THE CRETACEOUS AMMONITE *EOPACHYDISCUS* AND THE ORIGIN OF THE PACHYDISCIDAE

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ABSTRACT. *Eopachydiscus* Wright, 1955 is confirmed as the earliest, Upper Albian representative of the Pachydiscidae, derived in all probability from a bullate member of the Beaudanticeratinae and giving rise to the Cenomanian-Coniacian *Lewesiceras* Spath, 1939. Nuclei of *Eopachydiscus* are ribbed, tuberculate, and constricted, showing even at this stage and date typical pachydiscid ornament; the evolution of *Lewesiceras* simply involved retention of these features into middle growth. The suggestion that the Pachydiscidae arose from *Arrhaphoceras* Whitehouse, 1927 of the Hoplitinae is discounted on morphological, stratigraphical, and biogeographical grounds.

THE family Pachydiscidae Spath, 1922, is among the most important of late Cretaceous ammonites groups, having a cosmopolitan distribution in Turonian to Maastrichtian time. It includes some of the largest and the youngest normally coiled ammonites. In spite of this importance, the early history and origins of the group are ill-documented. In introducing the subfamily Pachydiscinae Spath (1922, p. 120) simply referred to it as 'a subfamily that includes a number of developments of *Puzosinae*'.

Wright (1955, p. 566) noted that the earliest admitted pachydiscid was *Lewesiceras*, and suggested that the earliest species of this genus was the *Pachydiscus* sp. of Pervinquière (1910, p. 37, pl. 12, figs. 1-3), and that the origins of this genus, and the family, lay in his new genus *Eopachydiscus* (type species *Pachydiscus laevicaniculatus* Lasswitz *ex* Roemer ms., 1904, p. 236, pl. 15, fig. 2; text-figs. 8, 9). Wright also pointed out that *Ammonites brazoensis* Shumard, 1860 (p. 594) was probably an inflated form of the species, and that the poorly known *A. marcianus* Shumard, 1854 (p. 183, pl. 4, fig. 5) might be the inner whorls of the same species, and have priority.

In 1979 Wiedmann and Schneider (p. 667, pl. 9, fig. 6; text-figs. 9A-B) described a new species of *Lewesiceras*, *L. cenomanense*, from the Cenomanian of Mülheim-Broich in Westphalia, and suggested that the pachydiscids might be derived from the hoplitid genus *Arrhaphoceras* instead of from unknown desmoceratids.

In order to clarify the origins of this group, we describe below the early development of *Eopachydiscus* on the basis of pyritic nuclei and limestone moulds from the Upper Albian of Texas that in our view confirm its pachydiscid affinities and the desmoceratacean origins of the Pachydiscidae.

SYSTEMATIC PALAEONTOLOGY

Superfamily DESMOCERATACEAE Zittel, 1895

[*nom. transl.* Wright and Wright, 1951 (ex Desmoceratidae Zittel, 1895)]

Family PACHYDISCIDAE Spath, 1922

[*nom. transl.* Spath, 1923, ex Pachydiscinae Spath, 1922]

Genus EOPACHYDISCUS Wright, 1955, p. 570

Type species. Pachydiscus laevicaniculatus Lasswitz, *ex* Roemer ms., 1904, p. 236 (16), pl. 15 (3), fig. 2; text-figs. 8, 9, by original designation = *Ammonites marcianus* Shumard, 1854, p. 183, pl. 4, fig. 5. Upper Albian of Texas.

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Diagnosis. Large, rather inflated to compressed, moderately involute. Sides convex, venter more or less narrowly rounded. Nuclei depressed, with primary ribs, bullate or not, and associated constrictions, with or without intercalated ribs. This variable ornament persists into middle growth, when the whorls become progressively higher. Ornament may decline on the body chamber. Suture with broad, open, minutely frilled elements and numerous auxiliaries.

Occurrence. The genus characterizes the '*Eopachydiscus brazoensis*', rightly *E. marcianus*, Zone in the Upper Albian of Texas, and is especially abundant in the Duck Creek Formation in north Texas. It ranges from west Texas/Chihuahua (El Paso-Ciudad Juarez area) up into New Mexico and northern Colorado (W. A. Cobban, pers. comm.). The *marcianus* (= *brazoensis*) Zone is approximately equivalent to part of the European *Mortoniceras inflatum* Zone. Matsumoto (1979, p. 31) has recorded a probable *Eopachydiscus* from the Cenomanian of southern India.

Eopachydiscus marcianus (Shumard, 1854)

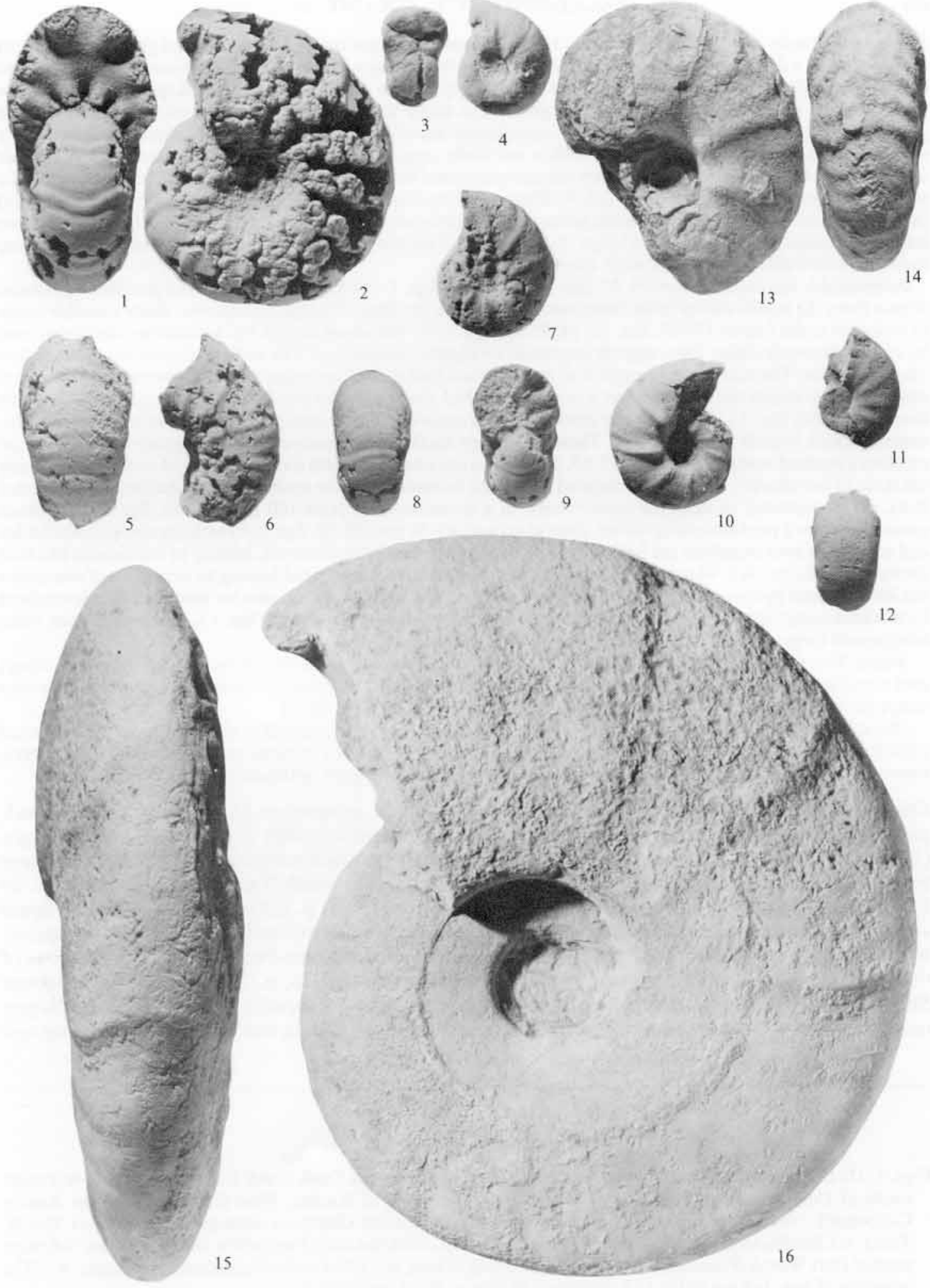
Plates 67, 68; text-fig. 1*b*, *c*

1854 *Ammonites marcianus* Shumard, p. 183, pl. 4, fig. 5.
1860 *Ammonites brazoensis* Shumard, 1860, p. 594.
1904 *Pachydiscus laevicaniculatus* F. Roemer Manuscript; Lasswitz, p. 236 (16), pl. 15 (3), fig. 2; text-figs. 8, 9.
1919 Gateposts and flower bed in Forest Park, built of the large ammonite, *Desmoceras brazoense* . . . Adkins and Winton, pl. 4, fig. 2.
1920 *Desmoceras brazoense* (Shumard); Adkins and Winton, pp. 18, 35, pl. 2, figs. 1-2.
1920 *Desmoceras* sp. A. Adkins and Winton, p. 35, pl. 2, fig. 3.
1923 *Pachydiscus*? sp. Reeside, p. 205, pl. 49, fig. 1.
1925 *Desmoceras brazonse* [*sic*] Winton, pl. 4, fig. 1.
1925 *Desmoceras brazoense* (Shumard); Bullard, pl. 20, figs. 1-2.
1926 *Desmoceras brazoense* (Shumard); Bullard, pl. 16, fig. 1.
1927 *Desmoceras brazoense* (Shumard); Adkins, p. 44, pl. 6, fig. 2.
1927 *Desmoceras laevicaniculatum* (Roemer); Adkins, p. 44, pl. 6, fig. 1.
1928 *Desmoceras* (?) *brazoense* (Shumard); Adkins, p. 220, pl. 9, fig. 2.
1928 *Desmoceras* (?) *laevicaniculatum* (Roemer); Adkins, p. 220, pl. 9, fig. 1.
1928 *Desmoceras* (?) *marcianum* Shumard, 1854; Adkins, p. 221.
1955 *Pachydiscus laevicaniculatus* Lasswitz ex Roemer ms.; Wright, p. 570.
1955 *Desmoceras brazoense* Shumard; Wright, p. 571.
1955 *Ammonites marcianus* Shumard; Wright, p. 571.
1957 *Eopachydiscus laevicaniculatus* (Lasswitz); Wright, p. L377, fig. 493, 1.
1960 *Eopachydiscus brazoense* (Shumard); Perkins, p. 26, pl. 10, fig. 1.
1979 *Eopachydiscus marcianus* (Shumard, 1854); Matsumoto, p. 37.
1979 *Eopachydiscus laevicaniculatus* (Roemer); Wiedmann and Schneider, p. 667.

Type. The holotype, by monotypy, is the original of Shumard 1854, p. 183, pl. 4, fig. 5, from 'cretaceous strata of Cross-Timbers, Texas'. The specimen has not been traced but the figure, albeit of a poor specimen shows clearly enough the nature of the species at an early growth stage. For further discussion see below (p. 658).

EXPLANATION OF PLATE 67

Figs. 1-16. *Eopachydiscus marcianus* (Shumard, 1854). 1-12, pyritic nuclei. 1, 2, from the Duck Creek Formation on the site of the Denison Dam, Grayson County, Texas, ×2. 3-12, from the same Formation north of Denison, Grayson County, Texas (Renfro Collection), ×2. 13-16, limestone moulds of septate juveniles from the same Formation; 13-14, from USGS locality 17904 on the eastern side of the eastern end of the Sierra Priata in the Sierra Diabolo Mountains, Texas, ×1. 15-16, from the 'Portland Cement Company strip pit north of Fort Worth, Texas' (ex Renfro Collection), ×1. All specimens are in the U.S. National Museum, Washington D.C.



KENNEDY, WRIGHT and CHANCELLOR, *Eopachydiscus*

Description. Nuclei up to 20 mm (Pl. 67, figs. 1-12). The earliest stages visible are smooth and globose. Ornament first appears at a diameter of approximately 2 mm, when the coiling is involute with a deep conical umbilicus and depressed reniform whorl section (Pl. 67, figs. 3, 4). There are five to seven variably developed umbilical bullae per half whorl (Pl. 67, figs. 7, 10, 11). These give rise to single thin or broad distant prorsiradiate and straight primary ribs. These initially die out over the ventrolateral shoulder (Pl. 67, figs. 11, 12), but as size increases they extend, sweeping across the shoulders with a markedly concave course to cross the venter with a distinct convexity (Pl. 67, figs. 8, 9). These primary ribs are associated with a weak to obsolete adapical constriction and a stronger adapertural one (Pl. 67, figs. 1, 8, 9). There may also be shorter, weaker intercalated ribs, arising around mid-flank, a maximum of three between primaries in a specimen 12·5 mm in diameter, five in a fragment with an estimated diameter of 18 mm (Pl. 67, figs. 5, 6). These are most obvious in inflated forms; some less-depressed individuals lack all but a trace of weak intercalatories.

Juveniles 45-160 mm diameter (Pl. 67, figs. 13-16; Pl. 68, figs. 1-11). Our material shows a gap between 20 and 45 mm from the pyritic nuclei to the limestone moulds. The smallest of the latter, however, show a similar range in variation to the former (Pl. 67, figs. 13, 14; Pl. 68, figs. 1-5). The whorl section has become less depressed, and by 45 mm diameter varies from slightly depressed to slightly compressed. The coiling remains involute, with a deep umbilicus. The maximum breadth is at the umbilical bullae or close to the umbilical shoulder with swollen inner and convergent outer flanks and a narrowly arched venter. At one extreme of ornament is the specimen shown in Pl. 67, figs. 13-14, which has distinct distant umbilical bullae that give rise to rounded flexuous ribs, some of which branch from the bulla. These ribs sweep markedy forwards over the ventrolateral shoulders to produce a marked ventral convexity (Pl. 67, fig. 14) and are associated with a strong adapical constriction. There are three to five shorter, weaker, intercalated ribs. With increasing size the umbilical bulla declines, but the inner flank rib strengthens, as does the constriction, to a diameter of at least 100 mm (Pl. 68, figs. 9-11). Other specimens show a predominantly ribbed stage at around 45-90 mm (Pl. 68, figs. 1-8) without conspicuous bullae and with up to nine primaries per half whorl and only one or two intercalatories, leading to individuals like that shown in Pl. 68, figs. 4, 5, where the intercalated ribs have already disappeared leaving an ornament of numerous bar-like flexuous primaries and constrictions. Pl. 68, figs. 6-8 shows a larger, slender specimen of intermediate form with a compressed whorl, many primaries, and weak secondary ribs; Pl. 67, figs. 15-16 shows an even more compressed form with almost obsolete ribs and prominent constrictions.

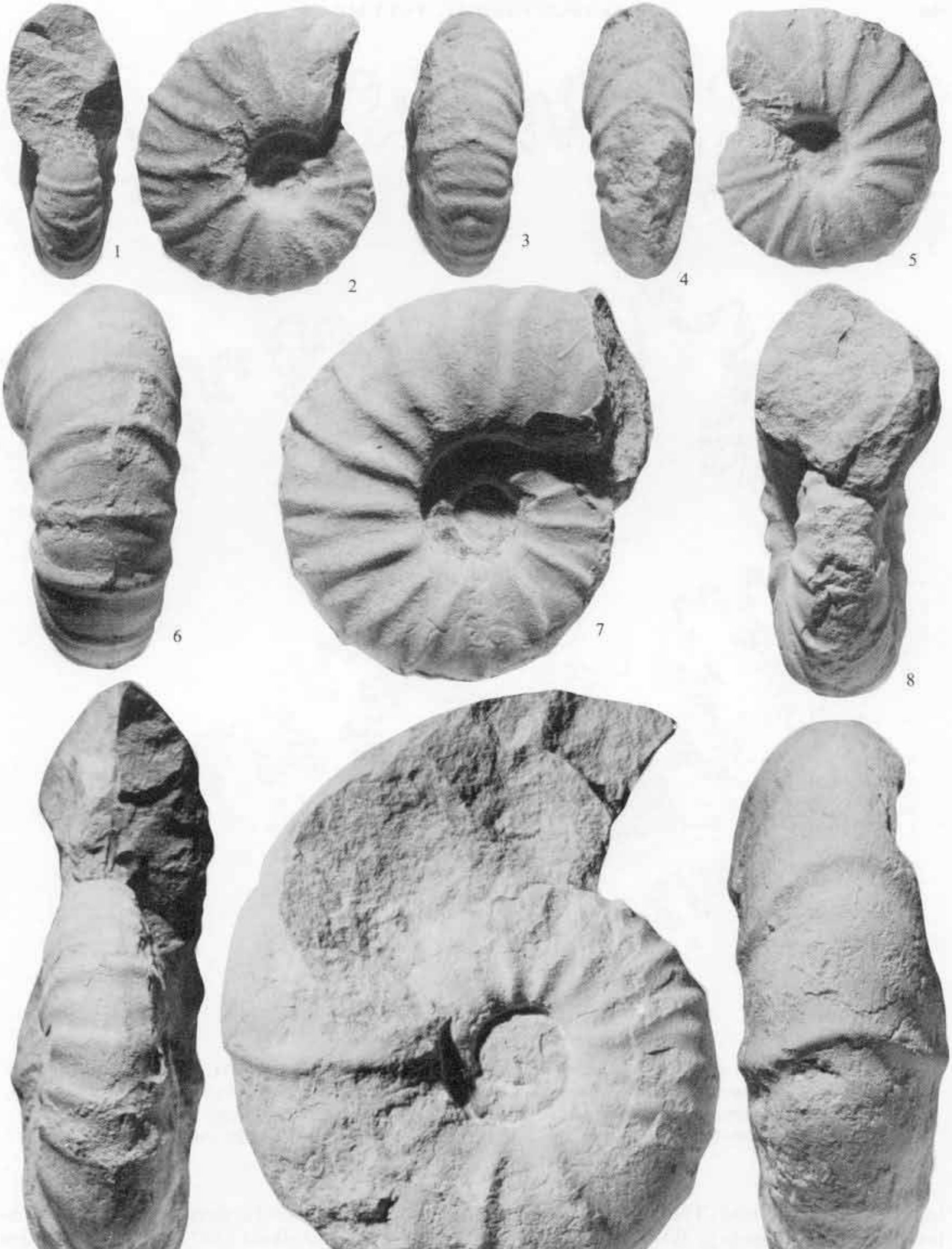
Adults. This species reaches diameters of almost half a metre and becomes increasingly compressed with a high oval whorl and narrowly rounded venter. Primary flank ribs persist in some (e.g. Adkins 1928, pl. 9, fig. 2) or may disappear before the end of the phragmocone (e.g. Adkins, 1928, pl. 9, fig. 1).

The suture line of a juvenile specimen is shown in text-fig. 1*b*. E is broad and slightly shallower than a broad trifid L, E/L narrow and bifid, L/U_2 asymmetrically bifid with a series of small auxiliaries. A mature suture, shown in text-fig. 1*c*, maintains the same pattern, with intense frilling of both lobes and saddles.

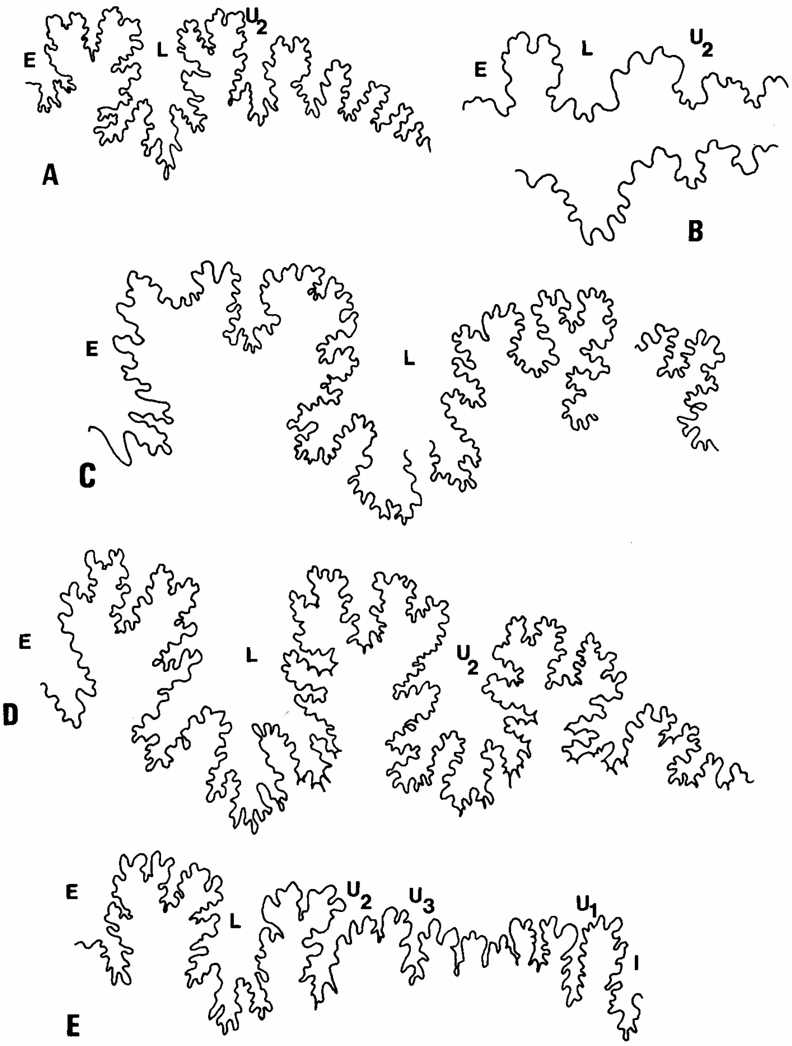
Discussion. Ammonites marciana Shumard, the senior name assigned to Upper Albian Duck Creek pachydiscids, was based on a single poorly preserved nucleus less than 30 mm in diameter. Cragin (1893, p. 237) stated 'It is not unlikely that Shumard's *Ammonites marciana* was based on a very young specimen of this species' [*Pachydiscus brazoensis*, Shumard]. Two years later (1895, p. 54 footnote) he considered it identical with *brazoense*. Adkins (1928, p. 221) said that Shumard's figure and description of *marcianum* 'might refer to the juvenile, strongly ribbed form which is widespread in the basal Duck Creek of North-Central Texas and northern Trans-Pecos Texas. The relations of this form to other species are as yet undetermined.' Adkins (1928, p. 220) said of *A. brazoensis* Shumard that 'Shumard's description leaves little doubt as to the identity of this species: his largest individual, in the State Geological Survey (Shumard Survey at Austin was 21 inches in diameter and

EXPLANATION OF PLATE 68

Figs. 1-11. *Eopachydiscus marcianus* (Shumard, 1854). 1-3, from the Duck Creek Formation twenty-five miles north of Fort Worth on Highway 81, about one mile north of Rhome, Wise County, Texas (ex Renfro Collection). 4-8, from the same Formation, 'Portland Cement Company strip pit north of Fort Worth, Texas' (ex Renfro Collection). 9-11, Wright's Collection, from the same Formation on Duck Creek '0·6 miles west of Fort Worth-Primrose Road, Tarrant County, Texas' (ex J. P. Conlin Collection). All figures × 1. The originals of figs. 1-8 are in the U.S. National Museum, Washington D.C.



KENNEDY, WRIGHT and CHANCELLOR, *Eopachydiscus*



TEXT-FIG. 1. A, suture of *Uhligella subornata* Casey, 1949 (after Casey 1961, text-fig. 51*c*). × 3. B–C, sutures of *Eopachydiscus marcianus* (Shumard, 1854); B, from a pyritic juvenile, × 12·5; C, from a limestone mould, × 3. D, *Lewesiceras mantelli* Wright and Wright, 1951 (after Matsumoto 1979, text-fig. 1), × 3. E, *Arrhaphoceras studeri* (Pictet and Campiche, 1860) (after Renz 1968, text-fig. 11*a*), × 3.

had 10 or 11 broad ribs'. This species is so abundant in the Duck Creek Limestone as to reach rock-forming proportions (e.g. Winton and Adkins 1919, pl. 4, fig. 2; Adkins 1927, text-fig. 4; Perkins 1961, p. 26, pl. 10, fig. 1). All the collections we have seen include both the strongly ornamented form (*A. brazoensis* Shumard) and the feebly ribbed and constricted form (*P. laevicaniculatus* Lasswitz) and this is confirmed by the observations of the late James P. Conlin of Fort Worth (*in litt.*). We conclude that they are the same species. Conlin (*in litt.*) suggested that the two forms might be dimorphs, but we are unable to confirm this.

The juvenile material described here confirms Cragin's opinion that *marcianus* was the nucleus of the species whose adults were subsequently described by Shumard as *brazoensis*. Despite the poor preservation of the holotype of *marcianus* and the absence of a figure of any of the syntypes of *brazoensis* the evidence of conspecificity is perfectly good and there is no reason not to use the earliest specific name among the three synonyms.

Occurrence. Duck Creek Limestone, Upper Albian, *Eopachydiscus marcianus* Zone and correlatives in Texas, Chihuahua, New Mexico, and northern Colorado.

DISCUSSION

Our redescription of *E. marcianus* shows that the genus *Eopachydiscus* has a typically desmoceratacean suture and a ribbing style and constrictions that recall the strongly ornamented *Uhligella* Jacob, 1907 (Beudanticeratinae).

Uhligella (see Casey 1961, p. 160 for a discussion of this genus, and text-fig. 1A for a suture) ranges from the Upper Aptian at least to the lower part of the Middle Albian, and is known from western and central Europe, North Africa, and Venezuela, so that it is both chronologically and geographically a potential ancestor.

The link from *Eopachydiscus* to later Pachydiscinae is via *Lewesiceras* Spath, 1939 (see Wright 1979 and Wright and Kennedy 1981 for a review of this genus). The nuclei of *Eopachydiscus* figured here are so similar to the innermost whorls of *Lewesiceras* in whorl section and ornament that the transition between the two involved no more than the retention of the ornament of the young of the former into the middle growth of the latter. The sutures of the two show close similarities (text-fig. 1). The precise line between *Eopachydiscus* and *Lewesiceras* is not known, for the two genera are rare between the low Upper Albian acme of the former and the Lower Turonian acme of the latter. However, Young's specimen of *Lewesiceras* from the Buda Limestone of Cormal County, Texas (Young 1979), the Pervinquière material from the Cenomanian of Algeria (1910, p. 37, pl. 12, figs. 1–3), *Lewesiceras cenomanense* from the Lower Cenomanian of Westphalia (Wiedmann and Schneider 1979, p. 667, pl. 9, fig. 6, text-fig. 9A–B), and Matsumoto's record of *Eopachydiscus* from southern India (1979, p. 31) indicate the persistence of the stock.

Derivations from *Arrhaphoceras*, proposed by Wiedmann and Schneider (1979), presents a number of problems. *Arrhaphoceras* has a suture that is consistently simpler than either *Eopachydiscus* or *Lewesiceras* (text-fig. 1E), never develops constrictions, and has ventrolateral tubercles (see Renz 1968, pl. 2, figs. 20–22; pl. 3, figs. 1–4, 6–11; pl. 4, figs. 1–3). It is also a younger genus than *Eopachydiscus*, clearly linked to the older Hoplitinae of the Old World Boreal realm. These stratigraphic and morphologic criteria are sufficient to eliminate it, in our view. Furthermore, it is difficult to see a group unknown outside the Old World during the late Albian giving rise to *Lewesiceras* which appears in the early Cenomanian of both North Africa and North America.

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