

## New Carboniferous (Namurian) glaciomarine ostracods from Patagonia, Argentina

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**ABSTRACT** – A new ostracod fauna (eight species belonging to five genera) from the lower part of the *Levipustula levis* Zone of the Pampa de Tepuel Formation, Patagonia is described. It consists of two new species (*Aurikirkbya tepuelensis* sp.nov., *Graphiadactylloides patagoniensis* sp.nov.) and six species described informally (*Graphiadactylloides* sp. aff. *G. moreyi* Green, *G.* sp., *Mauryella* sp., *Roundyella?* sp. and *Scrobicula* sp.), including one eridostracan (*Cryptophyllus* sp.). The assemblage probably lived in a large embayment, in the outer sublittoral (circalittoral) depth biofacies of the continental shelf, on a muddy substrate, within an extraglacial marine facies. Its age is consistent with the currently accepted Early (not earliest) Namurian age for this level. *J. Micropalaeontol.* 18(2): 97–109, December 1999.

### INTRODUCTION

The Pampa de Tepuel Formation, the middle and thickest unit of the Tepuel Group, has provided the most thorough record of Carboniferous marine invertebrate faunas in West Gondwana. Many fossil groups from this fauna have been studied, e.g. brachiopods by Amos (1958), bryozoans by Sabbattini (1972, 1983), trilobites by Amos *et al.* (1960), bivalves by González (1969, 1972a, 1972b, 1975a, 1975b, 1977, 1978, 1981), cephalopods by Miller & Garner (1953) and Riccardi & Sabbattini (1975), gastropods by Sabbattini (1978) and Sabbattini & Noirat (1969) and conularids by Mariñelarena (1970), and these have been collectively referred to the *Levipustula* Zone, or, more specifically, the *Levipustula levis* Zone. A complete list of taxa and bibliography on systematic palaeontology is available in Cuneo (1987) and a general correlation of biozones is provided by Archangelsky *et al.* (1987). To date, only one paper (Rossi de Garcia, 1972) has been published on the Carboniferous ostracods from Argentina.

In a preliminary study, Rossi de Garcia (1972) identified and described *Hollinella?* sp., *Roundyella?* sp. and *Hypotetragona?* sp. from the Late Carboniferous (Silesian) of Patagonia. These identifications were based on only a few samples and specimens, which are lodged at the Museo de La Plata (collection numbers MLP 12457, 12458, 12459). The samples were collected by Dr T. Suero, some 20 years before Rossi de Garcia's paper (1972) was published. They came from a horizon most probably sited at the middle section (LS5 Member) of the Las Salinas Formation in the Languiño hills, on the northern border of the Languiño–Genoa Basin. González (1972a) reported *Triceratina* sp., also from the LS5 Member of Las Salinas Formation, based on a single ostracod specimen (identified by Professor R. C. Whatley).

The Las Salinas Formation is a richly fossiliferous marine offshore and nearshore sequence that is almost equivalent to the Pampa de Tepuel Formation. The LS5 Member may be correlated with the lower richly fossiliferous section of the Pampa de Tepuel Formation (the lower part of the *Levipustula levis* Zone), which contains the ostracods described in this paper.

The ostracod species described herein form part of a cold-water fauna, associated with the Namurian glaciomarine rocks of Australia and Argentina (Campbell & McKellar, 1969;

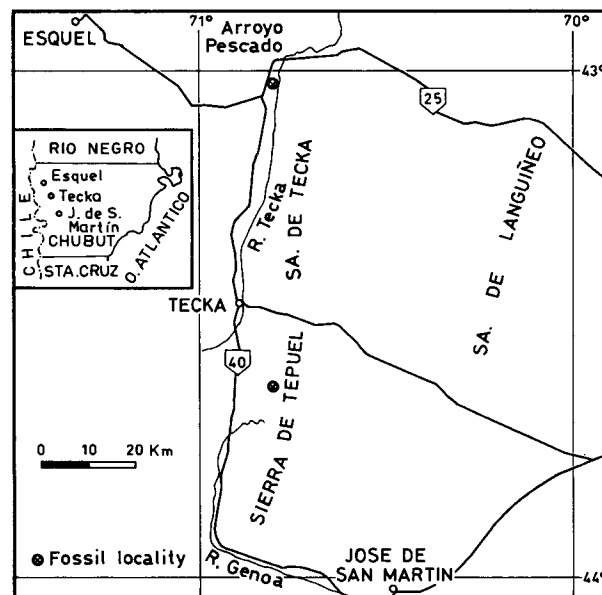


Fig. 1. Location of fossiliferous sites.

González, 1990; Roberts *et al.*, 1995). They provide an independent source of evidence with which to assess the age of the *Levipustula* Zone, and give additional information on its paleoecology and environment of deposition. All the material is lodged in the Micropalaeontology Section of the Instituto de Paleontología in the Miguel Lillo Foundation (IPM), Tucumán.

### LOCALITIES

The ostracods described in this paper were collected from two localities (Fig. 1). The first locality was the Tepuel Hills, 30 km SSE of Tecka and 130 km SSE of Esquel at roughly 70.66°W and 43.83°S. Here a richly fossiliferous bed (F-T1-13) 200 m above the base of the Pampa de Tepuel Formation yielded ostracods in association with other invertebrate groups in the lower part of the *Levipustula levis* Zone. The second locality was at Arroyo Pescado, 100 km E of Esquel, at Ap Iwan Farm, where one well-preserved steinkern was found in a thin

succession of Carboniferous nearshore sediments at the northern border of the Languiño–Genoa Basin. This section has been correlated with the previously mentioned LS5 section of Las Salinas Formation (González *et al.*, 1995).

### GEOLOGICAL SETTING

The Tepuel Hills trend N–S along the 70°40' W meridian and extend along 140 km between the localities of Tecka and José de San Martín (Fig. 1). They reach a maximum height of 1500 m above sea level at Cerro Montgomery, the type locality of the Tepuel Group (Suero, 1948), about 30 km south of Tecka. From base to top, the Tepuel Group encompasses the Jaramillo, Pampa de Tepuel and Mojón de Hierro formations. Except for the southern part of the Tepuel Hills, the Tepuel Group trends N–S, and is not folded. The base of the sequence is covered and its top is disconformably overlain by Early Jurassic sediments. A brief description of the stratigraphy of the Tepuel Group is given in the following; more detailed descriptions of this interval are provided by Suero (1948) and Page *et al.* (1984).

The Jaramillo Formation, probably a littoral deposit, consists of 1000 m of sandstone with minor mudstones and conglomerates. It is poorly fossiliferous and only a few, unidentifiable, brackish water molluscs have been reported (Freytes, 1971; González, 1987); plant remains of *Archeosigillaria conferta* (Frenguelli) Menéndez are more frequent (Petriella & Arrondo, 1978). The age of the formation probably ranges from Tournaisian to Early Visean (Azcuy *et al.*, 1990).

The Pampa de Tepuel Formation is a distinct marine sequence, more than 2900 m thick, consisting of diamictites and dropstone-laminites with intercalated sandstone and wackes—a remarkable record of Gondwana glaciation. It contains an excellent record of marine invertebrates, which are referred to the *Levipustula* Zone (Andreis *et al.*, 1987, chart 10). Almost all the sediments were deposited in periglacial seas during the Namurian and Westphalian (Suero, 1948; Page *et al.*, 1984; González Bonorino *et al.*, 1988). The lower part of the formation is equivalent to the glacial sequence (San Eduardo Formation) of the Precordilleran region (Calingasta–Upsallata Basin), western Argentina (González, 1993). Here, the San Eduardo Formation consists of three episodes of glaciation and two interglacials, within the Late Visean and Early Namurian interval (González, 1990). The presence of the *Levipustula levis* Zone in the San Eduardo Formation, in the last glacial episode (Hoyada Verde glaciation) and in its preceding interglacial (González, 1990) indicates a correlation with the lower part of the Pampa de Tepuel Formation.

The Mojón de Hierro Formation consists of mostly sandstone, with some conglomerates and a basal member of blue-black shale. It reaches nearly 500 m in thickness, being marine at its base and grading to continental sandstone beds bearing the *Glossopteris* flora at the top. Its uppermost levels may be Sakmarian in age. This formation represents a short-lived rise in sea level recognized on the margin of Gondwana after the Asselian glaciation (Dickins, 1985).

### THE LEVIPUSTULA LEVIS ZONE

The *Levipustula levis* Zone is a distinct biostratigraphic unit of the Carboniferous marine deposits of Australia and Argentina wherein both regions, it is associated with glacial sediments.

In the San Eduardo Formation in the Precordilleran region, western Argentina, the *Levipustula levis* Zone overlies the *Rugosochonetes–Bulahdelia* Zone (Taboada, 1989; González, 1990). As the latter zone contains a fauna that can be correlated with the *Marginirugus barringtonensis* Zone (and possibly the *Rhipidomella fortimuscula* Zone) of eastern Australia, it was referred to an age about the Visean–Namurian boundary (Roberts *et al.*, 1995). In Argentina, the *Levipustula levis* Zone is regarded as Namurian–Westphalian (González, 1981, 1993). In Australia, where isotopic dating is available, it is restricted to the Namurian by Roberts *et al.* (1995). According to these data, the base of the *Levipustula levis* Zone is probably Early (not earliest) Namurian in age. Ostracods from the *Levipustula levis* Zone of eastern Australia are present in the collections of the Australian Geological Survey Organisation, Canberra, but are undescribed.

### LABORATORY METHODOLOGY

The material consists of external and internal impressions and steinkerns. Some impressions remarkably preserved delicate details of internal and external structures. The separation and cleaning of ostracods was achieved using a number of laboratory procedures; rock cover was mechanically removed with a thin needle, although fragile specimens may be broken by using this method. In the case of bulk samples, chemical techniques were used: the material, previously disaggregated by pressure, was immersed in hydrogen peroxide or acetic acid. Casts were made following the technique described by Siveter (1982), but using vinylpolysiloxane, as suggested by Leiggi (1989). The advantages of this method are more rapid casting and excellent replication of delicate microsculpture. Specimens were mounted on a brass stub, gold-coated and photographed using a JEOL-JSM3 scanning electron microscope housed at the Fundación Miguel Lillo, Argentina.

### PALAEOECOLOGY OF THE OSTRACOD FAUNA

The ostracod specimens are numerically common (115) in samples from 200 m above the base of the Pampa de Tepuel Formation, where they are randomly distributed in small lenses within wackes and dropstone–mudstones between diamictites. These sediments were deposited in circalittoral environments, ranging from proglacial to extraglacial (*sensu* Brodzikowski & Van Loon, 1987). Our study of the fauna delineates eight benthic species belonging to five genera. Palaeocopida are represented by one kirkbyacean (*Aurikirkbya tepuelensis* sp.nov.), one drepanellacean (*Mauriyella* sp.) and two superfamiliae incertae (*Roundyella?* sp. and *Scrobicula* sp.). Podocopida (Metacopina) are represented by three quasillitaceans (*Graphiactylloides patagoniensis* sp.nov., *G.* sp. aff. *G. moreyi* Green, *G.* sp.). The Eridostraca (Branchiopoda?) are represented by *Cryptophyllus* sp.

Palaeobathymetric studies of ostracods in Recent sediments of the continental shelf and upper slope of the Gulf of Alaska (Brouwers, 1988a, 1988b) provide a modern analogue with which to assess the depth conditions of the Carboniferous ostracods of Patagonia, but such endeavours are constrained by the marked taxonomic contrast between Carboniferous and Recent genera and species, and the hazards of unjustifiable extrapolation. However, some general characterizations, such as

species richness (number of species) and abundance (number of specimens), may be relevant to the present study. Thus, a comparison of the ratios of the average number of species to the average number of specimens (Brouwers, 1988a, table 1) suggests that the outer sublittoral depth biofacies (0.095;  $N = 12.6$  species, 132 specimens) is the value closest to that of the Carboniferous ostracod (and eridostracan) fauna of the Pampa de Tepuel Formation (0.070;  $N =$  eight species, 115 specimens). In the Alaskan analogue, the values for this ratio in the inner sublittoral depth biofacies (0.031;  $N = 14.4$  species, 464 specimens) and the middle sublittoral depth biofacies (0.033;  $N = 16.7$  species, 503 specimens) are considerably lower (Brouwers, 1988a, table 1). This similarity perhaps implies comparable ecological conditions for both locations, viz. high nutrient levels and probably substantially high sedimentation rates.

The present material was considered unsuitable for species population structure studies, a necessary requirement to determine whether or not the fauna had been transported, either entirely or in part, from its original habitat into its environment of deposition. However, the surface relief of the specimens do not bear any marked evidence of abrasion, which suggests that the fauna probably represents a biocoenosis, and that post-mortem transportation, if it occurred, would have been minimal. More than 70% of the specimens belong to three species: *Aurikirkbya tepuelensis* sp. nov. (numerically, the dominant species), *Graphiadactylloides patagoniensis* sp. nov. and *Cryptophyllus* sp. This high proportion of individuals to species, and low species diversity, indicates deposition in a low-energy environment, probably below the wave base.

The notion that this benthic ostracod fauna is a biocoenosis that occupied a circalittoral depth biofacies is supported by the palaeoautecological interpretations of the Kirkbyidae and Scrobiculidae by several workers (as summarized by Melnyk & Maddocks, 1988). The Kirkbyidae, especially *Aurikirkbya*, were predominantly offshore crawlers and swimmers that lived on a substrate of firm calcareous mud (Melnyk & Maddocks, 1988). The Scrobiculidae were shallow shelf (middle sublittoral), possibly vagile benthic dwellers on calcareous terrigenous mud (Melnyk & Maddocks, 1988). The Quasillitidae (e.g. *Graphiadactyllis*, *Graphiadactylloides*), are found in sediments deposited near the shelf break between the outer shelf and slope in Early Carboniferous sequences in North America and Europe. In the Upper Mississippi Valley this family is well represented in the feather-edge of the Fern Glen Formation and in the condensed sequence off-shelf equivalent of the State Pond Member of the Springville Shale (Benson & Collinson, 1958; Lane, 1978). A similar palaeobathymetric relationship for this family is present in the Banff Formation, western Canada (Green, 1963), and in the Late Tournaisian subsurface rocks of the German Baltic islands of Rügen and Hiddensee (Blumenstengel, 1975; Gründel, 1975). Two depth biofacies have been suggested for the eridostracan *Cryptophyllus*, i.e. deep platform biofacies in the middle Ordovician of North America (Copeland, 1982) and the marine nearshore realm in the Late Devonian of western Europe (Bless, 1983) and the Late Devonian and Early Carboniferous of Western Australia (Jones, 1989).

The balance of the palaeoecological evidence from the ostracods suggests that they lived in the outer sublittoral

(circalittoral) depth biofacies, on a muddy substrate. Most probably, the entire *Levipustula* fauna lived in a large embayment, on the continental shelf, within an extraglacial marine facies. This scenario agrees with the one proposed by González (1984) i.e. a shallow marine environment affected by glaciers. It also concurs with observations by González Bonorino *et al.* (1988). The low-diversity, highly provincial, *Levipustula* fauna has been regarded as a 'cold fauna' because of its association with glaciomarine sediments (González, 1990; Roberts *et al.*, 1995).

#### AGE OF THE OSTRACOD FAUNA

The species described in this paper belong to genera that are known from Late Palaeozoic deposits elsewhere in the world, and a study of the combined stratigraphic ranges of these genera allows some indication of the age of the fauna.

*Aurikirkbya* ranges from the Pennsylvanian to the Late Permian (Becker, 1997c) and is recorded from North America, Spain, China and, doubtfully, from Japan. *Mauriyella* ranges from Late Devonian (Frasnian) to Mississippian (Chesterian) in North America, and in Europe it appears to be restricted to the latest Devonian of Germany and Poland. *Graphiadactylloides* appears to be restricted to the Mississippian in North America. The only recorded European species, *G. slowikensis* Olempska, 1981 from the Tournaisian of Poland, is now referred by Olempska (1997) to the genus *Ovatoquasillites*. *Graphiadactylloides* was originally described from the Lower Mississippian of Canada (Green, 1963). *G. axea* (Brayer, 1952), the youngest recorded species of the genus (Green, 1963), was described from the Salem Limestone of Missouri, a formation which is Meramecian (mid-Visean) in age (Baxter & Brenckle, 1982). The genus *Roundyella* occurs in Early Carboniferous to Permian sediments of Europe, and in Mississippian to Permian sediments of North America (Sohn, 1961b). *Scrobicula* is reported in the Middle Devonian of North America, in the Tournaisian to Namurian of Europe (Sohn, 1961b) and in the Visean of Australia (Jones, 1989). The eridostracan *Cryptophyllus* has a more extended range; it is recorded from the Ordovician to Late Devonian in North America and Europe, and from the Early Devonian to Early Carboniferous (Visean) of Australia and North Africa (Bless & Massa, 1982; Jones, 1962, 1968, 1989). In South America, *Cryptophyllus* has been described from the Lower Devonian Talacasto Formation in the San Juan Province (Baldis & Rossi de Garcia, 1975), the Lower Ordovician 'Emposadense Horizonte' in the Mendoza Province (Schallreuter, 1981, 1996) of Argentina, and the Middle Ordovician (Llanvirn) Contaya Formation of Peru (Siveter, in Hughes *et al.* 1980). The youngest known occurrence of *Cryptophyllus* is in the Upper Visean of western Libya (Bless & Massa, 1982).

Given the wide stratigraphic ranges of these genera, the most useful are those of *Aurikirkbya* and *Mauriyella*. So far, *Aurikirkbya* has not been recorded from rocks older than basal Pennsylvanian (Morrowan) and *Mauriyella* has not been recorded from rocks younger than uppermost Mississippian (Chesterian). Thus the association of these two genera in the lower part of the Pampa de Tepuel Formation suggests that their age lies somewhere about the Mississippian–Pennsylvanian boundary. It also indicates that the species of *Graphiadactylloides* from the *Levipustula* Zone of Patagonia now represents

the youngest known occurrence of the genus. The evidence is weighted in favour of a Late Mississippian age by the presence of *Mauriyella*, *Scrobicula* and the eridostracan *Cryptophyllus*, which are all unknown in the Pennsylvanian. Furthermore, the new species of *Aurikirkbya* appears to be a morphologically less developed form of the *Aurikirkbya* branch of the *Kirkbya* line, which indicates that the host rock is more likely to be Late Mississippian, than Early Pennsylvanian.

We conclude, therefore, that the age indicated by the ostracods in the base of the *Levipustula levis* Zone is consistent with the currently accepted Early (not earliest) Namurian age for this level.

#### PALAEOBIOGEOGRAPHY

During the Late Visean–Westphalian Gondwanan ‘ice age’, the lowlands of the western belt of Argentina were probably covered by extensive ice sheets (Keidel, 1922; González, 1990). Patagonia was especially affected by glaciers because this region was closer to the south palaeopole (Valencio, 1973). This period is recorded in the Pampa de Tepuel Formation, which was deposited into a broad ‘Pacific’ embayment in central Patagonia. As can be deduced from associated faunal assemblages and lithofacies, marine water temperatures fluctuated in response to the alternation of glacial and interglacial periods during the deposition of the Pampa de Tepuel Formation, and these conditions probably lasted from Late Visean to Early Namurian, and probably into the Westphalian.

The presence of *Aurikirkbya*, *Graphiadactylloides* and *Mauriyella* in the Pampa de Tepuel Formation represents the most southerly location of North American-type genera along the continental margin of western Gondwana. They presumably migrated southwards, aided by currents, along the shelf margins of the juxtaposed Laurentian and Western Gondwana blocks. In view of the marked palaeotemperature gradient between the palaeoequatorial belt and the polar region of central Patagonia, these genera were probably sufficiently tolerant to changes in water temperature to adapt to the cold-water milieu of the more provincial *Levipustula* fauna.

#### CONCLUSIONS

A new ostracod fauna is present in the lower part of the Pampa de Tepuel Formation, in the Languiño–Genoa Basin, central Patagonia. It is the second described ostracod fauna from the basin, the first being that described from the Las Salinas Formation (Rossi de Garcia, 1972).

The age indicated by the ostracod fauna is consistent with the currently accepted Early (not earliest) Namurian age for the base of *Levipustula levis* Zone. Most probably the ostracods lived in a large embayment, in the outer sublittoral (circalittoral) depth biofacies of the continental shelf, on a muddy substrate, within an extraglacial marine facies. The ostracods were probably sufficiently tolerant to changes in water temperature to adapt to the cold-water milieu of the more provincial *Levipustula* fauna.

#### SYSTEMATIC DESCRIPTIONS

The following abbreviations are used in the descriptions: C = carapace; s = steinkern; l or LV = left valve; r or RV = right valve; v = ventral view; h = holotype; A = pre-

sumed adult stage; j = juvenile; L = length; H = height; W = width; and H/L = height/length ratio. All dimensions are given in millimetres (mm). Because all the illustrated specimens are casts of external impressions, their dimensions (and possibly outline) are approximate.

Order **Palaeocopida** Henningsmoen, 1953  
Suborder **Palaeocopina** Henningsmoen, 1953  
Superfamily **Kirkbyacea** Ulrich & Bassler, 1906

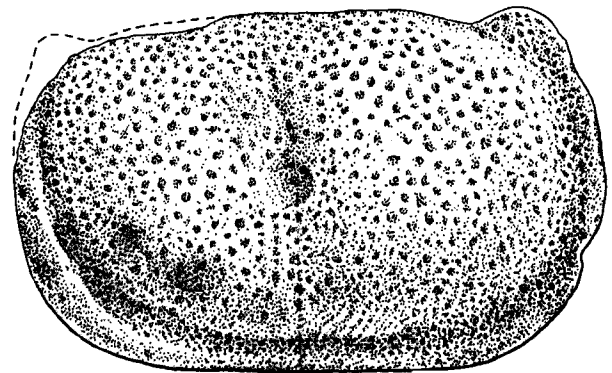
**Remarks.** The classification of the Kirkbyacea has been recently revised in a series of papers by Becker (1990, 1997a–d, 1998a,b). In this paper, we concur with his concept of the phylogeny of the Kirkbyacea as ‘a well-defined, homogenous group containing most advanced palaeocopines, with its roots in post-Ordovician drepanellids.’ We also use his terminology (Becker, 1997a, 1998b) to describe the adventral structures in the Kirkbyacea.

Family **Kirkbyidae** Ulrich & Bassler, 1906  
Genus **Aurikirkbya** Sohn, 1954

**Type species.** *Kirkbya wordensis* Hamilton, 1942.

**Diagnosis.** (Adapted from Becker, 1997c). Kirkbyidae with lateral lobes and subcentral connecting lobe; lobes well defined to subdued; adventral structures (marginia, velum) prominent (thickened ridges, tubular frills); adductor pit (spot) distinctly defined below connecting lobe; aggregate adductor muscle scars known.

**Stratigraphic range.** Pennsylvanian to Upper Permian (Becker, 1997c).



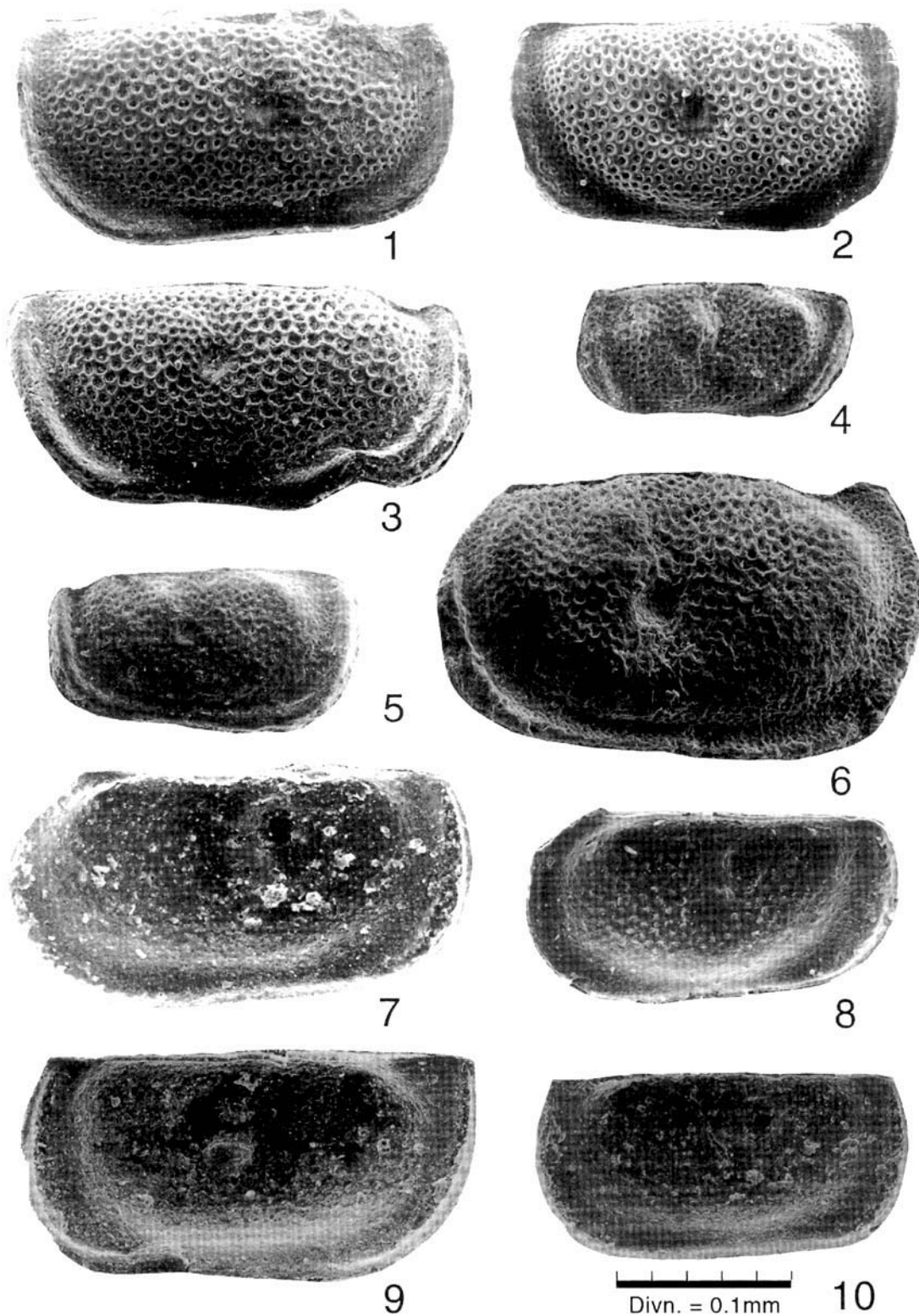
**Fig. 2.** Lateral view of right valve of *Aurikirkbya tepuelensis* sp. nov. showing details of marginal carina, kirkbyan pit and reticulate ornament.

*Aurikirkbya tepuelensis* sp. nov.  
(Plate 1, figs 1–10; Fig. 2)

**Derivation of name.** From Tepuel Hills.

**Diagnosis.** *Aurikirkbya* species with subdued lobation, well-developed subcentral rounded adductor pit, and thickened, outer frill-like carina.

**Holotype.** IPM 001/06



Explanation of Plate 1

figs 1–10. *Aurikirkbya tepuelensis* sp.nov. **fig. 1.** Right lateral view, IPM001-10. **fig. 2.** Left lateral view, IPM001-47. **fig. 3.** Left lateral view showing post-depositional deformation, IPM001-14. **fig. 4.** Left lateral view, IPM001-41. **fig. 5.** Left lateral view, IPM001-05. **fig. 6.** Left lateral view, with broken anterior cardinal corner, holotype IPM001-06. **fig. 7.** Right lateral view, with broken posterior cardinal corner, IPM001-03. **fig. 8.** Right lateral view, with broken posterior cardinal corner, IPM001-04. **fig. 9.** Left lateral view, IPM001-02. **fig. 10.** Right lateral view, IPM001-01. All specimens from locality F-T1-13, Tepuel Hills, Tepuel Formation; vinylpolyxyloxane casts. Magnification  $\times 55$ .

**Material.** Eighty well-preserved external impressions. IPM001/01-80.

**Type locality and horizon.** Tepuel Hills, 30 km south of Tecka, Chubut province. 200 m above the base of Pampa de Tepuel Formation. Lower *Levipustula levis* Zone, Early Namurian.

**Description.** Carapace large, lateral outline subquadrate to elongate. Dorsal border straight, with moderately developed posterior shoulder. Posterior cardinal angle 90° or slightly more; anterior cardinal angle slightly greater. Ventral margin nearly straight, inclined posteriorly. Anterior and posterior ends rounded. Greatest height behind midlength; greatest length at midheight. Outer carina, frill-like, thickened, with radial ribs; inner carina, narrow frill closer to the free margin. Curvature of lateral surface interrupted by subdued lobation. Surface reticulate, consisting of rows of fossae subparallel to outer carina. Adductorial pit rounded, large, well developed in subcentral area.

#### Dimensions.

Specimen	<i>L</i>	<i>H</i>	<i>H/L</i>	Material
IPM 001-10	1.29	0.62	0.48	Ar Pl. 1, fig. 1
IPM 001-47	1.13	0.54	0.49	Al Pl. 1, fig. 2
IPM 001-14	1.30	0.65	0.50	Al Pl. 1, fig. 3
IPM 001-41	0.78	0.38	0.48	jl Pl. 1, fig. 4
IPM 001-05	0.87	0.40	0.46	jl Pl. 1, fig. 5
IPM 001-06	1.35	0.82	0.60	Alh Pl. 1, fig. 6
IPM 001-03	1.30	0.60	0.46	Al Pl. 1, fig. 7
IPM 001-04	1.05	0.44	0.42	jl Pl. 1, fig. 8
IPM 001-02	1.25	0.55	0.44	Al Pl. 1, fig. 9
IPM 001-01	1.05	0.45	0.43	jr Pl. 1, fig. 10

**Remarks.** The variation in the range of the *H/L* ratios (0.42–0.60) may indicate, but does not prove, that proportional dimorphism exists in this species. This type of dimorphism has not been recorded in the Kirkbyacea.

The radial ribs of the outer carina and the 'aurikirkbyid lobation' are much less developed in *Aurikirkbya tepuelensis* sp. nov. than they are in the Westphalian species *A. hispanica* Becker, Bless & Sanchez de Posada, 1977, as figured by Becker (1978). With respect to these features, *A. tepuelensis* is morphologically closer to *A. triseriata* Shaver, 1959 (see Shaver & Smith, 1974, for a summary of the complex taxonomic history of this species), but, even then, its lobation is more subdued than that of the juvenile specimen figured by Sohn (1983, pl. 11, figs 5, 6) as *Aurikirkbya* spp. ex gr. *A. triseriata* Shaver, 1959. For this reason, we regard *A. tepuelensis* as an early representative of the *Aurikirkbya* branch, close to the *Kirkbya* evolutionary line (see Becker 1997a, fig. 1).

Superfamily Drepanellacea Ulrich & Bassler, 1923

Family Aechminellidae Sohn, 1961

Genus *Mauryella* Ulrich & Bassler, 1923

**Diagnosis.** Aechminellidae with six to eight rounded nodes superimposed on a reticulated valve.

**Type species.** *Mauryella mammillata* Ulrich & Bassler, 1923

**Discussion.** The genus *Mauryella* includes *Verrucosella* Croneis & Gale, 1938 (type species *V. golcondensis* Croneis & Gale, 1938) as a junior synonym (Sohn, 1961a). This species possesses eight

nodes. *Mauryella* resembles the nodose genus *Cornigella* Warthin, 1930 (type species *C. minuta* Warthin, 1930), but lacks the single upward pointing large spine near the dorsal margin that is characteristic of that genus. *Polytylites quincollina* (Harlton, 1929) was originally described as a species of *Mauryella* with five nodes, but the large central lobe indicates a kirkbyacean (amphissitid) relationship (Sohn, 1962).

**Stratigraphic range.** Late Devonian (Frasnian) based on *M. sola* Loranger, 1963 from Alberta, Canada, to Late Mississippian (Chesterian) based on *M. golcondensis* (Croneis & Gale, 1938) from Illinois, USA. Cooper (1941) gives the upper limit of the stratigraphic range of this species as Menard Limestone, which, in Western European terms, is Early Namurian (about the Pendleian–Arnsbergian boundary).

*Mauryella* sp.  
(Plate 2, Fig. 4)

**Material.** Two specimens, IPM003/01 and IPM003/02 (unfigured).

**Locality and horizon.** As for *Aurikirkbya tepuelensis* sp. nov.

**Description.** Valve small, subovate, slightly preplete in lateral view. Dorsal border straight, with distinct cardinal angles. Free border gently convex in posterior and ventral parts, truncated in anterior part. Lateral surface reticulate with six rounded nodes and a subdued (S2) sulcus. Figured LV = 0.63L, 0.32H.

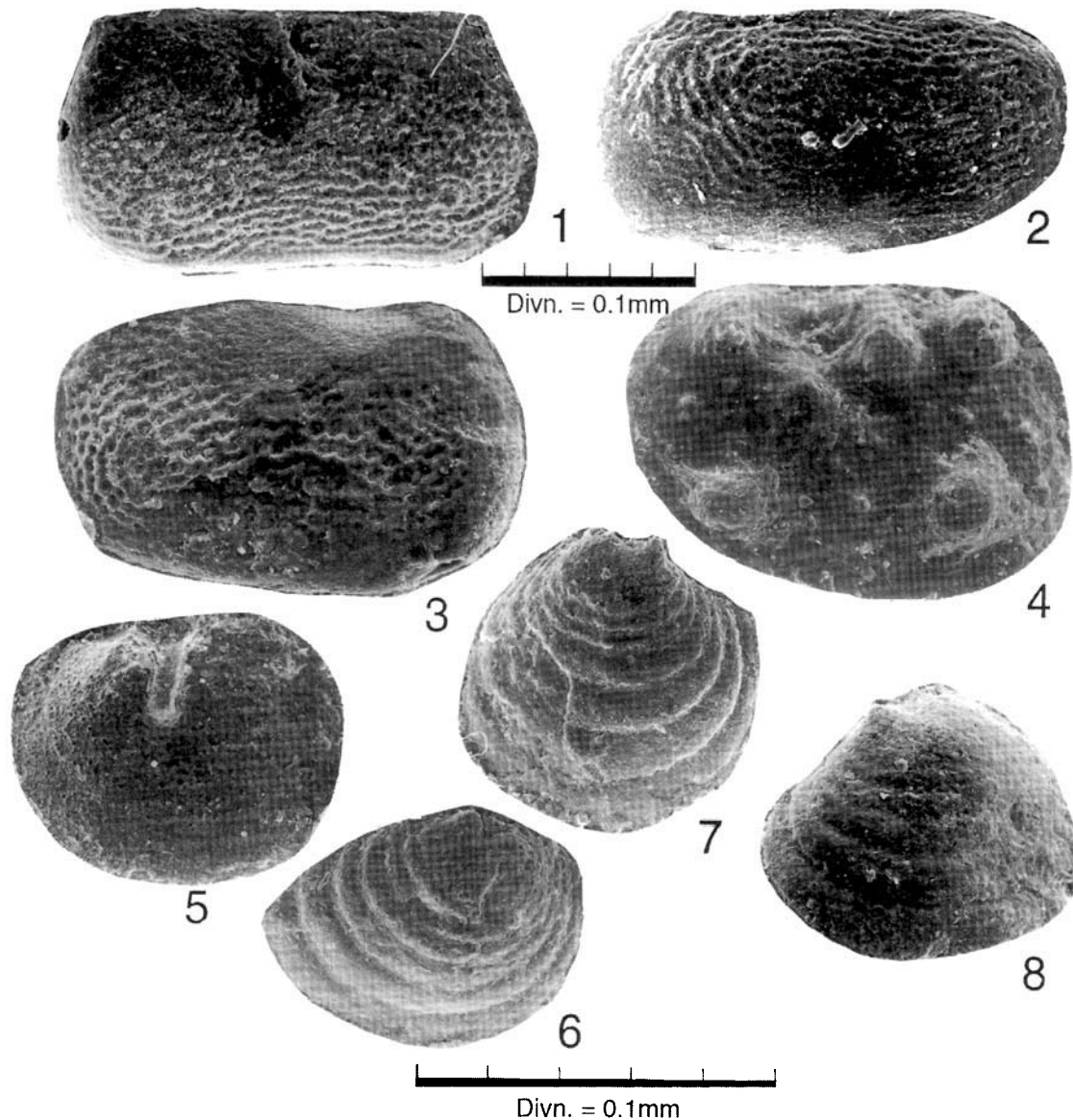
**Remarks.** The specimens to hand resemble the type species as described and figured by Benson & Collinson (1958) from the early Osagean of Illinois. These workers distinguished the primary characters of the adult stage of *M. mammillata* by the presence of 'six rounded nodes, a reticulate surface pattern on a straight hinged, anteriorly swung carapace with a very subdued S2 sulcus'. If the position of S2 is indicative of the anterior half of the carapace, then the orientation of this species used by Benson & Collinson (1958, fig. 14) should be reversed. The orientation of *Mauryella* sp. used here is the same as that used by Olempska (1997, fig. 9a–c) for *M. polonica* Olempska, 1997, described from the latest Famennian in the Holy Cross Mountains, Poland. The Patagonian species is also similar to *M. polonica* in the number, position and size of nodes, but differs in lateral outline. *M. sp.* may be new, but the material available is insufficient for formal description.

Superfamily uncertain

Family Scrobiculidae Posner 1951, emend Gramm 1976

**Diagnosis.** (After Jones, 1989). Small, subquadrate or suboval inequivalved (R/L overlap) carapace, and a simple rectodont hinge structure. Free margin without duplicature, homogeneous, with an uninterrupted contact groove. Outer lamella with many normal pores; external surface reticulate, pitted, rugate, occasionally tuberculate. Adductor muscle scar oval, transversely elongated, often pear-shaped, consisting of three or four fair indistinct rows, total number of spots 13 to 24; frontal spot present, during ontogeny the anterior spots are the first to appear.

**Stratigraphic range.** Middle Devonian to Upper Carboniferous (Namurian).



**Explanation of Plate 2**

**figs 1, 2.** *Roundyella?* sp. **fig. 1.** Lateral view showing reticulated surface, IPM004-02  $\times 60$ . **fig. 2.** Lateral view, IPM004-01  $\times 60$ . **fig. 3.** *Scrobicula* sp. lateral view showing reticulate sculpture and developed pit, IPM005-01  $\times 100$ . **fig. 4.** *Mauryella* sp. reticulate surface and rounded nodes on lateral LV, IPM003-01  $\times 100$ . **figs 5-8.** *Cryptophyllus* sp. **fig. 5.** Internal mould, detail of umbonal ridges, IPM002-02  $\times 100$ . **fig. 6.** Upper view showing grooves and ridges and umbonal sulcus and spines, IPM002-01  $\times 100$ . **fig. 7.** Upper lateral view showing umbonal spine and sulcus, IPM002-03  $\times 100$ . **fig. 8.** Tilted lateral view of external mould, IPM002-04  $\times 100$ . All specimens are vinylpolyxyloxane casts from locality F-T1-13, Tepuel Hills, Tepuel Formation.

Genus *Scrobicula* Posner, 1951

**Type species.** *Cytherella? scrobiculata* Jones, Kirkby & Brady, 1884

*Scrobicula* sp.  
(Plate 2, Fig. 3)

**Material.** One specimen, external impression. IPM005/01.

**Locality and horizon.** As for *Aurikirkbya tepuelensis* sp. nov.

**Description.** Carapace small, suboval to subelliptical in lateral view. Dorsal margin gently curved; ventral margin evenly concave, anterior and posterior ends arched. External surface reticulate, consisting of fine punctae concentrically arranged, that decrease through to the margins. Subcentral smooth muscle scars. Estimated dimensions 0.66L, 0.40H.

**Remarks.** This specimen shows some resemblance with *S.?* aff. *inaequalis* Jones, 1989, described from the Late Viséan of the Bonaparte Basin, Western Australia, but more material is

necessary for a closer comparison.

Family **Roundyellidae** Gramm, 1976

**Diagnosis.** (After Gramm, 1976). Small, subrectangular, inequivalved (R/L overlap) carapace, and a simple rectodont hinge structure. Free margin without duplicature, homogeneous, with an uninterrupted contact groove. Outer lamella with many normal pores; surface reticulate, with fairly numerous thin spines. Adductor muscle scar rounded, consisting of three or four inner spots surrounded by seven to nine peripheral spots; during ontogeny the inner spots emerge first.

Genus *Roundyella* Bradfield, 1935

**Type species.** *Amphissites simplicissimus* Knight, 1928.

**Diagnosis.** (After Sohn, 1961). Straight-backed, reticulated or papillose small ostracodes with subcentral smooth muscle spot and without marginal ridges.

**Stratigraphic range.** Devonian to Late Permian.

*Roundyella?* sp.  
(Plate 2, Figs 1 and 2)

**Material.** Two specimens, IPM004/ 01,02. external impressions.

**Locality and horizon.** As for *Aurikirkbya tepuelensis* sp. nov.

**Description.** Outline subrectangular. Dorsal margin straight. Ventral border subparallel to dorsal. Anterior and posterior ends rounded. External surface reticulated, with longitudinal rows, forming fossae polygonal to rounded in shape, and aligned subparallel to margins. Inconspicuous muscle scars like a smooth subcentral spot.

**Dimensions.** (estimated)

Specimen	L	H	Material
IPM 004-01	1.10	0.59	Ar
IPM 004-02	1.12	0.59	Al

**Remarks.** These specimens are questionably assigned to the genus *Roundyella*, because insufficient material is available for study. *Roundyella?* sp. Rossi de Garcia (1972) has antero-ventral and postero-ventral spines, which are absent in the species described in this paper.

Order **Podocopida** Müller, 1894

Suborder **Metacopina** Sylvester-Bradley, 1961

Superfamily **Quasillitacea** Coryell & Malkin, 1936

Family **Quasillitidae** Coryell & Malkin, 1936

Genus *Graphiadactylloides* Green, 1963

**Type species.** *Graphiadactylloides moreyi* Green, 1963.

**Remarks.** Green (1963) proposed the genus *Graphiadactylloides* as a morphological intermediate between *Quasillites* and *Graphiadactyllis*, to include those species formerly placed in *Graphiadactyllis*, which possess postero-ventral spines and well-developed marginal flanges, but lack posterior shoulders.

**Stratigraphic range.** Mississippian (Osagean–Meramecian) of North America.

*Graphiadactylloides patagoniensis* sp. nov.  
(Plate 3, figs 1–8)

**Derivation of name.** With reference to the region of origin, Patagonia.

**Diagnosis.** *Graphiadactylloides* species with subrhomboidal to oval lateral outline, lateral surface ornament with fingerprint pattern, without anterior marginal flange.

**Holotype.** IPM006/03.

**Material.** Twentyfour well-preserved external impressions. IPM006/ 01-24.

**Type locality and horizon.** As for *Aurikirkbya tepuelensis* sp. nov.

**Description.** Carapace large, lateral outline subrhomboidal to oval. Dorsal border straight, or slightly curved in posterior half. Anterior cardinal angle greater than posterior cardinal angle. Greatest height slightly behind anterior border; greatest length at mid-height; greatest width at mid-length position. Ventral border straight. Anterior and posterior ends rounded. Lateral surface ornamented by inosculating fine ribs, arranged in fingerprint pattern; ribs almost parallel to free margins. LV larger than RV, with moderate L/R overlap. Spines well developed at postero-ventral corner in both valves.

**Dimensions.**

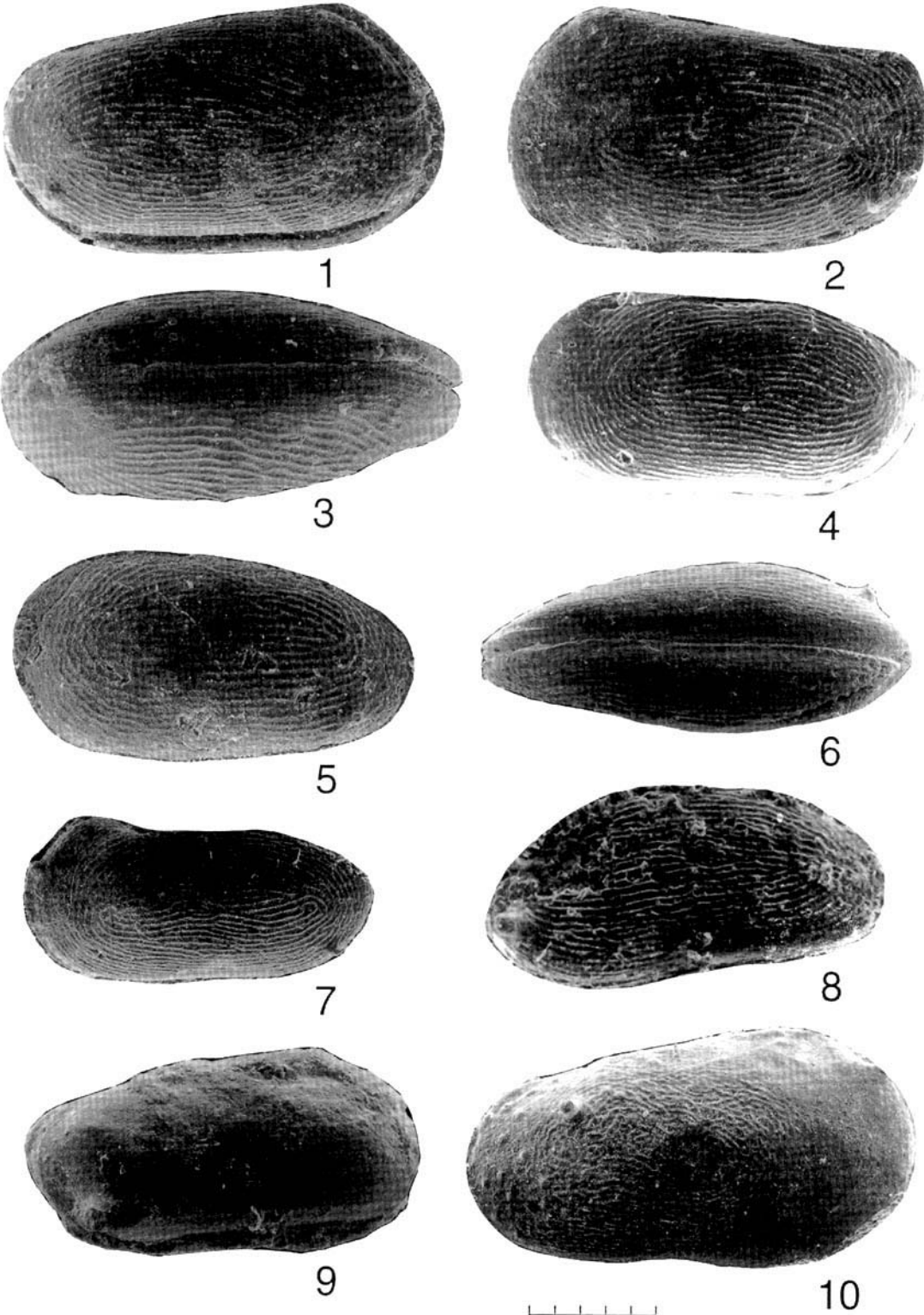
Specimen	L	H	H/L	Material
IPM 006-03	1.70	0.89	0.52	Arh Pl. 3, fig. 1
IPM 006-02	1.65	0.85	0.51	Al Pl. 3, fig. 2
IPM 006-05	1.80			Av Pl. 3, fig. 3
IPM 006-06	1.50	0.70	0.47	Al Pl. 3, fig. 4
IPM 006-04	1.55	0.70	0.45	Al Pl. 3, fig. 5
IPM 006-11	1.75			Av Pl. 3, fig. 6
IPM 006-17	1.40	0.62	0.44	Al Pl. 3, fig. 7
IPM 006-01	1.60	0.69	0.43	Al Pl. 3, fig. 8

**Remarks.** *Graphiadactylloides patagoniensis* sp. nov. is similar in lateral outline and ornamentation to *G. striatoreticulatus* Green, 1963, described from the lower and middle Banff Formation (Kinderhookian) of Alberta, Western Canada. It is larger than the Canadian species, which is probably based on juvenile instars, and lacks the characteristic antero-ventral spine and central smooth spot.

**Explanation of Plate 3**

**figs 1–8.** *Graphiadactylloides patagoniensis* sp. nov. **fig. 1.** Left lateral view, showing strong R/L overlap, holotype IPM006-03. **fig. 2.** Right lateral view, IPM006-02. **fig. 3.** Tilted dorsal view, showing straight depressed hinge-line, lateral surface sculpture and posteroventral spine on left valve, IPM006-05. **fig. 4.** Left lateral view, IPM006-06. **fig. 5.** Left lateral view, IPM006-04. **fig. 6.** Tilted ventral view showing lateral surface sculpture and posterior spine on right valve, IPM006-11. **fig. 7.** Right lateral view, IPM006-17. **fig. 8.** Right lateral view, IPM006-01. **fig. 9.** *Graphiadactylloides* sp. left lateral view of steinkern, IPM006-26, Arroyo Pescado (Ea. Ap-Iwan). **fig. 10.** *Graphiadactylloides* sp. aff. *G. moreyi* Green, right lateral view, IPM006-25. All specimens are vinylpolyxyloxane casts from locality F-T1-13, Tepuel Hills, Tepuel Formation unless stated otherwise. Magnification×40.





Divn. = 0.1mm

*Graphiadactylloides* sp.  
(Plate 3, fig. 9)

1995. González *et al.*, Revista de la Asociación Geológica Argentina T.50 (1–4):40–46.

**Material.** One specimen IPM006/ 26, a steinkern.

**Locality and horizon.** Arroyo Pescado (Ap Iwan Farm), 100 km east of Esquel, Chubut province; upper siltstones, 100 m above the base.

**Description.** Carapace large, subrhomboidal in lateral view; dorsal border straight, ventral border slightly concave. Anterior and posterior ends rounded. LV larger than RV, with moderate L/R overlap. Spines developed at postero-ventral corner in both valves.

**Remarks.** The sole specimen is a large steinkern (1.55 L; 0.73 H; 0.68 W), with a subrhomboidal outline and posteroventral spines on both valves, features which are characteristic of the genus *Graphiadactylloides*. Because of its poor preservation, the above description is provisional, and the given outline and dimensions are approximate. The species possesses a similar lateral outline as the specimen illustrated by Sohn & Rocha-Campos (1990) as *Graphiadactyllis* sp. aff. *G. yaurichambiensis* Pribyl & Pek, 1987, described from the Lower Permian of Bolivia. Sohn & Rocha-Campos (1990: 124) noted that more than one species may be present in their collection of this taxon.

*Graphiadactylloides* sp. aff. *G. moreyi* Green, 1963  
(Plate 3, fig. 10)

**Material.** One specimen, IPM006/ 25, external impression.

**Type locality and horizon.** As for *Aurikirkbya tepuelensis* n. sp.

**Description.** Carapace large, subrhomboidal in lateral view; dorsal border straight, ventral border slightly concave. Anterior and posterior ends rounded. LV larger than RV, with slight L/R overlap. Surface ornament in posterior half of carapace fingerprint pattern, anterior half smooth. Spines developed at postero ventral corner in both valves.

**Remarks.** As the sole specimen is a large poorly preserved RV (1.78 L; 0.75 H), the above description is provisional, and the given outline and dimensions are approximate. This species is distinguished from *Graphiadactylloides patagoniensis* sp. nov. by its different surface ornament; i.e. the posterior half of the carapace has a distinctive fingerprint pattern and the anterior half is smooth. In this respect, and in general outline, the specimen resembles *G. moreyi*; however, it lacks the characteristic anterior spine of *G. moreyi*.

Order **Eridostraca** Adamczak, 1961

**Remarks.** The taxonomic position and rank of this group is controversial. The Eridostraca may be an extinct group of marine branchiopods (Jones, 1968), or they may belong to the ostracod group Palaeocopida (Warshauer & Berdan, 1982). The diagnoses that appear below have been extracted from a manuscript prepared by P. J. Jones on the Eridostraca, which was submitted as a contribution to the revision of Palaeozoic Ostracoda for the Treatise of Invertebrate Paleontology (TIPPO) in 1997. As there appeared no chance that the TIPPO project would ever be completed, it was terminated in January

1999. The co-ordinators of the TIPPO project (D. J. Siveter and R. F. Lundin) returned the Eridostraca manuscript to the author, who will publish it elsewhere.

Family **Rhabdostichidae** Rusconi, 1954  
[= *Cryptophyllidae* Adamczak, 1961]

**Diagnosis.** (After P. J. Jones, TIPPO manuscript). Eridostraca without admarginal structure; free margins of lamellae with V-shaped grooves; with short hinge-line which shifts ventrally during ontogeny to form epicline dorsum and large umbo; lateral outline suboval to postplete.

Genus *Cryptophyllus* Levinson, 1951

**Type species.** *Eridoconcha oboloides* Ulrich & Bassler, 1923

**Diagnosis.** (After P. J. Jones TIPPO manuscript). Rhabdostichidae with up to 15 lamellae. The chitinous lamellae is calcified, invaginated into the interior of the shell, and forms a ridge of solid chambers.

**Stratigraphic range.** Middle Ordovician (Llanvirn) to Early Carboniferous (Late Viséan).

*Cryptophyllus* sp.  
(Plate 2, Figs 5–8)

**Material.** Five specimens, four external impressions, IPM002/ 01-04 and one internal impression of umbonal area IPM002/ 02.

**Locality and horizon.** As for *Aurikirkbya tepuelensis* n. sp.

**Description.** Carapace small, lateral outline subtriangular to subovate, umbonate, with 7 lamellae and a spinous nauplioconch. Surface smooth. Adductorial ridge, well developed on the internal surface (expressed as a deep furrow in exfoliated specimen IPM002/ 02).

**Dimensions.**

Specimen	<i>L</i>	<i>H</i>	<i>H/L</i>	Material
IPM 002-02	0.46	0.29	0.63	Pl. 2, fig. 5
IPM 002-04	0.43	0.35	0.81	Pl. 2, fig. 8
IPM 002-03	0.45	0.34	0.75	Pl. 2, fig. 7
IPM 002-01	0.42	0.27	0.64	Pl. 2, fig. 6

**Remarks.** Discrimination between species of *Cryptophyllus* is a difficult task because of the paucity of diagnostic features. The above description of the Patagonian species does not help in this regard. However, the presence of a spinous nauplioconch in *Cryptophyllus* sp. (Plate 2, fig. 7) is a feature that, at least, distinguishes this species from those described from the Early Carboniferous of Western Australia (Jones, 1962) and Libya (Bless & Massa, 1982). *Cryptophyllus* sp. is probably a new species, but insufficient material is available. A comparison between the figures of *Cryptophyllus* sp. B (Jones, 1962, pl. 3, figs 5, 6) and *Cryptophyllus* sp. (Plate 2, fig. 5) on the one hand, and that of *Hollinella?* sp. 1 (Rossi de Garcia, 1972, fig. 1.1) on the other, indicates that the latter is probably an exfoliated specimen of a species belonging to *Cryptophyllus*.

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