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A NEW EARLY ORDOVICIAN CONODONT GENUS FROM THE SOUTHERN MONTAGNE NOIRE, FRANCE

by ENRICO SERPAGLI*, ANNALISA FERRETTI†, DANIEL VIZCAÏNO‡ *and* JOSÉ JAVIER ÁLVARO§

*Dipartimento del Museo di Palaeobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia, Via Università 4, I-41100 Modena, Italy; e-mail: serpagli@unimore.it

†Dipartimento di Scienze della Terra, Università di Modena e Reggio Emilia, L.go S. Eufemia 19, 1-41100 Modena, Italy; e-mail: ferretti@unimore.it

‡7 rue Jean-Baptiste Chardin, Maquens, 11090-Carcassonne, France; e-mail: daniel.vizcaino@wanadoo.fr

§Dpto. Ciencias de la Tierra, Universidad de Zaragoza, 50009-Zaragoza, Spain; e-mail: Jose-Javier.Alvaro@univ-lille1.fr, and LP3, UMR 8014 CNRS, Université de Lille I, 59655-Villeneuve d'Ascq, France

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Abstract: Two species of a new Tremadocian (Early Ordovician) conodont genus from the Saint Chinian Formation of the southern Montagne Noire, France, are erected: *Hammannodus sarae* gen. et sp. nov. and *Hammannodus juliae* gen. et sp. nov. They were found within a single storm-induced limestone nodule interbedded with offshore shales belonging to the regional *Shumardia* (*C.*) *pusilla* (trilobite) Biozone, and to the *Paltodus deltifer deltifer* (conodont) Subzone. This conodont record is associated with the episodic development of carbonate productivity in temperate waters of the Montagne Noire platform, a process absent in neighbouring platforms of north-west Gondwana. The apparatus is composed of five coniform pyramidal elements occupying P and S positions and one bicostate element in the M position, having three or two sharp costae, respectively, with a subtriangular basal outline.

Key words: Ordovician, Tremadocian, conodonts, *Hammannodus*, Montagne Noire.

THE Early Ordovician is a crucial time span in the faunal evolution of conodonts. Tremadocian conodonts are known from many localities in North America (e.g. Miller 1969; Landing *et al.* 1986; Bagnoli *et al.* 1987; Pyle and Barnes 2002) and northern Europe (e.g. Lindström 1955; Löfgren 1997*a*; Löfgren *et al.* 1999). However, collections of this age, mostly composed of a few coniform elements, are rare in southern Europe and have been described from only scattered localities in the whole northern Gondwana margin (e.g. Küppers and Pohler 1992).

A recent re-sampling of some Lower Ordovician limestones from the southern Montagne Noire (Languedoc, France) (Text-figs 1–2) has provided a rich and diversified conodont fauna composed of 14 taxa, among which both subspecies of *Paltodus deltifer* [*P. deltifer pristinus* (Viira, 1970) and *P. deltifer deltifer* (Lindström, 1955)] are present (Text-fig. 3). The studied level can therefore be attributed to the *Paltodus deltifer deltifer* Subzone, thus expanding our knowledge of Early Ordovician conodont distribution. Löfgren (1997*a*, *b*, 1998, 1999) and Löfgren *et al.* (1999) recently produced detailed reconstructions of several coniform apparatuses, e.g. *Semiacontiodus* (Miller, 1969), *Cornuodus* Fåhræus, 1966, *Decoriconus peselephantis* (Lindström, 1955), and *Variabiliconus* Landing, Barnes and Stevens, 1986. These authors identified a common fundamental sexi- to septimembrate pattern in latest Cambrian–earliest Ordovician conodonts, in apparatuses comprising either coniform or ramiform elements (e.g. *Cordylodus*; Nicoll 1990). The same organization pattern also characterizes the new genus *Hammannodus*, described in this paper.

GEOLOGICAL SETTING AND STRATIGRAPHY

The Montagne Noire is located in the southern prolongation of the French Massif Central (Text-fig. 1A), and consists of a complex framework of tectono-stratigraphical units. These are grouped into three main structural domains (Text-fig. 1B): (1) a metamorphic axial zone of complex domes of gneiss and migmatites surrounded by mica schists; (2) a northern flank composed of imbricated tectonic nappes of Lower Cambrian–Silurian rocks; and (3) a southern flank comprising large nappes involving Lower Cambrian–Carboniferous sedimentary rocks. The Minervois and Pardailhan nappes of the southern Montagne Noire (Text-fig. 1B–C) are the reference areas for litho- and biostratigraphical correlations of Cambrian and Lower Ordovician sedimentary rocks. Both nappes

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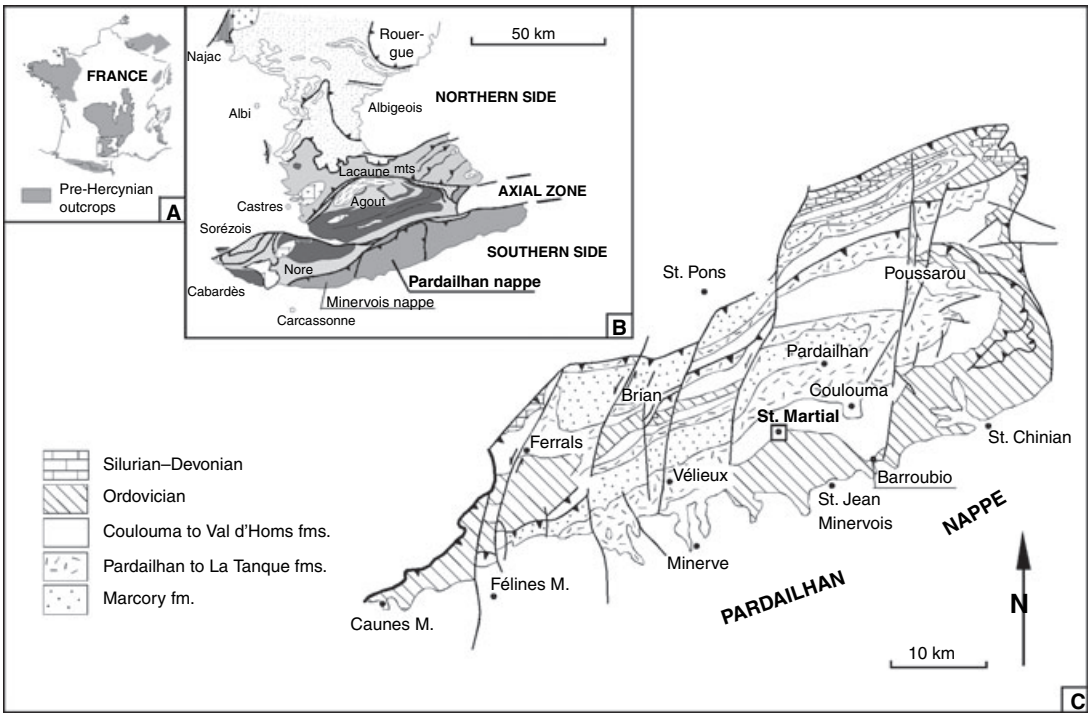


TEXT-FIG. 1. A, geological setting of the Montagne Noire. B, tectonostratigraphical units of the Montagne Noire. C, setting of the study area (boxed above) in the Pardailhan nappe; modified from Guérangé-Lozes and Burg (1990).

contain a thick and mixed (carbonate-siliciclastic) succession of shallow-marine, Upper Cambrian–Lower Ordovician sediments deposited in temperate waters of the north-west Gondwanan margin (Álvaro *et al.* 2003). Despite this palaeogeographical setting, the platform preserved in the southern Montagne Noire records important episodes of carbonate productivity, which are key elements for understanding biodiversity patterns at these palaeolatitudes, and the immigration of conodont faunas.

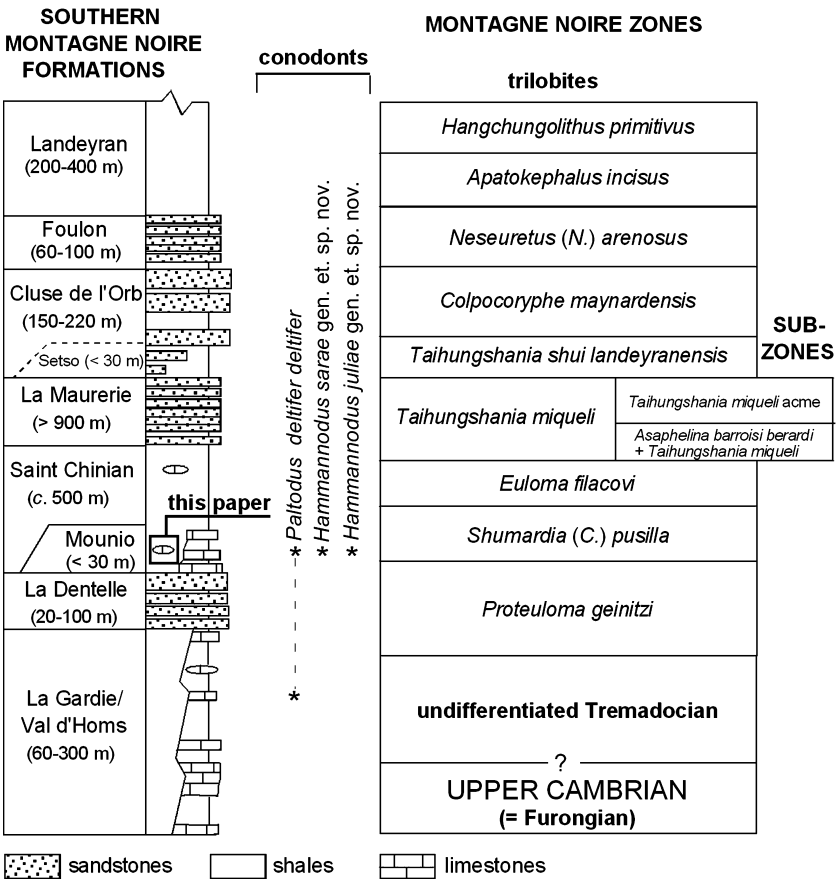
Recent revisions of the Upper Cambrian and Lower Ordovician strata of the southern Montagne Noire have provided a new stratigraphical and sedimentological framework for the Lower Palaeozoic of the Montagne Noire (Álvaro *et al.* 1998, 2001, 2003; Vizcaïno *et al.* 2001; Álvaro and Vizcaïno 2002; Vizcaïno and Álvaro 2003; see synthesis in Text-fig. 2). Analysis of limestone beds and nodules from the Val d'Homs Formation yielded a wide diversity of Mid–Late Cambrian fossil taxa, such as echinoderms (Ubaghs 1998; Vizcaïno and Lefebvre 1999), trilobites (Shergold *et al.* 2000; Álvaro *et al.* 2001) and linguliformean brachiopods (González-Gómez 2005). Detailed trilobite sampling in the limestone/shale alternations of the younger Mounio and Saint-Chinian formations allowed Vizcaïno and Álvaro (2003) and Tortello *et al.* (2006) to propose a formal regional biostratigraphical chart for the Lower Ordovician. Acid processing of these limestones has revealed the presence of a conodont fauna attributed to the *Paltodus deltifer* Zone (Álvaro *et al.* 2005). Within this rich and well-preserved fauna we have recognized a new conodont genus.

The taxa studied were recovered from the La Regagnade Valley, close to the village of St. Martial [UTM coordinates x: 0483838, y: 4806142; 43°24′N, 2°48′E; Saint-Pons (2444-Est) 1 : 25,000 map sheet] (Text-fig. 1C). In this area, the sandstones and quartzites of the La Dentelle Formation are covered by a thick, monotonous sedimentary succession of the Saint Chinian Formation composed of dark grey and green shales with fine- to medium-grained sandstone intercalations, and centimetre-thick siliceous and carbonate nodules. One of these lenticular limestone nodules, up to 10 cm thick, and located *c.* 25 m above the La Dentelle/Saint Chinian boundary, has yielded the conodonts described below that can be correlated with the *Paltodus deltifer deltifer* Subzone and with the regional *Shumardia* (*C.*) *pusilla* (trilobite) Biozone (Text-fig. 2).

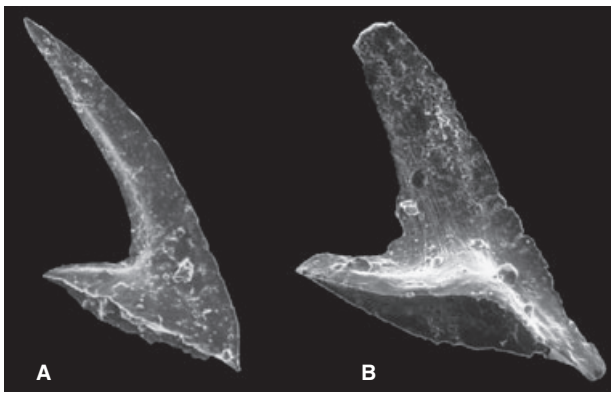
SYSTEMATIC PALAEONTOLOGY

(E. Serpagli and A. Ferretti)

Repository. All illustrated specimens are deposited in the Dipartimento del Museo di Paleobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia, Modena, Italy, under repository numbers IPUM 27930–27964.



TEXT-FIG. 2. Stratigraphical framework of the Upper Cambrian and Lower Ordovician of the southern Montagne Noire; modified from Vizcaïno and Álvaro (2003), and Álvaro *et al.* (in press).



TEXT-FIG. 3. Lateral views of the diagnostic M elements of the apparatuses of A, *Paltodus deltifer pristinus* (Viira, 1970), and B, *Paltodus deltifer deltifer* (Lindström, 1955); × 80 and × 105 respectively.

Genus HAMMANNODUS gen. nov.

Derivation of name. After a friend in our team, Wolfgang Hammann, who died in 2002 while collecting fossils in the Carnic Alps.

Type species. Hammannodus sarae gen. et sp. nov., from the Tremadocian of the Montagne Noire, France.

Diagnosis. Multimembrate coniform apparatus containing five pyramidal, deeply excavated, basically tri-costate element morphotypes in P and S positions and a bicostate element in the M position. P elements are usually more pyramidal and stouter than S elements. The position of the three main costae in P and S elements varies in the several elements of the apparatus. Main sharp costae usually reach the basal margin but do not extend beyond it. No denticulation or serration has been observed on the keeled edges. Faint supplementary costae may be present, as well as longitudinal constrictions producing carinae. Fine longitudinal striations have been noted on some specimens as well as basal filling. The cusp, usually short, can vary from erect to strongly proclined; a thin-walled basal cavity extends up to its tip. In specimens with cusp proclined over 45 degrees, no distinct differentiation between base and cusp really exists. The basal outline is always triangular but with the main apex of the triangle (corresponding to posterior margin) in an upper-central position in Pa, Pb and Sa elements and in a lower-central position (corresponding to anterior margin) in Sb and Sc elements.

Remarks. Many problems still exist in the taxonomy of Early Ordovician coniform-pyramidal costate (eu)cono-

dont elements that possess deep basal cavities. Many cannot be placed satisfactorily in any known taxon (e.g. New genus D sp. of Johnston and Barnes 2000, pl. 15, figs 20–21, 24–25), even though several recognized genera contain elements of this type. Pyramidal, costate, deeply excavated elements are present, for instance, in the apparatuses of *Coelocerodontus* Ethington, 1959, *Diaphanodus* Bagnoli, Barnes and Stevens, 1987, *Lundodus* Bagnoli and Stouge, 1997, *Stenodontus* Chen and Gong, 1986, *Stolodus* (Lindström, 1955) and *Kallidontus* Pyle and Barnes, 2002. Some of these genera, however, appear to need detailed revision, as in the case of *Coelocerodontus*, established for Middle–Late Ordovician forms but also used to house Late Cambrian–Early Ordovician elements (Müller and Hinz 1991). The status of *Coelocerodontus* in euconodonts or paraconodonts is a matter of discussion, as is its apparatus structure, which according to McCracken (2000) includes trigoniform, tetragoniform and pyramidiform elements (the latter being, respectively, tri-, quadri- and quinquecostate). Different views also exist regarding the composition of the apparatus of *Stolodus*, regarded as either quadrimembrate (without M and Sa elements), with the denticulate-serrated S elements housed in *Lundodus* (Bagnoli and Stouge 1997), or alternatively as quinquemembrate (Albanesi 1998).

In the material from the Montagne Noire there are many pyramidal-coniform, costate, deeply excavated elements that do not fit in either *Stolodus-Lundodus* or *Diaphanodus*. The former has a totally different apparatus structure and the latter includes delicate and compressed coelocerodontid elements. In addition, *Stenodontus* has an extremely narrow cross-section in all elements.

Close morphological affinities exist between elements of *Hammannodus* gen. nov. and some S elements of *Kallidontus* (*K. princeps* Pyle and Barnes, 2002, in particular), which bears large P elements in the apparatus that are often denticulated, and which are apparently missing in our material. Indeed, no denticulated subpyramidal elements are present in the Montagne Noire collection. In addition, the triangular outline of the S elements in *Kallidontus* appears to coincide with the presence of keeled anterior and posterior margins. By contrast, either the posterior or the anterior margin of S elements of *Hammannodus* is keeled. No longitudinal striations have been described for *Kallidontus* elements. Finally, bicostate (M) elements appear to be missing in *Kallidontus*.

The differences between the two new species of *Hammannodus* are relatively minor and lie primarily in the development of the base, which expands more posteriorly in *H. juliae*.

Hammannodus sarae sp. nov.
Plate 1, Text-figures 4–5

? 1974 *Distacodus latus* Lindström; Viira, pl. 3, fig. 16.
1992 *Coelocerodontus* sp.; Küppers and Pohler (*pars*), p. 490, figs 4.4*c–d*, 5.12–5.13.

Derivation of name. After Sara, granddaughter of one of us (ES).

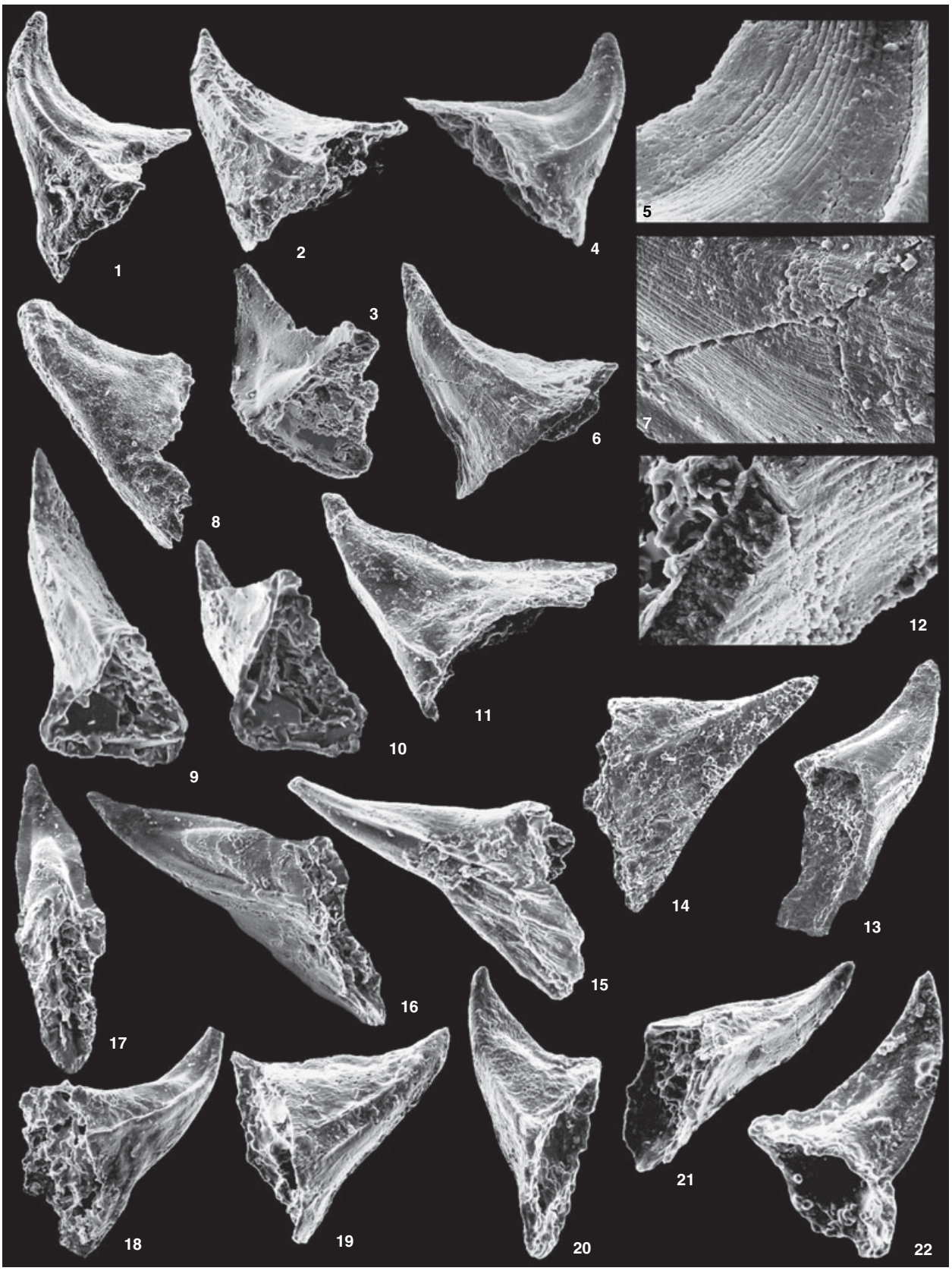
Holotype. Specimen IPUM 27933, Dipartimento del Museo di Paleobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia, Modena (Italy); Plate 1, figures 4–5.

Type locality and horizon. La Regagnade Valley (in the vicinity of St. Martial; Text-fig. 1C), lenticular limestone, up to 10 cm thick, located in the lowermost part of the Saint-Chinian Formation (Text-fig. 2), *c.* 25 m above the top sandstones of the underlying La Dentelle Formation (Álvaro *et al.* 2003); Early Ordovician (Tremadocian, *Paltodus deltifer deltifer* Subzone of the *P. deltifer* Zone and *Shumardia* (*C.*) *pusilla* Zone).

Diagnosis. A species of *Hammannodus* with an apparatus of deeply excavated coniform-pyramidal tricostate elements arranged in a transition series and characterized by a short and posterobasally expanded base and a triangular cross-section of the base in P and S elements.

EXPLANATION OF PLATE 1

Figs 1–21. *Hammannodus sarae* gen. et sp. nov., holotype and paratypes. Specimens from the *P. deltifer deltifer* Subzone, Saint Chinian Formation, Early Ordovician, La Regagnade Valley (St. Martial), Montagne Noire, France. 1–2, IPUM 27930–27931; Pa elements, lateral views; × 135 and ×120, respectively. 3, IPUM 27932; Pa element, posterolateral view; × 120. 4–5, IPUM 27933; Pa element, holotype. 4, lateral view; 5, detail of fine striations; × 135 and ×570, respectively. 6–7, IPUM 27934; Pb element. 6, lateral view; 7, detail of fine striations; × 100 and ×480, respectively. 8, IPUM 27935; M element, lateral view; × 100. 9–10, IPUM 27936; Sa element. 9, posterolateral, and 10, posterior views; × 200 and ×180, respectively. 11, IPUM 27937; Sa element, lateral view; × 160. 12–13, IPUM 27938; Sb-Sc element. 12, detail of fine striations; 13, lateral view; × 550 and ×90, respectively. 14, IPUM 27939; Sb element, lateral view; × 130. 15, IPUM 27940; Sb element, lateral view; × 140. 16–17, IPUM 27941; Sb element. 16, lateral, and 17, posterior views; × 170 and ×150, respectively. 18, IPUM 27942; Sb element, lateral view; × 110. 19, IPUM 27943; Sc element, lateral view; × 130. 20, IPUM 27944; Sc element, posterolateral view; × 115. 21, IPUM 27945; Sc element, posterolateral view; × 120. 22, IPUM 27946; Sc element, upper-posterior view; × 170.



SERPAGLI *et al.*, *Hammannodus*

Description

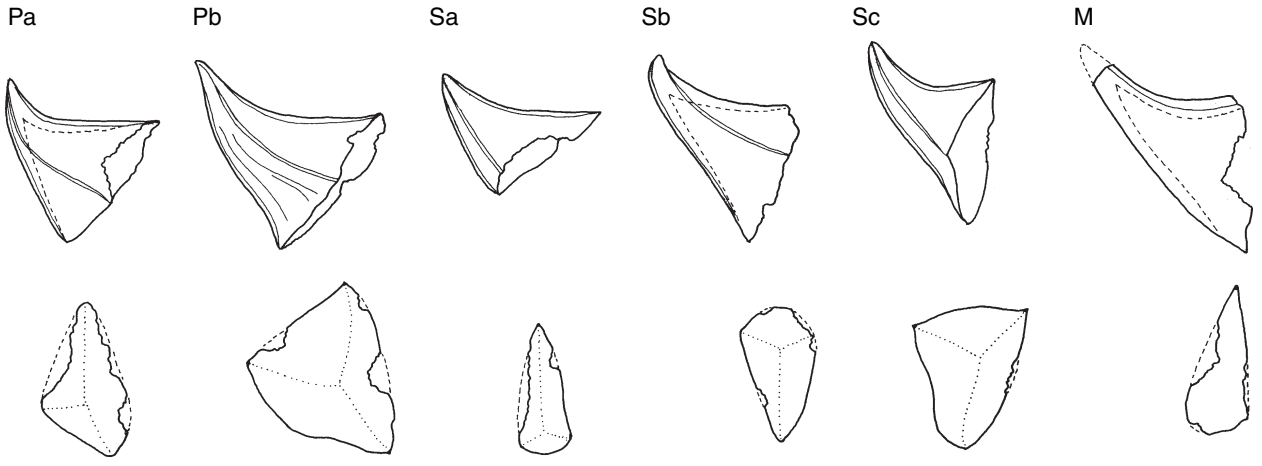
Pa element (Text-figs 4–5; Pl. 1, figs 1–5). Triangular, asymmetrical pyramidal-coniform element with short base and three costate sharp edges tapering rapidly to the tip. The three main costae originate from the cusp and are located in anterior, lateral and posterior positions. The element has, therefore, a broadly rounded outer side with a sharp lateral costa, usually medial in position, and a flat to slightly convex inner side. Between the posterior and lateral costae longitudinal constrictions producing carinae may be found. Fine striae can be seen on lateral faces of cusp between costae (Pl. 1, fig. 5). Posterior costa slightly longer than the other two costae. Basal cavity extends to the tip. Cusp short and stout, tip erect or slightly proclined. Element triangular (almost equilateral) in lateral view. Cross-section of the base triangular in outline.

Pb element (Text-fig. 4; Pl. 1, figs 6–7). Triangular, asymmetrical pyramidal-coniform element with short base and three sharp edges tapering rapidly to the tip. The three main costae originate from the cusp and are located in anterior, lateral and posterior positions. The element has, therefore, a broadly rounded outer side with a sharp lateral costa, usually medial in position, and a flat to slightly convex inner side. Supplementary costae and fine striae may be present on the inner side as well as on the outer side between the anterior and lateral costae (Pl. 1, fig. 7). Basal cavity extends to the tip. Cusp short and stout, tip mostly proclined at varying degrees. The apical part of the tip curves away from the plane of the element and appears slightly twisted laterally. Element profile triangular (almost equilateral) in lateral view, with posterior costa drawn out slightly. Cross-section of the base triangular in outline. Pb element differs from Pa element mostly in the curvature of the cusp, which in the former is always proclined and frequently twisted laterally.

Sa element (Text-fig. 4; Pl. 1, figs 9–11). Triangular, symmetrical pyramidal-coniform element with a relatively short base and three costate sharp edges tapering rapidly to the tip. The three main costae originate from the cusp. Two of these are located in an anterolateral position with the third in a posterior position. Therefore, the element has an evenly convex, narrow anterior face and two nearly planar posterolateral faces, gently convex at the base. Basal cavity extends to the tip. Cusp short and stout, tip erect or proclined. Element profile triangular in lateral view. Fine longitudinal striations have been noted on posterolateral faces of some elements. Cross-section of the base triangular in outline. Sa element differs from P elements in always being symmetrical.

Sb element (Text-fig. 4; Pl. 1, figs 14–18). Triangular, subsymmetrical pyramidal-coniform element with a short base and three costate sharp edges tapering rapidly to the tip. Two of the three main costae are lateral in position and posteriorly placed, whereas the third is anterior. In this element therefore, the posterior face is acostate and strongly convex and the two anterolateral faces are gently convex. The element, slightly compressed laterally, widens basally in the posterior half so that, in lateral view, the anterior margin shows a broad sigmoidal outline. Basal cavity extends to the tip. Cusp short, not particularly stout, tip proclined. Element roughly triangular in lateral view. Secondary costae and/or constrictions producing carinae have been noted on the anterolateral faces of some elements. The cross-section of the base is essentially triangular in outline with the upper side of the triangle arched and the main apex in the lower (anterior) position.

Sc element (Text-fig. 4; Pl. 1, figs 19–22). Triangular, subsymmetrical pyramidal-coniform element with a short base and three costate sharp edges tapering rapidly to the tip. Two of the three main costae are lateral in position and posteriorly placed, whereas the third is anterior. Therefore, in this element the posterior face is wide, acostate and planar or gently convex, and the two anterolateral faces are gently convex. Most elements widen basally in the posterior half so that in lateral view the anterior margin shows a broad sigmoidal outline. Basal cavity extends to the tip. Cusp short and stout, tip proclined. Element triangular in lateral view. Secondary costae have been noted on the anterolateral faces of some elements. The cross-section of the base is basically triangular in outline with the main apex of the triangle very rounded and in the lower (anterior) position.



TEXT-FIG. 4. Camera lucida drawings of *Hammannodus sarae*; all × 65.

M element (Text-fig. 4; Pl. 1, fig. 8). Triangular, subsymmetrical pyramidal-coniform element with a short, wide base and two sharp edges tapering rapidly to the tip. One of the two main costae runs on the posterior margin whereas the other is placed anterolaterally. The inner side is bordered by the two main costae and is almost flat whereas the outer side bears anteriorly a wide longitudinal carina. Therefore, in this element a broadly rounded anterior margin can be recognized. Basal cavity extends to the tip. Cusp short and stout, tip proclined. Element triangular in lateral view. Cross-section of the base subtriangular in outline.

Discussion. Differentiation of the element types is not always simple, owing to the existence of intermediate forms between (and within) P and S morphotypes. The main differences between the two P elements are in the curvature of the cusp, which in the Pb element is always proclined and frequently twisted laterally. The Sa element differs from the two P elements in always being symmetrical. The numbers of each element on the collection are as follows: 27 Pa, 12 Pb, 13 Sa, 21 Sb, 24 Sc and 5 M.

Hammannodus sarae elements differ from those of *Hammannodus juliae* sp. nov. in displaying a less well-developed base that is shorter and more expanded basally; furthermore, all elements of the apparatus are stout.

Distribution. Tremadocian (Early Ordovician) of the southern Montagne Noire and possibly of the East Baltic area (Viira 1974).

Hammannodus juliae sp. nov.
Plate 2, Text-figures 5–6

1992 *Coelocerodontus* sp.; Küppers and Pohler (*pars*), p. 490, figs 4.4*b*, 5.6, 5.11.
? 2003 *Coelocerodontus*? sp.; Pyle and Barnes, fig. 13.26.
? 2005*b* *Coelocerodontus* sp.; Zeballo, Albanesi and Ortega, pp. 50, 52, fig. 4A–H.

Derivation of name. After Giulia, granddaughter of one of us (ES).

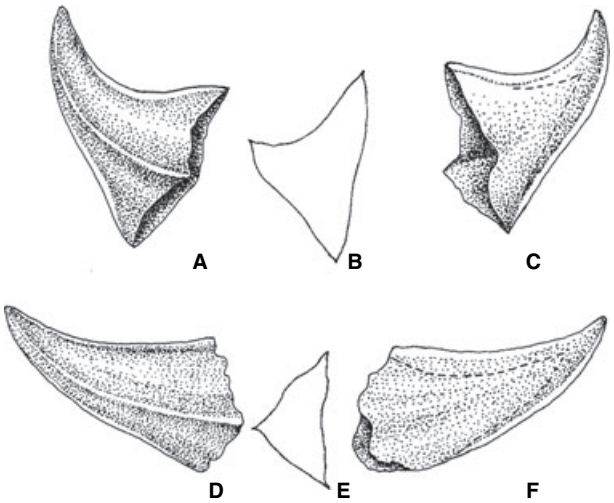
Holotype. Specimen IPUM 27952, Dipartimento del Museo di Palaeobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia, Modena (Italy); Plate 2, figure 6.

Type locality and horizon. As for *Hammannodus sarae* sp. nov.

Diagnosis. A species of *Hammannodus* with elements characterized by a long, posteriorly extended base.

Description

Pa element (Text-figs 5–6; Pl. 2, figs 1–5). Triangular, asymmetrical pyramidal-coniform element with a long base posteriorly extended and three sharp edges tapering rapidly to the tip. The three main costae originate from the cusp and are located in anterior, lateral and posterior positions. The element therefore has a broadly rounded outer side with a sharp lateral costa usually medial in position, and a flat to slightly convex inner side. Faint supplementary costae have been noted on the outer side between the posterior and lateral costae, as well as longitudinal constrictions producing carinae. Basal cavity extends to the tip. Cusp short and stout, tip suberect but most frequently proclined at various degrees. In most specimens there is no distinct differentiation between base and cusp. Element profile triangular (more or less isosceles) in lateral view. Cross-section of the base triangular in outline.



TEXT-FIG. 5. Camera lucida drawings of A, C–D, F, lateral views, and B, E, profiles of the basal cavity in the Pa element of *Hammannodus sarae* (IPUM 27930) and *Hammannodus juliae* (IPUM 27948), respectively; all × 95.

Pb element (Text-fig. 6; Pl. 2, fig. 6). Triangular, asymmetrical pyramidal-coniform, robust element with a long, posteriorly extended base and three sharp edges tapering rapidly to the tip. The three main costae originate from the cusp and are located in anterior, lateral and posterior positions. The element therefore has a broadly rounded outer side with a sharp lateral costa usually medial in position, and a flat to slightly convex inner side. Longitudinal constrictions may occur on the outer side between the posterior and lateral costae producing carinae and secondary costae towards the lower side. Basal cavity extends to the tip. Cusp short and stout, tip blunt and mostly proclined at varying degrees. The apical part of the tip curves away from the plane of the element, slightly twisting laterally. Element profile triangular (more or less isosceles) in lateral view. Cross-section of the base triangular in outline.

The main differences from Pa element are in the stouter cusp, which is always proclined and frequently twisted laterally.

Sa element (Text-fig. 6; Pl. 2, figs 10–12). Triangular, symmetrical pyramidal-coniform element with a long, posteriorly extended base and three sharp edges tapering rapidly to the tip.

The three main costae originate from the cusp with two in anterolateral positions and one in a posterior position. The element has, therefore, an evenly convex, narrow anterior face and two planar posterolateral faces that are gently convex at the base. Basal cavity extends to the tip. Cusp short and stout, tip erect or proclined. Element triangular in lateral view. Cross-section of the base triangular in outline.

The Sa element differs from P elements in always being symmetrical.

Sb element (Text-fig. 6; Pl. 2, figs 13–16). Triangular, almost subsymmetrical coniform element with a long, narrow base and three costate sharp edges tapering rapidly to the tip. Two of the three main costae are lateral in position and posteriorly placed, whereas the third is anterior. In this element therefore, the posterior face is acostate and gently convex and the two anterolateral faces are gently convex or planar. Some elements widen basally in the posterior half. Basal cavity extends to the tip. Cusp short, tip strongly proclined with no distinct differentiation between base and cusp. Some specimens appear laterally compressed. The cross-section of the base is essentially triangular in outline with the upper side of the triangle arched and the main apex in the lower position.

Sc element (Text-fig. 6; Pl. 2, figs 17–20). Triangular, subsymmetrical coniform element with a long, narrow base and three costate sharp edges tapering rapidly to the tip. Two of the three main costae are lateral in position and placed posteriorly, whereas the third is anterior. In this element therefore, the posterior face is acostate and planar or gently convex and the two anterolateral faces are gently convex. The element widens inferiorly in the posterior half so that in lateral view the anterior margin shows a broad sigmoidal outline. Basal cavity extends to the tip. Cusp short and stout, tip strongly proclined. In most specimens there is no distinct differentiation between base and cusp. Secondary costae have been noted on the anterolateral faces of some elements. Some elements appear to be dorsoventrally compressed. The cross-section of the base varies from semicircular to triangular in outline with the main 'apex' of the triangle very rounded and in a lower position. Fine longitudinal striations may occur on the lateral faces.

M element (Text-fig. 6; Pl. 2, figs 7–9). Triangular, subsymmetrical pyramidal-coniform element with a long, posteriorly extended base and two sharp edges that taper rapidly to the tip. One of the two main costae runs along the posterior margin whereas the other is placed anterolaterally. The inner side, bordered by the two main costae, is almost flat, whereas the outer side bears anteriorly a longitudinal wide carina. Therefore, in such elements a broadly rounded anterior margin can be recognized. Basal cavity extends to the tip. Cusp short and stout, tip proclined. Element triangular in lateral view. Cross-section of the base subtriangular in outline, but with rounded anterior and outer margins.

Discussion. All elements of this species are more extended posteriorly than those of *H. sarae* and some, such as the Sb and Sc elements, are definitely slighter and more delicate. Pa, Pb and Sa elements of *H. juliae* are very similar to S elements of *Kallidontus princeps* Pyle and Barnes, 2002, which, however, bear a longer cusp. A few Sa elements are transitional to *H. sarae* (Pl. 2, fig. 11).

The main differences between the two P elements of *H. juliae* must be sought in the cusp, which appears, in the Pb element, stouter, always proclined, and also frequently twisted laterally. The Sa element differs from the two P elements in always being symmetrical. The numbers of each element in the collection are as follows: 20 Pa, 16 Pb, 17 Sa, 22 Sb, 15 Sc and 6 M.

Distribution. Tremadocian (Early Ordovician) of the southern Montagne Noire and possibly of the Cordillera Argentina (Zeballo *et al.* 2005*a*, *b*). A more doubtful record is from the Ordovician of British Columbia (Canada) (Pyle and Barnes 2003).

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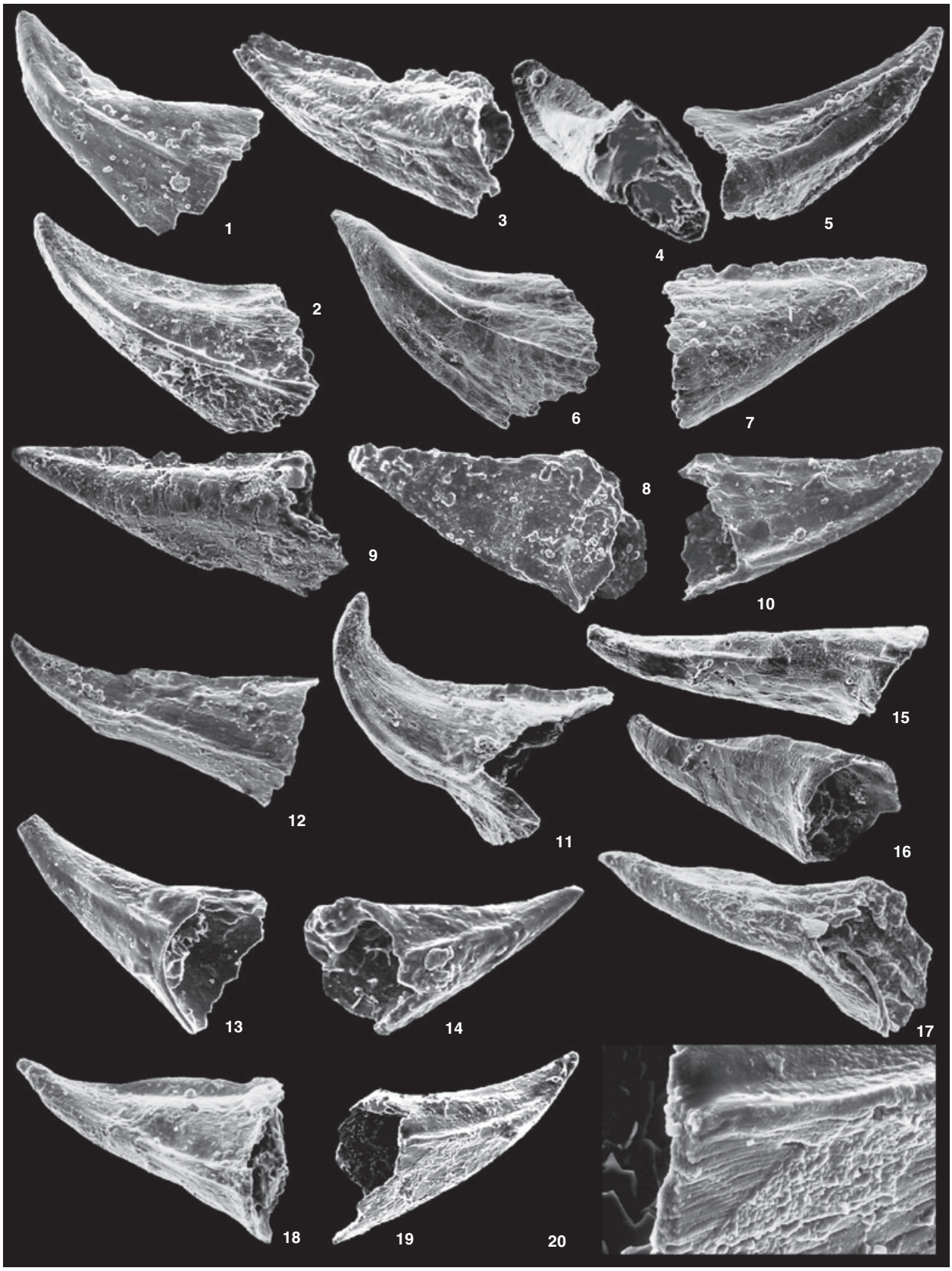
EXPLANATION OF PLATE 2

Figs 1–20. *Hammannodus juliae* gen. et sp. nov., holotype and paratypes. Specimens from the *P. deltifer deltifer* Subzone, Saint Chinian Formation, Early Ordovician, La Regagnade Valley (St. Martial), Montagne Noire, France. 1–2, IPUM 27947–27948; Pa elements, lateral views; × 135 and ×150, respectively. 3, IPUM 27949; Pa element, posterolateral view; × 190. 4, IPUM 27950; Pa element, posterior view; × 175. 5, IPUM 27951; Pa element, lateral view; × 145. 6, IPUM 27952; Pb element, holotype, lateral view; × 100. 7–9, IPUM 27953–27955; M elements, lateral views; × 150, × 125 and ×180, respectively. 10–12, IPUM 27956–27958; Sa elements, lateral views; × 130, × 160 and ×170, respectively. The element in 11 is possibly transitional to *H. sarae*. 13–14, IPUM 27959–27960; Sb elements, lateral views; × 170 and ×210, respectively. 15–16, IPUM 27961; Sb element. 15, lateral, and 16, posterolateral views; both × 160. 17–18. IPUM 27962–27963; Sc elements, posterolateral views; × 160 and ×170, respectively. 19–20, IPUM 27964; Sc element. 19, lateral view; 20, detail of fine striations; × 170 and ×710, respectively.



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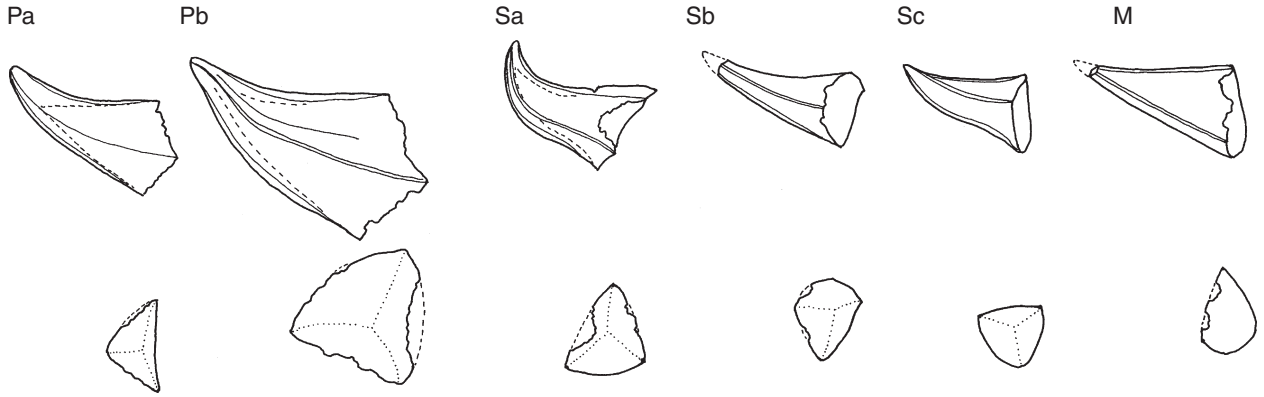

TEXT-FIG. 6. Camera lucida drawings of *Hammannodus juliae*; all × 65.

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