Xenobrochus norfolkensis (Brachiopoda: Dyscoliidae), a new species from the Norfolk Ridge, New Caledonia, South-West Pacific

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Abstract: The genus *Xenobrochus*, with the type species *Gryphus africanus* COOPER, 1973, was erected for short-looped brachiopods of small size, rectimarginate and having a loop with anteriorly convex transverse band. A new species of *Xenobrochus*, *X. norfolkensis* sp. nov. has been identified in the material collected during the French cruises SMIB 8, NORFOLK 1 and NORFOLK 2 to the Norfolk Ridge, New Caledonia, SW Pacific. This species differs from those hitherto described in the absence of cardinal process and relatively wide outer hinge plates. The genus, represented now by nine species, has a distribution restricted to the Indian Ocean and West Pacific.

Key Words: Xenobrochus; Dyscoliidae; Brachiopoda; Norfolk Ridge; South-West Pacific; new species.

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Résumé : Xenobrochus norfolkensis (*Brachiopoda: Dyscoliidae*), une nouvelle espèce de la Ride de Norfolk, Nouvelle-Calédonie, SW Pacifique.- Le genre Xenobrochus (espèce-type Gryphus africanus COOPER, 1973) a été établi pour des brachiopodes de petite taille, rectimarginés et ayant une boucle courte avec une bande transverse à convexité antérieure. Une nouvelle espèce, Xenobrochus norfolkensis sp. nov., a été identifiée au sein du matériel récolté au cours des campagnes françaises SMIB 8, NORFOLK 1 et NORFOLK 2 dans la Ride de Norfolk (Nouvelle-Calédonie, SW Pacifique). Cette espèce diffère des précédentes par l'absence du processus cardinal et par des plaques cardinales relativement larges. Le genre comporte maintenant neuf espèces ; sa distribution géographique est restreinte à l'Océan Indien et à l'Ouest de l'Océan Pacifique.

Mots-Clefs : *Xenobrochus* ; Dyscoliidae ; Brachiopoda ; Ride de Norfolk ; SW Pacifique ; nouvelle espèce.

1. Introduction

The genus *Xenobrochus*, with the type species *Gryphus africanus* COOPER, 1973, was erected by COOPER (1981) for short-looped brachiopods having a small size, rectimarginate anterior commissure, and a loop with anteriorly convex transverse band. So far this genus is represented by eight species (LOGAN, 2007; BITNER, 2008). Particular species differ from each other mostly in the presence or absence of the cardinal process, the size of the outer hinge plates, and the presence of a median fold in the transverse band.

The aim of this paper is to describe a new *Xenobrochus* species, previously erroneously attributed to *X. australis* COOPER, 1981 (see BITNER, 2009). However, examination of the type material of *X. australis* kept at the Muséum National d'Histoire Naturelle de Paris (MNHN-BRA-78-14a) excluded the present material from that species.

2. Material

The material examined here was collected during three cruises to the Norfolk Ridge south of New Caledonia, SW Pacific (Fig. 1). The major part of the material (272 specimens) was dredged during the cruise SMIB 8. This cruise was carried out within the research program Marines d'Intérêt Biologique" "Substances (SMIB) organized by the Institut de Recherche Développement pour le (IRD, formerly ORSTOM) and Muséum National d'Histoire Naturelle de Paris (MNHN). The aim of this program was to collect deepwater invertebrates for experimentation. The cruise SMIB 8 was carried out from 26 January to 3 February 1993 on board RV Alis (RICHER de FORGES & CHEVILLON, 1996; BOUCHET et alii, 2008). A minor part of the material was dredged during the cruises NORFOLK 1 and NORFOLK 2 in 2001 and 2003, respectively (see also BITNER, 2009).

The total number of specimens is 307 (210 articulated specimens and 97 separate valves), all housed in the Muséum National d'Histoire Naturelle de Paris, under the inventory numbers NMHN BRA-3211-3221.

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Figure 1: Map of the Caledonian part of the Norfolk Ridge with seamounts indicated; stations with brachiopods are indicated by a star. Map from the "programme ZoNéCo", simplified.

3. Systematic part

Phylum Brachiopoda DUMERIL, 1805 Subphylum Rhynchonelliformea WILLIAMS *et alii*, 1996 Order Terebratulida WAAGEN, 1883 Suborder Terebratulidina WAAGEN, 1883 Superfamily Dyscolioidea FISCHER et OEHLERT, 1891 Family Dyscoliidae FISCHER et OEHLERT, 1891 Subfamily Aenigmathyridinae COOPER, 1983

Genus Xenobrochus COOPER, 1981

Type species: *Gryphus africanus* COOPER, 1973, by original designation of COOPER (1981, p. 19).

Emended diagnosis: Small to medium, oval, ventribiconvex, smooth anterior commissure rectimarginate; beak long, erect, labiate, foramen large to small, submesothyrid to permesothyrid, symphytium visible; pedicle collar short, teeth large; cardinal process variable, absent or broad, semielliptical; hinge plates narrow, poorly defined or absent; loop narrow, rounded, transverse band convex anteriorly.

Remarks: Because of discrepancies between the diagnoses of the genus *Xenobrochus* by

COOPER (1981) and by LEE (2006), as well as the description of new material, the diagnosis needs emendation. In the original diagnosis COOPER (1981) described the foramen as submesothyrid to permesothyrid. Surprisingly, in the diagnosis given in the Treatise (LEE, 2006, p. 2140) a foramen is described only as permesothyrid, although most species of Xenobrochus have a mesothyrid foramen. Also the size of a foramen is variable, from large to small (see X. rotundus BITNER, 2008). Similarly, outer hinge plates can vary from relatively wide (see BITNER, 2009: fig. 6 C, D) to rudimentary or absent (see BITNER, 2008: fig. 6 F, H). The main controversy concerns a cardinal process. According to the diagnoses (COOPER, 1981; LEE, 2006) it should be broad and semielliptical in all species. However, the cardinal process is not mentioned in the description of X. africanus (see COOPER, 1973; HILLER, 1986; LAURIN, 1997) and the species X. translucidus has no trace of a cardinal process (DALL, 1920, p. 320).

Xenobrochus norfolkensis sp. nov. Figs. 2 - 3 - 4

Synonymy: 2009 *Xenobrochus australis* COOPER; BITNER, p. 11, fig. 6A-D.

Holotype: The specimen in Fig. 2 E-H (NMHN BRA-3211).

Paratypes: the specimens in Fig. 2 C, D, I-L; Fig. 3 A-K (NMHN BRA-3212-3217).

Type locality: Norfolk Ridge, seamount Eponge, stn DW 146-147, 24°55'E, 168°22'E, 508-532 m.

Etymology: Refers to the type locality, Nor-folk Ridge.

Diagnosis: Small *Xenobrochus* with elongate oval outline, rectimarginate; beak erect, foramen medium, mesothyrid, symphytium visible; no cardinal process, outer hinge plates triangular, loop rounded with a wide, anteriorly convex transverse band.

Material examined: The material examined comprises 271 specimens collected during the cruise SMIB 8, 33 specimens collected during the cruise NORFOLK 1, and 2 specimens collected during the cruise NORFOLK 2. In a few cases the material collected during the cruise SMIB 8 was joined in one sample from two or more neighbouring stations. For details see Table 1. All specimens are dry with many empty shells.

Depth range: 193-967 m.

Description: Shell small (maximum observed length 5.5 mm), thin, elongate oval to rounded pentagonal in outline, biconvex with the ventral valve slightly more convex. Shell surface smooth, ornamented only by growth lines. Beak erect, beak ridges rounded. Foramen of medium size, circular, mesothyrid. Deltidial plates conjunct forming a visible symphytium. Lateral commissures straight, anterior commissure rectimarginate.

Station	Location	Depth	Specimens			
SMIB 8						
Seamount Eponge						
DW 146	24°55.20'S, 168°21.73'E	514-522 m	89 articulated specimens, 17 ventral valves, 6 dorsal valves			
DW 147	24°54.90'S, 168°21.85'E	508-532 m				
DW 152	24°54.35'S, 168°22.23'E	514-530 m	one articulated specimen			
Seamount Stylaster						
DW 166	23°37.83'S, 167°42.69'E	433-450 m	51 articulated specimens, 26 ventral valves, one dorsal valve			
DW 167	23°38.13'S, 167°43.16'E	430-452 m	3 articulated specimens, one ventral valve			
DW 169	23°37.73'S, 167°42.57'E	447-450 m	6 articulated specimens, one dorsal valve			
Seamount Jumeaux West						
DW 170	23°41.23'S, 168°00.56'E	241-244 m				
DW 171	23°40.54'S, 168°00.26'E	233-250 m	3 articulated specimens			
DW 172	23°40.50'S, 168°01.50'E	280-290 m				
Seamount Antigonia						
DW 182	23°19.28'S, 168°04.82'E	314-330 m	6 articulated specimens			
DW 183	23°18.27'S, 168°04.95'E	330-367 m				
DW 184	23°18.32'S, 168°04.84'E	305-320 m				
Slope of the Isle of Pines						
DW 193	22°58.71'S, 167°20.06'E	500-508 m				
DW 194	22°59.63'S, 167°22.50'E	491 m	24 articulated specimens, 29 ventral valves, 7 dorsal valves			
DW 195	22°58.93'S, 167°20.23'E	508-514 m				
DW 196	22°58.52'S, 167°20.92'E	530-558 m				
DW 197	22°51.27'S, 167°12.54'E	414-436 m				
DW 198	22°51.59'S, 167°12.44'E	414-430 m	one articulated specimen			
DW 199	22°51.63'S, 167°12.22'E	408-410 m				
NORFOLK 1						
Seamount Stylaster						
DW 1665	23°43'S, 167°43'E	923 m	3 articulated specimens, one dorsal valve			
Seamount Eponge						
DW 1692	24°56'S, 168°21'E,	507-967 m	2 articulated specimens			
Seamount Crypthelia						
DW 1723	23°18'S, 168°15'E,	266-267 m	one articulated specimen, 3 ventral valves			
DW 1724	23°17'S, 168°14'E	200-291 m	19 articulated specimens, 4 ventral valves			
NORFOLK 2						
Seamount Eponge						
DW 2081	25°54.40'S, 168°21.64'E	500-505 m	one articulated specimen, one dorsal valve			

 Table 1: Data and specimens of Xenobrochus per station.

Station	Length	Width	Thickness	Figure
DW 146-147 (paratype)	5.5	4.4	2.9	Fig. 2 I-L
DW 146-147 (holotype)	5.3	4.7	3.1	Fig. 2 E-H
DW 152	5.0	3.9	2.7	-
DW 167	4.4	3.6	2.4	-
DW 167	3.9	3.2	2.1	-
DW 167	2.5	2.1	1.2	-

Table 2: Measurements (in mm) of Xenobrochus norfolkensis sp. nov.



Figure 2: Xenobrochus norfolkensis sp. nov., SEM micrographs, cruise SMIB 8, Norfolk Ridge.

A - B: dorsal view of articulated specimen, and enlargement of the posterior part to show details of the beak; st. DW 166, 433-450 m, NMHN BRA-3218.

C - D: interior of ventral valve, and enlargement of posterior part to show small teeth; paratype, st. DW 146-147, NMHN BRA NMHN BRA-3213.

E - H: ventral, dorsal, and lateral views of articulated specimen (G: enlargement of posterior part); holotype, st. DW 146-147, 508-532 m, NMHN BRA-3211.

I - L: ventral, dorsal, and lateral views of articulated specimen (K: enlargement of posterior part); paratype, st. DW 146-147, 508-532 m, NMHN BRA-3212.

Ventral valve interior with pedicle collar relatively wide, excavate anteriorly. Teeth small, hooked-shape with weak swollen bases (Fig. 3 B-C). Dorsal valve interior with short but high inner socket ridges and deep dental sockets. No cardinal process; the surface between socket ridges rough. Outer hinge plates triangular, relatively wide. Crural processes short, blunt, directed ventrally. Loop short with a broad, rounded transverse band convex anteriorly; a weak median fold on the transverse band observed in some specimens. Lophophore zygolophous. Muscle scars oval, well defined on both valves.



Figure 3: Xenobrochus norfolkensis sp. nov., SEM micrographs, SMIB 8, Norfolk Ridge.

A - C: interior of ventral valve, enlargement of posterior part (B) and tilted view (C) to show small teeth and weak swollen bases; paratype, st. DW 166, 433-450 m, NMHN BRA-3214.

D - F: interior of dorsal valve, enlargement (E) of posterior part to show details of cardinalia and loop, and side view (F); paratype, st. DW 166, 433-450 m, NMHN BRA-3215.

G - H: interior and lateral views of dorsal valve; paratype, st. DW 146-147, 508-532 m, NMHN BRA-3216.

I - K:, interior of dorsal valve, enlargement (J) of posterior part and side view (K) to show cardinalia and loop; paratype, st. DW 146-147, 508-532 m, NMHN BRA-3217.

Ultrastructural analysis was carried out on the transverse section as well as on the inner surface of both valves. The shell is composed of three layers (Fig. 4). The microgranular primary and fibrous secondary layers are very thin, 4.5-6 μ m and 3.5-4.6 μ m, respectively. The fibres are 12.5-26 μ m wide and 1.7-2.9 μ m thick. The tertiary layer, 125-130 μ m thick, consists of large prisms. The prisms observed on the internal surface are interlocking irregularly showing discrete character (Fig. 4 A-C). The punctae are wide. The maximum shell thickness in *X. norfolkensis* is 137 μ m.

Remarks: This species was first investigated with rather limited material (35 specimens) collected during the cruises NORFOLK 1 and NOR-FOLK 2 (BITNER, 2009). The additional material now available for investigation is much richer (272 specimens) and was collected earlier from the same region during the cruise SMIB 8.



Figure 4: Xenobrochus norfolkensis sp. nov., SEM micrographs, SMIB 8, Norfolk Ridge.

A: interior of dorsal valve showing prisms of the tertiary layer and fibres of the secondary layer on the margin; st. DW 146-147, 508-532 m, NMHN BRA-3219.

B: inner surface, visible discrete units of prisms interlocking irregularly; ventral valve, st. DW 166, 433-450 m, NMHN BRA-3220.

C: transverse section of the shell, visible prisms of tertiary layer (top); ventral valve, st. DW 166, 433-450 m, NMHN BRA-3220.

D: transverse section of the shell showing the relationship between the primary, secondary and tertiary layers, with two punctae; ventral valve, st. DW 166, 433-450 m, NMHN BRA-3221.

E - F: sections showing details of boundaries between the layers and caeca penetrated a shell with a radiating brush; ventral valve, st. DW 166, 433-450 m, NMHN BRA-3221.

Initially, based on the absence of the cardinal process, the material collected during NOR-FOLK 1 and NORFOLK 2 was assigned by me to Xenobrochus africanus (COOPER, 1973), a species already reported from the New Caledonia region (LAURIN, 1997). Nevertherless, I transferred it to X. australis COOPER, 1981, following the suggestions of one of the reviewers (BITNER, 2009). However, examination of the type material of this species allows excluding the Norfolk brachiopods from X. australis which is much larger (maximum length 15 mm), has a prominent cardinal process, very long crura and a distinct median angulation on the transverse band. None of those characters is observed in the studied material.

The presence of the cardinal process in such species as Xenobrochus indianensis (COOPER, 1973), X. agulhasensis (HELMCKE, 1939), X. anomalus COOPER, 1981, X. naudei Hiller, 1994, X. rotundus BITNER, 2008, as well as in as-yet undescribed material from the New Zealand region, clearly distinguish those species from the material from the Norfolk Ridge (COOPER, 1973, 1981, 1983; HILLER, 1986, 1994a, 1994b; BITNER, 2008). X. indianensis has incurved beak and partly concealed symphytium (COOPER, 1973, 1981; LAURIN, 1997), while in X. norfolkensis sp. nov. the symphytium is wholly visible. Additionally, the pedicle collar in X. anomalus is tubular and extravagantly developed (COOPER, 1981; HILLER, 1994b). In turn, X. rotundus can be distinguished from the studied

specimens by its rounded outline, a small for amen and absent outer hinge plates (BITNER, 2008).

Only two species of *Xenobrochus*, *X. africanus* (COOPER, 1973) and *X. translucidus* (DALL, 1920) have no cardinal process like *X. norfolkensis*. In size *X. norfolkensis* is closest to *X. africanus*, but they differ in hinge plate width and loop outline; in *X. africanus* the hinge plates are rudimentary and the loop has a characteristic angular boundary between the descending branches and the transverse band (see COOPER, 1973, 1981, 1983; HILLER, 1986). In turn, *X. translucidus* is larger than *X. norfolkensis* and has a partly concealed symphytium and narrower hinge plates (DALL, 1920; COOPER, 1983).

The microstructure of *Xenobrochus* has here been investigated for the first time. Although the shell of terebratulides is usually built of two layers, many short-looped brachiopods including *Xenobrochus* have a three-layered shell (MacKINNON & WILLIAMS, 1974; BITNER, 2007). The prismatic tertiary layer in *X. norfolkensis* is very thick when compared with the primary and secondary layers and the fibrous secondary layer is exceptionally thin, being even thinner than the primary layer.

Rare traces of gastropod predation activity are also observed on the investigated specimens. Of 307 specimens 25 (~8%) bear drill holes.



Figure 5: Geographical distribution of the species of *Xenobrochus*. Data from LOGAN (2007), BITNER (2008) and this paper.

4. Discussion

The family Dyscoliidae is characterized by a very short loop with a horizontal or anteriorly convex transverse band. Of 11 members of the family five genera are living today (LEE, 2006). While the genera Dyscolia FISCHER et OEHLERT, 1890, and Abyssothyris THOMSON, 1927, also have their representatives in the fossil record, three other genera, Goniobrochus COOPER, 1983, Acrobelesia COOPER, 1983, and Xenobrochus COOPER, 1981, are known only from modern waters. In addition, Dyscolia and Abyssothyris have a worldwide distribution, being recorded from all oceans (LOGAN, 2007). But Goniobrochus and Acrobelesia are monospecific and restricted to small regions; Goniobrochus to the south-east of Mar del Plata, Argentina (COOPER, 1983), while Acrobelesia to the Gulf of Gascogne and the Canary Islands, northeastern Atlantic (D'HONDT, 1976; COOPER, 1983; LOGAN, 1983; ÁLVAREZ & EMIG, 2005).

The genus Xenobrochus, including the species described herein, is now represented by nine species and is restricted to the Indian Ocean and West Pacific (Fig. 5) with a wide depth range from 65 to 1272 m (LOGAN, 2007; BITNER, 2008, this paper). Apart from X. africanus and X. indianensis that are recorded from the western Indian Ocean and southwestern Pacific (COOPER, 1973; LAURIN, 1997; BITNER, 2010), other Xenobrochus species seem to have restricted distributions: X. agulhasensis and X. naudei in the Indian Ocean off southern Africa (HILLER, 1986, 1994a). X. anomalus and X. australis are also found in the Indian Ocean; the former south-east of Marion Island (COOPER, 1981; HILLER, 1994b), the latter west of Heard Island (COOPER, 1981). In the Pacific Ocean three species are recorded. X. translucidus occurs off the Philippines and Borneo (DALL, 1920; JACKSON & STIASNY, 1937; COOPER, 1983) and X. rotundus in the region of Fiji and Wallis and Futuna Islands (BITNER, 2008), while X. norfolkensis can be regarded as endemic to the Norfolk Ridge.

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