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New record of *Discradisca* (Brachiopoda: Discinidae) from the Early Miocene of the Aquitaine Basin, south-western France*Nouvelles découvertes de Discradisca (Brachiopoda : Discinidae) dans le Miocène inférieur du Bassin d'Aquitaine, Sud-Ouest de la France*Maria Aleksandra Bitner^{a,*}, Bruno Cahuzac^b^a Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, 00-818 Warszawa, Poland^b Université Bordeaux 1, UFR Sciences de la Terre et de la Mer, 351, Cours de la Libération, 33405 Talence cedex, France

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ABSTRACT

The linguliform inarticulate brachiopod genus *Discradisca* Stenzel, 1964 has been identified for the first time from the Early Burdigalian (Early Miocene) sandy deposits of the Aquitaine Basin, south-western France. The species studied here, *D. multiradiata* (de Morgan, 1915), originally described from the Middle Miocene of the Loire Basin, north-western France, is characterized by a small size, ornamentation of numerous (up to 100), fine but distinct and beaded tuberculate ribs, and an apex situated subposteriorly to subcentrally. The ecological and taphonomic aspects of this species are also presented. The attribution of some previously described *Disciniscia* Dall, 1871 species from the Tertiary to the genus *Discradisca* is discussed.

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R É S U M É

Des brachiopodes linguliformes inarticulés appartenant au genre *Discradisca* Stenzel, 1964 ont été identifiés pour la première fois dans les sables du Burdigalien inférieur (Miocène inférieur) du Bassin d'Aquitaine, Sud-Ouest de la France. L'espèce étudiée ici, *D. multiradiata* (de Morgan, 1915), originellement décrite du Miocène moyen du Bassin de la Loire, Nord-Ouest de la France, est caractérisée par une petite taille, une ornementation de nombreuses (jusqu'à 100) côtes fines, mais distinctes et granuleuses, et un apex situé subpostérieurement ou subcentralement. Les aspects écologiques et taphonomiques de cette espèce sont aussi présentés. L'attribution de certaines espèces déjà décrites de *Disciniscia* Dall, 1871 du Tertiaire au genre *Discradisca* est discutée.

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1. Introduction

The linguliform inarticulate brachiopod genus *Discradisca* Stenzel, 1964, with an organophosphatic shell,

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was erected for those *Discinisca* species having fine radial ribbed ornamentation on the dorsal valve. This name was first proposed by Stenzel (1964, p.627) as a subgenus of *Discinisca* Dall, 1871, however, later Cooper (1977) elevated *Discradisca* to generic level.

Today *Discradisca* lives mostly in tropical and subtropical regions, restricted mainly to the continental shelves (Emig, 1997a), and contains six species (Bitner et al., 2008; Emig, 1997b). Its oldest fossil record is from the Lowermost Tertiary, Danian (Holmer and Popov, 2000; Stenzel, 1964). Although discinid brachiopods, because of their delicate, chitinophosphatic shells, are rare in the fossil record, several species were described from the Miocene of Europe (Ctyroky and Fejfar, 1963; Davidson, 1874; de Morgan, 1915; Dollfus and Dautzenberg, 1901; Dreger, 1889; Friedberg, 1921; Kroh, 2003; Radwańska and Radwański, 1984, 2003; Radwański and Wysocka, 2004; Schmid et al., 2001; Vincent, 1893, 1922). Some of those species attributed to the genus *Discinisca* display such features characteristic of *Discradisca* as fine, tuberculate ribs, and thus should be transferred to the latter genus.

The present paper deals with a newly collected fauna of discinid brachiopods from the Early Burdigalian of the Aquitaine Basin, south-western France. This rich material, represented by isolated dorsal valves, has been assigned to the species *Discradisca multiradiata* (de Morgan, 1915), which so far has been known only from the Middle Miocene. This new finding extends both the stratigraphical and geographical range of this species. However, it is worth mentioning that the presence of *D. multiradiata* was cited by Neuville (1942) from Saucats (Fig. 1). Thus, the aim of this paper is to describe and illustrate this poorly known species, and to discuss aspects of its ecology and taphonomy. The possible attribution of some previously described *Discinisca* species from the Tertiary to the genus *Discradisca* is also discussed.

Interestingly, the brachiopod assemblage described from the Upper Burdigalian of south-eastern France (Pajaud, 1984) contains no discinids, although seven other brachiopod species were recognized.

2. Geological setting and material

2.1. Geological setting

The stratotype of the Burdigalian stage (upper Early Miocene) was first described from the northern Aquitaine Basin, south of Bordeaux (Fig. 1). In this region, the Burdigalian begins with transgressive deposits and is represented by various marine facies, often containing a rich molluscan fauna. The investigated brachiopods were collected in the basal part of the Burdigalian represented by a unit of regional extent, the so-called “Sables à Macres” (Mactrid Sands) at Martillac (Fig. 1); this sequence has been described in detail by Cahuzac and Poignant (2005) and Lesport and Cahuzac (2005). The sequence at this outcrop begins with 1.3 m thick fine to silty carbonate sands, grey blue in colour with a locally abundant marine molluscan fauna represented by bivalves, gastropods, scaphopods and nautilids. Scleractinian corals, crustaceans, bryozoans, echinoderms, serpulids, fish remains, sponge

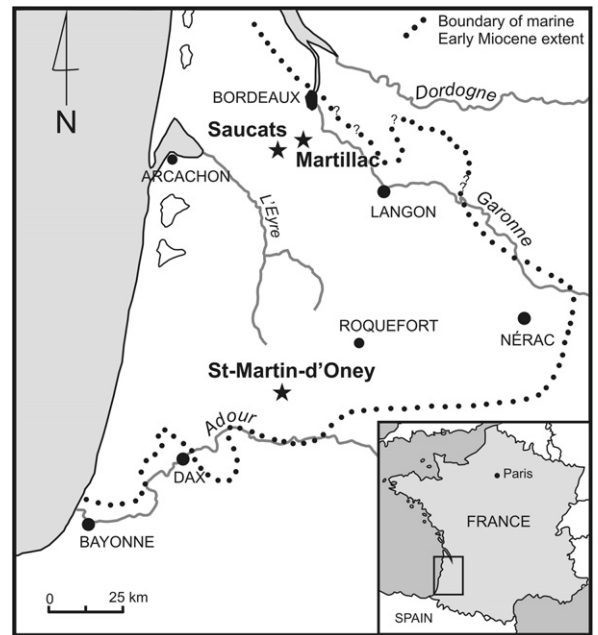


Fig. 1. Geographical map of the Aquitaine Basin with a maximum extent of the Burdigalian marine deposits. Asterisks indicate locations of outcrops yielding brachiopod fauna. After Cahuzac and Poignant (2005), simplified. **Fig. 1.** Carte géographique du Bassin d'Aquitaine montrant l'extension maximale des dépôts marins du Burdigalien. Les astérisques indiquent la localisation des gisements ayant livré la faune de brachiopodes. D'après Cahuzac et Poignant (2005), simplifié.

spicules and brachiopods are among the associated fauna. Based mostly on foraminifers and mollusks, these deposits are interpreted to have been deposited in a tidally influenced, relatively calm, tropical, shallow embayment, with very low detrital input and with normal salinity. Based on neritic larger foraminifera the fine-grained, grey-blue sands are attributed to the lowermost part of the Early Burdigalian biozone SBZ 25 [Shallow Benthic Zone] of Cahuzac and Poignant (1997). The zone N5 (planktonic foraminifers) is also present here (Cahuzac and Poignant, 2005).

The second locality with *Discradisca* is in the southern Aquitaine Basin, at Saint-Martin-d'Oney (Fig. 1). A section outcropping here begins with Aquitanian lagoonal marls overlain by a thick Burdigalian marine sequence, mostly sandy and very fossiliferous. The beds yielding brachiopods are carbonate sands, either yellow or grey, rich in mollusks, bryozoans, foraminifers, and echinoids, corresponding to a coastal facies of Early Burdigalian age, according to foraminiferal assemblages. From the yellow sands, a few specimens of *Joania* aff. *cordata* (Risso, 1826) have been recorded.

D. multiradiata, cited by Neuville (1942), comes from the Péloua outcrop at Saucats (Fig. 1), where reefal, coarse, rusty in colour 'faluns' (crags) are exposed (see ref. in Carriol et al., 2011), which were deposited in infralittoral tropical environments. The Péloua locality is one of the sections representing the Early Burdigalian stratotype, as defined by Depéret in 1892.

2.2. Material and methods

The material comes from two localities in the Aquitaine Basin: Martillac and Saint-Martin-d'Oney (Fig. 1). It consists of well-preserved, isolated dorsal valves; all have a blackish to dark brown colour. No horny ventral valve in *Discradisca* is preserved in the fossil record.

The investigated specimens were obtained by wet-sieving (large mesh sizes: 1 and 5 mm) of weakly consolidated carbonate sands. They were picked and initially examined under a binocular microscope. Later they were imaged using a Philips XL-20 scanning electron microscope (SEM) at the Institute of Paleobiology (Warszawa). The material described and illustrated here (83 valves from the Martillac site, Cahuzac collection) is housed in the collections of the University of Bordeaux 1, Talence, France, and registered under the numbers No.85-15-71 to No.85-15-78 (“Tyfipal, Types et figurés en Paléontologie” numbers in typotheque) for the figured specimens, and No.Mart1 for others. Additionally, other material from Martillac has been collected, 83 isolated dorsal valves by J.-F. Lesport and three valves by S. Buisson.

From the quarry at Saint-Martin-d'Oney, more than 110 specimens of dorsal valves have been collected by private collectors (e.g. 72 by G. Varone, 30 by A. Cluzaud, 12 by J.-J. Cladères, two by S. Buisson and one by J.-F. Lesport).

3. Systematic palaeontology

Phylum BRACHIOPODA Duméril, 1805

Subphylum LINGULIFORMEA Williams, Carlson, Brunton, Holmer and Popov, 1996

Class LINGULATA Gorjansky and Popov, 1985

Order LINGULIDA Waagen, 1885

Superfamily DISCINOIDEA Gray, 1840

Family DISCINIDAE Gray, 1840

Genus *Discradisca* Stenzel, 1964

Type species: *Orbicula antillarum* d'Orbigny, 1845

Discradisca multiradiata (Dollfus and Dautzenberg in de Morgan, 1915)

Figs. 2–4

1901 *Discina multiradiata* n. sp. – Dollfus and Dautzenberg, p. 280 (*nomen nudum*).

1915 *Disciniscia multiradiata* – de Morgan, p. 272; fig. 15.

2005 *Disciniscia* sp. – Lesport and Cahuzac, p. 91; pl. 3, fig. 1.

Material examined: 83 dorsal valves (in Cahuzac collection from Martillac), of which some are partly damaged; the other material (cited *supra*) was mentioned for information about frequency.

Description: Dorsal valve thin, small (maximum length 8.6 mm), variable in outline from subcircular to ovaly

elongate. Posterior margin usually more or less straight, lateral margins strongly irregular in some specimens. Dorsal valve low- to moderate-conical in profile (Fig. 2E); the apex situated subposteriorly to subcentrally (Fig. 2A, C; Fig. 3A, C, E). Larval shell (protegulum) smooth without growth lines, reaching about 0.4 mm in diameter (Fig. 3B, D); postlarval (brepheic) shell smooth ornamented only by numerous growth lines. External surface of the adult (neatic) shell covered with numerous, fine but well-pronounced, beaded tuberculate ribs, up to 80–100 in large specimens. The ribs never bifurcate increasing in number by intercalation. Concentric growth lines numerous, distinct. Apart from principal ribs there is microornamentation of regularly spaced radial lines and lamellae (Fig. 3H, I). The radial micro-lines occur both on ribs and rib interspaces and begin already on the outer part of the brephic shell. The muscle scars are weakly pronounced, and on some specimens they are hardly visible. Posterior adductor muscle scars subcircular, situated near the limbus (Fig. 2D). Anterior adductor muscle scars elongated, narrow, anteriorly curved in a horseshoe-like shape (Fig. 2B, D). Limbus well developed in larger specimens (Fig. 2B, D).

Remarks: The presence of radial ribbed ornamentation indicates that the specimens described here should be attributed to the genus *Discradisca*. The specimens under study are consistent in their size and ornamentation with those described by de Morgan (1915) from the Middle Miocene deposits of the Pontlevoy region, north-western France, as *D. multiradiata*. This species name was first used by Dollfus and Dautzenberg (1901); however, they presented neither illustrations nor sufficient description, and according to the ICZN rules this name is a *nomen nudum*. Thus de Morgan (1915, p. 272) who presented first adequate description and illustration should be regarded as the author of the species (see also discussion in Radwańska and Radwański, 1984). Neither holotype nor type locality was originally designated, but Pontlevoy, Loire Basin, might be considered as the type locality. The well-preserved material from Aquitaine allowed us to describe for the first time the shell microornamentation in this species.

Six discinid species have been described from the Miocene deposits of Europe, four of them are characterized by fine ribbing, and two species have smooth surface, thus those with ribbing ornamentation belong to *Discradisca* (see discussion below).

In the character of ribs, the Burdigalian specimens resemble mostly *Disciniscia polonica* Radwańska and Radwański, 1984 from the Badenian (Middle Miocene) of Poland, differing, however, in the number of ribs and position of the apex; in *D. polonica* the number of ribs is estimated at 40–55, and the apex is situated subcentrally (Radwańska and Radwański, 1984). Also the anterior adductor muscle scars of the latter species are broader and only slightly curved anteriorly.

In the other hand, the Early Miocene species from Moravia, Czech Republic, *Disciniscia carpathia* Ctyroky and Fejfar, 1963, although having similar number of ribs, reaches a much larger size (up to 30 mm), and its apex is subcentral (Ctyroky and Fejfar, 1963: fig. 1; pl. 7, fig. 1, 3). The species *Disciniscia scutellum* (Dreger, 1889) from the Middle Miocene of the Vienna Basin, Austria

Dimensions (in millimeters).

Specimen No.	Length	Width
Mart1-a	7.5	6.1
No. 85-15-71 (Fig. 2A)	6.4	5.9
No. 85-15-73 (Fig. 3A)	2.7	2.6
No. 85-15-75 (Fig. 3E)	4.3	3.8

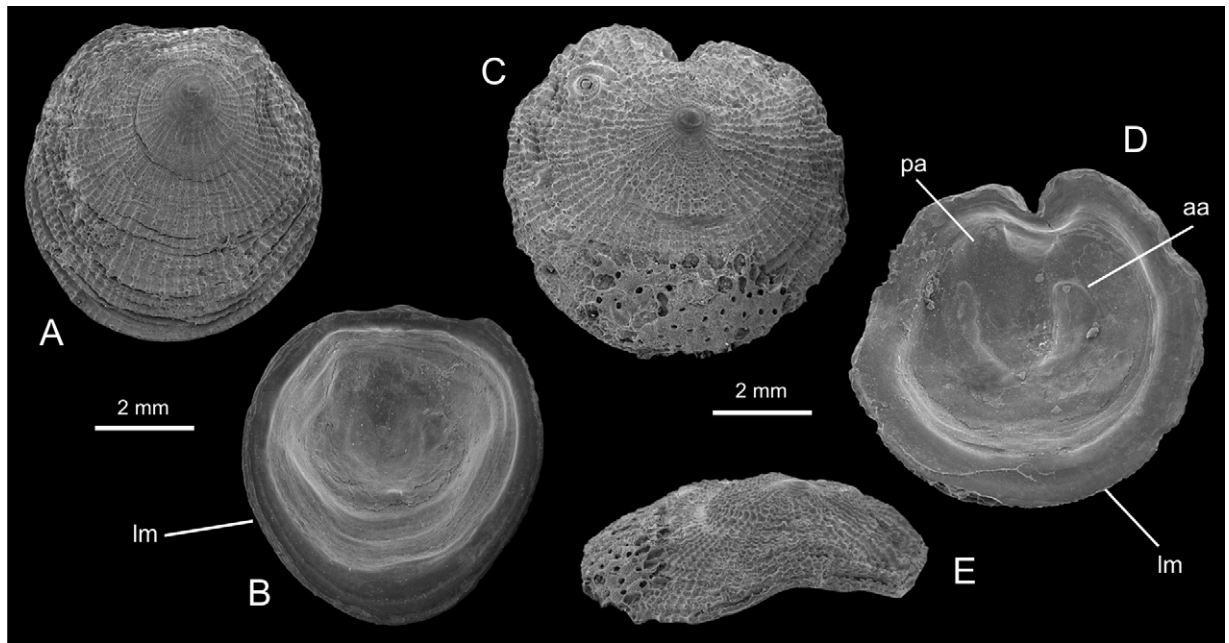


Fig. 2. SEM images of *Discradisca multiradiata* (de Morgan, 1915), dorsal valves, Burdigalian, Martillac, SW France; **A** and **B**: outer and inner views, muscle scars indistinctly marked, specimen No.85-15-71 (Bordeaux 1 University); **C**, **D**, **E**: outer, inner and lateral views, visible posterior (pa) and anterior (aa) adductor muscle scars, and limbus (lm), specimen No.85-15-72.

Fig. 2. Photos au MEB de *Discradisca multiradiata* (de Morgan, 1915), valves dorsales, Burdigalien, Martillac, Sud-Ouest de la France; **A** et **B**: vues externe et interne, empreintes musculaires indistinctement marquées, spécimen n° 85-15-71 (Université Bordeaux 1); **C**, **D**, **E**: vues externe, interne et latérale, empreintes du muscle adducteur postérieur (pa) et antérieur (aa), et du limbe (lm) visibles, spécimen n° 85-15-72.

is distinguished from the specimens described here in having a smaller size and ornamentation of much fewer (about 30), sparse ribs (Dreger, 1889; Kroh, 2003).

The studied specimens display also similarity to the Late Oligocene species *Discinisca steiningeri* Radwańska and Radwański, 1989 from Austria but differ in size and number of ribs. In *D. steiningeri* the ribs are finer and more numerous (up to 166), and its size is twice as large as that of *D. multiradiata* (see Radwańska and Radwański, 1989).

It is worth mentioning that in the rib character and number the studied specimens resemble the Recent species *Discradisca indica* (Dall, 1920) from the Indian Ocean (Bitner et al., 2008; Cooper, 1973; Dall, 1920); however, the position of the apex in *D. indica* is more stable, always slightly subposterior.

Occurrence: Middle Miocene of the Loire Basin, north-western France (Dollfus and Dautzenberg, 1901; de Morgan, 1915); Early Miocene of the Aquitaine Basin, south-western France (Neuville, 1942; present paper).

4. Discussion

4.1. Genus *Discradisca*

Today the family Discinidae is represented by four genera, *Discina*, *Discinisca*, *Discradisca* and *Pelagodiscus*. Two of them, *Discinisca* and *Discradisca*, have their representatives in the fossil record. Suggestions by Thomson (1927) that two fossil species, i.e. “*Discina*” *suessi* and “*Discina*” *fallens*, might belong to the genus *Pelagodiscus* have not been proven (Radwańska and Radwański, 1984, 2003).

Discradisca erected first as a subgenus of *Discinisca* is now considered as a separate genus (Cooper, 1977; Emig, 1997b; Holmer and Popov, 2000); those two genera differ in the ornamentation of the dorsal valve and in the type of the pedicle area. In *Discradisca* the pedicle track is wide, heart-shaped, and the ventral valve is very thin and fragile, not known from the fossil record. In modern seas, *Discradisca* is represented by six species, i.e. *D. antillarum* (d’Orbigny, 1845) from the western Atlantic, *D. cumingi* (Broderip, 1833) and *D. strigata* (Broderip, 1834) from the eastern Pacific, *D. indica* (Dall, 1920) from the Indian Ocean, *D. sparselineata* (Dall, 1920) and *D. stella* (Gould, 1862) from the western Pacific. Already Dall (1920, p. 275) recognized three groups among the Recent *Discinisca*: (A) without ribbing, and (B) and (C) having ribbed ornamentation. The species belonging to groups B and C correspond to the genus *Discradisca*.

The oldest stratigraphically species is *Discradisca littigensis* Stenzel, 1964 from the Lower Paleocene (Danian) of Texas, USA (Stenzel, 1964). Some of the Tertiary species referred previously to *Discinisca* but having fine ribbing should clearly be transferred to the genus *Discradisca*. From the Eocene of Great Britain, Muir-Wood (1929, 1939) described four *Discinisca* species, and two of them, *D. ferroviae* Muir-Wood, 1929 and *D. davisii* Muir-Wood, 1939, have radially ribbed shells indicating that they should be attributed to *Discradisca*. The former species resembles *D. multiradiata* but its ribs increase in number both by intercalations and bifurcations, while in *D. multiradiata* bifurcation is not observed. *D. davisii* is highly conical and has densely spaced ribs (Muir-Wood, 1939).

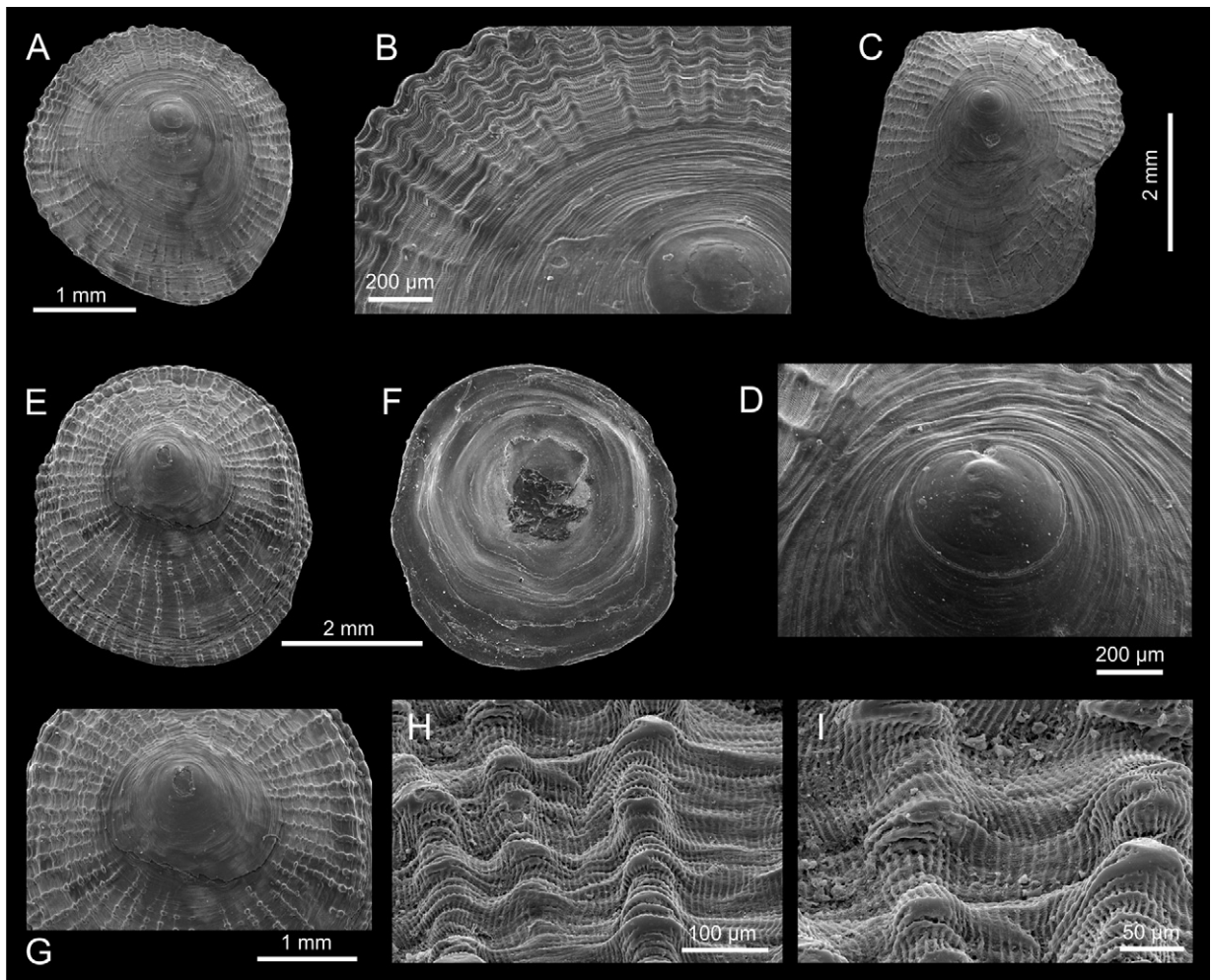


Fig. 3. SEM images of *Discradisca multiradiata* (de Morgan, 1915), dorsal valves, Burdigalian, Martillac, SW France; **A and B**: outer view of a young individual, and enlargement (B) to show the protegulum, smooth postlarval and mature ribbed parts of the shell, specimen No. 85-15-73; **C and D**: outer view, and enlargement of the apex, specimen No. 85-15-74; **E, F, G, H, I**: outer and inner views, and enlargements of the apex (G) and ribbed surface (H, I) to show the microornamentation, specimen No. 85-15-75.

Fig. 3. Photos au MEB de *Discradisca multiradiata* (de Morgan, 1915), valves dorsales, Burdigalien, Martillac, Sud-Ouest de la France; **A et B**: vue externe d'un individu juvénile, et agrandissement (B) montrant le protegulum, les parties postlarvaires lisse et mature costulée de la coquille, spécimen n° 85-15-73; **C et D**: vue externe, et agrandissement de l'apex, spécimen n° 85-15-74; **E, F, G, H, I**: vues externe et interne et agrandissements de l'apex (G) et de la surface costulée (H, I) montrant la micro-ornementation, spécimen n° 85-15-75.

Also Oligocene and Miocene species with radial ribs, such as *D. steiningeri* Radwańska and Radwański, 1989, *D. carpathia* Ctyroky and Fejfar, 1963, *D. scutellum* (Dreger, 1889) and *D. polonica* Radwańska and Radwański, 1984 clearly belong to the genus *Discradisca*.

The species *Disciniscia kamikatuensis* Yabe and Hatai, 1935 described from the Pleistocene of the Ryukyu Islands (Yabe and Hatai, 1935), Japan, and having a ribbed surface should be also transferred to *Discradisca*. This species is very close to Recent *D. stella* living off Japan.

The Pliocene species *Disciniscia miyagiensis* Hatai and Hayasaka, 1965 from Japan might also belong to *Discradisca*; however, the material is very limited and worn, and distinct ribs are visible only on the posterior part of its shell (Hatai and Hayasaka, 1965).

The only Miocene species really belonging to the genus *Disciniscia* are those having a smooth surface, i.e. *D. leopolitana* (Friedberg, 1921) from the central Paratethys and *D. elslooensis* Radwańska and Radwański, 2003 from the North Sea region. *D. leopolitana* was first described from the Middle Miocene of western Ukraine and has for long been regarded as endemic (Friedberg, 1921). Later, it has been recorded from other Paratethyan localities in Poland and Austria (Radwański and Wysocka, 2004; Schmid et al., 2001).

The second Middle Miocene smooth species, *D. elslooensis*, was first described under various species names, i.e. *suessi*, *davisoni* and *nysti* (Bosquet, 1862; Davidson, 1874; Vincent, 1893, 1922). As those species names had been already used for discinid brachiopods

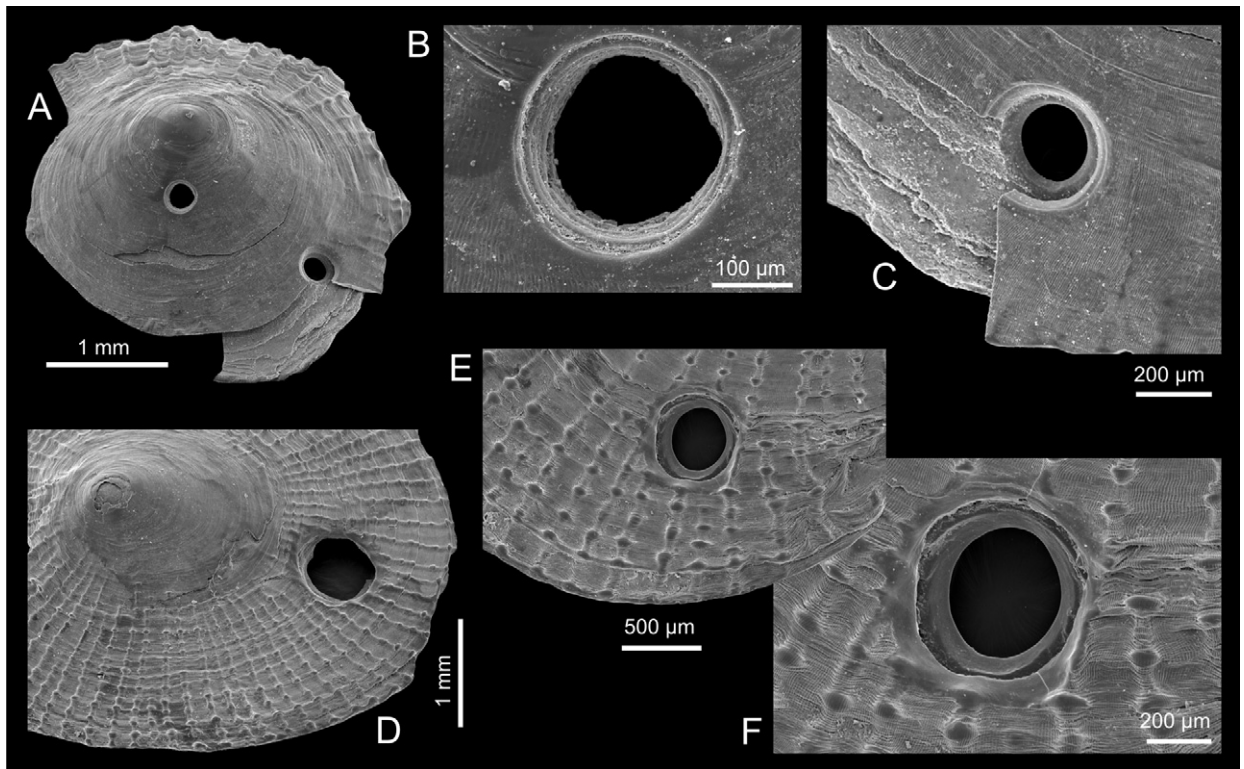


Fig. 4. SEM images of drilled specimens of *Discradisca multiradiata* (de Morgan, 1915), dorsal valves, Burdigalian, Martillac, SW France; **A, B, C:** outer view and close-up of the drill holes, specimen No. 85-15-76; **D:** outer view, specimen No. 85-15-77; **E and F:** outer view and close-up of the drill hole, specimen No. 85-15-78.

Fig. 4. Photos au MEB des spécimens percés de *Discradisca multiradiata* (de Morgan, 1915), valves dorsales, Burdigalien, Martillac, Sud-Ouest de la France ; **A, B, C :** vue externe et gros plans des orifices des trous, spécimen n° 85-15-76 ; **D :** vue externe, spécimen n° 85-15-77 ; **E et F :** vue externe et gros plan des orifices des trous, spécimen n° 85-15-78.

from various, stratigraphically older, deposits, to avoid nomenclatural confusion Radwańska and Radwański (2003) proposed a new separate species for the material from the Esloo Conglomerate.

Today, *Discradisca* occurs in the Pacific, Indian Ocean and western Atlantic but is not known from the Mediterranean Sea and eastern Atlantic (Bitner et al., 2008; Emig, 1997b). Such disjunct distribution of this genus is difficult to explain without considering its fossil occurrence where *Discradisca* had a Tethyan distribution. Thus, the present occurrence of the genus can be interpreted as a relict distribution due to closing of the Tethys during the late Early Miocene.

4.2. Palaeoecological remarks

Discradisca has the ventral valve oriented towards the substrate, living attached by a short pedicle in the shallow water of tropical and subtropical areas. The micro- and macrofaunas associated with *Discradisca* in the studied outcrops also indicate a shallow infralittoral to near-shore environment of a tropical-type climate (cf. 2.1. *supra*; Cahuzac and Poignant, 2005; Lesport and Cahuzac, 2005).

Encrusting organisms, such as sessile foraminifers, bryozoans, serpulids, and corals, are common on the shells of the investigated specimens. Some carried more than one

species of encrusters. In particular, almost all valves from Saint-Martin-d'Oney are encrusted. This situation is similar to that observed today. Epibionts are also frequent on Recent *Discradisca* shells; Emig (1997a) observed them on 33% of shells.

As shown by Taddei Ruggiero and Bitner (2008) drilling frequency on brachiopod shells is low in Cenozoic populations. However, locally predation can be very high with drilled brachiopod specimens constituting up to 40% of the whole assemblage (Baumiller and Bitner, 2004; Baumiller et al., 2006; Delance and Emig, 2004).

Traces of gastropod predation have also been observed in the studied material from Martillac, although the intensity is relatively low. Gastropod drillings (Fig. 4) have been found on 10 specimens (12% of all specimens of Cahuzac's collection). One valve bears two drill holes (Fig. 4A–C). The holes are conical in shape with outer diameter of 0.3–0.6 mm, thus suggesting naticids as predators. It is worth mentioning that naticid gastropod drillings were also observed on many bivalve shells at Martillac (Lesport and Cahuzac, 2005). The low frequency of drilling among *Discradisca* might result from the abundance of mollusks (mainly bivalves) in the studied deposits that seem to offer a more preferable food than brachiopods. Also at Saint-Martin-d'Oney, very few shells were drilled (about 3% of the population).

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