MOULLADELLA JOURDANENSIS (FOURY & MOULLADE, 1966) N. GEN., N. COMB.: VALANGINIAN-EARLY LATE BARREMIAN LARGER BENTHIC FORAMINIFERA FROM THE NORTHERN NEOTETHYAN MARGIN

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This work is dedicated to the memory of Bernard Clavel who recently passed away

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Abstract Since decades the taxonomic status of the "orbitoliniform" larger benthic foraminifer *Paracoskinolina*? *jourdanensis* (Foury & Moullade) described from the Barremian of France is ambiguous. Based on material mainly from the Valanginian and Barremian of Romania and the Valanginian of Serbia, it is taxonomically revised. It is here redescribed as *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. (synonym *Conicopfenderina*? *balkanica* Peybernès, 2004, Valanginian of Bulgaria) removed from the Orbitolinidae and assigned to the Pfenderinidae. *M. jourdanensis* is palaeobiogeographically restricted to a stripe along the northern Neotethyan margin, with occurrences stretching from the Spanish Pyrenees to Bulgaria.

Keywords: Foraminiferida, taxonomy, biostratigraphy, palaeobiogeography, Lower Cretaceous

INTRODUCTION

The lower Cretaceous shallow-water carbonates ("Urgonian") of southern France are a classical area for the study of orbitolinids (e.g., Moullade, 1962; Schroeder et al., 1967; Foury, 1968; Masse, 1976; Arnaud-Vanneau, 1980; Clavel et al., 2010; Clavel in Granier et al., 2013). From Barremian carbonates of the "vallon de Jourdan", Alpilles area (Bouches-du-Rhône), Foury and Moullade (1966) described the new species *Meyendorffina* (*Paracoskinolina*) *jourdanensis*. Pretty soon, the subgeneric status of this taxon was eliminated. Since decades it has repeated been recorded as *Paracoskinolina*? *jourdanenis* Foury & Moullade (see synonymy). Although, its generic status was questioned by several workers, it has so far not been revised systematically. For example, Arnaud-Vanneau (1980, p. 701–702) treated the taxon as "genre indéterminés d' Orbitolinidae" that might belong to a new genus of the family. Becker (1999, p. 427) also considered the belonging of the species to *Paracoskinolina* as doubtful and the creation of a new genus as conceivable. Peybernès (2004) described a new taxon as *Conicopfenderina*? *balkanica* from the Valanginian of Bulgaria. This species is here treated a junior synonym of *P*.? *jourdanensis.* The test structure, however, excludes its belonging to *Conicopfenderina* Septfontaine.

Based on new material from the Valanginian of Serbia and the Valanginian and Barremian of Romania, the species in question is taxonomically revised. It is here described as *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb., removed from the Orbitolinidae and assigned to the Pfenderinidae.

STUDIED SECTIONS

The samples containing the study specimens of foraminifera are coming from Romania and Serbia. Two additional illustrated specimens are from Austria (see Schlagintweit, 1991, for further details).

Romania

The Romanian samples come mainly from two different zones (Fig 1A): The Reşiţa-Moldova Nouă zone (southwestern part of the Southern Carpathians) (Fig. 1A1-1), and the Dâmbovicioara zone (eastern part of the Southern Carpathians) (Fig. 1A1-2). One single illustrated specimen is coming from the Pădurea Craiului massif (Apuseni Mountains).

Reşita – Moldova Nouă Zone

The Reşita – Moldova Nouă Zone is situated in the southwestern part of the Southern Carpathians (Fig. 1A1-1) and is part of the Getic domain or Getic Nappe (Săndulescu, 1984). The sedimentary deposits of this zone consist of upper Paleozoic (Carboniferous and Permian) and Mesozoic (Jurassic-Lower Cretaceous) (Bucur, 1997) formations. The Lower Cretaceous deposits are represented by calpionellid-bearing limestones and marls (Marila and Crivina formations, upper Tithonian-lower Valanginian), slope limestones (Valea Lindinei Member, lower part of the Plopa Formation, Upper Valanginian-Hauterivian), carbonate platform limestones (Valea Nerei Member, upper part of the Plopa Formation, lower Barremian), carbonate platform limestones with marl intercalations (Valea Minişului Formation, Upper Barremian-Middle Aptian), and glauconitic sandstone and shales (Valea Golumbului Formation, uppermost Aptian-Albian (Bucur, 1997; Fig. 1A2). *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. was found in samples collected from several sections belonging to the Valea Nerei Member of the Plopa Formation (Lower Barremian). Microfossils associated with *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. include:

- benthic foraminifera: *Banatia aninensis* Schlagintweit & Bucur, *Paracoskinolina* cf. *maynci* (Chevalier), *Paracoskinolina* cf. *sunnilandensis* Maync, *Mayncina*

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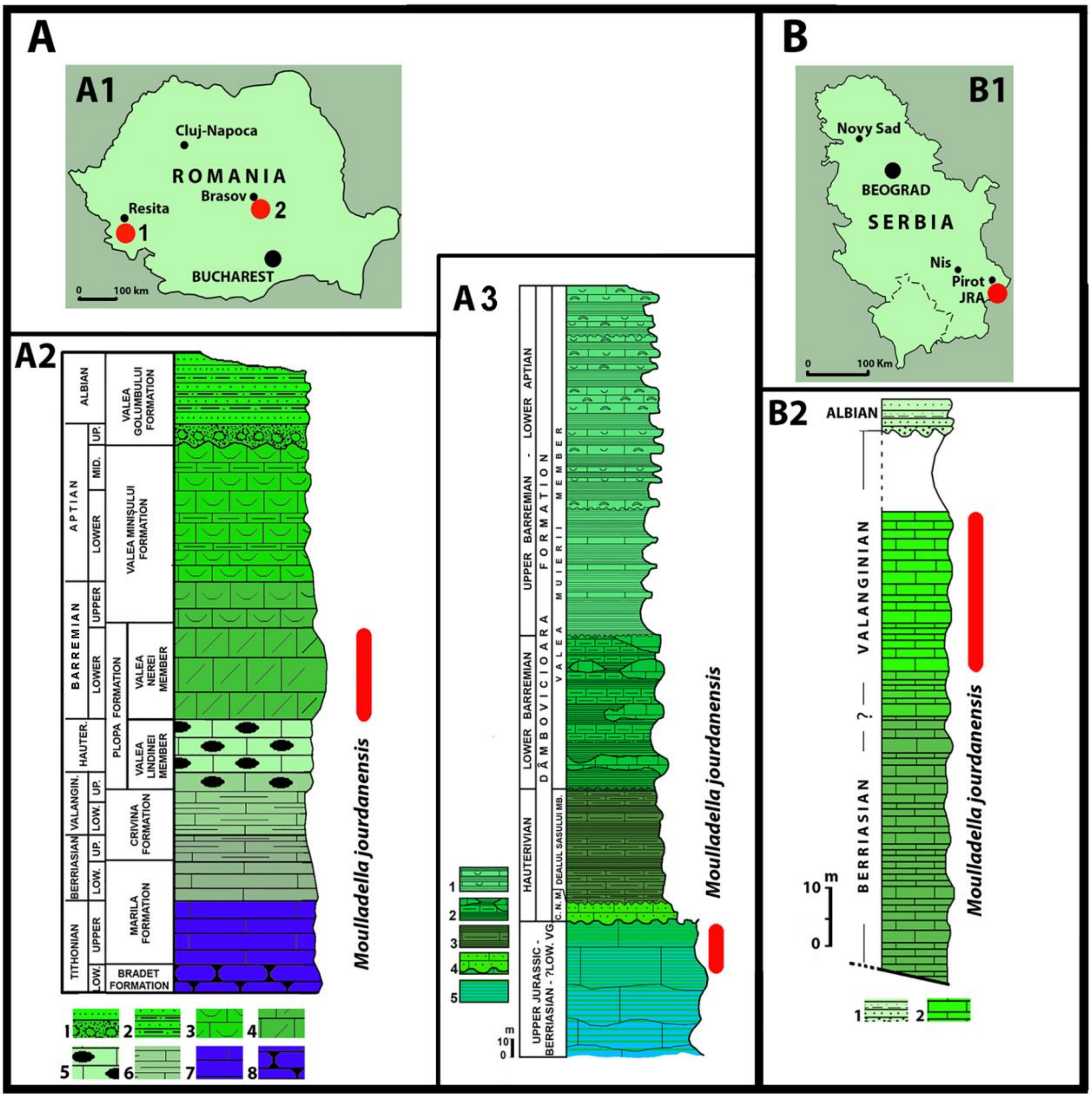

Fig. 1 Location of the studied sections on the Romanian **(A)** and Serbian **(B)** territory showing the occurrence intervals (red lines) of *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. **A1** – location of the two studied sections in Romania; 1, Reşiţa-Moldova Nouă zone; 2, Dâmbovicioara zone, **A2** – Succession of the Lower Cretaceous deposits from the Reşiţa-Moldova Nouă zone (modified from Bucur, 1997): 1, conglomerates and sandstones; 2, alternating sandstones and shales; 3, bedded bioclastic limestones; 4, massive bioclastic limestones; 5, chert-bearing limestones; 6, marly-limestones and marls; 7, micritic limestones; 8, micritic limestones with chert intercalations. **A3** – Succession of the Lower Cretaceous deposits from Dâmbovicioara zone (modified from Bucur et al., 2011): 1, alternating marls and limestones; 2, marls with patch-reef limestone intercalations; 3, marly-limestones and marls; 4, glauconite-bearing limestones; 5, bedded limestones; CNM = Cetatea Neamţului Member. **B1** – Location of the studied section in Serbia. JRA = Jerma River Area. **B2** – Succession of the Lower Cretaceous deposits from the Jerma River Canyon (modified from Bucur et al., 1995): 1, conglomerates, sandstones and shales; 2, bedded limestones.

bulgarica Laug, Peybernès & Rey, *Charentia cuvillieri* Neumann, *Ammobaculites* sp., *Nautiloculina cretacea* Peybernès, *Pseudolituonella gavonensis* Foury, *Pfenderina globosa* Foury, *Scythiolina camposaurii* (Sartoni & Crescenti);

- calcareous algae: *Clypeina* cf. *solkani* Conrad & Radoičić, *Cylindroporella*? *elliptica* Bakalova, *Falsolikanella danilovae* (Radoičić), *Salpingoporella muehlbergii* (Lorenz), *Salpingoporella patruliusi* Bucur, *Similiclypeina conradi* Bucur.

Dâmbovicioara area

The Mesozoic deposits from the Dâmbovicioara area (Fig 1A3) consist of (Patrulius 1969, Patrulius & Avram 1976, Lazăr et al., 2017): (1) a terrigenous-carbonate succession of Middle Jurassic (Bajocian-early Callovian) age; (2) upper Callovian – Oxfordian red limestones and radiolarites; (3) Kimmeridgian-lowermost Valanginian carbonate-platform limestones, over 1000 m thick in some areas (e.g. Piatra Craiului, Bucur, 1978; Mircescu et al. 2016); (4) a succession of marls with limestone intercala-

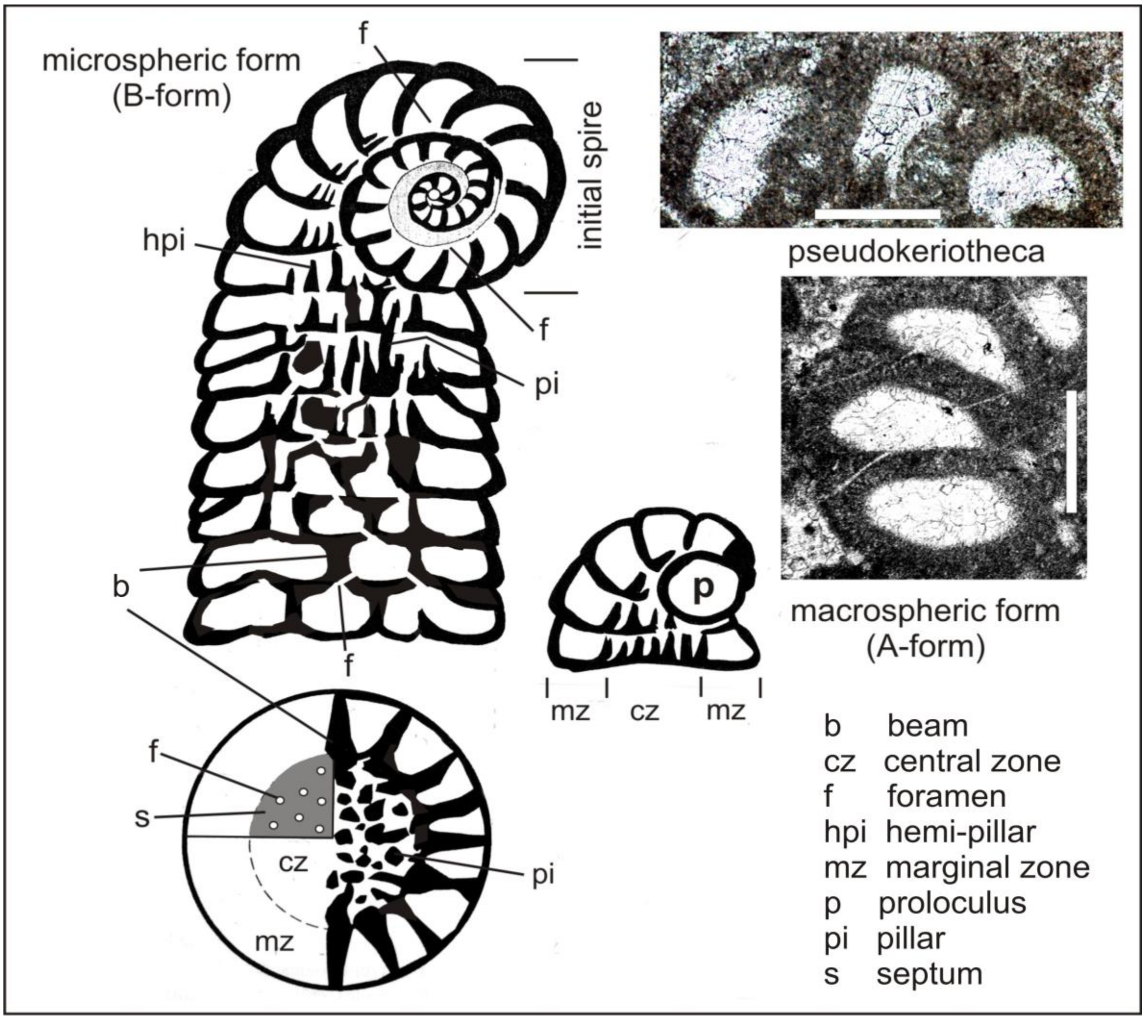

Fig. 2 Schematic test reconstruction of *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb. modified from Peybernès (2004, fig. 3, for *Conicopfenderina*? *balkanica*). Pseudo-kerioteka refers to the thin section 14731 Jerma river, Serbia (above), and RR4027 Kurilovo, Serbia (scale bar = 0.2 mm).

tions (Dâmbovicioara Formation, Patrulius and Avram, 1976, 2015) of latest Valanginian-early Aptian age. An important drowning unconformity separates the upper Jurassic-lowermost Valanginian platform carbonates, including the Cheile Dâmbovicioarei Formation at their upper part, from Cetatea Neamţului Member (lower part of the Dâmbovicioara Formation) (Grădinaru et al., 2016). The specimens of *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. have been found in samples from the Cheile Dâmbovicioarei Formation of Berriasian-lowermost Valanginian age (Patrulius and Avram, 2015; Săsăran et al., 2017). Microfossils associated with *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. include:

- benthic foraminifera: *Paracoskinolina* sp., *Paracoskinolina pfenderae* Canerot & Moullade, *Coscinophragma* sp., *Everticyclammina* sp., *Pseudocyclammina lituus* (Yokoyama), *Gaudryina* cf. *ectypa* Arnaud-Vanneau, *Ammobaculites* sp., *Bulbobaculites felixi* Pleş, Bucur & Săsăran, *Haghimashella* sp., *Siphovalvulina variabilis* Septfontaine, *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, *Mayncina* sp., *Charentia cuvillieri* Neumann, *Freixialina planispiralis* Ramalho, *Nautiloculina broennimanni* Arnaud-Vanneau & Peybernès, *Spiraloconulus suprajurassicus* Schlagintweit *Pfenderina neocomiensis* (Pfender), *Scythiolina* sp., *Vercorsella* sp., *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti), *Meandrospira favrei* (Charollais, Brönnimann & Zaninetti), *Danubiella cernavodensis* Neagu, *Danubiella gracilima* Neagu, *Spiroloculina* sp., *Troglotella incrustans* Wernli & Fookes, *Neotrocholina* sp., *Coscinoconus campanellus* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus cherchiae* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus delphinensis* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus molestus* (Gorbatchik), *Coscinoconus* cf. *perconigi* (Neagu), *Coscinoconus sagittarius* (Arnaud-Vanneau, Boisseau & Darsac), *Protopeneroplis ultragranulata* (Gorbatchik), *Mohlerina basiliensis* (Mohler), and
- calcareous algae: *Pseudocymopolia jurassica* (Dragastan), *Salpingoporella praturloni* (Dragastan), *Pseudotrinocladus piae* (Dragastan).

Serbia

Jerma River Canyon

The Serbian samples were collected from a profile in the Jerma River Canyon (Fig.1B). The canyon lies about 70 Km south-east of Niš city, and the carbonate deposits of

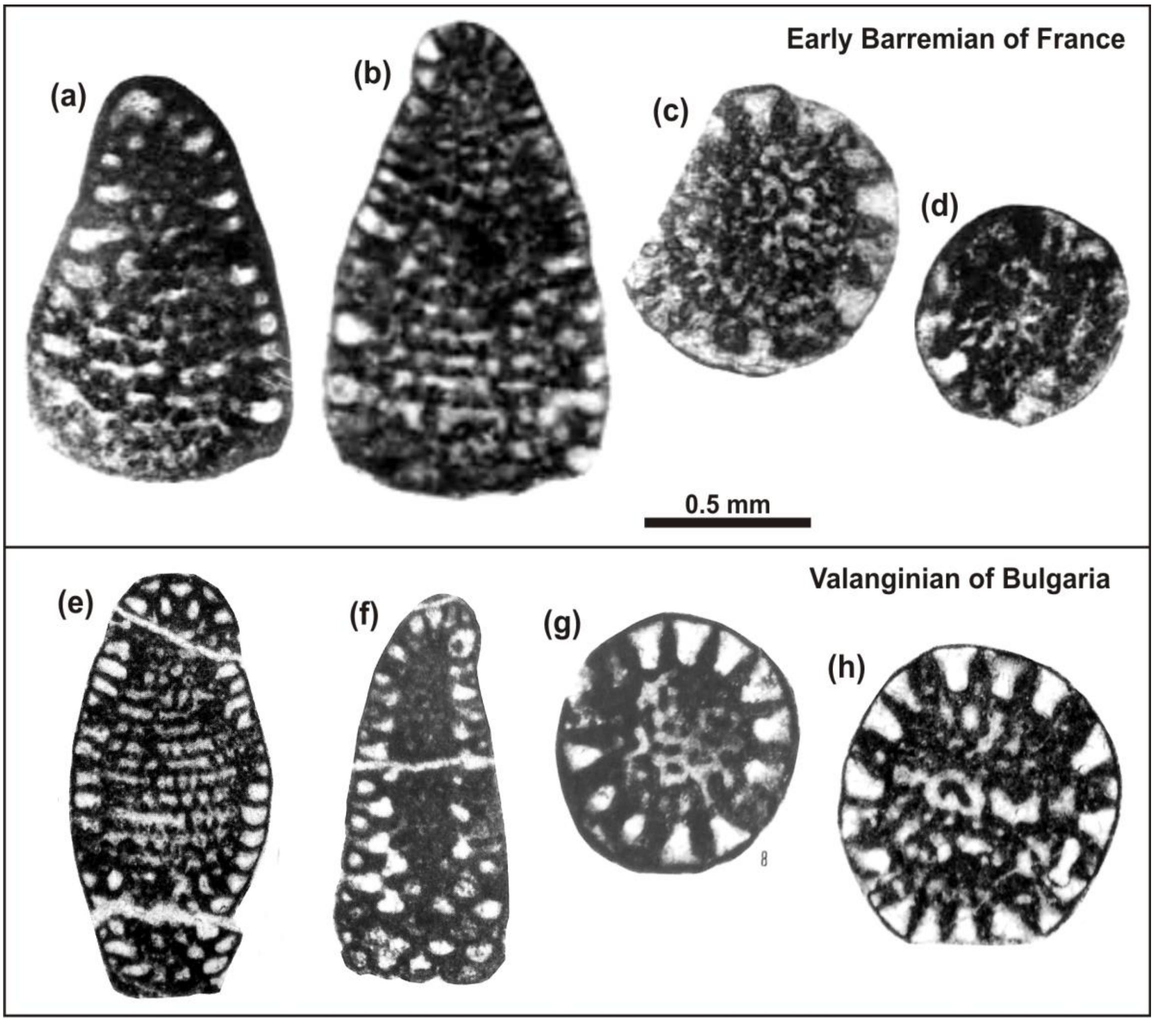

Fig. 3 *Paracoskinolina* (*Meyendorffina*) *jourdanensis* Foury & Moullade, Barremian of France **(a–d)**; holotype specimen in **(a)** (from Foury and Moullade, 1966, pl. 1, figs. 2–3, 5–6). **e–h** *Conicopfenderina*? *balkanica* Peybernès, Valanginian of Bulgaria; holotype specimen in **(f)** (from Peybernès, 2004, pl. 1, figs. 7, 1, 8–9).

the area belong to the Carpatho-Balkanides. This area represents the southern continuation of the Getic Domain (Southern Carpathians) (Grubič, 1974). The Berriasian-Valanginian age of the limestones from the Jerma River Canyon was established by Bucur et al. (1995) based on calcareous algae and benthic foraminifera assemblage including *Paracoskinolina*? *jourdanensis* Foury & Moullade. The limestones from the Jerma River area consist of shallow-water deposits. They are unconformably overlain by Albian?-Cenomanian terrigenous sediments, followed by Turonian-Senonian deep-water argillaceous limestones (Fig. 1B2).

Microfossils associated with *Moulladella jourdanensis* (Foury & Moullade) n. gen., nov. comb. include:

- benthic foraminifera: *Paracoskinolina* sp., *Everticyclammina* sp., *Pseudocyclammina lituus* (Yokoyama), *Charentia cuvillieri* Neumann, *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti), *Scythiolina* sp., *Pfenderina neocomiensis* (Pfender), *Danubiella gracilima* Neagu, *Derventina* sp., *Coscinoconus cherchiae* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus delphinensis* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus campanellus* (Arnaud-Vanneau, Boisseau & Darsac), *Coscinoconus chouberti* (Hottinger), *Lenticulina* sp., and
- calcareous algae: *Carpathocodium anae* (Dragastan), *Salpingoporella praturloni* (Dragastan), *Pseudocymopolia jurassica* (Dragastan).

Kurilovo anticline

Like the Jerma River Canyon, the carbonate deposits of the Kurilovo anticline lying north of Niš city, also belong to the Carpatho-Balkanides or Geticum. One specimen coming from this area is illustrated in the present paper. For further details on the geological setting of the section see Polavder (2014).

MATERIAL AND METHODS

The specimens illustrated in this paper from Romania and Serbia comprise 32 thin-sections. They are hosted by the Paleontology Museum, Department of Geology of the Babeş-Bolyai University, Cluj-Napoca, under the official depository numbers 24091 to 24113 (Dâmbovicioara zone, Romania), 24114 to 24117A (Reşiţa Zone, Romania) and 24118-24122 (Jerma River canyon, Serbia).

SYSTEMATIC PALAEONTOLOGY

The high-rank classification follows Pawlowski et al. (2013). For the low-rank classification see Kaminski (2014).

Phylum Foraminiferida d' Orbigny, 1826
Class Globothalamea Pawlowski et al., 2013
Order Loftusiida Kaminski and Mikhalevich, 2004
Suborder Orbitolinina Kaminski, 2004
Superfamily Pfenderinoidea Smout and Sugden, 1962
Family Pfenderinidae Smout and Sugden, 1962
Subfamily Paleopfenderininae Septfontaine, 1988

Remarks: The subfamily Paleopfenderininae was introduced by Septfontaine (1988, p. 245) for pfenderinids with trochospiral test, adult chambers may be uncoiled, wall with pseudo-keriotheca, endoskeletal pillars with calcitic-infilling in inter-pillars cavities giving the appearance of a columella (= secondarily infilled alveolar shell material, Loeblich and Tappan, 1988, p. 151). The Paleopfenderininae include seven genera all of Middle Jurassic age (Septfontaine, 1988; Kaminski 2014). The lower Cretaceous *Moulladella* n. gen., the youngest representative of the subfamily, can be considered an advanced paleopfenderinid where the curved septa of the spiral stage give rise to the broad and distally broadening radial partitions (exoskeletal beams) of the marginal zone.

Genus ***Moulladella*** n. gen.

Type species: *Meyendorffina* (*Paracoskinolina*) *jourdanensis* Foury & Moullade, 1966

Derivation of the name: The name is dedicated to Michel Moullade for his numerous contributions to Lower Cretaceous benthic foraminifera (orbitolinids and others).

Diagnosis: High conical test, dimorphic, with spiral chamber arrangement in the early stage, later becoming uniserial. The early growth stage of the megalospheric specimen consists of an eccentric embryo (biconch?) followed by a small, slightly inclined trochospire with few chambers. Microspheric specimen with voluminous early trochospire with up to two and a half whorls and numerous chambers. The spire may be strongly inclined, eccentric, and almost perpendicular to the cone axis. The septa of the spiral stage, connected by single basal foramina, give rise to the exoskeleton of the marginal zone in the uncoiled part. The exoskeleton consists of few radial partitions (beams) broadening distally and alternating from one chamber to the next. In tangential sections the chamberlets have a triangular-rounded shape and display a cross-wise foraminal system arranged in diagonal lines. The endoskeleton of the central zone consists of irregular distributed, variously shaped (mostly thin) pillars and hemi-pillars, thickened at their bases. They may anastomose forming a labyrinthic network and together with secondary infillings mask the inner structure giving rise to a columella. Irregular arranged foramina in the central zone between the endoskeletal elements, mostly straight. The chamber bases in the central zone are shifted downwards with respect to their marginal counterparts, resulting in a clear separation of both zones. Wall microgranular, and may display a pseudo-keriotheca.

Remarks and comparisons: Concerning the very detailed original description provided by Foury and Moullade (1966) we just remark upon the missing data on dimorphism, namely the prominent initial spire, and the occurrence of a pseudo-keriotheca (discernible only in some specimens). This incompleteness was obviously due to the available material at the disposal of the authors. Foury and Moullade (1966, p. 261) already noted features of their new taxon atypic for the orbitolinids accounting for their generic affiliation with some reservations. Among them, they stressed the clearly separated and complicated central zone (endoskeleton), the shape of the vertical partitions (exoskeletal beams) distinctly broadening distally, and the downward shift of the chamber bases in the central part with respect to the marginal zone.

A rather thick wall with pseudo-keriotheca is present in representatives of the Coskinolinidae Moullade (e.g., genus *Lituonella* Schlumberger) and Pfenderinidae Smout & Sugden (e.g., genus *Conicopfenderina* Septfontaine) but lacking in the thin-walled Orbitolinidae (e.g., Douglass, 1960; Hottinger and Drobne, 1980; Maync, 1972; Schroeder et al., 1975; Septfontaine, 1978; Peybernès, 2004; Vicedo et al., 2014). Except the type of exoskeleton *Paracoskinolina*? *jourdanensis* fits all characteristics of the genus *Conicopfenderina* Septfontaine 2000 (in Kaminski, 2000) non 1988. Without remarking any comparisons or the identity of his Valanginian specimens from Bulgaria with the ones described by Foury & Moullade (1966) from the Barremian of France, Peybernès (2004) described the new species *Conicopfenderina*? *balkanica* (Figs. 2, 3e–h). It is believed that *M. jourdanensis* is characterized by a high intraspecific variability referring to apical angle, size of the test and initial spire, as well as the structure of the central zone (secondary fillings, thickness/coarseness and distribution of endoskeletal elements). Such a variability can be seen within the same assemblage (samples) from both material studied from the Valanginian and Barremian of Romanian and Serbia. A compilation of the biometric data of "*P*." *jourdanensis* against "*C*." *balkanica* each taken from the original papers is presented in Table 1. The higher maximum number of chambers in the Valanginian specimens is related to a greater observed test height. Concerning the number of chambers per last mm of the test, Peybernès (2004) didn't provide data. Our measurements from original illustrations result in 14 to 18. The paratype shown by Foury and Moullade (1968, pl. 1, fig. 3), and re-illustrated here in Fig. 3b, displays 15 or 16 chambers per mm. In conclusions, there are overlapping ranges between the two taxa, or only minor differences. These are considered insufficient arguments enabling the creation of a second clear defined species of *Moulladella* for the Valanginian forms from Bulgaria. It is trivial to mention that two populations from two different stratigraphic and geographic occurrences might show different ecophenotypic variations. We also speculate that the Barremian type-material of "*P*." *jourdanensis* mostly consists of megalospheric specimens (with reduced initial spire) as can be deduced from the illustrations provided by Foury and Moullade (1968). The type-material of "*C*." *balkanica* includes both megalospheric (Peybernès, 2004, pl. 1,

Tabel 1 Biometric data of *Paracoskinolina*? *jourdanensis* (from Foury & Moullade 1968) against *Conicopfenderina*? *balkanica* (from Peybernès 2004).

	Paracoskinolina? *jourdanensis* Barreme France Foury & Moullade (1966)	*Conicopfenderina*? *balkanica* Valanginian Bulgaria Peybernès (2004)
Diameter test (D)	up to 1.175	up to 0.87, plate 1, fig. 9 in Peybernès
Height test (H)	0.95-1.45	up to 1.8
H/D	1.5-2	1.5-2
Number chambers uniserial part	12-16	up to 23
Number of chambers per mm	medium 12	14-18 measured from Peybernès

fig. 1, holotype) and microspheric forms (ibidem, pl. 1, fig. 4). Microspheric specimens with large initial spire are here also reported from the Barremian of Romania (Fig. 4g). For comparison purposes type-specimens of both "*P*." *jourdanensis* and "*C*." *balkanica* are displayed in Figure 3. Summarizing, *Conicopfenderina*? *balkanica* Peybernès, 2004 is therefore treated here as a junior synonym of *Paracoskinolina*? *jourdanensis* Foury & Moullade, 1966. The presence of an exoskeleton (= subdivided marginal zone) however excludes its belonging to the genus *Conicopfenderina* (see diagnosis of Septfontaine in Kaminski 2000, p. 215). It is worth mentioning that the presence/absence of architectural elements (here: exoskeleton) is generally considered a criteria of generic rank (e.g., Hottinger and Drobne, 1980; Vicedo et al., 2014). Apart from the presence of a marginal zone lacking an exoskeleton (= "undivided marginal ring" Maync, 1972, p. 262), the Lower Cretaceous *Moulladella* n. gen. shows striking similarities to the Middle Jurassic *Conicopfenderina mesojurassica* (Maync). Other genera that can be compared to the new genus include the Lower Cretaceous genera *Cantabriconus* Schlagintweit & Rosales, 2017 (Upper Aptian of Spain) and *Banatia* Schlagintweit & Bucur, 2017 (Upper Barremian of Romania). *Cantabriconus* differs from *Moulladella* n. gen. by its undivided marginal zone and the loose aspect of the endoskeleton with just a few and comparably thick pillars; hemi-pillars are also absent. *Banatia* differs from *Moulladella* n. gen. above all by its low to medium trochospiral test, marginally undivided chambers and a wide axial part. The latter is made up of pillars continuous between successive chambers and a labyrinthic endoskeleton (plates and pillars) and a fine canal system between.

Last but not least, *Moulladella* n. gen. differs from *Paracoskinolina* Moullade in several characteristics. *Paracoskinolina* belongs to the Orbitolinidae, subfamily Dictyorbitolininae, which includes genera displaying marginal foramina, and primary septules (beams) that are arranged along vertical lines from the apex to the base (Schroeder, in Schroeder et al., 1990, p. 196). The pillars are also aligned along the test and the simple embryonic apparatus of *Paracoskinolina* is located at the top of the test or within a slightly eccentric trochospire (Maync, 1955; Moullade, 1965; Arnaud-Vanneau 1980). Moreover the marginal zone is divided by vertical (beams) and sometimes also horizontal plates (rafters). Shallow tangential sections of *Moulladella* n. gen. can be mistaken with various sections of *Orbitolinopsis* Henson. These sections show alternating triangular-rounded chamberlets displaying a cross-wise foraminal system. *Orbitolinopsis* however differs by its embryo positioned at a slightly eccentric spire, a central zone with cupules, and a thin homogeneous wall (e.g., Arnaud-Vanneau, 1980; Clavel in Granier et al., 2013). Compared to the orbitolinids generally, the vertical radial partitions in the adult stage of *Moulladella* n. gen. are distinctly thicker. This is due to their development from septa of the spiral stage. In the same way the single basal foramina of the coiled stage were replaced by a system of oblique cross-wise stolon system in the adult uncoiled stage. Last but not least, the wall thickness in *Moulladella* n. gen. is greater than the orbitolinid epiderm (e.g., Douglass, 1960).

Moulladella jourdanensis (Foury & Moullade, 1966) nov. comb.
Figs. 2, 4–6

*1966 *Meyendorffina* (*Paracoskinolina*) *jourdanensis* n. sp. – Foury & Moullade, p. 249, pl. 1, figs. 1–6.
1976 "*Paracoskinolina*" *jourdanensis* Foury & Moullade – Masse, pl. 11, fig. 14.
1977 *Orbitolinopsis* aff. *kiliani* (Prever) – Bucur, p. 52, pl. 2, fig. 9.
1978 „*Valdanchella miliani*“ – Dragastan, pl. 8, figs. 6–10.
1978 *Orbitolinopsis capuensis* (De Castro) – Dragastan et al., pl. 6, fig. 2.
? 1979 *Pfenderina globosa* Foury – Cherchi, p. 627, pl. 2, fig. 11.
? 1980 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Arnaud-Vanneau, p. 702, pl. 102, figs. 1, 2-4 (?).
? 1982 *Orbitolinopsis buccifer* Arnaud-Vanneau & Thieuloy – Bucur et al., p., pl. 9, figs. 1, 3.
1982 "*Paracoskinolina*" *jourdanensis* Foury & Moullade – Schroeder et al., pl. 1, fig. 6.
? 1982 *Pfenderina globosa* Foury – Schroeder et al., p. 919–920, pl. 2, figs. 6, 8.
1988 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Bucur and Cociuba, p. 90, pl. 1, figs. 10–14, 18–19.
1991 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Schlagintweit, pl. 2, figs. 5, 7.
1993 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Bucur et al., p. 37, pl. 6, figs. 1, 2, 7.
1994 *Paracoskinolina*? *jourdanensis* – Bucur, p. 17, fig.A.

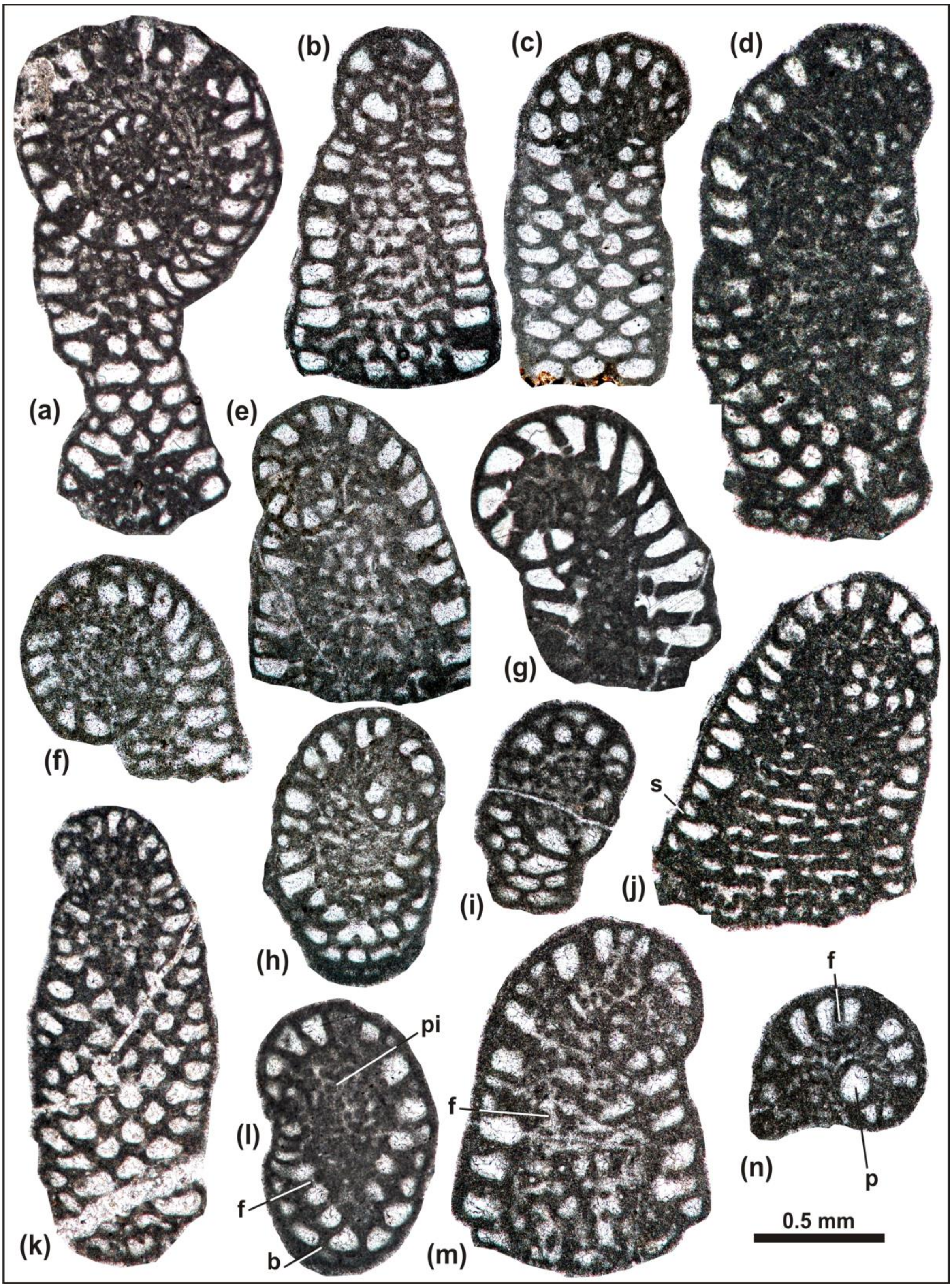

Fig. 4 *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb. **(a, g)** Tangential-oblique sections of microspheric specimens exhibiting voluminous initial spire. **(b)** Axial section of a macrospheric specimen. **(c, k)** Tangential sections showing alternating chamberlets of the marginal zone connected by oblique foramina. **(d)** Oblique-tangential section. **(e, j, m)** Axial sections. **(h, l)** Oblique sections**. (f, i)** Juvenile specimens in tangential sections. **(n)** Oblique section of the initial spire of a macrospheric specimen. b, beam; f, foramen; p, protoconch; pi, pillar, s, septum. Thin-sections: 14729 **(a)**, 12563-5 **(b)**, 14099-2 **(c)**, 12561-2 **(d, f)**, 12558A **(e)**, 42-Irimieş **(g)**, 12562-5 **(h)**, 12563-4 **(i)**, 12563-6 **(j)**, 14098-2 **(k)**, 12563 **(l)**, 12563-2 **(m)**, 12563-4 **(n)**. Location and age: **(a)** Jerma River Canyon, Eastern Serbia, Early Valanginian; **(b–f, h–n)** Dâmbovicioara area, Southern Carpathians, Romania (Early Valanginian); **(g)** Reşiţa-Moldova Nouă zone, Southern Carpathians, Romania (Early Barremian).

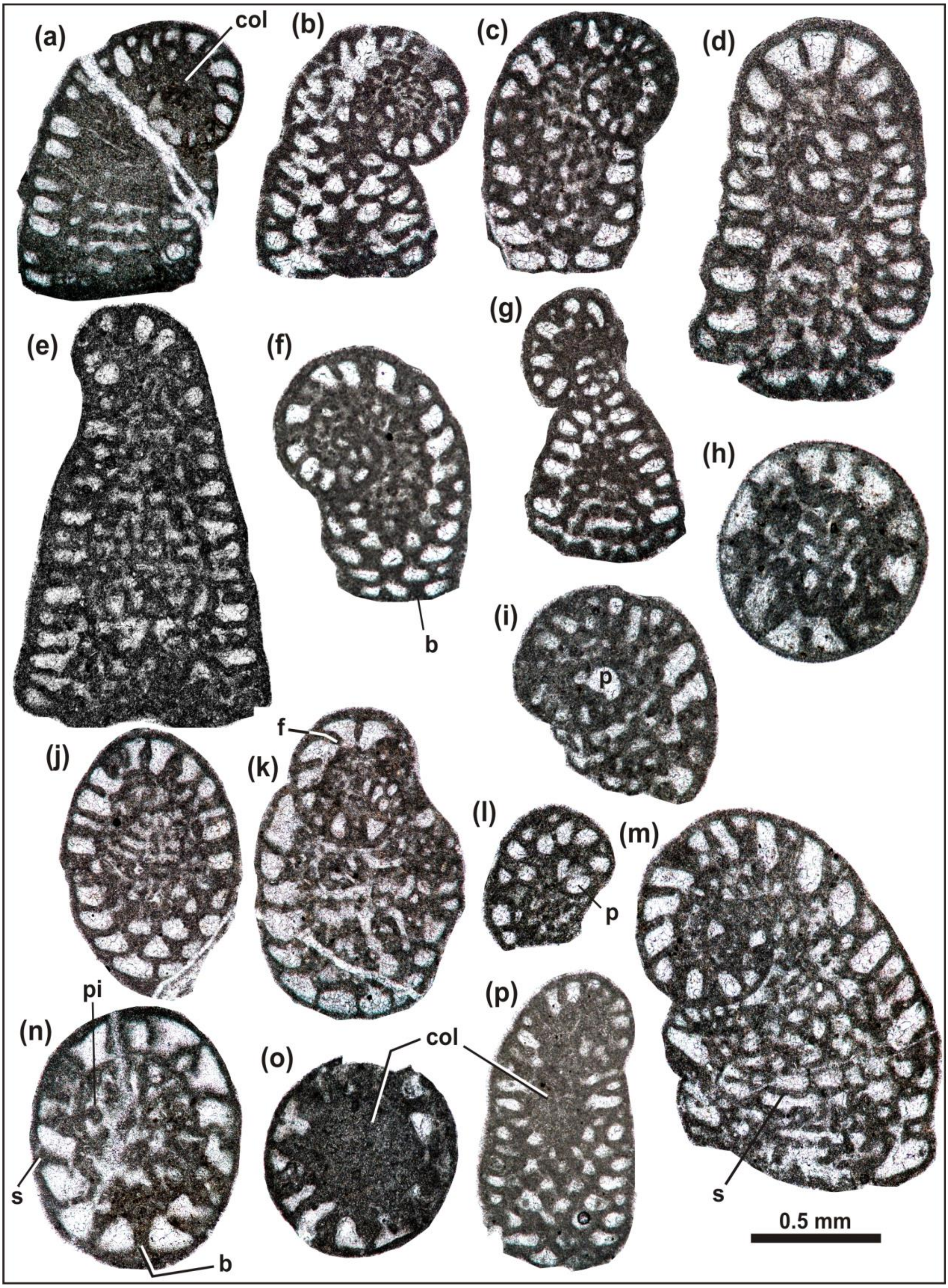

Fig. 5 (a–p) *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb.: **(a, e)** (sub)axial sections, note the densely filled central zone ("secondary deposits") in the upper part of **(a)**. **(b, p)** tangential sections. **(c–d, f–g, i–l, m)** oblique sections. **(h, n)** slightly oblique transverse sections. Note anastomizing pillars in **(h)**. **(o)** slightly oblique transverse section displaying densely filled central zone. b, beam; col, columella; f, foramen; p, protoconch; pi, pillar, s, septum. Thin-sections: 12562-5 **(a),** 12563-6 **(b),** 12564-1 **(c)**, 12563-3 (**d**), 3779-PdC (**e**), 12570 **(f)**, 12569-5 **(g)**, 13679 **(h)**, 14099 **(i),** 14095A **(j)**, 14098-2 **(k)**, 12563-6 **(l)**, 14097 **(m)**, 12562-6 **(n),** 14734 **(o),** 14099-2 **(p)**. Location and age: **(a-n, p)** Dâmbovicioara area, Southern Carpathians, Romania (Early Valanginian); **(e)** Pădurea Craiului, Apuseni Mountains, Romania (Early Barremian). **(o)** Jerma River Canyon, Estern Serbia (Early Valanginian).

1995 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Bucur et al., p. 358, pl. 7, figs. 1–6, 9.
1996 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Bucur and Cociuba, p. 40, pl. 2, figs. 4, 5.
1997 *Paracoskinolina? jourdanensis* (Foury & Moullade) – Bucur, p. 78, pl. 16, figs. 2–4.
1997 *Paracoskinolina*? *jourdanensis* – Hosu and Bucur, p. 90, pl. 3, figs. 9, 13–15, 17–19.
1999 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Becker, p. 426, pl. 23, figs. 10–12 (9 = cf.).
1999 *Meyendorffina jourdanensis* – Dragastan, p. 127, not figured.
2004 *Conicopfenderina*? *balkanica* n. sp. – Peybernès, p. 23, pl. 1, figs. 1–11.
2004 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Daoud et al., pl. 2, figs. 7–8.
2004 *Pfenderina neocomiensis* (Pfender) – Ivanova and Koleva-Rekalova, pl. 3, figs. 1–2.
2004 *Pfenderina trochoidea* Smout & Sugden – Ivanova and Koleva-Rekalova, pl. 3, figs. 5–7.
2004 *Paracoskinolina jourdanensis* Foury & Moullade – Ivanova and Koleva-Rekalova, pl. 4 figs. 1-3.
2004 *Paracoskinolina tunesiana* Peybernes – Ivanova and Koleva-Rekalova, pl. 4, figs. 4–6, non 7.
2005 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Polavder and Radulović, pl. 1, fig. 3, fig. 8 [figured as *Pfenderina globosa* (Foury)].
2007 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Clavel et al., pl. 4k–l.
2008 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Michetiuc et al., p. 220, pl. 3, fig. 3.
Non 2009 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Clavel et al., pl. 2, specimens illustrated in the first two rows above (without numbers).
2010 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Clavel et al., pl. 2 (two sections).
2012 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Michetiuc et al., p.35, fig. 4(10).
2013 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Granier et al., p. 153, pl. 4, figs. 6–7.
2014 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Polavder, pl. 6a–f.
2014 *Parakoscinolina*? *jourdanensis* (Foury & Moullade) – Bruchental et al., p. 34, fig. 3a.
2014 *Conicopfenderina*? *balkanica* Peybernes – Mircescu et al., p. 8, pl. 1, fig.7.
2015 *Paracoskinolina jourdanensis* – Pleş, p.59, Fig. 29G, H.
2016 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Grădinaru et al., p. 31, Fig. 14A
2016 *Paracoskinolina*? *jourdanensis* Foury & Moullade – Mircescu et al., p. 504, Fig. 6K, L.
2016 *Paracoskinolina*? *jourdanensis* – Pleş et al., p. 168, fig. 5G.
2017 *Paracoskinolina*? *jourdanensis* – Ungureanu et al., p. 30, Fig. 10c.
2017 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Săsăran et al., p. 40, figs. 18n, o.
2018 *Paracoskinolina*? *jourdanensis* (Foury & Moullade) – Bucur et al., pl. 3B.

Description: Specimens display mostly high, more rarely medium conical tests reaching a height of up to 2.0 mm and a diameter of up to 1.25 mm. The ratio between the diameter and height ranges from 0.5 to 1.2 (mostly 0.6 to 0.8). Chamber base convex in the juvenile stage becoming flatter during ontogeny. The inner part of the cone base (about 80 % of its total diameter) displays a slight convex bulge marking externally the transition from the marginal to central zones. The dimorphism of the species is restricted to the early spiral stages. The test of megalospheric specimens start with an ovoidal proloculus (diameter 0.08–0.2 mm) located eccentrically below the apex (Fig. 4p). The specimen illustrated in Figure 6a suggests the presence of a biconch (protoconch and hemispherical deuteroconch) separated by a thin septum. The embryo is followed by a trochospire (0.5–1 whorls) composed of about 5–15 chambers. By contrast, the test of microspheric specimens shows a more voluminous trochospire (up to 2.5 whorls and > 30 chambers) that usually is considerably inclined to the adult cone axis (Fig. 4a). A tiny microspheric proloculus has not been identified with certainty. The chambers of the trochospire are connected by a single basal foramen (Fig. 5k). The spiral stage is followed by series of up to 25 uniserial chambers. There are 13–14 chambers per 1 mm axial length in the adult part of the cone. The septa of the spiral stage, connected by single basal foramina, give rise to the exoskeleton of the marginal zone in the uncoiled adult part. The exoskeleton consists of few radial partitions (beams) broadening distally and alternating from one chamber to the next. In transverse sections there are about twenty beams in adult stages of 1.0 mm test diameter. In tangential sections the chamberlets of the marginal zone have a triangular-rounded shape and display a cross-wise foraminal system arranged in diagonal lines (Figs. 4k, 6i). The distally mostly widening beams may fuse with the irregular arranged pillars of the central zone. The endoskeleton of the central zone consists of irregular distributed, variously shaped (mostly thin) pillars and hemi-pillars, thickened at their bases. They may anastomose forming a labyrinthic network and together with secondary microcrystalline (micritic) fillings mask the inner structure giving rise to a columella. Then "*the structure...becomes indistinguishable*" (Clavel in Granier et al. 2013). Mostly the columella may be developed in the adult uncoiled part (Fig. 5o–p), but sometimes occurs in the initial coiled stage (Fig. 5a). Irregular arranged foramina in the central zone between the endoskeletal elements, mostly straight. The chamber bases in the central zone are shifted downwards with respect to their marginal counterparts, resulting in a clear separation of both zones. Chamber wall comparatively thick, microgranular-finely agglutinating and with pseudo-keriothecal texture. The rarely discernible, most likely unbranching canaliculi have a diameter of about 5 µm (see Fig. 3).

Remarks: Analyzing the dimensions, Foury and Moullade (1966) recognized two populations ("*hétérogénéité relative des dimensions d´une population*", p. 250), one with a more acute cone angle and larger dimensions, the other being smaller and exhibiting a wider cone angle. Foury and Moullade (1966) however communicated that they had no explication for this observation.

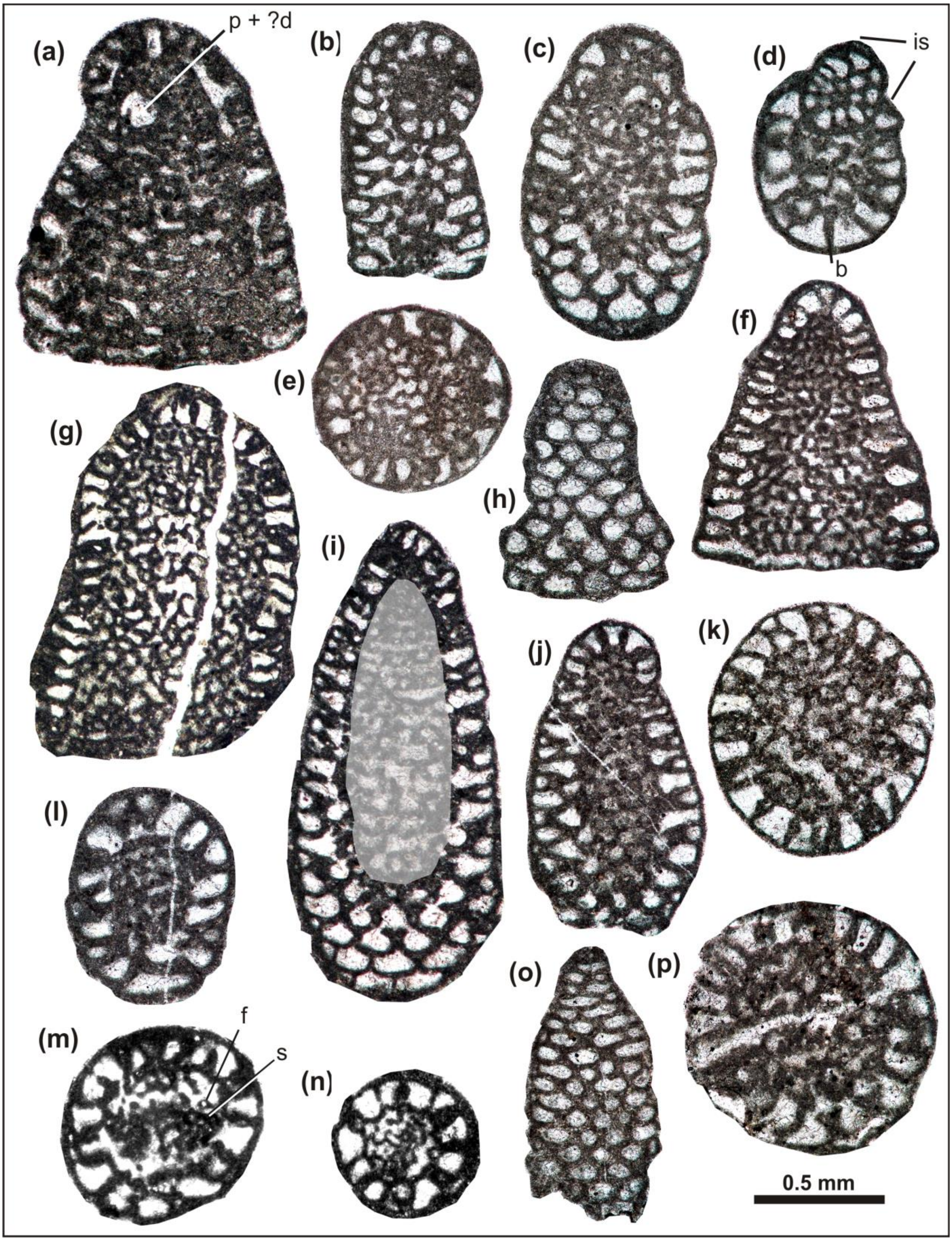

Fig. 6 *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb. **(a)** Axial section of a megalospheric specimen. **(b, f)** Subaxial sections. **(c–d, g, l)** Oblique sections. **(e, k, m–n, p)** Slightly oblique transverse sections. (**h, o)** Tangential sections. **(i–j)** Tangential-oblique sections. Central zone highlighted in grey. b, beam; d, ?deuteroconch; f, foramen; is, initial spire; p, proloculus; s, septum. Thin-sections: 14098-4 **(a, c)**, 12568-4 **(b)**, 12562-2 **(d)**, 9-Mandrisag **(e)**, 272-Ciclova **(f)**, 4222-Ilidia **(g)**, M10-Crivina **(h)**, 14729 **(i, l)**, 14734 **(j–k),** Lo 11 **(m–n)**, 14733 **(o)**. Location and age: **(a-d)** Dâmbovicioara area, Southern Carpathian, Romania (Early Valanginian); **(e-h)** Reşiţa-Moldova Nouă zone, Southern Carpathians, Romania (Early Barremian); **(i-l, o)** Jerma River Canyon, Eastern Serbia (Early Valanginian); **(m-n**) Losenstein, Northern Calcareous Alps, Austria (Early Barremian, cobbles in Albian-Cenomanian conglomerates).

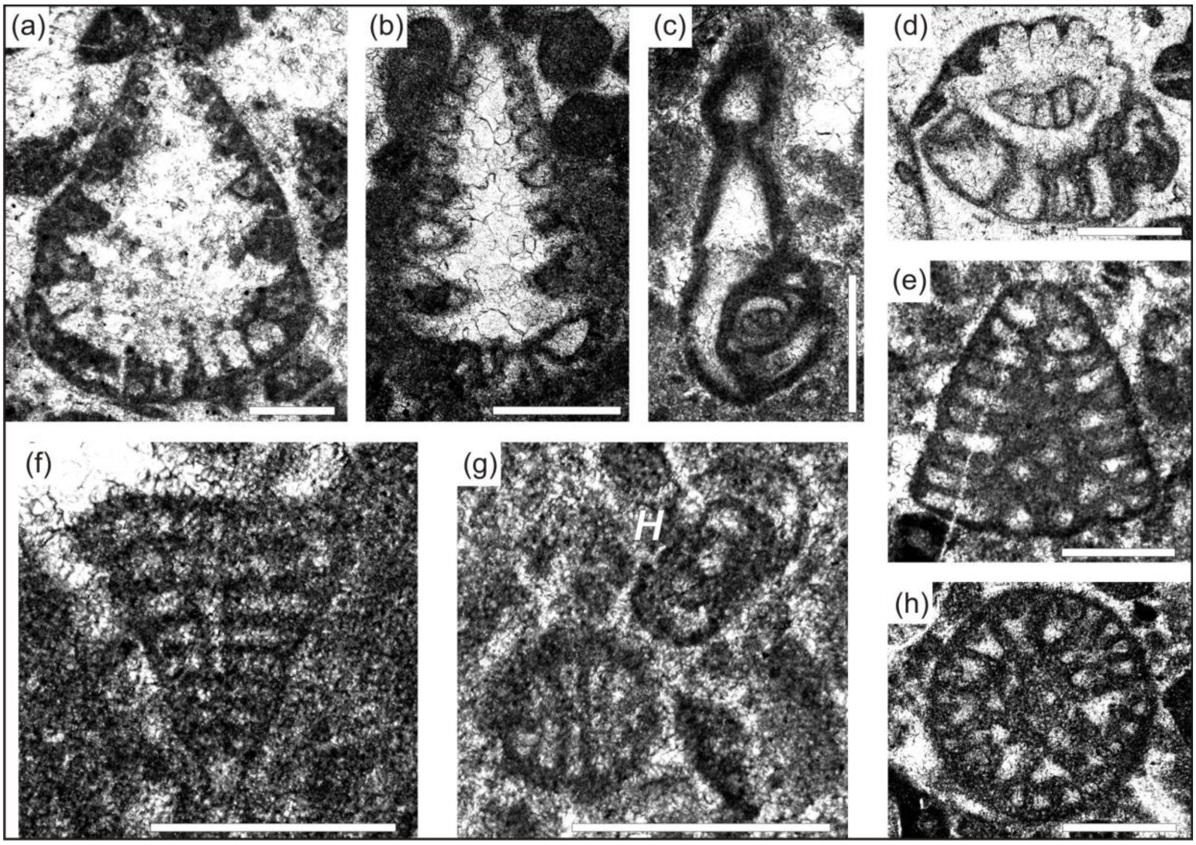

Fig. 7 Benthic foraminifera associated with *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb. from the Dâmbovicioara area, Romania. **(a)** *Coscinoconus campanellus* (Arnaud-Vanneau, Boisseau & Darsac), slightly oblique axial section. **(b)** *Coscinoconus cherchiae* (Arnaud-Vannaeu, Boisseau & Darsac), axial section. **(c)** *Danubiella gracillima* Neagu, subaxal section. **(d)** *Protopeneroplis ultragranulata* (Gorbatchik), oblique section. **(e, h)** *Paracoskinolina*? *pfenderae* Canerot & Moullade, axial and slightly oblique transverse sections. **(f, g)** *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti), slightly oblique axial section, and transverse section together with *Haplophragmoides joukowsky* Charollais, Brönnimann & Zaninetti (axial section) (*H*). Thin-sections: 14096 (**a**), 12562 **(b)**, 12569 **(c)**, 13697 **(d)**, 12568-2 **(e)**, 12563 **(f)**, 12564 **(g)** and 11867-6 **(h)**. Scale bars 0.3 mm.

A pronounced dimorphism was stressed by Peybernès (2004) in his description of *Conicopfenderina*? *balkanica* (= *Moulladella jourdanensis*), not directly related to dimensions but to the size of both the proloculus and the initial spire. In doing so, Peybernès distinguished megalospheric specimens with clearly discernible proloculus and a rather short initial spire and microspheric specimens with tiny (or not discernible) proloculus and a voluminous trochospire.

Comparisons: (Sub)axial sections of *M. jourdanensis*, not displaying the subdivision of the marginal zone, show some similarities with the Middle Jurassic *Conicorbitolina mesojurassica* (Maync) (e.g., Maync, 1972, plate 1). *C. mesojurassica* has larger test dimensions (D: up to 1.8 mm, H: up to 4.0 mm), the separation marginal to central zone is less marked, and the chambers of the uniserial part are saucer-shaped throughout.

Clavel et al. (2009) reported specimens of "*Paracoskinolina*? *jourdanensis*" from the early Barremian of southern France (see synonymy). This taxon is clearly different from *Moulladella jourdanensis* (Foury & Moullade) by its high number of beams (about 40) per 1 mm cone diameter (up to 25 in *M. jourdanensis*), distinctly thinner wall (lacking a pseudo-keriotheca?), and a much more delicate central zone. This form might represent a new taxon.

Stratigraphy: From the Spanish Pyrenes, *M. jourdanensis* was described by Becker (1999) from the Late Hauterivian (*balearis* ammonite zone). For the Urgonian-type limestones of southeastern France and the French-Suisse Jura Clavel et al. (2010) indicate a range for *M. jourdanensis* from the latest Hauterivian (upper part of *ligatus* ammonite zone) to the early late Barremian (lower part of *vandenheckii* ammonite zone). The upper limit indicated by Clavel et al. (2010) seems to correspond of the upper limit of the taxon range as shallow-water facies continued in this area into the early Aptian. Peybernès (2004) described *M. jourdanensis* (as *Conicopfenderina*? *balkanica*) from the Late Valanginian of Bulgaria. Peybernès considers "*C.*? *balkanica*" "as a good index of the *Valdanchella miliani* zone" of the Late Valanginian. Schroeder et al. (2000) however concludes that the "biozone à *Valdanchella miliani*" corresponds to the Early Valanginian. From the Jerma River canyon (Eastern Serbia) Bucur et al. (1995) reported *Paracoskinolina*? *jourdanensis* in carbonate deposits assigned to the Valanginian. In Romania, *M. jourdanensis* was frequently mentioned (as *Paracoskinolina*? *jourdanensis*) in limestones

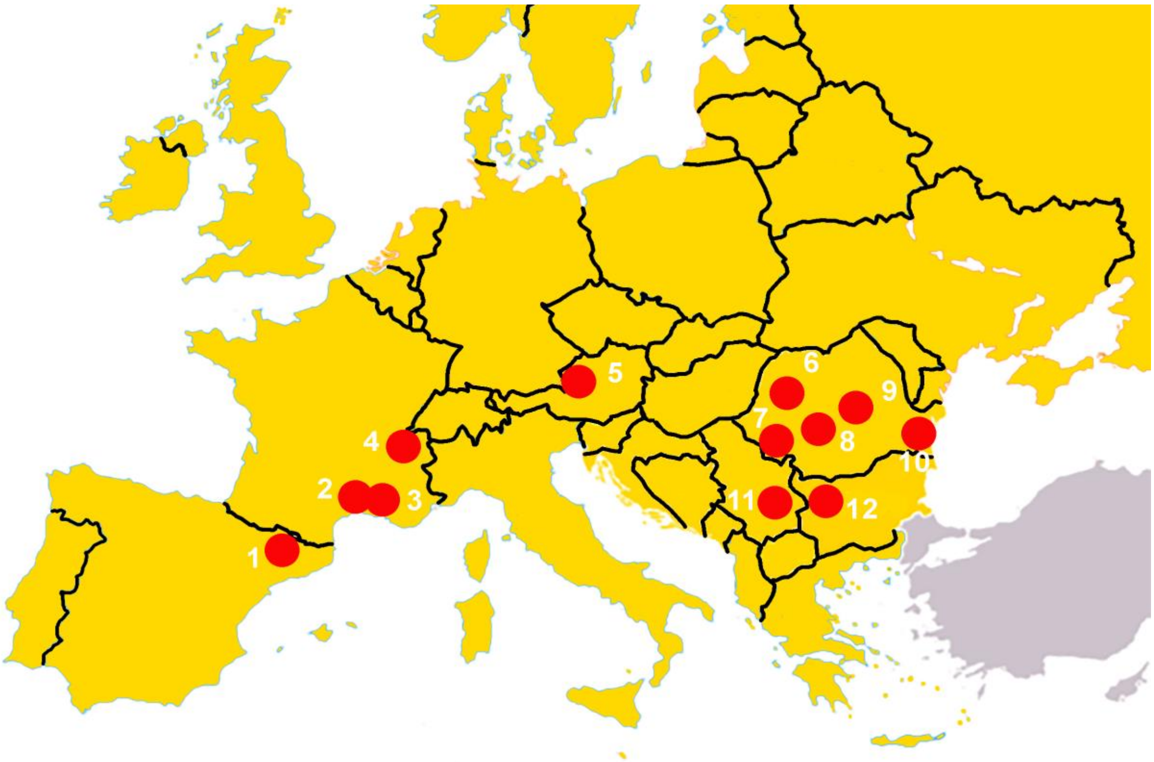

Fig. 8 Geographic distribution of occurrences of *Moulladella jourdanensis* (Foury & Moullade) n. gen., n. comb. **1**: Organya, Pyrenees, Spain **2**: Alpilles, Southern France **3**: Provence, Southern France **4**: Alpes occidentales and Jura, South-Eastern France and Switzerland **5**: Northern Calcareous Alps, Austria **6**: Pădurea Craiului, Apuseni Mountains, Romania **7**: Reşiţa-Moldova Nouă zone, Southern Carpathians, Romania **8**: Vâlcan and Vânturariţa Mountains, Southern Carpathians, Romania **9**: Dâmbovicioara zone, Southern Carpathians, Romania **10**: Dobrogea, South-East Romania **11**: Jerma River canyon, Eastern Serbia **12**: Western Bulgaria.

dated as early Barremian in Pădurea Craiului (Northern Apuseni Mountains) associated with *Salpingoporella genevensis* (Bucur and Cociuba, 1988, 1996; Bucur et al., 1993; Daoud et al., 2004; Bruchental et al., 2014), the Reşiţa-Moldova Nouă zone (South Carpathians) (Bucur, 1994, 1997; Hosu and Bucur, 1997), Vânturariţa Massif (South Carpathians) (Pleş, 2015; Pleş et al., 2016), and Vâlcan Mountains (South Carpathians) (Michetiuc et al., 2008, 2012). *M. jourdanensis* was also mentioned and illustrated (as *Conicopfenderina*? *jourdanensis*, or as *Paracoskinolina*? *jourdanensis*) from lowermost Valanginian limestones in Piatra Craiului Massif (Mircescu et al., 2014, 2016) and Dâmbovicioara area (Grădinaru et al., 2016; Săsăran et al., 2017; Ungureanu et al., 2017). Within the lower Valanginian from Piatra Craiului-Dâmbovicioara area, *M. jourdanenis* is associated with *Paracoskinolina*? *pfenderae*, *Montsalevia salevensis, Haplophragmoides joukowskyi, Coscinoconus cherchiae, C. campanellus, Danubiella gracilima*, *Protopeneroplis ultragranulata* (Fig. 7), an assemblage pointing to late Berriasian-early Valanginian age (Neagu, 1985; Husinec and Sokac, 2006; Schlagintweit and Gawlick, 2006; Masse et al., 2009; Bucur et al., 2014). Considering that the levels with *M. jourdanensis* are situated in the uppermost part of the Berriasian-lower Valanginian sequence ended by a hardground surface covered by deep-water deposits with *Neohoploceras submartini* (Mallada) of Verrucosum ammonite zone (Grădinaru et al., 2016, 2017), we can assign to these levels an early Valanginian age. Summarizing, the stratigraphic range of *M. jourdanensis* can be assigned to the Valanginian-early late Barremian interval. We may note a gap in the record referred to the early Hauterivian that might be closed by new future finds.

Occurrences and paleobiogeography: *M. jourdanensis* is palaeobiogeographically restricted to a stripe along the northern Neotethyan margin, with occurrences stretching from the Spanish Pyrenees, southern France, Austria, Romania, Serbia, to Bulgaria. The latter three occurrences refer to the so-called Carpatho-Balkanides (e.g., Kovács et al., 2010, Fig. 1B). Such a provincialism is reported from several taxa of primitive orbitolinids (Dictyoconidae) with restriction either to the Northern (= European) or Southern (= African) Neotethyan margin (e.g., Cherchi et al., 1981). With this respect, *M. jourdanensis* represents a typical "European" taxon (Fig. 8). Such a distributional pattern was already assumed by Schlagintweit (1991, p. 89, fig. 4), now substantiated by more detailed data. Therefore *M. jourdanensis* has not been reported from the well investigated Lower Cretaceous platform carbonates of the Italian Apennine mountains (Chiocchini et al., 2012) or the Dinarides (e.g. Croatia, see Velić, 2007).

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