ten.

Distribution: Known only from Recent, Darvel Bay, Sabah,
Malaysia.
Polycope transenna sp. nov.

Explanations of Plate A

Fig. 1, RV, ext. lat. (OS10104, 317 μm long);
fig. 2, LV, ext. lat. (holotype OS10103, 317 μm long).

Scale A (100 μm; x 208), fig. 1; scale B (100 μm; x 189), fig. 2.
**Polycope transenna** sp. nov.

**Explanation of Plate B**

Fig. 1, LV, sola showing apophytic growth of muri (holotype OS10103); fig. 2, LV, normal pore surrounded by mural wall (holotype OS10103); fig. 3, LV, int. lat. (holotype OS10103, 317 μm long).

Scale A (20 μm; x 623), fig. 1; scale B (5 μm; x 3402), fig. 2; scale C (100 μm; x 192), fig. 3.
Polycope vulcana sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10117; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°38.5'N, long. 118°39.6'E; Recent.

Derivation of name: Latin, vulcanus; volcanic, volcano; suggested by the prominent occurrence of volcano-like structures on the shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10117 (RV: Pl. A, fig. 1); OS10118 (LV: Pl. A, figs. 2, 3; Pl. B, figs. 1-3).

Specimen OS10117 (holotype) was collected at 34 fathoms in 1965; specimen OS10118 is from lat. 04°40.2'N, long. 118°44.0'E, collected at 40 fathoms in 1965. Both the figured specimens are from Darvel Bay, Malaysia, collected by HMS Dampier.

Diagnosis: Species of Polycope with more or less rectangular fossae and a prominently protrusive vulcanus on the posterior end. Anterior margin rounded.

Remarks: Valve oval to circular. Lines of maximum length and maximum height pass through the mid-point. Muri well developed. Vulcani bear minute spines. Peripheral muri are densely papillate. Hinge and muscle-scar regions are typical of the genus.

Polycope vulcana sp. nov. differs from Polycope clivosa sp. nov. in having a rounded anterior margin. In Polycope
clivosa the anterior process is prominently protrusive. P. vulcana also lacks the intermittent pores along the peripheral carina as found in P. clivosa sp. nov.

In P. vulcana sp. nov. the shape of the fossae is variable; in some it is more rectangular than in others (Pl. A, figs. 1, 2).

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Polycopé vulcana sp. nov.

Explanación de la Placa A

Fig. 1, RV, ext. lat. (holotipo OS10117, 268 μm long);
fig. 2, LV, ext. lat. (OS10118, 268 μm long);
fig. 3, LV, a vulcanus, inbetween post. dorsal and
mid. dorsal margin, bearing minute spines (OS10118).
Scale A (75 μm; x 239), fig. 1; (75 μm x 231), fig. 2;
scale B (25 μm; x 623), fig. 3.
Polycopæ vulcana sp. nov.

Explanation of Plate B

Fig. 1, LV, Protrusive vulcanus, posterior end (OS10118); fig. 2, LV, int. musc. sc. (OS10118); fig. 3, LV, int. lat. (OS10118).

Scale A (15 μm; x 871), fig. 1; scale B (25 μm; x 512), fig. 2; scale C (50 μm x 324), fig. 3.
Polycpe sp. from Norway

Locality: South of Bukhen, Norway, Recent.

slide no. 107 (LV: Pl. A, figs. 1, 2; Pl. B, figs. 1, 2).

The specimen was collected from a depth of 200 fathoms in 1878. It was unfortunately broken during SEM work.

Remarks: The oval shell is foveolate and covered by rounded puncta and mid-posteriorly bears delicate carinae. Lines of maximum height and maximum length pass through the central region of the valve.

This Polycpe sp. differs from Polycpe orbicularis Sars by the absence of polygonal reticulation pattern. The species is close to the description of P. punctata Sars, but in addition to the "conspicuous pits" of P. punctata it also has dense foveolation in between the puncta.
Polycpe sp. from Norway

Explanation of Plate B

Fig. 1, LV, ext. post., fig. 2, LV, ant. vent. region showing punctate and foveolate shell surface.
Scale A (200 μm; x 115), fig. 1; scale B (25 μm; x 987), fig. 2.
THE GENUS CYTHERELLOIDEA ALEXANDER, 1929

Introduction

The genus Cytherelloidea was erected by Alexander (1929). Since then many workers have described species of Cytherelloidea, mainly from America, e.g. — Van den Bold (1946, 1963), Crane (1965), Edwards (1944), Holden (1964), Howe (1934), Kornicker (1963), Krutak (1961), Leroy (1943), Munsey (1953); some from Europe — Apostolescu (1956), Bate (1963), Doruk (1976, 1977), Kay and Barker (1966), Keij (1957), McKenzie (1973); South Africa — Dingle (1969, 1971); Persian Gulf — Bate (1971), Paik (1976); Western India — Guha (1961, 1965); and New Zealand — Hornibrook (1952). ( *= Recent forms )

The Indo-Malaysian region is also particularly interesting for the study of the more ornate forms of this genus. Since the erection of the genus and the subsequent work from the Eocene and Oligocene of the Gulf Coast region by Howe (1934), the other major description of the species of Cytherelloidea was by Leroy (1941) from the East Indies. Leroy (1941, p.612) observed:

"There appears to be little in common between the East Indian forms and figures and descriptions of the species of the genus from the Eocene and Oligocene of the Gulf Coast region of the United States as recorded by Howe and Alexander".

This observation still holds good today; the Cytherelloidea species from the Indo-Malaysian region in general are more ornate than other species of the genus found elsewhere.
Since Leroy's (1941) work in the Dutch East Indies, Kingma (1948) and Keij (1964) described more species from the Indo-Malaysian region. Brady's (1869) species of Cytherella cingulata from Hong Kong was assigned to the genus Cytherelloidea by Kingma (1948).

Over 150 Cytherelloidea species have now been described in the literature, of which 14 new species were described by Leroy (1941), three by Kingma (1948) and ten by Keij (1964), all from the Indo-Malaysian region.

The present work from the Sabah area has yielded seven ornate Cytherelloidea species, of which four are new. The species are: Cytherelloidea bonanzaensis Keij, C. sparsa sp. nov. and C. depressa sp. nov. from the Recent of Darvel Bay and Cytherelloidea sabahensis Keij, C. cordata sp. nov., C. cingulata (Brady) and C. curvata sp. nov. from the Pliocene Togopi Formation.

The present investigation has resulted in the extension of occurrence from Recent to Pliocene for Cytherelloidea sabahensis Keij and Cytherelloidea cingulata (Brady). Cytherelloidea curvata sp. nov. has been found both from the Pliocene Togopi River section and the Recent of Darvel Bay.

It is appropriate here to mention the author's discovery of five highly ornate new species of Cytherelloidea from the Recent of Bangladesh (not described herein). These specimens, now in author's collection, will be deposited in the British Museum (Nat. Hist.). The discovery of these new species from Bangladesh further extends the distribution of highly ornate Cytherelloidea species into the Bay of Bengal.
Systematic descriptions

Suborder Platycopha Sars, 1866
Family Cytherellidae Sars, 1866
Genus Cytherelloidea Alexander, 1929

Type-species: Cythere (Cytherella)williamsoniae Jones, 1849

Generic diagnosis of Cytherelloidea (after Morkhoven 1963):

The shape is elongate-ovate, often distinctly subrectangular. Widest posteriorly. Anterior end usually evenly rounded, posterior end more angular.

Generally consisting of strong ridges, anteromarginal ridge present in most cases. Occasionally with anteromarginal denticulations.

Sexual dimorphism distinct with the presence of two shallow posterior cavities in the female valves. Male valves are less wide posteriorly.

The genera Cytherella and Cytherelloidea are related, especially in having a common muscle-scar pattern. But Cytherelloidea valves are thick-shelled and strongly ribbed. In Cytherella the valves are usually smooth and sometimes punctate and ridges are missing.
Cytherelloidea bonanzaensis Keij, 1964


Holotype: (not figured herein). Geological Institute of the State University of Utrecht, the Netherlands, coll. no. S 15960; ♀ RV.

Type locality: Collected at 07°05'10"N, long. 116°17'58"E, at a depth of 67 meters, near the western end of Big Bonanza Shoal, Sabah, South China Sea.

Derivation of name: After the Big Bonanza Shoal, Sabah (Keij, 1964).

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10142 (♂ LV: Pl. A, fig. 1); OS10143 (♀ RV: Pl. A, fig. 2); OS10144 (♂ LV: Pl. A, fig. 3; Pl. B, figs. 1-3).

All three specimens are Recent, from Darvel Bay, Malaysia and collected by HMS Dampier in 1965. Specimen OS10142 is from lat. 04°39.2'N, long. 118°40.5'E; collected at 34 fathoms. Specimens OS10143 and OS10144 are from lat. 04°40.2'N, long. 118°40.5'E, collected at 40 fathoms.

Diagnosis: Species of Cytherelloidea with two sets of fossae, one circular with rims and the other polygonal without rims. The two types of fossae are connected by low muri. This reticulation pattern is less prominent in median and dorso-median regions. The sola between muri are foveolate. Occasional conjunctive normal pores are seen on the shell.
surface. Muscle-scar area forms a well-marked depression on the external surface of the valve.

Remarks: The surface ornamentation of *C. bonanzaensis* Keij is unique among *Cytherelloidea* species.

Distribution: Recent, marine: off Sabah and Brunei in South China Sea (Keij, 1964); Darvel Bay, Malaysia (herein).
Cytherelloidea bonanzaensis Keij

Explanation of Plate A

Fig. 1, δ LV, ext. lat. (OS10142, 414 µm long);
fig. 2, φ RV, ext. lat. (OS10143, 341 µm long);
fig. 3, δ LV ext. lat. (OS10144, 390 µm long).
Scale A (100 µm; x 157), fig. 1; scale B (100 µm; x 199), fig. 2; scale C (100 µm; x 159), fig. 3.
Cytherelloidea bonanzaensis Keij

Explanation of Plate B

Fig. 1, δ LV, ant. dorsal region showing the two sets of fossae, one circular with rims and the other polygonal without rims (OS10144); fig. 2, δ LV, ant. dorsal region showing a rimmed fossa (OS10144); fig. 3, δ LV, musc. sc. region showing a depression on the external surface of the valve (OS10144).

Scale A (20 μm; x 731), fig. 1; scale B (5 μm; x 2862), fig. 2; scale C (50 μm; x 358), fig. 3.
**Cytherelloidea cingulata (Brady, 1869)**

1869 *Cytherella cingulata* Brady; Brady, G.S., *Les Fonds de la Mer*, vol. 1, pt. 1, p. 159, pl. 17, figs. 24-25.


1948 *Cytherelloidea cingulata* (Brady); J.T. Kingma, Utrecht Univ. Thesis, p. 65, pl. 6, fig. 10.

1964 *Cytherelloidea cingulata* (Brady); A. J. Keij, *Micropaleontology*, vol. 10, no. 4, p. 419, pl. 1, figs. 4-8.

Hong Kong valve: (not figured herein). Brady coll., Hancock Museum, Newcastle-upon-Tyne; ♀ LV, no catalogue number, from a red labelled slide, marked "Hong Kong". The valve has been figured (pl. 1, fig. 4) by Keij; (fide Keij, 1964).

Type locality: Hong Kong, Recent.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10137 (♀ RV: Pl. A, fig. 1; Pl. B, figs. 2, 3); OS10138 (♀ LV: Pl. A, fig. 2; Pl. B, fig. 1).

Specimens OS10137 and OS10138 are from the Pliocene Togopi Formation of Dent Peninsula, Sabah, Malaysia; approx. lat. 05°20'N, long. 119°15'E; British Museum sample no. NB 9452, collected by Dr. N. S. Haile in 1961. Specimen OS10156 is from Darvel Bay; lat. 04°38.5'N, long. 118°39.6'E; collected by HMS Dampier in 1965 at 34 fms.
Diagnosis: A prominent ridge encircles the periphery of the shell and forms a bulge which protrudes at the postero-dorsal margin. Ventro-median and antero-median regions are raised and the median region forms a depression. Subdued reticulation in the form of minor depressions are seen between postero-median and antero-median regions.

Remarks: Brady (1880) mentioned Hong Kong as the type locality for *Cytherella cingulata*, after which Kingma (1948) found the species from the Recent sediments of Java Sea. Keij's (1964) specimens are Recent and come from off Brunei. *Cytherella cingulata* specimens figured herein are of Pliocene and Recent from Sabah.

*Cytherella cingulata* specimens were mentioned by Brady from Torres Strait and Booby Island; but Keij (1964) found these to be not conspecific with *Cytherelloidea cingulata* (Brady) (*fide* Keij, 1964).

Distribution: Recent, marine: Hong Kong (Brady, 1880); Java Sea (Kingma, 1948); South China Sea (Keij, 1964); Darvel Bay (herein); Pliocene, Dent Peninsula, Sabah, Malaysia (herein). (see fig. 7).
Cytherelloidea cingulata (Brady)

Explanation of Plate A

Fig. 1, ♀ RV, ext. lat. (OS10137, 488 μm long);
fig. 2, ♀ LV, ext. lat. (OS10138, 488 μm long).
Scale A (125 μm; x 182), fig. 1; (125 μm x 188),
fig. 2.
Cytherelloidea cingulata (Brady)

Explanation of Plate B

Fig. 1, φ RV, int. lat. (OS10156, 560 μm long); fig. 2, φ RV, postero-dorsal region showing prominent bulge formed by ridge (OS10137); fig. 3, φ RV, a normal pore on the external shell surface (OS10137).

Scale A (150 μm; x 128), fig. 1; scale B (25 μm; x 480), fig. 2; scale C (2 μm; x 8008), fig. 3.
Cytherelloidea cordata sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10136; ♂ RV.

Type locality: Upper Togopi River section, Dent Peninsula, eastern Sabah, Malaysia; Pliocene.

Derivation of name: Latin, cordatus, heart-shaped; suggested by the heart-shaped muscle-scar region.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10136 (♂ RV: Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

Specimen OS10136 is from Brit. Mus. sample no. NB 9450, collected by Dr. N. S. Haile in 1961.

Diagnosis: Species of Cytherelloidea with three major ridges and spinose edges. The ridges join between the posterodorsal and antero-dorsal shell margin. The median ridge is connected to the peripheral ridge in the postero-ventral region. The median ridge is widest between ventro-median and antero-median region. Muscle-scar is heart-shaped.

Remarks: This species closely resembles Cytherelloidea sabahensis Keij but differs in having a curved mid-ventral margin. Moreover, the muscle-scar pattern in C. cordata sp. nov. is heart shaped while in C. sabahensis it is oval shaped.

Distribution: Known only from the Pliocene Togopi Formation, Sabah, Malaysia.
Cytherelloidea cordata sp. nov.

Explanation of Plate A

Fig. 1, & RV, ext. lat. (holotype OS10136, 610 μm long); fig. 2, & RV, int. lat. (holotype OS10136).

Scale A (150 μm; x 146), figs. 1, 2.
Cytherelloidea cordata sp. nov.

Explanation of Plate B

Figs. 1-2, δ RV, median region showing some misshapen spines (holotype OS10136); fig. 3, δ RV, antero-median region showing densely foveolate ridge (holotype OS10136).

Scale A (5 μm; x 3650), fig. 1; scale B (50 μm; x 350), fig. 2; scale C (25 μm; x 632), fig. 3.
Cytherelloidea curvata sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10139; ♀ RV.

Type locality: Upper Togopi River section, eastern Sabah, Malaysia; Pliocene.

Derivation of name: Latin, curvatus, bend; suggested by the bend in the central ridge.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10139 (♀RV: Pl. A, fig. 1; Pl. B, fig. 1); OS10140 (♂ LV: Pl. A, fig. 2); OS10141 (♂ LV: Pl. B, fig. 2).

Specimens OS10139 (holotype) and OS10140 are from Pliocene Togopi Formation, collected by Dr. N. S. Haile in 1961; approx. lat. 05°20′N, long 119°15′E; BM(NH) sample no. NB 9452. Specimen OS10141 is from Darvel Bay, Malaysia, lat. 04°54.2′N, long. 118°28.5′E; collected in 1962 at 114 feet by HMS Dampier.

Diagnosis: Peripheral ridge bears rounded to subrounded fossae in the antero-dorsal margin. This ornamentation continues down ventral margins to the mid-posterior margin. A central ridge rises from the boundary between mid-anterior and antero-median region and continues with an upward curve to join the peripheral ridge at the postero-dorsal margin. Two smaller ridges connect the median ridge and peripheral ridge mid-dorsally.

Remarks: This new species differs from Cytherelloidea leroyi
Keij (1964) in lacking branching of median ridge in the anterior area.

Sexual dimorphism is pronounced with an external bulbous expansion in the postero-ventral region in the female valve.

Distribution: Known from the Pliocene Togopi River section, eastern Sabah and from the Recent of Darvel Bay, Sabah, Malaysia.
Cytherelloidea curvata sp. nov.

Explanation of Plate A

Fig. 1, ♀ RV, ext. lat. (holotype OS10139, 488 μm long);
fig. 2, ♂ LV, ext. lat. (OS10140, 463 μm long).

Scale A (100 μm; x 195), fig. 1; (100 μm; x 209), fig. 2.
Cytherelloidea curvata sp. nov.

Explanation of Plate B

Fig. 1, ♀ RV, int. lat. (holotype OS10139, 488 μm long); fig. 2, ♂ LV, ext. lat. (OS10141, 463 μm long).

Scale A (100 μm; x 141), fig. 1; scale B (100 μm; x 145), fig. 2.
Cytherelloidea depressa sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10147; ♀ LV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, depressus, pressed down; suggested by the reticulations present in the form of minor depressions on the shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) no. Lost specimen (♂ RV: Pl. A, fig. 1); OS10147 (♀ LV: Pl. A, fig. 2; Pl. B, figs. 1-4). The RV was lost after the SEM photography.

Both figured specimens are from Darvel Bay, Malaysia, collected in 1965 by HMS Dampier. Specimen OS10147 was collected at depth 40 fathoms, lat. 04°40.2'N, long. 118°44.0'E; and the lost specimen in Pl. A, fig. 1 was collected at depth 48 fathoms, lat. 04°35.7'N, long. 118°58.4'E.

Diagnosis: A striated ridge extends all along the peripheral margin and is overridden at postero-dorsal margin by the bulbous end of a smaller ventrally originated ridge. The latter ridge has encircled a median region which bears a depression bordered by spines.

Remarks: This species differs from C. cingulata (Brady) in having a more rounded posterior margin and much more abundant reticulations in the form of minor depressions on the shell surface. Several spines are overlying the median region.
depression in *C. depressa* sp. nov. and are lacking in *C. cingulata* (Brady).

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Cytherelloidea depressa sp. nov.

Explanation of Plate A

Fig. 1, ♂ RV, ext. lat. (439 μm long); fig. 2, ♀ LV ext. lat. (holotype, OS10147, 488 μm long).

Scale A (100 μm; x 191), fig. 1; scale B (100 μm; x 184); fig. 2.
Cytherelloidea depressa sp. nov.

Explanation of Plate B

Fig. 1, ♀RV, mid. ant. region showing the striated ridge (holotype OS10147); fig. 2, ♀RV, median region depression is encircled by spiny projections (holotype OS10147); figs. 3-4, ♀RV, mid. posterior region showing normal pores on the ridges and thinly distributed foveolae (OS10147).

Scale A (25 μm; x 602), fig. 1; scale B (25 μm; x 511), fig. 2; scale C (50 μm; x 303), fig. 3; scale D (15 μm x 657), fig. 4.
Cytherelloidea sabahensis Keij, 1964

1964 Cytherelloidea sabahensis sp. nov. A. J. Keij,

Micropaleontology, vol. 10, no. 4, p. 423, pl. 3,
figs. 6-9.

Holotype: (not figured herein). Geological Institute of the
State University of Utrecht, the Netherlands, collection
no. S 16063; ♀ RV.

Type locality: Emerald Bank, Sabah, Malaysia, lat. 06°59'00"N,
long. 116°02'00"E (South China Sea); Recent, depth 96 m.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10135 (♂ RV:
Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

Specimen OS10135 is from the Pliocene Togopi Formation
of the Dent Peninsula, Sabah, Malaysia; Brit. Mus.(NH)
sample no. NB 9449, collected by Dr. N. S. Haile in 1961;
approx. lat. 05°20'N, long 119°15'E.

Diagnosis: Species of Cytherelloidea with a marginal ridge
along the dorsal, anterior and ventral periphery. Parallel to
the marginal ridge there is a second ridge which joins the
marginal ridge along the dorsal margin. A third ridge encircles the median region depression. The muscle-scar pattern
is ovoid.

Remarks: The present material extends the range of this species
from Recent to Pliocene time.

Distribution: Recent, marine: off Sabah in South China Sea
(Keij, 1964); Pliocene, Dent Peninsula, Sabah, Malaysia (herein).
Cytherelloidea sabahensis Keij

Explanation of Plate A

Fig. 1, ♂ RV, ext. lat. (OS10135, 439 μm long);
fig. 2, ♂ RV, int. lat. (OS10135).

Scale A (100 μm; x 200), fig. 1; (100 μm; x 205),
fig. 2.
Cytherelloidea sabahensis Keij

Explanation of Plate B

Fig. 1, ♂ RV, mid-posterior to mid-dorsal peripheral boundary showing a shallow groove which accommodated the smaller left valve (OS10135); figs. 2-3, ♂ RV, int. musc. sc. (OS10135).

Scale A (75 μm; x 228), fig. 1; scale B (50 μm; x 319), fig. 2; scale C (25 μm x 659), fig. 3.
Cytherelloidea sparsa sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10145; RV.

Type locality: Darvel Bay, Malaysia, lat. 04°42.44'N, long. 118°16.65'E; Recent.

Derivation of name: Latin, sparsus, few; suggested by the sparsely distributed fossae.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10145 (♀ RV: Pl. A, figs. 1, 3; Pl. B, fig. 3); OS10146 (♀ RV: Pl. A, fig. 2; Pl. B, figs. 1, 2).

Both specimens are from Darvel Bay, Malaysia, collected by HMS Dampier in 1961. The holotype is from depth 85 ft., and specimen OS10146 is from lat. 04°48.40'N, long. 118°18.10'E, depth 160 ft.

Diagnosis: Circular to subcircular sparsely distributed fossae are bounded within a subdued inner peripheral ridge. A centrally located ridge extends from behind the mid-anterior region to mid-posterior region. A vertical ridge has emerged in the postero-dorsal to postero-ventral region. Normal pores are randomly scattered all over the shell surface. A depression caused by the muscle-scar is visible in the external lateral view.

Remarks: This species with its artifact-like spear-head shape and sparsely distributed fossae, primarily along the sides
of ridges, is distinctive among Cytherelloidea species.

Distribution: Known only from Recent, Darvel Bay, Sabah, Malaysia.
Cytherelloidea sparsa sp. nov.

Explanation of Plate A

Fig. 1, ♀ RV, ext. lat. (holotype OS10145, 536 μm long); fig. 2, ♀ RV, ext. lat. (OS10146, 512 μm long); fig. 3, ♀ RV, int. lat. (holotype OS10145, 536 μm long).

Scale A (150 μm; x 110), fig. 1; scale B (150 μm; x 127), fig. 2; scale C (150 μm; x 121), fig. 3.
Cytherelloidea sparsa sp. nov.

Explanation of Plate B

Fig. 1, ♀ RV, depression caused by the musc. sc. region as seen from the ext. side of the valve (OS10146); fig. 2, ♀ RV, mid. ant. region in int. lat. view showing normal pores near the peripheral boundary (OS10146); fig. 3, ♀ RV, int. musc. sc. (holotype OS10145).

Scale A (50 μm; x 399), fig. 1; scale B (50 μm; x 311), fig. 2; scale C (25 μm; x 418), fig. 3.
CHAPTER VI

THE GENUS ATJEHELLA KINGMA, 1948

Introduction

The marine genus Atjehella was originally described by Kingma (1948) from the Pliocene of Indonesia. The type species was Atjehella semiplicata Kingma. The genus remained monospecific until December 1979 when Dr. A. J. Keij published five more new species: Atjehella kingmai (Holocene of the South China Sea, Java Sea and Strait of Makasar), A. mckenziei (Neogene of Sarawak, Malaysia), A. paiki (Holocene of Persian Gulf and Gulf of Oman), A. pentukensis (Neogene of Java) and A. tricarinata (Holocene of Luzon, Philippines).

Of the above species only A. pentukensis Keij has been found both in the Pliocene Togopi Formation and Darvel Bay of Sabah. New species proposed herein are:

- Atjehella cribella sp. nov. (Darvel Bay, Sabah),
- A. reticulata sp. nov. (Pliocene Togopi River section, Sabah),
- A. levigata sp. nov. (Darvel Bay, Sabah),
- A. apoxeia sp. nov. (Pliocene Togopi River section, Sabah).

Atjehella apoxeia sp. nov. was regarded as the ancestral species of the genus by Dr. A. J. Keij (Personal communication with Dr. Keij). Although this new species was found in Pliocene deposits it probably had a long previous evolutionary history.
Systematic descriptions

Suborder Podocopa Sars, 1866
Family Cytheridae Baird, 1850
Genus *Atjehella* Kingma, 1948

Type-species: *Atjehella semiplicata* Kingma, 1948

Systematic position of the genus *Atjehella*:

In the Treatise on Invertebrate Paleontology (Ed. Moore, 1961) the genus *Atjehella* was placed under family Uncertain. Van Morkhoven (1963) put *Atjehella* under the family Cytheridae.

Omatsola (1970, p. 115) has observed that the sieve-type pores are found in the family Cytheridae. Sandberg & Plusquellec (1969, p. 517) and Sylvester-Bradley & Benson (1971, p. 285) have noted that sieve-type pores are found in the superfamily Cytheracea.

The present work on *Atjehella* (illustrated herein) has revealed sieve-plates on the shell surface for the first time. This discovery of sieve-plates supports the view of Van Morkhoven (1963) that the taxonomic position of *Atjehella* should be under the family Cytheridae.

Generic description of *Atjehella* (modified after Morkhoven, 1963):

Valves of *Atjehella* are very shallow and in lateral view subrectangular, anterior end rounded and the posterior end is quadrate. Normally the dorsal and ventral margins are nearly straight and converging slightly towards the posterior end, but in *Atjehella apoxeia* sp. nov. the dorsal margin is prominently tapering and has high slope towards the posterior end. Caudal
process is below the mid-height in Atjehella species.

Normal pores are few and scattered. So far in the literature the presence of sieve plates in Atjehella has not been mentioned, but they do exist, and are especially prominent in the new species A. cribella. In contrast to the flush sieve-plate-type (where the sieve-plates are level with the external surface of the carapace) in most Cytheracea genera, these sieve-plates are sunk below the surface level of the shell.

Marginal pore-canals are moderate in number, single or branching, curved or undulating. Transmission light microscopy has revealed that the marginal pore canal arrangements in Atjehella differ from species to species (see figs. 9, 10, 11, 12, 13 and text-figs. 1-5).

Inner lamella is very wide anteriorly and ventrally. The line of concrescence, which coincides throughout with the inner margin, runs an irregular course with a prominent loop ending ventrally at postero-ventral region.

Hinge is merodont. In this compound hinge type, in the left valve a conspicuous anti-slip tooth is present below the anterior socket. The anterior tooth in the right valve is differentiated into two parts — a distal part (in front) and a proximal part, adjoining the median element. The proximal part is higher and bigger than the other part. In the right valve the posterior terminal tooth is clearly divided.

Atjehella has four adductor muscle-scars in a row and a J-shaped frontal scar. Dorsally just above the adductor muscle-scars a sub-rounded pit is present, it is probably a dorsal
muscle-scar.

Eye spot absent. Sexual dimorphism is pronounced. Females are wider posteriorly.

Geographic distribution (fig. 8): Philippines, western Indonesia, South China Sea, Dent Peninsula and Darvel Bay of Sabah, west coast of India, Persian Gulf and the Gulf of Oman. Van Morkhoven (1963) also reported the presence of Atjehella in the Red Sea.
Atjehella apoxeia sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10155; LV.

Type locality: Upper Togopi River section, eastern Sabah, Malaysia; Togopi Formation, Pliocene.

Derivation of name: Greek, apoxy, tapering; suggested by the shape of the shell.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10155 (LV: Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

The holotype is the only known specimen and is from Brit. Mus. (NH) sample no. NB 9449; collected by Dr. N. S. Haile in 1961; approx. lat. 05°20'N, long. 119°15'E.

Diagnosis: Species of Atjehella with the shell distinctly tapering towards the posterior region. Caudal process terminating at the junction of the mid-posterior and postero-ventral margin. Anterior region of the shell is smooth.

Remarks: Valve shallow. In lateral view the anterior margin broad and rounded. Two peripheral ridges prominent, with two additional longitudinal ridges on the posterior region. Median to dorso-median region of the shell reticulate. Inner lamella very wide anteriorly and ventrally. Hinge is mero-dont. Muscle-scar is typical of the genus. Since this species is known only from a single specimen it is not possible to decide with certainty its sex.

Atjehella apoxeia sp. nov. is probably the ancestral species of the genus Atjehella (Personal communication with
Dr. A. J. Keij). There seems to be an evolutionary trend within the genus from strongly tapering to more rectangular forms.

Distribution: Known only from the Pliocene, Togopi River section, eastern Sabah, Malaysia.
Atjehella apoxeia sp. nov.

Explanation of Plate A

Fig. 1, LV, ext. lat. (holotype OS10155, 512 /μm long);
fig. 2, LV, int. lat. (OS10155).

Scale A (100 /μm; x 185), fig. 1; (100 /μm; x 185),
fig. 2.
Atjehella apoxeia sp. nov.

Explanation of Plate B

Fig. 1, LV, median region showing reticulate shell surface (holotype OS10155); fig. 2, LV, dorsal margin showing the merodont hinge (holotype OS10155); fig. 3, LV, int. lat. musc. sc. (holotype OS10155).

Scale A (50 \(\mu\)m; x 333), fig. 1; scale B (100 \(\mu\)m; x 197), fig. 2; scale C (50 \(\mu\)m; x 416), fig. 3.
Explanation of Fig. 9

Transmission light photograph showing the marginal pore canals of *Atjehella apoxeia* sp. nov., left valve (OS10155) (x478).
*Atjehella cribella* sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10148; ♂ RV.

Type locality: Darvel Bay, Malaysia, lat. 04°55.1'N, long. 118°25.5'E; Recent.

Derivation of name: Latin, *cribellum*, sieve; suggested by the presence of sieve-type pores.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10148 (♂ RV: Pl. A, fig. 1; Pl. B, figs. 1, 2; Pl. C, figs. 1-3; Pl. D, figs. 1-3); OS10149 (♀ RV: Pl. A, fig. 2); OS10150 (♂ LV: Pl. A, fig. 3).

All the figured specimens are from Darvel Bay, Malaysia, lat. 04°55.1' N, long. 118°25.5'E; collected at depth 84 ft. by HMS Dampier in 1962.

Diagnosis: Species of *Atjehella* with well developed reticulation of the shell surface spreading from median to mid-dorsal region. Sieve-plates sparsely scattered over the shell surface. Three peripheral ridges in the anterior region.

Remarks: Valve shallow and, in lateral view, subrectangular; anterior end rounded, posterior end quadrate. Caudal process is just below mid-height. Inner lamella very wide anteriorly and terminating approximately between mid-ventral and postero-ventral region. Hinge merodont. Muscle-scar is typical of the genus.

*Atjehella cribella* sp. nov. characteristically bears sieve-plates with central openings, which suggest sensory

* See page 203
devices were present during life time of the individual.

Further, these sieve-plates are generally sunk below the surface level of the shell.

Distribution: Known only from Darvel Bay, Sabah, Malaysia.
Atjishella cribella sp. nov.

Explanation of Plate A

Fig. 1, ♂ RV, ext. lat. (holotype OS10148, 512 μm long); fig. 2, ♀ RV, ext. lat. (OS10149, 480 μm long); fig. 3, ♂ LV, ext. lat. (OS10150, 439 μm long).

Scale A (150 μm; x 131), fig. 1; (150 μm; x 135), fig. 2; (150 μm; x 143), fig. 3.
Atjehella cribella sp. nov.

Explanation of Plate B

Fig. 1, δ RV, int. lat. (holotype OS10148, 512 μm long); fig. 2, δ RV, int. lat. musc. sc. (OS10148).

Scale A (100 μm; x 191), fig. 1; scale B (50 μm; x 382), fig. 2.
Atjehella cribella sp. nov.

Explanation of Plate C

Fig. 1, ♂ RV, post. med. region showing sieve plates sunken below the general surface level of the shell (holotype OS10148); fig. 2, ♂ RV, mid. dors. region showing reticulation on the shell surface (holotype OS10148); fig. 3, ♂ RV, the merodont hinge (holotype OS10148).

Scale A (25 μm; x 655), fig. 1; scale B (50 μm; x 393), fig. 2; scale C (75 μm; x 249), fig. 3.
Atjehella cribella sp. nov.

Explanation of Plate D
Figs. 1-3, ♂ RV, showing sieve-plates with central openings at postero-median, ventro-median and antero-median regions respectively (holotype OS10148).
Scale A (3 μm; x 6288), fig. 1; scale B (3 μm; x 5240), fig. 2; scale C (3 μm; x 4323), fig. 3.
Explanation of Fig. 10

Transmission light photograph showing the marginal pore canals of Atjehella cribella sp. nov., left valve (0S10242) (x523).
Atjehella levigata sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10152; ♀ RV.

Type locality: Darvel Bay, Malaysia, lat. 04°40.2'N, long. 118°44.0'E; Recent.

Derivation of name: Latin, levigatus, smooth; suggested by the smooth shell surface.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS10152 (♀ RV: Pl. A, fig. 1; Pl. B, figs. 1-3); OS10153 (♂ LV: Pl. A, fig. 2).

Both the specimens are from lat. 04°40.2'N, long. 118°44.0'E, collected at 40 fathoms from Darvel Bay, Malaysia by HMS Dampier in 1965.

Diagnosis: Species of Atjehella with anterior marginal ridges which are fused. Shell surface generally smooth but with minor reticulation in the median region. Three longitudinal ridges elevated on the posterior region are all interconnected.

Remarks: Valve shallow and in lateral view subrectangular. Anterior end rounded, posterior end quadrate. Of the three distinct ventrally lateral longitudinal ridges the ventral one is longest and has reached the frontal boundary of the median region. Several normal pores are visible. Caudal process is just below mid-height.

Atjehella levigata is unusual in having a generally smooth shell surface.

Distribution: Known only from the Recent of Darvel Bay, Sabah, Malaysia.

* As a result of discussion subsequent to the preparation of the thesis the forms Atjehella cribella and Atjehella levigata are now considered as variants of Atjehella kingmai Keij.
Atjehella levigata sp. nov.

Explanation of Plate A

Fig. 1, ♀ RV, ext. lat. (holotype, OS10152, 463 μm long); fig. 2, ♂ LV, ext. lat. (OS10153, 488 μm long).

Scale A (100 μm; x 214), fig. 1; scale B (100 μm; x 197), fig. 2.
Atjehella levigata sp. nov.

Explanation of Plate B

Fig. 1, ♀ RV, ext. lat. post. region showing inter-connected ridges (holotype OS10152); fig. 2, ♀ RV, ext. vent. obl. (holotype OS10152); fig. 3, ♀ RV, ext. med. region showing simple reticulation pattern (holotype OS10152).

Scale A (100 μm; x 232), fig. 1; scale B (100 μm; x 162), fig. 2; scale C (50 μm; x 348), fig. 3.
Explanation of Fig. 11

Transmission light photograph showing the marginal pore canals of Atjehella levigata sp. nov., right valve (OS10152) (x540).
Atjehella pentukensis Keij, 1979

1948 Atjehella semiplicata gen. et sp. nov. J. T. Kingma,
Utrecht Univ., thesis, p. 76 (pars), non pl. VIII, fig. 1.

1979 Atjehella pentukensis sp. nov. A. J. Keij, Proceedings of
the Koninklijke Nederlandse Akademie van Wetenschappen,

Holotype: (not figured herein). Geological Institute of the
State University of Utrecht, the Netherlands, collection no.
T335; ♂ LV.

Type locality: Pentuk village, approx. 5 km W of Nagwi near
the confluence of the Bengawan Solo and the Madiun River,
East Java; Upper Pliocene.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10154 (♀ RV:
Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

The specimen is from the Pliocene of the Togopi River
section, eastern Sabah, Malaysia; Brit. Mus. (NH) sample no.
NB 9452, collected by Dr. N. S. Haile in 1961; approx. lat.
05°20'N, long. 119°15'E.

Diagnosis: Species of Atjehella with mid-dorsal region of the
shell reticulate and the anterior region smooth. Posterior
longitudinal ridges are interconnected. Two prominent peripheral
ridges are present.

Remarks: Valve shallow and in lateral view subrectangular.

Anterior end broadly rounded, posterior end quadrate. Caudal
process just below mid-height. Inner lamella very wide anteriorly and less wide ventrally. Hinge is merodont. Muscle-scar is typical of the genus.

Kingma's syntype specimens of *A. semiplicata* come from a locality at Pentuk, Indonesia. However, the ridge pattern of *Atjehella* specimens (D 31948—49) is different from that of *Atjehella semiplicata*, especially in the interruption of the lower longitudinal ridge and they must therefore be treated as a separate species. This view was independently concluded by both Dr. A. J. Keij and myself. Dr. Keij has subsequently erected (December 1979) the species *Atjehella pentukensis* for this material.

Distribution: Upper Pliocene of both Pentuk and Sangiran, Indonesia (Kingma, 1948); Pliocene of Togopi River section, Sabah, Malaysia (herein) and Darvel Bay, Sabah (herein).
Atjehella pentukensis Keij

Explanation of Plate A

Fig. 1, ♀ RV, ext. lat. (OS10154, 439 μm long);
fig. 2, ♀ RV, int. lat. (OS10154).

Scale A (100 μm; x 212), fig. 1; (100 μm; x 205),
fig. 2.
Atjehella pentukensis Keij

Explanation of Plate B

Figs. 1-2, φ RV, int. lat. musc. sc. (OS10154); fig. 3, RV, dors. margin showing the merodont hinge (φ OS10154).

Scale A (75/μm; x 268), fig. 1; scale B (50/μm; x 328), fig. 2; scale C (50/μm; x 298), fig. 3.
Explanation of Fig. 12

Transmission light photograph showing the marginal pore canals of *Atjehella pentukensis* Keij, right valve (OS10243) (x503).
Atjehella reticulata sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS10151; RV.

Type locality: Upper Togopi River section, eastern Sabah, Malaysia; Togopi Formation, Pliocene; approx. lat. 05°20'N, long. 119°15'E.

Derivation of name: Latin, reticulum, small net; suggested by the reticulate shell surface.

Figured specimen: Brit. Mus. (Nat. Hist.) no. OS10151 (RV: Pl. A, figs. 1, 2; Pl. B, figs. 1-3).

The specimen is from the Togopi River section; Brit. Mus. (NH) sample no. NB 9449; collected by Dr. N. S. Haile in 1961.

Diagnosis: Species of Atjehella with irregular reticulation all over the shell surface. The anterior part of the valve surface bears second-order mesh-like reticulation. Two ridges run along the periphery. In lateral view a trough exists on the dorsal margin at the junction of antero-dorsal and mid-dorsal region.

Remarks: Valve shallow and in lateral view subrectangular. In addition to peripheral ridges two other longitudinal ridges are present on the shell, one of which ends just behind the dorso-median region while the other extends up to ventro-median region. Caudal process is well below the mid-height.

This is the only species of Atjehella known to have second order reticulation. Since this species is known only from two specimens it has not been possible to decide with
certainty its sex.

Distribution: Known from the Pliocene, Togopi River section, eastern Sabah, Malaysia.
*Atjehella reticulata* sp. nov.

**Explanation of Plate A**

Fig. 1, RV, ext. lat. (holotype OS10151, 463 μm long);

fig. 2, RV, int. lat. (holotype OS10151).

Scale A (100 μm; x 192), fig. 1; (100 μm; x 196), fig. 2.
Atjehella reticulata sp. nov.

Explanation of Plate B

Fig. 1, RV, antero-dorsal region showing second-order mesh-like reticulations (holotype OS10151);

fig. 2, RV, int. lat. musc. sc. (holotype OS10151);

fig. 3, RV, the merodont hinge (holotype OS10151).

Scale A (50 μm; x 288), fig. 1; scale B (50 μm; x 374), fig. 2; scale C (50 μm; x 392), fig. 3.
Explanation of Fig. 13

Transmission light photograph showing the marginal pore canals of *Atjehella reticulata* sp. nov., right valve (OS10244) (x518).
Explanation of text-figures 1-5

Text-fig. 1 Marginal pore canals of *Atjehella apoxeia* sp. nov., left valve (OS10155) (x119).

Text-fig. 2 Marginal pore canals of *Atjehella cribella* sp. nov., left valve (OS10242) (x140).

Text-fig. 3 Marginal pore canals of *Atjehella levigata* sp. nov., right valve (OS10152) (x153).

Text-fig. 4 Marginal pore canals of *Atjehella pentukensis* Keij, right valve (OS10243) (x131).

Text-fig. 5 Marginal pore canals of *Atjehella reticulata* sp. nov., right valve (OS10244) (x140).
CHAPTER VII

FAUNAL AFFINITIES OF THE TOGOPI FORMATION
AND DARVEL BAY OSTRACODS

Work on ostracods from the Indian ocean and adjacent areas has been carried out from the West coast of Australia (Hartmann, 1978, 1979), Java-Sumatra (Kingma, 1948), Burma (Gramann, 1975), the West coast of India (Jain, 1978), the Persian Gulf and the Gulf of Oman (Paik, 1976, 1977). The ostracod faunas described by these authors are compared with the Togopi Formation and Darvel Bay ostracods.

The Indo-Pacific region contains the following genera which are widely distributed but restricted to this region. These are mainly

- Alocopocythere
- Atljehelle
- Hemicytheridea
- Hemikrithe
- Lankacythere
- Loxoconchella
- Neocytheretta
- Tanella

Using these geographically restricted genera, a broad ostracod faunal province of the Indo-Pacific region can be recognized, containing several discrete parts.

The ostracod genera described from the area of comparative study (fig. 14), by Hartmann (1978, 1979), Kingma (1948), Gramann (1975), Jain (1978), Paik (1976, 1977) and those found in the
Togopi Formation and Darvel Bay are as follows:

- **Actinocythereis** Puri, 1953
- **Aglaiella** Daday, 1910
- **Aglaiocypris** Sylvester-Bradley, 1946
- **Alocopocythere** Siddiqui, 1971
- **Argilloecia** Sars, 1866
- **Assymetricicythere** Bassiouni, 1971
- **Atjehella** Kingma, 1948
- **Aurila** Pokorny, 1955
- **Australimoosella** Hartmann, 1978
- **Austroparadoxostoma** Hartmann, 1979
- **Bairdia** McCoy, 1844
- **Basslerites** Howe, 1937
- **Brachycythere** Alexander, 1933
- **Bradleya** Hornibrook, 1952
- **Bythoceratina** Hornibrook, 1952
- **Bythocypris** Brady, 1880
- **Bythocythere** Sars, 1886
- **Callistocythere** Ruggieri, 1953
- **Carinocythereis** Ruggieri, 1956
- **Caudites** Coryell & Fields, 1937
- **Chrysocythere** Ruggieri, 1961
- **Cletoocythereis** Swain, 1963
- **Clithrocytheridea** Stephenson, 1936
- **Copytus** Skogsberg, 1939
- **Cushmanidea** Blake, 1933
- **Cyprideis** Jones, 1857
- **Cythere** Mueller, 1785
Cythereis Jones, 1849
Cytherideis Jones, 1857
Cytherella Jones, 1849
Cytherelloidea Alexander, 1929
Cytheretta Mueller, 1894
Cytheroma Mueller, 1894
Cytheropteron Sars, 1866
Cytherura Sars, 1866
Dampiercythere Hartmann, 1978
Echinocythereis Puri, 1954
Falsocythere Ruggieri, 1972
Haplocytheridea Stephenson, 1936
Hemicytheridea Kingma, 1948
Hemicythere Sars, 1922
Hemicytherura Elofson, 1941
Hemikrithe van den Bold, 1950
Hemitrachyleberis Hartmann, 1974
Henryhowella Puri, 1957
Hiltermannicythere Bassiouni, 1970
Hullingsina Puri, 1958
Javanella Kingma, 1948
Kangarina Coryell & Fields, 1937
Keijella Ruggieri, 1967
Krithe Brady, Crosskey and Robertson, 1874
Lankacythere Bhatia & Kumar, 1979
Leguminocythereis Howe, 1936
Leptocythere Sars, 1928
Loxoconcha Sars, 1866
Loxoconchella Triebel, 1954
Loxocorniculum Benson & Coleman, 1963
Macrocypris Brady, 1868
Microcythere Mueller, 1894
Microcytherura Mueller, 1894
Miocyprideis Kollmann, 1960
Moosella Hartmann, 1964
Mutilus Neviani, 1928
Neocytheretta van Morkhoven, 1963
Neomonoceratina Kingma, 1948
Orthonotacythere Alexander, 1933
Paijenborchella Kingma, 1948
Paracypris Sars, 1866
Paracytheridea Mueller, 1894
Paracytheretta Triebel, 1941
Paracytherois Mueller, 1894
Paracytheroma Juday, 1907
Paradoxostoma Fischer, 1855
Parakrithella Hanai, 1959
Pectocythere Hanai, 1957
Phalcocythere Siddiqui, 1971
Phlyctenophora Brady, 1880
Phlyctocythere Keij, 1958
Polycopae Sars, 1866
Procycytheis Skogsberg, 1928
Propontocypris Sylvester-Bradley
Pseudocythere Sars, 1866
Pseudocythereis Skogsberg, 1928
**Pterygocythereis** Blake, 1933
**Pyricythereis** Howe, 1936
**Quadracythere** Hornibrook, 1952
**Ruggiera** Keij, 1957
**Semicytherura** Wagner, 1957
**Tanella** Kingma, 1948
**Thalmannia** LeRoy, 1939
**Trachyleberis** Brady, 1898
**Tribelina** van den Bold, 1946
**Uroleberis** Tribel, 1958
**Vijaiella** Jain, 1978
**Xestoleberis** Sars, 1866

In addition to the above list, chart I shows the genera and some common species encountered between West Australia and the Persian Gulf area. Chart II shows the genera and species found in the Pliocene Togopi Formation and the Recent of Darvel Bay, Sabah. The total fauna studied from Sabah, both fossil (Togopi Fm. Pls. 1-24) and Recent (Darvel Bay Pls. 1-19) is illustrated by SEM micrographs.

**The sedimentary facies:**

From what little information there is available, the ostracod faunas of the study region are mostly described from fine grained clastic and poorly calcareous deposits.

In Darvel Bay the predominant sedimentary facies is light grey to light brownish grey clay. Some silt and fine sand are
also present in the far eastern side of the Bay (see fig. 4). All but four of the Darvel Bay samples come from the clay facies. Out of the four non-clay samples three come from silt and one from fine sand. From this data no detailed conclusion can be drawn on the distribution of ostracod species as related to sedimentary facies in the shallow waters of Darvel Bay.

Whittaker and Hodgkinson (1979, p. 5-6) said that the Togopi Formation was formed by "shallow marine sedimentation (inner shelf to littoral) ... In the river section the boundary with the underlying Ganduman Formation is said to be a rather sharp lithological change from grey sand with pebbly beds up to 1 inch (25mm) thick, cemented with limonite and full of plant and wood fragments, to the characteristic olive-grey and bluish-grey poorly-bedded clays of the lower Togopi (Haile sample NB 9456/57) in which plant remains are rare according to Haile & Wong (1965:32). No unconformity has been reported".

The Recent sedimentary facies in which the Persian Gulf fauna have been recorded are "poorly coarse grained clayey marl", "richly coarse grained calcareous marl" and "calcareous clay"(Paik, 1977, p. 38). Paik also mentions that in his research area the differences in temperature were very small, and had no noticable influence on horizontal and vertical distribution of species (Paik, 1977, p. 62). Similarly he observes that salinity differences were also very low and had no important influence on ostracod fauna in his area of study (Paik, 1977, p. 62).

Comparison between West Australian and Sabah faunas:

Hartmann (1978, 1979) in his principal work on the West
Australian tropical fauna has described 39 genera (see chart I). Of the total Indopacific ostracod fauna listed, 41% of the genera are found in the Australian region. Of these, twelve genera have so far been reported by Hartmann in the Indopacific area only from the Australian region. They are:

Aglaiella,  
Australimoosella,  
Austroparadoxostoma,  
Cletocythereis,  
Dampiercythere,  
Hiltermannicythere,  
Paracytheroma,  
Parakritheilla,  
Pectocythere,  
Procythereis,  
Pterygocythereis and  
Semicytherura.

Of these, Australimoosella, Austroparadoxostoma and Dampiercythere were new genera erected by Hartmann (1978, 1979). Whether these three genera are endemic to the Australian region will have to be determined by future work.

The ostracod genera common to both West Australia and Sabah are  
Actinocythereis,  
Alocopocythere,  
'Bairdia',  
Callistocythere,  
Caudites,  
Cyprideis.
Cytherella,
Cytherelloidea,
Cytherura,
Leptocythere,
Loxoconcha,
Loxoconchella,
Mutilus,
Neomonoceratina,
Paracytheridea,
Phlyctenophora,
Tanella and
Trachyleberis.

This represents 21% of the Indo-Pacific genera listed.

Those species from Sabah which also occur on the West coast of Australia are primarily restricted to northwestern Australia (Hartmann, 1978, 1979), thereby possibly indicating that those Australian species are essentially tropical. An exception is Phlyctenophora cf. zealandica Brady, which is also found at higher latitudes in New Zealand (Morkhoven, 1963) and therefore possibly has a greater degree of temperature tolerance; in northwest Australia this species has been found live in water temperatures of 21°–28°C. The following species have been found to be common to West Australia and Sabah:

Alopecocythere reticulata indaaustralia Hartmann,
Caudites cf. javana Kingma,
Neomonoceratina koenigswaldi Keij,
Paracytheridea remanei Hartmann,
Phlyctenophora cf. zealandica Brady.
Cosmopolitan ostracod genera: Those encountered over the whole area from northwestern Australia to the Persian Gulf:

About 11% of the genera recorded from the Indian Ocean and adjacent areas have a cosmopolitan distribution. They are

- Actinocythereis,
- Aloconocythere,
- 'Bairdia',
- Callistocythere,
- Cytherella,
- Cytherelloidea,
- Cytheroma,
- Loxoconcha,
- Phlyctocythere,
- Propontocypris and
- Tanella.

Other genera are more restricted; on reviewing the Recent ostracods of the western side of the Indian Ocean area, (i.e. from the Persian Gulf to the western coast of India) about 10% of the genera have so far been identified which have not been found in the eastern half of the area of comparative study. They are

- Aglaiocypris,
- Bassleritesa,
- Cytheretta,
- Echinocythereis,
- Haplocytheridea,
- Hemitrachyleberis,
- Henryhowella,
- Hullingsina,
- Leguminocythereis and
- Paracytheroida.
Comparison between the Pliocene Togopi Formation and Recent Darvel Bay faunas:

In the Togopi Formation and Darvel Bay samples 43 ostracod genera have been recognized (see chart II), which is about 45% of the total number of genera recorded in the Indo-Pacific region. Out of these 43 genera the following are known from the Togopi Formation but not Darvel Bay:

- Aurila,
- Brachycythere,
- Callistocythere,
- Chrysocythere,
- Cushmanidea,
- Falsocythere,
- Lankacythere,
- Leptocythere,
- Quadracythere and
- Tanella.

On the other hand

- Bradleya,
- Clithrocytheridea,
- Cyprideis,
- Cytherura,
- Hemikrithe,
- Loxocorniculum,
- Paracypris,
- Polycopae,
- Pseudocythereis,
- Ruggieria and
Trachyleberis occur in Darvel Bay, but not the Togopi Formation. Thus, of the 43 genera in Sabah only 22 (51%) are common to both fossil and Recent deposits.

Although the Togopi Formation of the Dent Peninsula and Darvel Bay lie geographically adjacent to each other, the big discrepancy in their respective ostracod fauna is puzzling and its cause a matter of speculation. There is no firm evidence to suggest any major ecological or climatic changes, though some changes in the substrate have been noted (see p. 75).

Affinity of the Sabah fauna to other faunas:

At the specific level the ostracod assemblages of the Togopi Formation and Darvel Bay are new. At the generic level the assemblage of each region studied by Hartmann (1978, 1979), Kingma (1948), Gramann (1975), Jain (1978), and Paik (1976, 1977) differ considerably (see chart I).

In comparing the fauna of the Togopi Formation and Darvel Bay with other faunas the percentage of genera common to:

a) Sabah and West Australia is 21%;
b) Sabah and Java-Sumatra 22%;
c) Sabah and Burma 18%;
d) Sabah and West coast of India 26%; and
e) Sabah and the Persian Gulf region 27%.

On the basis of this data the Sabah fauna at generic level is distinctive, but its 'closest' affinity is with the faunas of the West coast of India and the Persian Gulf region.
Cosmopolitan ostracod species and the ecology of the faunas:

Some of the ostracod species are found as fossils in the far eastern sediments (e.g. Sabah, Java-Sumatra) and also survive in the Recent of the Persian Gulf and elsewhere in the area of comparative study and it is of course only one possibility that they may have migrated from a point of origin in the east.

Alocopocythere reticulata indoaustralica Hartmann, now found in the entire region of comparative study, survives in the tropical lagoon of Abu Dhabi, which has a salinity higher than normal marine conditions, varying from 42.7% to 64.75% (Bate, 1971). Hartmann (1978) did not give any ecological information for this species because he did not find it alive, but it can be safely said that it has a high salinity tolerance for it survives from the Persian Gulf area to Burma, northwestern Australia and Darvel Bay. In the Persian Gulf (Paik, 1977) this species tolerates a pH range of 8.12 to 8.20, a salinity range 37% to 40.5% and a temperature range of 18.5 to 23°C.

Lankacythere Bhatia & Kumar, 1979, from Recent sediments of the western coast of India, the Persian Gulf (Paik, 1977, pl. 1, figs. 9-11 of Cythere cf. cribiformis) and originally from the coast of Ceylon (Brady, 1866: Cythere coralloides Brady), has also been found in the Pliocene Togopi Formation.

Loxoconchella is another genus, previously described from the Recent, which has now been found in the Togopi Formation; of special interest is the fact that Loxoconchella anomala (Brady) is present in the Togopi Formation. This species could possibly
have migrated towards the west coast of India, where it has been found by Jain (1978). *Loxoconchella* has been reported by Brady (1880) from the Recent of Hawaii (*Loxoconcha honoluliensis* Brady, 1880).

**Actinocythereis scutigera costata** Hartmann, 1978 tolerates a pH range of 7 to 8 and temperature range of 21.2° to 26°C. **Actinocythereis scutigera scutigera** (Brady) has been found both in the Pliocene of Sumatra (*Cythereis scutigera* (Brady) of Kingma, 1948, p. 83), in the Togopi Formation, and in the Recent of Darvel Bay, Java Sea, as well as in the Persian Gulf. In the Persian Gulf it lives in an environment with a temperature range of 17.6° to 23°C, salinity 36.6‰ to 40.6‰ and a pH range of 8.03 to 8.29. **Atjehella paiki** Keij also lives in the Gulf in the same environment, as does *Cythere*cf. *cribriformis* of Paik (1977) (= *Lankacythere coralloides* (Brady) gen nov. of Bhatia & Kumar, 1979).

The genus *Tanella*, erected by Kingma (1948) from the Pliocene of Java has been reported by Paik (1977) from the Persian Gulf, where he records *Tanella* cf. *gracilis* from a temperature range of 18.9 to 21.1°C, salinity range of 36.4‰ to 37.8‰ and pH range 7.88 to 8.08. *Tanella gracilis* Kingma has been reported by Hartmann (1978) from the whole of the tropical coast of northwestern Australia where he found it live in temperatures 19.5° to 25°C, salinities of 38.4‰ to 42.2‰ and a pH of 7.5. This species has also been found in river estuaries of Australia which indicates that the species is quite tolerant of large variations in salinity. *Tanella* is also recorded herein from the Togopi Formation.

**Phlyctenophora** cf. *zealandica* Brady, 1880 has been found
both in Darvel Bay and in the Togopi Formation and Hartmann (1978) also reports this species from Australia where it has been found over a temperature range of 21° to 28°C, salinity 37 - 43‰ and at a pH of 7.5; Hartmann further reports that Phlyctenophora zealandica Brady can withstand fresh water in the rivers, living in substrates of sand, mud and plant detritus.

Neomonoceratina koenigswaldi Keij, 1954, another species found in the Togopi Formation and originally described from the Recent of Philippines has also been recorded by Hartmann (1978) from northwestern Australia. In Australia, N. koenigswaldi has been found in the upper eulittoral zone between mangroves, where the water temperature is between 24.5°-27.5°C, salinity 37.5‰ to 38.4‰ and pH 7.5; the substrates being sand, mud and plant detritus.

The available ecological data from the Persian Gulf region and Australia on some species are summarized below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Salinity</th>
<th>Temp.</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aloconocytherea reticulata</td>
<td>37‰ to 40.5‰</td>
<td>18.5° to 23°C</td>
<td>8.12-8.20</td>
</tr>
<tr>
<td>Indoaustralica Hartmann</td>
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<tr>
<td>Actinocythereis scutigera</td>
<td>36.6‰ to 40.6‰</td>
<td>17.6° to 23°C</td>
<td>8.03-8.29</td>
</tr>
<tr>
<td>Costata Hartmann</td>
<td></td>
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</tr>
<tr>
<td>Actinocythereis scutigera (Brady)</td>
<td>36.6‰ to 40.6‰</td>
<td>17.6° to 23°C</td>
<td>8.03-8.29</td>
</tr>
<tr>
<td>Atjehella paiki Keij</td>
<td>36.6‰ to 40.6‰</td>
<td>17.6° to 23°C</td>
<td>8.03-8.29</td>
</tr>
<tr>
<td>Tanella cf. gracilis Kingma</td>
<td>36.4‰ to 37.8‰</td>
<td>18.9° to 21.1°C</td>
<td>7.88-8.08</td>
</tr>
</tbody>
</table>
 Though first hand data is not available, from the above data the inference can be drawn that Darvel Bay may have more or less similar ecological conditions and, further, in the Pliocene the ecological conditions in which the Togopi Formation was deposited may not have been vastly different from the present time. In this context it is to be noted that the following species have been found both in the Togopi Formation and Darvel Bay: Alocopocythere reticulata indoaustralia Hartmann, Actinocythereis scutigera (Brady),
Phlyctenophora cf. zealandica Brady.

In Sabah Neomonoceratina koenigswaldi Keij has been found in the Togopi Formation only. Tanella has been found in the Togopi Formation and Atjehella is present both in the Togopi Formation and Darvel Bay.

At specific level in the region from the Persian Gulf to Sabah and Western Australia, each area has its own individuality of faunas and thus represent distinct parts of a larger, broadly defined 'Indo-Pacific' faunal province which includes genera such as Alocopocythere, Atjehella, Hemicytheridea, Hemikrithe, Lankacythere, Loxoconchella,
Neocytheretta and Tanella.

More work needs to be undertaken in all parts of this vast region in order to further substantiate any claim for the discreteness of its fossil and Recent ostracod faunas from other global faunal provinces.

Statistical correlation of the faunal provinces:

Because of the great paucity of common species so far discovered in the entire area of comparative study, the Jaccard's coefficient of correlation:

\[
\frac{C}{N_1 + N_2 - C}
\]

could not at present be fruitfully applied for a true statistical comparison.

( \( N_1 \) and \( N_2 \) would represent number of species and \( C = \) species in common )
**OCCURRENCE OF OSTRACOD GENERA AND SOME COMMON SPECIES IN THE INDIAN OCEAN AND ADJACENT AREAS**

<table>
<thead>
<tr>
<th>Genus/M.</th>
<th>Persian Gulf &amp; the Gulf of Oman, Recent (Park, 1967)</th>
<th>West coast of India, Recent (Jain, 1978)</th>
<th>Burma, Tertiary &amp; Recent (Grammann, 1975)</th>
<th>Indonesia, Miocene &amp; Recent (Kingsma, 1948)</th>
<th>Sabah, Darvel Bay, Recent (Herein)</th>
<th>Sabah, Toppi Formation, Pleistocene (Herein)</th>
<th>Western Australia, Recent (Hartmann, 1938-79)</th>
</tr>
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<tbody>
<tr>
<td>Actinocythereis</td>
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<tr>
<td>Actinocythereis scutigera (Brady)</td>
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<td>Actinocythereis cf. scutigera (Brady)</td>
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<td>Aglaocythereis</td>
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<tr>
<td>Aglaiothecella</td>
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<tr>
<td>Alocopocythere reticulata indoaustralica Hartman</td>
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<td>●</td>
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<td>Argilloecia</td>
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<td>Atjehella</td>
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<tr>
<td>Aurila</td>
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<td>Australimoosella</td>
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</tr>
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| Paradoxostoma | | | | |
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| Polycope | | | | |
| Procythereis | | | | |
| Proponocypris | | | | |
| Pseudocythere | | | | |
| Pseuodocythereis | | | | |
| Pyrgocythereis | | | | |
| Pyricythereis | | | | |
| Quadracythere | | | | |
| Ruggieria | | | | |
| Semicytherura | | | | |
| Tanella | | | | |
| Thalmannia | | | | |
| Trachyleberis | | | | |
| Tribetina | | | | |
| Uroleberis | | | | |
| Vijatiella | | | | |
| Xestoleberis | | | | |

**Chart I**
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<tr>
<td>'Cythere' cribriformis Brady</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Cytherella sp. A</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Cytherella sp. B</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Cytherella sp. C</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

*Chart II / continued*
<table>
<thead>
<tr>
<th>TOGOFI FORMATION</th>
<th>DARVEL BAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytherella semitatis Brady</td>
<td>●</td>
</tr>
<tr>
<td>Cytherellioidea spp.</td>
<td>●</td>
</tr>
<tr>
<td>Cytherura sp.</td>
<td>●</td>
</tr>
<tr>
<td>Cytheropteron sp. A</td>
<td>●</td>
</tr>
<tr>
<td>Cytheropteron sp. B</td>
<td>●</td>
</tr>
<tr>
<td>Cytheropteron sp. C</td>
<td>●</td>
</tr>
<tr>
<td>Falsacythere sp.</td>
<td>●</td>
</tr>
<tr>
<td>Hemicytheridea reticulata Kingma</td>
<td>●</td>
</tr>
<tr>
<td>Hemikrithe sp.</td>
<td>●</td>
</tr>
<tr>
<td>Keijella sp.</td>
<td>●</td>
</tr>
<tr>
<td>Lankacythere sp.</td>
<td>●</td>
</tr>
<tr>
<td>Leptocythere sp.</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconcha sp. A</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconcha sp. B</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconchella anomata (Brady)</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconchella sp. A</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconchella sp. B</td>
<td>●</td>
</tr>
<tr>
<td>Loxoconchium sp.</td>
<td>●</td>
</tr>
<tr>
<td>Mutillus sp. A</td>
<td>●</td>
</tr>
<tr>
<td>Mutillus sp. B</td>
<td>●</td>
</tr>
<tr>
<td>Mutillus sp. C</td>
<td>●</td>
</tr>
<tr>
<td>Neocytheretta sp.</td>
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</tr>
<tr>
<td>Neocytheretta snelli (Kingma)</td>
<td>●</td>
</tr>
<tr>
<td>Neomonoceratina sp. A</td>
<td>●</td>
</tr>
<tr>
<td>Neomonoceratina sp. B</td>
<td>●</td>
</tr>
<tr>
<td>Neomonoceratina columbiformis Kingma</td>
<td>●</td>
</tr>
<tr>
<td>Neomonoceratina cf. entomon (Brady)</td>
<td>●</td>
</tr>
<tr>
<td>Neomonoceratina koenigswaldi Keij</td>
<td>●</td>
</tr>
<tr>
<td>Paracypris cf. zealandica (Brady)</td>
<td>●</td>
</tr>
<tr>
<td>Paracytheridea remanei Hartmann</td>
<td>●</td>
</tr>
<tr>
<td>Paracytheridea cf. remanei Hartmann</td>
<td>●</td>
</tr>
<tr>
<td>Phyctenophora cf. zealandica Brady</td>
<td>●</td>
</tr>
<tr>
<td>Polycopae spp.</td>
<td>●</td>
</tr>
<tr>
<td>Pseudocythereis sp.</td>
<td>●</td>
</tr>
<tr>
<td>Quadracythere sp.</td>
<td>●</td>
</tr>
<tr>
<td>Ruggieria sp.</td>
<td>●</td>
</tr>
<tr>
<td>Tanella sp.</td>
<td>●</td>
</tr>
<tr>
<td>Trachyleberis sp.</td>
<td>●</td>
</tr>
<tr>
<td>Uroleberis sp.</td>
<td>●</td>
</tr>
</tbody>
</table>

Chart II
Samples from the Neogene and Recent of Sabah, Malaysia have yielded thirty-one ostracod species belonging to the genera *Polycope*, *Cytherelloidea* and *Atjehella*; all are described in detail. Of these species twenty-seven are new.

The genus *Polycope* is recorded from this part of the world for the first time. All nineteen species of *Polycope* are from the Recent of Darvel Bay and are new. Of the seven ornate *Cytherelloidea* species, two in Darvel Bay and two in the Pliocene Togopi Formation are new. *C. sabahensis* Keij and *C. cingulata* (Brady), previously known in this region only from the Recent, have now been found in the Pliocene of the Togopi Formation. Of the five species of *Atjehella*, four are new. For the first time the sieve-plates are described from *Atjehella*. Transmission light microscopy has shown that the marginal pore-canal system is different for each species of *Atjehella*.

Possible shell strengthening mechanisms of ornate *Polycope* species occur as detailed surface features revealed by scanning electron microscopy, although their functional significance is not obvious in all cases. Differences in ornament (together with soft parts) may well form the basis of subgeneric groupings in *Polycope*.

The existing view, based on foraminifera (Whittaker & Hodgkinson, 1979), that the Togopi Formation was deposited in shallow marine conditions (inner shelf to littoral) is further substantiated by the finding of the same ostracod species both
in the Togopi Formation and Darvel Bay.

Ecological data on Recent species like *Alocopocythere reticulata indoaustralia* Hartmann, *Actinocythereis scutigera costata* Hartmann, *Tanella gracilis* Kingma, *Phlyctenophora cf. zealandica* Brady, *Neomonoceratina koenigswaldi* Keij suggest probable more or less similar ecological conditions during the deposition of the Pliocene Togopi Formation.

Some common ostracod genera and some of the common species which are found from the West Australian region to the Persian Gulf have been able to migrate probably along the paths of equatorial currents (see fig.15) and at the same time these species may have developed wider salinity-tolerances. It has been found that some of the shallow water ostracods of the area which live in the inner shelf to littoral zone are adapted to a variety of substrates and variations in salinity. The species *Alocopocythere reticulata indoaustralia* Hartmann which survives in the hypersaline conditions of Abu Dhabi Lagoon has also been found over the entire region, indicating its wide tolerance to salinity variation.

The following ostracods, previously described from the Recent, are recorded herein as fossils from the Togopi Formation:

*Alocopocythere reticulata indoaustralia* Hartmann,
*Lankacythere* Bhatia & Kumar,
*Loxoconchella* (Brady),
*Neomonoceratina koenigswaldi* Keij and
*Phlyctenophora cf. zealandica* Brady.

Pending further investigation of older sediments in the
area by future workers it can be argued that the above ostracods may have originated in the region of Malaysia during the Pliocene.

Besides the detailed description of Polycope, Cytherelloidea and Atjehella, forty other genera have been identified in the Sabah fauna. The fauna of Sabah has been compared to ostracods from the Indian Ocean and adjacent area. This comparative study has revealed that the Persian Gulf region, the West coast of India, Burma, Java-Sumatra, Sabah and Western Australia represent individual ostracod faunal areas within a broadly defined Indo-Pacific province.
THE WORLD: Temperature and Ocean Currents

JANUARY ISOOTHERMS AND OCEAN CURRENTS

JULY ISOOTHERMS AND OCEAN CURRENTS

### APPENDIX A: DATA ON DARVEL BAY SAMPLES COLLECTED BY HMS DAMPIER

<table>
<thead>
<tr>
<th>BM (NH) No.</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Depth</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961,269 (37)</td>
<td>04°41.64'N</td>
<td>118°15.58'E</td>
<td>46 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (38)</td>
<td>04°41.22'N</td>
<td>118°15.33'E</td>
<td>36 ft.</td>
<td>Medium grey clay</td>
</tr>
<tr>
<td>1961,269 (40)</td>
<td>04°42.44'N</td>
<td>118°16.65'E</td>
<td>85 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (44)</td>
<td>04°56.90'N</td>
<td>118°14.00'E</td>
<td>114 ft.</td>
<td>Dark grey clay</td>
</tr>
<tr>
<td>1961,269 (45)</td>
<td>04°42.70'N</td>
<td>118°17.80'E</td>
<td>96 ft.</td>
<td>Medium grey clay</td>
</tr>
<tr>
<td>1961,269 (46)</td>
<td>04°48.70'N</td>
<td>118°21.10'E</td>
<td>210 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (47)</td>
<td>04°47.90'N</td>
<td>118°20.80'E</td>
<td>190 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (48)</td>
<td>04°42.50'N</td>
<td>118°21.60'E</td>
<td>138 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (49)</td>
<td>04°43.10'N</td>
<td>118°21.40'E</td>
<td>150 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (50)</td>
<td>04°45.50'N</td>
<td>118°15.75'E</td>
<td>115 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (51)</td>
<td>04°45.10'N</td>
<td>118°23.50'E</td>
<td>170 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (52)</td>
<td>04°44.20'N</td>
<td>118°19.20'E</td>
<td>140 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (53)</td>
<td>04°43.05'N</td>
<td>118°15.40'E</td>
<td>72 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (54)</td>
<td>04°43.00'N</td>
<td>118°17.00'E</td>
<td>90 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (55)</td>
<td>04°47.00'N</td>
<td>118°20.00'E</td>
<td>180 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (56)</td>
<td>04°48.45'N</td>
<td>118°17.9'E</td>
<td>150 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (57)</td>
<td>05° 1.00'N</td>
<td>118°20.10'E</td>
<td>36 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (58)</td>
<td>04°48.40'N</td>
<td>118°18.10'E</td>
<td>160 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (59)</td>
<td>04°44.60'N</td>
<td>118°23.00'E</td>
<td>180 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (60)</td>
<td>04°39.86'N</td>
<td>118°16.10'E</td>
<td>8 ft.</td>
<td>Whitish sand</td>
</tr>
<tr>
<td>1961,269 (61)</td>
<td>04°41.15'N</td>
<td>118°15.30'E</td>
<td>30 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (62)</td>
<td>04°40.80'N</td>
<td>118°15.80'E</td>
<td>46 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (63)</td>
<td>04°40.40'N</td>
<td>118°16.20'E</td>
<td>36 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1961,269 (66)</td>
<td>04°41.60'N</td>
<td>118°17.15'E</td>
<td>78 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1961,269 (67)</td>
<td>04°42.00'N</td>
<td>118°17.50'E</td>
<td>84 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>BM (NH) no.</td>
<td>Latitude</td>
<td>Longitude</td>
<td>Depth</td>
<td>Lithology</td>
</tr>
<tr>
<td>------------</td>
<td>---------------</td>
<td>----------------</td>
<td>-------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°39.6'N</td>
<td>118°10.4'E</td>
<td>198 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°55.1'N</td>
<td>118°25.5'E</td>
<td>84 ft.</td>
<td>Medium grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°48.9'N</td>
<td>118°13.0'E</td>
<td>126 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°46.5'N</td>
<td>118°24.2'E</td>
<td>180 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°33.0'N</td>
<td>118°41.5'E</td>
<td>120 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°52.5'N</td>
<td>118°13.0'E</td>
<td>156 ft.</td>
<td>Grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°41.8'N</td>
<td>118°31.7'E</td>
<td>162 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°42.5'N</td>
<td>118°30.4'E</td>
<td>174 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°52.8'N</td>
<td>118°15.0'E</td>
<td>162 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°51.8'N</td>
<td>118°25.15'E</td>
<td>174 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°54.2'N</td>
<td>118°28.5'E</td>
<td>114 ft.</td>
<td>Medium grey silty clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°44.6'N</td>
<td>118°28.4'E</td>
<td>216 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°49.1'N</td>
<td>118°26.9'E</td>
<td>222 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°51.6'N</td>
<td>118°31.2'E</td>
<td>210 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°51.6'N</td>
<td>118°28.2'E</td>
<td>186 ft.</td>
<td>Light grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°55.2'N</td>
<td>118°23.0'E</td>
<td>126 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°43.8'N</td>
<td>118°32.7'E</td>
<td>222 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°52.2'N</td>
<td>118°23.7'E</td>
<td>180 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°48.0'N</td>
<td>118°29.8'E</td>
<td>236 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°49.1'N</td>
<td>118°32.9'E</td>
<td>240 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°51.0'N</td>
<td>118°35.1'E</td>
<td>252 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°45.15'N</td>
<td>118°36.0'E</td>
<td>264 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°47.0'N</td>
<td>118°33.0'E</td>
<td>252 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°42.5'N</td>
<td>118°36.2'E</td>
<td>240 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1962,215</td>
<td>04°48.3'N</td>
<td>118°37.2'E</td>
<td>276 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,854</td>
<td>04°45.2'N</td>
<td>118°24.7'E</td>
<td>210 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,860</td>
<td>04°47.6'N</td>
<td>118°25.8'E</td>
<td>228 ft.</td>
<td>Light grey plastic clay</td>
</tr>
<tr>
<td>1963,861</td>
<td>04°48.2'N</td>
<td>118°24.4'E</td>
<td>234 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>BM (NH) no.</td>
<td>Latitude</td>
<td>Longitude</td>
<td>Depth</td>
<td>Lithology</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>-------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1963,862</td>
<td>04°49.3'N</td>
<td>118°22.7'E</td>
<td>228 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,865</td>
<td>04°46.7'N</td>
<td>118°27.0'E</td>
<td>234 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,866</td>
<td>04°45.0'N</td>
<td>118°26.9'E</td>
<td>216 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,867</td>
<td>04°44.0'N</td>
<td>118°26.9'E</td>
<td>204 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,868</td>
<td>04°45.9'N</td>
<td>118°27.7'E</td>
<td>222 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,871</td>
<td>04°46.0'N</td>
<td>118°30.1'E</td>
<td>228 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1963,873</td>
<td>04°44.0'N</td>
<td>118°28.3'E</td>
<td>204 ft.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,179</td>
<td>04°42.6'N</td>
<td>118°30.8'E</td>
<td>60 fms.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,181</td>
<td>04°42.8'N</td>
<td>118°30.8'E</td>
<td>35 fms.</td>
<td>Grey clay</td>
</tr>
<tr>
<td>1965,0,182</td>
<td>04°42.4'N</td>
<td>118°35.4'E</td>
<td>36 fms.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,183</td>
<td>04°44.5'N</td>
<td>118°30.0'E</td>
<td>34 fms.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,184</td>
<td>04°38.5'N</td>
<td>118°39.6'E</td>
<td>34 fms.</td>
<td>Light grey silty clay</td>
</tr>
<tr>
<td>1965,0,185</td>
<td>04°44.6'N</td>
<td>118°43.5'E</td>
<td>46 fms.</td>
<td>Light brownish grey clayey sil</td>
</tr>
<tr>
<td>1965,0,186</td>
<td>04°35.7'N</td>
<td>118°58.4'E</td>
<td>48 fms.</td>
<td>Light brownish grey clayey sil</td>
</tr>
<tr>
<td>1965,0,187</td>
<td>04°39.2'N</td>
<td>118°40.5'E</td>
<td>34 fms.</td>
<td>Light brownish grey silty clay</td>
</tr>
<tr>
<td>1965,0,188</td>
<td>04°40.6'N</td>
<td>118°35.3'E</td>
<td>35 fms.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,189</td>
<td>04°44.7'N</td>
<td>118°34.9'E</td>
<td>38 fms.</td>
<td>Light brownish grey clay</td>
</tr>
<tr>
<td>1965,0,190</td>
<td>04°43.2'N</td>
<td>118°30.8'E</td>
<td>31 fms.</td>
<td>Light brownish grey clay</td>
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<td>1965,0,191</td>
<td>04°41.6'N</td>
<td>118°34.7'E</td>
<td>34 fms.</td>
<td>Light brownish grey clay</td>
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<td>04°40.2'N</td>
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<td>40 fms.</td>
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<td>04°40.0'N</td>
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<td>88 fms.</td>
<td>Light brown silty fine sand</td>
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APPENDIX B: THE DISTRIBUTION OF THE OSTRACOD GENERA WITHIN THE TOGOPI RIVER SECTION

(Samples are arranged in ascending stratigraphic order from left to right. □ = Genera present)

| Sample | Actinocythereis | Alocopocytphere | Archaeocythereid | Aurila | Bairdia | Brachocythere | Bythoceratina | Bythocythere | Callistocythere | Carnocythereis | Caudites | Chrysocythere | Cushmanidea | 'Cythere' | Cytzerella | Cytzerelloidea | Cytzeropteron | Falsocythere | Hemiocytheridea | Keijella | Lankacythere | Leftocythere | Loxoconcha | Loxoconchella | Mutilus | Neocytheretta | Neokonoceratina | Paracytheridea | Phlyctenophora | Quadracythere | Tanella | Uropleuroceras |
|--------|-----------------|-----------------|------------------|--------|---------|-------------|--------------|--------------|----------------|----------------|-----------|--------------|-------------|-----------|------------|----------------|--------------|------------|----------------|---------|----------------|----------------|-------------|----------------|----------------|---------|----------------|----------------|
Appendix C: The distribution of the ostracod genera in the Recent of Darvel Bay, Sabah

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### Appendix C

<p>| Year(s) | Actinocythereis | Aloconocythere | Atjehella | Bairdia | Bradleya | Bythocythere | Bythoceratina | Carinocythereis | Caudites | Clithrocytheridea | Cyprideis | 'Cythere' | Cytherella | Cytherelloidea | Cytheronteron | Cytherura | Hemicytheridea | Hemikrithe | Keijella | Loxoconcha | Loxoconchella | Loxocorniculum | Mutilus | Neocytheretta | Neomonoceratina | Paracypris | Paracytheridea | Phlyctenophora | Polycome | Pseudocythereis | Ruggiera | Trachyleberis | Uroleberis |
|---------|-----------------|---------------|-----------|---------|----------|--------------|---------------|----------------|----------|----------------|-----------|-----------|-----------|--------------|--------------|----------|----------------|-----------|---------|-------------|--------------|-------------|---------|----------------|-----------|-------------|---------|----------|---------|
| 1961, 269 (55) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (56) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (57) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (58) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (59) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (60) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (61) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (62) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (63) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (64) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (65) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (66) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (67) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1961, 269 (68) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1962, 215 (1) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1962, 215 (2) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
| 1962, 215 (3) |                |               |           |         |          |              |               |                |          |               |           |          |           |              |              |          |                |           |         |             |              |             |         |                |           |           |         |         |         |
|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Actinocythereis   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Alocopocythere    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Atjehella         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Bairdia           |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Bradleya          |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Bythoceratina     |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Bythocythere      |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Carinocythereis   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Caudites          |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Clithrocytheridea |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Cyprideis         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| 'Cythere'         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Cytherella        |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Cytherelloidea    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Cytheropteron     |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Cytherura         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Hemicytheridea    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Hemikrithe        |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Keijella          |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Loxoconcha        |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Loxoconchella     |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Loxocorniculum    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Mutilus           |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Neocytherettta    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Neomonoceratina   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Paracypris        |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Paracytheridea    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Phlyctenophora    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Polycope          |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Pseudocythereis   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Ruggieria         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
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Appendix D: Abundance of *Polycope*, *Cytherelloidea* and *Atjehella* species in Sabah samples

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<th>Frequent (6-50 valves)</th>
<th>Abundant (51 to &gt;100 valves)</th>
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<td><em>P. rama</em> sp. nov.</td>
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<td><em>P. spongia</em> sp. nov.</td>
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<td><em>P. transenna</em> sp. nov.</td>
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### Appendix D

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Appendix E: The distribution of *Polycope* species in the Recent of Darvel Bay, Sabah

- *P. arenula* sp. nov.
- *P. burostrata* sp. nov.
- *P. carticula* sp. nov.
- *P. caverna* sp. nov.
- *P. choane* sp. nov.
- *P. clivosa* sp. nov.
- *P. fistula* sp. nov.
- *P. foraminosa* sp. nov.
- *P. lacinia* sp. nov.
- *P. lacuntia* sp. nov.
- *P. lira* sp. nov.
- *P. monilia* sp. nov.
- *P. peitata* sp. nov.
- *P. rama* sp. nov.
- *P. regina* sp. nov.
- *P. retia* sp. nov.
- *P. spongia* sp. nov.
- *P. transenna* sp. nov.
- *P. vulcana* sp. nov.
Appendix E

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Appendix E

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P. burostrata sp. nov.
P. carticula sp. nov.
P. caverna sp. nov.
P. choane sp. nov.
P. clivosa sp. nov.
P. fistula sp. nov.
P. foraminosa sp. nov.
P. lacinia sp. nov.
P. lacuntis sp. nov.
P. 'lira sp. nov.
P. monilia sp. nov.
P. peltata sp. nov.
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*Addenda:


SAMPLES FROM THE NEOGENE AND RECENT MARINE OSTRACODS FROM SABAH, MALAYSIA:
A thesis submitted for the degree of Doctor of Philosophy in
the Faculty of Science, University of Leicester by Manzoor Hasan.

ABSTRACT

Samples from the Neogene and Recent of Sabah, Malaysia,
have yielded 43 cladocopine, platycopine and podocopine ostracod
genera which are recorded and variously described. The genera
Polycope, Cytherelloidea and Atjehella are described in detail
and contain a total of 27 new species.

Polycope is recorded from this part of the world for the
first time. Newly discovered morphological structures suggest
that shell ornament may be a valuable aid (to soft parts) in
the taxonomy of the genus. The functional significance of many
ornamental features of the shell is probably as strengthening
devices.

Morphology of the marginal pore canals is particularly
useful in distinguishing the originally monotypic Atjehella.

The existing view, based on foraminifera (Whittaker &
Hodgkinson, 1979), that the Pliocene Togopi Formation of Sabah
was deposited in shallow marine conditions (inner shelf to
littoral) is substantiated by its ostracod fauna.

At specific level the ostracod assemblages of the Pliocene
Togopi Formation and Recent of Darvel Bay, Sabah are new; a
comparison of the ostracod fauna of Sabah to known ostracod faunas
from the Indian Ocean and adjacent areas (e.g. Western Australia,
Java-Sumatra, Burma, Western India and the Persian Gulf) reveals
a pattern of discrete faunal areas within a broadly defined Indo-
Pacific faunal province.