Phormocyrtis cubensis (Riedel and Sanfilippo)

Eucyrtidium cubense Riedel and Sanfilippo, 1971, p.1594, pl.7, figs.10-11

Phormocyrtis cubensis (Riedel and Sanfilippo), Foreman, 1973, p.438, pl.7, figs.11-12, 14

DESCRIPTION

Upper three segments form a conical section of the shell, and fourth segment (separated from third by slight if any internal ledge) approximately cylindrical. Cephalis subspherical, with few small pores, and bearing a short bladed apical spine. Collar stricture indistinct externally. Thorax campanulate and abdomen inflated annular,



separated by pronounced internal and slight external lumbar stricture. Pores of both thorax and abdomen subcircular, larger and more closely spaced on the abdomen. In most specimens, longitudinal ridges on the surface of thorax and proximal part of abdomen separate longitudinal rows of pores. Fourth segment subcylindrical, of densely spongy material. Termination ragged or broken in all observed specimens (Riedel and Sanfilippo, 1971).

There are six collar pores, the two jugular pores very small, and an upwardly directed vertical pore emerging from the thoracic wall that envelopes the basal cephalis (Foreman, 1973).

DIMENSIONS

Based on 9 specimens. Length of first three segments 120-150 μ m, their maximum breadth 90-135 μ m (Riedel and Sanfilippo, 1971).

DISTINGUISHING CHARACTERS

This species differs from all other known multisegmented forms by the spongy nature of the fourth segment.

VARIABILITY

This species varies in the degree of inflation of the abdomen and the density of the spongy material covering the fourth segment.

DISTRIBUTION

This species is present in material from the tropical Pacific and Atlantic Oceans and from the Gulf of Mexico. Its morphotypic first appearance lies within the *Bekoma campechensis* Zone. Its morphotypic last appearance is approximately synchronous with the lower limit of the *Phormocyrtis striata striata* Zone.

PHYLOGENY

Unknown.

Phormocyrtis striata exquisita (Kozlova)

Podocyrtis exquisita Kozlova in Kozlova and Gorbovets, 1966, p.106, pl.17, fig.2

Phormocyrtis striata exquisita (Kozlova), Foreman, 1973, p.438, pl.7, figs.1-4, 7-8, pl.12, fig.5 (with synonymy)



DESCRIPTION

Shell as for *Phormocyrtis striata striata*, with the exception that the abdomen is triangular in transverse section with early forms frequently having keels at the angles of the triangle, and pores less regular in shape and arrangement (Foreman, 1973).

DIMENSIONS

Based on 20 specimens. Length overall, exclusive of horn, 150-220 μ m; greatest width of abdomen 70-130 μ m (Foreman, 1973).

DISTINGUISHING CHARACTERS

P. s. exquisita is distinguished from *P. s. striata* by its abdomen being concave-triangular in transverse section (Sanfilippo et al., 1985).

VARIABILITY

The abdomen is triangular in transverse section. Early forms frequently have keels at these angles and the pores are irregular in size and arrangement (Sanfilippo et al., 1985).

DISTRIBUTION

P. s. exquisita occurs in tropical assemblages of Paleocene to early Eocene age. Its morphotypic first appearance has not been determined. Its evolutionary transition to *Phormocyrtis striata striata* is approximately synchronous with the lower limit of the *Phormocyrtis striata striata* Zone.

PHYLOGENY

P. s. exquisita gave rise to *P. s. striata*, but its ancestor is unknown.

Phormocyrtis striata striata Brandt

Phormocyrtis striata Brandt in Wetzel, 1935, p.55, pl.9, fig.12; Riedel and Sanfilippo, 1970, p.532, pl.10, fig.7

Phormocyrtis striata striata Brandt, Foreman, 1973, p.438, pl.7, figs.5-6, 9

DESCRIPTION

P. striata striata is here limited to those forms having the abdomen circular in transverse section. Specimens observed agree well with those described by Riedel and Sanfilippo (1970). The collar stricture has four collar pores with a vertical pore emerging from the thoracic wall that envelopes the basal cephalis (Foreman, 1973).

DIMENSIONS

Length (excluding horn) 170-255 μm ; maximum breadth 70-100 μm (Sanfilippo et al., 1985).

DISTINGUISHING CHARACTERS

Shell approximately spindle-shaped with the abdomen (circular in transverse section) forming the major part (Foreman, 1973).

P. s. striata is distinguished from its ancestor *P. s. exquisita* by having the abdomen circular in transverse section. It differs from *Buryella clinata* and *Phormocyrtis turgida* (Krasheninnikov, 1960, p.301, pl.3, fig.17) in the relatively larger abdomen and lack of a fourth segment (Sanfilippo et al., 1985).

VARIABILITY

This three-segmented form, with the fusiform abdomen constituting the major part of the shell, has its greatest width usually near the middle. Abdominal pores are circular, in longitudinal rows commonly separated by ridges. Termination ragged, toothed, or in rare specimens closed (Sanfilippo et al., 1985).



DISTRIBUTION

P. s. striata occurs widely in tropical late early to middle Eocene sequences, but in low abundances, and sporadically in the upper part of its range. Its evolutionary transition from *Phormocyrtis striata exquisita* is approximately synchronous with the lower limit of the *Phormocyrtis striata striata* Zone. Its morphotypic last appearance is approximately synchronous with the lower limit of the *Podocyrtis chalara* Zone.

PHYLOGENY

Phormocyrtis s. striata arose from *P. s. exquisita,* and left no descendants.

Phormostichoartus corbula (Harting)

Lithocampe corbula Harting, 1863, p.12, pl.1, fig.21

Phormostichoartus corbula (Harting), Nigrini, 1977, p.252, pl.1, fig.10 (with synonymy)

DESCRIPTION



Shell thin-walled, smooth, subcylindrical consisting of 4 segments of which the fourth is the broadest. Cephalis approximately spherical with a well-developed, poreless, [vertical] tubule that curves downwards so as to lie close to the thorax; numerous subcircular pores; no apical horn. Collar stricture indistinct.

Thorax short, truncate conical, with circular to subcircular pores arranged approximately in transverse rows. Lumbar and post-lumbar strictures distinct.

Abdomen annular, somewhat longer than thorax. Pores small, subcircular to squarish, arranged in 5-8 regular closely spaced transverse rows.

Fourth segment 2-4 times as long as abdomen; pores similar in size and shape to those on abdomen, in 9-17 transverse rows. Segment tapers slightly distally and ends in a generally poreless peristome. Termination smooth [or, sometimes, small, pointed teeth are present] (Nigrini, 1967).

DIMENSIONS

Total length 130-165 μ m maximum breadth 65-75 μ m. Measurements given by Nigrini (1967) have a greater range for both length and breadth (Nigrini, 1977).

DISTINGUISHING CHARACTERS

Four-segmented form, the last segment being the longest. All postcollar strictures are distinct but not deep. Pores small, regularly arranged in dense transverse rows. Distinct poreless peristome somewhat constricted (Riedel and Sanfilippo, 1978a, as *Siphocampe corbula*).

P. corbula differs from *P. fistula* Nigrini (1977, p.453, pl.1, figs.11-13) in having smaller pores, usually more than twelve pores across the fourth segment in 9-17 rows, as compared to less than eight across in 5-8 rows in *P. fistula* (Sanfilippo et al., 1985).

VARIABILITY

This four-segmented artostrobiid has a well-developed poreless cephalic tube that curves downward along the thorax. The length of the fourth segment varies from one to four times the length of the third (Sanfilippo et al., 1985).

DISTRIBUTION

This middle middle Miocene through Quaternary species is found in latitudes less than 40°, except for DSDP Site 206 near New Zealand and Site 362 off southwest Africa. Its morphotypic first appearance lies within the *Dorcadospyris alata* Zone. It is extant.

PHYLOGENY

P. corbula may have evolved from P. fistula, and is extant.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1971, pl.1H, figs.18-25.

Phormostichoartus doliolum (Riedel and Sanfilippo)

Artostrobium doliolum Riedel and Sanfilippo, 1971, p.1599, pl.1H, figs.1-3, pl.8, figs.14-15

Phormostichoartus doliolum (Riedel and Sanfilippo), Nigrini, 1977, p.252, pl.1, fig.14.

DESCRIPTION



Spindle-shaped, four-segmented artostrobiid in which the intersegmental strictures are not strongly pronounced externally. Cephalis very small, spherical bearing a lateral tube that lies along the thoracic wall and is thus directed obliquely downward. Thorax and third segment truncate-conical; fourth segment the widest, tapering distally, in some specimens with a poreless peristome. All post-cephalic segments with pores in closely-spaced transverse rows (Riedel and Sanfilippo, 1971).

DIMENSIONS

Total length 110-155 μ m; maximum breadth 70-95 μ m. Riedel and Sanfilippo (1971) recorded total lengths as short as 95 μ m (Nigrini, 1977).

DISTINGUISHING CHARACTERS

Four-segmented, broadly spindle-shaped, without pronounced strictures externally. No horn (Riedel and Sanfilippo, 1978a, as *Artostrobium doliolum*).

This species was redefined by Westberg and Riedel (1978) as "including only those specimens in which the width of the third stricture is 65 μ m or greater (which corresponds, in most specimens, to a maximum shell breadth of 75 μ m). The width of the third stricture, instead of the maximum breadth, is now proposed as the distinguishing character because of the large number of specimens in which the fourth segment is broken."

DISTRIBUTION

This low-latitude species is very rare beginning in the *Didymocyrtis antepenultima* Zone, becoming increasingly common in younger sediments to a peak abundance in the *Stichocorys peregrina* Zone, then tapering off in the *Spongaster pentas* Zone (Nigrini, 1977).

Its morphotypic last appearance is a reliable and easily recognizable synchronous event.

PHYLOGENY

This species apparently developed from *Phormostichoartus marylandicus* (Nigrini, 1977, p.253, pl.2, figs.1-4), a form with less developed third segment, more widely separated rows of pores and somewhat more pronounced intersegmental strictures.

REMARKS

In the Indian Ocean, Johnson et al. (1989) used the upper limit of *P. doliolum* to subdivide the *Spongaster pentas* Zone.

Phormostichoartus fistula Nigrini

Phormostichoartus fistula Nigrini, 1977, p.253, pl.1, figs.11-13

DESCRIPTION

Shell thick-walled, smooth, subcylindrical, consisting of four segments. Cephalis

approximately spherical with well-developed, poreless vertical tube lying along thorax for about half thoracic length; few subcircular pores; no apical horn. Collar stricture indistinct.

Thorax short, truncate conical with two or three transverse rows of relatively large subcircular pores. Lumbar stricture and post-lumbar strictures distinct but not pronounced. Sometimes post-lumbar stricture marked by smooth poreless band.

Abdomen annular, elongate with five to eight closely spaced transverse rows of large subcircular pores.

Fourth segment approximately same width as or narrower than abdomen; pores similar in size and shape to those on abdomen, usually in three or four transverse rows. Segment narrowing to poreless peristome, sometimes with small, poorly developed terminal teeth. In some specimens fourth segment is elongate with more pore rows, often becoming irregular in arrangement and shape (Nigrini, 1977).

DIMENSIONS

Based on 15 specimens. Total length 110-190 μ m; length of cephalis and thorax 36-40 μ m; length of abdomen 35-53 μ m; length of fourth segment 35-70 μ m; maximum breadth 65-83 μ m (Nigrini, 1977).

DISTINGUISHING CHARACTERS

P. fistula may be distinguished from its descendant, *Phormostichoartus pitomorphus* (Caulet, 1986, p.850, pl.3, figs.3-4, 9-10, 12) by its greater size, larger pores and less pronounced lumbar stricture.



DISTRIBUTION

Rare or very rare from *Theocyrtis tuberosa* Zone to *Spongaster pentas* Zone. Eocene and Oligocene specimens usually incomplete, with fourth segment either broken or not originally developed. Characteristic vertical tube always well developed (Nigrini, 1977).

This species can be found in both tropical and temperate latitudes. Its morphotypic last appearance is a reliable and easily recognizable synchronous event.

PHYLOGENY

Origin unknown; evolved into *P. pitomorphus* in the early Pliocene; may also be the ancestor of *P. corbula*.

REMARKS

In the Indian Ocean, Johnson et al (1989) used the upper limit of *P. fistula* to subdivide the *Spongaster pentas* Zone.

Podocyrtis (Lampterium) acalles Sanfilippo and Riedel

Podocyrtis (Lampterium) acalles Sanfilippo and Riedel, 1992, p.12, pl.3, figs.2-5

DESCRIPTION

Three-segmented pterocorythid with a broad-based vaguely lobed cephalis, bearing a



short bladed horn. The lateral lobes of the cephalis have small irregular pores. Thorax campanulate, with pores in rows separated by longitudinal ridges. Lumbar stricture marked on the external contour by a slight indentation. Abdomen approximately the same length as the thorax, cylindrical to slightly inflated, terminating in a broad hyaline peristome bearing three wide shovel-shaped feet. The abdominal pores are slightly larger than the thoracic ones, in later forms arranged in rows separated by longitudinal ridges. Earlier forms tend to have abdominal pores that are irregular in size and arrangement but with some development of discontinuous ridges. (Sanfilippo and Riedel, 1992).

DIMENSIONS

Based on 40 specimens. Length (excluding horn), 170-240 μ m; length of cephalothorax, 90-115 μ m; width of thorax 85-115 μ m; width of abdomen 90-130 μ m (Sanfilippo and Riedel, 1992).

DISTINGUISHING CHARACTERS

This species is transitional between *Podocyrtis (P.) papalis* and *P. (Lampterium) sinuosa*. It is distinguished from *P. papalis* by the presence of a slight external lumbar stricture, and from *P. sinuosa* by the proportion of thoracic length to abdominal length (1:1 in the former, and 1:1.5 to 1:3 in the latter) (Sanfilippo and Riedel, 1992).

DISTRIBUTION

From its first appearance near the boundary between the *Buryella clinata* and *Phormocyrtis striata striata* Zones, *P. acalles* characteristically occurs in large numbers in early Eocene assemblages (up to 2% of the total) to paleolatitudes of 45° (Sanfilippo and Riedel, 1992).

PHYLOGENY

The evolutionary transition of *P. acalles* to *P. sinuosa* occurs in the *Theocotyle cryptocephala* Zone.

REMARKS

Podocyrtis (Podocyrtoges) ampla Ehrenberg

Podocyrtis(?) ampla Ehrenberg, 1873, p.248; 1875, pl.16, fig.7; Riedel and Sanfilippo, 1970, p.533, pl.12, figs.7-8

Podocyrtis (Podocyrtoges) ampla Ehrenberg, Sanfilippo and Riedel, 1992, p.14, pl.5, fig.4

DESCRIPTION

Cephalis [three-lobed], subspherical, with few small pores, bearing a stout conical horn of variable length. Collar and lumbar strictures not



pronounced. Thorax conical, of approximately the same length as the abdomen, with circular pores in longitudinal rows separated by ridges. Abdomen truncate-conical or subcylindrical, slightly inflated, with pores, larger than those of the thorax, usually arranged in approximate longitudinal rows without intervening ridges. Abdomen terminates in a narrow, thickened rim from which arise (in early specimens only) three small, shovel-shaped or spathulate feet (Riedel and Sanfilippo, 1970).

DIMENSIONS

Length (excluding horn and feet) 240-280 μm ; maximum breadth 170-205 μm (Sanfilippo and Riedel, 1970).

DISTINGUISHING CHARACTERS

P. (P.) ampla differs from *P. (P.) phyxis* in tending toward a conical shape by reduction of the lumbar stricture, the thorax becoming conical rather than campanulate, and the abdomen becoming widest distally rather than medially. Also, late forms have ribs between the longitudinal rows of thoracic pores. It differs from *P. (P.) diamesa* by the relatively more voluminous abdomen with larger pores not separated by longitudinal ribs (Sanfilippo et al., 1985).

VARIABILITY

Early specimens have three small, spathulate feet, absent in later specimens, and the thorax is less pronouncedly ribbed (Sanfilippo et al., 1985).

DISTRIBUTION

This middle middle Eocene species is found in large numbers in the Pacific Ocean and Caribbean, and much more rarely in the Indian Ocean. It occurs in moderate abundance in the eastern Atlantic. Its evolutionary transition from *Podocyrtis phyxis* defines the base of the *Podocyrtis ampla* Zone. Its morphotypic last appearance lies within the *Podocyrtis mitra* Zone.

PHYLOGENY

It seems that *P. (P.) ampla* evolved from *P. (P.) diamesa* by way of *P. (P.) phyxis,* and left no descendants. The only awkward aspect of this interpretation is the fact that a form with unribbed thorax (*P. phyxis*) is interposed between an ancestor and descendant with usually ribbed thorax (*P. diamesa* and *P. ampla*). This can only be explained by regarding the later occurrence of thoracic ribs as a secondary development (Sanfilippo et al., 1985).

REMARKS

Podocyrtis (Lampterium) chalara Riedel and Sanfilippo

Podocyrtis (Lampterium) chalara Riedel and Sanfilippo, 1970, p.535, pl.12, figs.2-3; Riedel and Sanfilippo, 1978a, p.71, pl.8, fig.3, textfig.3

DESCRIPTION

Cephalis [three-lobed], irregularly hemispherical, with few to many small pores, and bearing a stubby bladed horn. Thorax thickwalled with rough surface approximately hemispherical, with rather large subcircular



pores. Collar and lumbar strictures distinct. Abdomen robust, with smooth surface, of very large subangular meshes usually in approximate longitudinal rows; in outer form it expands slightly, then contracts distally. Abdominal pores commonly have short thorns projecting inward from their periphery. Vestigial triangular teeth are rarely present (Riedel and Sanfilippo, 1970).

DIMENSIONS

Thorax 40-65 μm long, 80-95 μm wide. Abdomen 155 (rarely 85) - 255 μm long and 125 (rarely 100) - 165 μm wide (Riedel and Sanfilippo, 1970).

DISTINGUISHING CHARACTERS

This species is distinguished from *P. (L.) mitra* by having less than 13 pores around the widest part of the circumference of the abdomen (Riedel and Sanfilippo, 1978a, p.86), and from *P. (L.) goetheana* as indicated under that species. From *P. (L.) trachodes, P. (L.) chalara* is distinguished by larger pores and usually smooth outline (Sanfilippo et al., 1985).

VARIABILITY

The small thorax, with rough surface and pores not longitudinally aligned, shows little variation. The abdomen is shorter in early than in

late forms, with the exception that in some of these latter it is reduced to two or three rows of large pores and is therefore abnormally short. The large, subangular pores of the abdomen increase in size with time, and towards the end of the range they lose their longitudinal alignment (Sanfilippo et al., 1985).

DISTRIBUTION

P. (L.) chalara occurs in tropical assemblages of late middle Eocene age. Its evolutionary transition from *Podocyrtis mitra* defines the base of the *Podocyrtis chalara* Zone. Its morphotypic last appearance is near the top of the *Cryptocarpium azyx* Zone.

PHYLOGENY

P. (*L.*) *chalara* evolved directly from *P.* (*L.*) *mitra*, and gave rise to *P.* (*L.*) *goetheana*.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1981, fig.12-7, nos.5-6, fig.12-8, nos.9-12.

Podocyrtis (Podocyrtoges) diamesa Riedel and Sanfilippo

Podocyrtis (Podocyrtis) diamesa Riedel and Sanfilippo, 1970, p.533 (*pars*), pl.12, fig.4, *non* figs.5-6; Sanfilippo and Riedel, 1973, p.531, pl.20, figs.9-10, pl.35, figs.10-11

Podocyrtis (Podocyrtoges) diamesa Sanfilippo and Riedel, 1992, p.14

DESCRIPTION

Cephalis elongate-hemispherical, with small pores, bearing a horn of variable length,



which is bladed in early specimens, conical and robust in late specimens. Collar stricture marked by change in contour. Thorax inflated-conical, with pores circular and in longitudinal rows separated by ridges in early specimens, larger and lacking intervening ridges in late specimens. Thorax and abdomen of variable proportions, but often of approximately the same length. Slight lumbar stricture. Abdomen tapering distally, sometimes slightly inflated. Abdominal pores subcircular in longitudinal rows, in early specimens similar in size to distal thoracic pores and separated by longitudinal ridges, in later specimens larger and lacking longitudinal ridges. Three feet shovel-shaped (Riedel and Sanfilippo, 1970).

DIMENSIONS

Length of thorax 140-160 μm ; total length (excluding horn) 220-390 μm ; maximum breadth 130-180 $\mu m.$

DISTINGUISHING CHARACTERS

Podocyrtis (P.) diamesa differs from *P. (Podocyrtis) papalis* in its larger size and the presence of a slight lumbar stricture, from *P. (P.) phyxis* by the presence of longitudinal ribs between pore rows and the pores being smaller, from *P. (P.) ampla* in its general form being spindle-shaped rather than conical, and from *P. (P.) dorus* by not having a strongly constricted mouth (Sanfilippo et al., 1985).

VARIABILITY

Horn in early specimens short and bladed, in late specimens conical and robust. Thorax and abdomen of variable proportions, but often of approximately the same length. Slight lumbar stricture. Abdomen tapering distally, sometimes inflated. Thoracic and abdominal pores circular to subcircular in longitudinal rows, in early specimens separated by distinct longitudinal ridges, in late specimens larger, with less distinct ridges (Sanfilippo et al., 1985).

DISTRIBUTION

This species occurs in low-latitude samples of late early Eocene to middle middle Eocene age, including DSDP Site 10 at about 30°N in the Atlantic. Its morphotypic first appearance lies within the *Phormocyrtis striata striata* Zone. Its evolutionary transition to *Podocyrtis phyxis* lies within the *Thyrsocyrtis triacantha* Zone.

PHYLOGENY

P. (*P.*) *diamesa* is the intermediate form between *P.* (*Podocyrtis*) *papalis* and *P.* (*P.*) *phyxis* in the evolutionary lineage leading to *P.* (*P.*) *ampla. P.* (*P.*) *dorus* and *P.* (*P.*) *platypus* are off-shoots from this evolutionary line at about the level of occurrence of *P.* (*P.*) *diamesa*.

REMARKS

Podocyrtis (Podocyrtoges) dorus Sanfilippo and Riedel

Podocyrtis (Podocyrtis) dorus Sanfilippo and Riedel, 1973, p.531, pl.35, figs.12-14

Podocyrtis (Podocyrtoges) dorus Sanfilippo and Riedel, 1992, p.14, pl.5, fig.3

DESCRIPTION

Thorax pronouncedly inflated-conical, and lumbar stricture distinct. Pores aligned strictly longitudinally on both thorax and abdomen, those of the abdomen somewhat larger than those of the thorax, separated by longitudinal ridges. Abdomen tapers distally to a mouth at least as narrow as that in the specimen illustrated



by Riedel and Sanfilippo (1970, pl.12, fig.5). Abdomen in some specimens short, as if compressed, narrowing abruptly rather than tapering distally. The poreless peristome bears a variable number of short triangular teeth, rather than three spathulate feet (Sanfilippo and Riedel, 1973).

DIMENSIONS

Based on 35 specimens. Total length (excluding horn) 250-430 μm ; length of cephalothorax 150-195 μm . Width of abdomen 155-205 μm (Sanfilippo, unpubl. data).

DISTINGUISHING CHARACTERS

This form differs from *Podocyrtis diamesa* and *P. phyxis* in having the mouth more strongly constricted, and from the latter in having smaller pores (Sanfilippo and Riedel, 1973).

General form of shell inflated spindle-shaped, with the mouth narrow, surrounded by a variable number of small triangular teeth. Pores of thorax and abdomen longitudinally aligned, not large (Riedel and Sanfilippo, 1978a).

VARIABILITY

The pronouncedly inflated thorax, with pores aligned longitudinally and separated by longitudinal ridges is rather constant. The abdomen, however, is quite variable in length and in the degree of inflation, but always tapering to a constricted aperture. The thoracic pore rows, separated by longitudinal ridges, continue in the abdomen, but are variably expressed depending on the degree of inflation of the abdomen. Sometimes additional pore rows are inserted and thus the longitudinal alignment is offset. Maximum width of the abdomen usually medianly, but varies from proximally to distally (Sanfilippo, unpubl. data).

DISTRIBUTION

This species occurs in middle middle Eocene sediments from the Gulf of Mexico and the Caribbean. Its morphotypic last appearance lies within the *Podocyrtis ampla* Zone.

PHYLOGENY

See under Podocyrtis (Podocyrtoges) diamesa herein.

REMARKS

Podocyrtis (Lampterium) fasciolata Nigrini

Podocyrtis (Podocyrtis) ampla fasciolata Nigrini, 1974, p.1069, pl.1K, figs.1-2, pl.4, figs.2-3

Podocyrtis (Lampterium) fasciolata Nigrini, Sanfilippo et al., 1985, p.697, fig.30.7

DESCRIPTION

Shell thick-walled, smooth. Cephalis subspherical with numerous subcircular pores,



bearing a short, 3-bladed apical horn approximately the same length as the cephalis. Thorax campanulate to almost conical with subcircular pores aligned longitudinally (4 to 7 in a row) and distinct ridges between the pore rows; six to eight pores on a half-equator. Lumbar stricture distinct. Abdomen inflated, wider than thorax at its maximum breadth, narrows distally. Subcircular pores, larger than thoracic pores, usually aligned longitudinally (3 to 7 in a row) but sometimes irregular; six to eight on a half-equator. Wide poreless peristome usually with a smooth termination, but may show some thickening indicative of incipient feet. Rarely, three spathulate feet present (Nigrini, 1974).

DIMENSIONS

Based on 20 specimens from the Indian Ocean. Thorax 50-83 μ m long, 65-100 μ m wide (usually 83-100 μ m). Abdomen 83-150 μ m long, 115-165 μ m wide (Nigrini, 1974).

DISTINGUISHING CHARACTERS

P. (L.) fasciolata differs from *P. (L.) sinuosa* in not having the pronounced abdominal ribs and well developed shovel-shaped feet of the latter. From *P. (Podocyrtoges) ampla* it differs in its smaller size - total length (excluding horn) 165-250 μ m (usually 200-230 μ m); maximum width of abdomen 105-175 μ m (usually 115-160 μ m); thoracic length 80-100 μ m - and shorter horn commonly bladed (Sanfilippo et al., 1985).

Measurements given by Sanfilippo et al., 1985 show a broader range than those reported by Nigrini (1974). Probably this is because Nigrini was measuring only Indian Ocean material whereas Sanfilippo et al. included material from the Pacific, Atlantic and Caribbean and from a longer stratigraphic range.

VARIABILITY

The campanulate to conical thorax has pores aligned in longitudinal rows and separated by more or less pronounced ridges. Lumbar stricture moderately distinct. The inflated abdomen has large pores of variable size (6-10 pores on a half-equator), sometimes irregularly arranged and sometimes in longitudinal rows with very vague ridges between them. These pores, in well preserved specimens, tend to be subdivided by an internal, fine, irregular meshwork. When the pores are irregularly arranged, the outline of the abdomen is rough. The wide, pore less peristome is usually smooth and thick, but may rarely have indications of three spathulate feet (Sanfilippo et al., 1985).

DISTRIBUTION

P. (L.) fasciolata has a short range in the middle middle Eocene and has been found in the Gulf of Aden at DSDP Pacific Site 40, in the Gulf of Mexico and in the Caribbean. Its morphotypic first appearance lies within the *Podocyrtis ampla* Zone. Its morphotypic last appearance lies within the *Podocyrtis mitra* Zone.

PHYLOGENY

Instead of being a geographic variant of *P. (Podocyrtoges) ampla* (Nigrini, 1974, p.1069), this form is now considered to be an off-shoot of the lineage from *P. (L.) sinuosa* to *P. (L.) mitra*. For this reason it is elevated to species rank and placed in the subgenus *Podocyrtis (Lampterium)*. At the time of its acme, *P. (L.) fasciolata* far outnumbers the co-occurring *P. (L.) sinuosa*.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1973, pl.4, figs.1-3.

Podocyrtis (Lampterium) goetheana (Haeckel)

Cycladophora goetheana Haeckel, 1887, p.1376, pl.65, fig.5

Podocyrtis (Lampterium) goetheana (Haeckel), Riedel and Sanfilippo, 1970, p.535

DESCRIPTION

Large, three-segmented pterocorythid. Cephalis irregularly hemispherical with few to many small pores and bearing a stubby, sometimes expanded distally, bladed horn.



Thorax, approximately hemispherical, short (30-50 microns), thickwalled with rough surface. The abdomen, which varies considerably in length, is made up of a series of very large, elongated pores separated by long straight bars. Between the lumbar stricture and the large elongated pores, is a single row of smaller pores (diameter 38-62 μ m). Some specimens terminate with a distal row of smaller pores. Prior to its extinction rare *P. goetheana* morphotypes exhibit a tendency to extreme reduction in abdominal size, by eliminating the large elongated pores (Sanfilippo, unpubl. data).

DIMENSIONS

Based on 35 specimens. Total length (excluding horn) 230-465 μ m; length of cephalothorax 75-90 μ m. Width of thorax 70-90 μ m; of abdomen 120-190 μ m (Sanfilippo, unpubl. data).

DISTINGUISHING CHARACTERS

P. (L.) goetheana is distinguished from *P. (L.) chalara* by the abdomen having a series of very large, elongated pores separated by long, straight bars (Sanfilippo et al., 1985).

VARIABILITY

Through its brief stratigraphic range the thorax is constantly short (30-50 μ m), the most variable features being the length of the long

abdominal pores (120-260 μ m) and the presence or absence of another row of pores distal to them. The horn in some specimens is expanded distally (Sanfilippo et al., 1985).

DISTRIBUTION

The few latest middle to early late Eocene samples in which this species has been found are all from the tropics. Its morphotypic first appearance defines the base of the *Podocyrtis goetheana* Zone. Its morphotypic last appearance is in the early part of the *Calocyclas bandyca* Zone.

PHYLOGENY

This species evolved directly from *P*. (*L*.) *chalara*, and terminates the *Lampterium* lineage.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1978a, pl.8, fig.6.

Podocyrtis (Lampterium) helenae Nigrini

Podocyrtis (Lampterium) helenae Nigrini, 1974, p.1070, pl.lL, figs.9-11, pl.4, figs.4-5

DESCRIPTION

Shell smooth, quite thick-walled. Cephalis [three-lobed], subspherical with many subcircular pores and thorn-like 3-bladed apical horn. Thorax campanulate with subcircular pores either aligned



longitudinally (5 to 7 in a row) or irregularly arranged, seven to nine on a half-equator. Lumbar stricture distinct. Abdomen elongate, expanded distally with subcircular pores sometimes aligned longitudinally (8 to 13 in a row) but often irregular, 8 to 12 on a half-equator. Ridges between the longitudinal rows may become sinuous to follow irregularities in pore arrangement. Peristome rather wide, smooth, poreless with three spathulate feet (Nigrini, 1974).

DIMENSIONS

Based on 20 specimens. Length of thorax 50-65 μ m; of abdomen (including peristome and feet) 133-248 μ m. Breadth of thorax 83-100 μ m; of abdomen 115-150 μ m (Nigrini, 1974).

DISTINGUISHING CHARACTERS

P. (L.) helenae is distinguished from *P. (L.) sinuosa* and *P. (L.) mitra* by the abdominal pores being smaller and less regularly arranged, and the abdominal wall being generally thinner (Sanfilippo et al., 1985).

VARIABILITY

The smooth shell resembles that of *P. (L.) mitra* in its general truncate-conical form, and varies from thick-walled to (more usually) quite delicate. Abdominal pores are sometimes aligned longitudinally but are more often irregularly arranged and unevenly distributed. Ridges between the longitudinal rows in some specimens become sinuous because of the irregularities in pore arrangement (Sanfilippo et al., 1985).

DISTRIBUTION

This middle middle Eocene species is found in low latitudes in the Atlantic and Indian Oceans. No samples of this age are available from higher latitudes. Its morphotypic first appearance lies within the *Podocyrtis ampla* Zone. Its morphotypic last appearance lies within the *Podocyrtis mitra* Zone.

PHYLOGENY

This species is apparently an evolutionary offshoot from *P. (L.) sinuosa,* and left no descendants.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1973, pl.4, figs.4-6.

Podocyrtis (Lampterium) mitra Ehrenberg

Podocyrtis mitra Ehrenberg, 1854, pl.36, fig.B20; 1873, p.251; *non* Ehrenberg, 1875, pl.15, fig.4; Riedel and Sanfilippo, 1970, p.534, pl.11, figs.5-6; 1978a, text-fig.3

DESCRIPTION

Cephalis [three-lobed], hemispherical, with few to many small pores, bearing a bladed horn of about the same length. Thorax thick-walled, conical to campanulate, with usually rather large subcircular pores and rough surface. Collar and



lumbar strictures distinct. Abdomen thick-walled, expanding distally and contracting abruptly near its end, with large subcircular pores longitudinally aligned and in some specimens with the rows separated by ribs. Abdominal pores in many specimens have delicate spines projecting into them from their periphery. Abdominal surface is usually smooth, sometimes rough. Three short feet and flat, spathulate or triangular, or absent (Riedel and Sanfilippo, 1970).

DIMENSIONS

Length of thorax in early forms $60-80 \ \mu\text{m}$, in late forms $55-60 \ \mu\text{m}$. Abdominal length (excluding feet) in early forms $115-160 \ \mu\text{m}$, in late forms $185-205 \ \mu\text{m}$. The number of longitudinal rows of abdominal pores ranges from 26 in early specimens to 13 in late ones (Sanfilippo et al., 1985).

DISTINGUISHING CHARACTERS

P. (L.) mitra is distinguished from *P. (L.) trachodes* by having a smooth rather than a rough outline, from *P. (L.) sinuosa* by having its abdomen widest distally rather than medially, and from *P. (L.) chalara* by having more than 13 pores on the circumference of the abdomen at its widest part. The abdomen has a thicker wall, and larger, more regularly arranged pores, than those of *P. (L.) helenae* (Sanfilippo et al., 1985).

VARIABILITY

P. (L.) mitra, being a member of the evolutionary lineage from *P. (P.) papalis* to *P. (L.) goetheana*, shows a continuous reduction in the size of the thorax and feet, and an increase in abdominal length and the size of the abdominal pores, with time (Sanfilippo et al., 1985).

DISTRIBUTION

This middle middle Eocene species is common and widely distributed in low-latitude assemblages. Sometimes it is overwhelmed by abundant *P*. (*L*.) *fasciolata* during a brief part of its range, and by abundant *P*. (*L*.) *trachodes* later in its range. Its evolutionary transition from *Podocyrtis sinuosa* defines the base of the *Podocyrtis mitra* Zone. Its evolutionary transition to *Podocyrtis chalara* defines the base of the *Podocyrtis chalara* Zone.

PHYLOGENY

This species is descended directly from *P*. (*L*.) *sinuosa*, and is ancestral to *P*. (*L*.) *chalara*.

REMARKS

Additional illustrations can be found in Nigrini, 1974, pl.lL, fig.5, *non* fig.6; Riedel and Sanfilippo, 1981, figs.12-18, 5-8.

Podocyrtis (Podocyrtis) papalis Ehrenberg

Podocyrtis papalis Ehrenberg, 1847b, p.55, fig.2; Riedel and Sanfilippo, 1970, p.533, pl.11, fig.1; Sanfilippo and Riedel, 1973, p.531, pl.20, figs.11-14, pl.36, figs.2-3

DESCRIPTION

Cephalis subhemispherical, with many small pores, bearing a horn of variable length, which is usually three-bladed, sometimes conical. Collar stricture marked by change in contour. Thorax inflated-conical, with circular pores in longitudinal rows separated by ribs. Lumbar stricture not (or only very slightly)



expressed externally. Abdomen inverted truncate-conical, with pores and ribs similar to those of thorax. Pored part of abdomen generally shorter than thorax, and this is followed by a poreless part of the abdominal wall from which arise three large, shovel-shaped feet (Riedel and Sanfilippo, 1970).

DIMENSIONS

Length (excluding horn) 170 (rarely 150) to 280 μm maximum breadth 95-140 μm (Riedel and Sanfilippo, 1970).

DISTINGUISHING CHARACTERS

P. papalis is distinguished from *P. (Podocyrtoges) diamesa* by being smaller, and spindle-shaped, without an external change in contour at the lumbar stricture. The cephalis is more distinctly three-lobed than in members belonging to the ancestral genus *Cryptocarpium*, from which *P. papalis* also differs by having longitudinal costae between rows of pores on the thorax and the abdomen. It is distinguished from the earliest member of the *Lampterium* subgenus, *P. (Lampterium) acalles*, by the shell being widest just above the lumbar stricture. Three shovel-shaped feet are

always present, except in the earliest form where the abdomen terminates in a broad poreless zone (Sanfilippo, unpubl. data).

VARIABILITY

Early forms are smaller, the cephalis is approximately uniformly perforated by pores, bearing a short, broad-based three-bladed horn. In these early forms the unpaired lobe is only slightly longer than the paired lobes. The earliest specimens have ridges separating longitudinal rows of pores and no feet, but terminate in a broad, poreless zone. In later forms the unpaired lobe is approximately twice as long as the paired lobes, poreless or with a few scattered pores, bearing a horn of variable length that is usually three-bladed, sometimes conical (Sanfilippo, unpubl. data).

DISTRIBUTION

P. papalis is a prominent constituent of Eocene assemblages from paleolatitudes lower than 45°. The morphotypic first appearance of this species lies within early part of the *Bekoma bidartensis* Zone and its morphotypic last appearance is approximately synchronous with the lower limit of the *Cryptocarpium ornatum* Zone.

PHYLOGENY

P. papalis developed from *Cryptocarpium* in the late Paleocene *B. bidartensis* Zone and gave rise to the subgenera *Lampterium*, *Podocyrtoges* and *Podocyrtopsis*.

REMARKS

Podocyrtis (Podocyrtoges) phyxis Sanfilippo and Riedel

- *Podocyrtis (Podocyrtis) diamesa* Riedel and Sanfilippo, 1970, p.533, (*pars*), pl.12, fig.6
- *Podocyrtis phyxis* Sanfilippo and Riedel, 1973, p.531
- *Podocyrtis (Podocyrtoges) phyxis* Sanfilippo and Riedel, Sanfilippo and Riedel, 1992, p.14

DESCRIPTION

Similar in general form to *P. diamesa*, but rather stocky, with relatively larger, somewhat more inflated abdomen, and larger pores on both abdomen and thorax. No longitudinal ribs between pores (Sanfilippo and Riedel, 1973).



DIMENSIONS

Total length (excluding horn) 240-385 μ m; length of abdomen 105-245 μ m; maximum breadth of abdomen 140-175 μ m (Sanfilippo et al., 1985).

DISTINGUISHING CHARACTERS

This species is distinguished from its ancestor *P. (P.) diamesa* by lacking longitudinal ribs on the thorax. The conical horn and thorax are relatively larger than in the superficially similar *P. (L.) trachodes* (which, in addition, occurs later, has a three-bladed horn, and has a very rough abdominal outline) (Sanfilippo et al., 1985).

VARIABILITY

This species has been found at only very few localities, apparently because of its short stratigraphic range, and it is therefore difficult to distinguish geographic from chronologic variability.

In some assemblages the thoracic outline is smooth and in others it is slightly rough, and the spacing of the abdominal pores varies a little (2.5 - 3 pore centers in 50 μ m in DSDP 13A-1-1, 130-132 cm to 2.5 - 3.5

pore centers in 50 µm in DSDP 149-40-1, 80-83 cm). The lumbar stricture tends to be more distinct in younger assemblages (Sanfilippo et al., 1985)

DISTRIBUTION

This short-ranged, middle middle Eocene species is found only in the Caribbean, the eastern tropical Atlantic and the eastern tropical Pacific. Its evolutionary transition from *Podocyrtis diamesa* lies within the *Thyrsocyrtis triacantha* Zone. Its evolutionary transition to *Podocyrtis ampla* defines the base of the *Podocyrtis ampla* Zone.

PHYLOGENY

There is little doubt that *P*. (*P*.) *phyxis* is descended from *P*. (*P*.) *diamesa*, and it seems likely that *P*. (*P*.) *ampla* is its descendant.

REMARKS

Podocyrtis (Lampterium) sinuosa Ehrenberg

Podocyrtis sinuosa Ehrenberg, 1873, p.253; 1875, pl.15, fig.5; Riedel and Sanfilippo, 1970, p.534, pl.11, figs.3-4; 1978a, text-fig.3

DESCRIPTION

Cephalis [three-lobed], hemispherical, with many small pores, and bearing a threebladed horn of about the same length. Collar



stricture marked by a change in contour, obscure in late specimens. Thorax campanulate (conical in some late specimens); and the abdomen subcylindrical, slightly inflated, both segments with subcircular pores in longitudinal rows usually (but not in some late specimens) separated by longitudinal ribs. Pores of the abdomen larger than those of thorax. Lumbar stricture moderate to slight. Three feet are generally shovelshaped but spathulate in some late specimens (Riedel and Sanfilippo, 1970).

DIMENSIONS

Thorax in early specimens 55-80 μ m long and 85-110 μ m wide. Length of abdomen (including feet) in early specimens 125-180 μ m, in late specimens 145-225 μ m. Maximum breadth of abdomen in early specimens 115-140 μ m, in late specimens 135-170 μ m (Riedel and Sanfilippo, 1970).

DISTINGUISHING CHARACTERS

From *P. (Podocyrtis) papalis* and *P. (Podocyrtoges) aphorma, P. (L.) sinuosa* differs in having a smaller thorax, and pores of the abdomen larger than those of the thorax. From *P. (L.) mitra* it differs in having its greatest abdominal width medially rather than distally, and from *P. (L.) fasciolata* in constantly possessing well developed feet (Sanfilippo et al., 1985).

VARIABILITY

The thorax, with pores in longitudinal rows usually separated by ribs, is rather constant in structure, though it decreases in size through

time. The abdomen is always widest medially, inflated to a varying degree, with longitudinal pore rows separated by ribs, and variability is expressed by an increase in pore size (to approximately double the diameter of the earliest ones) and abdominal length with time (Sanfilippo et al., 1985).

DISTRIBUTION

This species occurs in low-latitude (below 30°N in the Atlantic) samples of middle middle Eocene age. It does not occur at DSDP Site 148 in the Indian Ocean, which was at about 45°S during the Eocene according to Firstbrook et al. (1979), but this may be a consequence of the age of the sample rather than of its geographic position. Its evolutionary transition from *Podocyrtis acalles* lies within the *Theocotyle cryptocephala* Zone. Its evolutionary transition to *Podocyrtis mitra* defines the base of the *Podocyrtis mitra* Zone.

PHYLOGENY

P. (*L.*) *sinuosa* apparently evolved from *P.* (*L.*) *acalles*, which in turn developed directly from *P.* (*P.*) *papalis*), and gave rise to *P.* (*L.*) *mitra*. At the time of that transition, *P.* (*L.*) *trachodes* developed as an offshoot, and slightly earlier than that *P.* (*L.*) *fasciolata* and *P.* (*L.*) *helenae* diverged from *P.* (*L.*) *sinuosa*.

REMARKS

Additional illustrations can be found in Riedel and Sanfilippo, 1981, figs.12-8, 1-4.

Podocyrtis (Lampterium) trachodes Riedel and Sanfilippo

Podocyrtis (Lampterium) trachodes Riedel and Sanfilippo, 1970, p.535, pl.11, fig.7, pl.12, fig.1

DESCRIPTION

Cephalis [three-lobed], hemispherical, with many small pores, bearing a three-bladed horn of about the same length. Thorax campanulate and abdomen moderately inflated, broadest at about its middle; both segments thick-walled with rough surface and with subcircular pores, larger



in abdomen than in thorax, in indistinct longitudinal rows. Collar and lumbar strictures moderately distinct. Three feet short and flat, spathulate or triangular. In occasional specimens, feet are absent (Riedel and Sanfilippo, 1970).

DIMENSIONS

Thorax 45-70 μ m long; 85-100 μ m wide; abdomen 135-230 μ m long (including feet) 135-185 μ m wide (Riedel and Sanfilippo, 1970).

DISTINGUISHING CHARACTERS

The general form usually resembles that of *P*. (*L*.) *mitra*, from which *P*. (*L*.) *trachodes* is distinguished by the rough surface [and knobby outline] of the abdomen. Specimens with a short abdomen and poorly developed feet differ from *P*. (*L*.) *fasciolata* by having neither the thickened peristome nor longitudinally aligned thoracic pores (Sanfilippo et al., 1985).

VARIABILITY

The surface of the abdomen is always rough, but the thorax is smooth in early specimens and rough in late ones. When the abdomen is short it is widest medially, and when long it tends to be widest distally. Spathulate feet are normally well developed, rarely vestigial (Sanfilippo et al., 1985).

DISTRIBUTION

This middle middle Eocene species is only found in assemblages from low latitudes. Its morphotypic first appearance lies within the *Podocyrtis ampla* Zone. Its morphotypic last appearance lies within the *Podocyrtis chalara* Zone.

PHYLOGENY

This species is evidently an offshoot from the main *Podocyrtis* (*Lampterium*) lineage, at about the level of transition from *P*. (*L*.) *sinuosa* to *P*. (*L*.) *mitra*. It left no known descendants.

REMARKS

Pterocanium prismatium Riedel

Pterocanium prismatium Riedel, 1957, p.87, pl.3, figs.4-5; *emend*. Riedel and Sanfilippo, 1970, p.529

DESCRIPTION

Cephalis subspherical, pitted, bearing a sharply pointed, cylindro-conical apical horn with a length of approximately 1.5 times cephalic diameter, and sometimes smaller accessory spines. Thorax having overall shape of



a triangular prism surmounted by an obtuse triangular pyramid, terminating at pronounced collar stricture: this general shape often modified by shallow concavity of the prismatic faces, and slight swellings between the proximal parts of the 3 thoracic ribs. In relation to the general thorax surface, the thoracic ribs are usually depressed in furrows proximally, and raised on ridges distally. Thoracic pores subpolygonal to almost circular, separated by thin bars, arranged approximately hexagonally in apparent longitudinal rows. Upper part of thorax usually bears small spines: these spines often concentrated on the proximal swellings, and thorns often occur on the ridged part of the thoracic ribs. Opening at base of thorax somewhat constricted. Feet three-bladed, proximally fenestrated, straight or slightly curved, usually almost parallel or somewhat divergent, usually shorter than thorax. Abdomen, when present, short, delicate, with irregular meshes smaller than those of thorax, usually entirely separate from and surrounded by the feet (Riedel, 1957).

The original description of this species admitted specimens without thorns on the three thoracic ribs, but such forms are now excluded (Riedel and Sanfilippo, 1970).

DIMENSIONS

Usual length of apical spine 28-40 μ m, of cephalis 20-26 μ m, of thorax 110-132 μ m, of feet 60-120 μ m, of abdomen 5-50 μ m. Breadth of thorax usually 110-150 μ m (Riedel, 1957).

DISTINGUISHING CHARACTERS

Major part of the long thorax triangular prismatic, with a distinct "shoulder"-like change in contour in the upper part. At this "shoulder", the ribs extending from the collar region to the feet are distinctly thorny. Feet short, straight, approximately parallel, proximally latticed (Riedel and Sanfilippo, 1978a).

P. prismatium is distinguished from co-occurring *P. praetextum* (Ehrenberg) (Riedel, 1957, p.86, pl.3, figs.13) by its larger, prismatic thorax and shorter feet, and from *P. trilobum* (Haeckel) (Nigrini, 1967, p.71, pl.7, figs.3a-3b) by its pronounced shoulders with thorns (Sanfilippo et al., 1985).

VARIABILITY

P. prismatium is a two-segmented theoperid with three feet and a thorax of characteristic prismatic shape. The variable features are the length of the thorax, which tends to be shorter in older specimens (77-110 μ m in *Spongaster pentas* Zone), and longer at the end of the range (90-120 μ m in *P. prismatium* Zone); and the robustness of the skeleton accompanied by a varying degree of thorniness. The test may be very delicate with narrow bars between pores and short thorns on the shoulders, or heavier with thick thorns along the entire length of the ribs as well as on the shoulders (Sanfilippo et al., 1985).

DISTRIBUTION

P. prismatium is found in middle to late Pliocene assemblages at latitudes lower than 15°. Its extinction, which a sharp, reliable and easily recognizable event, marks the top of *Pterocanium prismatium* Zone. The event is globally synchronous and corresponds approximately to the top of the Olduvai and the Pliocene-Pleistocene boundary (Hays et al., 1969; Berggren et al., 1980). However, it is often rare (1-2 specimens in tens of thousands) in the Indian Ocean. Its morphotypic first appearance is approximately synchronous with the lower limit of the *Spongaster pentas* Zone.

PHYLOGENY

Unknown.

REMARKS

Additional illustrations can be found in Nigrini, 1971, pl.34.1, fig.4; Johnson and Knoll, 1975, pl.1, fig.9.

Pterocodon ampla (Brandt)

Theocyrtis ampla Brandt in Wetzel, 1935, p.56, pl.9, figs.13-15

Pterocodon(?) ampla (Brandt), Foreman, 1973, p.438, pl.5, figs.3-5

DESCRIPTION

Shell subcylindrical, of three segments,



with relatively smooth surface and ragged distal margin. Cephalis subhemispherical with no, or a few, small, circular pores; bearing a sturdy, moderately long cylindro-conical horn with a roughened tip, or roughened overall. Collar stricture not very well defined externally, with a vertical pore, and with four collar pores internally. Thorax subhemispherical with regular circular to subcircular pores arranged quincuncially in transverse rows. Abdomen cylindrical with diameter equal to or less than that of thorax. Lumbar stricture may or may not be expressed externally; internally a distinct septum that varies considerably in thickness among individual specimens; thick on specimens with abdominal pores smaller or equal in size to those of the thorax, thin on specimens with abdominal pores larger. There is some tendency towards segmental division of the abdomen. Pores circular to subquadrangular, generally transversely aligned, fairly uniform in size and shape on individual specimens but varying considerably among them (Foreman, 1973).

DIMENSIONS

Based on 50 specimens. Length overall, exclusive of horn, 150-210 μ m. of cephalis and thorax 80-100 μ m; greatest width of thorax 60-90 μ m (Foreman, 1973).

DISTINGUISHING CHARACTERS

P. ampla is distinguished from *P. lex* Sanfilippo and Riedel (1979, p.505, pl.1, figs.9-10) by its larger size (the length of cephalothorax being more than 80 µm), and from *P. tenellus* Foreman (1973, p.439, pl.5, fig.7, pl.12, fig.4) by the more expanded thorax, the larger, less numerous pores and the better developed lumbar septum. *Calocyclas talwanii* Bjørklund

and Kellogg (Bjørkund, 1976, pl.21, figs.1-3) is larger (Sanfilippo et al., 1985).

VARIABILITY

Variable features are the number of pores on the cephalis (from none to about ten), the robustness and length of the cylindro-conical horn, and degree of widening of the skeleton distally. When the horn is robust it completely encloses the cephalis, and the collar stricture thus is not well defined externally. The lumbar stricture, internally, is a distinct septum that varies in thickness, being thick in specimens with abdominal pores small or equal in size to those of the thorax, thin in specimens with larger abdominal pores. Abdomen, varying in length, has an undifferentiated margin and a tendency to segmental division. The pores are circular to subquadrangular, transversely aligned, varying in size and shape between specimens (Sanfilippo et al., 1985).

DISTRIBUTION

P. ampla ranges across the Paleocene/Eocene boundary. It has been found in northern Europe, the tropical Pacific, the Gulf of Mexico and the Caribbean. Its morphotypic first appearance lies within the *Bekoma campechensis* Zone and its morphotypic last appearance lies within the *Buryella clinata* Zone.

PHYLOGENY

Pterocodon ampla evolved from P. lex.

REMARKS

Additional illustrations can be found in Sanfilippo and Riedel, 1979, pl.1, figs.7-8.

Pterocodon ? anteclinata Foreman

Pterocodon ? anteclinata Foreman, 1975, p.621, pl.9, figs.32-34

DESCRIPTION

Shell small, of four segments, subcylindrical to spindle-shaped. The small subspherical porous cerebalis bears a slender, relatively long born and an



DIMENSIONS

Based on 10 specimens. Length of first three segments including horn 125-140 μ m (majority 125-130 μ m). Width of abdomen 60-80 μ m (majority 60-70 μ m) (Foreman, 1975).

DISTINGUISHING CHARACTERS

Pterocodon ? anteclinata is distinguished from *Buryella clinata* by possessing a roughened cylindrical horn (rather than a well-developed, heavily ridged bladed horn), which encloses the cephalis at its base. In *P.? anteclinata* the thorax is subhemispherical and longer than in *B. clinata*, and the abdomen subcylindrical rather than inflated. It is distinguished from *P. ampla* in having four segments rather than three, and by not having a distinct internal septum at the lumbar stricture (Sanfilippo, unpubl. data).

VARIABILITY

Early forms have the horn cylindrical with a roughened blunt tip or roughened overall. This gradually becomes conical, sharper, basally ridged with, in late forms, the ridges beginning to extend onto the cephalis. In late forms also, the thorax becomes relatively shorter and the abdomen more inflated, barrel-shaped. When the horn becomes pointed, completely ridged with well-developed ridges extending down to the base



of the cephalis so that the change in contour from the cephalis to the horn is obscure and the abdomen is inflated, barrel-shaped, this species passes over to *Buryella clinata* (Foreman, 1975).

DISTRIBUTION

The morphotypic first appearance of this species lies near the lower limit of the *Bekoma campechensis* Zone. Its evolutionary transition to *Buryella clinata* defines the base of the *Buryella clinata* Zone.

PHYLOGENY

Origin unknown; ancestor of *Buryella clinata*.

Pterocorys campanula Haeckel

Pterocorys campanula Haeckel, 1887, p.1316, pl.71, fig.3; Caulet and Nigrini, 1988, p.226, pl.1, figs.2-5 (with synonymy)

DESCRIPTION

Shell conical to ovate, thin-walled, smooth except for longitudinal ridges at irregular intervals on the thorax. Rarely, there is a single ridge, which is prolonged into the abdominal wall. Cephalis trilocular with numerous



subcircular pores. Stout three-bladed apical horn about the same length as of a little longer than the cephalis. Primary lateral and dorsal spines aligned with three ribs in the thoracic wall.

Thorax inflated conical with subcircular to circular pores arranged in longitudinal rows, ornamented by irregular longitudinal ridges. In some specimens thoracic ribs project as small thorns or triangular, pored wings. Lumbar stricture distinct.

In Pacific Ocean sediments, early forms have a much inflated abdomen (> 120 μ m), broader than the thorax, but with similar pores. In later specimens the abdomen is less inflated (< 120 μ m), more cylindrical. In Indian Ocean sediments early forms have a rather narrow abdomen (< 120 μ m) and later forms are more inflated (> 120 μ m). Termination always ragged (Caulet and Nigrini, 1988).

DIMENSIONS

Total length (excluding apical horn) 139-217 μ m. Length of apical horn 28-43 μ m; of cephalis 26-37 μ m; of thorax 48-68 μ m; of abdomen 77-115 μ m. Maximum breadth of cephalis 24-29 μ m; of thorax 90-110 μ m; of abdomen 110-140 μ m (Caulet and Nigrini, 1988).

DISTINGUISHING CHARACTERS

More than three longitudinal ridges on the thorax; very rarely a single ridge projects into the upper part of the abdomen (Caulet and Nigrini, 1988).

We have been able to observe the intermediate form in which a single rib continues for a short distance into the abdomen. Initially we consider this form to be a *P. campanula*, but we now record it separately as an unnamed transitional form (Caulet et al., 1993).

DISTRIBUTION

Common in both tropical Indian and tropical Pacific Ocean sediments. Its morphotypic first appearance lies within the *Stichocorys peregrina* Zone and its morphotypic last appearance is a synchronous event that lies within the *Amphirhopalum ypsilon* Zone.

PHYLOGENY

Evolved from *P. clausus* (see Caulet and Nigrini, 1988, p.229) during the lowermost Pliocene. Ancestor of *Pterocorys hertwigii*.

Pterocorys hertwigii (Haeckel)

Eucyrtidium hertwigii Haeckel, 1887, p.1491, pl.80, fig.12

Pterocorys hertwigii (Haeckel), Caulet and Nigrini, 1988, p.229, pl.1, figs.11-12 (with synonymy)

DESCRIPTION

Shell conical to ovate, thin-walled, smooth



except for longitudinal ridges at irregular intervals. Cephalis trilocular with numerous subcircular pores, heavier than rest of shell. Stout threebladed apical horn usually about the same length or a little longer than cephalis. Primary lateral and dorsal spines aligned with the ribs in the thoracic wall.

Thorax campanulate with subcircular pores arranged in longitudinal rows. Lumbar stricture distinct. Abdomen broader than thorax, but with similar pores. In complete specimens abdomen slightly constricted distally with a smooth termination, but most specimens are incomplete.

Both thorax and abdomen ornamented by poreless ridges that run more or less longitudinally, irregularly spaced and not necessarily continuous for entire shell length. On the thorax some of the ridges frequently bear 1 or 2 small spines (Nigrini, 1967).

DIMENSIONS

Total length (excluding apical horn) 119-191 μ m. Length of apical horn 2-45 μ m; of cephalis 23-32 μ m; of thorax 45-63 μ m; of abdomen up to 109 μ m. Maximum breadth of cephalis 27-32 μ m; of thorax 81-100 μ m; of abdomen 100-136 μ m (Nigrini, 1967).

DISTINGUISHING CHARACTERS

Shell generally conical, with distinct collar and lumbar strictures. Wall of thorax and abdomen thin, with pores longitudinally aligned, and more than three thin, longitudinal ribs not necessarily continuous throughout thorax and abdomen. No differentiated peristome (Riedel and Sanfilippo, 1978a).

DISTRIBUTION

Extant. Few to common in the tropical Pacific Ocean, but rare in the tropical Indian Ocean. It does not occur in samples from south of 35°S. Its morphotypic first appearance is a synchronous event, which lies within the *Amphirhopalum ypsilon* Zone.

PHYLOGENY

Extant, descendant of Pterocorys campanula.