

Phacoiderhynchus, a new middle Famennian rhynchonellid genus from the Anti-Atlas, Morocco, and Phacoiderhynchidae n. fam.

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Abstract

Phacoiderhynchus n. gen., type species *P. antiatlasicus* n. sp., is described from the middle (UD III-B to IV-B) Famennian of Maïder, southern Morocco; the genus is also probably present in Central Morocco. The new genus results from a further restriction of the meaning of the genus *Planovatiostrum* SARTENAER 1970, and is type of Phacoiderhynchidae n. fam.

Key-words: *Phacoiderhynchus*, Phacoiderhynchidae, rhynchonellid, brachiopod, Famennian, Morocco.

Résumé

Phacoiderhynchus n. gen., avec *P. antiatlasicus* n. sp. du Famennien moyen (UD III-B à IV-B) du Maïder, Maroc méridional, comme espèce-type, est décrit; le genre est aussi probablement présent au Maroc Central. Le nouveau genre résulte de l'éclatement du genre *Planovatiostrum* SARTENAER 1970 et est le genre-type de Phacoiderhynchidae n. fam.

Mots-clefs: *Phacoiderhynchus*, Phacoiderhynchidae, Rhynchonellide, Brachiopode, Famennien, Maroc.

This paper is a further step towards the unravelling of the Famennian rhynchonellids of Moroccan Anti-Atlas. Special attention is paid to those occurring with goniatites, because the ammonoid deep water facies zonation is a key element for ascertaining the precise stratigraphical range of new rhynchonellid taxa. In this respect, the description of the Jebel el Mrakib section by BECKER *et al.* (1999) is very helpful, because 78 per cent of the specimens of the new species described below come from this locality. Old and recent collections were examined in order to describe *Phacoiderhynchus* n. gen., which is a stratigraphically restricted genus showing a combination of characters leading to the establishment of a new family.

Superfamily Rhynchonellacea GRAY, 1848 Phacoiderhynchidae n.fam.

TYPE GENUS

Phacoiderhynchus n. gen.

DIAGNOSIS

Large-sized, flat, elliptical outline. Ventral sulcus, dorsal fold. Costae few, relatively high, strong, starting at some distance from the beak. Median costae commonly divided. Dental plates; no septum; no crural plates; divided hinge plate; simple cardinal process.

COMPOSITION

Phacoiderhynchus n. gen. as sole genus so far.

REMARK

The flatness of the shell combined with the absence of a septum, the presence of dental plates and of a simple cardinal process, and the absence of crural plates allow the separation of the new family from all known families, in particular from Tetragonorhynchidae SARTENAER, 1999, which has a bilobate cardinal process, and no dental plates.

Phacoiderhynchus n.gen.

DERIVATIO NOMINIS

Φακοειδής, ής, ές (Greek) = lenticular; τό ρυγχος (Greek, neuter) = beak. The name draws attention to the characteristic lenticular profile of the shell.

TYPE SPECIES

Phacoiderhynchus antiatlasicus n.gen., n.sp.

DIAGNOSTIC FEATURES

Large-sized. Strongly costate. Uniplicate. Flatly biconvex. Elliptical outline. Commissure sharp. Sulcus, fold, and median costae beginning at some distance from beak. Sulcus well marked, shallow, and wide. Fold low and commonly marked by a slight depression. Tongue low, wide, and well defined. Top of tongue always located lower, often considerably lower, than top of shell. Costae in moderate number, wide, and relatively high. Divisions and intercalations common in median costae. Width exceeding length considerably. Wide apical angle. Dental plates tortuous and convergent. Relatively small umbonal cavities. Septum and crural plates absent. Divided hinge

plate with wide outer plates. Simple cardinal process. Crura slender, crescent-shaped in their distal part.

SPECIES ATTRIBUTED TO THE GENUS

Only the type species is attributed to the genus.

Two poorly preserved moulds of pedicle valves (one of them figured) of *Planovatiostrum* sp. described by BRICE & DROT (in BRICE *et al.*, 1984, p. 447, pp. 450-451, pl. XII, fig. 3) could belong to the new genus, and even to its type species, although they have shorter median and lateral costae. In the absence of sufficient material and better preserved specimens, the problem must remain open.

DESCRIPTION

Large-sized. Both valves shallow. Anterior commissure uniplicate to slightly parasulcate. Outline transversely elliptical in ventral and dorsal views. Commissure sharp, and projecting clearly postero-laterally where valve margins are concave. Frontal and lateral commissures clearly and deeply indented by the costae. Sulcus and fold beginning imperceptibly at a great distance from the beak. External median costae on fold slightly higher than middle ones when fold is slightly depressed medially. Hinge line relatively long.

Flanks of pedicle valve flat to slightly convex, sloping gently from umbonal region almost without relief. Well marked shallow sulcus starting wide, widening rapidly, and wide at front. Bottom of sulcus flat to slightly convex. Tongue low, well defined, and trapezoidal. Top of tongue always lower, often considerably lower, than top of shell. Upper part of tongue elongated anteriorly. Beak small, wide, slightly incurved, overhanging the hinge line. Interarea low, relatively long, clearly separated from flanks. Extremely short deltidial plates have been observed in serial transverse sections.

Brachial valve slightly and uniformly convex. Flanks sloping gently towards the commissure. Fold low, clearly separated from flanks. Fold often marked on almost its whole length by a very shallow depression affecting the part between the external costae. Top of valve located posterior to the frontal commissure.

Costae in moderate number, clearly marked, high, regular, wide, and angular with rounded crest. Median costae arising with sulcus and fold. One to three divisions of median costae commonly present in the anterior half of the shell, and even often in its anterior third or quarter, break the regularity of the costation. Lateral costae simple, restricted to the anterior half of shell. No parietal costae.

Valves have subequal depths with maximum width of shell somewhat anterior to mid-length. Maximum depth of brachial valve, and thus of shell, always located in posterior half, and from which point the valve slopes gently towards the commissure. Very wide apical angle and angle of the cardinal commissure.

Shell moderately thick in the apical region. Dental plates tortuous and robust. Umbonal cavities irregular and relatively small. Teeth widely spaced, short, and

stout. Delthyrial cavity wide. Neither septum nor septulum present. Instead of a septum a slight median swelling or even a low crest is present on the valve floor. Dental sockets deep and narrow. Hinge plate divided, of variable thickness, but always thin anteriorly. Outer plates wide, slightly convex and slightly inclined towards each other, and extending some distance anteriorly as appendages of the crura. Extremely short (0.3 to 0.4 mm in serial transverse sections) and simple cardinal process resting on the hinge plate. No crural bases to speak of. Slender crura with Phrygian cap shape in section posteriorly, becoming grooved forward. Crura very slightly curved at their distal end.

COMPARISONS

Before comparing *Phacoiderhynchus* n. gen. with the middle-late (UD IV-V) Famennian genus *Planovatiostrum* SARTENAER, 1970, to which *Phacoiderhynchus anti-atlasicus* n. gen., n. sp. has been assigned previously under the name *Planovatiostrum undulatum*, an up to date reassessment of that genus is needed.

The following species were already eliminated from the genus *Planovatiostrum*: *P. fibrosissimum* (TIETZE, 1870), and *P. richteri* (OPPENHEIMER, 1916). Apart from the originally figured specimen of *P. fibrosissimum*, this late Famennian (UD VI) species from the Sudetes [Ebersdorf near Neurode in county Glatz (Dzikowiec near Nowa Ruda in county Klodzko nowadays)] is so far only known with two Thuringian specimens of the same age figured by WEYER (1979, p. 103, pl. 4, fig. 14; 1990, p. 29, fig. 14), BARTZSCH & WEYER (1986, pl. I, right column, fig. 5), BARTZSCH *et al.* (1993, fig. 14, p. 35), and BLUMENSTENGEL (1995, pl. 4.3.4.-I, fig. 14, p. 141). On this limited base SARTENAER & XU (1989, p. 39) suggested that the species could probably be assigned to the genus *Pugnaria* BIERNAT & RACKI, 1986. This problem will be solved when more material allowing the investigation of the internal structure becomes available. Problems connected with the late Famennian [UD V (and VI)] Moravian species *P. richteri*, concerning which information is sparse, was discussed by SARTENAER & XU (1989, p. 38, p. 43, p. 44), and by SARTENAER (1997, pp. 25-27, p. 31, p. 32, pp. 33-34), who excluded from it representatives of the species mentioned from northern Sauerland and southeastern Thuringia. SARTENAER (1999, pp. 67-68, p. 73) indicated that *P. richteri* could belong to the genus *Tetragonorhynchus* SARTENAER, 1999.

The following species and forms from Morocco and Poland have also to be excluded from the genus *Planovatiostrum* on the basis of the morphological criteria detailed below: *Calvinaria undulata*, *Pseudoleiorhynchus undulatus*, *Planovatiostrum undulatum*, ?*Planovatiostrum* cf. *undulatus*, and *Planovatiostrum* sp.

The following two conclusions regarding Moroccan species are drawn from the discussion of the synonymy (see below): (1) no specimen of the type series of *Calvinaria undulata* is assignable to the genus *Planovatiostrum* [this includes the specimen from Oued Aricha "seeming close to *Planovatiostrum*" that led BRICE &

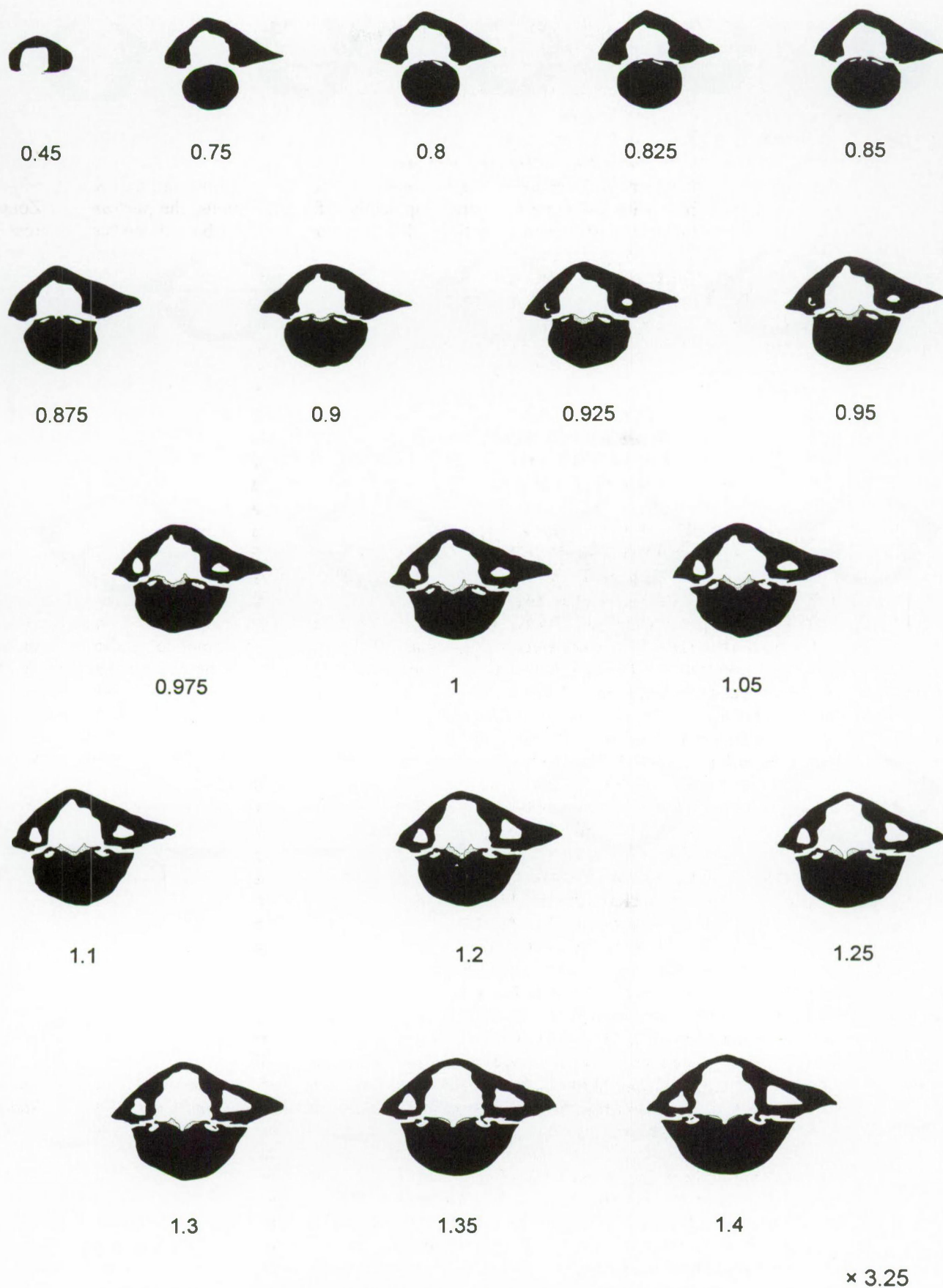


Fig. 1 — *Phacoiderhynchus antiatlasicus* n. gen., n. sp. Camera lucida drawings of serial transverse sections; figures are distances in mm forward of the ventral umbo. Paratype K, IRScNB a11084. Measurements: length = 20.9 mm; width = (32.4) mm; thickness = 11.7 mm.

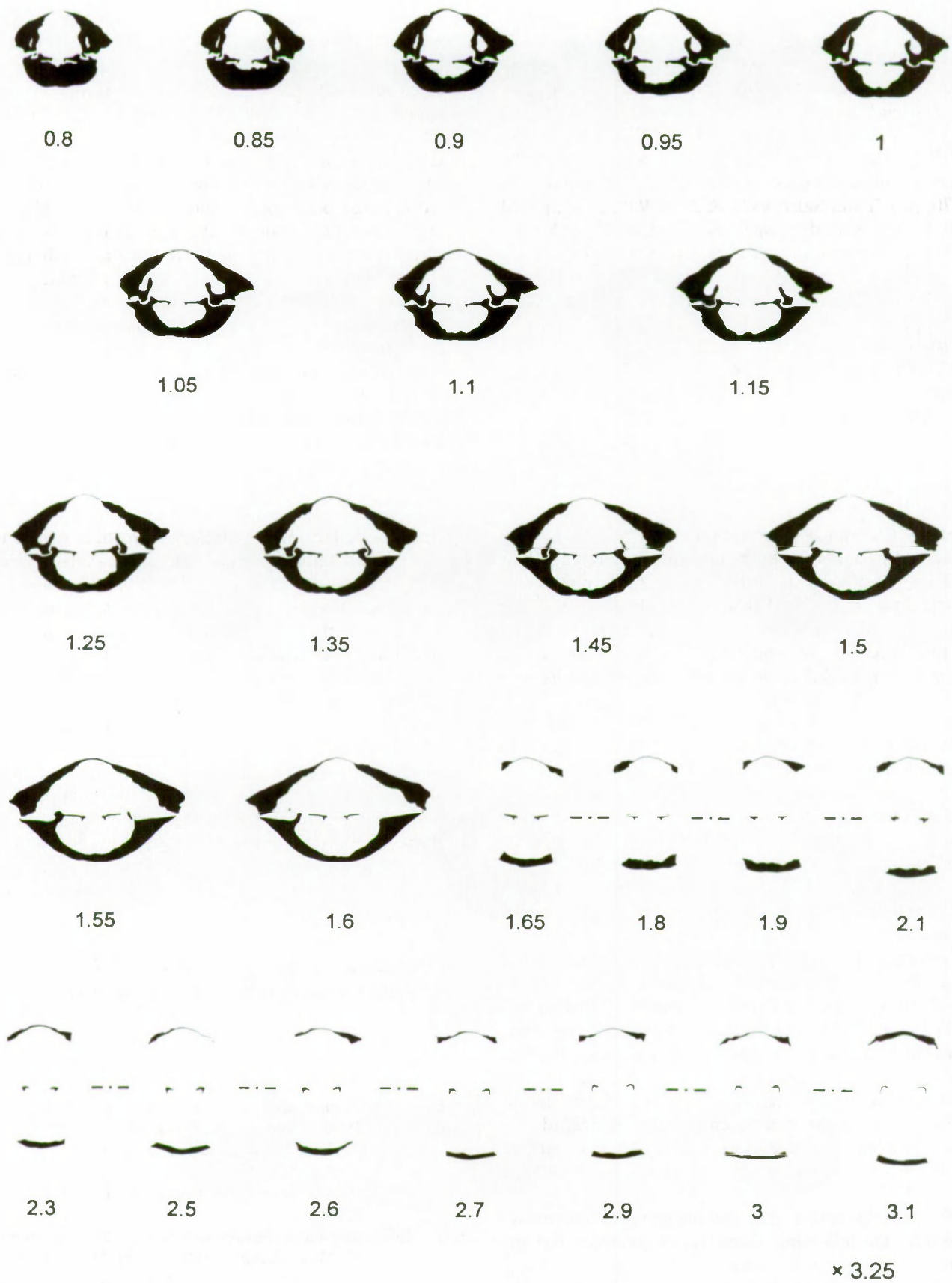


Fig. 2 — *Phacoiderhynchus antiatlasicus* n. gen., n. sp. Camera lucida drawings of serial transverse sections; figures are distances in mm forward of the ventral umbo. Paratype P, IRScNB a11089. Measurements: length = 18.7 mm; l = (26.5) mm; thickness = 8.9 mm.

DROT (in BRICE *et al.*, 1984, p. 447, p. 451) to conclude that the genus "seemed to exist in Central Morocco", and none belongs to *Phacoiderhynchus antiatlasicus* n. gen., n. sp.; (2) specimens described as *Pseudoleiorhynchus undulatus* by DROT (1964, p. 21, table, p. 94, pp. 169, 172, fig. 69, p. 170, pl. 23, figs. 8a-c, 9a-c) do not belong to that species. They also do not belong to the genus *Planovatiostrum* contrary to what SARTENAER (1970, p. 17) and SARTENAER & XU (1989, p. 37, p. 38) thought, but most of the specimens of UD IV age belong to *Phacoiderhynchus antiatlasicus* n. gen., n. sp.

The following Holy Cross Mountains forms of Famennian UD?III or IV age described by BIERNAT & RACKI (1986, p. 100, p. 101, pl. 40, figs. 5a-d) as ?*Planovatiostrum* cf. *undulatus*, and by BIERNAT (1988, p. 328, p. 329, fig. 2, p. 330, pl. 1, p. 331, figs. 5a-d) as ?*P.* cf. *undulatus* or *P.* sp. and *P. undulatus* belong neither to the species nor to the genus.

The specimens of Famennian IV age (a Famennian V age being however not totally excluded) described as *Planovatiostrum* sp. by BRICE & DROT (in BRICE *et al.*, 1984, p. 447, pp. 450-451, pl. XII, fig. 3), and mentioned again by CHARRIERE & RÉGNAULT (1989, p. 33), were collected by RÉGNAULT in the uppermost part of a 100 m thick carbonate unit in the Immouzer du Kandar inlier (topographic sheet 1/50,000 Sefrou) at about 40 km south of Fès, are not assignable to the genus *Planovatiostrum*. As mentioned above, some of these specimens could belong to *Phacoiderhynchus* n. gen., and even to its type species.

These various assignments result in a further restriction of the meaning of *Planovatiostrum*. In fact, the genus is restricted to its type species, *P. planoovale* (NALIVKIN, 1937) (forms erroneously assigned to it being excluded), because the following forms included in it with reservations by SARTENAER (1970, p. 17) and SARTENAER & XU (1989, p. 37, p. 38) have not been so far described: "some forms identified as *Liorhynchus ursus* NALIVKIN 1947", and "another species of the genus...in central and western Kazakhstan".

Consequently, the "world-wide *Planovatiostrum* range Zone" proposed by SARTENAER & XU (1989, p. 44), considering the "wide geographic distribution" of the genus, is brought down to a regional range zone restricted to northeastern Kazakhstan and northern Xinjiang.

None of the restrictions has a bearing on the definition of *Planovatiostrum*, and no emendation is needed, because the genus was already redefined by SARTENAER & XU (1989, pp. 43-44) when they redescribed its type species.

Phacoiderhynchus n. gen. and the genus *Planovatiostrum* have the following characters in common: flat appearance with gently biconvex profile; large size; strong costation; commissure sharp, protruding, and clearly indented by the costae; shallow sulcus and low fold, both well marked, beginning at some distance from the beak, and wide at front; tongue wide, shallow, trapezoidal with sharp borders; slight depression commonly affecting the

fold; top of tongue always lower than top of shell; ventral beak small, slightly incurved, and overhanging the hinge line; costae in moderate number; well marked and wide costae, relatively high and regular, and angular with rounded top; simple lateral costae; irregular and relatively small umbonal cavities; wide delthyrial cavity; tortuous and robust dental plates; short, stout, and widely spaced teeth; absence of septum; narrow and deep dental sockets; divided hinge plate; outer plates of the hinge plate of variable thickness (but always thin anteriorly), wide, slightly convex, slightly inclined towards each other, and extending some distance anteriorly as appendages of the crura; extremely short and simple cardinal process; no crural bases to speak of; slender crura slightly curved at their distal end.

Many characters make *Phacoiderhynchus* n. gen. distinct from *Planovatiostrum*: smaller minor axis of the elliptical outline; longer hinge line; sulcus relatively narrower at front; top of tongue generally located lower; longer ventral area; top of brachial valve, and thus of shell, located more posteriorly; higher number of lateral costae; slight shift (within the limits of similar number of median costae) of the number of median costae towards higher values; divided and intercalated median costae much more common, and two to three divisions on a specimen are not rare (in *Planovatiostrum* there is never more than one division in a given specimen); wider apical angle and angle of the commissure; greater width and smaller length (l/w , t/w , t/l = 0.60-0.71, 0.32-0.43, 0.48-0.60 for the type species of *Phacoiderhynchus*, 0.70-0.79, 0.31-0.34, 0.41-0.47 for the type species of *Planovatiostrum*); shell thicker in the apical region; umbonal cavities less exteriorly located; different contour of delthyrial cavity; dental plates and umbonal cavities convergent (they are divergent in *Planovatiostrum*); absence of crural plates; crescent-shaped crura in distal serial transverse sections (in *Planovatiostrum* crura are hockey-stick-shaped in distal serial transverse sections).

Phacoiderhynchus antiatlasicus n. gen., n. sp.

Plate 1, Figures 1-30, Plate 2, Figures 31-65,
Text-figures 1,2

SYNONYMY

- e.p.* 1964 *Pseudoleiorhynchus* (?) *undulatus* - DROT, p. 21;
- e.p.* 1964 *Pseudoleiorhynchus undulatus* (G. & H. TERMIER, 1950) - DROT, table, p. 94, pp. 169, 172, p. 173, pl. 23, figs. 8a-c, 9a-c, text-fig. 69, p. 170, *non synonymia*;
- e.p.* 1967 *Pseudoleiorhynchus undulatus* - HOLLARD, fig. 4, p. 209;
- non* 1970 spécimens illustrés sous le nom de *Pseudoleiorhynchus undulatus* (TERMIER & TERMIER) par J. DROT (1964, pl. 23, figs. 8a-c, 9a-c) - SARTENAER, p. 17, p. 18;
- e.p.* 1972 *Pseudoleiorhynchus?* *undulatus* (G. TERMIER & H. TERMIER, 1950) (sensu J. DROT, 1964) - WEYER, p. 84;
- e.p.* 1972 *Pseudoleiorhynchus undulatus* (TERMIER & TER-

MIER 1950) sensu DROT, 1964 - WEYER, foot note 1, p. 84;
e.p. 1984 *Pseudoleiorhynchus undulatus* (G. et H.Termier, 1950); Drot, p. 169, 170, 172, Pl. 23, fig. 8a-c, 9a-c - BRICE & DROT in BRICE *et al.*, p. 450;
? 1984 *Planovatiostrum* sp. - BRICE & DROT in BRICE *et al.*, p. 447, pp. 450-451, pl. XII, fig. 3;
non 1986 *Planovatiostrum undulatus* (G. et H.Termier) (Drot 1964: pl. 23: 8a-8c, 9a-9c) - BIERNAT & RACKI, p. 100;
non 1989 specimens called *Pseudoleiorhynchus undulatus* (TERMIER & TERMIER, 1950) by DROT (1964, pl. 23, figs. 8a-c, 9a-c) - SARTENAER & XU, p. 37, p. 38, column 2, lines 15-16;
e.p. 1989 *Pseudoleiorhynchus undulatus* - SARTENAER & XU, p. 38, column 1, column 2, line 19, line 33;
1989 new species - SARTENAER & XU, p. 38, column 2, line 29, p. 44;
1999 *Planovatiostrum* sp. - BECKER *et al.*, p. 97, p. 98.

DERIVATIO NOMINIS
From Anti-Atlas, type area of the new species.

TYPES
All from Jebel el Mrakib, N 30°45,410', W 04°42,757', ridge 27 km southeast of the village of Fezzou in Maïder, southern Morocco (Fezzou 1/100,000 sheet), locality 102a. This locality, as well as beds E-G, N-Q mentioned below, was plotted by BECKER *et al.* (1999, pp. 92-93, 96-98, fig. 36, p. 105, fig. 37, p. 106).
Holotype, MB.B.1309 (Pl. 1, Figs. 16-20). Bed O, lower part of Famennian UD IV-B. Collector: R.T.Becker, 1997.
Paratypes A, IRScNB a11074, B, IRScNB a11075 (Pl. 2, Figs. 56-60). Between beds E and G (talus), Famennian UD III-B. Collector: V. Ebbighausen, between 1990 and 1996.
Paratype C, IRScNB a11076 (Pl. 1, Figs. 26-30). Famennian UD IV [lower part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8d. Collector: P.Sartenaer, 1984.
Paratypes D, IRScNB a11077 (Pl. 2, Figs. 46-50), E, IRScNB a11078 (Pl. 2, Figs. 51-55), F, IRScNB a11079 (Pl. 2, Figs. 61-

65). Famennian UD IV [middle part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8e. Collector: P.Sartenaer, 1984.
Paratype G, IRScNB a11080 (Pl. 2, Figs. 31-35). Bed N2 (top of Famennian UD IV-A) and base of bed O (base of Famennian UD IV-B). Collector: V. Ebbighausen, 1996.
Paratype H, IRScNB a11081 (Pl. 2, Figs. 36-40). Beds O to Q (talus), Famennian UD IV-B. Collector: V. Ebbighausen, 1996.
Paratypes I, IRScNB a11082 (Pl. 1, Figs. 6-10), J, IRScNB a11083 (Pl. 1, Figs. 21-25), K, IRScNB a11084 (Fig. 1), L, IRScNB a11085, M, IRScNB a11086, N, IRScNB a11087, O, IRScNB a11088. Famennian UD IV (talus). Collector: V. Ebbighausen, 1995.
Paratype P, IRScNB a11089 (Fig. 2). Famennian UD IV [upper part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8f. Collector: P. Sartenaer, 1984.
Paratypes Q, IRScNB a11090 (Pl. 1, Figs. 1-5), R, IRScNB a11091 (Pl. 1, Figs. 11-15), S, IRScNB a11092 (Pl. 2, Figs. 41-45). Famennian UD IV (talus). Collector: V. Ebbighausen, between 1990 and 1996.

MB.B. = Paläontologisches Museum des Museums für Naturkunde (MFN), Humboldt Universität zu Berlin.

LOCUS TYPICUS
Jebel el Mrakib, N 30°45,410', W 04°42,757', ridge 27 km southeast of the village of Fezzou in Maïder, southern Morocco (Fezzou 1/100,000 sheet), locality 102a (see BECKER *et al.*, 1999, fig. 36, p. 105).

STRATUM TYPICUM
Bed O, lower part of *Cymaclymenia* n. sp. Zone = Famennian UD IV-B (see BECKER *et al.*, 1999, pp. 97-98, fig. 37, p. 106).

MATERIAL
34 of the 169 specimens examined are in good state of preservation, 20 satisfactory, and 24 poor; 91 specimens are fragmental.

Table 1 — Number of median and lateral costae.

Median costae			Lateral costae		
Number of costae	Number of specimens	%	Number of costae	Number of specimens	%
3/2	12	10.1	1/2	2	1.8
4/3	48	40.4	2/3	9	8
5/4	40	33.6	3/4	37	33
6/5	15	12.6	4/5	41	36.6
7/6	3	2.5	5/6	15	13.4
8/7	1	0.8	6/7	7	6.3
			7/8	1	0.9
	119	100		112	100

DESCRIPTION

Remark

Due to various reasons (designation of the lectotype, synonymy, figured specimens) that will be outlined below, DROT's description [1964, p. 21, table, p. 94, pp. 169, 172, fig. 69, p. 170, pl. 23, figs. 8a-c, 9a-c as *Pseudoleiorhynchus undulatus* (TERMIER, 1950)] covers more than one species and one genus and, with few exceptions, cannot be adopted for the new species here described.

What follows refers only to specific characters in need of further elaboration.

Sulcus starting at 38 to 58 per cent of the shell length, most of the values varying from 45 to 58 per cent, or 39 to 60 per cent of the unrolled length of the valve, most of the values varying from 48 to 60 per cent. Sulcus starting with a width of 28 to 51 per cent of the width at front, and reaching its greatest width (50 to 64 per cent of the shell width, most of the values varying from 56 to 64 per cent) at the junction of the frontal and lateral commissures. Top of tongue 33 to 50 per cent lower than point of maximum shell thickness. Length of ventral interarea varying from 56 to 68 per cent of shell width. Median depression on the fold in 62 per cent of specimens; it means that the external median costae are slightly higher than the middle ones. The general costal formula, which is a grouping of at least 75 per cent of the specimens in median, parietal, and lateral categories, is: $\frac{4 \text{ to } 6}{3 \text{ to } 5}$; 0 ; $\frac{3 \text{ to } 5}{4 \text{ to } 6}$. The ratios of median and lateral costae

are given in Table 1. Width of costae at front generally varies from 2 to 3.5 mm, but may reach 4 to 4.5 mm, and exceptionally 5 mm. Out of 106 specimens, 31 show one division on the fold, 23 show two divisions, 4 show three divisions, and 48 none; intercalated costae in the sulcus correspond to these divisions. A divided lateral costa was observed in four specimens. In 10 specimens the internal lateral costa (on one flank, never on both) is located slightly higher than the others.

Measurements of sixteen specimens, of which eleven have been photographed, are given in Table 2. The last column refers to one of the smallest specimens at hand. Maximum width occurs at a point between 50 and 58 per cent of the shell length anterior to the ventral beak. Top of pedicle valve located posteriorly at a variable point between 29 and 42 per cent of the shell length, and top of brachial valve, and thus of the shell, at a point varying between 30 and 44 per cent of shell length anterior to the ventral beak. From these points valves curve gently towards the frontal commissure. Top of tongue is 33 to 50 per cent lower than point of maximum shell thickness. Apical angle varying from 143° to 157° (most values are between 147° and 154°). Angle of the cardinal commissure varying from 147° to 161° .

Serial transverse sections of two specimens (paratypes K, IRScNB a110084, P, IRScNB a11089) are shown in Text-figures 1, 2. Sections of a third specimen were published by DROT (1964, fig. 69, p. 170 as *Pseudoleiorhynchus undulatus*).

DISCUSSION OF SYNONYMY

Since its foundation, *Calvinaria undulata* TERMIER, G. et H. 1950 [*C.?* *undulata* in text, *C. undulata* in explanation of plate] has been a source of taxonomical, stratigraphical, and nomenclatorial confusion. On account of the common mention of the species in the literature dealing with the early (UD II) and middle-late (UD IV,V) Famennian of pre-Sahara Morocco it is both useful and necessary to consider the problems connected with a species that HOLLARD (1967, fig. 4, p. 209) called a "fossile-guide principal" of the upper part (UD IV) of the middle Famennian of atlasic Morocco.

TERMIER (1950, table, p. 71, p. 99) gave a short (four lines) description (table, p. 71) and an even shorter (three lines) diagnosis (p. 99) of *C. undulata*. They illustrated it abundantly [pl. XCIX (= p. 199), figs. 13, 14, 16-19, 23, 24 = six specimens from Famennian II of Bou Gzem (Central Morocco) collected by them, figs. 25-34 = ten specimens from Famennian V of Oued Aricha (Central Morocco) collected by them, and figs. 35, 36 = one specimen from Famennian V of Fezzou (Maïder) collected by L. Clariond], but did not designate an holotype. All figures are poor drawings of specimens (some of them fragmentary) of which the locality is imprecise. Not mentioning the confusion in the numbering of figures on p. 198 (explanation of pl. XCIX), many contradictions are to be found in the information given on the species: figs. 13-14, 16-19, 23-36 on pl. XCIX, but only figs. 25-36 are referred to in the table (p. 71) and on p. 99; Famennian V on p. 99, but Famennian II and V on p. 198; *C.?* *undulata* in the table (p. 71) and on p. 99, but *C. undulata* on p. 198; three general areas [CS = South Chaouia (Benahmed region); TM = Tafilelt, Todra, Maïder, Taouz; MC = Central Morocco] are indicated in the table (p. 71), two localities (Oued Aricha, Fezzou) are mentioned on p. 99, and three (Bou Gzem, Oued Aricha, Fezzou) on p. 198. This poor account suggests that TERMIER considered the group of specimens of Famennian II age from Bou Gzem (pl. XCIX, figs. 13, 14, 16-19, 23, 24) as different from the group of specimens of Famennian V age from Oued Aricha and Fezzou (pl. XCIX, figs. 25-36), but that something went wrong during the printing process. Of course, this is mere speculation. To add to the confusion, some specimens of the type series are either misplaced or lost. During arduous search both in the "Direction générale des Mines" in Rabat and in the "Muséum national d'Histoire naturelle" in Paris, SARTENAER managed to locate the specimens from Famennian II of Bou Gzem and from Famennian V of Fezzou, but none of the ten specimens from Famennian V of Oued Aricha.

A quick look at the figures shows immediately that *C.?* *undulata* and *C. undulata* cover various taxa. The definition of the species is irrevocably imposed by the designation of a lectotype (table, p. 71 *pro parte*, p. 99 *pro parte*, pl. XCIX, figs. 35, 36 in TERMIER, 1950) by DROT (1964, p. 169), who gave a full description of the species (table, p. 94, pp. 169, 172, p. 173, pl. 23, figs. 8a-c, 9a-c, text-fig. 69, p. 170) under the name *Pseudoleiorhynchus un-*

Table 2 — Measurements (in mm) based on sixteen specimens; figures in parentheses are reasonable estimates on damaged specimens. Abbreviations used: l = length; w = width; t = thickness; pv = pedicle valve; bv = brachial valve.

in mm	Paratype M a11086	Holotype MB.B.1309	Paratype A a11074	Paratype I a11081	Paratype N a11087	Paratype S a11092	Paratype R a11091	Paratype Q a11090	Paratype L a11085	Paratype G a11080	Paratype H a11081	Paratype C a11076	Paratype J a11083	Paratype D a11077	Paratype O a11088	Paratype B a11075
l	22.6	21.9	21.8	21.6	21.3	20.7	20.6	20.4	20.2	20.1	19.9	(19.8)	19	18.9	18.7	18
w	33.5	31.2	33	34	(33.3)	29.8	31.2	33.4	(33.8)	29.9	29.2	28.8	29.2	29	26.3	26.3
lpv unrolled	27.5	26	(26)	27.5	(27)	25	25	25.5	24.5	25	24.5	(25)	22.5	24.5	23.5	24
t	11.6	10.9	11.4	12	12.2	10.5	10.6	12.3	10.9	(10.2)	9.6	11.6	10.3	10.5	11.2	10.1
tpv	5.4	4.8	4.8	5.5	4.9	4.4	4.9	5.2	4.4	(4.5)	4.5	5.1	4.7	4.4	4.7	4.2
tbv	6.2	6.1	6.6	6.5	7.3	6.1	5.7	7.1	6.5	5.7	5.1	6.5	5.6	6.6	6.5	5.9
l/w	0.67	0.70	0.66	0.64	(0.64)	0.69	0.66	0.61	(0.60)	0.67	0.68	(0.69)	0.65	0.65	0.71	0.68
t/w	0.35	0.35	0.35	0.35	(0.37)	0.35	0.34	0.37	(0.32)	(0.34)	0.33	0.40	0.35	0.36	0.43	0.38
t/l	0.51	0.50	0.52	0.56	0.57	0.51	0.51	0.60	0.54	(0.51)	0.48	(0.59)	0.54	0.56	0.60	0.56
apical angle	147°	149°	(150°)	148°	157°	148°	151°	154°	152°	147°	145°	?	151°	148°	143°	147°
angle of the cardinal commissure	150°	152°	(153°)	153°	161°	152°	155°	158°	155°	151°	147°	?	155°	153°	147°	151°

undulatus [*P. (?) undulatus* is also cited p. 21]. The lectotype is a small rounded specimen that belongs neither to the late Frasnian genus *Calvinaria* STAINBROOK, 1945 nor to the late Famennian genus *Pseudoleiorhynchus* ROZMAN, 1962, which is a junior synonym of the genus *Trifidoroestellum* SARTENAER, 1961 as stated by SARTENAER & ROZMAN (1965, p. 149), and SARTENAER (1998, p. 116). It does not belong either to the genus *Planovatiostrum* as indicated by SARTENAER (1970, p. 17), and SARTENAER & XU (1989, p. 38). It belongs to a new genus SARTENAER plans to describe, and of which he made a satisfactorily large collection from the Famennian UD V (probably the upper part of UD V) in the area of the lectotype here discussed.

Besides the selection of a lectotype, another positive aspect of the new description by DROT was the exclusion from the species of the six specimens from Famennian II of Bou Gzem (Central Morocco), which she described in the same publication as *Pseudoleiorhynchus (?) zemoulensis* DROT (1964, p. 14, pp. 172-173, pl. 23, figs. 2a-c, 3a-c, 4, 5, text-fig. 70, p. 171, and table, p. 94, p. 113 as *P. zemoulensis*). SARTENAER (1967, p. 2) assigned this species to the genus *Tenuisinurostrum* SARTENAER, 1967, but in 1987 he designated it as the type species of the genus *Evanidisinurostrum* SARTENAER 1987, and at the same time rejected (p. 135, p. 137) the synonymy proposed by DROT (1964, p. 172). The three elements of this synonymy refer to specimens figured by TERMIER (1950); one of them, *Stenochisma* cf. *acutelobata* Sandberger, pl. XCVII, fig. 35-37, 40 from Hamer el Khdad in Tafilalet was put by SARTENAER (1988, p. 72) into the synonymy of *Perrarisinurostrum desertum* SARTENAER, 1988, while the two others, *Calvinaria undulata* nov. sp., pl. XCIX, fig. 13, 14, 16-17, 24 and *Septalaria* sp., pl. XCIX, fig. 15, 21, 22 from Bou Gzem, are being investigated.

The negative aspect of the new description by DROT is that it brings up further complications: (1) the description applies to the three figured specimens (two photographed, and one sectioned), and to most of the specimens mentioned by her in the paragraph "Matériel et gisements", but does not apply to the lectotype; (2) if the description excludes the specimens from Famennian II of the original description by TERMIER (1950) (see above), leaving in the species only those from the Famennian V, it adds two poor and fragmental internal moulds (TM39, N of Arho-n-Kou) from Famennian V, and a vast majority of specimens from Famennian IV; (3) in including into the synonymy of *Pseudoleiorhynchus undulatus* specimens of *Calvinaria undulata* from Oued Aricha (pl. XCIX, figs. 25-34) and Fezzou (pl. XCIX, figs. 35, 36), DROT (1964, p. 169) accepts the presence of one and the same species in both localities. Firstly, on account of the unavailability of the paralectotypes from Oued Aricha (see above), such a conclusion cannot be accepted at its face value. Secondly, none of the TERMIER's drawings suggests that a single of the ten figured specimens belongs to the species or to the genus described in the present paper; SARTENAER has already indicated (1998,

p. 115, p. 116, p. 117) that figures 30 and 31 could questionably be assigned to *Hadyrhyncha meridionalis* SARTENAER 1998.

This lengthy discussion leads to a twofold conclusion: (1) the following specimens of UD V age considered hitherto to belong to *Calvinaria undulata* or *Pseudoleiorhynchus undulatus* have to be excluded from the genus and the species described in the present paper: the lectotype of *Calvinaria undulata*, the two internal moulds (TM39) which are in too poor a state of preservation for identification, and the ten specimens from Oued Aricha (Central Morocco); (2) the lectotype of *C. undulata* belongs to a new genus to be described.

This discussion accounts also for *e.p.* written in front of references to the collection studied by DROT (1964). When these references apply only to the two specimens figured by this author *non* is indicated in the synonymy list. Neither pl. 23, figs. 8a-c nor pl. 23, figs. 9a-c belong to *Phacoiderhynchus antiatlasicus* n. gen., n. sp.; the former is smaller and has a different costation pattern, the elliptical outline of the latter has a larger minor axis (the specimen is almost rounded), and the costation pattern is also different. The questionmark in front of 1984 indicates that it is not impossible that *Planovatiostrum* sp. could belong to the species (see above).

STRATIGRAPHICAL RANGE AND GEOGRAPHICAL DISTRIBUTION

The following specimens are part of the old collections of the "Direction de la Géologie" in Rabat, Morocco, and were referred to by DROT with maps indicating the location of outcrops (1964, p. 169, fig. 69, p. 170, p. 227, p. 229, p. 230 as *Pseudoleiorhynchus undulatus*; maps: fig. 90, p. 224, fig. 91, p. 228, fig. 92, p. 230):

- Arho-n-kou, Maïder, "Famennien à Platyclyménies (zone IV)" according to DROT (1964), Iourharène n°Mibaouâne horizon (ds IV) of the Ibaouâne Formation according to HOLLARD (1981†, table 3), TM 34 (15 sp.)
- Right bank of the lower Addis oued (Taïba), Draa Plains, Upper Famennian according to DROT (1964), "pélites et calcaires" forming the top (ds IV) of the El Douiya Formation according to HOLLARD (1981†, table 5), Ak 73bis (2 sp.)
- Same locality, formation, and age, Ak 77 (6 sp.); DROT (1964, fig. 69, p. 170) gave serial transverse sections of a specimen from this locality.
- Hill east of Dfeil trail, Draa Plains, "schistes à nodules calcaires des lumachelles du Dra. Famennien zone IV" according to DROT (1964), "lumachelles gréseuses et grès" corresponding to the lower half of the Lemgaïrinat Formation, i.e. the lower part of ds V according to HOLLARD (1981†, table 5), AT 139 (1 sp.)

Recent collections derive from the Upper Ibaouâne Formation within a restricted area in Maïder [west of Tizi i Baouâne at the Aguelmous (Missi 1/100,000 sheet) (12 sp.), Rich Bou Kourazia (Fezzou 1/100,000 sheet) (2 sp.), and Jebel el Mrakib (Fezzou 1/100,000 sheet) (131 sp.) (see BECKER, 1995, fig. 1, p. 609):

- West of Tizi i Baouâne, Famennian UD IV [upper part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-7a, collected by P. Sartenar, 1984 (12 sp.)
- Rich Bou Kourazia:

- Famennian UD IV [*Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-9b, collected by P. Sartenauer, 1984 (1 sp.)
 - Talus, Famennian UD IV, in the upper part of main slope, collected by R.T. Becker, 1996 (1 sp.)
 - Jebel el Mrakib [N 30°45,410' W 04°42,757', ridge 27 km south-east of Fezzou, locality 102a (see BECKER *et al.*, 1999, fig. 36, p. 105)]:
 - Famennian UD IV [lower part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8d, collected by P. Sartenauer, 1984 (19 sp.)
 - Famennian UD IV [middle part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8e, same collector (27 sp.)
 - Famennian UD IV [upper part of *Platyclymenia* (*Platyclymenia*) *annulata* Zone], MA-84-8f, same collector (51 sp.)
 - Bed N2 (top of Famennian UD IV-A) and base of Bed O (base of Famennian UD IV-B), collected by V. Ebbighausen between 1990 and 1996 (3 sp.)
 - Talus from Beds O to Q, Famennian UD IV-B, same collector, 1996 (1 sp.)
 - Famennian UD IV (talus), same collector (3 sp.)
 - Between Beds E and G, Famennian UD III-B, collected by V. Ebbighausen, 1994 and 1995 (3 sp.)
 - Famennian UD IV (talus), same collector (12 sp.)
 - Bed M1, Famennian UD III-C2, collected by R. T. Becker, 1997 (2 sp.)
 - Bed N, Famennian UD IV-A, same collector (4 sp.)
 - Bed O, lower part of Famennian UD IV-B, same collector (3 sp.)
 - Bed P, middle part of Famennian UD IV-B, same collector (2 sp.)
 - Talus, same collector (1 sp.)
- Beds mentioned in the Jebel el Mrakib section are parts of the

goniatite succession adopted by BECKER *et al.* (1999): Beds E to G are in the middle part of the *Planitornoceras euryomphalum* Zone (Famennian UD III-A/B) (Beds A to H1); Bed M1 is in the upper part of the *Sulcoclymenia sulcata* Zone (Famennian UD III-C2) (Beds J2 to M2); Beds N1 and N2 = the *Prionoceras divisum* Zone (Famennian UD IV-A); Beds O to Q = *Cymaclymenia* n. sp. Zone (Famennian UD IV-B)

In summary, *Phacoiderhynchus antiatlasicus* is found in a restricted area of southern Morocco (Maïder and eastern Draa Plains). The age of the species is Famennian UD III-B to UD IV-B. Its presence in Central Morocco cannot be dismissed (see above).

The present study does not allow confirmation of the following statement by SARTENAER & XU (1989, p. 38): “the specimens from the do IV [read: lower part of do IV] are shorter than the specimens from do V [read: upper part of do IV].”

Acknowledgments

The author is grateful to R.T. Becker, Berlin, and V. Ebbighausen, Odenthal, who put their collections at his disposal, and provided the fundamental stratigraphical information in terms of the cephalopod zonation. He also wishes to express his thanks to R.T. Becker, J.L. García-Alcalde, and two anonymous reviewers, for critically reading the manuscript, and for their helpful comments. The author is also greatly indebted to the late J. Drot, Paris, who showed him the collection on which she based her description of *Pseudoleiorhynchus undulatus*, and to P. Morzadec, Rennes, who kindly sent him the specimens of *Planovatiostrum* sp. from the Immuouzer du Kandar inlier (Central Morocco).

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Typescript submitted June 30, 1999

Revised typescript submitted June 13, 2000

Explanation of Plates 1 and 2

All figures are natural size

Phacoiderhynchus antiatlasicus n. gen., n. sp.

- Figs. 1-5 — Paratype Q, IRScNB a11090. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 5/4; 0; 5/6.
Figs. 6-10 — Paratype I, IRScNB a11082. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 7/6; 0; 5/6.
Figs. 11-15 — Paratype R, IRScNB a11091. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 4/5.
Figs. 16-20 — Holotype, MB.B.1309. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 6/5; 0; 4/5 and 5/6.
Figs. 21-25 — Paratype J, IRScNB a11083. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 3/4 and 4/5.
Figs. 26-30 — Paratype C, IRScNB a11076. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 3/4 and 4/5.
Figs. 31-35 — Paratype G, IRScNB a11080. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 4/5 and 5/6.
Figs. 36-40 — Paratype H, IRScNB a11081. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 4/5.
Figs. 41-45 — Paratype S, IRScNB a11092. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 4/5 and 5/6.
Figs. 46-50 — Paratype D, IRScNB a11077. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 6/5; 0; 3/4 and 4/5.
Figs. 51-55 — Paratype E, IRScNB a11078. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 4/5.
Figs. 56-60 — Paratype B, IRScNB a11074. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 4/3; 0; 5/6 and 6/7.
Figs. 61-65 — Paratype F, IRScNB a11079. Ventral, dorsal, frontal, apical, and lateral views. Costal formula: 3/2; 0; 3/4 and 4/5.

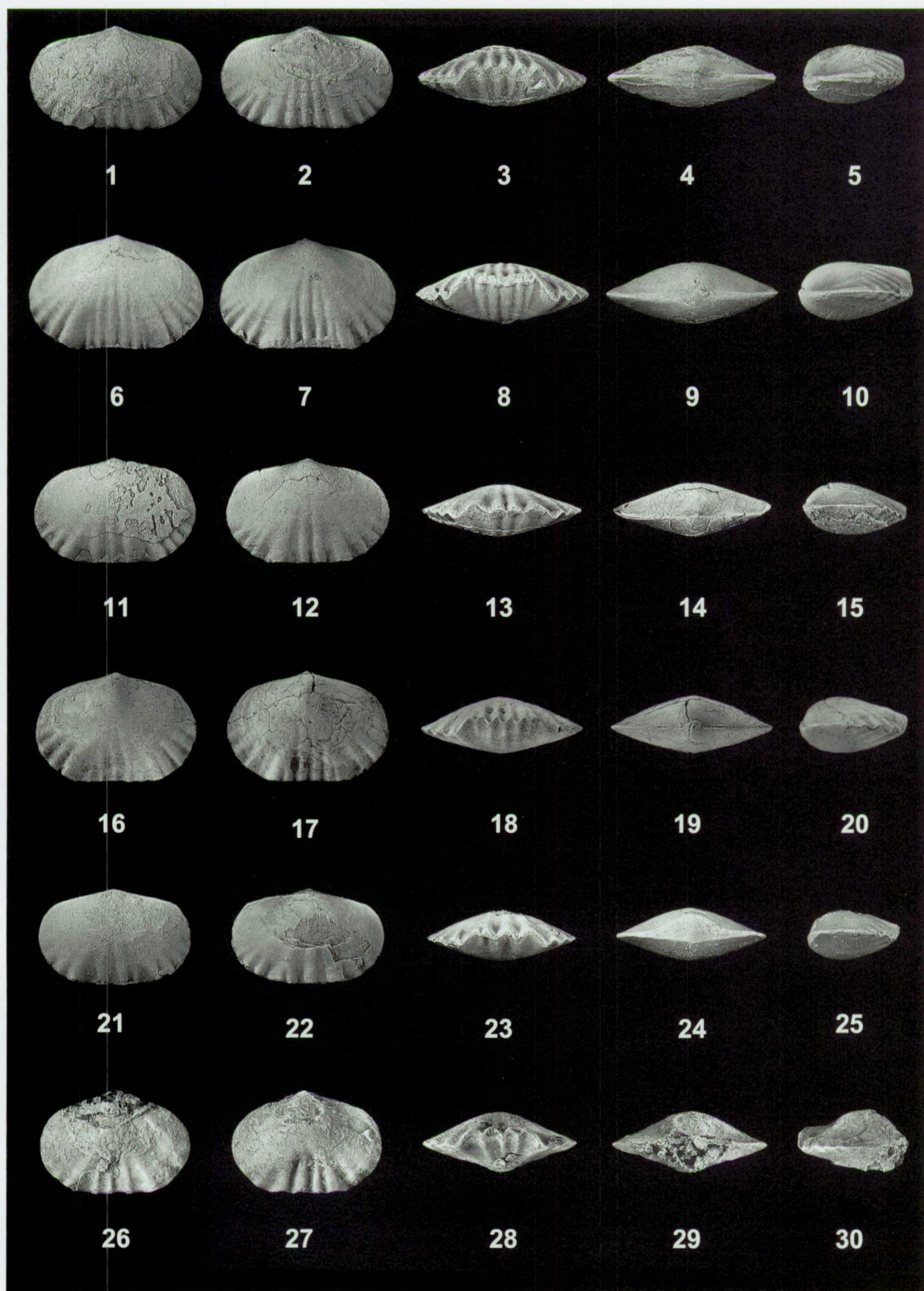


PLATE 1

