

# NEW POROCHARACEAE FROM THE BATHONIAN OF EUROPE: PHYLOGENY AND PALAEOECOLOGY

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**ABSTRACT.** The anatomical characters of some European Bathonian charophyte gyrogonites have been studied. The presence of a multipartite basal plate in representatives of the Porocharaceae/Porocharoideae justifies the creation of a new genus, *Musacchiella* gen. nov., represented by three new species: *M. douzensis*, *M. palmeri*, *M. sp. A*. No clear relationship has been demonstrated with extant and fossil Characeae/Nitelloideae in which a multipartite basal plate is also to be found. On the other hand, the outline of the apical pore suggests relationships with the family Raskyellaceae. A possible link is suggested between the unusual 'Y calcification' in the spiral wall cells of these species and a brackish water habitat.

IN the long history of the charophytes, the Middle Jurassic represents one of the intervals that is still practically uninvestigated. Thus, from the Bajocian to the Oxfordian, the only known species are the three described by Peck (1957) from Montana and Wyoming, U.S.A., and the seven studied by Bhatia and Mannikeri (1977) from the Callovian of Western India. Other than in these two publications, only undetermined forms or unattributed species of genus *Porochara* Mädlar have been cited. The present study is part of a comprehensive work on the charophyte flora from the Middle Jurassic. It is based mainly on our own collecting in the Bathonian of the 'Causses' (Southern France) and also on material from contemporaneous deposits of other regions: those from the English Midlands were found by Dr. T. Palmer, University of Wales, and those from Eastern Sardinia by Dr. I. Dieni, University of Padua. Amongst these Bathonian floras we have restricted ourselves in the present study to those representatives of the family Porocharaceae Grambast which possess a gyrogonite with a segmented basal plate (genus *Musacchiella* gen. nov.). This is because of the great phylogenetic importance of this structure and its relative rarity amongst fossil forms.

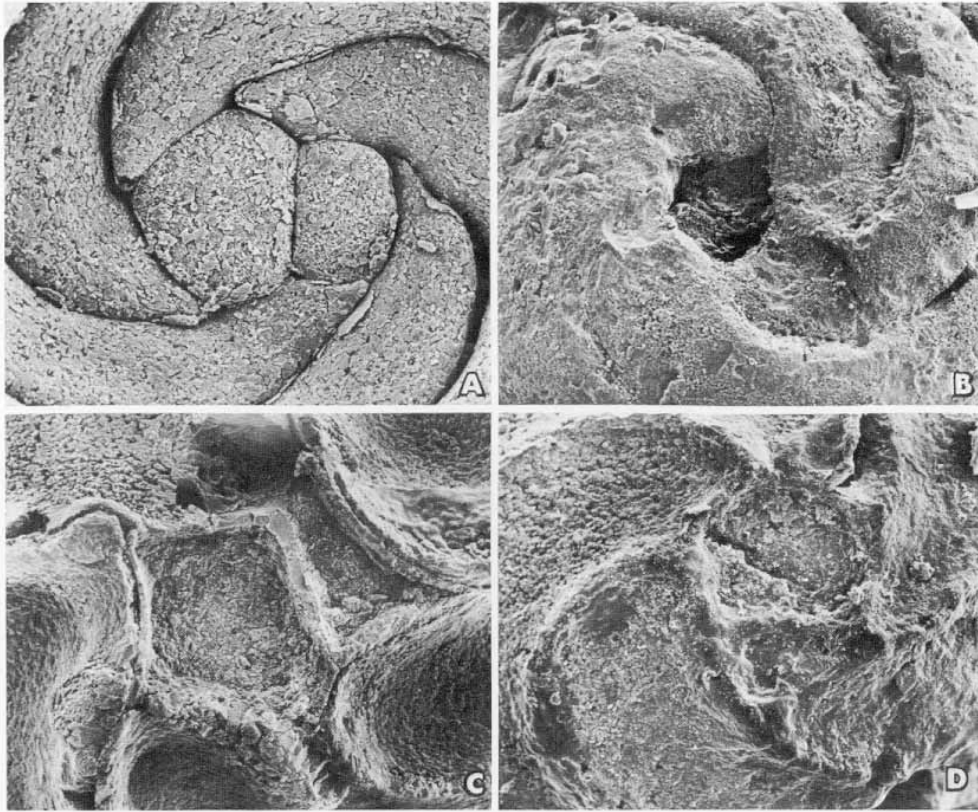
The abundance and the excellent state of preservation of these fossils has permitted new observations on the apical opening of the gyrogonite, suggesting a direct relationship with a family first known in the Upper Cretaceous. The presence of a special structure in the calcified gyrogonite wall of the three described species is also noted and discussed with relation to the original environmental conditions.

## THE SEGMENTED BASAL PLATE

### *Occurrence of a divided basal plate amongst the Charophyta*

Grambast (1956b) first pointed out that, amongst the fossil Charophyta, there existed representatives with a divided basal plate, and he assigned these to the genus *Tolypella* (Characeae Nitelloideae). This structure corresponds to the assemblage of calcified sister cells of the oosphere = sterile oogonial cells. These true *Tolypella* (with a multipartite plate) were first noted from the Lutetian (Grambast 1958; C120, Pont Bernard, unpublished material). Only one pre-Tertiary example is known: *T. grambasti* Musacchio (Uliana and Musacchio 1978) from the late Cretaceous of Argentina.

Amongst the extant forms, those which possess several sterile oogonial cells all belong to the non-calcified Nitelloideae: genus *Nitella* and genus *Tolypella* section *Tolypella*. Daily (1969) and Sawa and Frame (1974) have in fact pointed out that the calcified *Tolypella* (section *Rothia* R. D. Wood) possess an undivided plate, resulting from the calcification of a single sterile cell.



TEXT-FIG. 1. Multipartite basal plates. A, *Musacchiella palmeri* sp. nov., inside view of the gyrogonite,  $\times 455$ . B, *M. palmeri* sp. nov., external view,  $\times 273$ . C, *M. douzensis* sp. nov., external view,  $\times 455$ . D, *M. douzensis* sp. nov., external view.

With regard to the representatives of the three subfamilies of the Porocharaceae, all of which are fossil, often no mention has been made of the existence of a basal plug. When it does exist the illustration does not always allow its presence to be seen (e.g. Mäddler 1952, pl. B, fig. 28). In other cases, only a single plate has been described or illustrated, e.g. some species from the Upper Jurassic of Mongolia (Kyansep-Romashkina 1975, pl. I, fig. 3) and the Upper Cretaceous of China (Wang 1978, pl. 3, figs. 9–14 and 31–34). In the case of *Porochara gildemeisteri* Koch and Blissenbach from the Upper Cretaceous of Peru, the section given by Grambast (*in* Grambast *et al.* 1967, pl. I, fig. 14) appears to show a vertical wall crossing the middle of the plate. However, in sections at this level it is generally extremely difficult to distinguish true cell walls from fractures or crystal faces. On the other hand, Grambast (1964, p. 72) mentions, without giving any information on the age or origin of the material, the existence of Porocharaceae with a segmented plate. It is on the basis of this reference alone that Soulié-Märsche (1979a) formulated her hypothesis concerning the origin of extant forms with three sterile oogonial cells.

The observations described herein provide the first unequivocal evidence for the coexistence, within the family Porocharaceae, of two types of basal plate.

*The divided basal plate in the Bathonian Porocharaceae*

In the specimens studied the different parts of the basal plate are especially conspicuous in internal views of hollow unrecrystallized gyrogonites. In such cases, the number of parts observed is always two. They are small sized, and one is pentagonal, the other smaller, triangular or nearly rectangular (text-fig. 1A). From the exterior, observation is generally more difficult, because the partition wall is often hidden by the ends of the spiral cells or reduced by wear or by the presence of sedimentary particles. This is the aspect shown by the basal view of *Musacchiella palmeri* sp. nov. (text-fig. 1B). In certain cases, however, the partition may appear rather more clearly, as in *M. douzensis* sp. nov. (text-fig. 1C) or as in an internal pyritized mould of *M. sp. A* from Sardinia (text-fig. 1D).

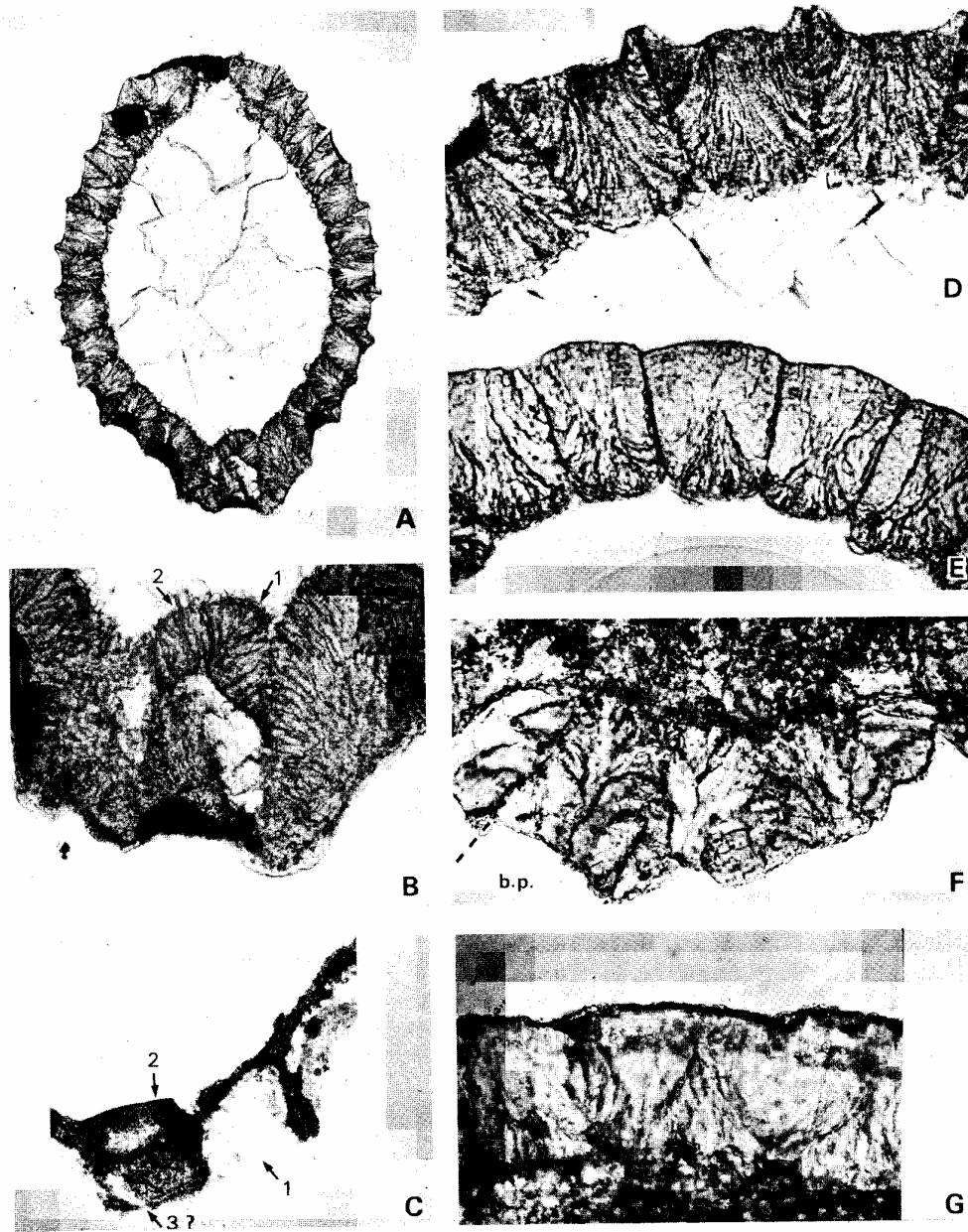
The presence of two components at the basal plate level is also conspicuous in longitudinal axial sections of *M. douzensis* sp. nov. (text-fig. 2A, B) and of *M. palmeri* sp. nov. In a section of a pyritized internal mould of *M. sp. A* (text-fig. 2C) the presence of three cavities is visible at the gyrogonite base and these cavities might represent the location of the three sterile oogonial cells. The three corresponding calcified pieces appear to be present again in the section of *M. sp. A* where the calcite shell is preserved (text-fig. 2F).

*Comparison with the other known occurrences of multipartite basal plates*

The only variation in all known cases is in the number of components observed. There are generally two in the Bathonian *Musacchiella* described here, as well as in *T. grambasti* Musacchio from the Maastrichtian and in a *Tolypella* species from the Upper Eocene of the Paris Basin illustrated by Soulié-Märsche (1979b, pl. 45, fig. 7). In *T. pumila* Grambast from the Lower Oligocene of Belgium, two components are also seen in a basal exterior view (Grambast in Stockmans 1960, fig. 39a). However, the same species from the Paris Basin shows a tripartite basal plate *in situ* in an inner side view of the gyrogonite and Grambast (1956b, 1958) mentions that the number and arrangement of the plate elements are here variable. In the Bathonian *Musacchiella*, a bipartite basal plate seems to be the norm, but in *M. sp. A* this seems to vary according to the angle of observation, and the elements may appear to be two (text-fig. 2F) or three (text-fig. 2c). It must be noted that amongst the extant species possessing several sterile oogonial cells, the number of these cells is controversial. According to Sawa and Frame (1974), and contrary to the views of other authors like Maier (1973), the third cell ought always to be present and, if it is not observed, it is probably due to its small development. In the present state of knowledge of extant as well as fossil forms, no particular significance is attached here to the biological (reproductive cycle) or phyletic nature of the number of components (2 or 3), but only to the fact that the basal plate is multipartite.

*Multipartite basal plate and phylogeny*

Other than in the Bathonian Porocharaceae, multipartite plates are known only amongst the Characeae/Nitelloideae and naturally it is with this group that affinities are to be sought. Although we now have evidence that forms with a divided plate have existed since the Middle Jurassic, it is only at the end of the Cretaceous that another species with this character (*T. grambasti* Musacchio) is to be found. These represent two widely spaced steps which do not for the moment allow the reconstruction of a direct lineage exhibiting no anatomical particularity other than the basal plate. The genera *Musacchiella* and *Tolypella* clearly belong, on account of their apical structure, to two markedly distinct groups. We shall see later on that in *M. douzensis* sp. nov. the other anatomical characters of the gyrogonite (apical opening, wall of spiral cells) suggest multiple relationships, without apparent connections with the demonstrated affinities of the Nitelloideae. We consider for this reason that the Bathonian Porocharaceae with a segmented basal plate may belong to the ancestral stock of the Nitelloideae, but we cannot state that they represent their direct ancestor. It is, therefore, difficult to agree with the phylogenetic diagram drawn by Soulié-Märsche (1979a) in which the origin of the extant genera of Characeae goes back to the Jurassic or even, for some, to the basal Trias. Indeed, as a result of the successive allocations of all the Triassic species to the family Porocharaceae (Grambast 1962; Saïdakovsky 1971), it appears that no true representative of the Characeae is to be found before



TEXT-FIG. 2. Longitudinal sections of the gyrogonite. A, *Musacchiella douzensis* sp. nov.,  $\times 70$ . B, Same, detail of the basal pole,  $\times 200$ ; 1, 2, the two parts of the basal plate. C, *M. sp. A*,  $\times 250$ ; 1, 2, 3, location of the three basal cells. D, *M. douzensis* sp. nov.,  $\times 300$ , detail of the wall of the spiral cells. E, *M. palmeri* sp. nov.,  $\times 300$ , detail of the wall of the spiral cells. F, *M. sp. A*,  $\times 370$ , detail of the basal pole; b.p., site of the multipartite basal plate. G, *Lamprothamnium priscum* Castel and Grambast (topotype),  $\times 300$ , detail of the wall of the spiral cells.

the Middle or even the Upper Jurassic. Moreover, the basal plate morphology in the Jurassic species is in no case typical of the Nitelloideae genera: *Sphaerochara* (plate undivided, thick, visible at outer surface level), *Tolypella* and *Nitella* (segmented plate).

*Taxonomic implications of the presence of a segmented plate*

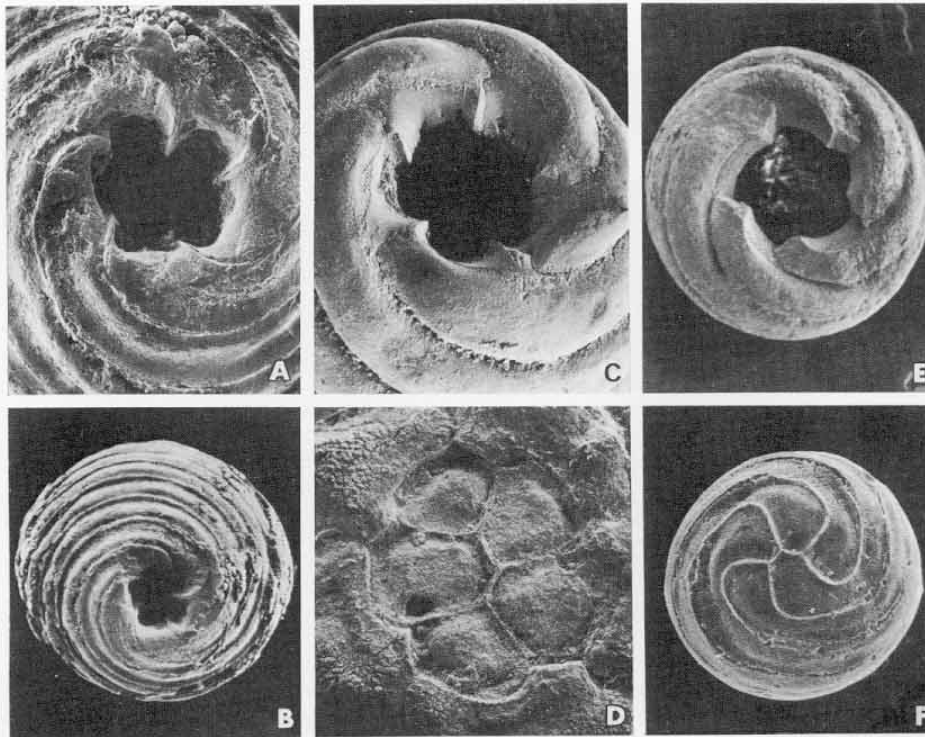
In the classification of fossil Charophyta (Grambast 1962, 1974) and more particularly of the order Charales to which all the post-Palaeozoic species belong, the apical structure of the gyrogonite is considered to be of primary importance. The species studied here, in which the apical pore is always open, but not lying at the top of a neck, belong, without any doubt, to the Porocharaceae/Porocharoideae. Within this subfamily, there coexist species with a single basal plate and others, first described here, with a divided one. The systematic value of this character can be argued. Grambast (1956*b*) has shown that, in the Tertiary Characeae, the basal plate constitutes an important diagnostic character and the presence of a segmented basal plate justifies the inclusion of a species in a special subfamily. In the present case, the described species are quite closely related to each other, both on account of their morphology and chronological isolation in the Middle Jurassic. So it seems to us that they naturally fall into a single new genus. It is possible, however, that in the future a higher rank division may have to be considered, particularly if other ancient forms with a segmented plate are discovered.

#### THE APICAL OPENING OF THE GYROGONITE

In the Porocharaceae/Porocharoideae the apical pore of the gyrogonite is always open and is often somewhat sunken, with a small diameter and with a more or less rounded pentagonal shape. Some specimens of *Musacchiella* gen. nov. show a somewhat different form. In *M. douzensis* sp. nov. for example (text-fig. 3A, B) the shape and arrangement of the spiral cell ends are seen very distinctly: the central part of these cells outlines a rounded recess limited by the forwardly tapering intercellular sutures which form tooth-shaped projections. The whole shape is that of a rose and looks like the opening left by the loss of the calcified operculum in the family Raskyellaceae, as seen for example in *Rantzieniella nitida* Grambast (text-fig. 3C). Such a form differs fundamentally from the cog-wheel shape ('roue dentée' in Grambast 1956*a*) evident in a dehiscent gyrogonite of the family Characeae, shown here in *Gyrogona lamarcki* Grambast (text-fig. 3E). In this case, dehiscence takes place through the breakage of the spiral cell ends and not through the loss of special opercular cells (text-fig. 3D) such as occurs in the Raskyellaceae (Grambast 1957; Feist in Anadón and Feist 1981).

From a biological point of view the shape of the apical opening in *Musacchiella* suggests the possibility in the Porocharoideae of closure by means of an operculum made of five apical cells which, in the Middle Jurassic, would not have been calcified. Moreover, the Porocharoideae and Raskyellaceae exhibit other similar features in the fructifications. They are often ovoidal in shape, with a thick lime-shell and basal plate, and a small apical pore compared to the general diameter of the gyrogonite. As for *Musacchiella* this combination of characters implies even more affinities with the Raskyellaceae than with the Nitelloideae which, however, have in common with the Jurassic forms the peculiarities of the basal plate as discussed above. The evolution of the Porocharoideae to the Raskyellaceae may have taken place by the calcification of the operculum, most probably amongst forms with an undivided basal plate, in the Upper Cretaceous, i.e. not long before the extinction of the Porocharaceae, near the Cretaceous-Tertiary boundary (Feist 1979).

The apical structure of *Musacchiella* also shows an inclination of the ends of the cells into the centre of the somewhat sunken apex. This bending is commonly observed within the genus *Porochara*, for example in *P. globosa* Grambast and Gutiérrez (1977, pl. I, fig. 8). The distinction of the genus *Euaclistochara* Wang, Huang and Wang, 1976, which depends upon this feature alone, is thereby questionable. As no segmented plate has been described in the species attributed to *Euaclistochara*, we consider all of them as belonging to the genus *Porochara* Mädlar. In fact, the four species of Peck (1957) attributed by Wang *et al.* (1976) to *Euaclistochara* were previously ascribed to this genus.



TEXT-FIG. 3. Apical structures of the gyrogonite. A, *Musacchiella douzensis* sp. nov. (Porocharaceae),  $\times 155$ . B, Same, paratype, CF2098-4, apical view,  $\times 60$ . C, *Rantzieniella nitida* Gramb. (Raskyellaceae), (topotype—Aquitanian), dehiscent summit,  $\times 95$ . D, *Raskyella vadaszi* Gramb. (Raskyellaceae), (Laguarrés, prov. Huesca, Spain; Upper Eocene; from Anadón and Feist 1981, pl. 2, fig. 2), entire summit,  $\times 110$ . E, *Gyrogonia lamarcki* Gramb. (Characeae), (Nogent l'Artaud, Aisne, France; Upper Eocene; from Grambast and Grambast-Fessard 1981, pl. 1, fig. 7), dehiscent summit,  $\times 30$ . F, *Psilochara* aff. *repanda* Gramb. (Characeae), (La Débruge, Vaucluse, France; Upper Eocene; from Feist-Castel 1977, pl. 5, fig. 6), entire summit,  $\times 50$ .

#### THE CELL WALL STRUCTURE

*Description.* The Bathonian *Musacchiella* species studied here exhibit in longitudinal sections (text-fig. 2A, D, E, F) a peculiar aspect of the calcified wall of the spiral cells, that is quite different from that generally observed. A system of radial convergent lines is found here in addition to the usual parallel lamination first described by Mígula (1897, p. 49). These lines depart from the suture and from the adaxial wall, going towards the median part of the spiral cell. At a low magnification, the limit of these radial stripes outlines, in the middle of the cell, a letter 'Y', the fork of which is directed towards the centre of the gyrogonite.

This structure strongly recalls that described by Soulié-Märsche (1979b, pl. 9; 1982) in the extant species of the genus *Lamprothamnium*, under the name of 'structure en éventail' (fan-shaped). However, in this case, the laminae depart only from the intercellular sutures and form divergent

bunches, the junction of which again delimits a Y at the cell centre. The same aspect can be seen, less distinctly, in the fossil species *Lamprothamnium priscum* Castel and Grambast from the Eocene (text-fig. 2G). A similar structure is also present in one species of Porocharaceae/Stellatocharoideae: *Stellatochara selligii* (Horn af Rantzien 1954, pl. 2, figs. 4, 5) from the Trias of Sweden.

*Phylogenetic relationships.* It is tempting to search for relationships between the forms with the 'Y' calcification wall structure, but it seems that this character alone cannot be used to demonstrate natural affinities. On the one hand, the genera *Stellatochara* and *Musacchiella* belong to distinct subfamilies, Stellatocharoideae and Porocharoideae, which, separate since the Permian, apparently correspond to distinct phyla (Saidakovsky and Shajkin 1976). On the other hand, we have shown above, on the grounds of the anatomical characters of the base and apex of the gyrogonite, that the likely affinities of *Musacchiella* lie with the Nitelloideae and Raskyellaceae, and not with the Charoideae, to which *Lamprothamnium* belongs. Thus, although this peculiar 'Y' calcification appears to be characteristic of some genera, these are not necessarily linked through a direct line. The most we can say is that they may have possessed a remote common ancestor.

*Ecological relationships.* The question also arises as to whether the presence of the 'Y' calcification of the spiral cells is related to the life conditions of the studied *Musacchiella*. The extant representatives of the genus *Lamprothamnium* live in lagoons and may tolerate high salinity (Burne *et al.* 1980). Likewise, *L. priscum* from the Eocene comes from a brackish facies (Castel and Grambast 1969). However, other Characeae species found in the same outcrop that yields *L. priscum*, such as *Nitellopsis (Tectochara) thaleri* Feist-Castel, do not have the same wall structure. Horn af Rantzien (1954, p. 20) does not provide any precise information on the habitat of *Stellatochara selligii*.

With regard to the outcrops yielding *Musacchiella*, some information on the primary environmental conditions, especially the salinity, is provided by the ostracod faunas. According to Palmer (1979, p. 194), at Wood Eaton 'the ostracod fauna is predominantly brackish' and 'the abundance of charophytes also suggests the influence of fresh water'. Furthermore, he states that the absence of vegetative fragments implies that the fructifications were transported from lakes upstream. It may be noted, however, that several living and fossil species have been reported, herein and elsewhere, from brackish lagoons. Moreover, not all charophytes possess a calcified thallus. It is thus quite likely that *M. palmeri* shared the same environment as the ostracods. Dr. Palmer (pers. comm. 1982) acknowledges this as being quite compatible with his own palaeoecological analysis of the basal part of the Hampen Marly Formation at Wood Eaton.

The ostracods associated with *M. douzensis* at the southern France locality (F. Dépêche, pers. comm.) are mainly freshwater species, but may have been transported as suggested by the poor state of preservation of the shells. In addition, there is one euryhaline species, *Klieana levis* Oertli. As communicated by Dr. I. Dieni (pers. comm.), this latter species is predominant at the Sardinian locality and indicates there a brackish environment. Thus it seems to be true that the forms showing a 'Y' calcification are found preferentially in somewhat saline environments, but it cannot be said that there is a causal relationship between these two facts.

## SYSTEMATIC PALAEOONTOLOGY

Division CHAROPHYTA

Order CHARALES

Family POROCHARACEAE Grambast 1962

Subfamily POROCHARAOIDEAE

Genus MUSACCHIELLA nov.

*Type species.* *Musacchiella douzensis* sp. nov.

*Derivation of name.* The genus is named in honour of Dr. E. Musacchio, Buenos Aires, for his work on fossil charophytes.

*Occurrence.* Middle Jurassic (Bathonian) of Oxfordshire, England; Causses, southern France; eastern Sardinia.

*Diagnosis.* Gyrogonite of Porocharoideae with a small apical pore, ovoidal shape, and segmented basal plate.

*Affinities.* The new genus bears most resemblance to *Porochara* Mädlér amongst the Porocharoideae (characterized by an apical opening not lying at the top of a neck), in its general ovoidal to ellipsoidal shape and in the morphology of the somewhat sunken apical opening which may occasionally possess a 'rose' outline. It differs in the particular character of a divided basal plate. We limit, therefore, the genus *Porochara* to forms with an undivided, or unknown, basal plate. In practice, of course, it will not always be possible to recognize the new genus, since the basal plate structure will not always be visible.

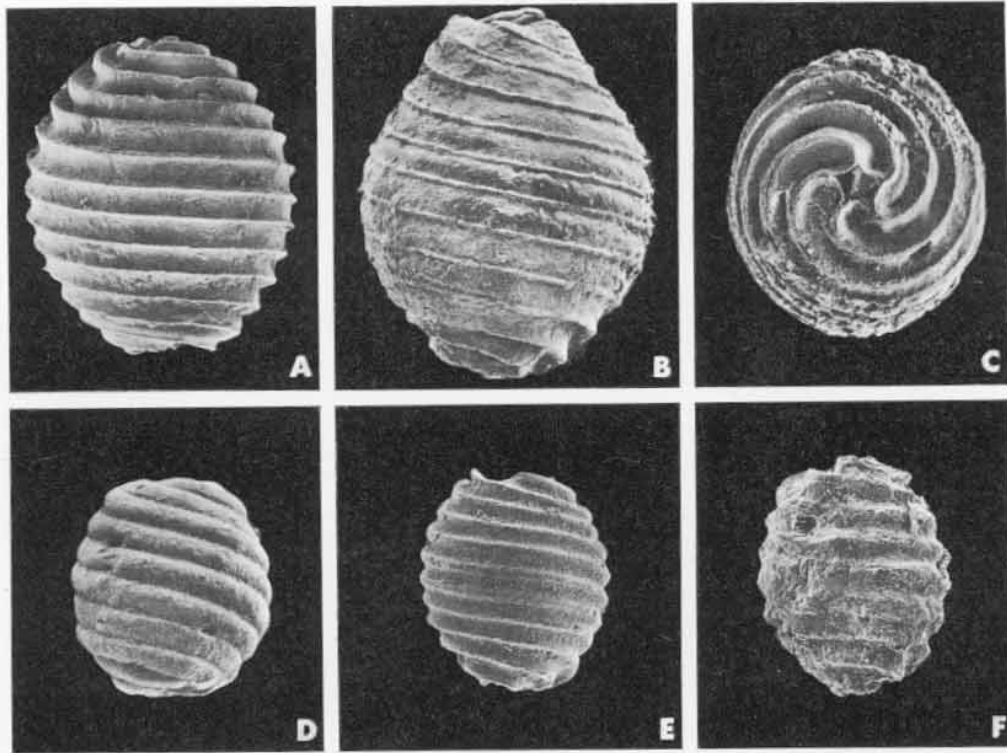
*Musacchiella douzensis* sp. nov.

*Types.* Holotype (text-fig. 4A), CF2038-1. Paratypes (text-figs. 4B, C; 3B), CF2038-2 to 5. Coll. M. Feist Université des Sciences et Techniques du Languedoc, Montpellier, France.

*Type horizon and locality.* Lignitic marls from the Bathonian, Middle Jurassic; Les Douzes, commune of Mures-la-Parade, Lozère, France.

*Material.* About 300 specimens.

*Derivation of name.* From the name of the type locality.



TEXT-FIG. 4a-c, *Musacchiella douzensis* sp. nov.,  $\times 60$ . A, holotype, CF2098-1, profile. B, paratype CF2098-2, profile. C, paratype, CF2098-3, base. D, E, *M. palmeri* sp. nov.,  $\times 60$ . D, holotype, C 1094-1, profile. E, paratype C1094-2, profile. F, *M. sp. A*, specimen CF1598-1, profile,  $\times 60$ .



*Diagnosis.* Gyrogonite of *Musacchiella*, the largest diameter being at mid height. Segmented basal plate, visible from the outer side at the bottom of a shallow pit bordered by the truncation of the spiral cells. Dimensions: 625–975  $\mu\text{m}$  long, 500–550  $\mu\text{m}$  wide; 10–13 convolutions; L/W ratio varying from 1.1 to 1.4.

*Remark.* The spiral cells are frequently concave, but even when they are plane or slightly convex in the middle part of the gyrogonite, they become more hollow at its base where the sutures are always prominent.

*Affinities.* Other than in plate characters, *M. douzensis* differs from the *Porochara* present in the same bed in its distinctly larger dimensions and its widened outline at the equator of the gyrogonite. In this latter character the new species is reminiscent of *Porochara rotunda* (Peck) Shajkin from the Middle Jurassic of U.S.A., the basal plate of which is unknown; however the dimensions and the number of convolutions are distinctly smaller in the latter species (Peck 1957). Similarly, (*S.*) *raoi* Bhatia and Mannikeri 1977, from the Callovian of India, is rather enlarged at the equator of the gyrogonite but is smaller overall and apparently has an undivided basal plate. According to the divisions established by Grambast (1962), the features of the apex, which is open and not drawn into a neck, lead us to ascribe this species to the Porocharoideae, and more precisely to the genus *Porochara* Mädlar, with regard to its general shape and apical morphology.

*Musacchiella palmeri* sp. nov.

*Types.* Holotype (text-fig. 4D), C1094-1. Paratypes (text-fig. 4E), C1094-2 to 5. Coll. Grambast, Université des Sciences et Techniques du Languedoc, Montpellier, France.

*Type horizon and locality.* Lignitic marls of the Bathonian, Middle Jurassic; Wood Eaton, 5 miles north-east of Oxford, Oxfordshire, England (Palmer 1973).

*Material.* About 250 specimens.

*Derivation of name.* The species is named after Dr. T. J. Palmer, who collected the material at Wood Eaton and sent it for study to the late Dr. L. Grambast in 1970.

*Diagnosis.* Gyrogonite of *Musacchiella*, most often ellipsoidal, tapering near the apical and basal ends. Segmented basal plate nearly on a level with the basal pore. Dimensions: 275–650  $\mu\text{m}$  long, 250–500  $\mu\text{m}$  wide, 7–9 (exceptionally 6–10) convolutions; L/W ratio varying from 1.08 to 1.36.

*Remarks.* In the Wood Eaton outcrop, only representatives of the genus *Musacchiella* are found, as confirmed by the examination of basal plates. In histograms of the dimensions, the specimens are divided in two sets with bimodal peaks interfering for lengths 400–450  $\mu\text{m}$  and widths 350  $\mu\text{m}$ . As the characters, other than the convexity or concavity of the spiral cells, do not vary significantly, we assign the whole population to a single species.

*Affinities.* *M. palmeri* differs from *M. douzensis* by its more dumpy shape, its smaller dimensions, and the conformation of the basal region. However, the two species have in common two characters: the variability of the cell relief (concave to convex) as well as the salient features of the lime-shell, these peculiarities being also found in *M. sp. A* from Sardinia. On the other hand, the largest specimens with concave cells look somewhat like *P. sublaevis* (Peck) Grambast in Saidakovsky (1966, p. 132) from the Middle Jurassic of Montana, U.S.A., of which the basal plate has not been described. The specimens with large dimensions may also be compared with '*S.*' *sahnii* and '*S.*' *jaisalmerensis* both described by Bhatia and Mannikeri (1977). Their number of convolutions is however higher and there is no mention of the basal plate. These two taxa seem to us to belong to only one species with various degrees of calcification. Their apical morphology leads us to conclude that they must be ascribed, together with '*S.*' *raoi*, to the genus *Porochara*.

*Musacchiella* sp. A

Text-fig. 4F

*Occurrence.* Funtana sa Mela, near Siniscola, Nuoro province, Sardinia; Bathonian, Middle Jurassic (specimens collected by Dr. I. Dieni).

*Description.* Gyrogonite ellipsoidal, with concave spiral cells; basal plate apparently made of three pieces, which have been observed in longitudinal section (text-fig. 2C). Basal plate not visible from the outer side of the gyrogonite.

*Remark.* The small number of specimens and the often rather poor state of preservation do not allow the creation of a new species, so we are leaving the described form in open nomenclature. However, it would appear that, on the basis of their morphology and in spite of the deformations observed, the specimens from Sardinia cannot be assigned to either of the two former species of *Musacchiella*.

## CONCLUSIONS

Within the present work on Bathonian charophytes, we have described a new genus, *Musacchiella*, which includes Porocharaceae/Porocharoideae species combining an unusual assemblage of characters in the gyrogonite: the apical opening recalling the family Raskyellaceae (Upper Cretaceous–Lower Miocene), the divided basal plate of the Characeae/Nitelloideae type (Upper Cretaceous–Recent), and the ‘Y’ calcification of the wall resembling that in *Lamprothamnium* (Characeae/Charoideae, Upper Cretaceous–Recent). Furthermore, this particular calcification appears to be related to a brackish habitat. Thus a great diversity of valuable characters is present amongst forms which are rather unspectacular at first sight: small-sized gyrogonites without any ornamentation. One may see in this contrast the expression of an evolutionary potential amongst these Porocharaceae from the Middle Jurassic. It has been previously suggested (Grambast 1962, 1974) that the Porocharaceae constitute the common stock from which the families Raskyellaceae and Characeae, which comprise nearly all the Tertiary forms, are derived. The example of *Musacchiella* lends support to this point of view. In addition, the genus *Musacchiella* has a wide geographical distribution in Western Europe: England, France, Sardinia. Also associated with this genus are species now ascribed to *Porochara* which are currently being investigated.

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