Berliner paläobiologische Abhandlungen	10	61-128	Berlin	2009-11-11

Upper Givetian ammonoids from Dar Kaoua (Tafilalt, SE Anti-Atlas, Morocco)

Jürgen Bockwinkel [1], Ralph Thomas Becker [2] & Volker Ebbighausen [3]

Abstract: The Upper Givetian at Dar Kaoua (Tafilalt, SE Anti-Atlas, Morocco) yielded regionally the best preserved ammonoid fauna from the widespread Lower Marker Bed (*disparilis* conodont zone) of the pelagic Tafilalt Platform. It is currently the richest ammonoid assemblage of the *Synpharciceras clavilobum* Zone (MD III-C) on a global scale and dominated by members of the Pharciceratidae and Taouzitidae (Agoniatitida). The Tornoceratidae (Goniatitida) are represented by few *Epitornoceras mithracoides* Frech, 1888. *Timanites meridionalis* Petter, 1959 is an important index species of the Lower Marker Bed and the type species of the oxyconic *Darkaoceras* n. gen. (Taouzitidae) with two outer U-lobes. *Keuppites singulus* n. gen. n. sp., named in honor of the renown ammonoid specialist H. Keupp, is a very rare related form with additional umbilical lobes. The Pharciceratidae are divided into evolute to subinvolute Pharciceratinae and the involute Synpharciceratinae. *Pharciceras* Hyatt, 1884, which has four umbilical lobes and a biphasic post-embryonal conch ontogeny, is represented by *Ph. tridens* (Sandberger & Sandberger, 1850), *Ph. evolvens* n. sp., *Ph. lateseptatum* (Frech, 1902), *Ph.* aff. *lateseptatum*, *Ph. pargai* Montesinos & Henn, 1986 (with three morphotypes), *Ph. darkaouense* n. sp., and *Ph. kayseri* Wedekind, 1918. Subevolute, discoidal pharciceratids with three internal and two or three external umbilical lobes fall in *Extropharciceras* n. gen., with the type-species *Ex. conex* n. sp., and also with *Ex. librum* n. sp. and *Ex. arenicum* (Petter, 1959). *Lunupharciceras* Korn & Klug, 2002 is restricted to taxa with evolute, serpenticonic whorls, at least until median stages, and with three external but only two internal U-lobes. The genus is represented by *Lun. serpentinum* n. sp. whilst the generic position of the more multilobed *?Lun. nejjakhense* n. sp. is open. *Stenopharciceras* Montesinos & Henn 1986, is restricted to the involute and compressed group around its type-species, *St. kseirense* (Termier & Termier, 1950). *St. protectum* n. sp. is characterized by umbilical shell extensions (flares) that completely seal the umbilicus. The same feature is typical for *Synpharciceras*, which is represented by the rather variable *Syn. clavilobum* (Sandberger & Sandberger, 1850) and *Syn. spirale* n. sp. *Clariondites tegoideus* n. gen. n. sp. is the phylogenetic link between the Pharciceratinae (*Extropharciceras* n. gen.) and Petteroceratidae (with three external lobes).

Zusammenfassung: Das Ober-Givetium von Dar Kaoua (Tafilalt, SE-Anti-Atlas, Marokko) erbrachte regional die am besten erhaltene Ammonoideen-Fauna aus dem weit verbreiteten “Lower Marker Bed” (*disparilis*-Conodontenzone) der pelagischen Tafilalt-Plattform. Es handelt sich weltweit gesehen um die diverste Ammonoideen-Vergesellschaftung der *Synpharciceras clavilobum*-Zone (MD III-C), welche durch Vertreter der Pharciceratidae und Taouzitidae (Agoniatitida) dominiert wird. Die Tornoceratidae (Goniatitida) werden nur durch wenige Exemplare von *Epitornoceras mithracoides*, Frech 1888 vertreten. *Timanites meridionalis* Petter, 1959 ist eine wichtige Leitart des „Lower Marker Bed“ und die Typus-Art von *Darkaoceras* n. gen. (Taouzitidae) mit zwei externen U-Loben. *Keuppites singulus* n. gen. n. sp. wird zu Ehren des angesehenen Ammonoideen-Spezialisten H. Keupp für eine verwandte Form mit zusätzlichen Umbilicalloben eingeführt. Die Pharciceratidae werden in die evoluten-subinvoluten Pharciceratinae und die involuten Synpharciceratinae geteilt. *Pharciceras* Hyatt, 1884 besitzt vier Umbilicalloben und eine zweiphasige post-embryonale Gehäuseontogenie. Die Gattung wird durch *Ph. tridens* (Sandberger & Sandberger, 1850), *Ph. evolvens* n. sp., *Ph. lateseptatum* (Frech, 1902), *Ph.* aff. *lateseptatum*, *Ph. pargai* Montesinos & Henn 1986 (mit drei Morphotypen), *Ph. darkaouense* n. sp., und *Ph. kayseri* Wedekind, 1918 repräsentiert. Subevolute, discoidale Pharciceraten mit drei inneren und zwei-drei externen U-Loben werden zu *Extropharciceras* n. gen. gestellt, mit der Typus-Art *Ex. conex* n. sp., sowie mit *Ex. librum* n. sp. und *Ex. arenicum* (Petter, 1959). *Lunupharciceras* Korn & Klug, 2002 wird auf Taxa mit weitnabeligem, serpenticonem Gehäuse, zumindest bis zu mittleren Gehäusestadien, und mit drei externen, aber nur zwei internen U-Loben beschränkt. Die Gattung wird repräsentiert durch *Lun. serpentinum* n. sp. während die generische Position von *?Lun. nejjakhense* n. sp. mit weiteren Loben gegenwärtig unklar ist. *Stenopharciceras* Montesinos & Henn, 1986 wird auf involute Verwandte der Typus-Art *St. kseirense* (Termier & Termier, 1950) beschränkt. *St. protectum* n. sp. besitzt bezeichnende umbilicale Schalenlamellen, welche den Nabel komplett

verschliessen. Das gleiche Merkmal ist typisch für *Synpharciceras*, welches durch das variable *Syn. clavilobum* (Sandberger & Sandberger, 1850) und durch *Syn. spirale* n. sp. vertreten ist. *Clariondites tegoideus* n. gen. n. sp. ist eine phylogenetische Zwischenform zwischen den Pharciceratinae (*Extropharciceras* n. gen.) und den Petteroceratidae mit drei Externloben.

Keywords: Ammonoids, Devonian, taxonomy, stratigraphy, Morocco

Address of the authors:

1 J.Bockwinkel, Dechant-Fein-Str. 22, D-51375 Leverkusen. E-mail: jbockwinkel@t-online.de

2 R. Th. Becker, Westfälische Wilhelms-Universität, Institut für Geologie und Paläontologie, Corrensstr. 24, D-48149 Münster. E-mail: rbecker@uni-muenster.de

3 V. Ebbighausen, Engstenberger Höhe 12, D-51519 Odenthal. E-mail: volker@vxr.de

Introduction

Through most of the Middle Devonian, ammonoids developed a wide range of shell forms, such as the fast expanding and brevidomic agoniatitids, or the slowly expanding, longidomic anarcestids, but sutures remained relative simple and widely rounded flank lobes predominated. In the short-lived Eifelian *Exopinacites* a maximum of ten lobes was reached by the introduction of secondary external and umbilical lobes. A similar level of septal complexity, but with pointed flank lobes, appeared near the Eifelian-Givetian boundary (Walliser et al. 1995) with the oldest Maenioceratidae. At the end of the Middle Givetian, in the course of the global Taghanic Crisis (Aboussalam & Becker 2001, Aboussalam 2003), multilobed forms with complexly folded septa appeared suddenly and radiated rapidly, forming the families Pharciceratidae and Taouzitidae. Eventually this led for a short time to a level of unprecedented sutural complexity (Becker 2009) that was kept subsequently, in the basal Frasnian, only by rare last survivors (*Neopharciceras*) and by the homoeomorphic, ribbed Triainoceratidae. Because of similar shell form and sutures, especially because of the proliferation of umbilical lobes out- and inside the umbilical seam, the Upper Givetian multilobate goniatites were assigned at the turn from 19th to the 20th century to the Carboniferous prolecanitids (e.g., Frech 1887a, Zittel 1895, Foord & Crick 1897, Denckmann 1900) although no Famennian phylogenetical links were known. As first suggested by Vöhringer (1960), and recently well documented by Korn et al. (2003), the latter arose independently at the base of the Carboniferous from the Prionoceratidae (Goniatitida), which possess adventitious lobes. The Upper Givetian Pharciceratidae and related or derived families were not only the first ammonoids with complex septal structures and shell ontogenies, but they are even more remarkable since they were restricted to a clearly defined and rather narrow time interval between the global Taghanic and Frasnes Crises. The sudden and drastic increase of septal complexity must mirror some important change of global outer shelf environments at the end of the Givetian (*Pharciceras* Stufe of House 1985) that is not yet understood but evidence for climatic overheating followed by cooling has been presented by Joachimski et al. (2004).

Since the early discoveries in the Rhenish Massive (von Buch 1832, Beyrich 1837, Sandberger & Sandberger 1850) and in the Montagne Noire (Frech 1887a), Upper Givetian pharciceratid faunas have been recorded, often without any description, from the Harz Mountains (Beushausen 1900), Sudetes of Poland (Bederke 1929), the Graz area of Austria (Heritsch & Schouppé 1941, Flügel 1947), the Cantabrian Mountains (Henn 1985, Montesinos & Henn 1986), Pyrenees (Kullmann 1973), Celtiberia (Walliser in Carls 1989), New York State (recent review in House & Kirchgasser 2008), Kentucky (Work et al. 2007), the Tafilalt (Termier 1929, Schindewolf 1940, Termier & Termier 1950, Petter 1959) and Maider (Hollard 1974) of SE Morocco, the Dra Valley of SW Morocco (Bensaid 1974), the Ougarta Mountains (Menchikoff 1930), Saoura Valley (Petter 1951, 1959, Göddertz 1987), Ahnet (Follot 1952) and Ben Zireg regions (Menchikoff 1936) of Algeria, from the Rudnyi Altai (Bogoslovskiy 1958, 1969, Borisenkov 2002) along the Kazakhstan-Russian border, and from Guangxi, South China (Ruan 1978, 1981). It is remarkable that these occurrences are concentrated in the western Prototethys realm, with only low-diversity extensions into the Appalachians and central to southeastern Asian seaways, but not into the Urals Ocean. Questionable records from the Lower Frasnian of West Virginia (House 1978) are rejected here. Upper Givetian ammonoid faunas from the Canadian Rocky Mountains (House & Pedder 1963) include only early members of the Acanthoclymeniidae (*Pseudoprobeloceras*, *Ponticeras*). There are no records from the Great Basin of the Western United States. Alleged ”Prolecanitidae in Devonian limestones” from the Klamath Mountains, California (Diller 1903), are in fact based on Triassic ammonoids (pers. comm. A. Boucot).

Following the early reports by Termier (1929) and Clariond (1934, 1935), many localities with pharciceratid faunas of the SE Anti-Atlas were mentioned in Termier & Termier (1950), Petter (1959), Massa (1965), Bensaid (1974), and Bensaid et al. (1985). Although it became clear that the Tafilalt is the best region on a global scale to study rich pharciceratid successions, their faunas were never documented in fine detail. Becker & House (2000a, 2000b, 2000c) established briefly the refined Upper Givetian goniatite zonation of the region, which was correlated with the conodont zonation by Aboussalam & Becker (2005, 2007). But the full taxonomic composition of faunas has not yet been investigated and there is a wealth of undescribed and new taxa. This study concentrates on the fauna from Dar Kaoua in the central Tafilalt, where the wide-spread so-called Lower Marker Bed (Becker & House 2000a) yielded the richest and best preserved goniatite assemblage of its time. This documentation of the Dar Kaoua fauna will be the first step to describe all pharciceratid faunas of the Anti-Atlas, based on detailed morphometric analysis and on comparisons with German or Spanish types. Only the full knowledge will eventually allow to further elucidate other aspects, such as biodiversity changes at species level and precise biofacies and palaeobiogeographic comparisons between North African localities and with European faunas.

Locality, Fauna and Stratigraphy

The general Eifelian to Frasnian stratigraphy at Dar Kaoua, central Tafilalt, ca. 22 km SE from Erfoud, was first outlined by Choubert (1952). Becker (1993) described the Lower Famennian succession and ammonoid faunas, which was updated by Ebbighausen et al. (2002). The best collecting from the prominent and massive Lower Marker Bed is near the eastern end of Dar Kaoua (DK, see map and locality description in Becker 1993), at ca. x = 627.8, y = 478.7 (GPS N 31° 17.648 W 4° 3.352). The unit consists of solid, rather pure, grey micrites. The ammonoids show a slight reddish hematite impregnation of the shells. The phragmocones are either filled with matrix or by white orthosparite; the conch ontogeny is frequently well preserved. The composition of the ammonoid assemblage is distinctive since there are two dominant genera, *Darkaoceras* n. gen. and *Synpharciceras*, followed by moderately common *Pharciceras* and *Extropharciceras* n. gen. At the species level also only two forms are common, *D. meridionale* and *Syn. clavilobum*, followed by the moderately common *Pharciceras pargai*, *Ph. lateseptatum, Extropharciceras librum* n. gen. n. sp., *Ex. arenicum*, *Ex. conex* n. gen. n. sp., and *Synpharciceras spirale* n. sp. *Epitornoceras*, *Keuppites* n. gen., *Lunupharciceras*, *?Lunupharciceras*, *Stenopharciceras*, and *Clariondites* n. gen. are accessory rare genera each represented by single species and few specimens. Similarly rare are *Ph. tridens*, *Ph. evolvens* n. sp., *Ph. darkaouense* n. sp., and *Ph. kayseri*. The high diversity of rare ammonoid taxa contrasts with the sparse other macrofauna that consists only of rare phacopid trilobites, few small brachiopods, and a single breviconic nautiloid. Microfauna consists of styliolinids, ostracods, few agglutinating foraminiferes, and conodonts. The poor benthos points to a strongly oligotrophic, subphotic outer shelf setting of the central Tafilalt Platform, with an estimated water depths between 100 and 150 m.

The condensed Lower Marker Bed falls in the *Synpharciceras clavilobum* Zone (MD III-D). Aboussalam & Becker (2007, Tab. 2) documented a small conodont fauna of the *disparilis* Zone, including two *Klapperina* specimens, from Dar Kaoua goniatite residues. The low sedimentation rate and the fact that the unit represents a whole conodont zone suggest that it is “time-rich”. As a consequence “time-averaging” of the available goniatite collection has to be taken into consideration. Not all taxa must have co-existed, which could explain the rather high alpha diversity and the presence of rare phylogenetic intermediates between some forms. The poor outcrop of non-resistant beds does not allow to provide a detailed section log. The contact to the Middle Givetian is not well exposed. Limestones with *Sellagoniatites* follow at close distance below the Lower Marker Bed, which suggests an incomplete and very condensed sequence. Between the Lower Marker Bed and the dark grey Kellwasser Limestone equivalent there are ca. 10 m thick, discontinuously exposed marls and limestones. Loose single *Pseudoprobeloceras* and *Petteroceras* specimens show the presence of sparsely fossiliferous topmost Givetian strata.

Systematic Palaeontology

All types and figured specimens from Dar Kaoua are kept in the collection of the Museum für Naturkunde, Berlin, under the numbers MB.C.19101 to MB.C.19121. The following generic abbreviations are used: *Ph.* = *Pharciceras*, *St.* = *Stenopharciceras*, *Ex.* = *Extropharciceras* n. gen., *Lun.* = *Lunupharciceras*, *Syn.* = *Synpharciceras*, *D.* = *Darkaoceras* n. gen., *Ep.* = *Epitornoceras*. Shell parameters are as follows: dm = diameter, wh = whorl width, ah = apertural height, ww = whorl width, WER = whorl expansion rate, IZR = imprint zone rate (rate of whorl overlap). E = external/ventral lobe, A = adventitious flank lobe, L = lateral

lobe, U = umbilical lobe, I = internal/dorsal lobe, E_1-E_2- = median saddle, E_2-L- = ventral saddle; "plurilobes" refer to irregular, episodic or unilateral secondary incisions in saddles between U-lobes; they are not referred to in suture formules. The key for the description of shell features of Palaeozoic ammonoids, including an explanation of methods, will be published by D. Korn (in press). Zonal abbreviations (with MD = Middle Devonian) follow Becker & House (2000c). The used sutural terminology is explained in Korn et al. (2003).

Order Goniatitida Hyatt, 1884

Suborder Tornoceratina Wedekind, 1918 (nom. transl. Ruzhencev, 1957)

[Korn & Klug (2002) give authorship of this suborder to Wedekind (1914), which, however, includes on p. 10 only an "order Tornoceracea". Since synonymy rules only apply up to the family level of taxa, the naming of an order does not automatically provide a subsequent suborder authorship. Hence, Wedekind (1918) is the correct author of the suborder, named by him originally as "Tornoceracea". As noted in Wedekind (1918, p. 104), and based on Wedekind´s then still unpublished work, the term Tornoceratina first appears in Pompeckj (1912) but was referred to as "section" not as order, suborder or superfamily. Therefore, Pompeckj is not awarded authorship of the formal suborder Tornoceratina.]

Superfamily Tornoceratacea von Arthaber, 1911 (nom. transl. Ruzhencev, 1957)

Family Tornoceratidae von Arthaber, 1911 (nom. corr. Smith, 1913)

Subfamily Tornoceratinae von Arthaber, 1911 (nom. transl. Pompeckj, 1912)

***Epitornoceras* Frech, 1902a** (emend.)

Type species: *Goniatites mithracoides,* Frech 1888 (OD).

Diagnosis (emend.): Large to very large-sized; post-embryonic shell compressed and involute, with closed umbilicus, WER high, smooth apart from weakly biconvex growth lines; mature whorls with narrowly rounded to oxyconic venter. Sutures with deeply rounded and flexured A-lobe on outer flank, narrow, subacute to acute ventral saddle, and v-shaped, moderately deep E-lobe.

Included species:

Goniatites mithracoides Frech, 1888, Upper Givetian, Rhenish Massif.
Goniatites peracutus Hall, 1876, Upper Givetian to Lower Frasnian, New York State
Epitornoceras aff. *peracutum* in House (1965), Lower Frasnian, New York State
Epitornoceras aff. *peracutum* in House (1978), Lower Frasnian, West Virginia

Other taxa included by Frech (1902a) belong to Eifelian *Mithraxites* and Pinacitidae; the originally also included *Goniatites (Tornoceras) stachei* Frech, 1887b from the Carnic Alps is a nom. dub. The Upper Givetian of Morocco contains a new species that is slightly intermediate between *Ep. mithracoides* and *Ep. peracutum*.

Discussion: As emphasized by House (1978) and House & Kirchgasser (2008), the type-species is not oxyconic, not even at late maturity. Consequently, the diagnosis of the genus has to be expanded, with the shape of the flank lobe and ventral saddle becoming the main distinctive features that allow the separation from *Tornoceras*. The Lower Frasnian *Tornoceras arcuatum* House, 1965 from Michigan and New York State, including topmost Middle Givetian cf. specimens from the Upper Tully Limestone of New York State (House 1965, House & Kirchgasser 2008), is intermediate between *Tornoceras* and *Epitornoceras* and could be placed in either of the two genera. The shell has strongly converging flanks and the A-lobe is deeply flexured as in *Ep. mithracoides* but the ventrolateral saddle is still rounded. The homoeomorphic Lower Famennian *Oxytornoceras* Becker, 1993 is smaller-sized than *Epitornoceras* and possesses internal shell thickenings (mould constrictions). A second, still un-named Lower Famennian lineage of oxyconic tornoceratids described by Makowski (1991) has shallow A-lobes and may have been derived from *Phoenixites frechi* (Falcitornoceratinae).

Stratigraphical range: Topmost Middle Givetian (MD III-A) to Lower Frasnian (UD I-B).

Geographical distribution: Rhenish Massif (Frech 1888), Montagne Noire (House et al. 1985), Tafilalt (Becker 1993, p. 136) and Dra Valley (Aboussalam et al. 2004) of southern Morocco, Algeria (Ougarta, Petter 1959), New York State (Hall 1876), West Virginia (House 1978).

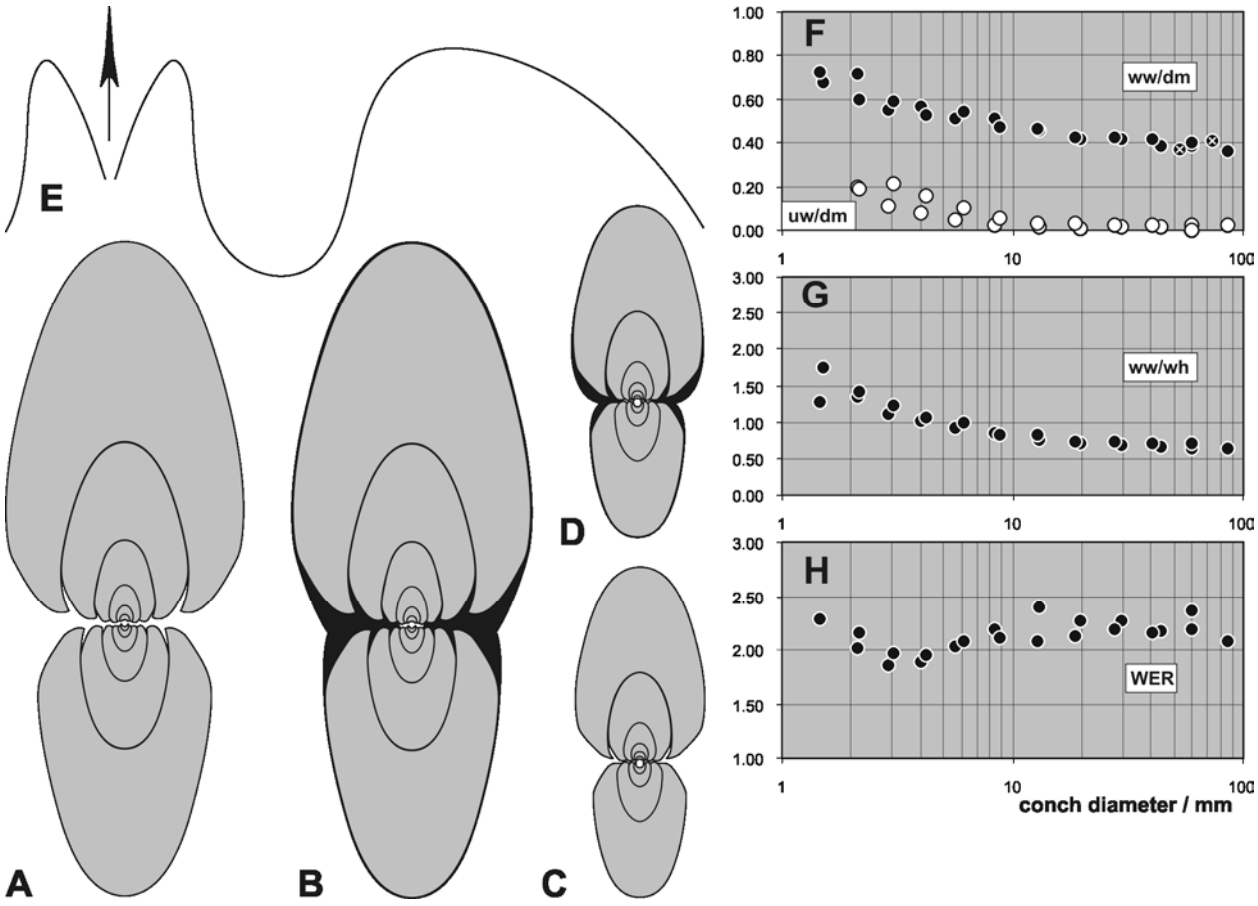


Fig. 1: *Epitornoceras mithracoides* (Frech, 1888) from Dar Kaoua. **A-B**. Cross sections of MB.C.19101.3, drawn without and with shell thickenings; x 1. **C-D**. Cross sections of MB.C.19101.2, drawn with and without shell thickenings; x 1. **E**. Suture of MB.C.19101.3 at 30 mm ww and 44 mm wh; x 1.5. **F-H**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all available specimens, plotting for comparison (crossed dots in Fig. F) the ww/dm ratios of Berlin syntypes.

***Epitornoceras mithracoides* (Frech, 1888)** (emend.)

Figs. 1A-H, 2

v	1887b	*Goniatites (Tornoceras) mithracoides* Frech: 433 [nom. nud.]
*v	1888	*Goniatites (Tornoceras) mithracoides* Frech: 30-31, pl. 2, figs. 1a-1ß
v	1902a	*Tornoceras (Epitornoceras) mithracoides* Frech: 51, fig. 14b1-2
v	1902b	*Tornoceras* (*Epitornoceras*) *mithracoides* Frech: 172
v	1928	*Goniatites (Tornoceras) mithracoides* Dienst: 105
cf. e.p.	1959	*Tornoceras (Tornoceras) simplex* Petter: 193, pl. XVI, fig. 3 [only]
v	1978	*Epitornoceras mithracoides* House: 60, pl. 10, figs. 2-3 [syntype re-illustration]
non	1985	*Epitornoceras mithracoides* House et al.: 5, figs. 5A-B
v	2000a	*Epitornoceras mithracoides* Becker & House: 28, 31
v	2000b	*Epitornoceras mithracoides* Becker & House: 53
v	2001	*Epitornoceras mithracoides* Aboussalam & Becker: fig. 3
e.p.	2002	*Epitornoceras mithracoides* Korn & Klug: 158 [non fig. 144T)
cf.	2008	*Epitornoceras* cf. *mithracoides* House & Kirchgasser: 170, text-fig. 57F

Fig. 2: *Epitornoceras mithracoides* (Frech, 1888), Dar Kaoua, MB.C.19101.1, adoral and lateral views; x 1.

Types: Syntype MB.C.469, Museum für Naturkunde, Berlin (see Dienst 1928), collected by C. Koch, figured by Frech (1888: pl. 2, figs. 1b, 1ß), re-illustrated by House (1978), is here designated as lectotype. The second, larger and incomplete syntype, now paralectotype, also collected by C. Koch and from the same locality, is also kept in Berlin (MB.C.470).

Type locality and horizon: Volpertseiche Mine near Eibach, geological sheet 5216 Oberscheld, Dill Syncline, southern Rhenish Massif; Roteisenstein-Grenzlager (hematite iron ore), Upper Givetian, undifferentiated.

Material: Three specimens (MB.C.19101.1-3).

Diagnosis (emend.): Large-sized, first whorls until ca. 4 mm dm weakly depressed and pachyconic, with falling WER values and rapidly closing umbilicus; subsequent whorls with ww/dm constantly decreasing from 0.6 to ca. 0.4; mature ww/wh ca. 0.7; with tegoid, thinly discoidal cross-section, fast expanding whorls (mature WER ca. 2.1 – 2.3), closed umbilicus, and narrowly rounded venter. Sutures with asymmetrically arched lateral saddle, deeply rounded, subsymmetric A-lobe on outer flank, very narrow, subacute ventral saddle that is as high as lateral saddle, and v-shaped, medium deep ventral lobe.

Tab. 1: Conch ontogeny of *Epitornoceras mithracoides* (Frech, 1888) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subinvolute (ww/dm = 0.60-0,70; uw/dm ~ 0.20)	weakly depressed; strongly embracing (ww/wh =1.30-1.40; IZR = 0.30-0.45)	high (WER = 2.00-2.15)
8 mm	thickly discoidal; involute (ww/dm ~ 0.50; uw/dm ~ 0.03)	weakly compressed; strongly embracing (ww/wh =0.80- 0.85; IZR ~ 0.45)	high (WER = 2.10-2.20)
20 mm	thinly discoidal; involute (ww/dm ~ 0.42; uw/dm ~ 0.03)	weakly compressed; strongly embracing (ww/wh = 0.70-0.75; IZR ~ 0.45)	high to very high (WER = 2.20-2.30)
40 mm	thinly discoidal; involute (ww/dm ~ 0.40; uw/dm ~ 0.02)	weakly compressed; strongly embracing (ww/wh ~ 0.70; IZR ~ 0.45)	high (WER ~ 2.15)

Tab. 2: Conch dimensions of *Epitornoceras mithracoides* (Frech, 1888) from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19101.3	86.4	31.4	49.0	2.1	26.6	0.36	0.64	0.02	2.08	0.46
MB.C.19101.1	60.0	24.0	34.0	0.02	21.0	0.40	0.71	0.00	2.37	0.38
MB.C.19101.2	42.6	17.0	25.3	0.6	14.0	0.39	0.67	0.01	2.17	0.45
MB.C.19101.2	8.4	4.3	5.0	0.2	2.7	0.51	0.85	0.03	2.2	0.45
MB.C.19101.2	3.98	2.26	2.22	0.32	1.08	0.57	1.02	0.08	1.89	0.51
MB.C.19101.2	2.13	1.52	1.14	0.41	0.63	0.72	1.34	0.19	2.02	0.44

Description: The two cross-sections MB.C.19101.2 (Figs. 1C-D) and 19101.3 (Figs. 1A-B) allow for the first time to establish the shell ontogeny of the species. Most characteristic are the strong shell involution (Fig. 1F), the increasing whorl expansion from 4 mm dm on (Fig. 1H), and the continuously increasing shell compression (Figs. 1F-G), with little signs of variability of ww/wh values during median to mature stages (20 - 85 mm dm). The umbilicus starts to close from the second whorl on. Moulds display an oblique and somewhat flattened umbilical ramp (Fig. 1A), producing a wide, funnel-shaped umbilicus, but the shell is thickened in that region (Fig. 1B, D), giving a gently rounded umbilicus of shell specimens. There is no evidence that the venter becomes suboxyconic at full maturity. MB.C.19101.3 is still septate at more than 75 mm dm, which suggests a maximum dm of 120 mm or more. Typical outer sutures are preserved in MB.C.19101.3 (Fig. 1E) and 19101.1. MB.C.19101.2 displays the deep and diverging dorsal lobe adorally on a partly exposed septal face.

Discussion: A direct comparison of the Dar Kaoua specimens with the Berlin syntypes confirmed that they are very similar and conspecific. The syntype shell parameters plot directly on the ww/dm curve of the Dar Kaoua cross-sections (crossed dots in Fig. 1F). The new material allows to specify partly the stratigraphic age of the species within the Upper Givetian. Older material from the *Pharciceras* Zone (e.g., Aboussalam & Becker 2001; MD III-A) of the Tafilalt appears to be conspecific but morphometric details are not yet known. A supposed *Ep. mithracoides* figured by House et al. (1985) from the Montagne Noire, re-figured by Korn & Klug (2002), is much more compressed (ww/wh = ca. 0.47 at 47.5 mm wh) and more suboxyconic; it belongs to a new species intermediate to *Ep. peracutum*. A tornoceratid illustrated by Petter (1959) from Erg Djemel, unfortunatey without a ventral view, belongs either to *Ep. mithracoides* or to that new species. The poorly preserved *Ep*. aff. *mithracoides* in Clausen (1989) has *Tornoceras*-type sutures.

Stratigraphical range: Topmost Middle Givetian (MD III-A) to Upper Givetian (MD III-C/?D).

Geographical distribution: Rhenish Massif, southern Morocco (Tafilalt, Dra Valley), possibly (cf.) Algeria (Ougarta), cf. New York State.

Order Agoniatitida Ruzhencev, 1957

Family Taouzitidae Korn, 2001 (emend.)

Type genus: *Taouzites* Korn, 2001

Diagnosis (emend): Moderately to very large, earliest whorls thickly discoidal, weakly depressed, subevolute, ribbed; median to mature whorls extremely discoidal, trochoid to oxyconic, subinvolute smooth; whorl expansion increases during ontogeny to high or extremely high mature values (WER 2.1 to 2.75), whorl overlap moderate to weak (IZR 0.30 to 0.15); growth lines strongly biconvex, undulose, with high ventrolateral salient adjacent to shallow spiral furrows. Sutures with small, ontogenetically shortened median E_1-lobe, high median saddle, deep and pointed or lingulate E_2-lobe, high and prominent ventral saddle, shortened, moderately deep or deep L-lobe, and one to five outer umbilical lobes, with a total of three to eight U-lobes. Suture formule: $E_1E_2LU_2{:}U_3U_1I$ to $(E_1E_1)E_2LU_2U_4U_5U_7U_8{:}U_6U_3U_1I$.

Included genera:

Mzerrebites Becker & House, 1994
Darkaoceras n. gen.
Keuppites n. gen.
Taouzites Korn, 2001

Discussion: Becker & House (1993) placed the *Mzerrebites-Taouzites* lineage as Eobeloceratidae in the Pharciceratacea, Korn (2001) placed his new family in the Gephuroceratina, which were kept separate. The Taouzitidae differ from the Pharciceratidae mostly by their prominent, wide ventral saddle and by much faster expanding median and mature whorls. However, the latter difference is less distinctive when early members (*Mzerrebites*) or side-branches (*Keuppites* n. gen.) of the first and late members (specific *Stenopharciceras* and *Synpharciceras*) of the second are compared.

Stratigraphical range: Topmost Middle (MD III-A) to topmost Upper Givetian (MD III-E).

Geographical distribution: Rhenish Massif, Cantabrian Mts., Tafilalt, Maider and Dra Valley of southern Morocco, Ougarta, Saoura Valley and Ahnet of southern Algeria.

Darkaoceras n. gen.

e.p. 1959 *Timanites* Petter: 159-160
e.p. 1963 *Komioceras* House & Pedder: 526
e.p. 1969 *Komioceras* Bogoslovskiy: 272
1993 *"Timanites" meridionalis* Group Becker & House: 117
1994 *"Timanites" meridionalis* Group Becker & House: 113
2000a Eobeloceratidae n. gen. 1 Becker & House: 31

Type species: *Timanites meridionalis* Petter, 1959.

Etymology: Named after Dar Kaoua, which yielded abundant material of the type-species.

Diagnosis: Moderately large, earliest whorls thickly discoidal, subevolute, ribbed, and with narrowly rounded venter, median stages thinly discoidal, compressed, subinvolute, suboxyconic to oxyconic, smooth, adult stages strongly oxyconic (keeled). Growth lines strongly biconvex with low dorsolateral and projecting ventrolateral salient; shallow spiral furrows, which may disappear at maturity, border the ventrolateral salient. Mature sutures with small and short E_1, deep and pointed E_2, dominant and rather wide E_2-L-saddle, pointed L-lobe that is shorter than E_2, two small outer and inner U-lobes. Suture formule: $E_1E_2LU_2U_4{:}U_3U_1I$.

Included species:

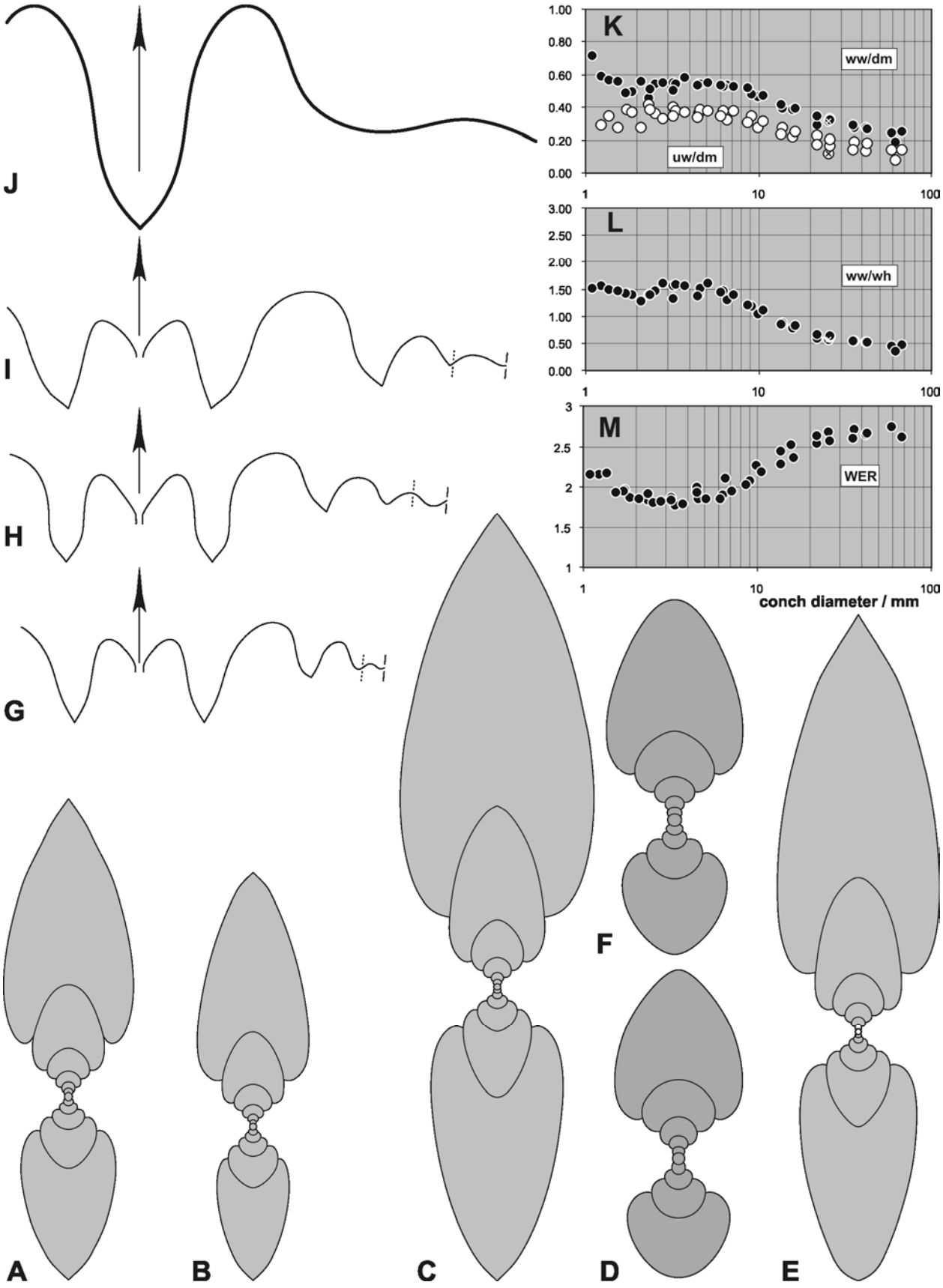
Pharciceras acutum Matern, 1931, Upper Givetian, Rhenish Massif
Timanites complanatum Petter, 1959, Upper Givetian, Saoura Valley, Algeria
?Pharciceras flenderi Wedekind, 1918, ?Upper Givetian, Rhenish Massif
Timanites meridionalis Petter, 1959, Upper Givetian, Ougarta, Algeria

Discussion: Members of the new genus were assigned to various genera early in their research history, for example to *Pharciceras* (Matern, 1931), *Timanites* (Petter, 1959) or *Komioceras* (House & Pedder, 1963, Bogoslovskiy 1969). Clausen (1971) assumed a pharciceratoid nature of *"Timanites" meridionalis* and *"T." complanatus*. Subsequently, the new genus was recognized by Becker & House (1993, 1994, 2000a) but not named. *Darkaoceras* n. gen. is slightly homoemorphic to the Lower Frasnian *Timanites*, which explains why some species have been placed in that genus in the past. This probably applies also to alleged old records of *Timanites* from German pharciceratid levels (e.g., Denckmann 1901, Correns 1934). True *Timanites* are more involute, have subcircular outer saddles, have only three U-lobes, and lack the depressed, costate early whorls of *Darkaoceras* n. gen. The latter feature give evidence that the new genus was derived from *Mzerrebites* by sharpening of the venter and by the addition of extra umbilical lobes. *Timanites Hoeninghausi* in Frech (1902a), *Koenenites hoeninghausi* in Petter (1959), and *Koenenites galeatus* Matern, 1931 may represent an intermediate phylogenetic stage with only one outer umbilical lobe and oxyconic conch, which should be given a separate generic name after revision. *Taouzites* and *Keuppites* n. gen. have additional U-lobes.

Stratigraphical range: Upper Givetian, *Syn. clavilobum* (MD III-C) to *Taouzites taouzensis* (MD III-D) Zones.

Geographical distribution: Rhenish Massif (?Denckmann 1901; Matern 1931), southern Morocco (Tafilalt, Termier & Termier 1950, Becker & House 2000a), southern Algeria (Erg Djemel, Ougarta, Petter 1959; Saoura Valley, Petter 1959).

Fig. 3: *Darkaoceras meridionale* (Petter, 1959) from Dar Kaoua. **A-F**. Cross sections of MB.C.19102.3-5, 134, 01, and MB.C.19102.27; x 2, magnified inner whorls (D and F) x 4. **G**. Suture of MB.C.19102.12 at 15.3 mm wh; x 2.5. **H**. Suture of MB.C.19102.6 at 20 mm wh; x 2.5. **I**. Suture of MB.C.19102.1 at 22 mm wh; reversed, x 2.5. **J**. Course of growth lirae of MB.C.19102.2 at 28 mm wh; x 2.5. **K-M**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all measured specimens. Crossed dots in Fig. 3K refer to syntypes of Petter (1959).


J
I
H
G
K
ww/dm
uw/dm
1.00
0.80
0.60
0.40
0.20
0.00
L
ww/wh
3.00
2.50
2.00
1.50
1.00
0.50
0.00
M
WER
3
2.5
2
1.5
1
1
10
100
conch diameter / mm
A
B
C
D
E
F

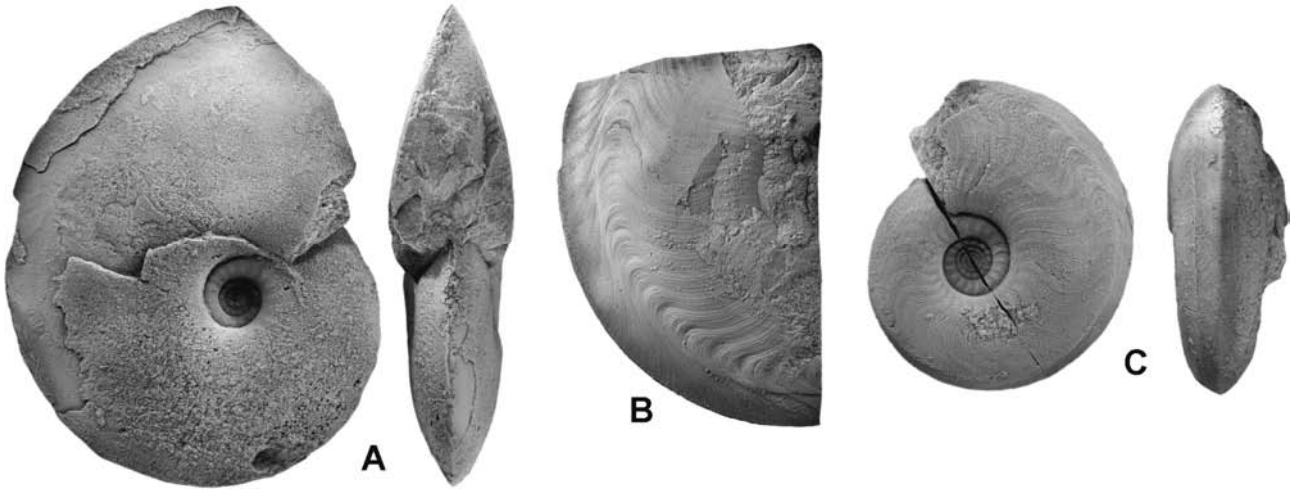


Fig. 4: Taouzitidae from Dar Kaoua. **A**. *Darkaoceras meridionale* (Petter, 1959), MB.C.19102.1, lateral and adoral views; x 1. **B.** *Darkaoceras meridionale* (Petter, 1959), MB.C.19102.2, lateral view showing growth ornament; x 1. **C**. *Keuppites singulus* n. gen. n. sp., holotype MB.C.19103, lateral and ventral views; x 1.

***Darkaoceras meridionale* (Petter, 1959)** (emend.)

Figs. 3A-M, 4A-B

?	1935	*Timanites* cf. *Hoeninghausi* Clariond: 8
?	1952	*Timanites* cf. *hoeninghausi* Choubert: 120
*v	1959	*Timanites meridionalis* Petter: 160, fig. 41C, pl. IX, figs. 8-10
	1963	*Komioceras meridionale* House & Pedder: 526
?	1965	*Timanites* sp. Massa: 107
	1969	*Komioceras meridionale* Bogoslovskiy: 272
	1970	*Timanites meridionalis* Kullmann & Ziegler: 81
v	2000a	Eobeloceratidae n. gen. n. sp. 1 Becker & House: 31
	2002	*?Timanites meridionalis* Korn & Klug: 118

Type: Petter (1959) and Bensaid (1974) did not select types. Therefore, Petter´s original of plate IX, fig. 8 (Paris Natural History Museum) is here selected as lectotype. It is the specimen that was the base for given shell measurements and seems to have formed the base for suture illustrations in Petter´s text-figure 41.

Type locality and horizon: Piste NE of the Erg el Djemel, Ougarta, southern Algeria; "Frasnian 1 α", which after re-definition of the Middle/Upper Devonian series boundary refers to the undifferentiated Upper Givetian. The ammonoid assemblage from the type locality contains *Synpharciceras* and *Mzerrebites* but no species that is restricted to the upper part of the *Pharciceras* Stufe. Hence, the type level is mostly likely the *Syn. clavilobum* Zone (MD III-C), which is the level of material described here.

Material: 33 specimens (including MB.C.19102.1-27) up to 68 mm conch diameter.

Diagnosis (emend.): First two whorls ribbed, subevolute and weakly depressed (serpenticonic), from the 3rd whorl on ww/dm, uw/dm and ww/wh decline steadily whilst WER rises from < 2 to 2.7; the 5th whorl becomes compressed (ww/dm around 0.4 at 15 – 20 mm dm), thinly discoidal and oxyconic; at maturity extremely discoidal, subinvolute, with keel crenulated by growth lines, ww/dm = ca. 0.2 and uw/dm around 0.15. Growth lines are undulose, bundled and strongly biconvex, with low dorsolateral and strongly projecting, tongue-shaped ventrolateral salient that may be bordered by shallow spiral depressions. Mature sutures with moderately high median saddle, high and broad E_2-L-saddle, deep, pointed, subsymmetric or asymmetric E_2-lobe, asymmetric, dorsally incurved L-lobe that is much shorter than E_2, two small subumbilical outer U-lobes, two small internal U-lobes, and moderately deep, narrow I-lobe.

Tab. 3: Conch ontogeny of *Darkaoceras meridionale* (Petter, 1959) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; subevolute (ww/dm = 0.50-0.60; uw/dm = 0.30-0.40)	weakly depressed; moderately embracing (ww/wh = 1.30-1.40; IZR = 0.20-0.30)	moderate (WER = 1.85-1.95)
8 mm	thickly discoidal; subevolute (ww/dm ~ 0.50; uw/dm = 0. 30-0.35)	weakly depressed; moderately embracing (ww/wh = 1.10-1.35; IZR = 0.25-0.30)	moderate to high (WER = 1.95-2.20
20 mm	extremely discoidal; subinvolute (ww/dm 0.30- 0.35; uw/dm 0.15-0.25)	weakly compressed; moderately tembracing (ww/wh = 0.65-0.75; IZR ~ 0.25)	very high (WER =2.50-2.65)
35 mm	extremely discoidal; subinvolute ww/dm 0.25- 0.30; uw/dm = 0.15-0.20)	weakly compressed; moderately embracing (ww/wh = 0.55-0.60; IZR = 0.25-0.30)	very high (WER = 2.60-270)

Tab. 4: Conch dimensions of *Darkaoceras meridionale* (Petter, 1959) from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19102.5	65.7	17.1	35.7	9.7	25.9	0.25	0.48	0.14	2.63	0.27
MB.C.19102.10	62.2	12.0	34.2	5.0	-	0.19	0.35	0.08	-	-
MB.C.19102.27	58.7	14.3	31.7	8.1	23.3	0.24	0.45	0.14	2.74	0.24
MB.C.19102.1	57.5	12.4	28.4	8.9	c. 22.5	0.22	0.44	0.16	c. 2.70	c. 0.21
MB.C.19102.3	42.3	11.4	21.6	7.6	16.4	0.27	0.53	0.18	2.66	0.24
MB.C.19102.4	35.8	9.8	18.4	6.7	14.1	0.27	0.54	0.19	2.71	0.23
MB.C.19102.5	25.7	8.4	13.7	4.2	10.0	0.33	0.61	0.17	2.69	0.27
MB.C.19102.5	9.9	4.6	4.5	2.7	3.3	0.47	1.04	0.27	2.26	0.26
MB.C.19102.5	4.51	2.45	1.75	1.63	11.32	0.54	1.40	0.36	2.00	0.24
MB.C.19102.5	1.72	0.84	0.59	0.67	0.5	0.49	1.41	0.39	1.97	0.16

Description: Petter (1959) described only small to median-sized haematitic moulds. Our material shows that the common species reached more than 100 mm dm. MB.C.19102.23 is still septate at ca. 65 mm dm. The Dar Kaoua population allows to establish the complex shell ontogeny and its variability of umbilical width and whorl expansion. The first two whorls are serpenticonic (MB.C.19102.5, Fig. 3F), with rising uw/dm ratio (Fig. 3K) and decreasing whorl expansion (Fig. 3M) to an early post-embryonic low of < 2.0. The 3rd whorl fast gains thickness (Figs. 3D, F, K) whilst WER ratios reverse, rising quickly and constantly until ca. 40 mm dm. During median stages the shell becomes gradually more and more compressed (thinly discoidal), oxyconic and subinvolute. In MB.C.19102.2 and 19102.27 the venter is sharp at 20 mm dm (Fig. 3D). The last whorl shows a constant or slight decline of WER to values between 2.3 and 2.6 (Fig. 3M). The umbilical wall is flatly rounded and the maximum ww lies in the lower third of the whorl (Fig. 4A). Umbilical shell thickenings explain some differences between uw/dm ratios of shell and mould specimens. The protoconch has ca. 0.7 mm dm in MB.C.19102.4 (Fig. 3B).

Specimens with well preserved shell display widely spaced growth line bundles (4-6/cm) on the mid flank bound by fine lirae. The individual growth lines disappear on the lower flank and re-enter in the ventral sinus (well visible in MB.C.19102.9), where they cause a dense crenulation (e.g., MB.C.19102.3, 19102.2, 19102.19; ca. 5 fine crenulae per 2 mm). Early whorls, sometimes up to 12 mm wh (MB.C.19102.1), display in addition umbilical ribbing, with several lirae sitting on low and rounded ribs. The distinctive course of the growth ornament is illustrated in Figs. 3J and 4B. There is considerable variation of spiral ornament. Some specimens show a flattening (e.g., MB.C.19102.18) or spiral depression (e.g., MB.C.19102.6, 19102.2) just ventrally of the outer salient, others have in addition a minor groove running close to the peak of the salient, producing incipient double furrows (MB.C.19102.25, 19102.19). The feature may be more prominent on some internal moulds (MB.C.19102.12, 19102.4) or may be completely absent (MB.C.19102.1), especially at maturity (MB.C.19102.23). A distinctive keel is produced by spiral depressions in MB.C.19102.5,

19102.2, and 19102.4. MB.C.19102.5, 19102.11, and 19102.25 display a dense, radial, spaghetti-type wrinkle layer.

Petter (1959) illustrated parts of the sutural ontogeny, with a late forming of the external U_4. In MB.C.19102.12 the latter is present at 15 mm wh (Fig. 3G) but not yet at 8 mm wh. The U_2 lobe becomes subangular at 15 mm wh in MB.C.19102.4 (see also Fig. 3I) but remains shallowly rounded until 30 mm wh in MB.C.19102.20. The L-lobe is mostly pointed at 15 mm wh (MB.C.19102.12, Fig. 3G) apart from MB.C.19102.13. The E_2 lobe is variably subsymmetric (MB.C.19102.6, Fig. 3H) or slightly curved outwards (MB.C.19102.1, Fig. 3I). Dorsal sutures have not been observed but Petter (1959: fig. 41C1-2) illustrated two narrow internal U-lobes.

Discussion: The Dar Kaoua population has similar shell parameters as given by Petter (1959) for the Erg Djemel type material. The Algerian syntypes plot on the ww/dm curve and near to the uw/dm curve for the Dar Kaoua material (crossed dots in Fig. 3K). However, a more detailed morphometric comparison based on Algerian cross-sections would be desirable. *D. complanatum* is much more compressed at small size. *D. acutum* is more involute and has a mid-flank lobe (L-lobe), which is deeper than the E_2-lobe next to the venter. *?D. flenderi* is characterized by adult outer flank ribbing. In a fragmentary specimen identified as *Timanites angustus* by Kullmann & Ziegler (1970), a second outer U-lobe sits on the umbilical seam and it has much higher dorsolateral saddles beneath and between the outer U-lobes. This specimen, which comes from a condensed bed spanning the uppermost Givetian to upper Lower Frasnian, may represent the only true *Timanites* from Germany.

Stratigraphical range: The species is perhaps restricted to the *Synpharciceras* Zone (MD III-C) but closely similar forms (*Ph.* cf. *meridionalis* in Bensaid 1974), which require a detailed morphometric study, occur in the next younger *Taouzites* Zone (MD III-D). *D. meridionale* is common in the Lower Marker Bed throughout the Tafilalt and an excellent and easy identifiable marker form.

Geographical distribution: Southern Morocco (Tafilalt) and southern Algeria (Ougarta).

Keuppites n. gen.

Type species: *Keuppites singulus* n. sp.

Etymology: In honor of Prof. Dr. Helmut Keupp, for his 60th birthday, and in recognition of his numerous and significant contributions to ammonoid research.

Diagnosis: Moderately large, early whorls moderately depressed, subevolute (serpenticonic) and ribbed, mature whorls moderately compressed, fast expanding (WER 2.0 to 2.2), subinvolute and oxyconic, growth lines strongly biconvex with high ventrolateral salient and spiral furrows. Sutures with moderately high median saddle, deep, pointed E_2-lobe, elevated and wide ventral saddle, pointed L-Lobe, and three shallow, rounded outer U-lobes. Assumed suture formule: $E_1E_2LU_2U_4U_6{:}U_5U_3U_1I$ (but dorsal suture not observed).

Included species: Currently monospecific.

Discussion: *Keuppites* n. gen. differs from *Darkaoceras* n. gen. in the presence of an additional pair of U-lobes and in the slower expanding (adult WER > 2.5 in *Darkaoceras*) and more strongly embracing whorls (IZR near 0.3). The values for the imprint zone exceed those given for the Taouzitidae in the original family diagnosis by Korn (2001) but the overall similarities of shell form and ontogeny leave no question concerning its systematic affinities.

Keuppites singulus n. sp.

Figs. 4C, 5A-G

Type: Holotype MB.C.19103, figured in Figs. 4C and 5.

Type locality and horizon: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: Only the holotype.

Etymology: Because of its singularity; none of the other numerous outcrops of the Lower Marker Bed in the Tafilalt yielded a similar goniatite.

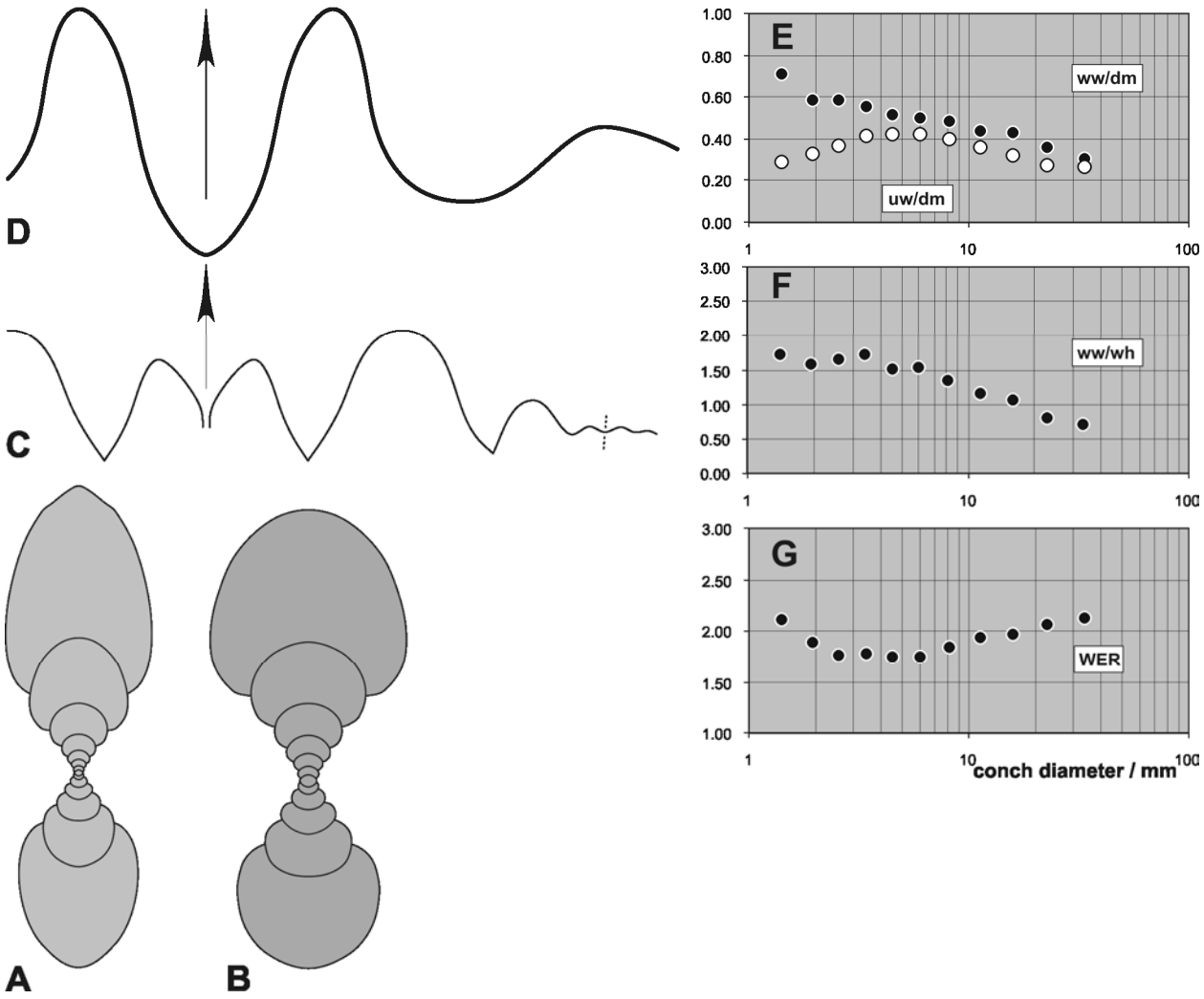


Fig. 5: *Keuppites singulus* n. gen. n. sp. from Dar Kaoua, holotype MB.C.19103. **A-B**. Cross section; x 2, magnified inner whorls x 4. **C**. Suture at 9 mm ww, 12 mm wh; x 4.0. **D**. Course of growth lirae at 10 mm ww, 12.5 mm wh; x 4.0. **E-G**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER.

Diagnosis: First four whorls until 5-6 mm dm moderately depressed, subevolute (serpenticonic), with rising uw/dm values (up to ca. 0.4) and falling ww/dm (down to 0.5) and WER (down to 1.7) ratios, ribbed, and with rounded venter; subsequently weakly depressed to weakly compressed (from ca. 20 mm dm on), and with decreasing uw/dm ratio (down to 0.25), and rising WER (to ca. 2.0); mature whorls oxyconic with constant umbilical width, and high WER (> 2.0). Growth lines with low dorsolateral and narrow, projecting ventrolateral salient. Sutures with small, diverging and short median E_1, moderately high, subtriangular median saddle, deep and v-shaped E_2, prominent, symmetric ventral saddle, asymmetrically pointed, dorsally incurved L-Lobe, and three very shallow and rounded outer umbilical lobes separated by very low saddles.

Tab. 5: Conch ontogeny of *Keuppites singulus* n. gen. n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; subevolute (ww/dm ~ 0,59; uw/dm ~ 0.33)	moderately depressed; moderately embracing (ww/wh ~ 1.58; IZR ~ 0.26)	moderate (WER ~ 1.90)
8 mm	thickly discoidal; subevolute (ww/dm ~ 0.49; uw/dm ~ 0. 40)	weakly depressed; moderately embracing (ww/wh ~ 1.34; IZR ~ 0.27)	moderate (WER ~ 1.85)
20 mm	thinly discoidal; subinvolute (ww/dm ~ 0.36; uw/dm ~ 0.27)	weakly compressed; strongly embracing (ww/wh ~ 0.81; IZR ~ 0.31)	high (WER ~ 2.05)

Tab. 6: Conch dimensions of *Keuppites singulus* n. gen. n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	44.0	12.8	19.3	11.4	-	0.29	0.66	0.26	ca. 2.20	-
holotype	33.3	10.1	14.4	8.8	10.5	0.30	0.70	0.26	2.13	0.27
holotype	22.8	8.2	10.1	6.3	7	0.36	0.81	0.27	2.07	0.31
holotype	11.3	4.9	4.3	4.1	3.2	0.43	1.15	0.36	1.93	0.26
holotype	6.0	3.0	2.0	2.5	1.5	0.50	1.53	0.42	1.75	0.25
holotype	1.94	1.14	0.72	0.64	0.53	0.59	1.58	0.33	1.89	0.26

Description: The shell ontogeny is triphasic. In the first 2 ½ cadiconic whorls WER decreases. Subsequent early stages up to ca. 15 mm dm keep depressed cross-sections (Fig. 5B) but are not as broad as early stages of open umbilicate pharciceratids. The venter remains rounded until ca. 25 mm dm (Fig. 5A). An earlier ontogenetic turning point lies between 5 and 6 mm dm, after the maximum of relative umbilical width (uw/dm = ca. 0.4, Fig. 5E), when the ww/wh ratio starts to decline (Fig. 5F) whilst WER gradually starts to rise (Fig. 5G). The course of the growths lines is illustrated in Fig. 5D. The second last whorl has ca. 15 low, rounded, subumbilical ribs. There are marked but somewhat irregularly spaced (every 0.3 to 0.8 mm) lirae on the mature flanks or, earlier, on the ribs. The spiral depressions do not run in the ventrolateral salient but border an incipient keel. The outer suture is shown in Fig. 5C; the inner suture is not preserved.

Discussion: Several morphological aspects resemble *D. meridionale*: the ribbing of early whorls, the mature growth ornament, the incipient keel bordered by spiral depresions outside the ventrolateral salient, the shape of the L-Lobe. It is likely that both species had a common ancestor.

Stratigraphical range and geographical distribution: Restricted to the type locality and level.

Family Pharciceratidae Hyatt, 1900

Diagnosis: Early whorls pachyconic, depressed, very low to low, evolute to subinvolute, sometimes finely ribbed, mature whorls depressed (low) to strongly compressed (high), evolute to completely involute; venter rounded or oxyconic. Sutures with two ventral lobes and three to more than twenty U-lobes; “plurilobes” may occur randomly and asymmetrically.

Included subfamilies:

Pharciceratinae, Hyatt 1900
Synpharciceratinae, Schindewolf 1940
?Eobeloceratinae Becker & House, 1993 (nom. transl.)

Discussion: As outlined by Korn (2001), the large-sized, evolute, and oxyconic *Eobeloceras* differs strongly from all members of the Taouzitidae and, therefore, is not related. Until more material allows a better understanding, the rather enigmatic *Eobeloceras* is placed as a distinctive but questionable subfamily within the Pharciceratidae. Relationships with the Frasnian Beloceratidae (see systematics of Korn & Klug 2002) are strongly contradicted by its rounded saddles.

Stratigraphical range and geographical distribution: See subfamilies.

Subfamily Pharciceratinae Hyatt, 1900 (emend.)

Diagnosis (emend.): Early whorls pachyconic, depressed, evolute, mature whorls pachyconic to extremely discoidal, depressed to moderately compressed, WER low to moderate (1.5 - 2.0), open umbilicate (subinvolute to evolute), lacking umbilical shell flares. Growth ornament consists of distinctive, strongly biconvex, sharp, rib-like lirae. Sutures with three to nine U-lobes.

Included genera:

Pharciceras, Hyatt, 1884 (type genus)
Extropharciceras n. gen.
Lunupharciceras Korn & Klug, 2002

Discussion: Within the Pharciceratinae there are two different types of U-lobe proliferation. In the main group, starting from *Pharciceras*, the ontogenetic addition of U-lobes alternates regularly internally (U_1, U_3 etc.) and externally (U_2, U_4 etc.). In other taxa, this rule is partly changed, with U_3 arising externally, followed by an external or internal U_4, which results in a higher number of external than internal U-lobes. This distinction may eventually allow a taxonomic subdivision, when the sutural ontogenies of more taxa are well established.

Stratigraphical range: Topmost Middle Givetian (MD III-A) to topmost Upper Givetian (MD III-E).

Geographical distribution: Rhenish Massif, Graz Palaeozoic (Austria), New York State, Kentucky, Montagne Noire, Pyrenees, Cantabrian Mts., Tafilalt, Maider and Dra Valley of southern Morocco, Ougarta, Saoura Valley and Ahnet of southern Algeria, Rudnyi Altai, Guangxi (South China).

Pharciceras **Hyatt, 1884** (emend.)

Type species: *Goniatites tridens* Sandberger & Sandberger, 1850; subsequently designated in Holzapfel (1889: p. 39), not by the original author, as noted by Korn & Klug (2002), nor by Wedekind (1918), as stated by House (1978) and Göddertz (1987).

Diagnosis (emend.): Early stages evolute to subevolute, strongly to extremely depressed (serpenticonic to cadiconic), sometimes finely ribbed, mature stages weakly depressed to weakly compressed, with weak to strong, single or paired ventrolateral furrows, venter rounded or tabulate. Sutures with two outer and two inner U-lobes, large, mid-flank L-lobe, high and narrow ventral saddle and, at maturity, deep or shortened median E_1 lobe. Suture formule: $E_1E_2LU_2U_4{:}U_3U_1I$.

Included species:

Group I (depressed throughout ontogeny)
Goniatites amplexus Hall, 1886, topmost Middle Givetian, New York State
Pharciceras aff. *amplexum* in Ziegler & Klapper (1982), topmost Middle Givetian, Tafilalt
Pharciceras barnetti Work et al., 2007, basal Upper Givetian, Kentucky
Pharciceras bidentatum Petter, 1959 [fide Bensaid 1974 a synonym of *Ph. tridens*], Upper Givetian, Tafilalt
Sphaeropharciceras sandbergerorum Bogoslovskiy, 1955 [synonym of *Ph. tridens*], Upper Givetian, Rhenish Massif
Goniatites tridens Sandberger & Sandberger, 1850, Upper Givetian, Rhenish Massif
Pharciceras evolvens n. sp., Upper Givetian, Tafilalt

Group II (with compressed mature whorl)
Pharciceras applanatum Bensaid, 1974, Upper Givetian, Tafilalt
Pharciceras darkaouense n. sp., Upper Givetian, Tafilalt
Pharciceras galeatum Wedekind, 1918, Upper Givetian, Rhenish Massif
Pharciceras aff. *galeatum* in House et al. (1985), Upper Givetian, Montagne Noire
Pharciceras Kayseri Wedekind, 1918, Upper Givetian, Rhenish Massif
Prolecanites lateseptatus Frech, 1902a, Upper Givetian, Montagne Noire
Pharciceras aff. *lateseptatum*, Upper Givetian, Tafilalt
Pharciceras pargai Montesinos & Henn, 1986, Upper Givetian, Cantabrian Mts.

The extremely compressed *Goniatites (Prolecanites) triphyllus*, Frech 1888 from the Lower/Middle Frasnian of the Eifel Mts. does not belong to the Pharciceratacea.

Discussion: *Pharciceras* currently includes all pharciceratids with four U-lobes at maturity. All species show biphasic post-embryonic ontogenies with distinctive turning points in changing shell parameters. Therefore, all species identification need to consider the specific ontogenetic trajectories that are established here. Based on late mature shell changes, two species groups can be separated that may warrant future taxonomic recognition. The group around the type-species keeps depressed whorls until maturity, although there is a slight shift to higher WER in the terminal whorl. The median E_1- remains deeper or almost as deep as the E_2-lobe and the ventral saddle is dominant. In the second group around *Ph. applanatum* and *Ph. pargai*, the last whorl is compressed and expands faster, leading to larger shell size. The median saddle rises and in the most advanced species it may be as high as the ventral saddle, whilst the median E_1 is strongly shortened. There is also some variation whether the U_4-lobe sits on the umbilical seam (*Ph. amplexum*, *Ph. lateseptaum* type) or

slightly subumbilical (*Ph. applanatum, Ph. pargai*). Work et al. (2007) showed that this feature changes within the ontogeny of *Ph. barnetti*.

Stratigraphical range: Topmost Middle Givetian (MD III-A) to topmost Upper Givetian (MD III-E).

Geographical distribution: Rhenish Massif (Sandberger & Sandberger 1850), New York State (Hall 1886), Kentucky (Work et al. 2007), Graz Palaeozoic (Flügel 1947), Montagne Noire (Frech 1902a), western Pyrenees (Kullmann 1973), Cantabrian Mts. (Montesinos & Henn 1986), Tafilalt (Termier 1929), Maider (Hollard 1974) and Dra Valley (Bensaid 1974) of southern Morocco, Ougarta (Menchikoff 1930), Saoura Valley (Göddertz 1987) and ?Ahnet (Moussine-Pouchkine 1971) of southern Algeria.

Pharciceras tridens (Sandberger & Sandberger, 1850) (emend.)

Figs. 6A-G, 7A

*	1850	*Goniatites tridens* Sandberger & Sandberger: 66, pl. 4, figs. 2, 2a-e, pl. 9, figs. 2, 2a-b
	1851	*Goniatites tridens* Sandberger: 296, pl. 2, fig. 13 [syntype illustration]
	1931	*Pharciceras tridens* Matern: 93-94
*	1955	*Sphaeropharciceras sandbergerorum* Bogoslovskiy: 1104 [fide House & Ziegler 1977]
*	1959	*Pharciceras bidentatum* Petter: 131-132, fig. 33M, pl. 7, figs. 11, 11a [fide Bensaid 1974]
	1962	*Pharciceras tridens* House: 273: text-figs. 10A-B [syntype sutures]
	1977	*Pharciceras tridens* House & Ziegler: 88, pl. 5, figs. 24-26 [syntype re-illustration]
e.p.	1978	*Pharciceras tridens* House: 54, text-fig. 9K [lectotype suture]
	1985	*Pharciceras tridens* House et al.: 5, figs. 4E-G
	1987	*Pharciceras tridens* Göddertz: 181-183, figs. 29a-c, pl. 13, figs. 3-4
e.p.	2002	*Pharciceras tridens* Korn & Klug: 142, e.p. fig. 131 [not figs. 134A, H]
	2008	*Pharciceras tridens* House & Kirchgasser: 90, pl. 1, fig. 10 [adoral view of lectotype]

Types: Lectotype, designated in Göddertz (1987), is specimen 29 (old no. 62.11./W.20) at the Landesmuseum Wiesbaden, original of Sandberger & Sandberger (1850: pl. 4, figs. 2, 2a-e), partly re-illustrated by House (1962, 1978), Korn & Klug (2002), and House & Kirchgasser (2008). Since the original description included at least three specimens from the collections of Dannenberg, Odernheimer, and Giebeler, the holotype designation in Matern (1931) is invalid. Also, the taxonomic exclusion of the syntype illustrated on the original pl. 9 as *Sphaeropharciceras* by Bogoslovskiy (1955) did not result in an automatic type assignment of the specimen figured on pl. 4 since unfigured syntypes are also available for lectotype designations. A third syntype, a septal fragment, was figured by Sandberger (1851) but is not preserved at Wiesbaden. House & Kirchgasser (2008) overlooked Göddertz´ valid type designation.

Type locality and horizon: Oberscheld, Dill Syncline, southern Rhenish Massif; iron-rich limestones, undifferentiated Upper Givetian.

Material: Two specimens, the fragmentary MB.C.19104.2 (Fig. 6D) and MB.C.19104.1 (Figs. 6A-C, 7A).

Diagnosis (emend.): Relative small-sized, first five whorls, until ca. 10 mm dm, increasingly depressed and evolute (cadiconic), with rising ww/wh (up to 2.65), ww/dm near constant (0.6-0.65) and strongly increasing uw/dm (up to 0.55) ratios and decreasing WER (down to 1.5), umbilical wall deeply rounded; subsequently less depressed (ww/wh down to below 1.5), with late ontogenetic slight rise of WER (up to 1.7), and with lower relative umbilical width (down to 0.4). Growth lines with distinctive, evenly spaced lirae, strongly biconvex, high ventrolateral salient marked by spiral double furrows and keel. Sutures with narrow E_1-lobe that is shortened very late in ontogeny, moderately high median saddle, deep, rounded to bell-shaped E_2-lobe, very high, narrowly rounded ventral saddle, rounded to slightly bell-shaped L-lobe that is not as deep as the E_2, narrow U_2-lobe, equally deep U_4 lobe just outside or at the umbilical seam, two narrow, pointed internal U-lobes, and v-shaped, wide I-lobe.

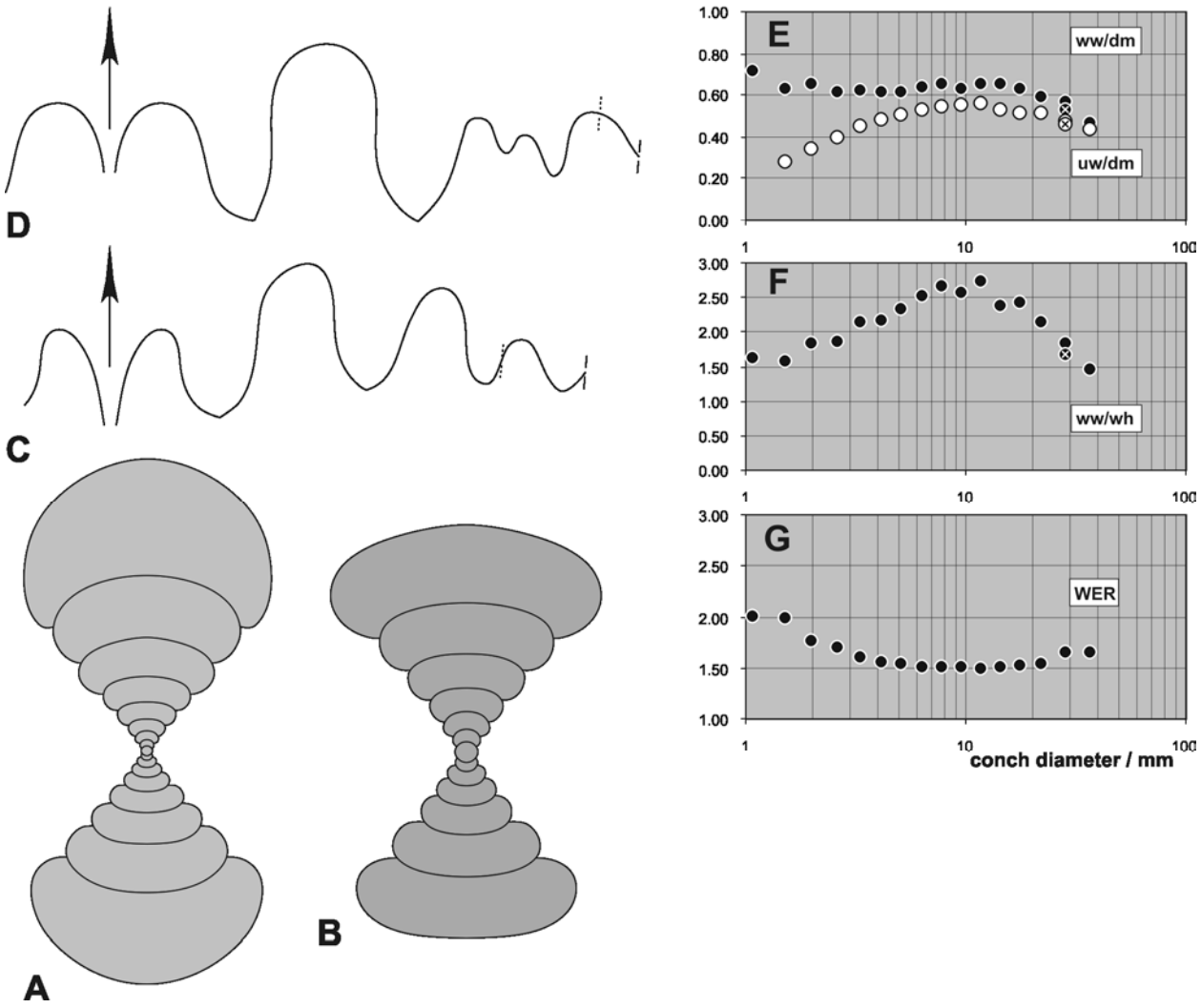


Fig. 6: *Pharciceras tridens* (Sandberger & Sandberger, 1850) from Dar Kaoua. **A-B**. Cross sections of MB.C.19104.1; x 2, inner whorls x 4. **C**. Suture of MB.C.19104.1 at 26 mm dm and 7.5 mm wh; reversed, x 5. **D**. Suture of MB.C.19104.2 at 10 mm wh, with "plurilobate" U_2-L-saddle; x 5. **E-G**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of both specimens; crossed dots refer to measurements of the Wiesbaden lectotype.

Tab. 7: Conch ontogeny of *Pharciceras tridens* (Sandberger & Sandberger, 1850) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subevolute (ww/dm ~ 0,65; uw/dm ~ 0.35)	moderately depressed; moderately embracing (ww/wh ~ 1.85; IZR ~ 0.30)	moderate (WER ~ 1.76)
8 mm	thinly pachyconic; evolute (ww/dm ~ 0.65; uw/dm ~ 0. 55)	very strongly depressed; moderately embracing (ww/wh ~ 2.65; IZR ~ 0.23)	low (WER ~ 1.52)
20 mm	thickly discoidal; evolute (ww/dm ~ 0.60; uw/dm ~ 0.52)	strongly depressed; moderately embracing (ww/wh ~ 2.15; IZR ~ 0.29)	low (WER ~ 1.54)
36 mm	thinly discoidal; subevolute (ww/dm ~ 0.47; uw/dm ~ 0.44)	weakly depressed; strongly embracing (ww/wh ~ 1.46; IZR ~ 0.31)	low (WER ~ 1.66)

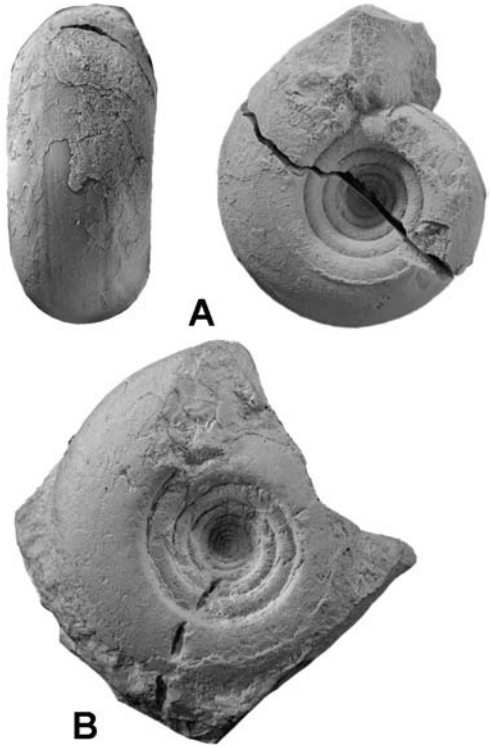


Fig. 7: A. *Pharciceras tridens* (Sandberger & Sandberger, 1850) from Dar Kaoua, MB.C.19104.1, ventral and lateral views; x 1. **B.** *Pharciceras evolvens* n. sp., holotype MB.C.19105, lateral view; x 1.

Tab. 8: Conch dimensions of *Pharciceras tridens* (Sandberger & Sandberger, 1850) from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19104.1	36.4	17.1	11.7	15.9	8.1	0.47	1.46	0.44	1.66	0.31
MB.C.19104.1	22.0	13.0	6.1	11.3	4.3	0.59	2.14	0.52	1.54	0.29
MB.C.19104.1	14.3	9.4	3.9	7.6	2.7	0.65	2.39	0.53	1.52	0.31
MB.C.19104.1	9.5	6.0	2.3	5.3	1.8	0.63	2.58	0.55	1.51	0.24
MB.C.19104.1	5.1	3.1	1.3	2.6	1.0	0.61	2.35	0.51	1.54	0.26
MB.C.19104.1	1.99	1.31	0.71	0.68	0.49	0.66	1.85	0.34	1.76	0.30

Description: MB.C.19104.1 illustrates for the first time the characteristic, biphasic post-embryonic shell ontogeny (Figs. 6E-G), with an allometric turning point at ca. 10 mm dm. The first whorl expands faster (WER = 2.0) than all later stages. Both Dar Kaoua specimens are rather similar and a restricted variability is supported by additional specimens from other Tafilalt localities. The ornament is partly preserved and consists of distinctive, closely and regularly spaced lirae that are pronounced on the umbilical wall. At maturity their spacing is 0.5 to 0.6 mm. A spiral double furrow is weakly indicated, sandwiching a low, rounded keel just ventral to the peak of the ventrolateral projection. The ornament is somewhat hidden under a very fine, radial wrinkle layer, which shows that an additional whorl was originally present. Therefore, the specimen must have had at least nine whorls. The protoconch had ca. 0.7 mm dm (Fig. 6B).

Sutures in MB.C.19104.1 show slightly more pointed outer flank lobes than in the lectotype and a median E_1 that is still as deep as E_2 at ca. 26 mm dm (Fig. 6C). It is shortened in MB.C.19104.2 (Fig. 6D) that also displays a plurilobate (subdivided) L-U_2-saddle, which might be mistaken as evidence for a third outer U-lobe. The septal surface and inner suture of the species has been illustrated by Sandberger (1851).

Discussion: *Ph. tridens* has a more uniform shell ontogeny than most other species of the genus, retaining a weakely depressed cross-section at maturity. This has earlier been noted by Matern (1931), who questioned a mature change to rather compressed whorls as illustrated by Wedekind (1918). The Dar Kaoua specimens support Matern´s observations and the lectotype shell parameters (crossed dots in Fig. 6E) given in House (1962) agree rather well with those in MB.C.19104.1. *Ph. tridens* has been reported by many authors and from several regions but the name has been used for forms with different shell ontogeny or sutures. A revision of such forms and occurrences is beyond the scope of this paper. *Ph. amplexum* is more compressed and has strong ventrolateral furrows at maturity, *Ph. barnetti* is thicker and displays distinctive ventrolateral

double keels. Early whorls of *Ph. lateseptatum* and *Ph. galeatum* are somewhat similar to early stages of *Ph. tridens*; the first is less cadiconic and evolute.

Stratigraphical range: *Syn. clavilobum* (MD III-C) to upper *Taouzites taouzensis* Zone (MD III-D), possibly ranging lower.

Geographical distribution: Proven records are from the Rhenish Massif and Tafilalt; probably also present in the Montagne Noire and southern Algeria.

***Pharciceras evolvens* n. sp.**

Figs. 7B, 8A-F

v 2001 *Pharciceras* cf. *tridens* Aboussalam & Becker: 87, pl. 1, fig. 7

Type: The somewhat incomplete holotype MB.C.19105, figured in Figs. 7B and 8A-F, which was casted before cutting for cross-section.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype, a second specimen (MB.C.3301) from Pic de Bissous, Montagne Noire, figured by Aboussalam & Becker (2001), and a paratype (MB.C.19106) from the type level of Mdoura-East (western Tafilalt).

Etymology: According to the widely evolving whorls.

Diagnosis: Relatively small-sized, depressed and evolute throughout ontogeny (serpenticonic), first five whorls, until ca. 10 mm dm, with slowly increasing uw/dm (up to 0.6); ww/dm (up to 0.53) and ww/wh (up to 2.5) ratios rise sharply after the 2nd whorl (after ca. 3 mm dm) whilst WER drops to values < 1.5; median to mature whorls with decreasing uw/dm (down to ca. 0.47 at 45 mm dm), ww/dm (down to ca. 0.4 at 45 mm dm), and ww/wh (down to ca. 1.3 at 45 mm dm) ratios; the last whorl shows a slight increase of WER (to ca. 1.6) and is becoming higher. Growth lines strongly biconvex. Mature sutures with shortened median E_1-lobe, rather prominent, rounded median saddle, lanceolate, deep E_2-lobe, narrow, very high lateral saddle, lanceolate, moderately deep L-lobe, rather high, narrow L-U_2-saddle, narrow, slightly pointed U_2-lobe, and small U_4-lobe outside the umbilical seam.

Tab. 9: Conch ontogeny of *Pharciceras evolvens* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; subevolute (ww/dm ~ 0,50; uw/dm ~ 0.45)	moderately depressed; weakely embracing (ww/wh ~ 1.75; IZR ~ 0.10)	moderate (WER ~ 1.80)
8 mm	thickly discoidal; evolute (ww/dm ~ 0.52; uw/dm ~ 0. 57)	strongly depressed; moderately embracing (ww/wh ~ 2.14; IZR ~ 0.25)	very low (WER ~ 1.45)
20 mm	thinly discoidal; evolute (ww/dm ~ 0.47; uw/dm ~ 0.54)	moderately depressed; moderately embracing (ww/wh ~ 1.88; IZR ~ 0.20)	very low (WER ~ 1.48)
35 mm	thinly discoidal; evolute (ww/dm ~ 0.39; uw/dm ~ 0.48)	weakly depressed; moderately embracing (ww/wh ~ 1.39; IZR ~ 0.27)	low (WER ~ 1.60)

Tab. 10: Conch dimensions of *Pharciceras evolvens* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	44.8	17.2	13.2	21.2	9.1	0.38	1.30	0.47	1.57	0.38
holotype	35.7	14.4	10.3	17.6	7.5	0.40	1.39	0.49	1.60	0.27
holotype	22.8	10.8	5.8	12.2	3.8	0.47	1.85	0.54	1.45	0.34
holotype	10.6	5.6	2.2	6.3	1.6	0.52	2.48	0.59	1.39	0.28
holotype	5.33	2.80	1.27	2.99	0.89	0.53	2.20	0.56	1.44	0.30
holotype	1.91	0.98	0.55	0.86	0.50	0.51	1.77	0.45	1.83	0.10

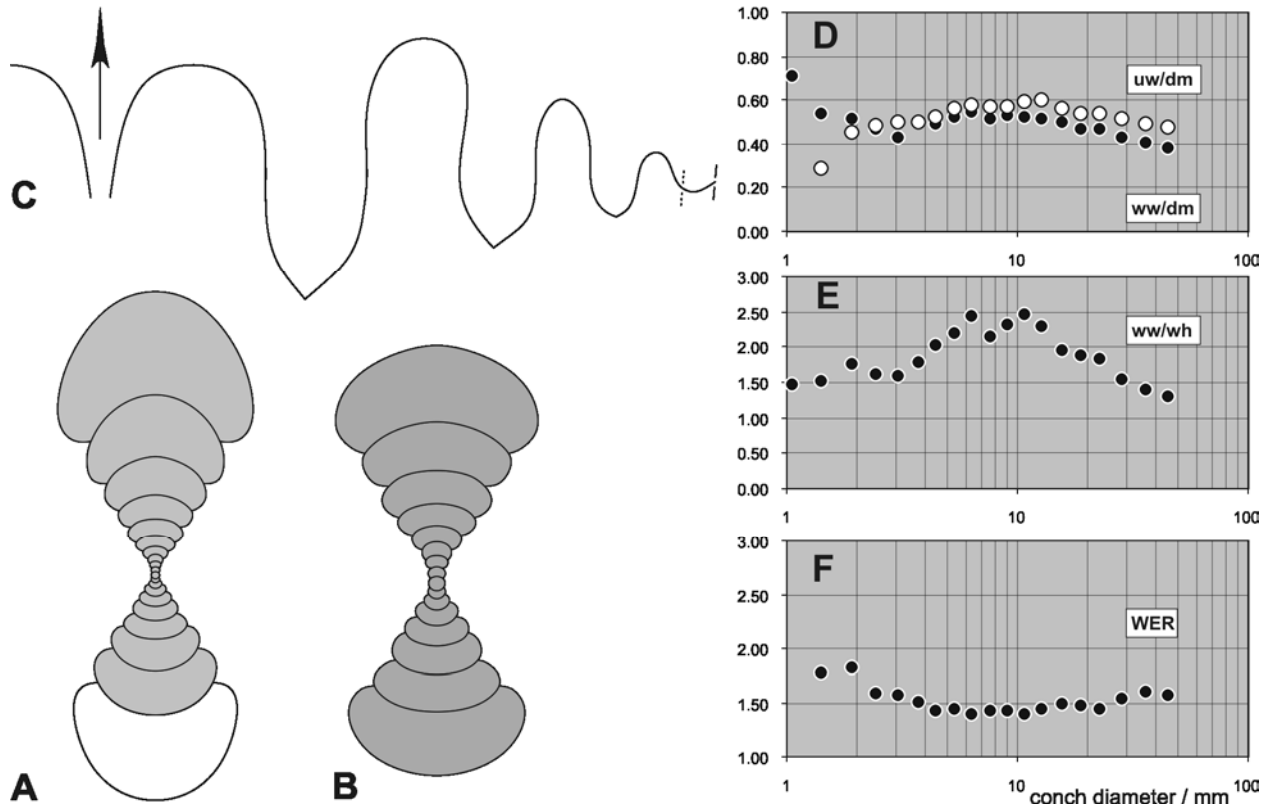


Fig. 8: *Pharciceras evolvens* n. sp., holotype MB.C.19105 from Dar Kaoua. **A-B.** Cross sections; x 1.5, inner whorls x 4. **C.** Suture at 44 mm dm and 15 mm wh; x 4. **D-F.** Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER.

Description: The holotype is partly embedded in matrix and only one side is well preserved. The cross-sections (Figs. 8A-B) and ww data (Fig. 8D) became available after mirroring through the protoconch centre. There are 9 ½ slowly expanding whorls with very low WER values at ca. 45 mm dm (Fig. 8F), which suggests that the species did not grow much larger. Only the first two and last 1 ½ whorls expand slightly faster, with WER > 1.5. A first minor change of shell form occurs after the 2nd whorl at ca. 2 mm dm. The marked allometric change at ca. 10 mm dm is best expressed in the ww/wh values (Fig. 8E) but also results in a slowdown of umbilical expansion and in decreasing relative umbilical width (Fig. 8D). The Montagne Noire specimen is very similar to the holotype, perhaps slightly thinner at 35 mm dm. The Mdoura paratype is an internal mould with ca. 43 mm max. dm; one side and the umbilical centre are corroded. It is equally evolute as the holotype (uw/dm = 0.47) and shows ventrolateral double furrows, with the outer furrow being more prominent. Partly due to the lack of shell it is slightly thinner. The holotype suture is illustrated in Fig. 8C and characterized by a linear increase of lobe depth from the umbilicus (U_4) to the venter (E_2). The mature median saddle is wider than the external saddle.

Discussion: *Ph. evolvens* n. sp. is closest to *Ph. tridens* but significantly thinner throughout ontogeny. In the combined ww/dm and uw/dm plots this is easily visualized by higher uw/dm than ww/dm ratios from 2.5 mm dm on. There is no evidence that the fields of variation of both taxa touch. Slight differences in sutures of MB.C.19104.1 (*Ph. tridens*) and 19105 (*Ph. evolvens* n. sp.), such as the height of the median saddle and sharpening of the flank lobes, may reflect ontogenetic changes but the regular, stepwise decline of lobe depth towards the umbilicus is not seen in *Ph. tridens*. *Ph. amplexum* has a flat venter bound by strong spiral furrows, *Ph. galeatum* a sudden late ontogenetic change to a rather compressed terminal whorl. The poorly known *Pharciceras* n. sp. A of Matern (1931) is compressed at maturity and has four isometric flank lobes that suggest relationships with *Lunupharciceras*. All other *Pharciceras* species are more involute and thicker.

Stratigraphical range: Topmost Middle Givetian (MD III-A) to Upper Givetian (MD III-C).

Geographical distribution: Tafilalt and Montagne Noire.

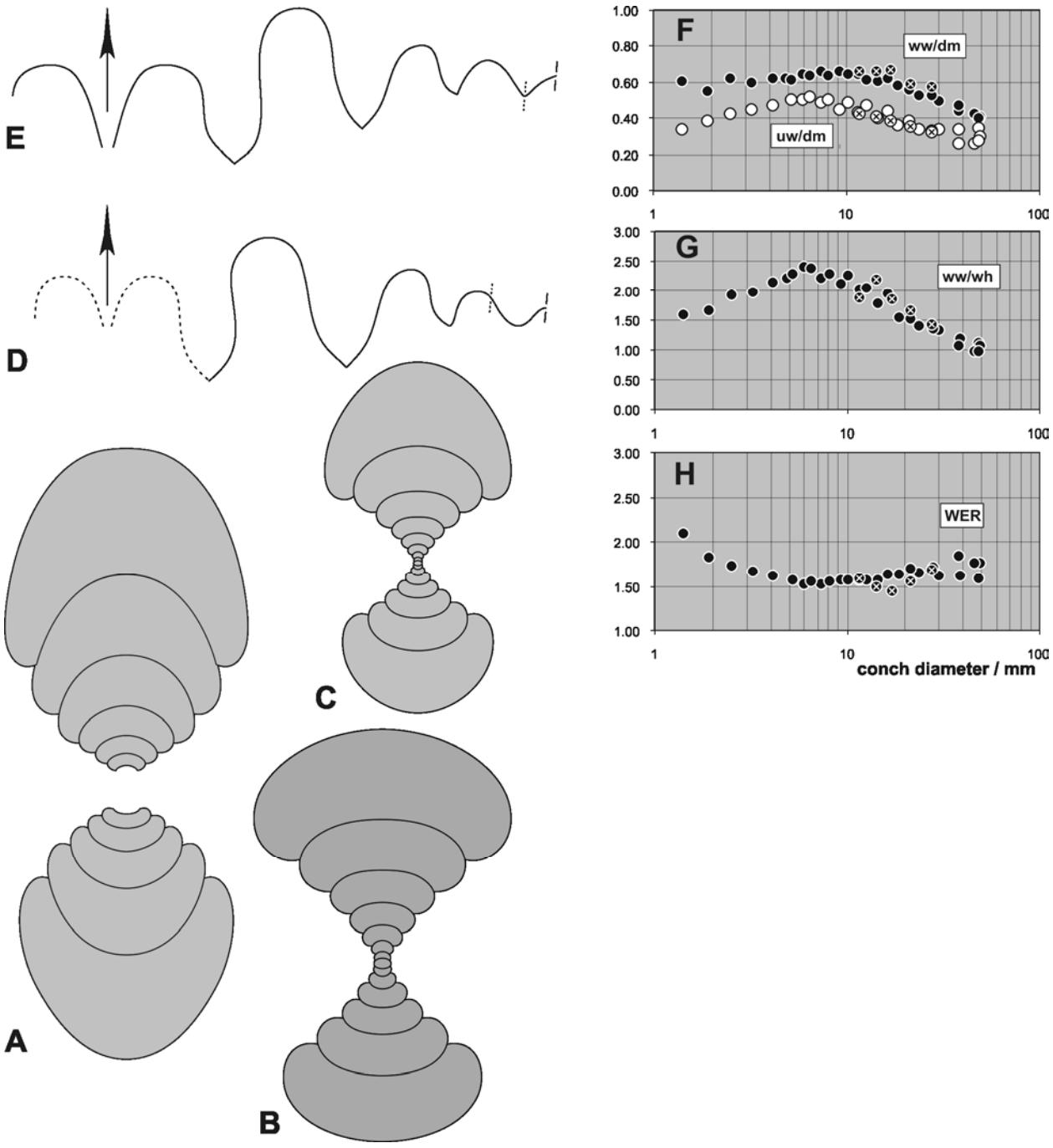


Fig. 9: *Pharciceras lateseptatum* (Frech, 1902a) from Dar Kaoua. **A**. Cross section of MB.C.19107.3; x 2. **B-C**. Cross sections of MB.C.19107.4; x 2, inner whorls x 4. **D**. Suture of MB.C.19107.1 at 12.8 mm wh; x 4. **E**. Suture of MB.C.19107.6 at 12.5 mm wh; x 4. **F-H**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all available specimens. Crossed dots refer to measurements taken from the cross-section illustrated by Frech (1902a).

***Pharciceras lateseptatum* (Frech, 1902a)** (emend.)

Figs. 9A-H, 10A-B, J

*	1902a	*Prolecanites lateseptatum* Frech: 65, pl. 3, figs. 11a-c
cf.	1921	*Pharciceras lateseptatum* Paeckelmann: 121, pl. 3, fig. 7
?	1929	cf. *Pharciceras lateseptatum* Termier: 259
	1982	*Pharciceras lateseptatum* Korn & Wunderlich: 93-95, figs. 1d-e, 4a-e

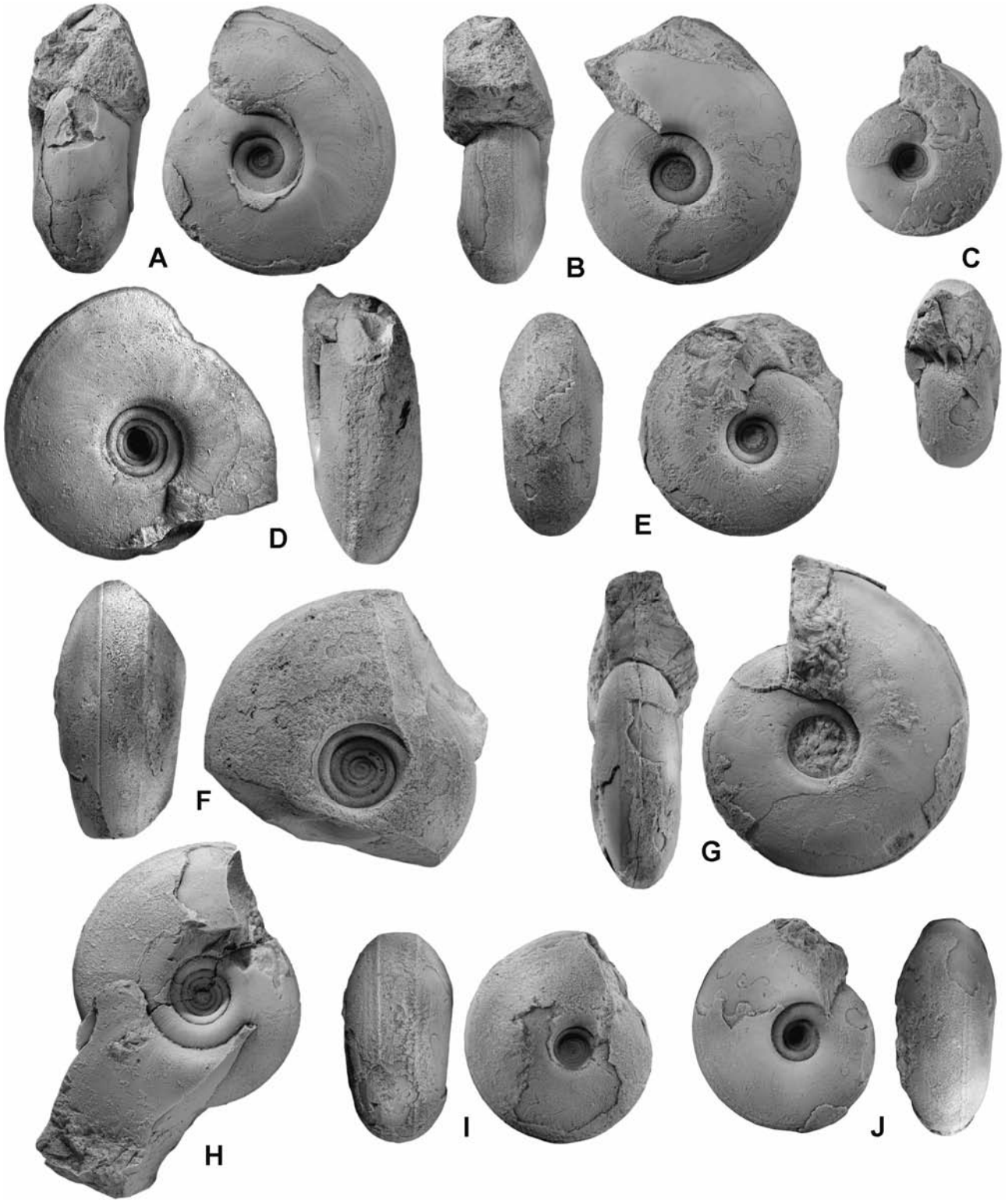


Fig. 10: Species of *Pharciceras* from Dar Kaoua. **A.** *Ph. lateseptatum* (Frech, 1902a), MB.C.19107.1, adoral and ventral views; x 1. **B.** *Ph. lateseptatum* (Frech, 1902a), MB.C.19107.2, adoral and lateral views; x 1. **C.** *Ph. pargai* Montesinos & Henn, 1986, Morphotype II, MB.C.19114.3, lateral and adoral views; x 1. **D.** *Ph. pargai* Montesinos & Henn, 1986, Morphotype I, MB.C.19114.9, lateral and ventral views; x 1. **E.** *Ph. pargai* Montesinos & Henn, 1986, Morphotype II, MB.C.19114.8, ventral and lateral views; x 1. **F.** *Ph. darkaouense* n. sp., holotype MB.C.19109.1, ventral and lateral views; x 1. **G.** *Ph. kayseri* Wedekind 1918, MB.C.19110.1, adoral and lateral views; x 1. **H.** *Ph. pargai* Montesinos & Henn, 1986, Morphotype II, MB.C.19114.2, lateral view; 1. **I.** *Ph. pargai* Montesinos & Henn, 1986, Morphotype III, MB.C.19114.1, ventral and lateral views; x 1. **J.** *Ph. lateseptatum* (Frech, 1902a), MB.C.19107.5, lateral and ventral views; x 1.

Type: The original of Frech (1902a: Figs. 11a-b) is here designated as lectotype. However, this specimen was part of Frech´s private collection, of which there is no trace. It was most likely destroyed at Breslau University (now Wroclaw) during the 2nd World War. Consequently, a neotype needs to be selected from the Pic de Bissous type locality but subsequent re-sampling (House et al. 1985; Aboussalam & Becker 2001) did not produce any new specimen. There is also no material from any other adjacent Montagne Noire locality, which results in an unsatisfactorily unsettled type question.

Type locality and level: Pic de Cabrières (= Pic de Bissous), Montagne Noire; Upper Givetian, undifferentiated.

Material: Eight specimens up to 50 mm dm (MB.C.19107.1-8).

Diagnosis (emend.): Moderate-sized, first five whorls, ca. until 8 mm dm, increasingly depressed and evolute (cadiconic), with strongly increasing ww/wh (up to ca. 2.5), weakly increasing ww/dm (up to ca. 0.65) and fast rise of uw/dm (up to 0.5) ratios whilst WER decreases to ca. 1.5; subsequently less depressed (ww/wh = ca. 1.5 at 20 mm dm), with decreasing relative umbilical width (uw/dm = ca. 0.35 at ca. 30 mm dm) and slightly faster expanding whorls (adult WER = 1.6 to 1.8); last whorl slightly compressed (ww/wh near 1.0) and subevolute (uw/dm 0.25 to 0.3). Evenly spaced growth lirae strongly biconvex, with ventrolateral double furrows near the narrow ventrolateral salient. Mature sutures with diverging E_1-lobe, moderately high to high median saddle, deep, lanceolate E_2-lobe, elevated and relative narrow ventral saddle, moderately deep to deep lanceolate L-lobe, moderately narrow, asymmetric, pointed U_2-lobe, and wide, rounded to subangular, subumbilical U_4-lobe.

Tab. 11: Conch ontogeny of *Pharciceras lateseptatum* (Frech, 1902a) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; subevolute (ww/dm = 0.55-0.60; uw/dm ~ 0.40)	moderately depressed; moderately embracing (ww/wh =1.65-1.70; IZR ~ 0.21)	moderate (WER ~ 1.80)
8 mm	thinly pachyconic; evolute (ww/dm ~ 0.65; uw/dm ~ 0.50)	strongly depressed; strongly embracing (ww/wh = 2.20 -2.30; IZR = 0.30-0.36)	low (WER ~ 1.55)
20 mm	thickly discoidal; subevolute (ww/dm ~ 0.55; uw/dm ~ 0.35-0.40)	weakly depressed;strongly embracing (ww/wh ~1.50; IZR = 0.35- 0.40)	low (WER = 1.65-1.70)
48 mm	thinly discoidal; subinvolute or subevolute (ww/dm ~ 0.40; uw/dm = 0.28-0.35)	weakly depressed to compressed; strongly embracing (ww/wh =0.95-1.10; IZR = 0.35-0.42)	low or moderate (WER = 1.60-1.80)

Tab. 12: Conch dimensions of *Pharciceras lateseptatum* (Frech, 1902a) from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19107.1	48.7	20.0	18.5	14.7	12.0	0.41	1.08	0.30	1.76	0.35
MB.C.19107.3	48.3	19.2	17.3	16.7	10.0	0.40	1.11	0.35	1.59	0-42
MB.C.19107.2	48.3	19.3	2.00	13.5	-	0.40	0.97	0.28	-	-
MB.C.19107.6	45.6	19.5	19.9	12.0	11.2	0.43	0.98	0.26	1.76	0.44
MB.C.19107.8	38.2	18.0	16.9	9.9	10.0	0.47	1.07	0.26	1.83	0.41
MB.C.19107.4	27.8	14.7	10.8	9.1	6.6	0.53	1.36	0.33	1.72	0.39
MB.C.19107.4	16.3	10.2	5.2	7.2	3.6	0.62	1.94	0.44	1.64	0.32
MB.C.19107.4	10.1	6.5	2.9	5.0	2.0	0.65	2.27	0.49	1.57	0.29
MB.C.19107.4	5.18	3.16	1.38	2.60	1.05	0.61	2.29	0.50	1.58	0.24
MB.C.19107.4	1.90	1.06	0.63	0.74	0.50	0.55	1.67	0.39	1.83	0.21

Description: Apart from the last two, slightly faster expanding whorls, the cross-section appears to be relative uniform (Figs. 9A-C) but the morpometric plots (Figs. 9F-H) clearly outline the significant allometric turning point near 7-8 mm dm. At all stages, the umbilical wall is steeply rounded (Figs. 10A-B) and ornamented by distinctive growth lirae, which are sharp and rib-like in early stages. Their width varies

between 0.3-0.4 (MB.C.19107.1) to 06-0.8 (MB.C.19107.7). The venter is always broadly rounded (Figs. 10A-B). Three shallow spiral furrows border two ventrolateral keels in the position of the projecting ventrolateral salient (e.g., in MB.C.19107.5, Fig. 10J). Other specimens display the fine, dense, radial wrinkle layer (e.g., MB.C.19107.7, 19107.2). The ontogenetic sharpening of flank lobes varies, as does the shortening of the median E_1. Before 10 mm dm (MB.C.19107.7) all flank lobes are still narrowly rounded. Typical sutures with variably subangular (MB.C.19107.6) or rounded (MB.C.19107.1) U_4-lobe at 12.5 to 13 mm dm are shown in Figs. 9D-E. In MB.C.19107.8, the E_1-lobe is still very long at 13.5 mm wh. At late maturity, at 19 mm wh and 45 mm dm, in the last septum of MB.C.19107.2, the median saddle has risen strongly and becomes as high as the neighbouring ventral saddle; the E_1-lobe is significantly shortened. The inner suture is visible in MB.C.19107.4 at ca. 36 mm dm. It consists of a narrow and deep I-lobe, three equally high saddles, a moderately deep, lanceolate U_1-lobe, and a diverging, shorter U_3-lobe. MB.C.19107.2 suggests that the species reaches 9 ½ to 10 whorls and a maximum size of more than 65 mm dm.

Discussion: The loss and insufficient knowledge of the types of *Ph. lateseptatum* prevent its easy recognition. Petter (1959), House et al. (1985), and Göddertz (1987) regarded it as a junior synonym of *Ph. tridens* but this is contradicted by our morphometric data. Both species seem to be closely related but measurements obtained from Frech´s cross-section (1902a: pl. 2, fig. 11c) generally agree with distinctive Dar Kaoua specimens assigned here (see crossed dots in Figs. 9F-H). Interestingly, the first Moroccan pharciceratids ever reported by Termier (1929) were assigned with cf. to *Ph. lateseptatum*; this identification needs to be revised based on the Termier collection. The main distinction of *Ph. lateseptatum* in comparison with *Ph. tridens* lies in its narrower umbilicus from ca. 8 mm dm on (uw/dm ratios < 0.4 of median and mature whorls), in an earlier reduction of ww/wh ratios, and in more compressed last whorls, combined with slightly higher mature WER. This ontogenetic change is more drastic in *Ph. galeatum*. *Ph. amplexum* and *Ph. evolvens* n. sp. are both thinner, all other *Pharciceras* species more involute and compressed. Specimens assigned to *Ph. lateseptatum* by Korn & Wunderlich (1982; e.g., No. 78059.7, which was re-examined) have somewhat higher uw/dm values (0.44 at 20 mm dm) than the lectotype and the Dar Kaoua material.

Stratigraphical range: *Syn. clavilobum* Zone (MD III-C), possibly ranging higher and lower within the Upper Givetian.

Geographical distribution: Montagne Noire, Tafilalt.

Pharciceras aff. *lateseptatum* (Frech, 1902a)

Figs. 11A-F

Description: A single, rather poorly preserved specimen (MB.C.19108) differs from the associated population of *Ph. lateseptatum* in its ontogeny (Fig. 11A-B), especially in its first five whorls until 8-9 mm dm (Figs. 11D-F). Notably, the first three whorls are more serpenticonic instead of cadiconic, resulting in higher uw/dm and much lower ww/dm ratios (Fig. 11D) until an allometric turn at ca. 4 mm dm. The uw/dm plot crosses twice the ww/dm plot, whilst both are strictly separate in *Ph. lateseptatum*. The turn to decreasing ww/wh ratios occurs slightly later, at 8 mm dm, but at the same value of ca. 2.5 (Fig. 11E) as in *Ph. lateseptatum*. WER rates (Fig. 11F) show a slightly faster early ontogenetic decline to 1.5 at 3.5 to 4 mm dm. Sutures (Fig. 11C) give no distinction.

Tab. 13: Conch ontogeny of *Pharciceras* aff. *lateseptatum* (Frech, 1902a) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; subevolute (ww/dm ~ 0.48; uw/dm ~ 0.35)	weakly depressed; moderately embracing (ww/wh ~ 1.47; IZR ~ 0.28)	moderate (WER ~ 1.75)
8 mm	thinly pachyconic; evolute (ww/dm ~ 0.63; uw/dm ~ 0.53)	strongly depressed; strongly embracing (ww/wh ~ 2.40; IZR ~ 0.35)	low (WER ~ 1.45)
20 mm	thickly discoidal; subevolute (ww/dm ~ 0.58; uw/dm ~ 0.42)	moderately depressed; strongly embracing (ww/wh ~ 1.70; IZR ~ 0.40)	low (WER ~ 1.60)
33 mm	thickly discoidal; subevolute (ww/dm ~ 0.49; uw/dm ~ 0.31)	weakly depressed; strongly embracing (ww/wh ~ 1.20; IZR ~ 0.39)	moderate (WER = 1.77)

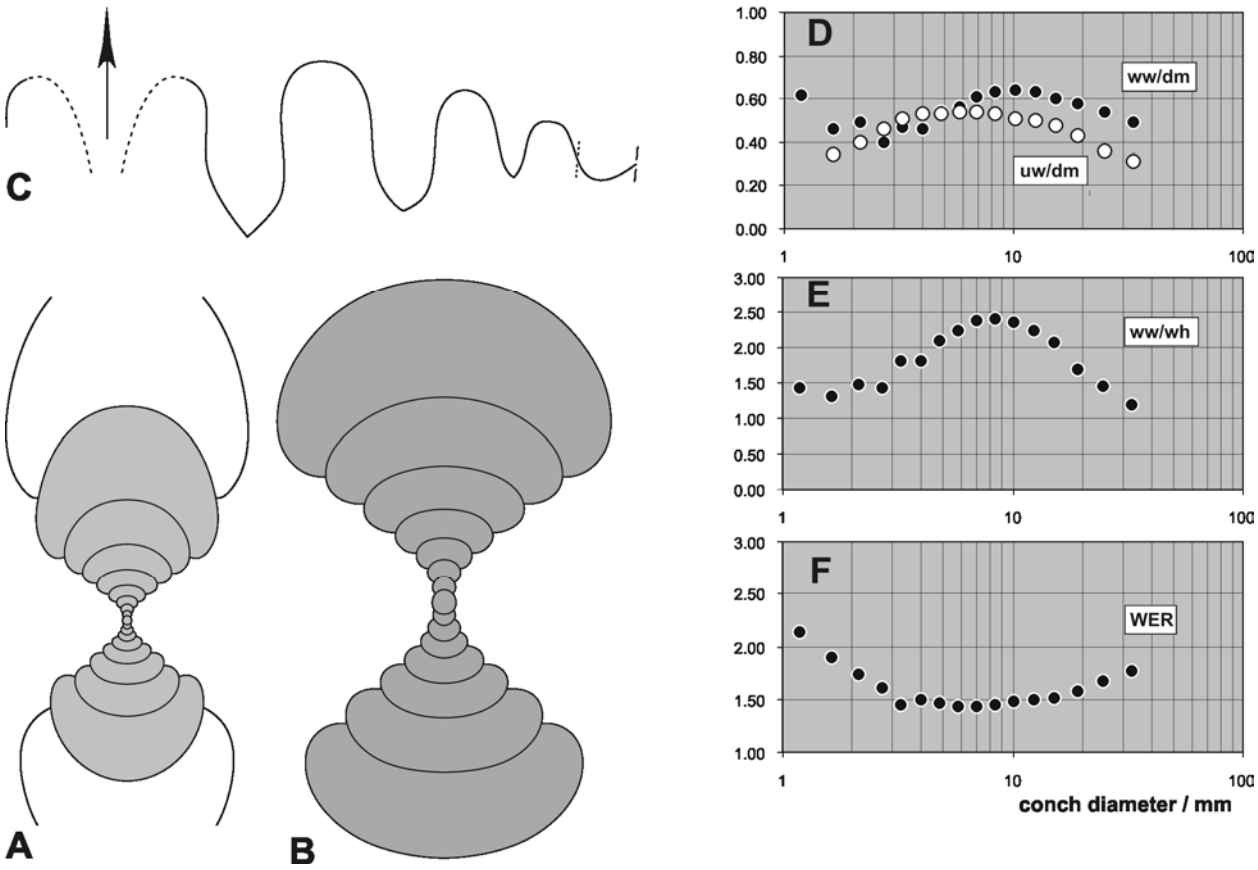


Fig. 11: *Pharciceras* aff. *lateseptatum* (Frech, 1902a), MB.C.19114.1, from Dar Kaoua **A-B**. Cross sections; x 2, inner whorls x 4. **C**. Suture at 15.5 mm wh; x 4. **D-F**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER.

Tab. 14: Conch dimensions of *Pharciceras* aff. *lateseptatum* (Frech, 1902a) from Dar Kaoua

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19108	33.0	16.0	13.4	10.4	8.2	0.49	1.20	0.31	1.77	0.39
MB.C.19108	24.8	13.5	9.3	9.0	5.7	0.54	1.45	0.36	1.68	0.39
MB.C.19108	15.2	9.2	4.4	7.3	2.8	0.60	2.07	0.48	1.51	0.36
MB.C.19108	10.1	6.5	2.8	5.2	1.8	0.64	2.36	0.51	1.48	0.35
MB.C.19108	4.83	2.6	1.24	2.58	0.83	0.54	2.10	0.53	1.46	0.33
MB.C.19108	2.15	1.06	0.72	0.86	0.52	0.49	1.47	0.40	1.73	0.28

Discussion: MB.C.19108 lies outside the variability spectrum of *Ph. lateseptatum* but only early whorls are different. There is no other known pharciceratid with similar shell ontogeny. With respect to the poor preservation of the single specimen, which is not suitable as a type, we apply open nomenclature.

Stratigraphical range: *Syn. clavilobum* Zone (MD III-C).

Geographical distribution: So far only known from Dar Kaoua.

***Pharciceras pargai* Montesinos & Henn, 1986** (emend.)

Figs. 10C-E, H-I, 12A-F,13A-K,14A-F

* 1986 *Pharciceras pargai* Montesinos & Henn: 66-67, figs. 3-4, 5B, 6F, 6I [further synonymy]

v non 2000a *Stenopharciceras* aff. *pargai* Becker & House: 31

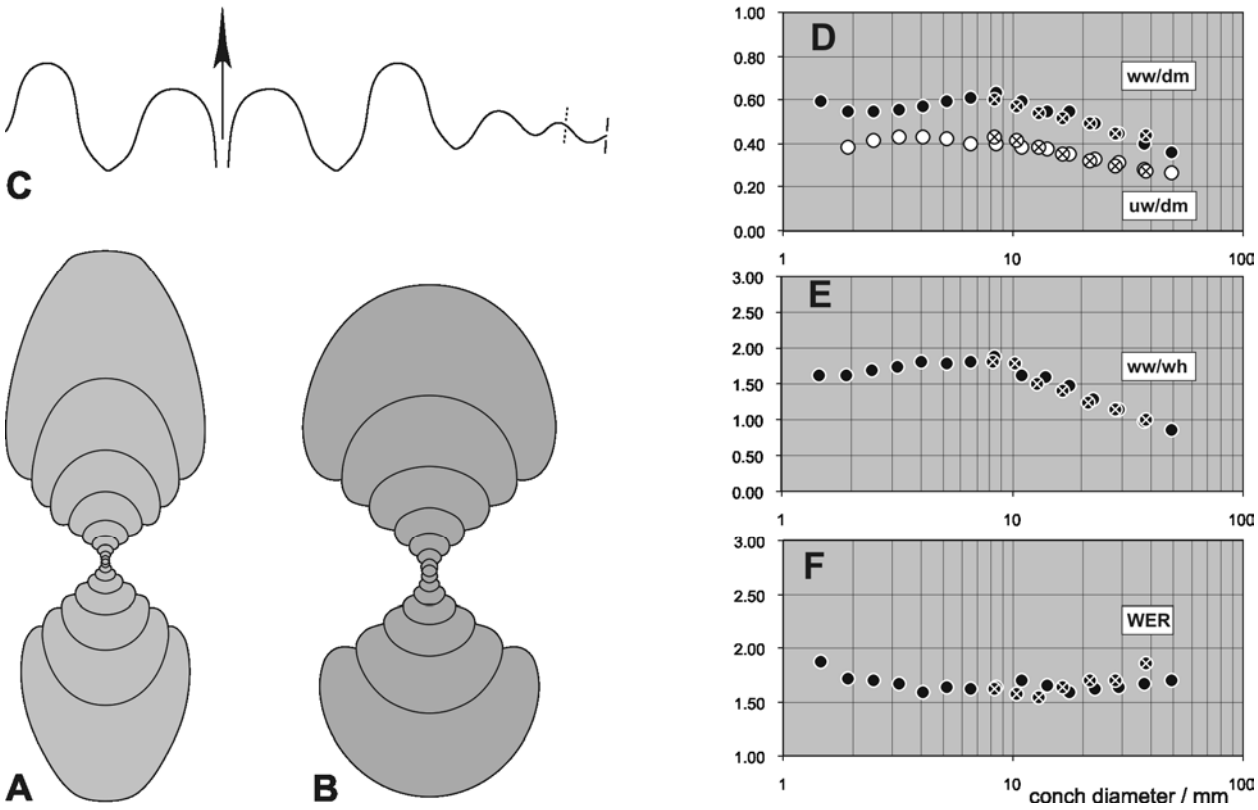


Fig. 12: *Pharciceras pargai* Montesinos & Henn, 1986, Morphotype I (typical morphotype), MB.C.19114.9, from Dar Kaoua **A-B**. Cross sections; x 1.5, inner whorls x 4. **C**. Suture at ~ 20 mm wh; x 2.5. **D-F.** Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER. Crossed dots refer to measurements taken from the cross-section illustrated by Montesinos & Henn (1986).

Type: Holotype DPO 113.012, illustrated in Montesinos & Henn (1986).

Type locality and horizon: Section Cardaño 3, NNE Pico Gildar, 6 km SSE of Posado de Valdéon, Léon Province, Cantabrian Mts.; sample 18, Cardaño Formation, *Taouzites* Zone (MD III-D; based on direct association with *Taouzites palantianus*), Upper Givetian.

Material: One specimen (MB.C.19114.9) with 48 mm conch diameter of the typical morphotype (Morphotype I), seven specimens of Morphotype II up to 60 mm dm (MB.C.19114.2-8), and one specimen of Morphotype III (MB.C.19114.1).

Diagnosis (emend.): Shell rather variable, first five whorls, ca. until 8-9 mm dm, increasingly depressed and subevolute, with ww/dm reaching 0.6-0.73, ww/wh ratios rising up to 1.9-2.2, and uw/dm 0.35-0.43 whilst WER decreases to ca. 1.6; subsequent whorls thinner, less depressed, and with decreasing uw/dm (subinvolute, uw/dm 0.2 - 0.3); mature stages slightly compressed from 40 mm dm on, with ww/dm near 0.4, slightly faster expanding whorls (WER = 1.7 to 1.85), and with gently rounded venter bordered by rounded marginal shoulders. Evenly spaced growth lirae are strongly biconvex, with ventrolateral double or triple furrows and two spiral keels around the narrow ventrolateral salient, the outer one forming a ventral edge. Mature sutures with narrow, moderately deep to short E_1-lobe, moderately high, rounded median saddle, deep, lanceolate to bell-shaped E_2-lobe, elevated ventral saddle, moderately deep to deep, subangular to pointed L-lobe, and two small outer U-lobes, with U_4 sitting outside the umbilical seam.

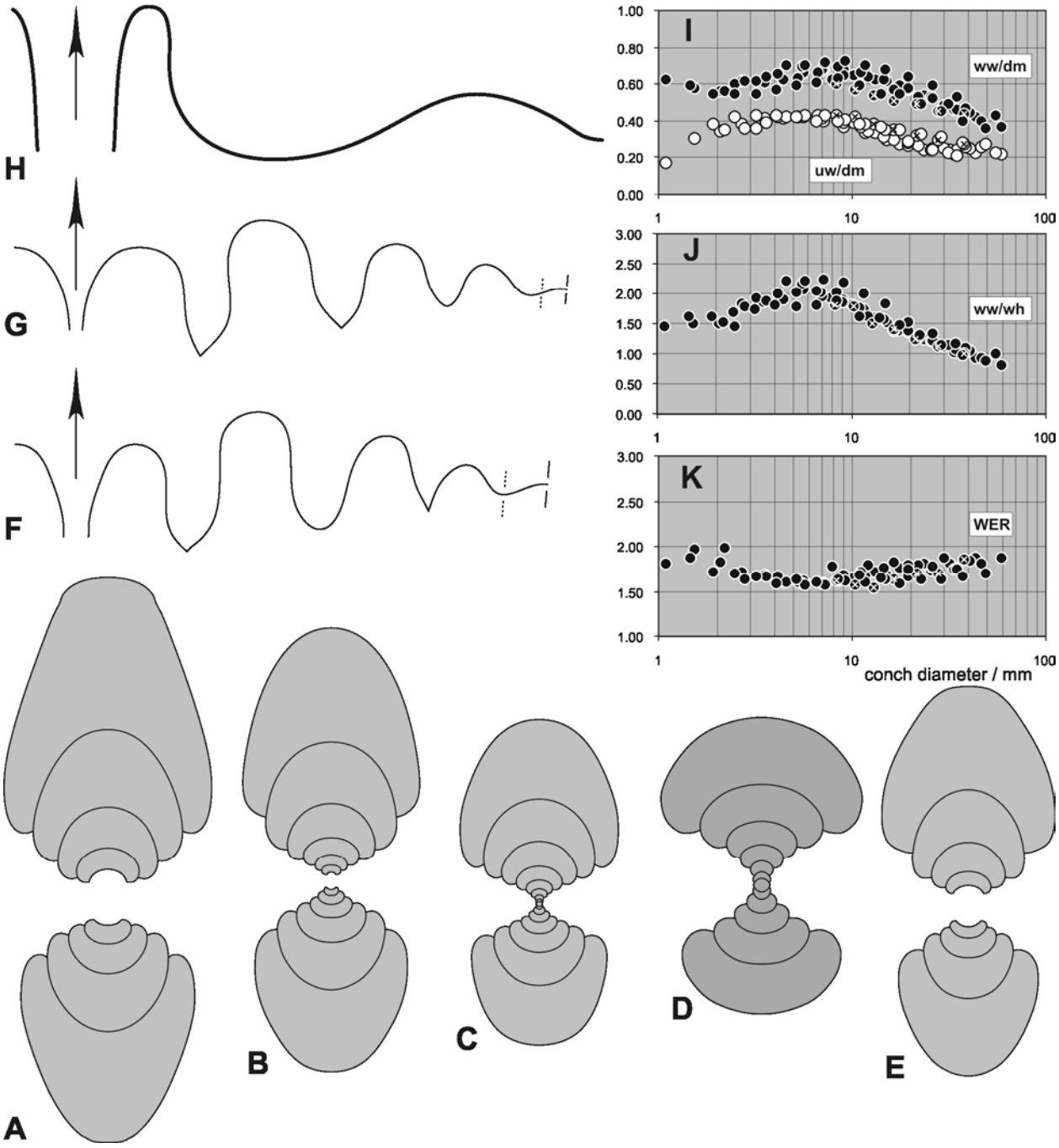


Fig. 13: *Pharciceras pargai* Montesinos & Henn, 1986, Morphotype II, from Dar Kaoua. **A.** Cross section of MB.C.19114.5; x 1.5. **B**. Cross section of MB.C.19114.7; x 1.5. **C-D**. Cross sections of MB.C.19114.4; x 1.5, inner whorls x 4. **E**. Cross section of MB.C.19114.6; x 1.5. **F**. Suture of MB.C.19114.6 at 11.5 mm wh; reversed, x 4. **G**. Suture of MB.C.19114.4 at 14 mm wh; reversed, x 4. **H**. Course of growth lirae of MB.C.19114.4 at 14.5 mm wh; x 4. **I-K**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all available *Ph. pargai* specimens.

Tab. 15: Conch ontogeny of *Pharciceras pargai* Montesinos & Henn, 1986 from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
Morphotype I (sensu the holotype, thin)			
2 mm	thickly discoidal; subevolute (ww/dm ~ 0,55; uw/dm ~ 0.38)	moderately depressed; moderately or strongly embracing; (ww/wh ~ 1.65; IZR ~ 0.30)	low (WER ~ 1.72)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.62; uw/dm ~ 0.40)	moderately depressed; strongly embracing (ww/wh ~ 1.88; IZR ~ 0.35)	low (WER ~ 1.62)
20 mm	thickly discoidal; subevolute (ww/dm ~ 0.50; uw/dm ~ 0.33)	weakly dempressed; strongly embracing (ww/wh ~ 1.40; IZR ~ 0.44)	low (WER ~ 1.60)
38 mm	thinly discoidal; subinvolute (ww/dm ~ 0.40; uw/dm ~ 0.28)	weakly compressed; strongly embracing (ww/wh ~ 0.97; IZR ~ 0.40)	low (WER ~ 1.67)
Morphotype II (moderately thick)			
2 mm	thickly discoidal; subevolute (ww/dm = 0,55-0.60; uw/dm ~ 0.35)	weakly depressed; moderately or strongly embracing (ww/wh ~ 1.50; IZR ~ 0.30)	moderate (WER ~ 1.85)
8 mm	thinly pachyconic; subevolute (ww/dm = 0.60-0.70; uw/dm = 0. 35-0.40)	moderately depressed; strongly embracing (ww/wh = 1.90-2.00; IZR = 0.30-0.40)	low (WER = 1.60-1.70)
20 mm	thickly discoidal; subinvolute (ww/dm = 0.55-0.60; uw/dm = 0.25-0.30)	weakly depressed; strongly embracing (ww/wh = 1.25-1.40; IZR = 0.40-0.45)	low or moderate (WER = 1.70-1.80)
35 mm	thinly to thickly discoidal; subinvolute (ww/dm = 0.45-0.50; uw/dm = 0.20- 0.25)	weakly depressed; strongly to very strongly embracing (ww/wh = 1.00-1.15; IZR = 0.40-0.50)	moderate (WER = 1.75-1.85)
Morphotype III (thick)			
2 mm	thickly discoidal; subevolute (ww/dm ~ 0,55; uw/dm ~ 0.35)	moderately depressed; moderately embracing (ww/wh ~ 1.52; IZR ~ 0.21)	moderate or high (WER ~ 2.00)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.72; uw/dm ~ 0.42)	strongly depressed; strongly embracing (ww/wh ~ 2.20; IZR ~ 0.36)	low (WER ~ 1.60)
20 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.65; uw/dm ~ 0.30)	weakly to moderately depressed; strongly embracing (ww/wh ~ 1.50; IZR ~ 0.43)	low or moderate (WER ~ 1.75)
35 mm	thickly discoidal; subinvolute (ww/dm ~ 0.53; uw/dm ~ 0.20)	weakly depressed; very strongly embracing (ww/wh = 1.17; IZR = 0.46)	low or moderate (WER ~ 1.75)

Description: The available rather variable material (Figs. 13I-K) allows to separate three morphotypes, I-III, mostly based on their ontogenetic changes of whorl and umbilical width. These are described separately. MB.C.19114.9, the only representative of the relative thin Morphotype I, is partly preserved (Fig. 10D) but shows well the cross-section (Figs. 12A-B), sutures (Fig. 12C) and ornament. The umbilical wall is short and steeply rounded. At ca. 50 mm dm there are nine whorls. Characteristic are the relative small changes in umbilication (Fig. 12D) and WER (Fig. 12F) during ontogeny. The post-embryonic conch ontogeny is less biphasic than in the other morphotypes (Figs. 12D-E).

The somewhat thicker Morphotype II is best represented by MB.C.19114.8 (Fig. 10E) and locally dominant (Figs. 13A-E). MB.C.19114.5 shows a mature cross-section with flank flattening and subangular ventro-lateral edges (Fig. 13A). The internal mould of MB.C.19114.7 possesses an oblique umbilical wall with a rounded edge at ca. 42 mm dm; normally it is deep and rounded. The allometric turning point at 9-10 mm dm is distinctive in the ww/wh ratio (Fig. 13J) whilst the uw/dm (Fig. 13I) and WER ratios (Fig. 13K) show little change between ca. 3-4 and 8 mm dm. The trend towards less depressed and more narrowly umbilicate whorls is steady between ca. 10 and 40 mm dm. The mature 9th whorl has the highest WER.

The much thicker Morphotype III is only represented by MB.C.19114.1, a small specimen with eight whorls (Figs. 14A-B) that is fully septate. The venter and steep umbilical wall are rounded (Fig. 10I). Its markedly

biphasic conch ontogeny is illustrated in Figs. 14D-F. The ww/wh values produce a plateau at ca. 2.2 between 4.5 and 9 mm dm (between 3 ½ and 5 whorls), before declining steeply to values close to 1.1 (Fig. 14E). WER stays constant from ca. 25 mm dm on.

Tab. 16: Conch dimensions of *Pharciceras pargai* Montesinos & Henn, 1986 from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
Morphotype I (sensu the holotype, thin)										
MB.C.19114.9	48.6	17.5	20.2	13.0	11.3	0.36	0.87	0.27	1.70	0.44
MB.C.19114.9	28.9	13.0	11.3	9.0	6.3	0.45	1.15	0.31	1.64	0.44
MB.C.19114.9	17.7	9.7	6.6	6.3	3.7	0.55	1.47	0.35	1.59	0.44
MB.C.19114.9	10.9	6.5	4.0	4.2	2.5	0.59	1.63	0.38	1.69	0.36
MB.C.19114.9	5.17	3.06	1.71	2.19	1.13	0.59	1.79	0.42	1.64	0.34
MB.C.19114.9	2.48	1.36	0.81	1.03	0.58	0.55	1.68	0.42	1.7	0.28
MB.C.19114.9	1.45	0.86	0.53	--	0.39	0.59	1.62	--	1.87	0.26
Morphotype II (moderately thick)										
MB.C.19114.5	59.2	21.7	26.7	12.8	15.9	0.37	0.81	0.22	1.87	0.40
MB.C.19114.7	46.8	18.5	19.8	11.9	11.9	0.40	0.94	0.26	1.81	0.40
MB.C.19114.6	40.8	18.1	17.4	10.2	10.8	0.44	1.04	0.25	1.85	0.38
MB.C.19114.8	38.9	18.3	16.9	10.0	c. 10.5	0.47	1.08	0.26	1.88	-
MB.C.19114.2	38.4	17.3	17.2	10.2	10.5	0.45	1.01	0.27	1.89	0.39
MB.C.19114.4	33.8	15.6	15.2	7.5	8.2	0.46	1.03	0.22	1.74	0.46
MB.C.19114.3	31.5	15.5	13.5	7.2	-	0.49	1.15	0.23	-	-
MB.C.19114.5	23.5	12.6	10.3	5.8	6.0	0.54	1.23	0.24	1.81	0.41
MB.C.19114.5	13.2	8.2	5.1	4.5	3.1	0.62	1.6	0.34	1.71	0.39
MB.C.19114.5	7.8	4.9	2.5	--	2.0	0.63	1.93	--	1.77	0.23
MB.C.19114.4	4.43	2.77	1.46	1.83	0.92	0.62	1.90	0.41	1.60	0.36
MB.C.19114.4	2.07	1.16	0.77	0.71	0.54	0.56	1.51	0.34	1.83	0.30
Morphotype III (thick)										
MB.C.19114.1	34.5	18.4	15.7	7.3	8.4	0.53	1.17	0.21	1.75	0.46
MB.C.19114.1	26.1	15.4	11.5	6.3	6.5	0.59	1.34	0.24	1.77	0.44
MB.C.19114.1	14.9	10.2	5.5	5.2	3.2	0.68	1.83	0.35	1.63	0.42
MB.C.19114.1	9.2	6.7	3.1	3.8	2.0	0.73	2.18	0.41	1.62	0.36
MB.C.19114.1	5.74	4.01	1.81	2.49	1.16	0.70	2.21	0.43	1.57	0.36
MB.C.19114.1	2.19	1.23	0.81	0.77	0.64	0.56	1.52	0.35	1.99	0.21

The growth lirae of all three morphotypes of *Ph. pargai* show the typical strongly biconvex course of *Pharciceras* (Fig. 13H), with a low, subsymmetric dorsolateral projection and a much higher, narrow ventrolateral salient embracing spiral double to triple furrows and a low ventrolateral keel. A second minor keel delimits the rounded venter, often sharply, especially in Morphotype III (Fig 10I). At maturity (at ca. 25 mm wh in MB.C.19114.5), the double furrows may change into a flattening zone or wider depression (on the mould), with the outer keel becoming a distinctive ventral edge. On the venter the lirae spacing varies considerably between 1 and 3 per mm. Radially aranged wrinkles are partly preserved on the flank of several specimens (e.g., MB.C.19114.4).

There is some variability in the width of saddles and subsymmetric to asymmetric shape of lobes (Figs. 12C, 13F-G, 14C). Below 10 mm wh, the L and U_2-lobes are still rounded (MB.C.19114.3), this continues in MB.C.19114.8 until ca. 16 mm wh and in MB.C.19114.9 (Fig. 12C) until 20 mm wh but both lobes are already pointed at 12 mm wh in MB.C.19114.6 (Fig. 13F), 19114.4 (Fig. 13G), and in MB.C.19114.1 (Fig. 14C). The inner lobes, with two U-lobes, are visible on the cross-section of MB.C.19114.6 and in the adoral septal face of MB.C.19114.3 (both Morphotype II).

Discussion: Morphotype I closely resembles the Spanish *Ph. pargai* but in the holotype there is a trend to flattening of the last whorl, producing a more strongly tegoid whorl profile. The shell parameters of both specimens plot so similar (crossed dots in Figs. 12D-F and 13I-K) that there is no doubt about their taxonomic identity. The variability field of the thicker main population from Dar Kaoua, here assigned to Morphotype II, touches the plot of Morphotype I (Figs. 13I-K), which is seen as evidence that both are intraspecific variants. Especially in the ww/wh plot, Morphotype III is slightly separated from all other specimens but the available morphometric data do not justify to separate this single specimen taxonomically. We do not exclude the possibility of future subspecies separations once the morphology of *pargai* populations is better traced through time and space.

Ph. pargai can be easily distinguished from *Ph. tridens*, *Ph. evolvens*, *Ph. lateseptatum*, *Ph. galeatum*, and *Ph. barnetti* by its much less depressed whorls throughout ontogeny and the much narrower umbilicus, in the case of *Ph. lateseptatum* at least of the first five volutions. *Ph. amplexum* is also more evolute and displays deep ventrolateral furrows. *Ph. lateseptatum* is the most similar species that can also be separated by its different ontogenetic trend of ww/wh ratios (*pargai* Morphotype II: ca. 2.0 at 5-6 mm dm, 1.7-1.8 at 10 mm dm, and 1.0 at 40 mm dm; *lateseptatum*: ca. 2.5 at 5-6 mm dm, 2.2 –2.3 at 10 mm dm, and > 1.0 at 40 mm dm). The closely related *Ph. applanatum* has a tabulate mature venter and stronger overlap of median stages (see Bensaid 1974, fig. 19a_1).

Stratigraphical range: *Synpharciceras* (MD III-C) to *Taouzites* (MD III-D) Zones.

Geographical distribution: Northern Spain (Cantabrian Mts.) and southern Morocco (Tafilalt).

***Pharciceras darkaouense* n. sp.**

Figs. 10F, 15A-H

Type: Holotype MB.C.19109.1, cast before sectioning, illustrated in Figs. 10F, 15A-B.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype and paratype MB.C.19109.2.

Etymology: After the type locality.

Diagnosis: First whorls, ca. until 5 mm dm, depressed and subevolute (serpenticonic), with rapidly decreasing ww/dm (from 0.9 to 0.65) and WER ratios (from 2.2 to 1.6) whilst the umbilical width expands fast (up to uw/dm = 0.4); subsequently with steadily decreasing relative whorl width (wd/dm 0.6 at 10 mm dm and 0.4 at 40-50 mm dm), less depressed cross-section, stable umbilical width and low whorls; at maturity more subinvolute (uw/dm ratios = 0.2-0.3) with slightly compressed and faster expanding (WER = 1.65 – 1.8) tegoid whorls and narrowly rounded venter. Growth lirae strongly biconvex, with ventrolateral double furrows and two spiral keels along the narrow ventrolateral salient. Mature sutures with diverging, moderately deep E_1-lobe, moderately high, broadly rounded median saddle, deep, lanceolate E_2-lobe, elevated ventral saddle, moderately deep, bell-shaped L-lobe, narrowly rounded U_2-lobe and wide, shallowly rounded, subumbilical U_4-lobe.

Tab. 17: Conch ontogeny of *Pharciceras darkaouense* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
3 mm	thinly pachyconic; subevolute (ww/dm ~ 0.70 ; uw/dm ~ 0.30)	moderately depressed; moderately embracing (ww/wh ~1.95; IZR = 0.25-0.30)	moderate (WER ~ 1.90)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.65; uw/dm ~ 0.42)	moderately to strongly depressed; strongly embracing (ww/wh = 1.95-2.05; IZR = 0.30-0.35)	low (WER = 1.60-1.70)
20 mm	thickly discoidal; subevolute (ww/dm = 0.50 - 0.55; uw/dm ~ 0.40)	moderately depressed; strongly embracing (ww/wh ~ 1.55; IZR ~ 0.35)	low (WER = 1.60-1.70)
~40 mm	thinly discoidal; subevolute (ww/dm ~ 0.45; uw/dm ~ 0.35)	weakly depressed; strongly embracing (ww/wh ~ 1.15; IZR ~ 0.40)	low (WER = 1.65-1.75)

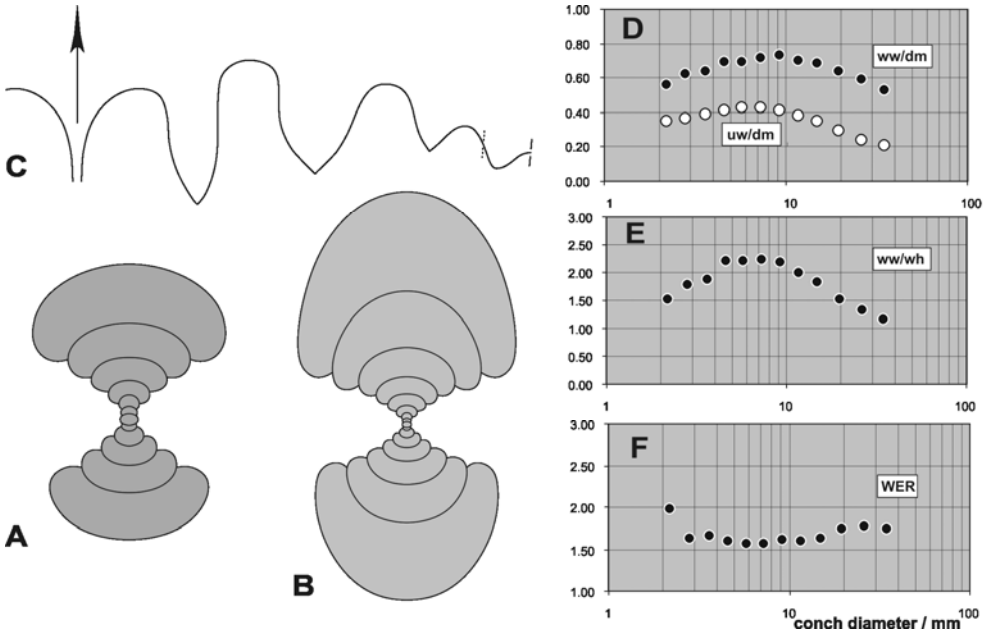


Fig. 14: *Pharciceras pargai* Montesinos & Henn, 1986, Morphotype III (thick morphotype), MB.C.19114.1 from Dar Kaoua **A**-**B**. Cross sections; inner whorls x 4, complete section x 2. **C**. Suture at 15.5 mm wh; x 4. **D**-**F**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER.

Tab. 18: Conch dimensions of *Pharciceras darkaouense* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	50.8	21.4	21.4	14.6	13.2	0.42	1.00	0.29	1.83	0.38
MB.C.19109.2	43.2	18.7	16.9	14.0	9.7	0.43	1.10	0.32	1.66	0.43
MB.C.19109.2	33.5	15.4	12.4	12.2	7.6	0.46	1.25	0.36	1.67	0.38
MB.C.19109.2	20.3	10.5	6.7	7.7	4.3	0.52	1.56	0.38	1.61	0.36
MB.C.19109.2	9.6	6.0	3.2	3.9	2.3	0.62	1.86	0.41	1.73	0.28
MB.C.19109.2	5.62	3.68	1.74	2.22	1.26	0.65	2.11	0.40	1.66	0.27
MB.C.19109.2	4.35	3.33	1.66	1.50	1.07	0.76	2.01	0.34	1.76	0.35
MB.C.19109.2	2.37	2.18	1.20	-	0.78	0.92	1.81	-	2.21	0.35

Description: The holotype is missing a piece of the last whorl (Fig. 10F) but illustrates well the tegoid, just slightly compressed mature whorl form, the deep umbilicus, and a triplet of spiral furrows that embrace two keels. The outer of these is more distinctive and forms a sharp margin of the narrow venter. The peculiar early stages of the new species, with rather wide and relative high whorls, are illustrated in the holotype and well-preserved paratype MB.C.19109.2 (Figs. 15A-D). Subsequently the shell shape continues and, unlike in related species, there is no marked allometric turn at 8-10 mm dm (Figs. 15F-H). The slightly compressed final whorls in the holotype (Fig. 15B) and paratype MB.C.19109.2 converge strongly to a narrowly rounded venter that is sharply bound by the outer ventrolateral keel. The umbilical wall is very steep and subangular to rounded. The suture of the holotype, with typical, pointed E_2- and L-lobes and wide U_4-lobe, is illustrated in Fig. 15E.

Discussion: Two specimens from Dar Kaoua differ from the morphotypes of *Ph. pargai* in important details of their shell ontogeny. Especially different are the early whorls between 2 and 5 mm dm, which are significantly wider and higher, with ww/dm starting at > 0.9 and an initial WER of 2.2. Stages between 10 and 35 mm are wider umbilicate than in the *pargai* morphotypes (uw/dm at 20 mm dm: *darkaouense* n. sp. = 0.4, *pargai* MI = ca. 0.33, *pargai* MII = 0.25-0.3, *pargai* MIII = 0.3). At the same size, the whorls of the new species are also slightly wider and lower than in *Ph. pargai* (ww/wh at 30 mm dm: *darkaouense* n. sp. = 1.3-

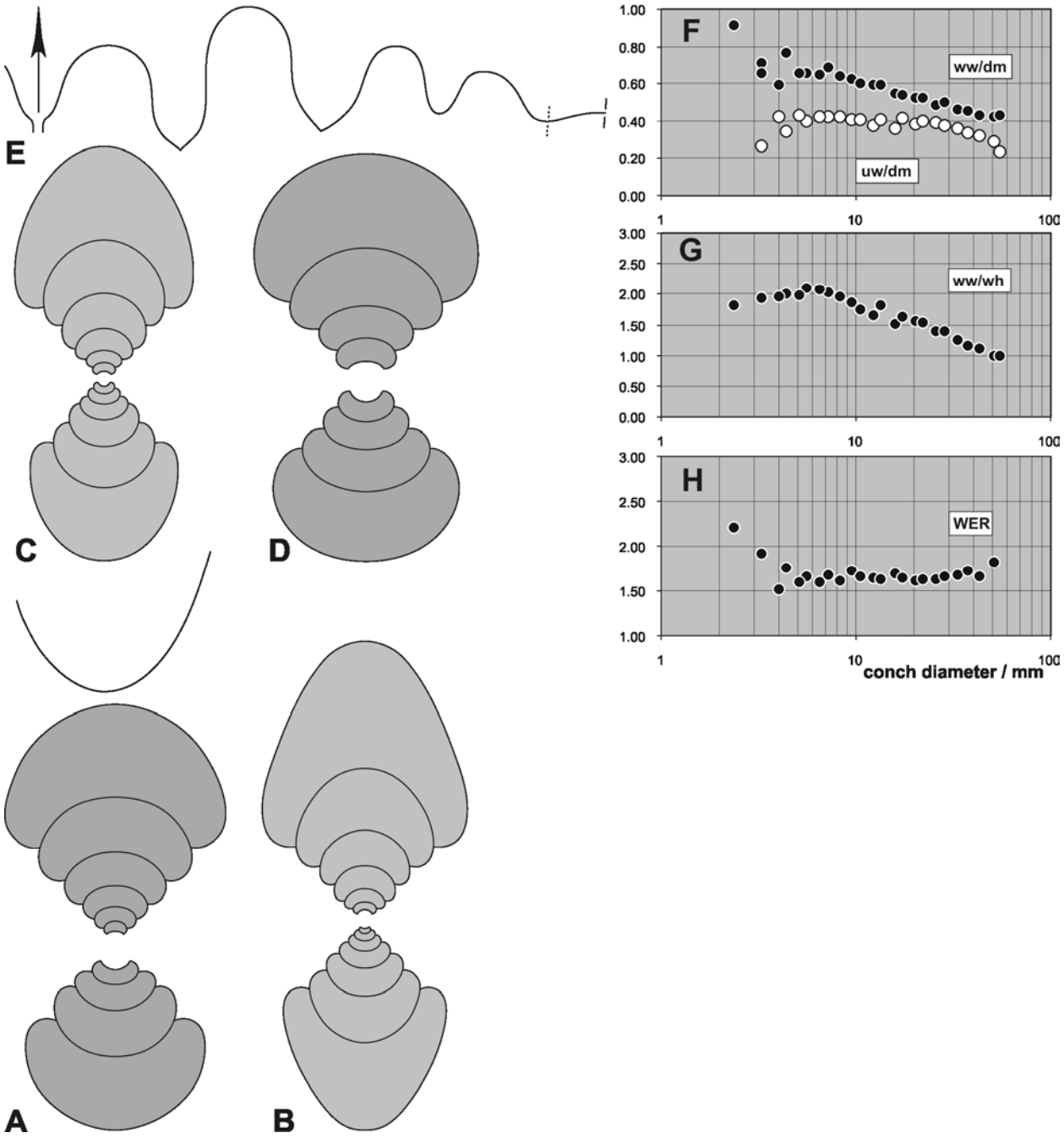


Fig. 15: *Pharciceras darkaouense* n. sp. from Dar Kaoua. **A-B**. Cross sections of holotype MB.C.19109.1; inner whorls x 4, complete section x 1.5. **C-D**. Cross sections of paratype MB.C.19109.2; x 1.5, inner whorls x 4. **E**. Suture of paratype MB.C.19109.2 at 18.4 mm wh; x 4. **F-G**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of both specimens.

1.4, *pargai* MII = ca. 1.1, *pargai* MII = 1.1-1.15). The plots of ww/dm, uw/dm, ww/wh, and WER differ all markedly between *Ph. darkaouense* n. sp. and *Ph. pargai* MIII. Ornament and sutures show overall similarities with *Ph. pargai* and *Ph. applanatum*. *Ph. lateseptatum* is wider umbilicate and has more depressed whorls, especially until 15 mm dm. Its mature cross-section is not marked tegoid as *in Ph. darkaouense* n. sp.

Stratigraphical range and geographical distribution: Restricted to the type locality and level.

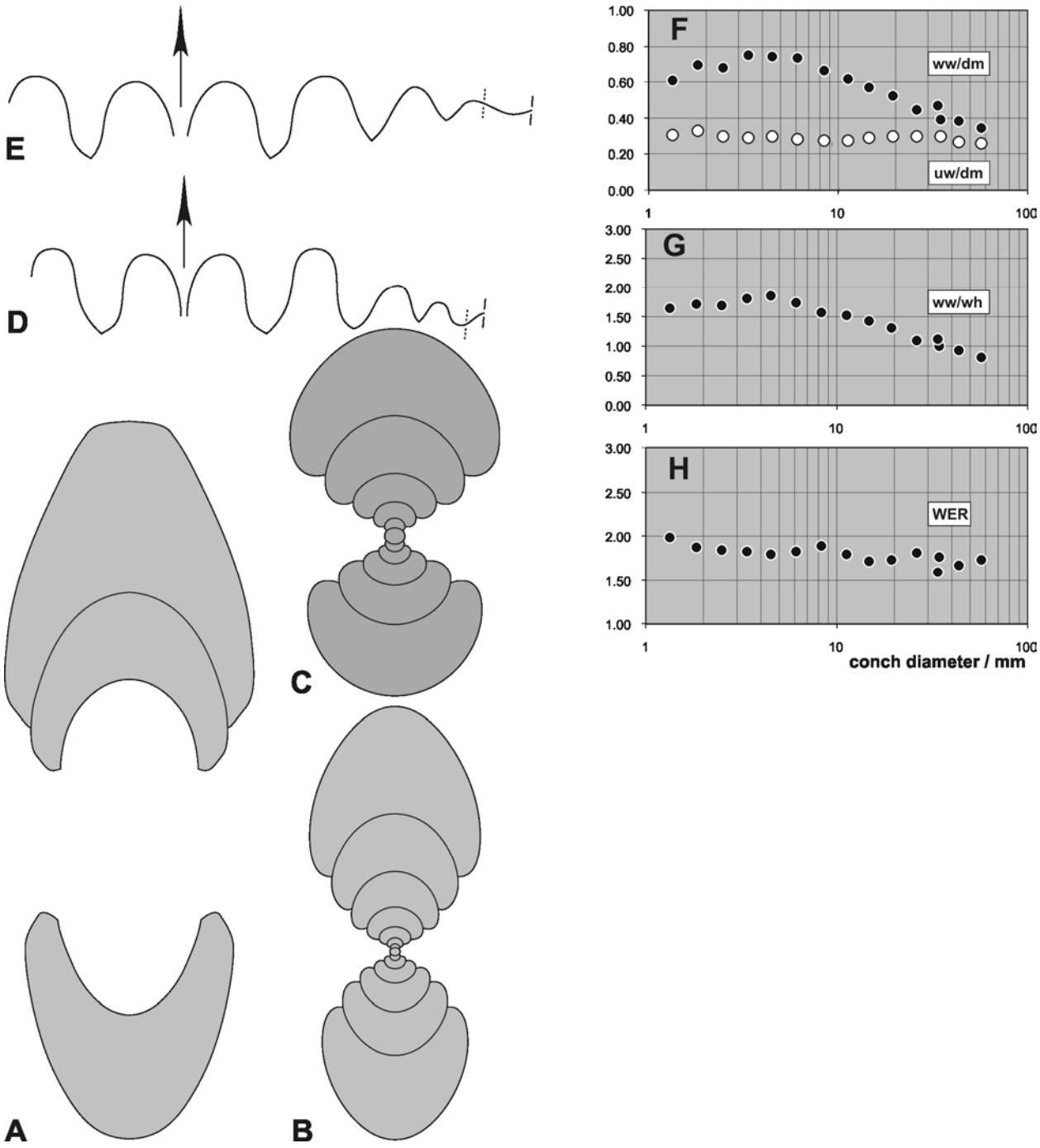


Fig. 16: *Pharciceras kayseri* Wedekind, 1918 from Dar Kaoua. **A**. Cross section of MB.C.19110.1; x 2. **B-C**. Cross sections of MB.C.19110.2; x 2, inner whorls x 4. **D**. Suture of MB.C.19110.2 at 15.5 mm wh; x 2.5. **E**. Suture of MB.C.19110.1 at 15.5 mm wh; x 2.5. **F-H**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of both specimens.

***Pharciceras kayseri* Wedekind, 1918 (**emend.)

Figs. 10G, 16A-H.

*	1918	*Pharciceras kayseri*: Wedekind: 129, 169-170, figs. 37c$_{1-2}$, pl. 20, fig. 2
e.p.	1931	*Pharciceras kayseri* Matern: 92-93
non	1959	*Pharciceras kayseri* Petter: 134-135, fig. 33J, pl. 7, figs. 1, 1a, 14, 14a

Type: Lectotype, designated here, is the original of Wedekind (1918: pl. 20, fig. 2), kept in the collection of Marburg University.

Type locality and level: Prinzenkessel Mine near Oberscheld, Dill Syncline, Rhenish Massif; Upper Givetian, undifferentiated.

Material: Two specimens (MB.C.19110.1-2).

Diagnosis (emend.): First three whorls, ca. until 4.5 mm dm, increasingly depressed (ww/dm up to 0.75, ww/wh up to 1.85) and with WER decreasing from 2.0 to 1.8; subsequently less depressed (ww/wh = ca. 1.5 at 10 mm dm) and compressed from 35 mm dm on, WER (ca. 1.7) and the umbilical width (uw/dm ca. 0.3) are rather stagnant. At maturity the venter is narrow, flattened and bordered by distinctive edges. Growth lirae strongly biconvex, with spiral double furrows along the ventrolateral salient; the outer furrow is more prominent. Sutures with shortened E_1-lobe, rather high median saddle, bell-shaped, deep E_2-lobe, elevated ventral saddle, relative deep (but not as deep as the E_2), subangular to v-shaped L-lobe, small, v-shaped U_2-lobe, and shallow, rounded, wide U_4-lobe.

Tab. 19: Conch ontogeny of *Pharciceras kayseri* Wedekind, 1918 from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subinvolute (ww/dm ~ 0,68; uw/dm ~ 0.30)	moderately depressed; strongly embracing (ww/wh ~ 1.70; IZR ~ 0.35)	moderate (WER ~ 1.85)
8 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.67; uw/dm ~ 0. 28)	moderately depressed; strongly embracing (ww/wh ~ 1.60; IZR ~ 0.36)	moderate (WER = 1.85-1.90)
20 mm	thickly discoidal; subinvolute (ww/dm ~ 0.52; uw/dm ~ 0.30)	weakly depressed; strongly embracing (ww/wh ~ 1.30; IZR ~ 0.40)	low (WER ~ 1.75)
35 mm	thinly discoidal; subinvolute (ww/dm = 0.40-0.45; uw/dm = 0.26-0.30)	weakly depressed; strongly to very strongly embracing (ww/wh = 1.00-1.10; IZR = 0.35-0.50)	low (WER = 1.60-1.75)

Tab. 20: Conch dimensions of *Pharciceras kayseri* Wedekind, 1918 from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19110.1	57.3	19.9	24.4	14.9	13.7	0.35	0.81	0.26	1.72	0.44
MB.C.19110.2	34.6	13.6	13.6	10.4	8.5	0.39	1.00	0.30	1.76	0.37
MB.C.19110.2	26.1	11.6	10.6	7.8	6.7	0.45	1.10	0.30	1.82	0.37
MB.C.19110.2	14.7	8.4	5.9	4.2	3.5	0.59	1.43	0.29	1.71	0.41
MB.C.19110.2	8.4	5.6	3.5	2.3	2.3	0.67	1.58	0.27	1.90	0.35
MB.C.19110.2	4.49	3.32	1.79	1.32	1.14	0.74	1.86	0.29	1.79	0.36
MB.C.19110.2	1.83	1.27	0.74	0.59	0.49	0.69	1.71	0.32	1.87	0.34

Description: MB.C.19110.1 is a submature specimen (Fig. 10G), whose early whorls are not preserved. It shows the ventrolateral double furrows at ca. 17 mm wh and the mature change (Fig. 16A) to a narrowly tabulate venter bordered by rather sharp edges and spiral depressions at ca. 52 mm dm. The umbilical wall becomes oblique on the last whorl. The cross-section of MB.C.19110.2 (Fig. 16B-C) illustrates the characteristic, biphasic post-embryonic conch ontogeny (Figs. 16F-G). A fine radial wrinkle layer is partly preserved. Sutures (Figs. 16D-E) are characterized by the relative high median saddle whilst the shape of the flank lobe varies. The typical rather wide flank saddles and the wide, shallow subumbilical U_4, as illustrated in the photo of the holotype in Wedekind (1918), seem to develop towards maturity (MB.C.19110.1, Fig. 16E). The septal attachment accreted on the wrinkle layer in MB.C.19110.2 proves the presence of two inner U-lobes.

Discussion: The mature shell form and sutures, especially the narrowly flattened venter of MB.C.19110.1, fit the short description and illustrations by Wedekind (1918). Matern (1931) confirmed Wedekind´s observations but did not figure any specimen of the additional material from the Lahn Syncline. Measurements of the holotype made available by the late M.R. House plot on the ontogenetic trajectory of

the Moroccan material, which removes any doubts about the taxonomic identity. *Ph. kayseri* differs from all other *Pharciceras* species in its near constant umbilical width and relative high WER throughout ontogeny. The allometric turning point of the post-embryonic shell ontogeny occurs also rather early, at the end of the third whorl. The also tabulate but slightly younger *Ph. applanatum* is less compressed late in ontogeny and shows narrower flank saddles.

Stratigraphical range: Perhaps restricted to the *Syn. clavilobum* Zone (MD III-C).

Geographical distribution: Rhenish Massif and Tafilalt.

Extropharciceras n. gen.

Type-species: *Extropharciceras conex* n. sp.

Etymology: From extra = additional; because of the two additional U-lobes.

Diagnosis: Shell ontogeny markedly biphasic to triphasic: early whorls until 10 mm dm discoidal (serpenticonic) to pachyconic (cadiconic), increasingly depressed and subevolute to evolute, subsequently less depressed, with decreasing relative umbilical width (subevolute to subinvolute) and rising WER; at maturity compressed, thinly to extremely discoidal, often with re-opening umbilicus and constant WER. Growth lirae strongly biconvex, ventrolateral salient combined with spiral furrows. Sutures with moderately high to high median saddle, lanceolate E_2-lobe, high ventral saddle, pointed L-lobe, two or three small outer U-lobes, three inner U-lobes, and deep, narrow I-lobe. Suture formule: $E_1E_2LU_2U_4$:$U_5U_3U_1I$ to $E_1E_2LU_2U_4U_6$:$U_5U_3U_1I$.

Included species:

Pharciceras arenicum Petter, 1959, Upper Givetian, Ougarta, Algeria,
Pharciceras arenicum var. *carinata* Petter, 1959, Upper Givetian, Ougarta,
Extropharciceras conex n. sp., Upper Givetian, Tafilalt
Extropharciceras librum n. sp., Upper Givetian, Tafilalt
Pharciceras sp. A in Montesinos & Henn (1986), Upper Givetian, Cantabrian Mts.
Ammonites Becheri v. Buch, 1832, Upper Givetian, Rhenish Massif (nom. dub.)

The lost type of *Ex. becheri* has never been properly described or figured and it is impossible to re-recognize it; hence it is a nom. dub. The originally illustrated three internal U-lobes and compressed cross-section (at rather small size) suggest to assign it to *Extropharciceras* n. gen. The species name has been used subsequently (e.g., Frech 1888; Petter 1959; Massa 1965) for forms that fall in *Extropharciceras* n. gen., probably including the Tafilalt *Ph.* sp. aff. *becheri* identified by O.H. Walliser (in Ziegler & Klapper 1982).

Discussion: The new genus embraces compressed, discoidal, subevolute to subinvolute forms with five to six U-lobes that originate alternatively inside and outside the umbilical seam. Some species were previously (Korn & Klug 2002) included in *Lunupharciceras*, in which, reversely, there are only two internal and three external U-lobes, because U_3 and U_4 form externally before a second internal U-lobe develops. *Lunupharciceras* has also more evolute and serpenticonic early to median stages and often rather self-similar lobes and saddles.

Stratigraphical range: Upper Givetian (upper MD III-B to MD III-D).

Geographical distribution: Rhenish Massif (Frech, 1888), Montagne Noire (House et al. 1985), Cantabrian Mts. (Montesinos & Henn 1986), Tafilalt (Massa 1965) and Maider (Bultynck & Jacobs 1981) of southern Morocco, Ougarta (Petter 1959) and Ahnet (Petter 1959) of southern Algeria.

Extropharciceras librum n. gen. n. sp.

Figs. 17A-J, 18B, 18E.

Type: Holotype MB.C.19111.1, illustrated in Figs. 17G and 18B.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype and seven paratypes up to 70 mm dm (MB.C.19111.2-8), one additional large fragmentary specimen (MB.C.19111.9).

Etymology: From librus = free, because of the late mature change to more evolute whorls.

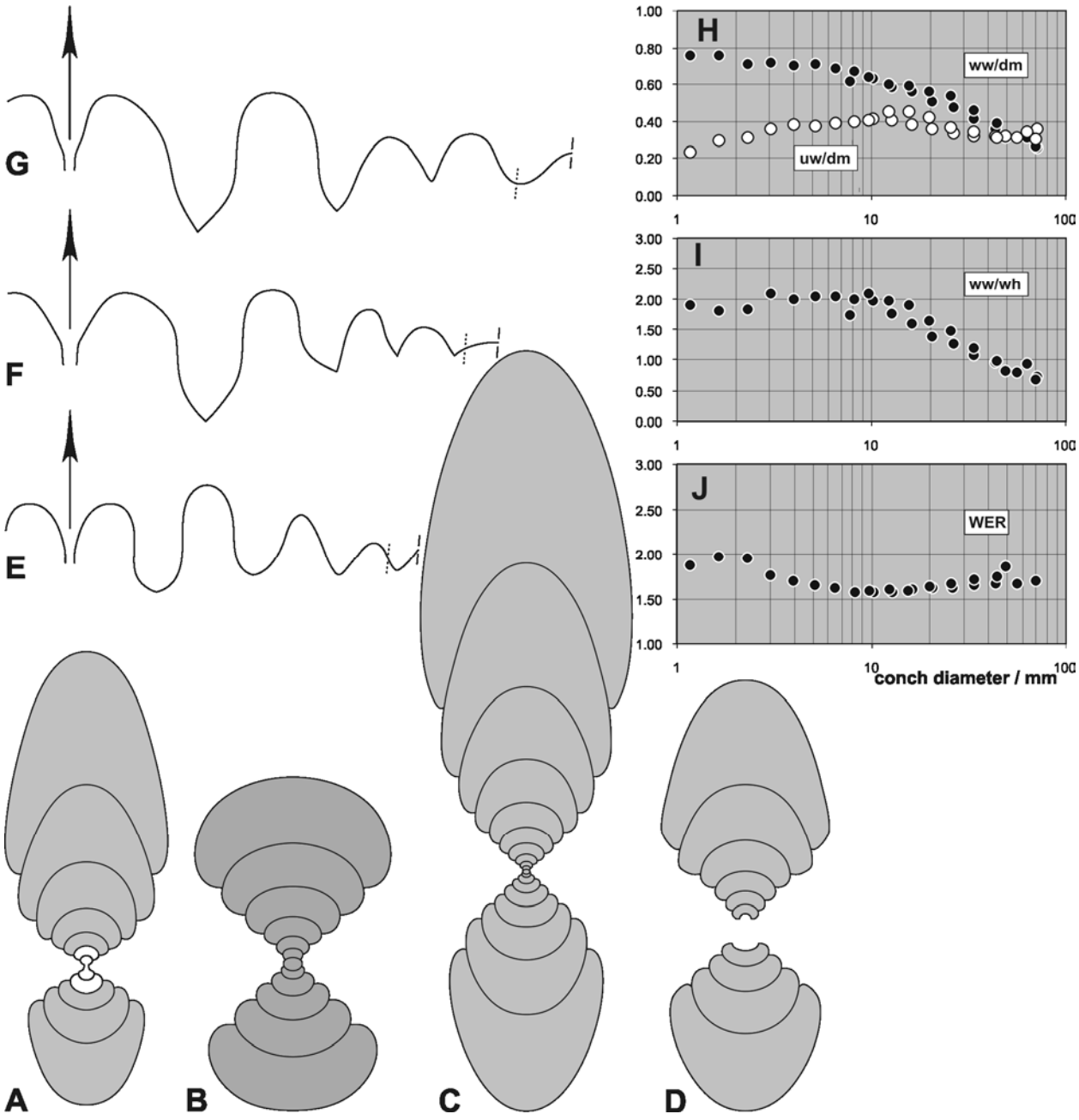


Fig. 17: *Extropharciceras librum* n. gen. n. sp. from Dar Kaoua. **A**. Cross section of paratype MB.C.19111.5; x 1.5. **B-C**. Cross sections of paratype MB.C.19111.4; inner whorls x 4, complete section x 1.5. **D**. Cross section of paratype MB.C.19111.6; x 1.5. **E**. Suture of paratype MB.C.19111.8 at 16.8 mm wh; x 2.5. **F**. Suture of paratype MB.C.19111.3 at 22.5 mm wh; x 2.5. **G**. Suture of holotype at 24 mm wh; x 2.5. **H-J**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all available specimens.

Diagnosis: Large-sized, early whorls until ca. 10 mm dm pachyconic, markedly depressed (ww/dm = ca. 0.7, ww/wh near 2.0), with broadly rounded venter, and increasingly subevolute (uw/dm reaching 0.4) whilst WER falls to 1.6; median stages until ca. 45 mm dm fast becoming less depressed (ww/dm down to 0.4), slightly faster expanding and more involute (uw/dm down to 0.25 – 0.3); mature whorls extremely discoidal (ww/dm < 0.3), with rather flat umbilical wall and narrowly rounded venter, again somewhat more subevolute (uw/dm = ca. 0.35) and with WER 1.7-1.9. Distinctive and sharp growth lirae are rather evenly spaced and strongly biconvex, with indistinctive double furrows along the high ventrolateral salient. Mature sutures with strongly shortened, diverging E_1-lobe, very high and asymmetric median saddle, deep, widely lanceolate E_2-lobe, elevated, subsymmetric ventral saddle, moderately deep, slightly asymmetric, pointed L-lobe, and two variably shaped, well-developed outer U-lobes.

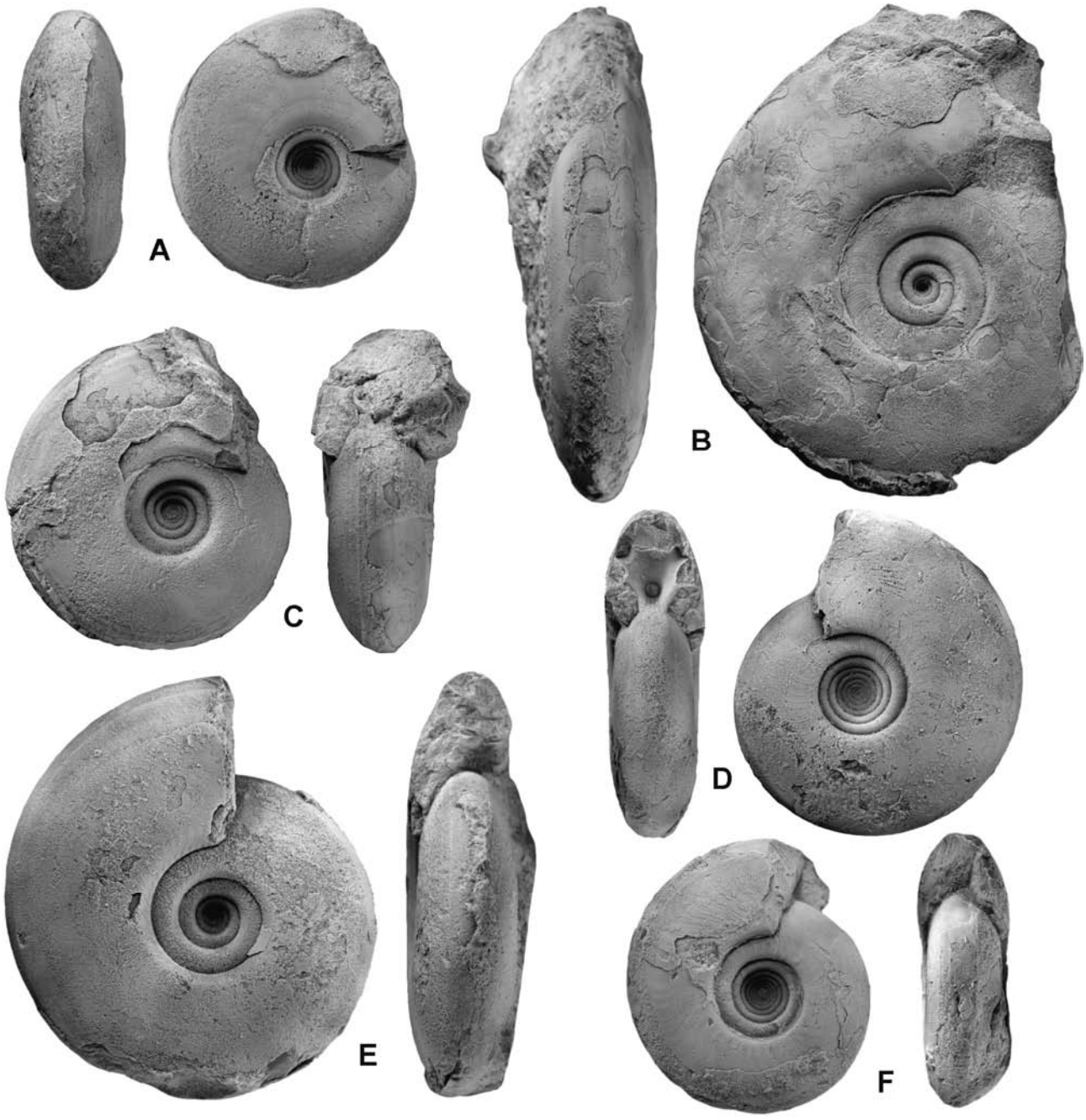


Fig. 18: Species of *Extropharciceras* n. gen. from Dar Kaoua. **A**. *Ex. arenicum* (Petter, 1959), MB.C.19113.1, ventral and lateral views; x 1. **B.** *Ex. librum* n. gen. n. sp., holotype MB.C.19111.1, lateral and dorsal views; x 1. **C.** *Ex. arenicum* (Petter 1959), MB.C.19113.2, lateral and ventral views; x 1. **D.** *Ex. conex* n. sp., holotype MB.C.19112.1, adoral (with septal face) and lateral virws; x 1. **E.** *Ex. librum* n. sp., paratype MB.C.19111.2, lateral and ventral views; x 1. **F.** *Ex. conex* n. sp., paratype MB.C.19112.2, adoral and lateral views; x 1.

Tab. 21: Conch ontogeny of *Extropharciceras librum* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly pachyconic; subevolute (ww/dm ~ 0,74; uw/dm ~ 0.30)	moderately depressed; strongly embracing (ww/wh ~ 1.82; IZR ~ 0.30)	moderate (WER ~ 1.95)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.65; uw/dm ~ 0.40)	moderately depressed; strongly embracing (ww/wh ~ 2.00; IZR = 0.30-0.40)	low (WER = 1.55-1.60)

20 mm	thickly discoidal; subevolute (ww/dm = 0.50-0.55; uw/dm = 0. 35-0.42)	weakly to moderately depressed; strongly embracing (ww/wh = 1.40-1.65; IZR = 0.35-0.40)	low (WER = 1.60-1.65)
45 mm	thinly discoidal; subevolute (ww/dm = 0.35-0.40; uw/dm = 0.30-0.35)	weakly compressed; strongly embracing (ww/wh ~ 0.95-1.00; IZR ~ 0.40)	low (WER = 1.65-1.75)

Tab. 22: Conch dimensions of *Extropharciceras librum* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	71.7	18.5	25.8	25.9	-	0.26	0.72	0.36	-	-
MB.C.19111.2	70.0	18.5	27.5	21.2	16.2	0.26	0.67	0.30	1.69	0.41
MB.C.19111.3	63.5	20.0	21.5	22.0	-	0.31	0.93	0.35	-	-
MB.C.19111.4	56.2	17.4	22.0	17.7	12.7	0.31	0.79	0.32	1.67	0.42
MB.C.19111.8	49.0	15.3	18.5	15.7	13.0	0.31	0.83	0,32	1.85	0.30
MB.C.19111.6	44.1	17.2	17.4	13.8	10.7	0.39	0.99	0.31	1.74	0.39
MB.C.19111.4	33.6	13.9	12.9	10.9	7.4	0.41	1.07	0.32	1.65	0.43
MB.C.19111.4	20.6	10.5	7.5	7.4	4.5	0.51	1.39	0.36	1.63	0.41
MB.C.19111.4	12.8	7.6	4.3	5.2	2.6	0.59	1.76	0.41	1.57	0.40
MB.C.19111.4	5.11	3.64	1.79	1.92	1.14	0.71	2.03	0.38	1.65	0.36
MB.C.19111.4	2.29	1.62	0.89	0.71	0.65	0.71	1.82	0.31	1.95	0.27

Description: The species is larger than most other pharciceratids and, based on paratype MB.C.19111.4 (Fig. 17C) and the holotype (Fig. 18B), which is still septate at 70 mm dm, the 10th whorl reached more than 100 mm maximum dm. The post-embryonic shell ontogeny is triphasic, with allometric turning points at ca. 10 (end of 5th whorl, Fig. 17I) and 45 mm dm (end of 8th whorl, Fig. 17H). There is also a minor very early ontogenetic change at the end of the 2nd whorl, at ca. 2 mm dm, when a first WER maximum of almost 2.0 is reached (Fig. 17J) and when the whorl shape changes to cadiconic, with a minor increase of ww/wh rates (Figs. 17B, I). In early stages the umbilical wall is deep and steeply rounded but it becomes flat and gently rounded, sometime with a slight concavity (paratype MB.C.19111.4) on the mould in the last two whorls. Most specimens show densely lirate inner flanks in the umbilical opening. There are 2-3 lirae/mm (holotype). Two spiral furrows embrace the ventrolateral salient; the inner is more distinctive and the outer delimits the venter (Fig. 18E). The fine radial wrinkle layer is preserved in paratypes MB.C.19111.3, 19111.8, and 19111.2.

Sutures (Figs. 17E-G) are characterized by two well developed outer U-lobes, which shape fluctuates between rounded, subangular, v-shaped and asymmetrically pointed. They are separated by relative high saddles. U_4 is still rounded at maturity in the holotype (Fig. 17G) but subangular in all other specimens. MB.C.19111.5 displays an incipient, very shallow third external U-lobe on the umbilical wall at maturity (25 mm wh). Since its conch closely resembles all other paratypes, it is not taxonomically separated. The mature shape of the asymmetric median saddle is distinctive. It becomes as high as the ventral saddle and its lateral slope is oblique (holotype and paratype MB.C.19111.3). The dorsal suture with three well-developed U-lobes can be discerned from the cross-section and septal attachment encrusted on the previous whorl in paratype MB.C.19111.4. In a septal face of MB.C.19111.5, U_1 is deep and pointed, U_3 small, narrowly rounded, and U_5 shallow and widely rounded. The holotype shows a considerable diagenetic thickening of septa.

Discussion: The large size, triphasic post-embryonic conch ontogeny, relative strong compression of the last two whorls, the lack (in typical specimens) or very late and incipient forming of a third outer U-lobe, and high median saddle separate *Ex. librum* n. sp. easily from all other species of the genus.

Stratigraphical range and geographical distribution: So far restricted to the type locality and level.

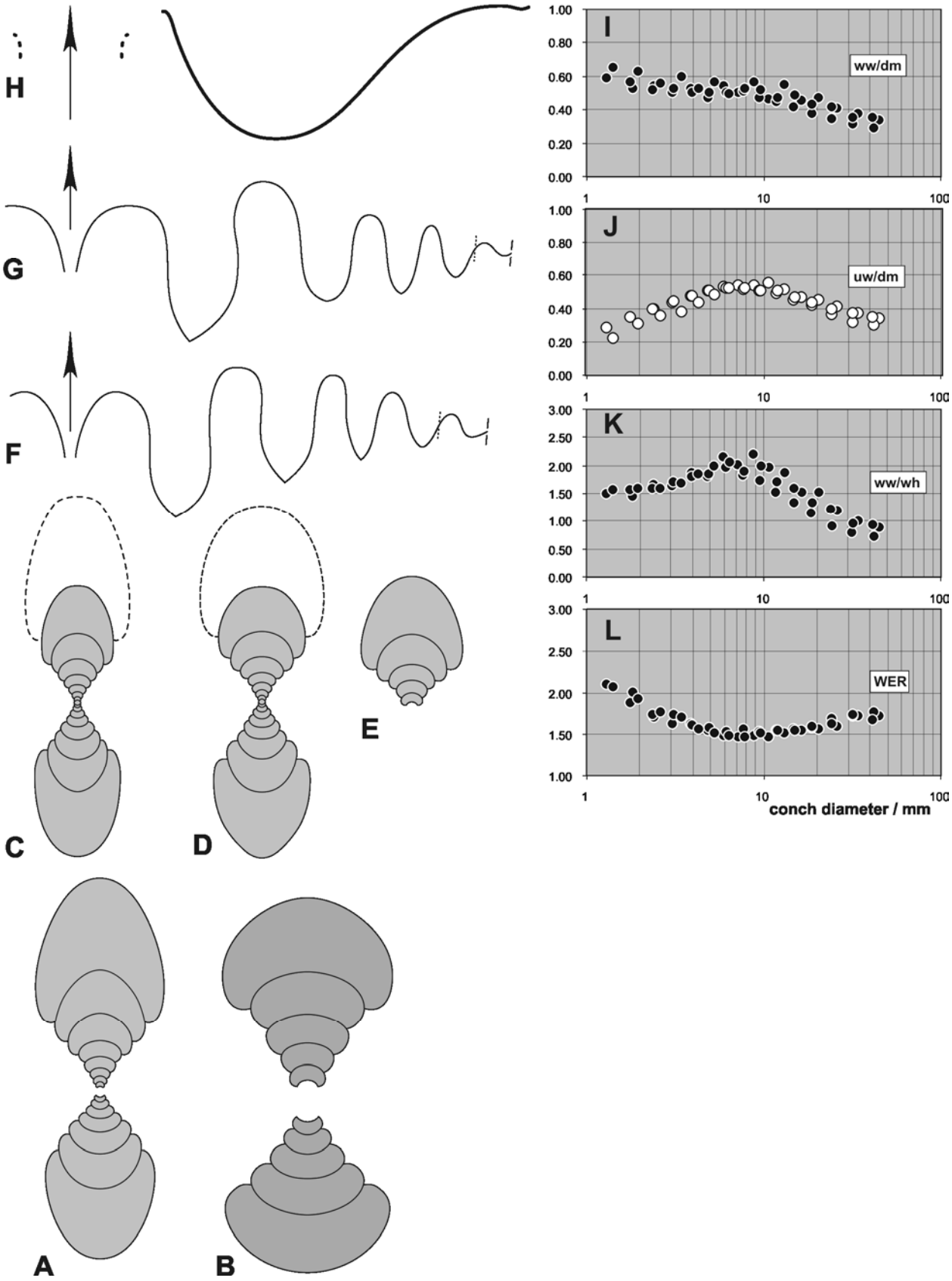


Fig. 19: *Extropharciceras conex* n. gen. n. sp**.** from Dar Kaoua. **A-B.** Cross sections of paratype MB.C.19112.3; x 1.5., inner whorls x 4. **C.** Cross section of paratype MB.C.19112.4; thin morphotype, x 1.5. **D**. Cross section of paratype MB.C.19112.5; thick morphotype, x 1.5 **E.** Partial cross section of paratype MB.C.19112.6; x 1.5. **F**. Suture of paratype MB.C.19112.6 at 13.5 mm wh; x 4.0. **G.** Suture of paratype MB.C.19112.5 at 14.5 mm wh; x 4.0. **H.** Course of growth lirae of paratype MB.C.19120 at 43 mm dm, 14.5 mm ww, 16 mm wh; x 4. **I-L.** Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all available specimens.

***Extropharciceras conex* n. gen. n. sp.**

Figs. 18D, 18F, 19A-L

Type: Holotype MB.C.19112.1, illustrated in Fig. 18D.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype and seven paratypes (MB.C.19112.2-8), one additional specimen (MB.C.19112.9) with slightly simpler sutures. The species is common in the Lower Marker Bed of other Tafilalt localities (e.g., at Hassi Nebech, where it is the dominant taxon).

Etymology: From Latin conex = junction; according to its morphologically intermediate position in the genus.

Diagnosis: Early whorls until ca. 10 mm dm discoidal, increasingly depressed and evolute (serpenticonic), with rapid increase of uw/dm (up to 0.55) and ww/wh (up to ca. 2.2) whilst WER ratios fall continuously from 2.0 to 1.5; median to mature whorls gradually thinner (stronger discoidal), subevolute (uw/dm = 0.4 at 25 mm dm and ca. 0.3 > 40 mm dm), eventually compressed (from 25-30 mm dm on), and with slightly rising WER values (up to 1.7); flanks and venter are gently rounded. Growth lirae dense, strongly biconvex, with relative high dorsolateral saddle and very narrow, high ventrolateral salient bordered by spiral double furrows. Mature sutures with short, funnel-shaped E_1-lobe, high and asymmetric median saddle, very deep, lanceolate E_2-lobe, elevated, very narrow ventral saddle, and four inner flank lobes of ascending depth separated by narrow saddles of descending height; the subumbilical U_6-lobe is rounded.

Tab. 23: Conch ontogeny of *Extropharciceras conex* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal to thinly pachyconic; subevolute (ww/dm = 0.52-0.63; uw/dm = 0.35-0.40)	moderately depressed; moderately to strongly embracing (ww/wh = 1.58-1.65; IZR = 0.26-0.37)	moderate (WER = 1.70-1.90)
8 mm	thickly discoidal; subevolute (ww/dm = 0.51-0.56; uw/dm = 0. 35-0.40)	moderately to strongly depressed; moderately embracing (ww/wh = 1.90-2.10; IZR = 0.26-0.29)	low (WER = 1.55-1.60)
20 mm	thinly discoidal; subevolute (ww/dm = 0.38-0.42; uw/dm = 0.40-0.45)	weakly depressed; moderately to strongly embracing (ww/wh = 1.20-1.50; ZR = 0.26-0.39)	low (WER = 1.55-1.60)
30 mm	thinly discoidal; subevolute ww/dm ~ 0.35; uw/dm = 0.32-0.37)	weakly compressed; strongly embracing (ww/wh = 0.80-1.00; IZR = 0.34-0.40)	low (WER = 1.70-1.75)

Tab. 24: Conch dimensions of *Extropharciceras conex* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	55.7	16.2	21.9	17.2	13.9	0.29	0.74	0.31	1.78	0.36
MB.C.19112.3	44.6	15.0	16.9	15.2	10.7	0.33	0.89	0.34	1.73	0.37
MB.C.19112.4	42.1	12.2	16.8	12.8	10.5	0.29	0.72	0.30	1.77	0.38
MB.C.19112.5	41.1	14.4	15.3	14.2	9.4	0.35	0.94	0.35	1.68	0.38
MB.C.19112.4	31.6	9.9	12.5	10.0	7.5	0.31	0.80	0.32	1.72	0.40
MB.C.19112.3	20.4	9.6	6.3	9.2	4.1	0.47	1.52	0.45	1.56	0.36
MB.C.19112.3	10.6	5.0	2.5	5.9	1.9	0.47	1.97	0.55	1.47	0.26
MB.C.19112.3	5.90	3.22	1.50	3.13	1.06	0.55	2.15	0.53	1.49	0.29
MB.C.19112.3	2.39	1.29	0.78	0.94	0.56	0.54	1.65	0.39	1.71	0.28

Description: The holotype is well-preserved, complete, fully septate, and shows adorally a septal face, and especially the very deep I-lobe (Fig. 18D). The very fine (10/mm) radial wrinkle layer is visible on the last whorl in front of the last septum. The biphasic shell ontogeny, with an allometric turn of umbilical width

(Fig. 19J), ww/wh (Fig. 19K), and WER (Fig. 19L) at 9-10 mm dm (end of 5th whorl), is illustrated by several cross-sections. It is possible to separate somewhat thinner (paratype MB.C.19112.4, Fig. 19C) and thicker (paratypes MB.C.19112.5 and 19112.3, Figs. 19A, D) morphotypes but their ontogenetic trajectories (Figs. 19I, K) touch or partly overlap. Apart from some variability in whorl width, the ww/wh ratios form a broad plot at median size whilst the umbilical width is variable in the first five whorls. There are eight whorls at ca. 40 mm dm (paratype MB.C.19112.4, Fig. 19C) but, based on the phragmocone size of the holotype, the species may have reached a maximum size of ca. 90 mm. The umbilical wall is short and rounded, the venter first broadly rounded, later narrowly rounded (paratype MB.C.19112.5, Fig. 19D) or slightly flattened (Fig. 18D). All specimens show regular, distinctive, strongly biconvex (Fig. 19H) growth lirae, at least in the umbilical opening. In the holotype, the lirae of the arched dorsolateral salient are 0.4-0.5 mm wide. Ventrolateral double furrows are rather weak and sometimes difficult to recognize along the highly projecting outer flank salient. On paratype MB.C.19112.7 the outer furrow produces a slight ventral edge.

Two typical outer sutures with gradually shorter, narrow and pointed lobes towards the umbilicus are illustrated in Figs. 19F-G. At 10 mm wh, the U_6-lobe is small and lies on the short umbilical wall (paratype MB.C.19112.2). It is incipient and very shallow at ca. 7.5 mm wh in the fragmentary paratype MB.C.19112.8. The median saddle is high from at least 13 mm wh on (Fig. 19F) and becomes as high as the adjacent ventral saddle, with an oblique lateral slope in the last preserved septum of the holotype. Three narrow and pointed internal U-lobes are visible as encrusted septal attachments on paratypes MB.C.19112.4 and 19112.6. At the end of the 5th whorl only two internal U-lobes have been observed in the cross-section of paratype MB.C.19112.5. One large specimen (MB.C.19112.8) with typical shell form and umbilicus, which is still septate at 60 mm dm, differs from the type-series by a slightly simpler suture, with an incipient U_6 at 55 mm dm (21.5 mm wh) that becomes fully developed in the last preserved septa.

Discussion: The relative common new species has a distinctive, slightly variable shell form that allows easy identification; therefore *Ex. conex* n. gen. n. sp. can serve as an index species for the Lower Marker Bed. The well-developed third outer U-lobe, the thinner early whorls, and the wider umbilicus between 5 and 20 mm dm give a clear distinction from *Ex. librum* n. gen. n. sp. MB.C.19112.9 (*conex*-type shell and late formation of U_6) and MB.C.19111.5 (*librum*-type shell and early, incipient U_6) show that both species are connected by single phylogenetic intermediates. *Ex. arenicum* and the poorly known *Ex. carinatum* are thicker throughout ontogeny.

Stratigraphical range: Restricted to the type level.

Geographical range: Restricted to the Tafilalt.

***Extropharciceras arenicum* (Petter, 1959)** (emend.)

Figs. 18A, 18C, 20A-L

*v	1959	*Pharciceras arenicum* Petter: 138
non	1985	*Pharciceras arenicum* House et al.: 5, 6, 13
non	1985	*Pharciceras arenicum* Henn: 91, pl. 1, fig. 3, text-fig. 41 [fide Montesinos & Henn 1986]
	1981	*Pharciceras arenicus* Bultynck & Jacobs: fig. 4
	2002	*Lunupharciceras arenicum* Korn & Klug: 142

Type: Lectotype, here designated, is the original of Petter (1959: pl. 9, figs. 3, 3a).

Type locality and level: Erg el Djemel, Ougarta, Algeria; probably *Syn. clavilobum* Zone (MD III-C).

Material: Seven specimens (MB.C.19113.1-7).

Diagnosis (emend.): First ca. 5 whorls, until ca. 10 mm dm, increasingly depressed and slowly expanding, with ww/dm reaching 0.68 and WER down to 1.5-1.6 whilst the uw/dm ratio fluctuates around 0.4; median to mature whorls gradually less depressed, with ww/wh near 1.0 from 35 mm dm on, and with slower increase of the rather variable umbilical width (uw/dm 0.2-0.35) and with slightly rising WER. Growth lirae strongly biconvex with arched dorsolateral and very narrow, projecting ventrolateral salient, bordered by spiral triple furrows and a pair of minor keels. Mature sutures with shortened E_1-lobe, moderately high median saddle, deep, narrow, lanceolate E_2-lobe, high, narrow ventral saddle, moderately deep, pointed L-lobe, and three pointed or rounded external U-lobes.

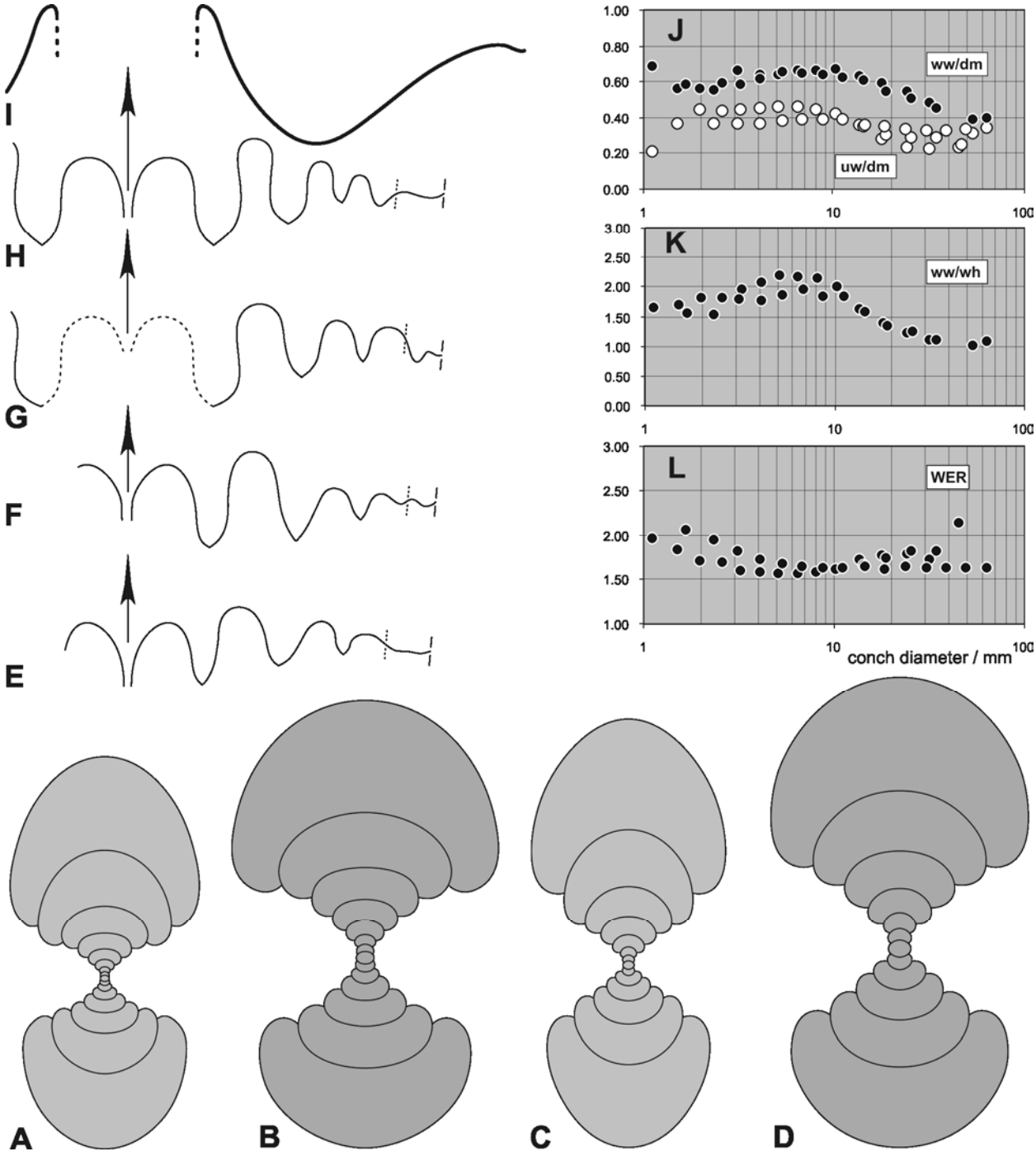


Fig. 20: *Extropharciceras arenicum* (Petter, 1959) from Dar Kaoua. **A-B**. Cross sections of MB.C.19113.4 (typical morphotype); x 2, inner whorls x 4. **C-D**. Cross sections of MB.C.19113.3 (advanced morphotype); x 2, inner whorls x 4. **E**. Suture of MB.C.19113.4 (typical morphotype) at 13.6 mm wh; x 2.5. **F**. Suture of MB.C.19113.2 (typical morphotype) at 14.2 mm wh; x 2.5. **G**. Suture of MB.C.19113.5 (advanced morphotype) at 13.5 mm wh; x 2.5. **H**. Suture of MB.C.19113.6 (advanced morphotype) at 15 mm wh; x 2.5. **I**. Course of growth lirae of MB.C.19113.6 at 18 mm wh; x 2.5. **J-L**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER, of all available specimens.

Tab. 25: Conch ontogeny of *Extropharciceras arenicum* (Petter, 1959) from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
initial morphotype (e.g., MB.C.19113.4)			
2 mm	thickly discoidal; subevolute (ww/dm = 0.56; uw/dm = 0.44)	moderately depressed; moderately embracing (ww/wh = 1.81; IZR = 0.23)	low (WER = 1.70)
8 mm	thinly pachyconic; subevolute (ww/dm = 0.67 uw/dm = 0. 45)	strongly depressed; strongly embracing (ww/wh = 2.14; IZR = 0.34)	low (WER = 1.58)
20 mm	thickly discoidal; subinvolute (ww/dm ~ 0.58; uw/dm ~ 0.26)	weakly depressed; strongly embracing (ww/wh ~ 1.30; ZR = 0.42)	moderate (WER = 1.79)
30 mm	thickly discoidal; subinvolute ww/dm = 0.48; uw/dm = 0.23)	weakly depressed; strongly embracing (ww/wh = 1.11; IZR = 0.45)	-
advanced morphotype (e.g., MB.C.19113.3)			
2 mm	thickly discoidal; subevolute (ww/dm = 0.60; uw/dm = 0.37)	moderately depressed; moderately embracing (ww/wh + 1.55; IZR = 0.21)	moderate (WER = 1.95)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.65 uw/dm = 0. 39)	moderately depressed; strongly embracing (ww/wh ~ 1.85; IZR = 0.35)	low (WER = 1.63)
25 mm	thickly discoidal; subinvolute (ww/dm ~ 0.50; uw/dm ~ 0.30)	weakly depressed; strongly embracing (ww/wh ~ 1.25; IZR ~ 0.37)	moderate (WER = 1.82)

Tab. 26: Conch dimensions of *Extropharciceras arenicum* (Petter, 1959) from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
initial morphotypes										
MB.C.19113.2	53.3	21.0	20.7	16.5	-	0.39	1,01	0,31	-	-
MB.C.19113.4	31.4	15.2	13.6	7.2	7.5	0.48	1.11	0.23	1.72	0.45
MB.C.19113.4	24.0	13.1	10.6	5.7	6.0	0.55	1.23	0.24	1.79	0.43
MB.C.19113.4	13.5	8.5	5.2	4.8	3.2	0.63	1.63	0.36	1.72	0.38
MB.C.19113.4	6.4	4.26	1.96	2.95	1.28	0.67	2.18	0.48	1.56	0.35
MB.C.19113.4	2.56	1.52	0.83	1.13	0.60	0.59	1.83	0.44	1.70	0.28
advanced morphotypes										
MB.C.19113.1	46.6	17.0	19.5	11.5	-	0.36	0.87	0.25	-	-
MB.C.19113.6	45.3	17.7	20.2	10.7	14.3	0.39	0.88	0.24	2.14	0.29
MB.C.19113.3	34.3	15.6	14.0	9.9	8.8	0.45	1.11	0.29	1.81	0.37
MB.C.19113.3	25.5	13.0	10.5	7.4	6.6	0.51	1.24	0.29	1.83	0.37
MB.C.19113.3	14.3	8.7	5.5	5.1	3.2	0.61	1.59	0.36	1.66	0.41
MB.C.19113.3	8.7	5.6	3.0	3.4	1.9	0.64	1.85	0.39	1.63	0.38
MB.C.19113.3	4.10	2.54	1.43	1.51	0.97	0.62	1.77	0.37	1.72	0.30
MB.C.19113.3	1.66	0.98	0.62	-	0.50	0.59	1.57	-	2.05	0.20

Description: Based on the outer sutures, with either very shallow or narrow and deeper U_4-lobe at 13-15 mm wh, initial (e.g., MB.C.19113.4 and 19113.2, Figs. 20E-F) and more advanced (e.g., MB.C.19113.5 and 19113.6, Figs. 20G-H) morphotypes can be recognized. Two sectioned representatives (Figs. 20A-D) turned out to show distinctive shell form differences until the ontogenetic turning point at ca. 10 mm dm. MB.C.19113.4 is more evolute (uw/dm > 0.4, Fig. 20J) and has more depressed, lower and more slowly expanding whorls, giving higher ww/wh (> 2.0, Fig. 20K) and lower WER (Fig. 20L) ratios. In MB.C.19113.3, by contrast, the juvenile uw/dm value lies below 0.4 and ww/wh below 2.0. Despite the early ontogenetic differences, median to mature stages of MB.C.19113.4 and 19113.3 have indistinguishable ww/dm and ww/wh trajectories whilst there is some variation in umbilical width and the gradual increase of WER. MB.C.19113.5 differs from both and is more evolute (uw/dm > 0.3) in the second stage and keeps rather low WER values. All data together point to a considerable variability of shell parameters in the species, whilst the overall shell form is similar. The umbilical wall is deep, short and rounded (Figs. 18A, C)

but it can become shallower at maturity (MB.C.19113.1) or oblique on large internal moulds (MB.C. 19113.2). The gently rounded venter is bordered by the minor spiral keels formed by the double furrows. The strongly biconvex course of the lirate ornament, with arched dorsolateral and very narrow, asymmetric ventrolateral salients, is illustrated in Fig. 20I. The spacing of individual lirae varies at the umbilical wall between 0.3 and 0.6 mm. The very fine (7-10/mm) wrinkle layer is preserved in MB.C.19113.1 and 19113.6. The spiral triple furrows are best preserved in MB.C.19113.2 and 19113.3. The outer keel is slightly more prominent. On the centre of the venter, both on the shell (MB.C.19113.2) or on the mould (MB.C.19113.4), a very fine hair keel can be developed. MB.C.19113.1 shows a dorsolateral spiral grove on the steinkern that may be a pathological feature.

Sutures are best preserved on MB.C.19113.6, which shows that the median saddle remains lower than the ventral saddle until maturity (ca. 44 mm dm). An attached spiral ridge as the relict of a succeeding additional whorl suggests that the species may have reached 80 mm dm or more. The subumbilical U_6-lobe starts to form with the allometric change between 9 and 10 mm wh (MB.C.19113.7). A septal face in MB.C.19113.3 shows the dorsal suture with three narrow and pointed internal U-lobes at 15 mm wh.

Discussion: Petter (1959) illustrated for the Algerian type population that the outer U_6-lobe is formed between 26 and 35 mm dm, which translates into ca. 11 to 14 mm wh. This fits the Dar Kaoua population. The chosen lectotype has ca. 36 mm dm, possesses the $U_{5/6}$-lobes and a diverging, subangular U_4-lobe. In this respect, its sutures are closest to MB.C.19113.6. Based on its mould preservation, it is slightly thinner (ww/dm = 0.39) then our similar-sized shelly material. Additional material has to clarify whether there is a dense, wide morphological continuum in *Ex. arenicum* or whether the species was about to split into different forms with specific ontogenetic trajectories at the time of the Lower Marker Bed. This can be best acomplished by the future comparison with slightly younger and older populations and from different regions.

The poorly known Algerian *Ex. carinatum* differs in its suboxyconic median stages. Montagne Noire specimens assigned by House et al. (1985) to *Ph. arenicum* are much more involute, have a very high and compressed cross-section from the 5th whorl on, and display additional outer U-lobes. They do not belong to *Extropharciceras* n. gen. but seem to represent a still un-named taxon of the Synpharciceratinae.

Stratigraphical range: Upper Givetian (MD III-C/D).

Geographical distribution: Tafilalt and Maider of southern Morocco, Ougarta, southern Algeria.

Lunupharciceras **Korn & Klug, 2002** (emend.)

Type-species: *Goniatites lunulicosta* Sandberger & Sandberger, 1850 (OD).

Diagnosis (emend.): Early to median stages widely to extremely evolute and discoidal (serpenticonic), adult stages serpenticonic or strongly compressed, extremely evolute to subevolute, venter rounded or tabulate; undulose ribbing occurs rarely. Sutures often with regularly bell-shaped saddles and lobes; median ventral lobe short at maturity; the ventral saddle becomes high and pronounced in late stages; with three external and two internal U-lobes. Suture formule: $E_1E_2LU_2U_3U_4{:}U_5U_1I$.

Included species:

Schindewolfoceras alcadei Montesinos & Henn, 1986, Upper Givetian, Cantabrian Mts.
Prolecanites Kiliani Frech, 1902a, Upper Givetian, Montagne Noire
Goniatites lunulicosta Sandberger & Sandberger, 1850, Upper Givetian, Rhenish Massif
Lunupharciceras serpentinum n. sp., Upper Givetian, Tafilalt

Pharciceras n. sp. A in Matern (1931), with only two outer U-lobes, and ?*Lunupharciceras nejjakhense* n. sp., with additional outer U-lobes, obviously fall in closely related genera but due to their incomplete knowledge they are currently not suitable as type-species of new taxa.

Discussion: Korn & Klug (2002) introduced their new genus for pharciceratids with moderately wide umbilicus and supposedly six U-lobes that they thought originate in the usual, alternating pattern. However, they did not re-study the chosen type-species, *Ph. lunulicosta*, which in fact has a rather different septal ontogeny. Already Petter (1959) noted the lack of an internal U_5-lobe in her suture formule for North African forms assigned to *Ph. lunulicosta*; there are three external but only two internal U-lobes. This is confirmed

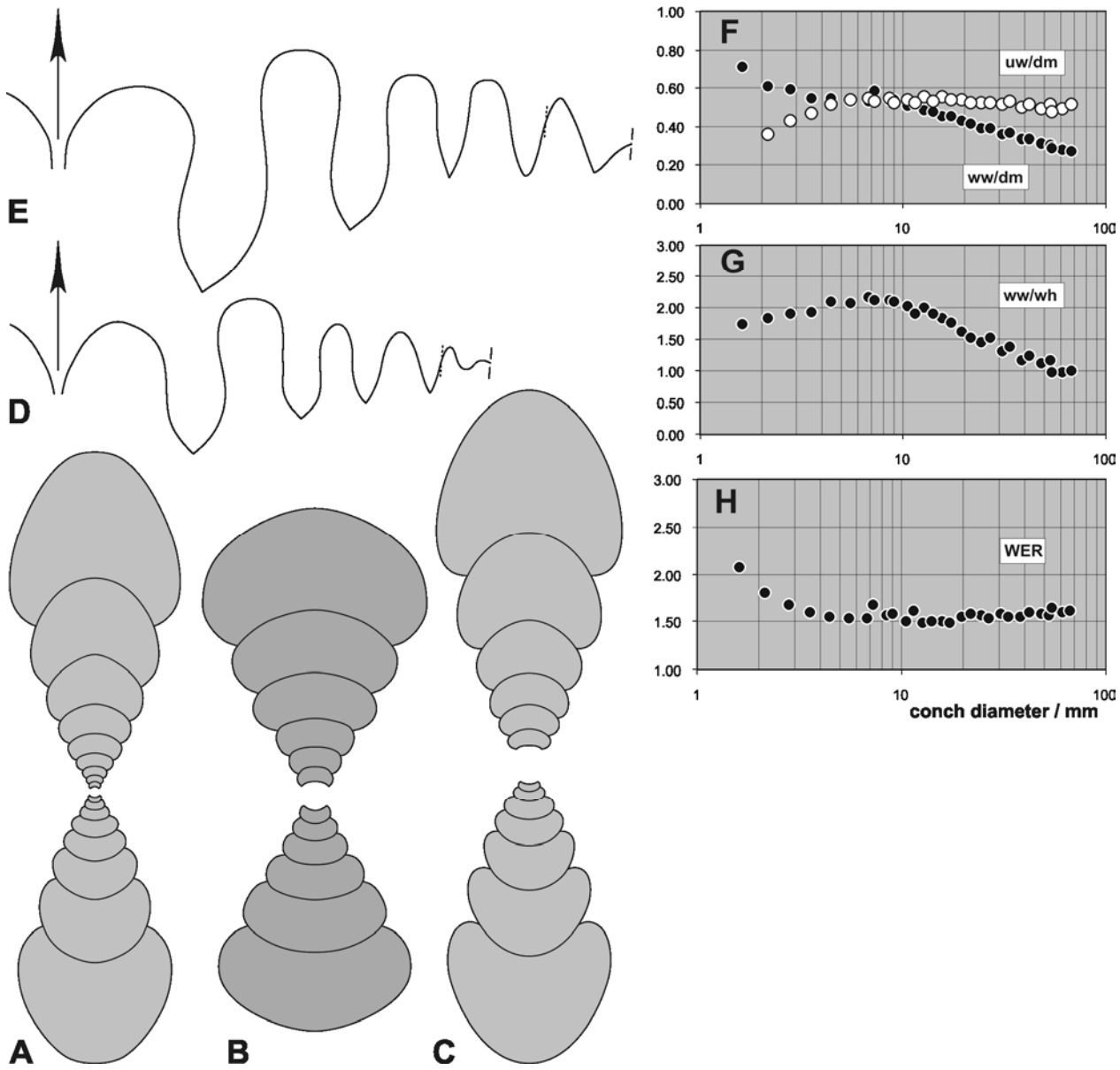


Fig. 21: *Lunupharciceras serpentinum* n. sp. from Dar Kaoua. **A-B**. Cross sections of paratype MB.C.19115.2; x 1.5, inner whorls x 4. **C**. Cross section of paratype MB.C.19115.3; x 1.5. **D**. Suture of holotype MB.C.19115.1 at 12.6 mm ww, 11.5 mm wh; reversed, x 4. **E**. Suture of paratype MB.C.19115.3 at 17.6 mm ww, 16.5 mm wh; x 4. **F-H**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all three specimens.

for one of the *lunulicosta* syntypes, the original of Sandberger & Sandberger (1850: pl. 3, fig. 14e, re-examined by loan), which shows adorally a septal surface with only two internal U-lobes at ca. 27 mm dm whilst the outer suture is typical for the species. The same is seen in a lunupharciceratid from the Sahlgrund Mine (MB.C.3668), collected by W. Kegel and originally described as *Pharciceras* sp., which shows clearly two internal and three external U-lobes. The detailed ontogeny of a younger but related new species from Hassi Nebech that will be described elsewhere suggests that the second internal U-lobe forms later than the third external U-lobe, resulting in the suture formule given above.

Schindewolfoceras alcadei Montesinos & Henn is a slightly ribbed species, but its Givetian age and lower number of outer U-lobes than in North American *Schindewolfoceras* types (see House & Kirchgasser 2008) suggest that it is a *Lunupharciceras*.

Stratigraphical range: Upper Givetian (upper MD III-B to III-E).

Geographical distribution: Rhenish Massif (Sandberger & Sandberger 1850), Montagne Noire (Frech 1902a; House et al. 1985), Cantabrian Mts. (Henn 1985), Tafilalt (Clariond 1935) and Maider (Bultynck & Jacobs 1981) of southern Morocco, Ougarta (Menchikoff 1930) of southern Algeria, Rudnyi Altai (Bogoslovskiy 1958; Borisenkov 2002).

Lunupharciceras serpentinum n. sp.

Figs. 21A-H, 22A

Type: Holotype MB.C.19115.1, illustrated in Figs. 22A and 21D.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype and two sectioned paratypes, MB.C.19115.2-3. The new species occurs also at other Tafilalt localities (Bine Jebilet).

Etymology: Because of the strongly serpenticonic shell form.

Diagnosis: First four whorls, ca. until 7 mm dm, serpenticonic, increasingly depressed (ww/wh up to 2.15) and fast becoming rather evolute (uw/dm = 0.55) whilst WER drops to 1.5; median to mature stages gradually become relative thinner (extremely discoidal, ww/dm down to < 0.3) and much less depressed to slightly compressed (ww/wh = ca. 1.0 at > 50 mm dm) whilst the umbilicus is only slightly narrower (uw/dm = ca. 0.5) and WER increases very slightly to 1.6. Growth lirae evenly spaced, strongly biconvex; high ventrolateral salient bordered by faint double furrows. Mature sutures with strongly shortened E_1-lobe, wide and moderately high median saddle, deep and lanceolate E_2-lobe, and four narrow, pointed flank saddles and lobes that gradually become lower and shorter towards the umbilicus; inner suture with two narrow U-lobes.

Description: The holotype is a well-preserved, complete specimen with associated negative that shows all aspects of shell form (Fig. 22A), ornament, and suture (Fig. 22D). The two cross-sections (Figs. 21A-C) illustrate a rather uniform serpenticonic coiling that changes in the last two whorls (from ca. 50 mm dm on) to a slightly compressed whorl profile with wh > ww (Fig. 21G) but there is only a very small change in whorl expansion (Fig. 21H). A biphasic shell allometry is best expressed in the ww/wh plot (Fig. 21G), with a turning point, as in other pharciceratids, between 8 and 10 mm dm. The umbilical wall is short and rounded, the venter broadly rounded to slightly flattened at maturity (Fig. 22A). Growth lirae are sharp, rib-like, strongly biconvex and regularly spaced (ca. 2/mm). Ventrolateral triple furrows are very weak but visible in the holotype, where the outer of two spiral keels delimits sharply the venter. On moulds (paratype MB.C.19115.3) only one broad furrow may be discerned.

Tab. 27: Conch ontogeny of *Lunupharciceras serpentinum* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinnly pachiconic; subevolute (ww/dm ~ 0.61; uw/dm ~ 0.36)	moderately depressed; moderately embracing (ww/wh = 1.91; IZR ~ 0.24)	moderate (WER = 1.80)
8 mm	thickly discoidal; evolute (ww/dm ~ 0.53; uw/dm ~ 0. 54)	moderately to strongly depressed; moderately embracing (ww/wh = 1.90 – 2.12; IZR = 0.21-0.22)	low (WER = 1.55-1.60)
20 mm	thinly discoidal; evolute (ww/dm ~ 0.42; uw/dm ~ 0.53)	moderately depressed; moderately embracing (ww/wh = 1.53-1.62; IZR = 0.23-0.27)	low (WER = 1.55-1.60)
60 mm	extremely discoidal; evolute (ww/dm ~ 0.28; uw/dm ~ 0.50)	weakly depressed; moderately embracing (ww/wh = 1.00; IZR = 0.22-0.24)	low (WER = 1.60)

Fig. 22: A. *Lunupharciceras serpentinum* n. sp., holotype MB.C.19115.1 from Dar Kaoua, ventral and lateral views; x 1. **B.** *?Lunupharciceras nejjakhjense* n. sp., holotype MB.C.19116 from Dar Kaoua, lateral and ventral views; x 1.

Tab. 28: Conch dimensions of *Lunupharciceras serpentinum* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.19115.3	67.0	18.5	18.5	34.5	14.2	0.28	1.00	0.51	1.61	0.23
MB.C.19115.2	60.9	17	17.4	29.9	12.6	0.28	0.98	0.49	1.59	0.27
holotype	54.4	15.7	15.9	25.9	12	0.29	0.99	0.48	1.65	0.25
MB.C.19115.3	42.2	14.3	11.6	21.8	8.8	0.34	1.24	0.52	1.59	0.24
MB.C.19115.2	30.7	11.0	8.4	15.8	6.3	0.36	1.32	0.51	1.58	0.25
MB.C.19115.2	19.5	8.4	5.2	10.5	3.8	0.43	1.62	0.54	1.55	0.26
MB.C.19115.2	10.5	5.3	2.6	5.7	2.0	0.51	2.02	0.54	1.51	0.26
MB.C.19115.2	5.49	2.90	1.40	2.94	1.07	0.53	2.07	0.54	1.54	0.24
MB.C.19115.2	2.16	1.32	0.72	0.78	0.55	0.61	1.83	0.36	1.80	0.24

The shortened ventral lobe reaches about the depth of the U_2-lobe at maturity. The median saddle remains lower than the ventral saddle (Figs. 21D-E). On the cross-section of paratype MB.C.19115.2 only one internal lobe is visible at 25 mm dm; a second internal U-lobe is certainly present at 47.5 mm dm but a third external U-lobe can be seen as early as at ca. 6.5 mm wh in paratype MB.C.19115.3. The last septum of the latter is formed at 18 mm wh (ca. 65 mm dm) and, therefore, the maximum size of the species exceeded 80 mm.

Discussion: *Lun. serpentinum* n. sp. differs from *Lun. lunulicosta* in its mostly serpenticonic shell form, especially in the mature whorls that hardly become compressed. *Lun. kiliani* is even more compressed. The poorly known *Lun. alcadei* is more involute and possesses low and wide ribs; its cross-section is unknown.

Stratigraphical range: *Syn. clavilobum* Zone (MD III-C).

Geographical distribution: Restricted to the Tafilalt.

***?Lunupharciceras nejjakhense* n. sp.**

Figs. 22B, 23

Type: Holotype MB.C.19116, illustrated in Figs. 22B and 23.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: Only the holotype.

Etymology: After the Oued en Nejjakh (see topographic sheet Erfoud, NH-30-XX-2) that terminates the Dar Kaoua ridge just E of the main collecting spot.

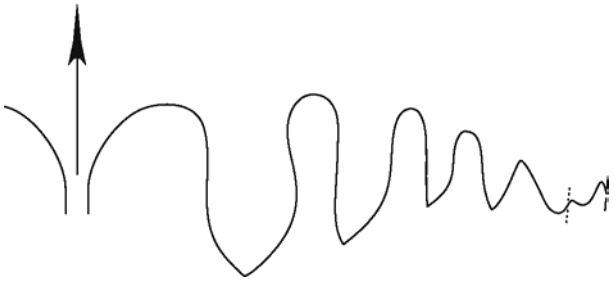


Fig. 23: *?Lunupharciceras nejjakhense* n. sp., sutur of the holotype, MB.C.19116, at ca. 14.5 mm wh and 40 mm dm; x 4.

Diagnosis: At maturity extremely discoidal, with gently rounded flanks and narrowly rounded venter, subevolute (uw/dm = ca. 0.35), with low WER and faint ventrolateral double furrows and spiral keels that delimit the venter. Mature sutures with shortened E_1-lobe, wide and high median saddle, broadly lanceolate, deep E_1-lobe, three very narrow, high flank saddles separated by asymmetric, pointed L- and U-lobes, two small ascending U-lobes close to the umbilicus and a small U-lobe sitting on the umbilical seam, giving a total of five external U-lobes. Dorsal suture unknown.

Tab. 29: Conch dimensions of ?*Lunupharciceras nejjakhense* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	53.7	c. 12.8	20.0	18.8	12.1	c. 0.24	c. 0.64	0.35	1.67	0.40
holotype	41.9	12.4	13.9	14.3	-	0.30	0.89	0.34	-	-

Description: The holotype is fairly well-preserved, complete, and shows the characteristic, thin shell form and many consecutive sutures (e.g., Fig. 23). The umbilical wall is short and steep, the maximum ww lies at ca. 1/3 of the whorl height. The mould of the preserved part of the body chamber displays two very shallow depressions or flattening zones on the outer flank, followed by a spiral keel that produces a sharp ventral margin (Fig. 22B). Growth lirae are not preserved.

Discussion: The combination of the strongly compressed, subevolute shell and the distinctive sutures, with their high and wide median saddles that contrast with the very narrow flank saddles, and the presence of five outer U-lobes allow no confusion with any named pharciceratid. Unfortunately it cannot be decided whether the small sinus in the saddle next to the umbilicus represents a “plurilobe” or a full U-lobe. Due to its shortness, it appears to result from saddle incision, the defining character of a “plurilobe”, but its symmetric presence on both shell sides and in consecutive septa leaves the second interpretation. Only additional specimens may solve the question. The new species probably represents a new genus that is closely related to and derived from *Lunupharciceras*. But since the internal suture is not visible in the holotype, it is not possible to give a suture formule. The small lobe centered on the umbilical seam could be an externally shifted U_5 or an additional $U_{6/7}$. With respect to such uncertainties, it is currently not wise to select *?Lun. nejjakhense* n. sp. as the type of a new genus.

The strongly compressed shell form resembles the poorly known *Lun. kiliani*, which has different, more self-similar and bell-shaped flank elements. Its number of flank lobes is not clear and subsequent specimens described by House et al. (1985) did not settle the problem. Montagne Noire specimens identified by House et al. (1985) as *Ph.* aff. *kilinai* may have up to five outer U-lobes, as in *?Lun. nejjakhense* n. sp., but, again, the shape of saddles and lobes is not similar. Other still un-named *Lunupharciceras* relatives with four to five outer U-lobes occur in the Tafilalt and South China (*Synpharciceras* sp. in Ruan 1981).

Stratigraphical range and geographical distribution: Restricted to the type locality and level.

Subfamily Synpharciceratinae Schindewolf, 1940 (emend.)

Diagnosis (emend.): Early whorls pachyconic, depressed and open umbilicate, median to mature whorls compressed, thinly to extremely discoidal, and with very narrow to closed umbilicus, caused by overlap of whorls over the umbilicus or by umbilical shell flares. Growth ornament indistinctive. Mature sutures with from six to more than twenty U-lobes.

Included genera:

Stenopharciceras Montesinos & Henn, 1986
Synpharciceras Schindewolf, 1940
Neopharciceras Bogoslovskiy, 1955
?*Meropharciceras* Becker & House, 1993

Discussion: The involute pharciceratids form a distinctive phylogenetic lineage within the Pharciceratidae, in which sutures became increasingly complex in parallel with the open umbilicate (subinvolute to evolute) main lineage. The very involute conch of *Meropharciceras* suggests that it was derived from *Synpharciceras* and that its incipient third ventral lobe arose independently from the E_3 in the widely umbilicate petteroceratids. *Meropharciceras* may deserve independent status at family level.

Stratigraphical range: Upper Givetian (MD III-C) to Lower Frasnian (UD I-A).

Geographical distribution: Rhenish Massif, Harz Mts., cf. Graz Palaeozoic, Montagne Noire, Pyrenees, Cantabrian Mts., Tafilalt and Maider of southern Morocco, Ougarta and Saoura Valley of southern Algeria, Kazakhstan (Karaganda Basin), Rudnyi Altai, Yunnan and Guangxi of South China.

Stenopharciceras Montesinos & Henn, 1986 (emend.)

Type species: *Pharciceras tridens* var. *kseirense* Termier & Termier, 1950 (OD).

Diagnosis (emend): Early stages pachyconic, open umbilicate and depressed, median to mature stages compressed, thinly discoidal, with closed umbilicus and high WER (> 2.0). Growth ornament biconvex, ventrolateral furrows very weak. Mature sutures with short E_1-lobe, high median saddle, deep, pointed E_2-lobe, elevated, narrow ventral saddle, relative short, pointed L-lobe, three small external U-lobes and three to four internal U-lobes. Suture formule: $E_1E_2LU_2U_4U_6{:}U_5U_3U_1I$ to $E_1E_2LU_2U_4U_6{:}U_7U_5U_3U_1I$.

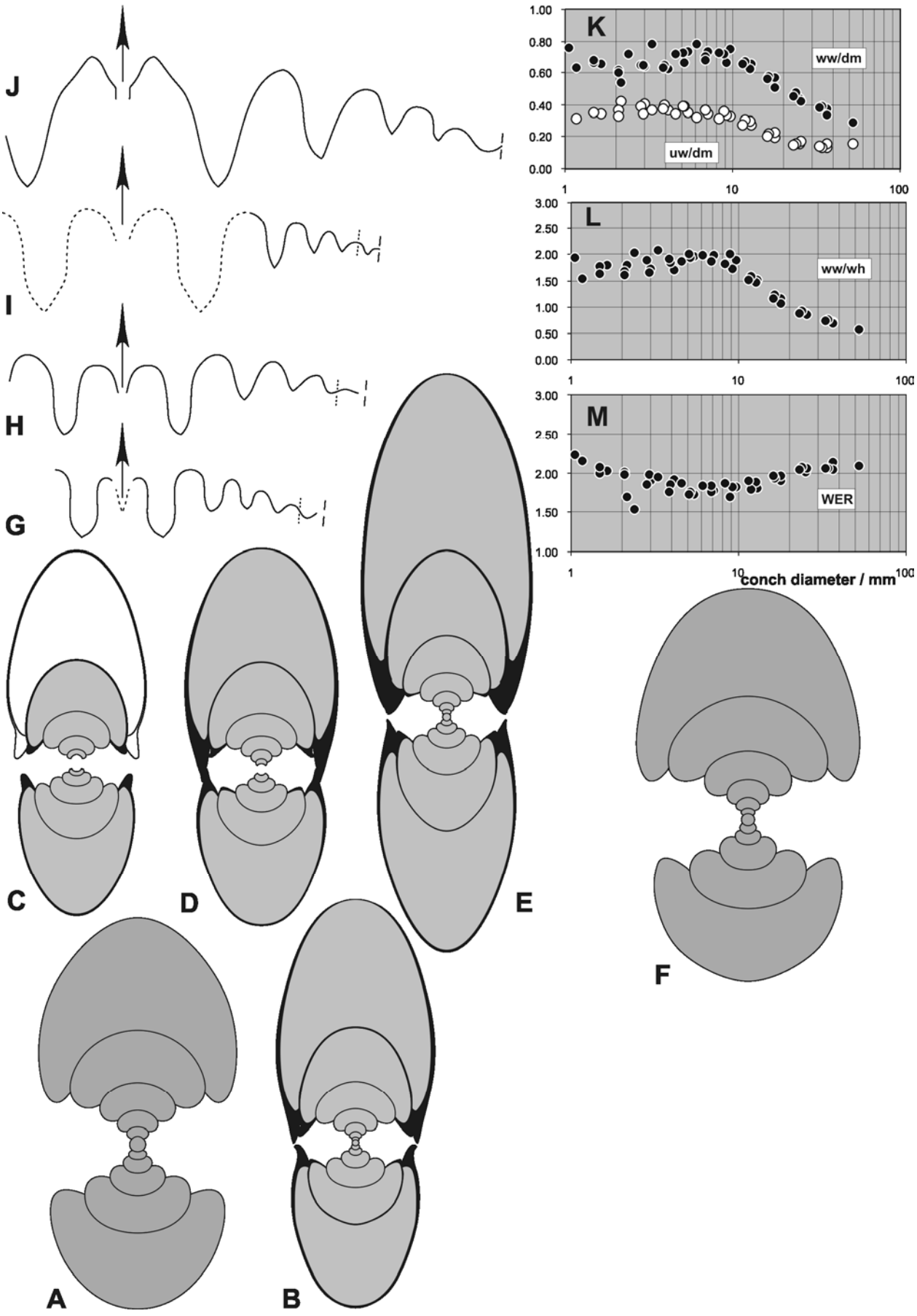
Included species:

Stenopharciceras protectum n. sp., Upper Givetian, Tafilalt
Pharciceras tridens var. *kseirensis* Termier & Termier, 1950, Upper Givetian, Tafilalt
Pharciceras cf. *kseirense* in Göddertz (1987), Upper Givetian, Saoura Valley

Discussion: Montesinos & Henn (1986) introduced *Stenopharciceras* for multilobate pharciceratids and as a phylogenetic intermediate between *Pharciceras* and *Synpharciceras*. Korn & Klug (2002) separated the involute forms around *St. kseirense* from the evolute to subinvolute species and assigned the latter to *Lunupharciceras*, also assuming that *Stenopharciceras* has two additional U-lobes. The diagnostic feature of the emended *Stenopharciceras* that justifies its placing in the Synpharciceratinae is its completely closing umbilicus with growth. Umbilical sealing is either reached by overlap of the whorls over the umbilical space (type-species) or by umbilical shell extensions (*St. protectum* n. sp.). It is possible that this difference allows a generic subdivision when more involute species become known.

There is some confusion concerning the authorship and type of the type-species. Montesinos & Henn (1986) wrongly gave the authorship of *St. kseirense* to Petter (1959). However, as corrected by Korn & Klug (2002), the first illustration and characterisation of the species in Termier & Termier (1950) is valid. This is important because this narrows the syntypes to Clariond´s collection from the Tafilalt and it excludes Petter´s Ougarta population, from which Montesinos & Henn (1986) incorrectly chose a lectotype. The original of Termier & Termier (1950: pl. 40, figs. 38-39), a specimen from Oued Kseir in the southern Tafilalt, is here selected as lectotype since it is the only syntype which conch was illustrated. In this specimen there are three external U-lobes.

Stratigraphical range: Upper Givetian (MD III-C/D).


J
I
H
G
K
ww/dm
uw/dm
1.00
0.80
0.60
0.40
0.20
0.00
1
10
100
L
ww/wh
3.00
2.50
2.00
1.50
1.00
0.50
0.00
M
WER
conch diameter / mm
C
D
E
F
A
B

← **Fig. 24:** *Stenopharciceras protectum* n. sp. from Dar Kaoua. **A**. Cross section of inner whorls of holotype MB.C.19117.1, x 4. **B**. Cross section of paratype MB.C.19117.3; x 2. **C**. Cross section of paratype MB.C.19117.5; x 2. **D**. Cross section of paratype MB.C.19117.4; x 2. **E**. Complete cross section of holotype MB.C.19117.1, x 2. **F**. Cross section of inner whorls of paratype MB.C.19117.3; x 4. **G**. Suture of paratype MB.C.19117.5 at 12 mm wh, 10 mm ww; x 2.5. **H**. Suture of paratype MB.C.19117.3 at 13.3 mm wh, 12.3 mm ww; x 2.5. **I.** Suture of paratype MB.C.19117.2 at ca. 15.5 mm wh, 12.5 mm ww; x 2.5. **J**. Mature suture of holotype MB.C.19117.1 at 25.5 mm wh, 14.5 mm ww; x 2.5. **K-M**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all specimens.

Geographical distribution: Cantabrian Mts. (Montesinos & Henn 1986), Tafilalt (Termier & Termier 1950) and Maider (Bultynck & Jacobs 1981) of southern Morocco, Ougarta (Petter 1959) and Saoura Valley (Göddertz 1987) of southern Algeria.

***Stenopharciceras protectum* n. sp.**

Figs. 24A-M, 25A-B

v 2000a *Stenopharciceras kseirense* Becker & House: 31

Type: Holotype MB.C.19117.1, illustrated in Figs. 24A, E and 25B, cast before sectioning.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: The holotype, four paratypes (MB.C.19117.2-5), and one additional specimen (MB.C.19117.6).

Etymology: Because of the protective sealing (flare closing) of the umbilicus.

Diagnosis: First 4 ½ whorls until ca. 10 mm relative variable, pachyconic, depressed, with ww/dm up to ca. 0.7-0.8 and ww/wh up to 2.0, subevolute (uw/dm 0.3-0.4) and with broadly rounded venter whilst WER declines to 1.7-1.9; median to mature stages gradually less depressed to compressed (from ca. 20 mm dm on), reaching mature values of ww/dm < 0.3 (extremely discoidal) and ww/wh = ca. 0.5, with high WER > 2.0 and gradual closure of the umbilicus by shell flares; without growth lirae but with weak ventrolateral furrows. Mature sutures with very short E_1-lobe, strongly elevated and tectiform median saddle, very deep, pointed E_2-lobe, high ventral saddle, moderately deep, pointed L-lobe, three small, pointed or rounded external and four internal U-lobes.

Tab. 30: Conch ontogeny of *Stenopharciceras protectum* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subevolute (ww/dm 0.6-0.7; uw/dm 0.33-0.37)	moderately depressed; moderately to strongly embracing (ww/wh 1.60 - 1.90; IZR 0.20-0.45)	moderate or high (WER ~ 2.00)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.70 - 0.75; uw/dm 0.30-0.35)	moderately depressed; strongly embracing (ww/wh 1.80-1.95; IZR ~ 0.35)	moderate (WER 1.70-1.85)
20 mm	thickly discoidal; subinvolute (ww/dm ~ 0.50; uw/dm 0.17-0.20)	weakly compressed; strongly embracing (ww/wh ~ 1.00; IZR ~ 0.40)	moderate or high (WER ~ 2.00)
35 mm	thinly discoidal; subinvolute to involute ww/dm 0.35-0.40; uw/dm 0.13-0.16)	weakly compressed; strongly embracing (ww/wh ~ 0.70-0.75; IZR ~ 0.40)	high (WER ~ 2.05)

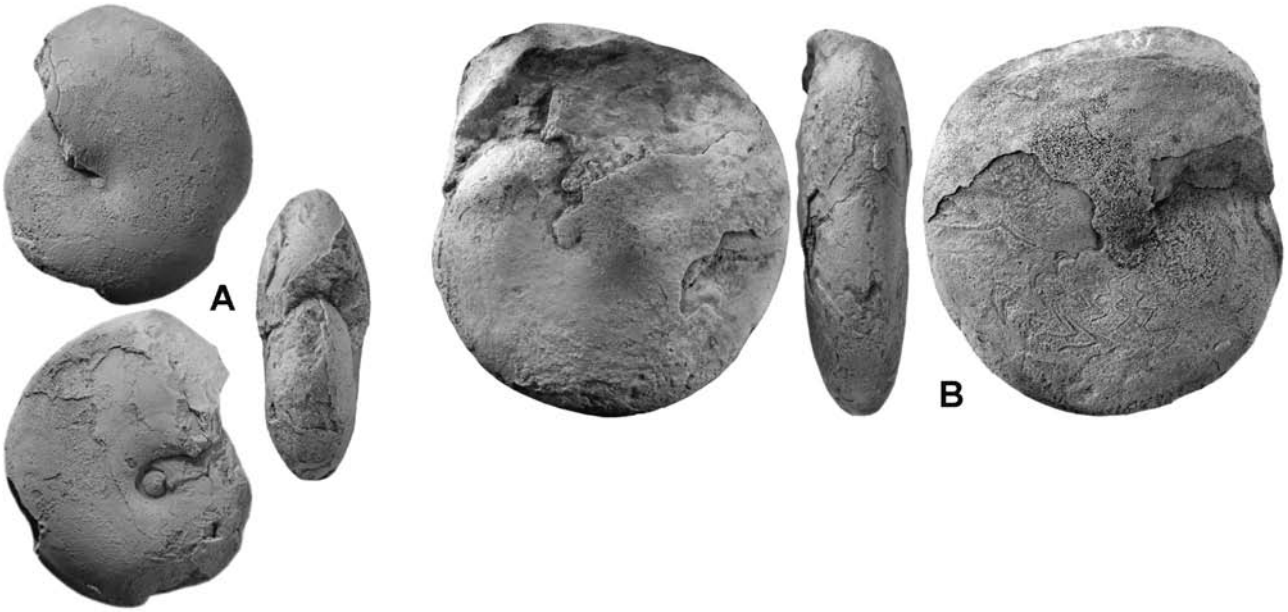


Fig. 25: *Stenopharciceras protectum* n. sp. from Dar Kaoua. **A.** Paratype MB.C.19117.2, both lateral and adoral views, showing the strong difference of umbilical width in mould and shell preservation; x 1. **B.** Holotype MB.C.19117.1, ventral and both lateral views, showing sutures and the impact of preservation on umbilical width; x 1.

Tab. 31: Conch dimensions of *Stenopharciceras protectum* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	52.4	15.1	26.2	8.2	16.1	0.29	0.58	0.16	2.08	0.38
MB.C.19117.3	36.9	13.7	19.2	5.0	11.6	0.37	0.71	0.14	2.13	0.40
MB.C.19117.4	34.1	13.3	17.4	4.5	10.3	0,39	0.76	0.13	2.06	0.40
MB.C.19117.5	33.0	12.4	16.7	4.6	9.9	0.38	0.74	0.14	2.05	0.41
holotype	25.4	10.8	12.6	4.4	7.7	0.42	0.86	0.17	2.05	0.39
holotype	12.6	7.9	5.4	3.7	3.4	0.63	1.47	0.29	1.88	0.36
holotype	6.83	4.80	2.56	2.50	1.68	0.70	1.87	0.37	1.76	0.35
holotype	2.85	1.84	0.97	1.11	0.75	0.64	1.90	0.39	1.85	0.22
holotype	1.48	0.98	0.55	0.52	0.43	0.66	1.78	0.35	1.99	0.22

Description: The holotype is a moderately large specimen with seven whorls (Fig. 24E) that shows the typical cross-section with umbilical flares and the very distinctive mature suture (Fig. 24J). The biphasic shell ontogeny, with an allometric turn at 9-10 mm dm, is illustrated by several cross-sections (Figs. 24A-F). Early whorls show considerable varibility of whorl thickness (ww/dm and ww/wh plots, Figs. 24K-L) but there is a slight trend towards more depressed shell form. The post-embryonic whorls soon reach WER values below 2.0, with a minimum of 1.7-1.8 in the 3rd to 4th whorl (Fig. 24M). The median and mature conch is less variable and the umbilicus is closed by extensive shell flares, that appear thorn-like in cross-sections, at ca. 35 mm dm (paratypes MB.C.19117.4 and 19117.3, Figs. 24B, D). The initiation of umbilical flares occurs at the end of the 4th whorl (9-10 mm dm, MB.C.19117.4), in parallel with the allometric change. The flares are first short and bent outwards, later they are directed towards the umbilical centre and finally they touch. The uw/dm plot (Fig. 24K) is based on the mould values. The last whorl of the holotype (Fig. 24E) and paratype MB.C.19117.2 (Fig. 25A) show a sudden uncoiling that is balanced by even more excessive shell extensions. Subtle ventrolateral furrows are visible on the shell of paratype MB.C.19117.2 but are not marked on moulds. The absence of any growth lirae on the shell is striking. The fine (ca. 8/mmm) radial, branching wrinkle layer is excellently preserved on paratype MB.C.19117.3.

All observed sutures from 12 mm wh on (Figs. 24G-J) display three external umbilical lobes. The subumbilical U_6 remains rounded whilst U_2 and U_4 are subangular to pointed. From ca. 15 mm wh on, the median saddle rises and eventually, in the holotype, it is higher than the adjacent ventral saddle. Its tip is tectiform. The oblique lateral flank shows a slight tendency to develop an incipient E_3-lobe. There are three internal U-lobes between 16 and 22.5 mm dm in paratype MB.C.19117.4 but four in the 7th whorl of the holotype. MB.C.19117.6 is a small specimen with three outer U-lobes and relative coarse, radial wrinkle layer that possesses three unusual dorsolateral shell folds between 20 and 25 mm dm.

Discussion: In topotypes of *St. kseirense* from the Oued Kseir-Hassi Nebech outcrop belt of the southern Tafilalt, as well as in the Ougarta *kseirense* population (Petter 1959), the umbilicus is closed by overlap of the median whorls, at least from 20 mm dm on. This gives a strong difference to the new species with its striking difference of the umbilicus in shell and mould preservation. The tectiform median saddle separates *St. protectum* n. sp. from all other members of the Synpharciceratinae.

Stratigraphical range: Restricted to the type level.

Geographical distribution: Restricted to the Tafilalt.

Synpharciceras Schindewolf, 1940

Type-species: *Goniatites clavilobus* Sandberger & Sandberger, 1850 (OD).

Diagnosis (emend.): Early stages increasingly depressed, pachyconic, subevolute to subinvolute, median to mature stages less depressed to strongly compressed, extremely discoidal, with rising WER and gradual closure of the umbilicus by umbilical shell flares. Growth lines biconvex, with broad and low dorsolateral and high ventrolateral salient; ventrolateral furrows weak. Mature sutures with small E_1-lobe, moderately high median saddle, deep, narrow E_2-lobe, and towards the umbilicus with gradually smaller, often self-similar L- and U-lobes, five to six external and five to seven internal U-Lobes.

Mature suture formule: $E_1E_2LU_2U_4U_6U_8U_{10}(U_{12}):(U_{13})U_{11}U_9U_7U_5U_3U_1I$.

Included species:

Goniatites clavilobus Sandberger & Sandberger, 1850, Upper Givetian, Rhenish Massif
Synpharciceras n. sp. aff. *clavilobum* in Schindewolf (1940), Upper Givetian, Tafilalt
Synpharciceras aff. *clavilobum* in Bensaid (1974), Upper Givetian, Tafilalt
Synpharciceras plurilobatum Petter, 1959, Upper Givetian, Tafilalt
Synpharciceras spirale n. sp., Upper Givetian, Tafilalt
?Pharciceras tafilense Termier & Termier, 1950, Upper Givetian, Tafilalt
Pharciceras n. sp. in Bensaid (1974), Upper Givetian, Tafilalt
Pharciceras arenicum in House et al. (1985), Upper Givetian, Montagne Noire

Syn. daizhaimenense Yang, 1984 from Yunnan (South China) has much more complex sutures and falls in *Neopharciceras* (see Korn & Klug 2002).

Discussion: The thorn-shaped (in cross-section) typical umbilical flares of the genus were first figured by Klug & Korn (2002). They are regarded as an important, diagnostic feature. An oxyconic sharpening of the venter, as figured by Wedekind (1918), has not been observed so far in Tafilalt representatives.

Stratigraphical range: Upper Givetian (MD III-C to III-E).

Geographical distribution: Rhenish Massif (Sandberger & Sandberger 1850), Harz Mts. (Beushausen 1900), cf. Graz Palaeozoic (Austria, Heritsch & Schouppé 1941), Montagne Noire (House et al. 1985), western Pyrenees (Kullmann 1973), Tafilalt (Clariond 1935) of southern Morocco, Ougarta (Petter 1959: Erg Djemel) and Saoura Valley (Petter 1959) of southern Algeria.

Synpharciceras clavilobum (Sandberger & Sandberger, 1850)

Figs. 26A-G, 27A-M, 28D-E

*v	1850	*Goniatites clavilobus* Sandberger & Sandberger: 67, pl. 8, figs. 3, 3a-b
	1902a	*Prolecanites clavilobus* Frech: 63, pl. 3, fig. 10
v	1977	*Synpharciceras clavilobum* House & Ziegler: pl. 5, figs. 18-19

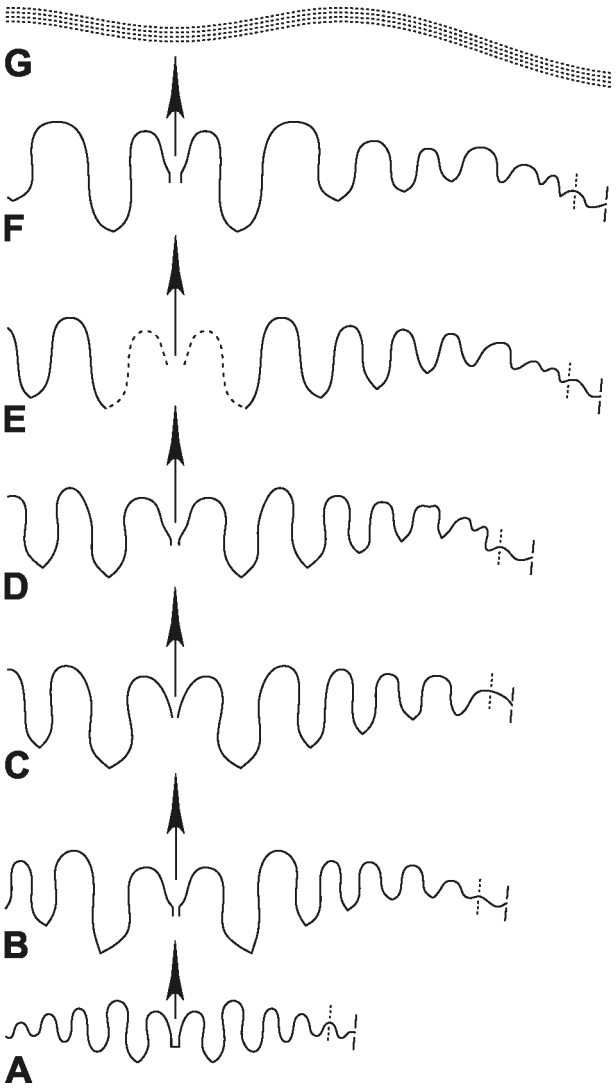
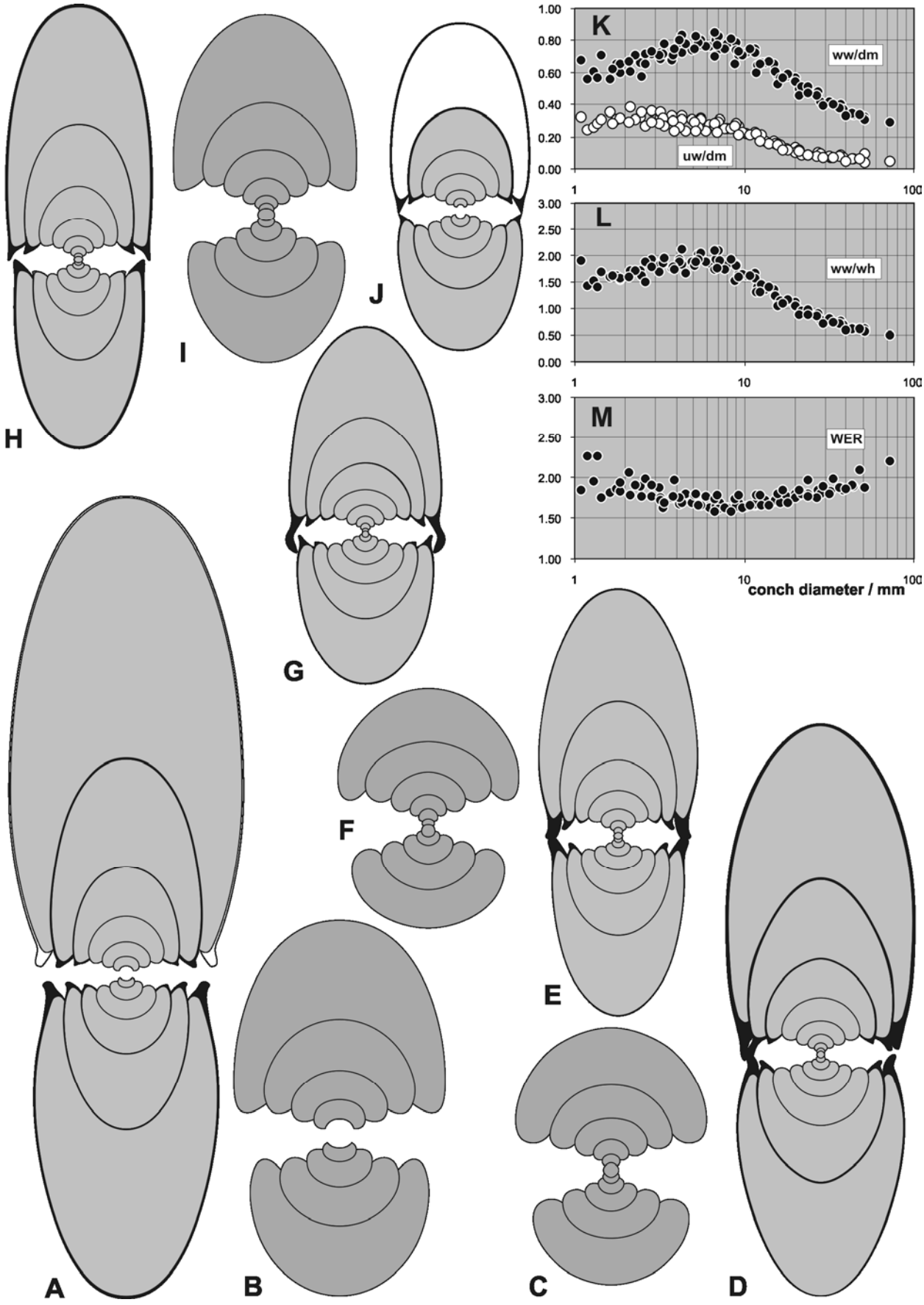


Fig. 26: *Synpharciceras clavilobum* (Sandberger & Sandberger, 1850) from Dar Kaoua. **A**. Suture of MB.C.19118.27 at 7.2 mm wh; x 2.5. **B**. Suture of MB.C.19118.37 at 13.6 mm wh; x 2.5. **C**. Suture of MB.C.19118.23 at 13.6 mm wh; x 2.5. **D**. Suture of MB.C.19118.12 at 19 mm wh; x 2.5. **E**. Suture of MB.C.19118.32 at 19 mm wh; x 2.5. **F**. Suture of MB.C.19118.9 at 15 mm wh; x 2.5. **G**. Course of wrinkle layer of MB.C.19118.37 at 21.5 mm wh; x 2.5.

v	2000a	*Synpharciceras clavilobum* Becker & House: 31
v	2000b	*Synpharciceras plurilobatum* Becker & House: 31
	2002	*Synpharciceras clavilobum* Klug & Korn: 922, text-fig. 4B
	2002	*Synpharciceras clavilobum* Korn & Klug: 145, figs. 134C, F, I, J, cf. 135C, E

Type: Holotype (by monotypy) is the original of Sandberger & Sandberger (1850: pl. 8, figs. 3, 3a-b), re-figured by House & Ziegler (1977) and Korn & Klug (2002), No. 67 (old no. 62.11./W.33), Museum Wiesbaden.

Fig. 27: *Synpharciceras clavilobum* (Sandberger & Sandberger, 1850) from Dar Kaoua. **A-B**. Cross sections of MB.C.19118.3, morphotype with narrow umbilicate inner whorls and fast expanding last whorl; x 2, inner whorls x 4. **C-D**. Cross sections of MB.C.19118.29, typical morphotype; inner whorls x 4, complete section x 2. **E**. Cross section of MB.C.19118.4; x 2. **F-G**. Cross sections of MB.C.19118.5; inner whorls x 4, complete section x 2. **H-I**. Cross sections of MB.C.19118.7, relative thin morphotype with slight overlap of sixth whorl over the umbilicus; x 2, inner whorls x 4. **J**. Cross section of MB.C.19118.6, moderately thick morphotype with slight overlap of sixth whorl over the umbilicus; x 2. **K-M**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER of all measured specimens, showing the decrease of shell variability with growth. →


K
ww/dm
uw/dm
L
ww/wh
M
WER
conch diameter / mm
A
B
C
D
E
F
G
H
I
J

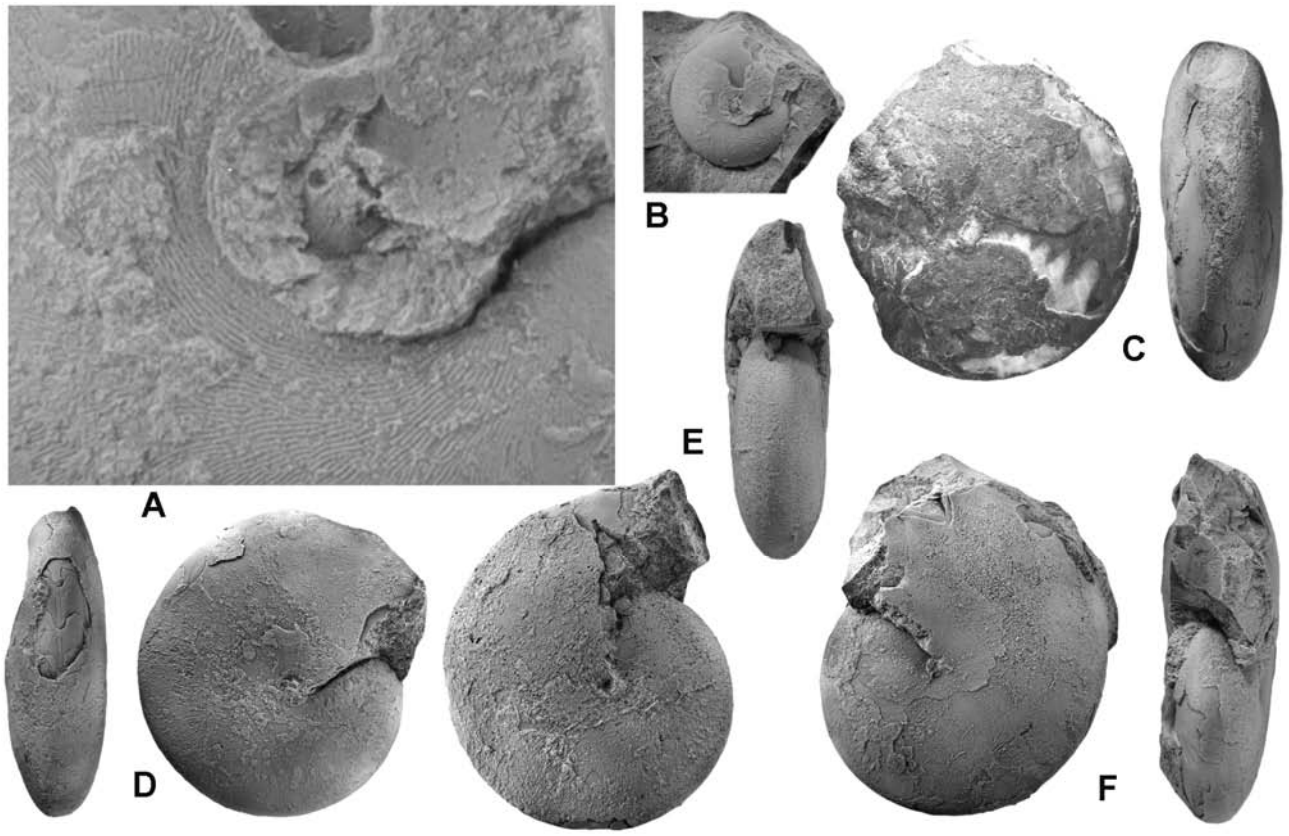


Fig. 28: *Synpharciceras* from Dar Kaoua. **A-B.** *Syn. spirale* n. sp., paratype MB.C.19119.2, details of spirally oriented subumbilical wrinkle layer, x 4, and lateral view, x 1. **C.** *Syn. spirale* n. sp., holotype MB.C.19119.1, lateral and ventral views; x 1. **D.** *Syn. clavilobum* (Sandberger & Sandberger, 1850), MB.C.19118.1, ventral and lateral views; x 1. **E.** *Syn. clavilobum* (Sandberger & Sandberger, 1850), MB.C.19118.2, lateral and adoral views, the latter with weak ventrolateral furrows; x 1. **F.** *Syn*. cf. *spirale* n. sp., MB.C.19121, lateral and ventral views; x 1.

Type locality and level: Königszug Mine at Eibach, Lahn Syncline, Rhenish Massif; hematite ore, Upper Givetian, undifferentiated.

Material: 40 specimens up to 56 mm dm (MB.C.19118.1-40).

Diagnosis (emend.): First four whorls up to 7 mm dm variably pachyconic, increasingly depressed, with ww/dm values reaching 0.7-0.8 and ww/wh values reaching 1.7-2.0, umbilical width changing from slightly subevolute to subinvolute (uw/dm = 0.2-0.3) whilst WER drops to 1.6-1.8; median to mature stages become gradually less depressed to compressed (from ca. 20 mm dm on) and finally (60-70 mm dm) strongly compressed whilst the umbilicus is completely closed by umbilical shell flares; WER rises constantly to mature values of 2.0 and more. Wrinkle layer fine and radial. Sutures with proliferation of U-lobes until ca. 20 mm wh (35 mm dm); mature sutures with shortened E_1-lobe, high and narrow median saddle, deep, narrowly bell-shaped E_2-lobe, slightly elevated, narrow ventral saddle and four similarly shaped, gradually smaller flank lobes (L-lobe and U_2- to U_6-lobes) and saddles; near the umbilicus with small U_8-, U_{10}- and U_{12}-lobes, inner sutures with up to seven U-lobes; external "plurilobes" are common, especially in the U_4-U_6- and U_6-U_8-saddles. Suture formule: $E_1E_2LU_2U_4U_6U_8U_{10}U_{12}$:$U_{13}U_{11}U_9U_7U_5U_3U_1I$.

Tab. 32: Conch ontogeny of *Synpharciceras clavilobum* (Sandberger & Sandberger, 1850) from Darkaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subinvolute or subevolute (ww/dm = 0.60-0.70; uw/dm 0.30-0.40)	moderately depressed; strongly embracing (ww/wh =1.55-1.70; IZR 0.30-0.33)	moderate to high (WER = 1.75-2.05)
8 mm	thinly to thickly pachyconic; subinvolute (ww/dm = 0.65-0.80; uw/dm 0.20-0.30)	moderately depressed; strongly to very strongly embracing (ww/wh = 1.6-2.0; IZR 0.40-0.50)	low to moderate (WER = 1.60-1.80; median to mature)
20 mm	thinly to thickly discoidal; involute (ww/dm = 0.47-0.60; uw/dm 0.10-0.15)	weakly depressed to compressed; very strongly embracing (ww/wh = 0.90-1.15; IZR 0.47-0.55)	moderate (WER = 1.75-1.95)
35 mm	thinly discoidal; involute (ww/dm 0.35-0.40; uw/dm 0.05-0.10)	weakly compressed; very strongly embracing (ww/wh = 0.60-0.75; IZR 0.47-0.50)	moderate to high (WER = 1.85-2.00)
70 mm	extremely discoidal; involute (ww/dm ~ 0.30; uw/dm ~ 0.05)	strongly compressed; strongly embracing (ww/wh ~0.50; IZR ~ 0.43)	high (WER ~ 2.20)

Tab. 33: Conch dimensions for different morphotypes of *Synpharciceras clavilobum* (Sandberger & Sandberger, 1850) from Dar Kaoua

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
"normal" (moderately thick) morphotypes										
MB.C.19118.29	51.2	16.6	26.7	4.6	13.9	0.32	0.62	0.09	1.88	0.48
MB.C.19118.28	44.3	15.0	24.4	2.7	12.0	0.34	0.61	0.06	1.89	0.51
MB.C.19118.1	43.4	15.2	24.3	2.6	12.0	0.35	0.63	0.06	1.91	0.51
MB.C.19118.4	38.4	14.2	20.6	2.9	10.1	0.37	0.69	0.07	1.84	0.51
MB.C.19118.26	36.5	13.9	19.7	2.8	9.8	0.38	0.71	0.08	1.87	0.50
MB.C.19118.5	32.0	13.6	17.1	2.5	8.1	0.42	0.80	0.08	1.79	0.53
MB.C.19118.29	20.0	11.4	10.2	2.6	5.1	0.57	1.11	0.13	1.79	0.51
MB.C.19118.29	11.5	8.6	5.2	2.5	2.6	0.75	1.66	0.22	1.66	0.50
MB.C.19118.29	5.35	4.36	2.16	1.51	1.19	0.81	2.02	0.28	1.65	0.45
MB.C.19118.29	2.43	1.60	0.93	0.79	0.66	0.66	1.72	0.33	1.88	0.29
thin morphotype with slight overlap of sixth whorl over umbilicus (Fig. 27I)										
MB.C.19118.7	39.7	12.9	21.7	2.1	10.6	0.33	0.60	0.05	1.86	0.51
MB.C.19118.7	29.1	11.5	17.0	2.1	7.9	0.39	0.72	0.07	1.89	0.50
MB.C.19118.7	21.2	9.8	11.1	2.2	5.6	0.46	0.88	0.11	1.84	0.50
MB.C.19118.7	11.7	7.1	5.4	2.5	2.9	0.60	1.30	0.22	1.78	0.46
MB.C.19118.7	5.06	3.78	2.10	1.46	1.27	0.75	1.80	0.29	1.78	0.40
MB.C.19118.7	2.08	1.38	0.87	0.60	0.63	0.67	1.59	0.29	2.06	0.28
thin, early more subinvolute and later faster expanding morphotype (Fig. 27A-B)										
MB.C.19118.3	71.7	20.8	40.9	3.9	23.5	0.29	0.51	0.05	2.21	0.43
MB.C.19118.3	48.2	16.4	26.9	3.1	14.8	0.34	0.61	0.06	2.09	0.45
MB.C.19118.3	33.3	13.5	18.3	2.3	9.7	0.40	0.74	0.07	1.99	0.47
MB.C.19118.3	23.6	11.2	12.8	2.2	6.8	0.47	0.88	0.09	1.97	0.47
MB.C.19118.3	12.4	8.0	8.1	2.0	3.1	0.65	1.32	0.17	1.78	0.49
MB.C.19118.3	6.9	5.4	3.0	1.6	1.73	0.77	1.77	0.23	1.78	0.43
MB.C.19118.3	3.89	2.93	1.67	0.92	1.12	0.75	1.75	0.24	1.97	0.33

moderately thick morphotype with slight overlap of sixth whorl over umbilicus (Fig. 27J)										
MB.C.19118.6	21.7	11.1	11.6	2.0	5.5	0.51	0.95	0.09	1.79	0.53
MB.C.19118.6	16.2	9.3	8.0	2.5	3.7	0.57	1.15	0.15	1.68	0.54
MB.C.19118.6	9.8	6.9	4.2	2.3	2.1	0.71	1.65	0.23	1.63	0.50
MB.C.19118.6	6.0	4.6	2.4	1.5	1.5	0.76	1.87	0.24	1.76	0.40

Description: The Dar Kaoua population suggests a considerable intraspecific variability of shell form and parameters (Figs. 27K-M), especially in the juvenile stages of the strongly biphasic conches. It is possible to separate somewhat thinner and involute (e.g., MB.C.19118.32) morphotypes, in some of which there is a slight overlap of the sixth whorl over the umbilical space (MB.C.19118.7, Figs. 27H-I), whilst others (MB.C.19118.3, Figs. 27A-B) tend to fast expanding whorls with high WER rates at maturity. As in other ammonoids there is a co-variation of whorl and umbilical width. The allometric turn lies around 7-8 mm dm and is characterized by a trend to less variable shells, especially concerning ww/dm, uw/dm, and ww/wh values. Umbilical shell flares, that appear as outwardly bent small thorns in cross-section, originate at the end of the 5th (MB.C.19118.4, Fig. 27E) or in the 6th whorl (MB.C.19118.8, 19118.30), between 11.5 and 13 mm dm, and may finally seal the umbilicus completely (MB.C.19118.5, Fig. 27G; 19118.29, Fig. 27D) whilst a small opening stays in MB.C.19118.3 (Fig. 27A). The latter specimen shows a high ventrolateral salient of the hardly visible growth ornament and shallow ventrolateral furrows. The fine (7-8/mm) subradial, branching wrinkle layer is well preserved in many specimens, e.g. in MB.C.19118.6 (Fig. 26G) and 19118.37. In the large MB.C.19118.20, the mould shows an oblique and slightly irregular, pathological furrow on the outer flank.

The ontogenetic development of the suture in median to mature whorls is illustrated in Figs. 26A-F. Below 9-10 mm wh (19 mm dm) there are only three external U-lobes (MB.C.19118.27, Fig. 26A), at 11-14 mm wh there are four (MB.C.19118.10), sometimes with an additional "plurilobe" in the U_4-U_6- (MB.C.19118.25) or U_6-U_8-saddle (MB.C.19118.37, Fig. 26B), or already five (MB.C.19118.7). At 16-17 mm wh, the fifth outer U-lobe is developed in MB.C.19118.12 (Fig. 26D), 19118.13, and 19118.23, and the sixth follows soon between 18 and 20 mm wh (MB.C.19118.9, Fig. 26F; 19118.32, with one "plurilobe", Fig. 26E; 19118.1, with two "plurilobes"). The median saddle remains slightly lower than the ventral saddle. The accreted septal wall of a subsequent whorl in MB.C.19118.23 and 19118.22 prove that internal "plurilobes" may also develop, either in the saddle between the U_5- and U_7- or in the saddle between the U_7- and U_9-lobes. The position of incised saddles corresponds exactly on the septa. The adoral last septum of MB.C.19118.40 shows seven internal U-lobes at 38 mm dm.

Discussion: The poor state of knowledge of the Rhenish material prevents a morphometric comparison with the Dar Kaoua population. Unfortunately, there is no published cross-section of any specimen from the Lahn-Dill area and not even the number of external U-lobes (probably five at ca. 25 mm dm) is definite for the holotype. The latter is characterized by more prominent ventrolateral furrows than in most other material that has been assigned to the species. Other Rhenish specimens identified as *Syn. clavilobum* (e.g., MB.C.3653, Lotz collection, Oberscheld; see specimen leg. C. Koch in Frech 1902a) have six outer U-lobes at 17.5 mm wh, which resembles the Dar Kaoua material. But only a morphometric approach will clarify which of the numerous, partly rather different forms published from many regions fall indeed in the somewhat variable but discrete morphological spectrum of *Syn. clavilobum*; this task lies beyond the scope of this paper. The shell parameters of the Wiesbaden holotype provided by the late M.R. House fall in the middle of the variability field of the Dar Kaoua population. The small, poorly preserved and relative thin MB.C.19118.34 differs from the rest of the *Syn. clavilobum* population in rather high WER values until 5 mm dm and from 10 mm dm on and in an early onset of umbilical flares in the 5th whorl; it is identified as *Synpharciceras* sp.

The common development of "plurilobes" has been illustrated by Petter (1959) for the slightly younger, thinner, and faster expanding *Syn. plurilobatum*, but it was so far unknown in *Syn. clavilobum*. This peculiar but very variable feature, therefore not noted in the suture formule, explains previous reports of *Syn. plurilobatum* from the Lower Marker Bed of the Tafilalt, e.g. in Becker & House (2000a). Interestingly, there are so far no described plurilobate *clavilobum* specimens from Germany.

Stratigraphical range: *Syn. clavilobum* Zone (MD III-D), possibly to the topmost Upper Givetian (MD III-E).

Geographical distribution: Proven records are from the Rhenish Massif and Tafilalt; probably also present in southern Algeria and in other regions.

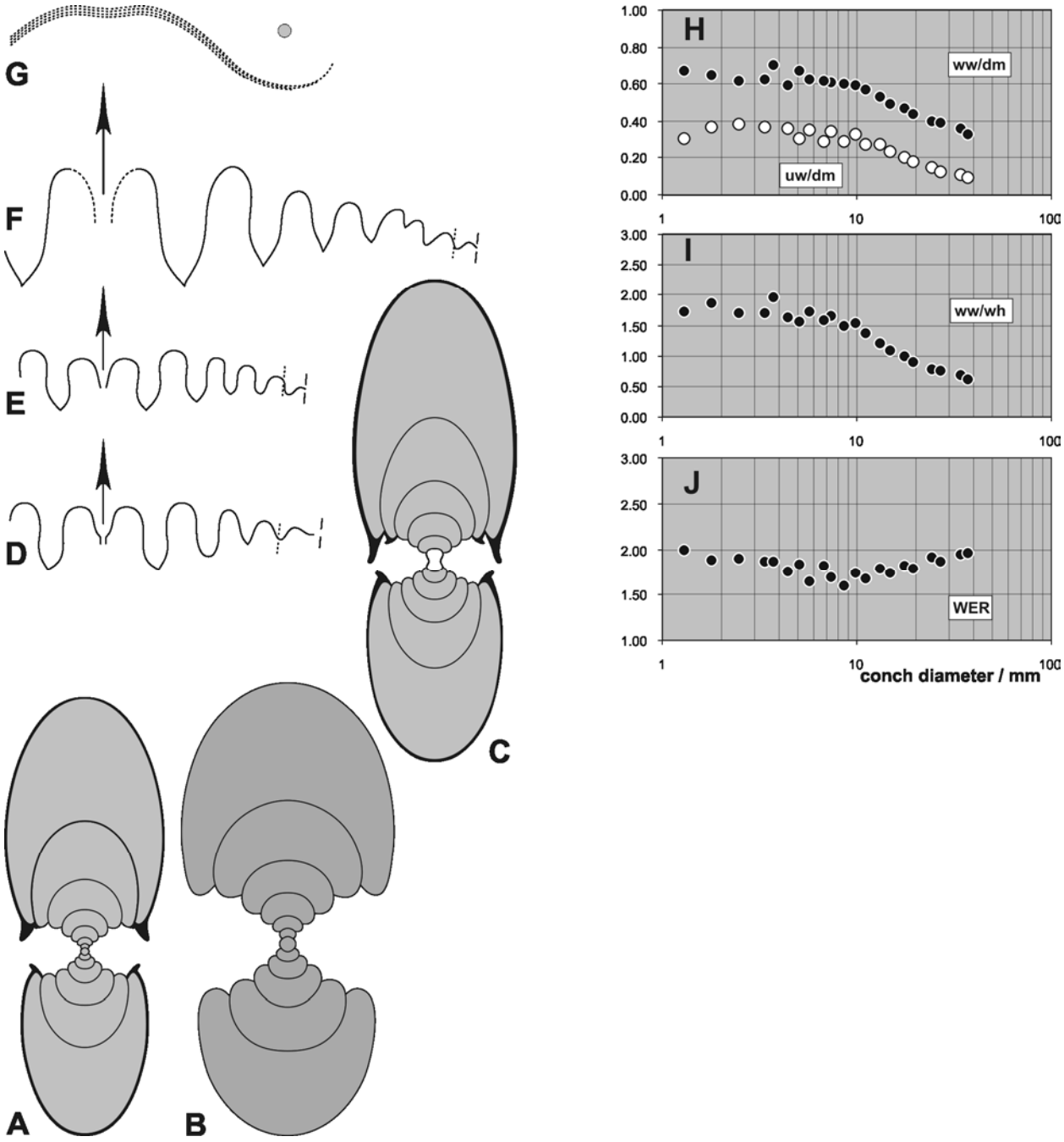


Fig. 29: *Synpharciceras spirale* n. sp. from Dar Kaoua. **A-B**. Cross sections of paratype MB.C.19119.7; x 2. inner whorls x 4. **C**. Cross section of paratype MB.C.19119.8; x 2. **D**. Suture of paratype MB.C.19119.2 at 10 mm wh; x 2.5. **E**. Suture of paratype MB.C.19119.7 at 10.5 mm wh; x 2.5. **F**. Suture of holotype MB.C.19119.1 at 20 mm wh; x 2.5. **G**. Course of wrinkle layer in paratype MB.C.19119.2 at 8.5 mm wh; x 2.5, small circle = position of umbilicus. **H-J**. Ontogenetic development ww/dm, uw/dm, ww/wh, WER of all cross-sections.

***Synpharciceras spirale* n. sp.**

Figs. 28A-C, cf. 28F, 29A-J

Type: Holotype MB.C.19119.1, illustrated in Figs. 28C and 29F.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Etymology: After the protruding, spirally oriented wrinkles of the distinctive wrinkle layer near the umbilicus.

Material: The holotype and eight paratypes (MB.C.19119.2-9), one cf. specimen (MB.C.19121).

Diagnosis: First 4 ½ whorls until ca. 10 mm dm pachyconic (ww/dm near 0.6), moderately depressed (ww/wh mostly between 1.5 and 1.7), and subevolute (uw/dm 0.3-0.4), whilst WER declines slightly from 2.0 to 1.6-1.7, venter broadly rounded; median to mature stages increasingly discoidal (ww/dm < 0.3 from 40 mm dm on) and compressed (from 20 mm dm), with closure of the umbilicus by shell flares, and with rising WER (up to 2.0), venter narrowly rounded. Growth ornament biconvex with high, subtriangular ventrolateral salient; wrinkle layer with distinctive spiral course near the umbilicus. Mature sutures with short E_1-lobe, high and narrow median saddle, deep, narrow and lanceolate E_2-lobe, lelevated, narrow ventral saddle, and four to five gradually smaller flank lobes (L to U_{10}-lobes) towards the umbilicus; "plurilobes" may occur and the U_{10} appears late in ontogeny. Suture formule: $E_1E_2LU_2U_4U_6U_8U_{10}$:$U_9U_7U_5U_3U_1I$

Tab. 34. Conch ontogeny of *Synpharciceras spirale* n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subevolute (ww/dm ~ 0.64; uw/dm ~ 0.38)	moderately depressed; moderately embracing (ww/wh ~ 1.85; IZR ~ 0.23)	moderate (WER ~ 1.90)
8 mm	thinly pachyconic or thickly discoidal; subinvolute to subevolute (ww/dm ~ 0.60; uw/dm = 0.29-0.34)	moderately depressed; strongly embracing (ww/wh = 1.50 -1.60; IZR ~ 0.40)	low (WER =1.60 - 1.70)
20 mm	thinly discoidal; subinvolute (ww/dm ~ 0.45; uw/dm ~ 0.20)	weakly compressed; strongly or very strongly embracing (ww/wh ~ 0.90; IZR ~ 0.45)	moderate (WER ~ 1.80)
35 mm	thinly discoidal; involute (ww/dm ~ 0.35; uw/dm ~ 0.11)	weakly compressed; very strongly embracing (ww/wh = 0.60 - 0.70; IZR ~ 0.46)	moderate (WER ~ 1.95)

Tab. 35. Conch dimensions of *Synpharciceras spirale* n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	48.7	16.5	27.0	0.0	14.4	0.34	0.61	0.00	2.02	0.47
MB.C.19119.8	37.4	12.3	20.1	3.4	10.7	0.33	0.61	0.09	1.96	0.47
MB.C.19119.7	34.0	12.2	17.7	3.8	9.6	0.36	0.69	0.11	1.94	0.46
MB.C.19119.8	26.8	10.4	13.9	3.4	7.1	0.39	0.75	0.13	1.86	0.49
MB.C.19119.8	19.6	8.5	9.4	3.5	4.9	0.43	0.90	0.18	1.78	0.48
MB.C.19119.8	11.1	6.3	4.6	3.0	2.5	0.57	1.37	0.27	1.67	0.45
MB.C.19119.8	5.04	3.38	2.18	1.54	1.32	0.67	1.55	0.30	1.84	0.39
MB.C.19119.7	2.45	1.51	0.89	0.95	0.67	0.62	1.70	0.39	1.89	0.25
MB.C.19119.7	1.30	0.88	0.51	0.39	0.38	0.68	1.72	0.30	2.00	0.26

Description: The holotype is a median-sized, complete and well-preserved phragmocone that shows the characteristic shell form, wrinkle layer, and mature sutures, including the inner sutures on an adoral septal face. Large sectioned paratypes, such as MB.C.19119.7 and 19119.8 provide details of the complete shell ontogeny (Figs. 29A-C), which is biphasic. The early ontogenetic phase occupies four to five whorls and is characterized by somewhat variable but rather stable ww/dm, ww/wh, and uw/dm values (Figs. 29H-J). The umbilicus opens gradually (Fig. 29B). Umbilical flares, which appear as outward bent thorns in cross-sections, appear in the 6th whorl, between 15 and 20 mm dm (17.5 mm dm in MB.C.19119.7, Fig. 29A).

Median to mature shells are extremely discoidal and moderately compressed. The peculiar wrinkle layer is well-preserved on the holotype, on the small paratype MB.C.19119.2 (Figs. 28A, 29G), and on many other paratypes (MB.C.19119.5, 19119.4, 19119.1, 19119.7). The indistinctive biconvex growth lines are visible in paratype MB.C.19119.3.

Sutures of paratype MB.C.19119.2 (Fig. 29D) and 19119.7 (Fig. 29E) have only three external U-lobes at 10 and 11 mm wh. A fourth outer or U_8-lobe is seen in MB.C.19119.6 at 16 mm wh and in MB.C.19119.7 at 20 mm wh. At the same size as the latter, the rather thin MB.C.19119.9 displays a "plurilobe" in the U_4-U_6-saddle. The holotype develops an U_{10} on the umbilical seam at 23 mm wh (Fig. 29F) and a small, pointed "plurilobe" between the U_4 and U_6. Dorsal sutures can be seen partly on septa of the holotype and of the smaller paratype MB.C.19119.7.

Discussion: The new species differs from *Syn. clavilobum* in its distinctively thinner and more subevolute shells, especially until 20 mm dm, in the later onset of umbilical flares, in its peculiar, spiral wrinkle layer, and in its less advanced sutures, with one pair of U-lobes less throughout ontogeny. The variability fields of the ww/dm plot do not touch between ca. 3 and 20 mm dm. WER values are always slightly higher. MB.C.19121 (Fig. 28F) displays at 17.5 mm wh only four outer U-lobes (plus one "plurilobe") and fits the shell morphology of *Syn. spirale* n. sp. However, the wrinkle layer is radial, as in *St. protectum* n. sp. and *Syn. clavilobum*. This specimen, which appears to be intermediate between the latter two forms, is identified as *Syn*. cf. *spirale* n. sp. *Syn. plurilobatum* is even more compressed than *Syn. spirale* n. sp. and has faster expanding whorls. Its U_8- and U_{10}-lobes appear slightly earlier. The poorly known *?Syn. tafilense* has very broad, depressed whorls at 30 mm dm.

Stratigraphical range: Restricted to the type level.

Geographical distribution: Restricted to the Tafilalt.

Family Petteroceratidae Becker & House, 1993

Clariondites n. gen.

Type-species: *Cl. tegoideus* n. sp.

Etymology: In honor of L. Clariond, who was among the first geologists to report on the Devonian ammonoid faunas of the Tafilalt.

Included species: Currently monospecific.

Diagnosis: See type-species. Suture formule: $E_1(E_3)E_2LU_2U_4U_6{:}U_5U_3U_1I$.

Discussion: Based on its sutures and intermediate shell ontogeny, with strongly converging flanks of the extremely discoidal mature conch, the new genus is the phylogenetic link between subevolute Pharciceratinae and *Petteroceras*. There are strong similarities with *Ex. librum* n. sp. and *Ex. conex* n. sp., especially in the oblique, straight lateral flank of the median saddle, which is only slightly divided by an incipient E_3 in the new genus. Bensaid (1974) illustrated only slightly more advanced E_3-lobes in juvenile *Pett. errans*. *Petteroceras* differs generally in the presence of fully developed E_3-lobes, by two more U-lobes, and in its oxyconic mature stage. Although only weakly developed, the E_3 is an apomorphic feature that requires placing of *Clariondites* n. gen. in the Petteroceratidae.

Stratigraphical range: The new genus is two zones older (*Syn. clavilobum* Zone, MD III-C) than all other known petteroceratids. Currently, there is a record gap for the family in the *Taouzites* Zone (MD III-D).

Geographical distribution: Restricted to the Tafilalt.

Clariondites tegoideus n. gen. n. sp.

Figs. 30A-F, 31A-B

Type: Holotype MB.C.19120, illustrated in Figs. 30-31.

Type locality and level: Dar Kaoua, central Tafilalt; Lower Marker Bed, *Syn. clavilobum* Zone (MD III-C).

Material: Only the holotype.

Etymology: Due to its tegoid mature whorl form.

Diagnosis: First two whorls serpenticonic and increasingly depressed, with ww/dm > 0.6 and ww/wh reaching values up to 1.75; between ca. 3 mm and 10 mm dm gradually weakly depressed and more subinvolute (uw/dm down to 0.2) whilst WER rises very slowly; median to mature stages extremely discoidal (ww/dm < 0.3 at 35 mm dm), with near-constant umbilical width, tegoid cross-section, short umbilical wall, and WER reaching ca. 1.8. Growth lirae strongly biconvex. Sutures with short E_1-lobe, very high, asymmetric median saddle, which oblique lateral flank is subdivided by a shallow, incipient E_3-lobe, very deep, narrow, v-shaped E_2-lobe, elevated, subsymmetric ventral saddle, short, pointed lateral, U_2-, and U_4-lobes separated by narrow saddles, and small U_6-lobe well outside the umbilical seam; inner sutures with three narrow U-lobes.

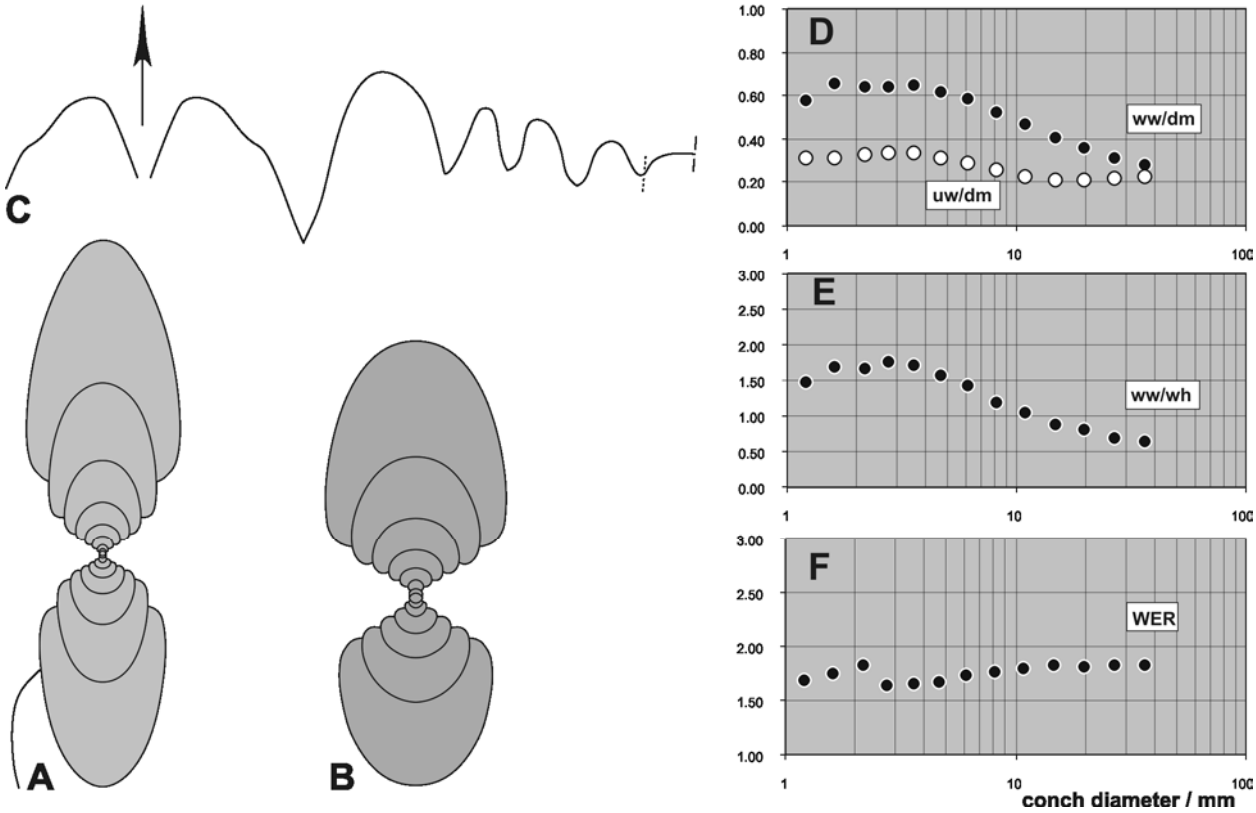


Fig. 30: *Clariondites tegoideus* n. gen. n. sp., holotype MB.C.19120 from Dar Kaoua. **A**-**B**. Cross sections; x 1, inner whorls x 4. **C**. Suture at 32.5 mm wh; x 2. **D**-**F**. Ontogenetic development of ww/dm, uw/dm, ww/wh, and WER.

Tab. 36: Conch ontogeny of *Clariondites tegoideus* n. gen. n. sp. from Dar Kaoua.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; subevolute (ww/dm =0.64; uw/dm = 0.33)	moderately depressed; strongly embracing (ww/wh = 1.67; IZR ~ 0.35)	moderate (WER = 1.83)
8 mm	thickly discoidal; subinvolute (ww/dm = 0.52; uw/dm = 0. 26)	weakely depressed ; strongly embracing (ww/wh = 1.19; IZR = 0.43)	moderate (WER = 1.77)
20 mm	thinly discoidal; subinvolute (ww/dm = 0.36; uw/dm = 0.21)	weakly compressed; strongly embracing (ww/wh = 0.80; ZR = 0.42)	moderate (WER = 1.82)
30 mm	extremely discoidal; subinvolute ww/dm = 0.30; uw/dm = 0.22)	weakly compressed; strongly embracing (ww/wh ~ 0.68; IZR = 0.42)	moderate (WER = 1.82)

Tab. 37: Conch dimensions of *Clariondites tegoideus* n. gen. n. sp. from Dar Kaoua.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype	c. 70.0	c. 19.5	30.0	-	-	c. 0.28	c. 0.65	-	-	-
holotype	36.2	10.2	16	8.3	9.5	0.28	0.64	0.23	1.83	0.41
holotype	26.7	8.3	11.9	5.9	6.9	0.31	0.70	0.22	1.82	0.42
holotype	14.7	6.0	6.8	3.0	3.8	0.41	0.88	0.21	1.82	0.44
holotype	10.9	5.1	4.9	2.5	2.7	0.47	1.04	0.23	1.79	0.44
holotype	4.64	2.87	1.84	1.44	1.06	0.62	1.56	0.31	1.68	0.42
holotype	2.16	1.39	0.83	0.71	0.56	0.64	1.67	0.33	1.83	0.32
holotype	0.93	0.51	0.36	0.33	0.30	0.55	1.43	0.35	2.16	0.16

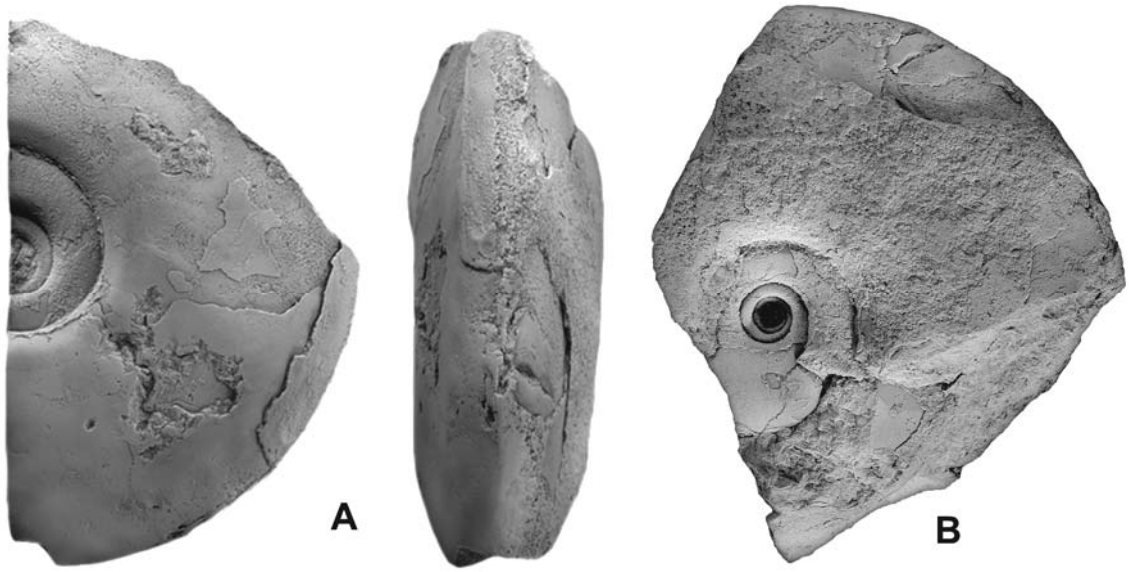


Fig. 31: *Clariondites tegoideus* n. gen. n. sp., holotype MB.C.19120 from Dar Kaoua. **A.** Lateral (after sectioning) and ventral views; x 1. **B**. Other lateral view (before sectioning), showing the incipient E_3-lobe; x 1.

Description: The holotype is incomplete but shows all relevant shell features, including, after sectioning, the shell ontogeny (Figs. 30A-B), parts of the ornament, and sutures (Fig. 30C). There is a allometric turn rather early in ontogeny, after the 2nd whorl. The allometric shift at 10 mm is rather indistinctive and mostly concerns the uw/dm ratios (Fig. 30D), whilst the conch becomes constantly thinner and compressed (Fig. 30E). The WER ratios increase only very slightly (Fig. 30F). There are nine whorls at ca. 70 mm dm. Since the specimen is still septate beyond, at 32.5 mm wh, the max. dm exceeded 100 mm significantly. In the first eight whorls the umbilicus is steeply rounded; it becomes shorter in the strongly tegoid mature whorls. The adult conch is thinner than in most other pharciceratids. The outer suture with the peculiar median saddle and wide ventral saddle is illustrated in Fig. 30C. The inner suture is visible by remnants of the septal accretion on the previous whorl (Fig. 31).

Discussion: The extremely condensed shell form and the outer suture are unique and allow no confusion with any other pharciceratacean.

Stratigraphical range and geographical distribution: Restricted to the type locality and level.

Acknowledgements

The initial study of Dar Kaoua goniatites commenced during the field seasons with the late M.R. House from 1985 on; he provided us with important measurements of German pharciceratid types and collected a few of the specimens. A few others were collected by the Berlin Excursion Team from 1996, and donated by Prof. Dr. H. Keupp. Work permits and export licences were provided by Dr. M. Bensaid and Dr. M. Dahmani (Ministère de l´Energie et des Mines, Rabat). We appreciate the close co-operation with Prof. Dr. A. El Hassani (Institut Scientifique, Rabat) and the field company of Dr. Z. S. Aboussalam (Münster). G. Schreiber and the preparation team at the WWU prepared specimens and produced casts of types. JB & VE express their thank to Dr. D. Korn (MfN, Berlin) for introducing them to the various techniques of goniatite analyses and morphometry. We thank Dr. D. Weyer (Berlin) for critically reading the manuscript.

References

Aboussalam, Z.S. (2003): Das «Taghanic-Event» im höheren Mittel-Devon von West-Europa und Marokko.- Münstersche Forschungen zur Geologie und Paläontologie, **97:** 1-332.

Aboussalam, Z.S. & Becker, R.T. (2001): Prospects for an upper Givetian substage.- Mitteilungen aus dem Museum für Naturkunde Berlin, Geowissenschaftliche Reihe, **4:** 83-99.

Aboussalam, Z.S. & Becker, R.T. (2005): Late Givetian to basal Frasnian ammonoid-conodont correlations and extinctions.- In: Yolkin, E.A. et al. (eds.): International Conference "Devonian terrestrial and marine environments: From continent to shelf" (IGCP 499 Project / SDS joint field meeting), Contributions: 5-6, Novosibirsk (Publishing House of SB RAS "Geo" Branch).

Aboussalam, Z.S. & Becker, R.T. (2007): New Upper Givetian to basal Frasnian conodont faunas from the Tafilalt (Anti-Atlas, southern Morocco).- Geological Quarterly, **51(4):** 345-374.

Aboussalam, Z.S., Becker, R.T., Bockwinkel, J. & Ebbighausen, V. (2004): Givetian biostratigraphy and facies development at Oufrane (Tata region, eastern Dra Valley, Morocco).- Documents de l`Institut Scientifique, **19:** 71-78.

Arthaber, G. von (1911): Die Trias von Albanien.- Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients, **24:** 169-277, pls. 17-24.

Becker, R.T (1993): Stratigraphische Gliederung und Ammnonoideen-Faunen im Nehdenium (Oberdevon II) von Europa und Nord-Afrika.- Courier Forschungsinstitut Senckenberg, **155:** 1-405.

Becker, R.T. (2009): Strange Times: Sea-Level and Climate Related Upper Givetian Evolutionary Extremes.- 9th North American Paleontological Convention, Abstracts, Cincinnati Museum Center Scientific Contributions, **3:** 458.

Becker, R.T. & House, M.R. (1993): New early Upper Devonian (Frasnian) goniatite genera and the evolution of the "Gephuroceratacea".- Berliner geowissenschaftliche Abhandlungen, **E9:** 111-133.

Becker, R.T. & House, M.R. (1994): International Emsian to Givetian (Devonian) goniatite zonation with new records from Morocco.- Courier Forschungsinstitut Senckenberg, **169:** 79-135.

Becker, R.T. & House, M.R. (2000a): Late Givetian and Frasnian ammonoid succession at Bou Tchrafine (Anti-Atlas, Southern Morocco).- Notes et Mémoires du Service Géologique, **399:** 27-36.

Becker, R.T. & House, M.R. (2000b): Devonian ammonoid succession at Jbel Amelane (Western Tafilalt, Southern Morocco).- Notes et Mémoires du Service Géologique, **399:** 49-56.

Becker, R.T. & House, M.R. (2000c): Devonian ammonoid zones and their correlation with established series and stage boundaries.- Courier Forschungsinstitut Senckenberg, **220:** 113-151.

Bederke, E. (1929): Die variskische Tektonik der mittleren Sudeten. Stratigraphisch- und petrographisch-tektonische Untersuchungen in der Eulengebirgsgruppe.- Fortschritte der Geologie und Paläontologie, **23:** I-V, 429-523.

Bensaid, M. (1974): Etude sur des Goniatites a la limite du Devonien Moyen et Supérieur, du Sud Marocain.- Notes de Service Carte géologique du Maroc, **36(264):** 81-140.

Bensaid, M., Bultynck, P., Sartenaer, P., Walliser, O.H. & Ziegler, W. (1985): The Givetian-Frasnian Boundary in pre-Sahara Morocco.- Courier Forschungsinstitut Senckenberg, **75:** 287-300.

Beushausen, L. (1900): Das Devon des nördlichen Oberharzes.- Abhandlungen der Königlich Preussischen Geologischen Landesanstalt, neue Folge, **30:** 1-38.

Beyrich, E. (1837): Beiträge zur Kenntnis der Versteinerungen des Rheinischen Übergangsgebirges.- 44 pp., 2 pls., Berlin (Königliche Akademie der Wissenschaften).

Bogoslovskiy, B.I. (1955): O semenstve Pharciceratidae.- Doklady Akademiy Nauk SSSR, **103(6):** 1103-1106.

Bogoslovskiy, B.I. (1958): Devonskie Ammonoidei Rudnogo Altai.- Trudy Paleontologicheskogo Instituta, **64:** 1-152.

Bogoslovskiy, B.I. (1969): Devonskie Ammonoidei. I. Agoniatity.- Trudy Paleontologicheskogo Instituta, **124:** 1-341.

Borisenkov, K.V. (2002): New locality of the Devonian Ammonoids in Rudnyj Altaj.- In: Yushkin, N.P. et al. (eds.): Geology of the Devonian System, Proceedings of the International Symposium, Syktyvkar, Komi Republic, July 9-12, 2002, 75-76, Syktyvkar (Geoprint).

Buch, L., von (1832): Ueber Goniatiten.- Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, **1830:** 108-132, pls. 11-12.

Bultynck, P. & Jacobs (1981): Conodontes et sédimentologie des couches de passage du Givetien au Frasnien dans le nord du Tafilalt et dans de Ma´der (Maroc Présaharien).- Bulletin de l´Institute royal des Sciences naturelle de Belgique, Sciences de la Terre, **53(2):** 1-43.

Carls, P. (1989): The Devonian of Celtiberia (Spain) and Devonian palaeogeography of SW Europe.- Canadian Society of Petroleum Geologists, Memoirs, **14(I):** 421-466.

Choubert, G. (1952): Livret-guide de l´excursion A36, Anti-Atlas occidental.- XIX^{éme} Congress Géologie International, Alger 1952, série Maroc, **10:** 1-79.

Clariond, L. (1934): A propos d´une coupe de la region d´Erfoud.- Comte Rendus Somnaire de la Societe géologique du France, **1934:** 223-224.

Clariond, L. (1935): Etudes stratigraphiques sur les terrains du sud Marocain: La série primaire du Sarro, du Maider et du Tafilalet.- Association pour l´etude géologique de la Méditerranée occidentale, **5(1):** 3-10.

Clausen, C.-D. (1971): Geschichte, Umfang und Evolution der Gephuroceratidae (Ceph.; Oberdevon) in heutiger Sicht.- Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, **137(2):** 175-208.

Clausen, C.-D. (1989): Die Goniatiten der Bohrung Balve 1 (Sauerland, östliches Rheinisches Schiefergebirge).- Fortschritte in der Geologie von Rheinland und Westfalen, **35:** 31-56.

Correns, C.W. (1934): Blatt Buchenau.- Erläuterungen zur Geologischen Karte von Preußen 1 : 25 000, Neue Nr. 5117, 46 pp., Berlin (Preußische Geologische Landesanstalt).

Denckmann, A. (1900): Das Vorkommen von Prolecaniten im Sauerlande.- Zeitschrift der Deutschen Geologischen Gesellschaft, **52:** 112-116.

Denckmann, A. (1901): Goniatiten aus dem unteren Oberdevon der Gegend von Iserlohn-Letmathe.- Zeitschrift der Deutschen Geologischen Gesellschaft, **54**: 16-18.

Dienst, P. (1928): Zusammenstellung der im Geologischen Landesmuseum zu Berlin aufbewahrten Originale. I. Paläozoologischer Teil.- 133 pp., Berlin (Preußische Geologische Landesanstalt).

Diller, J.S. (1903): Klamath Mountain section, California.- American Journal of Science, 4th series, **15:** 342-362.

Ebbighausen, V., Becker, R.T. & Bockwinkel, J. (2002): Morphometric Analyses and Taxonomy of oxyconic Goniatites (Paratornoceratinae n. subfam.) from the Early Famennian of the Tafilalt (Anti-Atlas, Morocco).- Abhandlungen der Geologischen Bundesanstalt, **57:** 167-180.

Flügel, H. (1947): Nachweis der Oberdevonstufe II im Grazer Paläozoikum.- Verhandlungen der geologischen Bundesanstalt, **1947:** 190-195.

Follot, J. (1952): Ahnet et Mouydir.- XIXéme Congress Géologie International, Monographie regionale, 1re série, Algérie, **1:** 1- 80.

Foord, A.H. & Crick, G.C. (1897): Catalogue of the fossil Cephalopoda in the British Museum (Natural History). Part III. Containing the Bactritidae, and part of the suborder Ammonoidea.- 303 pp., London.

Frech, F. (1887a): Die palaeozoischen Bildungen von Cabrières (Languedoc).- Zeitschrift der Deutschen Geologischen Gesellschaft, **39:** 360-487, pl. 24, 2 foldouts.

Frech, F. (1887b): Ueber das Devon der Ostalpen, nebst Bemerkungen über das Silur und einem paläontologischen Anhang.- Zeitschrift der Deutschen Geologischen Gesellschaft, **39:** 659-738, pls. 28-29.

Frech, F. (1888): Geologie der Umgebung von Haiger bei Dillenburg (Nassau).- Abhandlungen der Königlich Preussischen Geologischen Landesanstalt, **8(3):** 223-258, pls. 1-3.

Frech, F. (1902a): Über devonische Ammoneen.- Beiträge zur Paläontologie Österreich-Ungarns und des Orients, **14:** 27-112, pl. 2-5.

Frech, F. (1902b): Ueber *Epitornoceras* und *Tornoceras*.- Centralblatt für Mineralogie, Geologie und Palaeontologie, **1902:** 172-176.

Göddertz, B. (1987): Devonische Goniatiten aus SW-Algerien und ihre stratigraphische Einordnung in die Conodonten-Abfolge.- Palaeontographica, Abt. A, **197(4-6):** 127-220.

Hall, J. (1876): Illustrations of Devonian fossils: Gasteropoda, Pteropoda, Cephalopoda, Crustacea and Corals of the Upper Helderberg, Hamilton and Chemung Groups.- 7 pp., 136 pls., Albany (New York Geological Survey and Weed, Parsons).

Hall, J. (1886): Fifth Annual Report of the State Geologist for 1885.- New York Assembly Document, **105:** 47 pp.

Henn, A.H. (1985): Biostratigraphie und Fazies des hohen Unter-Devons bis tiefen Ober-Devon der Provinz Palencia, Kantabrisches Gebirge, N-Spanien.- Göttinger Arbeiten zur Geologie und Paläontologie, **25:** 1-100.

Heritsch, F. & Schouppé, A. (1941): Zur Gliederung des Mitteldevons in der nächsten Umgebung von Graz.- Anzeiger der Akademie der Wissenschaften Wien, mathematisch-naturwissenschaftliche Klasse, **78:** 77-81.

Hollard, H. (1974): Recherches sur la stratigraphie des formations du Dévonien moyen, de l´Emsien supérieur au Frasnien, dans le Sud du Tafilalt et dans le Ma´der (Anti-Atlas oriental).- Notes du Service géologiques du Maroc, **36(264):** 7-68.

Holzapfel, E. (1889): Die Cephalopoden-führenden Kalke des unteren Carbon von Erdbach-Breitscheid bei Herborn.- Paläontologische Abhandlungen, Neue Folge, **1:** 1-74, pls. 1-8.

House, M.R. (1962): Observations on the ammonoid succession of the North American Devonian.- Journal of Paleontology, **36(2):** 247-284.

House, M.R. (1965): A study in the Tornoceratidae: The succession of *Tornoceras* and related genera in the North American Devonian.- Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, **250(763):** 79-130.

House, M.R. (1978): Devonian ammonoids from the Appalachians and their bearing on international zonation and correlation.- Special Papers in Palaeontology, **21:** 1-70.

House, M.R. (1985): Correlation of mid-Palaeozoic ammonoid evolutionary events with global sedimentary perturbations.- Nature, **313(5997):** 17-22.

House, M.R. & Kirchgasser, W.T. (2008): Late Devonian Goniatites (Cephalopoda, Ammonoidea) from New York State.- Bulletins of American Paleontology, **374:** 1-285.

House, M.R. & Pedder, A.E. (1963): Devonian goniatites and stratigraphical correlations in Western Canada.- Palaeontology, **6:** 451-539.

House, M.R. & Ziegler, W. (1977): The Goniatite and Conodont sequences in the early Upper Devonian at Adorf, Germany.- Geologica et Palaeontologica, **11:** 69-108.

Hyatt, A. (1884): Genera of fossil cephalopods.- Proceedings of the Boston Society of Natural History, **22:** 273-338 [p. 253-272 published in 1883]

Hyatt, A. (1900): Cephalopoda.- In: Zittel, K.A. von & Eastman, C.R. (eds.): Text-book of Palaeontology, **1:** 502-604, London, New York (Macmillan).

Joachimski, M.M., van Geldern, R., Breisig, S., Buggisch, W. & Day, J. (2004): Oxygen isotope evolution of biogenic calcite and apatite during the Middle and Late Devonian.- International Journal of Earth Sciences, **93:** 542-553.

Klug, C. & Korn, D. (2002): Occluded umbilicus in the Pinacitinae (Devonian) and its palaeoecological implications.- Palaeontology, **45(5):** 917-931.

Korn, D. (2001): Morphometric evolution and phylogeny of Palaeozoic ammonoids. Early and Middle Devonian.- Acta Geologica Polonica, **51(3):** 193-215.

Korn, D. (in press): A key for the description of Palaeozoic ammonoids.- Fossil Record, **13**.

Korn, D. & Klug, C. (2002): Ammoneae Devonicae.- Fossilium Catalogus Animalia, **138:** 1-375.

Korn, D. & Wunderlich, K. (1982): Ammonoideen aus der *Pharciceras*-Zone (Oberdevon Iα) von Wuppertal.- Jahresberichte des naturwissenschaftlichen Vereins Wuppertal, **35:** 89-95.

Korn, D., Ebbighausen, V., Bockwinkel, J. & Klug, C. (2003): The A–mode sutural ontogeny in prolecanitid ammonoids.- Palaeontology, **46(6):** 1123-1132.

Kullmann, J. (1973): Los goniatites del Devónico superior y del Carbonífero de los Pirineos Occidentales de España.- Boletin Geológico y Minero, **84:** 93-100.

Kullmann, J. & Ziegler, W. (1970): Conodonten und Goniatiten von der Grenze Mittel-/Oberdevon aus dem Profil Martenberg (Ostrand des Rheinischen Schiefergebirges).- Geologica et Palaeontologica, **4:** 73-85.

Makowski, H. (1991): Dimorphism and evolution of the goniatite *Tornoceras* in the Famennian of the Holy Cross Mountains.- Acta Palaeontologica Polonica, **36(3):** 241-254.

Massa, D. (1965): Observations sur les Séries Siluro-Dévonniennes des Confins Algéro-Marocains du Sud.- Notes et Mémoires, Compagnie Francaise des Pétroles, **8:** 1-187.

Matern, H. (1931): Das Oberdevon der Dill-Mulde.- Abhandlungen der Preußischen Geologischen Landesanstalt, Neue Folge, **134:** 1-139.

Menchikoff, N. (1930): Recherches géologiques dans le nord du Sahara occidental.- Revue de Géographie physique et Géologie dynamique, **8:** 1-144.

Menchikoff, N. (1936): Etudes géologiques sur les confines Algero-Marocaines du Sud.- Bulletin Société Géologique de la France, 5^{éme} Série, **6:** 131-148.

Montesinos, R.A & Henn, A.H. (1986): La fauna de *Pharciceras* (Ammonoidea) de la Formacion Cardano (Dominio Palentino, Cordillera Cantabrica, NO de Espana).- Trabajos de Geologia, **16:** 61-76.

Moussine-Pouschkine, A. (1971): Les constructions recifales du Dévonien moyen du pays de l´Ahnet (Sahara Central, Algérie).- Bulletin de la Societe Histoire naturelle du Africain Nord, **62(3-4):** 79-88.

Paeckelmann, W. (1921): Oberdevon und Untercarbon der Gegend von Barmen.- Jahrbuch der Preußischen Geologischen Landesanstalt, **41:** 52-147, pl. 1-3.

Petter, G. (1951): Dévonien moyen et supèrieur de la Saoura et du environs d´Ougarta.- Bulletin Société Géologique de la France, 6ème Série, **1:** 351-362.

Petter, G., (1959): Goniatites Dévoniennes du Sahara.- Publications du Service de la Carte Géologique de l´Algérie, Nouv. Série, Paléontologie, **2:** 1-313.

Pompeckj, J.F. (1912): Cephalopoda. Paläontologie.- Handwörterbuch der Naturwissenschaften, **2:** 265-296, Jena (Fischer)

Ruan, Y.-P. (1978): The zonation of Devonian ammonoids in China.- Acta Stratigraphica Sinica, **3(2):** 134-137.

Ruan, Y.-P. (1981): Devonian and earliest Carboniferous ammonoids from Guangxi and Guizhou.- Memoirs of the Nanjing Institute of Geology and Paleontology, Academia Sinica, **15:** 1-140.

Ruzhencev, V.E. (1957): Filogeneticheskaya sistema paleozoyskikh ammonoidey.- Byulleten Moskovskogo obshchestva ispytately prirody, novaya seriya, otdel geologicheskiy **31(2):** 49-64.

Sandberger, G. (1851): Beobachtungen über mehrere schwierige Puncte der Organisation der Goniatiten.- Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau, **7:** 292-304.

Sandberger, G. & Sandberger, F. (1850-1856): Die Versteinerungen des Rheinischen Schichtensystems in Nassau.- 564 pp., 49 pls., Wiesbaden [p. 1-72 and pls. 1-8 published in 1850]

Schindewolf, O.H. (1940): Konvergenzen bei Korallen und bei Ammoneen.- Fortschritte der Geologie und Palaeontologie, **12(41):** 389-492.

Smith, J. P. (1913.): Ammonoidea.- In: Zittel, K.A. von & Eastman, C.R. (eds.): Text-book of Palaeontology, 2nd edition: 617-677, London.

Termier, H. (1929): Sur le Dévonien du Tafilalet.- Comte rendus de l´Academie des Sciences, **1929:** 258-260.

Termier, H. & Termier, G. (1950): Paléontologie Marocaine. II. Invertébres de l´ère Primaire. Fascicule III. Mollusques.- Notes et Mémoires du Service Géologique, Rabat, **78:** 1-246.

Vöhringer, E. (1960): Die Goniatiten der unterkarbonischen *Gattendorfia*-Stufe im Hönnetal (Sauerland).- Fortschritte in der Geologie von Rheinland und Westfalen, **3(1):** 107-196.

Walliser, O.H., Bultynck, P., Weddige, K., Becker, R.T. & House, M.R. (1995): Definition of the Eifelian-Givetian Stage boundary.- Episodes, **18(3):** 107-115.

Wedekind, R. (1914): Beiträge zur Kenntnis der oberkarbonischen Goniatiten.- Mitteilungen aus dem Museum der Stadt Essen, **1:** 5-22, pl. 1.

Wedekind, R. (1918): Die Genera der Palaeoammonoidea (Goniatiten).- Palaeontographica, **62:** 85-184.

Work, D.M., Mason, C.E. & Klapper, G. (2007): The Middle Devonian (Givetian) ammonoid *Pharciceras* from the New Albany Shale, Kentucky.- Journal of Paleontology, **81(6):** 1510-1515.

Yang. J.K. (1984): Devonian goniatites from Baoshan area, Western Yunnan.- Journal of the Chengdu College of Geology, **11:** 1-39.

Ziegler, W. & Klapper, G. (1982): The *disparilis* conodont zone, the proposed level for the Middle-Upper Devonian boundary.- Courier Forschungs-Institut Senckenberg, **55:** 463-492.

Zittel, K.A. von (1895): Grundzüge der Palaeontologie (Palaeozoologie).- 971 pp., München, Leipzig (von R. Oldenbourg).