PHOSPHATIZED OSTRACODS WITH APPENDAGES FROM THE LOWER CRETACEOUS OF BRAZIL

by RAYMOND HOLMES BATE

ABSTRACT. A new ostracod, *Pattersoncypris micropapillosa* gen. et sp. nov., is described from the Aptian to Albian Santana Formation, Serra do Araripe, Ceará, Brazil. Of the 253 specimens obtained, 138 are complete carapaces of which 103 contain appendages in an excellent state of preservation. Of the total number of specimens only 15 are pre-adult instars and 6 are males. A small number (24) of single valves possibly represent moulted carapaces, the remainder were living up to the time of burial and fossilization. The original calcium carbonate and chitin of the ostracod was replaced by apatite immediately after death. The ostracods were found entombed with a teleost fish, *Cladocyclus gardneri* Agassiz, the decaying body of which, on which the ostracods are considered to have been feeding, is considered to have been the source of the phosphate salts responsible for the mineralization of the ostracod anatomy.

THE Santana Formation of Serra do Araripe, Ceará, northern Brazil, is a gypsiferous marl succession dated as ranging from the Upper Aptian to the Lower Albian (Beurlen, 1970). Fish-bearing nodules are particularly common in the marl beds and are collected and sold commercially for their well-preserved fish remains. Several such nodules have been prepared recently by Dr. Colin Patterson of the British Museum [Natural History], hereafter abbreviated (B.M.N.H.); the enclosed fish skeletons being etched from the nodule with acetic acid. In all previous preparations the calcareous ostracods present dissolved in the acid and were lost. In one nodule, however, examination of the washed residue revealed a number of well-preserved ostracods, complete with their appendages. A careful examination of further residues from the same nodule resulted in the recovery of 253 specimens consisting of whole carapaces and single valves of both adult and juvenile instars. In addition, many hundreds of eggs were recovered (Pl. 67, fig. 8) which may belong to this ostracod although they are small compared to the eggs of comparable living forms. In transmitted light the eggs appear completely transparent, with what was probably the yolk sac now apparently replaced by calcium carbonate.

The ostracods all belong to the same species and are clearly resistant to the acetic acid. An X-ray powder analysis of the carapace and of the body and appendages, by Dr. R. Davies (B.M.N.H.), revealed that both are preserved as apatite. Some carapaces still retain a calcium carbonate infilling but none of this material appears in the carapace itself.

Of the 138 complete carapaces, 103 retain appendages, many in an excellent state of preservation, and all represent individuals living up to the time of burial and mineralization. The remainder, together with the 24 single valves, probably represent moulted instars. Although an almost complete instar range has been obtained for *Pattersoncypris micropapillosa* only 15 pre-adult instars have been found; the remainder being adults falling into the final instar cluster as illustrated in text-fig. 1. Of the adult instars, only 6 have been identified as being males.

Although this discovery represents the best-preserved fossil ostracod material ever found, it is not the first record of fossil appendages. Brongniart (1876) was the first to

record these in his *Palaeocypris edwardsii* from the Carboniferous of Saint-Étienne, whilst Sylvester-Bradley (1941) records the presence of appendages in Pleistocene specimens of *Cypris pubera* O. F. Müller. Subsequently, Gocht and Goerlich (1957) obtained chitinous appendages from some Jurassic and Cretaceous ostracods by dissolving complete carapaces in dilute hydrochloric acid. Gramann (1962) similarly observed chitinous antennae and antennules in the Liassic *Bairdia molesta* Apostolescu. More recently, Schmidt and Sellmann (1966) and Eagar (1970) have described mummified ostracods from the Pleistocene of Alaska and New Zealand respectively. Sohn (personal communication), however, is of the opinion that Eagar's find is a fresh-water mite and not an ostracod. None of these previous records attains the excellent state of preservation of *Pattersoncypris micropapillosa*.

The only previous records of ostracods from the Santana Formation appear in Santos and Valença (1968), where *Candonopsis* sp. and *Schuleridea* sp. were recognized, and more recently in Krömmelbein and Weber (1972), see p. 388. The occurrence of *Pattersoncypris micropapillosa* in the Santana Formation has been briefly recorded elsewhere (Bate, 1971).

The photographic illustrations for this paper were taken on a Cambridge Stereoscan scanning electron microscope whilst the text-figs. were drawn using a Leitz camera lucida.

All the specimens of *Pattersoncypris micropapillosa* are registered in the Collections of the Department of Palaeontology, British Museum [Natural History].

SYSTEMATIC DESCRIPTION

Subclass OSTRACODA Latreille 1806
Order PODOCOPIDA Müller 1894
Suborder PODOCOPINA Sars 1866
Family CYPRIDIDAE Baird 1845
Subfamily CYPRIDINAE Baird 1845
Genus PATTERSONCYPRIS nov.

Type species. Pattersoncypris micropapillosa sp. nov.

Derivation of name: in honour of Dr. Colin Patterson.

Diagnosis: Cypridinae having oval carapace with acute antero-dorsal hump.

Description: Carapace ovoid in lateral view, convex in dorsal view. Greatest length of carapace passes through medial line. Shell surface without coarse ornamentation. Right valve with acutely projecting anterior cardinal angle and concave antero-dorsal slope. Hinge adont: groove situated in right valve, terminally expanded and accepting dorsal margin of left valve. Muscle scars as for family. First thoracic appendage adapted for feeding, with distal hook in both dimorphs. Antennules with 7 podomeres; antennae with 3 podomeres: first podomere with 6 swimming setae on inner face. Second and third thoracic appendages elongate, with 4 and 3 podomeres respectively. Furcae long. Paired hemipenes with broad, triangular proximal shield.

Remarks. Pattersoncypris is a typical member of the Cyprididae, having the muscle scars, carapace detail, and appendages of that family. Although without the marginal spines

of the Recent *Cypris pubera* O. F. Müller, there is a close similarity between the two genera with respect to the strong dorsal hump in the region of the anterior cardinal angle. The dorsal hump in *Pattersoncypris* is, however, a development of the anterior part of the hinge separate from the cardinal angle, and this, together with the more generally ovoid carapace outline serves to distinguish it from the genus *Cypris*.

The only fossil genus which approaches *Pattersoncypris* in carapace outline is *Brasacypris* Krömmelbein (1965a), described from the (?) Upper Jurassic to lower Cretaceous Bahia Series of Brazil. This genus, represented by the single species *B. ovum* Krömmelbein, differs from *Pattersoncypris* in the angular development of the posterior cardinal angle thereby giving it a more quadrate outline in lateral view. The right valve is also noticeably smaller than the left whilst in *Pattersoncypris* the carapace is virtually equivalve.

The following are currently placed in *Pattersoncypris*:

Pattersoncypris micropapillosa—type species, Santana Formation, Serra do Araripe, Brazil.

Hourcqia angulata salitrensis Krömmelbein and Weber, 1792, Santana Formation, Pernambuco, Brazil = *Pattersoncypris angulata salitrensis* (K. and W.).

Hourcqia angulata sinuata Krömmelbein and Weber, 1972, Riachuelo beds, Alagôas, Brazil = *Pattersoncypris angulata sinuata* (K. and W.).

Pattersoncypris micropapillosa sp. nov.

(Pls. 66–71, text-figs. 1–12)

Derivation of name. With reference to the small papillae which cover the shell.

Geological horizon and locality. Aptian/Albian, Santana Formation, Serra do Araripe, Ceará, northern Brazil and from Continental beds from Liberia, N.W. Africa. Material from Liberia is not, however, included in the description of the species.

Description. Carapace oval in outline, virtually equivalve, with distinct antero-dorsal hump produced by the dorsal extension of the anterior hinge element, especially of the right valve (Pl. 66, fig. 1). Antero-dorsal slope of right valve concave; convex in the left valve. Anterior and posterior margins rounded. Instars III; V; VIII; and IX have been recognized and the length/height measurements plotted (text-fig. 1). A single clustering of individuals in the adult (IX) instar indicates that although both males and females are present the sexes are indistinguishable on carapace outline. The variable gape of the carapace in ventral view makes an accurate width measurement difficult. Eggs, which may through their association be regarded as belonging to this species despite their small size, have been plotted on text-fig. 1.

The shell surface is covered by very small papillae which are especially apparent on the ventral surface (Pl. 68, fig. 4).

Normal pore canals have sensory bristles projecting, although much shortened by breaking off at the tips, and are particularly well developed and more closely spaced in the anterior part of the carapace (Pl. 68, fig. 5).

The hinge is adont with the terminally expanded groove situated in the right valve (text-fig. 2). The left valve hinge is simply the dorsal edge of the valve (text-fig. 9).

Internally the selvage is set well back from the anterior free margin (text-fig. 2),
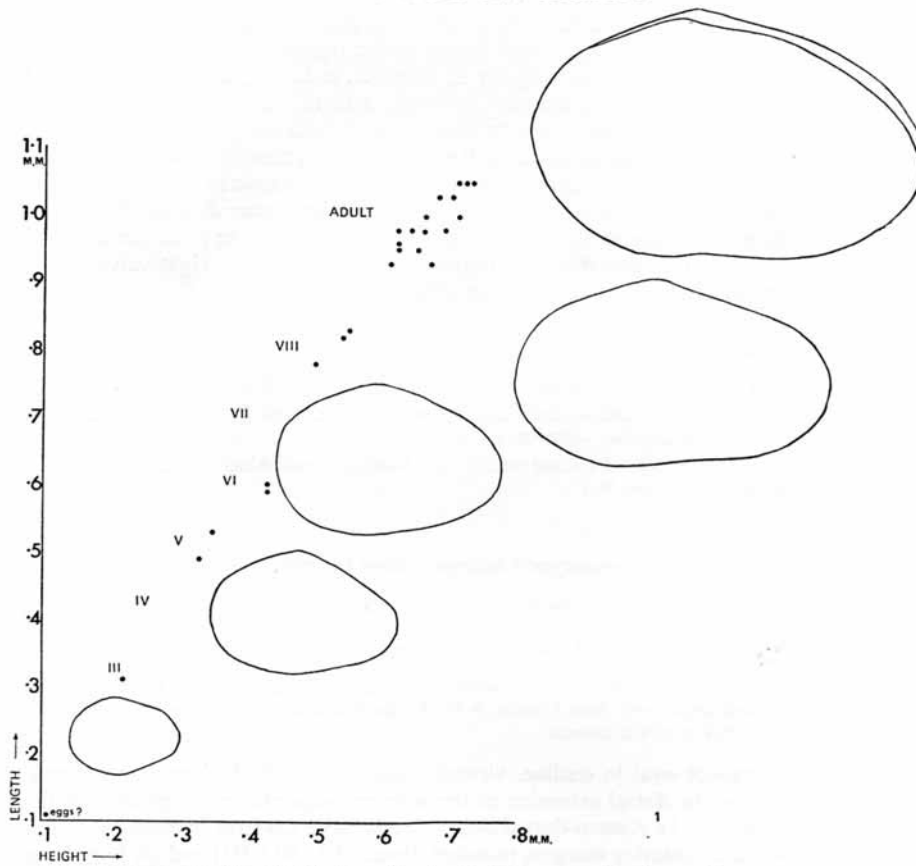
TEXT-FIG. 1. Size distribution of instars in *Pattersoncypris micropapillosa* sp. nov.

EXPLANATION OF PLATE 66

Figs. 1–6. *Pattersoncypris micropapillosa* sp. nov. All figs. ×70. 1. External view, right side, female carapace, paratype Io. 4692. 2. External view, right side showing extended furcal rami, female carapace, paratype Io. 4693. 3. External view, left side, female carapace, paratype Io. 4704. 4. External view, left side, juvenile carapace, paratype Io. 4706. 5. External view, right side, juvenile carapace, paratype Io. 4702. 6. Dorsal view, female carapace, paratype Io. 4704.

EXPLANATION OF PLATE 67

Figs. 1–5. *Pattersoncypris micropapillosa* sp. nov. 1. Appendage and body muscles, some attached to inside of carapace, showing typical mammillated crystal growth of apatite. Paratype Io. 4712 ×230. 2. Egg with small surface fracture. ×337. 3. Ventral view of female carapace to show extension of selvage over body of the animal. Female paratype, Io. 4698 ×70. 4. Ventral view, female carapace to show outer and inner lamella and appendages, holotype Io. 4680 ×70. 5. Enlarged view of oral region of holotype Io. 4680, to show basal podomere and endopodite of mandible, upper lip, maxillae, and proximal end, with setae, of first thoracic appendages. ×280.
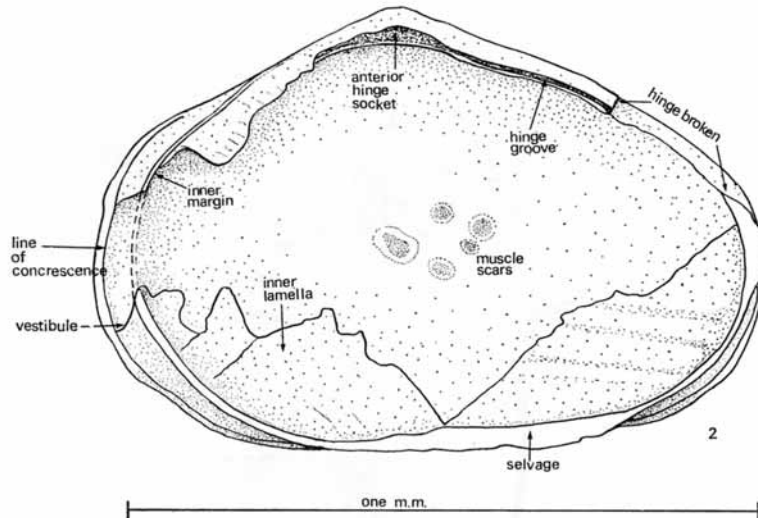
TEXT-FIG. 2. Internal details, right valve paratype, Io. 4685.
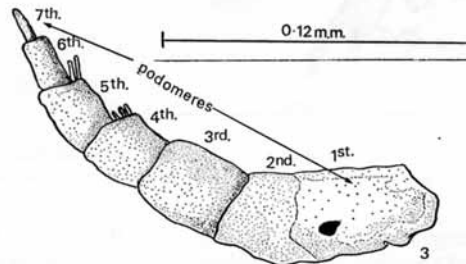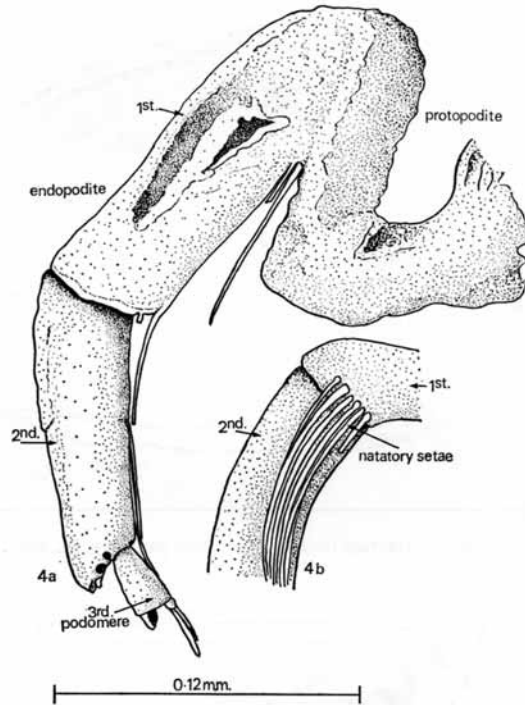

TEXT-FIG. 3. Left antennule, female paratype, Io. 4713.

whilst ventrally it develops into a prominent flap which covers the thorax when the valves are closed (text-fig. 2, Pl. 67, fig. 3).

The inner margin and line of concrescence do not coincide and a distinct vestibule, broader anteriorly, is developed along the valve margin. The line of concrescence is so close to the valve margin that there is no fused duplicature for the development of radial pore canals, which are not developed.

The muscle scars (Pl. 68, fig. 1) are typical of the family.

Antennules are long and possess seven elongate podomeres (text-fig. 3) as in the recent *Cypridopsis vidua* (Müller); but apart from those shown in Pl. 69, fig. 1, they are not sufficiently well preserved to show the setae. The length of the antennules suggests that they were used in swimming and that normally long, swimming setae would be present.

TEXT-FIG. 4. *a*, outside face, left antenna. *b*, inside face, right
antenna to show natatory setae. Female paratype, Io. 4707.

The antennae are large and powerful (text-fig. 4*a*, *b*, Pl. 69, figs. 3, 4) and were useful
in both swimming and crawling over the substratum. Six long, swimming setae, one of
which has a feathered distal end, are situated on the inner face of the first of the three
endopodite podomeres, whilst additional long setae, approximately 5 in number, are
present at the distal end of the second podomere. Further setae are also present at the
distal end of the smaller third podomere. The protopodite of the antenna appears to
consist of two podomeres which may have fused to form a single segment, but this is
difficult to determine and may be a product of fossilization.
    The mandibles (text-fig. 5, Pl. 67, fig. 5) bear well-developed terminal teeth situated


EXPLANATION OF PLATE 68

Figs. 1–5. *Pattersoncypris micropapillosa* sp. nov. 1. Muscle scars, female carapace, paratype Io. 4693
×282. 2. Internal view, left valve ×70 [specimen lost]. 3. Branchial plate of maxilla. Paratype
Io. 4714 ×203. 4. Ventral view, female carapace to show papillose ventral surface and appendages.
Paratype Io. 4709 ×238. 5. Bristle bases projecting through normal pore canal openings, anterior
part of female carapace, paratype Io. 4721 ×2,380.

at the distal end of the large basal podomere, the outer edge of which is serrated (text-fig. 5), the significance of the latter being uncertain. Long setae are present on both the endopodite and the exopodite, but the exact number has not been determined. The precise number of setae is generally not visible on other appendages but they are too brittle for dissection.

The maxillae (text-fig. 6, Pl. 67, fig. 5) consist of an outer palp and an outer, middle, and inner masticatory process. There appears to be a minimum of 5–6 setae on each process of the maxilla. The branchial plate has been observed only in a single specimen
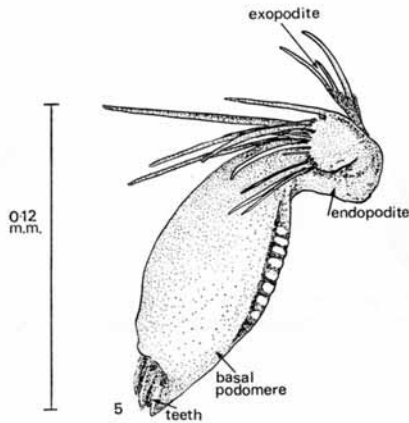
TEXT-FIG. 5. Left mandible, female paratype, Io. 4680.
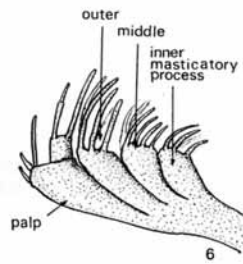
TEXT-FIG. 6. Right maxilla, female paratype, Io. 4720.

(Pl. 68, fig. 3) where it consists of a long, narrow arm and a paddle-shaped terminal blade bearing at least 10 short spines.

The upper lip is posteriorly a broad and triangular-shaped structure having a serrated edge on both sides of the centre point (Pl. 70, fig. 2). Anteriorly the upper lip becomes elongate and fuses with the forehead of the animal (Pl. 67, fig. 5).

The first thoracic appendage is, as in other Cyprididae, adapted as a second maxilla used in feeding rather than for locomotion (text-figs. 7a–c, Pl. 70, fig. 1). Proximally there are approximately 13 setae used to propel food towards the mouth whilst distally the appendage terminates in a strong hook in both sexes. In the male, the first thoracic appendage is slightly longer than in the female.

The second thoracic appendage (text-fig. 8b) has four elongate endopodite podomeres, each of which has a distal seta. The seta of the fourth podomere, being the terminal spine or claw, has a strongly serrated or saw-toothed edge (Pl. 70, fig. 3).

The third thoracic appendage (text-fig. 8a) has three endopodite podomeres. The protopodite and the first and second podomeres of the endopodite possess a distal seta, whilst the third podomere of the endopodite terminates in a claw composed of 2 setae.

0·12
m.m.

7a

7b

7c
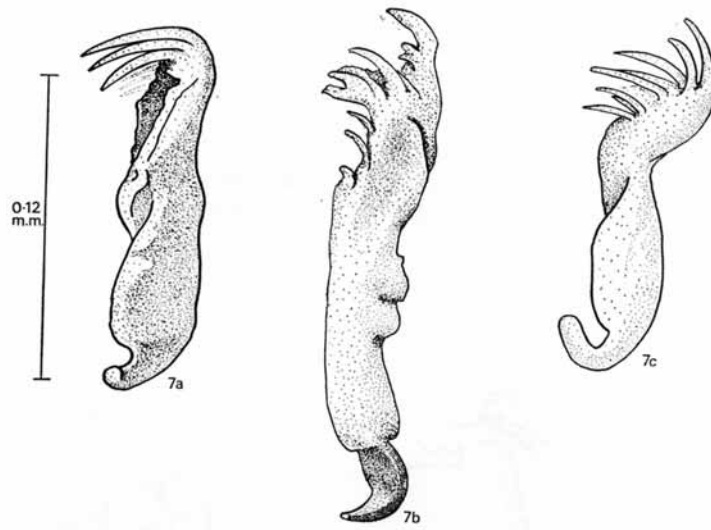
TEXT-FIG. 7. *a*, left first thoracic appendage, male? paratype, Io. 4719. *b*, left first thoracic appendage, male paratype, Io. 4682. *c*, left first thoracic appendage, female paratype, Io. 4681.

protopodite

0·12
m.m.

1st.

2nd.

3rd.
podomere

claw
8a

protopodite

1st.

2nd.

3rd.

4th. podomere

claw
8b
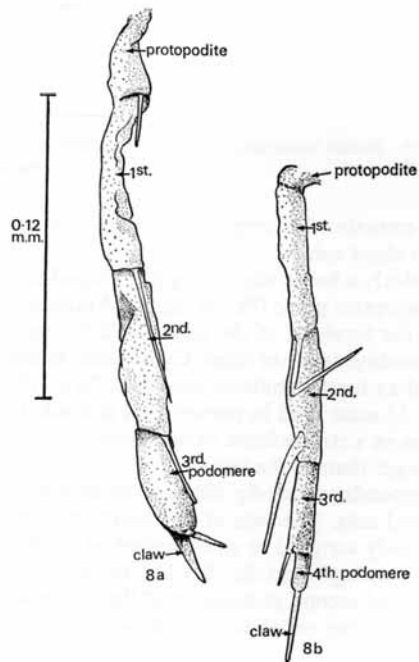
TEXT-FIG. 8. *a*, right third thoracic appendage, female paratype, Io. 4681. *b*, right second thoracic appendage, female paratype, Io. 4681.

The furca (text-fig. 10, Pl. 71, fig. 6) are long and appear to have simple rami, the extreme tip of which has either been broken off or is obscured. So far, however, there is no evidence of bifurcation.

The testes (Pl. 71, fig. 4) are coiled and situated postero-ventrally. The hemipenes (Pl. 71, figs. 1–5) are large, having a broad, triangular proximal shield, and in nearly every case project below the carapace due to the relaxation of the retaining musculature on the death of the animal.
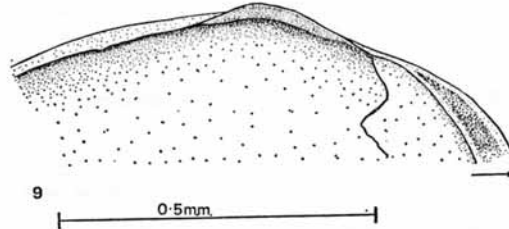
TEXT-FIG. 9. Anterior hinge, left valve paratype, Io. 4684.
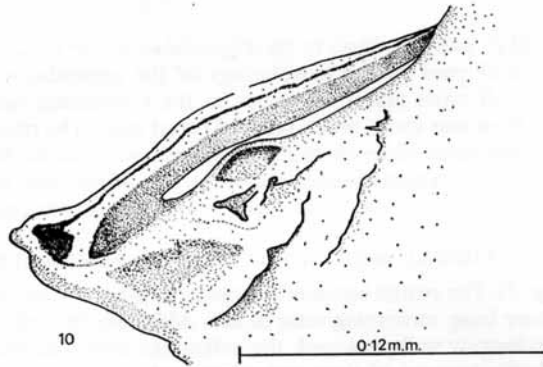
TEXT-FIG. 10. Furcal rami, female paratype, Io. 4715.

No eyes have been observed in this material although possibly present in the species. An eye has been included in the reconstruction of the ostracod in text-fig. 12.

Dimensions (in mm)		length	height	width
Holotype, ♀ Io. 4680		0·93	0·67	0·61
Paratypes, ♀ Io. 4681		0·98	0·62	0·54
♂ Io. 4682		0·95	0·65	0·58
♀ Io. 4692		1·05	0·72	0·62
♂ Io. 4696		0·98	0·64	0·58
♀ Io. 4700		1·03	0·68	0·55
juv. R.V. Io. 4702		0·65	0·43	
juv. Io. 4705		0·49	0·33	0·27
juv. Io. 4706		0·64	0·43	0·36
R.V. Io. 4707		0·70 (broken)	0·54	
♂ Io. 4710		1·03	0·68	0·61

TAXONOMIC DISCUSSION

In their account of the ostracod fauna of Pernambuco and Alagôas, Brazil, Krömmelbein and Weber (1972) describe a new species of freshwater ostracod, *Hourcqia angulata*, of which *H. angulata salitrensis* comes from the Santana Formation of Pernambuco and *H. angulata sinuata* comes from the Riachuela beds, Alagôas.

Hourcqia Krömmelbein 1965*b*, was first described as a monotypic genus (type species, *Hourcqia africana*) from the Lower Cretaceous of the Congo, West Africa. It is clearly distinguished from *Pattersoncypris* by the more quadrate carapace outline, absence of the diagnostic umbonate dorsal outline of the latter, possession of reversed valvular overlap—the right valve being the larger, and the development of marked sexual dimorphism of the carapace—the males clearly identified by their more elongate carapace in lateral view. All these characters are considered to set *Hourcqia* well apart from *Pattersoncypris*.

The assignment of *Hourcqia angulata* to *Hourcqia* by Krömmelbein and Weber necessitated this comparison of *Hourcqia* and *Pattersoncypris* because *Hourcqia angulata* is considered here to belong more naturally to *Pattersoncypris*.

Hourcqia angulata sinuata is a small subspecies of *angulata* coming from a different basin of deposition to the larger *salitrensis*, and is probably slightly younger in age (Krömmelbein, personal communication).

Hourcqia angulata salitrensis, although of somewhat similar carapace outline to *Pattersoncypris micropapillosa*, differs significantly in size (it is larger) and in details of carapace outline as compared in text-fig. 11*a–f*.

The assignation of *P. micropapillosa* to the Cyprididae on the fundamental structure of the carapace is confirmed by the morphology of the appendages. The additional information of the soft parts places the genus in the Cypridinae rather than in the Cypridopsinae which possess short, much-reduced furcal rami. The phylogenetic importance of the appendage detail observed in *P. micropapillosa* lies in the fact that it shows the Cypridinae to be an extremely conservative group which has remained largely unchanged over the last 100 million years, since Lower Cretaceous times.

FUNCTIONAL MORPHOLOGY OF APPENDAGES

Antennules (text-fig. 3). The paired antennules possess 7 rather square podomeres which almost certainly bore long, swimming setae in life. Although the other appendages of this ostracod are extremely well preserved, the antennules have lost their setae through breaking off, probably because of their rather exposed position, projecting from the antero-dorsal part of the carapace. The length of this slender appendage suggests considerable flexibility in movement and strongly supports the contention that the podomeres bore long, swimming setae and that this animal was a powerful swimmer.

Antennae (text-fig. 4*a, b*). The paired antennae are powerful appendages bearing 6 long, swimming setae on the inner surface, distal end, of the first podomere with additional

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EXPLANATION OF PLATE 69

Figs. 1–4. *Pattersoncypris micropapillosa* sp. nov. 1. Paired antennules (lower part of photograph) with swimming setae present on right antennule (inside face). Paired antennae (upper part of photograph) with setae visible. Photograph taken in dorsal view, female carapace, paratype Io. 4718 ×555. 2. External view, right side, juvenile carapace, paratype Io. 4705 ×70. 3. Antennules, antennae (with 6 swimming setae), mandible (with basal podomere, endo-, and expodites), maxilla (with arm of branchial plate), and first thoracic appendage. Paratype Io. 4707 ×222. 4. Enlarged view of endopodite podomeres 1 to 3 of antenna. Note feathered end (lower right of photograph) of swimming seta. Paratype Io. 4707 ×555.
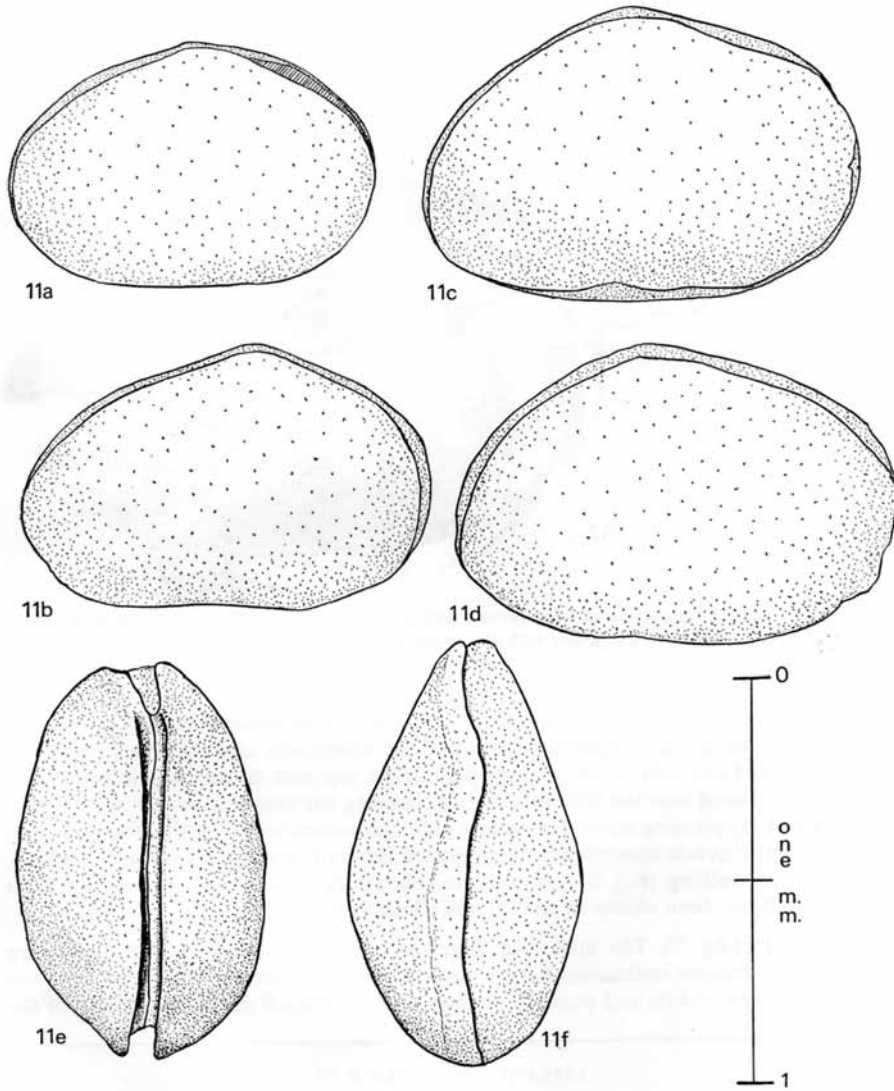
TEXT-FIG. 11. *a, b, e, Pattersoncypris micropapillosa* sp. nov. *a*, right view, female carapace, holotype. Io. 4680. *b, e*, right and dorsal views, female carapace, paratype, Io. 4692. *c, d, f, Pattersoncypris angulata salitrensis* (Krömmelbein and Weber). Right and dorsal views, complete carapaces.
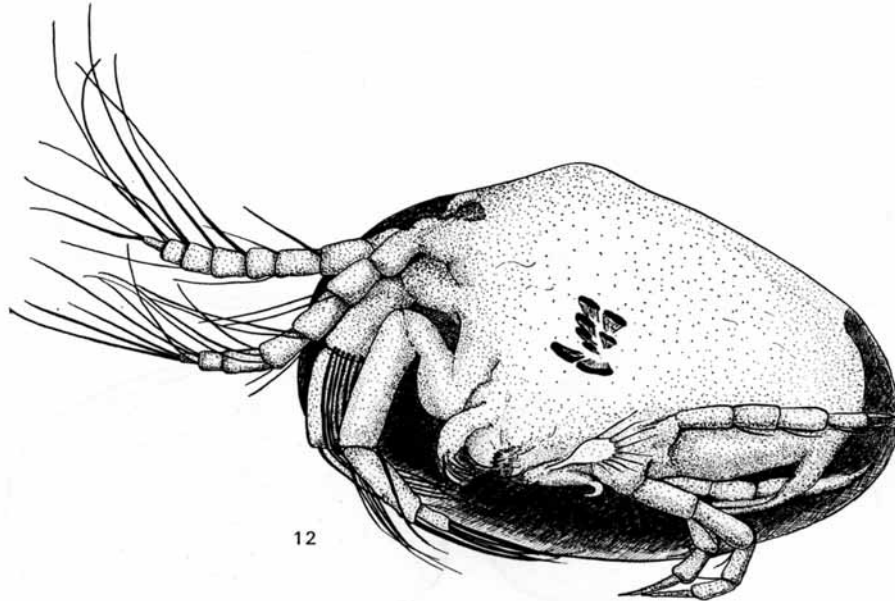
TEXT-FIG. 12. Reconstruction of adult female with left valve removed. The severed ends of the central muscles are shown together with the appendages and a hypothetical eye at the base of the antennule.

long setae situated at the distal ends of the second and third podomeres. The podomeres are more powerfully developed than those of the antennules and the antennae would have been used not only as swimming appendages, but also as walking limbs, to pull the animal forward over the substratum. In doing this, the antennae would be projected forward and, by pressing down and pulling back the animal would, with a forward push from the 2nd thoracic appendages, be projected forward in a slightly jerky movement. This type of walking may be observed in laboratory cultures of *Cypridopsis vidua* (Müller) and has been clearly described and illustrated by Kesling (1951, p. 85).

Mandibles (text-fig. 5). The mandibles bear the only 'teeth' used in feeding and are powerful appendages indicating that the animal was a scavenger, feeding on decaying plant and animal debris and possibly rasping algal growth off plants and stones of the

EXPLANATION OF PLATE 70

Figs. 1–3. *Pattersoncypris micropapillosa* sp. nov. 1. Ventral view of female carapace, to show appendages. Note distal hook of first thoracic appendage and elongate second and third thoracic appendages. Paratype, Io. 4708 ×230. 2. Enlarged view of oral region to show serrated edge of upper lip, maxillae, and first thoracic appendages. Lower lip or hypostome situated in lower centre of photograph between paired maxillae. Paratype Io. 4708 ×570. 3. Enlarged view second thoracic appendage to show serrated edge of terminal spine or claw. Paratype Io. 4708 ×570.

substratum. This type of feeding has been observed in laboratory cultures of both *Cypridopsis vidua* and *Heterocypris incongruens* (Ramdohr).

Upper lip. The broad, rather triangular upper lip has a strongly serrated edge used to assist the movement of food into the mouth.

Maxillae (text-fig. 6). The maxillae are modified appendages used to push food forward to the mouth, where it is either pushed inside or held whilst being torn by the more powerful mandibles. In addition to feeding, the maxillae have the exopodite developed into a flattened branchial plate, rapid forward and backward movement of which assists in producing a flow of water through the carapace. In this way the branchial plate assists in respiration and possibly in flushing out smaller particles of unwanted debris. In *P. micropapillosa* the branchial plate is long and paddle-shaped.

1st thoracic appendage (text-fig. 7a–c). As in other members of the family Cyprididae, the first thoracic appendages are adapted for feeding rather than being used as walking legs. The proximal end of the appendage is adapted, as are the maxillae, for pushing food towards the mouth, the 'masticatory' setae curving inwards to the centre of the ventral surface. The distal end of the appendage (endopodite) terminates in a strong, inwardly curved hook in both male and female dimorphs. In living species of the Cypridinae the first thoracic appendage is dimorphic, terminating distally in a strong hook only in the male as a copulatory adaptation. The male has been observed in many species to adopt a postero-dorsal position relative to the female during mating, the distal hook serving to prevent him sliding off the carapace of the female. In *P. micropapillosa*, however, the distal hook is present in both dimorphs and, if used in copulation suggests the mating position was not postero-dorsal. Instead a venter to venter posture is implied. The increased number of papillae on the ventral surface could be corroborative evidence for the ventral mating position, a slightly roughened surface being much easier to hold on to than a smooth one. Such a position has not yet been recorded within the Cypridinae, although Elofson (1941, p. 359) does record this method of mating in a number of marine cytheracean species. There is a general paucity of information on the mating habits of ostracods (McGregor and Kesling 1969) and it should not be assumed that a venter to venter position is never adopted in the Cypridinae at the present time.

2nd thoracic appendage (text-fig. 8b). These paired appendages are true walking limbs and are used to assist the antennae in forward movements. The appendages are bent under the body of the animal, the distal end facing anteriorly. Pressure downwards and backwards would propel the animal forwards when used in association with the forward pull of the antennae. The second thoracic appendage is an elongate, uniramous appendage consisting of 4 podomeres and terminating in a long spine or claw, as such it is ideally suited to locomotion.

3rd thoracic appendage (text fig. 8a). Attached immediately behind the 2nd thoracic appendages the 3rd thoracic limbs are also uniramous, almost certainly very flexible, and used in cleaning out the inside of the carapace. The 3rd podomere terminates in a double claw used to grasp unwanted particles from inside the carapace and to eject them. It is possible that the terminal claw also assisted in locomotion by gripping weeds or the substratum.

Furcae (text-fig. 10). The paired furcae are long, without any observable terminal bifurcation. In fact the furca appears to be a very simple elongate structure and in length differs from the rather short furcae which characterize the Cypridopsinae. Although the appendage detail of *P. micropapillosa* is very close to that of *Cypridopsis vidua* the immediately noticeable differences between the two are the size of the furcae and the shape of the branchial plate.

Sensory bristles. The presence of sensory bristles projecting through pores in the carapace is a common feature of ostracods, particularly in the anterior region. The absence of true radial pore canals and associated bristles has been compensated for in *P. micropapillosa* by the development of additional normal pore canal bristles in the anterior region of the carapace.

ENVIRONMENT AND PRESERVATION

The excellent state of preservation of these specimens of *P. micropapillosa* is the result of chance mineralization under unique conditions, the phosphate material causing the mineralization being almost certainly derived from the body of the dead teleost fish, *Cladocyclus gardneri* Agassiz, upon which the ostracods had been feeding. Other fish-bearing nodules are crowded with the same ostracod, yet these are merely calcareous carapaces without chitinous appendages. It seems probable that the ostracods were suddenly buried, and rapidly asphyxiated, dying with their valves slightly agape. Phosphate salts derived from the decaying fish permeated the immediate environment of the dead ostracods and a rapid replacement of the calcium carbonate and chitin of the animals by apatite took place.

Freshwater environments are often characterized by the dominance of only one or two ostracod species and in general the number of species present is limited. The numbers of individuals varies depending on food supply and the nature of the water, whether freely flowing or static. In marine environments, however, the number of species is greatly increased. In the Santana Formation only a single ostracod species has so far been observed in the calcareous nodules. This is evidence of a freshwater environment, although it might be caused by other factors also. However, without more comprehensive sampling it is impossible to assume that only the single species *Pattersoncypris micropapillosa* is present in the Santana Formation. From the proportions of juvenile instars to adults, the population of *P. micropapillosa* does not appear to be normal and some selection between adults and juveniles might be possible. In this context it is suggested that juvenile instars most probably lived amongst aquatic vegetation and only a very small number descended upon the dead fish; the vast majority of the ostracods

present being either eggs or adults. Alternatively, the relationship may result from seasonal fluctuation of instars leaving only a primarily adult population with a subordinate number of juveniles and a large number of eggs. A close examination of a much larger number of nodules would be needed to produce more evidence on these relationships, as it cannot be suggested that every nodule represents a group of ostracods feeding on a dead fish. Indeed, it is most probable that the present nodule was the only instance so far found where this was so, and represents an important factor in the preservation of the ostracods by mineral replacement.

A second nodule containing specimens of *P. micropapillosa*, similarly mineralized, has been found since this paper was written. The specimens, however, lacked appendages.

REFERENCES

BATE, R. H. 1971. Phosphatized ostracods from the Cretaceous of Brazil. *Nature, London*, **230**, 397–398.

BEURLEN, K. 1970. *Geologie von Brasilien*, viii+444 pp. Berlin.

BRONGNIART, M. C. 1876. Note sur un nouveau genre d'entomostracé fossile provenant du terrain carbonifère des environs de Saint-Étienne. *Ann. sci. Géol. Paris*, **7**, 1–6, pl. 6.

EAGAR, S. H. 1970. A Pleistocene mummified ostracod from the Wairarapa District. *N.Z. Jl. mar. freshw. Res.* **3**, 607–609.

ELOFSON, O. 1941. Zur Kenntnis der marinen Ostracoden Schwedens mit besonderer Berücksichtigung des Skageraks. *Uppsala Univ. Zool. Bigrog.* **19**, 215–534.

GOCHT, H., and GOERLICH, F. 1957. Reste des Chitin-Skelettes in fossilen Ostracoden-Gehäusen. *Geol. Jb.* **73**, 205–214, pl. 14.

GRAMANN, F. 1962. Extremitätenfunde an liassischen Bairdien (Ostracoda). *Paläont. Z.* **36**, 28–32.

KESLING, R. V. 1951. The morphology of ostracod molt stages. *Illinois Biol. Monogr.* **21**, 1–324, pls. 1–96.

KRÖMMELBEIN, K. 1965a. Neue, für Vergleiche mit West-Afrika wichtige, Ostracoden-Arten der brasilianischen Bahia-Series (Ober-Jura?/Unter-Kreide in Wealden-Fazies). *Senck. leth.* **46a**, 177–213, pls. 11–15.

—— 1965b. Ostracoden aus der nicht-marinen Unter-Kreide (Westafrikanischer Wealden) des Congo-Küstenbeckens. *Meyniana*, **15**, 59–74, pls. 1–4.

—— and WEBER, R. 1972 [in press].

MCGREGOR, D. L., and KESLING, R. V. 1969. Copulatory adaptations in ostracods. Part II. Adaptations in living ostracods. *Contrib. Mus. Paleontol. Univ. Michigan*, **22**, 221–239.

SANTOS, R. DA S., and VALENÇA, J. G. 1968. A Formação Santana e sua Paleoictifauna. *Anais Acad. bras. Cienc.*, Rio de Janeiro, **40**, 339–360.

SCHMIDT, R. A. M., and SELLMANN, P. V. 1966. Mummified ostracods in Alaska. *Science*, **153**, 167.

SYLVESTER-BRADLEY, P. C. 1941. The shell structure of the Ostracoda and its application to their palaeontological investigation. *Ann. Mag. nat. Hist.* **8**, 1–33.

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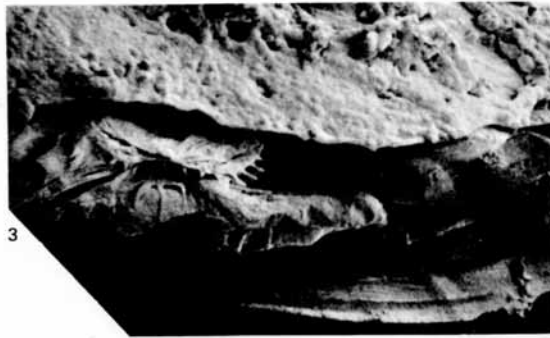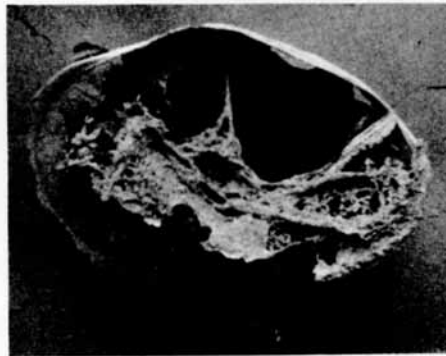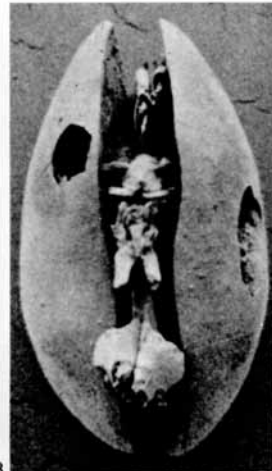
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