



Valanginian belemnites: New taxonomical and stratigraphical observations

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Abstract: Six new Valanginian belemnite species (*Duvalia crassa* sp. nov., *Duvalia elongata* sp. nov., *Duvalia kleini* sp. nov., *Duvalia superconstricta* sp. nov., *Castellanibelus vaubellensis* sp. nov., and "*Hibolithes*" *lebresensis* sp. nov.) are described here and two species (*Duvalia* aff. *elongata* and "*Hibolithes*" aff. *pistilliformis* (BLAINVILLE, 1827)) are left in open nomenclature. They come from both the distal and proximal parts of the Vocontian Basin in south-east France and the Baetic Cordillera in south-east Spain. In addition lectotypes are selected for *Castellanibelus orbignyanus* (DUVAL-JOUVE, 1841), *Castellanibelus picteti* (MAYER, 1866), and *Duvalia lata* (BLAINVILLE, 1827).

Key-words:

- Coleoidea;
- Duvaliidae;
- Valanginian;
- Vaubelle;
- Vergol

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Résumé : *Bélemnites du Valanginien : Nouvelles observations taxonomiques et stratigraphiques.*- Six espèces nouvelles de bélemnites (*Duvalia crassa* sp. nov., *Duvalia elongata* sp. nov., *Duvalia kleini* sp. nov., *Duvalia superconstricta* sp. nov., *Castellanibelus vaubellensis* sp. nov. et "*Hibolithes*" *lebresensis* sp. nov.) sont décrites ici alors que deux autres (*Duvalia* aff. *elongata* et "*Hibolithes*" aff. *pistilliformis* (BLAINVILLE, 1827)) sont laissées en nomenclature ouverte. Elles proviennent du Valanginien des parties distales et proximales du bassin vocontien dans le sud-est de la France et des Cordillères bétiques dans le sud-est de l'Espagne. De plus, des lectotypes sont désignés pour les espèces *Castellanibelus orbignyanus* (DUVAL-JOUVE, 1841), *Castellanibelus picteti* (MAYER, 1866) et *Duvalia lata* (BLAINVILLE, 1827).

Mots-clefs :

- Coleoidea ;
- Duvaliidae ;
- Valanginien ;
- Vaubelle ;
- Vergol

Introduction

Six new belemnite species from the Valanginian are introduced herein. They were collected from Valanginian sediments in the Vocontian Basin (south-east of France, Fig. 1.B) and the Baetic Cordillera (south-east of Spain, Fig. 1.C), and result from bed-by-bed collections made, mainly from ammonite controlled sections. These new taxa are described in prelude to a forthco-

ming paper in which a biozonation based on belemnites for the Valanginian will be introduced.

Most of the material originates from the Vergol (VGL) and Vaubelle (VBL) sections (south-east of France). Details of bed-numbers and ammonite distribution of the Vergol section can be found in REBOULET (1996, 2015, 2017a, 2017b), McARTHUR *et al.* (2007), and KENJO *et al.* (2014). Other material from the south-east of France was collected from La Charce (LCH), Serre de la Croix (SCX),

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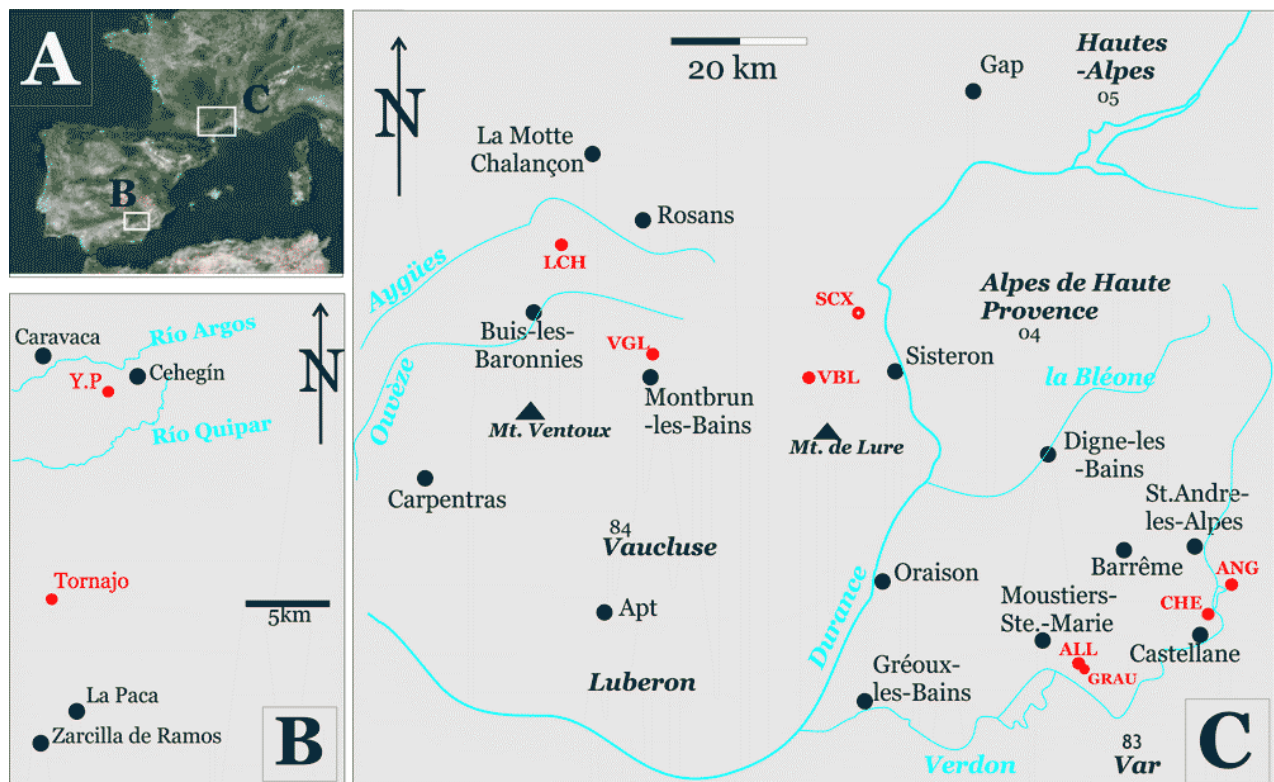


Figure 1: Geographical location. **1A.** Part of Western Europe with areas/sections mentioned in Spain (**Fig. 1B**) and France (**Fig. 1C**). The following acronyms are used: ALL = Les Allaves, ANG = Angles, CHE = Cheiron, GRAU = Grau de Lèbres, SCX = Serre de la Croix, VBL = Vaubelle, VGL = Vergol (all Vocontian Basin, France), and Y.G. = Barranco del Garranchal (Baetic Cordillera, Spain).

and Cheiron (CHE). In addition some material comes from the more proximal southern part of the Vocontian Basin at Les Allaves (THIEULOY *et al.*, 1991). Most of the new species also occur in the Baetic Cordillera of south-east Spain, in sections south of the Cehegín-Caravaca area, region of Murcia (COMPANY & TAVERA, 2015) and in the Tornajo.

The recent fine-tuning of the "standard ammonite zones" (cf. REBOULET *et al.*, 2011, 2014), due to taxonomical and stratigraphical issues discussed in COMPANY & TAVERA (2015), results in a fundamentally different ammonite zonation for the early Valanginian. A comparison between former schemes and the new ammonite zonation is presented in Figure 2. Since sections in the Vocontian Basin for the most part can be correlated bed-by-bed, ammonite divisions ("Horizon", Subzone (= Sz), and Zone) are herein used as chronostratigraphic units (= Chronozone; cf. SALVADOR, 1994, p. 83-84).

Morphological terminology of belemnites follows KRYMGOL'TS (1960) and STOYANOVA-VERGILOVA (1970).

Specimens are stored in the paleontological collection of Naturalis (Leiden, The Netherlands) bearing the storage code RGM.

Taxonomy

The use of infrasubspecific rank indication "var." (variety) is according to ICZN, 1999 (Art. 45.6). It relates, here, to differences in the outer-morphology of a species that do not, in the author's opinion, justify a new specific name. However, the use of "aff." is used here for possible new species, but either the amount of specimens is too low, or differences are not yet well-enough constrained to justify a new species name at this time.

Family Duvaliidae PAVLOW, 1914

Genus *Duvalia* BAYLE, 1878

Type *Belemnites dilatatus* BLAINVILLE, 1827 (SD DOUVILLÉ, 1879)

Duvalia can be grouped in morphologically similar species based on the similarity of the juvenile rostrum, in addition to the general similarity of the adult rostrum morphology. Herein new species from the *Duvalia lata*-group and the *Duvalia binervia*-group are introduced.



rock	Ammonite Zonation (Vergol)						Chronozonation	time	
	modified after: Reboulet, 1996;		taxonomy : C&T, 2015		zonation after: C&T, 2015		used herein		
	Zones	Subzones	Zones	Subzones	Zones	Subzones			
Upper Valanginian	<i>C. furcillata</i>	<i>T. callidiscus</i>					Furcillata	Callidiscus	
	<i>V. peregrinus</i>	<i>O. nicklesi</i>					Peregrinus	Nicklesi	
		<i>V. peregrinus</i>						Peregrinus	
<i>S. verrucosum</i>	<i>K. prone-costatum</i>					Verrucosum	Prone-costatum		
	" <i>N. neocom.</i> "						"Neocom."		
	<i>S. verrucosum</i>						Verrucosum		
Lower Valanginian (p.p.)	<i>B. campylo-toxus</i>	<i>N. (E.) platycostatus</i>	<i>"B. campylo-toxus"</i>	" <i>N. platycostatus</i> "	<i>K. inostranzewi</i>	<i>S. contestanum</i>	Inostranzewi	Platy-costatus	
		<i>K. biassalense</i>		<i>K. inostranzewi</i>					<i>K. inostranzewi</i>
		<i>S. fuhri</i>		<i>S. nov.sp.1</i>					
		<i>K. quadri-strangulatum</i>		<i>B. subcampylo-toxus</i>					
	<i>N. neocomi-ensiformis</i>	<i>L. superba</i>	<i>N. neocomi-ensiformis</i>	<i>N. neocomi-ensiformis</i>	<i>N. neocomi-ensiformis</i>	<i>V. dolioliformis</i>	<i>B. hirsutus</i>	Neocomiensiformis	Subcampylo-toxus
	<i>T. pertransiens</i>	<i>N. salinarium</i>	<i>T. pertransiens</i>	<i>T. pertransiens</i>	<i>T. pertransiens</i>	<i>V. salinarium</i>		Pertr.	

Figure 2: Ammonite stratigraphical data for the Vergol section (VGL), modified after REBOULET (1996), KENJO (2014), COMPANY & TAVERA (2015) (= C&T, 2015), and field observations (range of *B. hirsutus* in VGL). Both *S. contestanum* and *Valanginites* are extremely rare in the distal parts of the Vocontian Basin, therefore *N. (E.) platycostatus* and *B. subcampylo-toxus* are probably more appropriate as sub(Chrono-)zonal index ammonites in the Vocontian Basin. Abbreviations used: neocom. = neocomiensis, Pert. = Pertransiens. For affiliation of ammonite genera see references cited.

Duvalia lata-group: Juvenile rostra with a long dorsal alveolar groove. Mature specimens show either elongate or rounded cross-sections, while the *rostrum solidum* (post alveolar region) and *rostrum cavum* (alveolar region) are in line. The *rostrum cavum* is generally restricted to the anterior half to one-third of the rostrum but for strongly constricted species it is shorter. These taxa range from the middle Berriasian to the early Valanginian.

Belemnites latus BLAINVILLE (1827, p. 121, Pl. 5, fig. 10) is sometimes (COMBÉMOREL, 1974) indicated to be the type species of *Duvalia* BAYLE, 1878, or the holotype for the nominal species. BLAINVILLE (1827, p. 121) clearly stated that he has seen three or four specimen, so the depicted (teratological) specimen can only serve as a lectotype. Besides LEMOINE (1907, p. 114, fig. H-H^b) indicated a specimen from Cheiron, apparently from the collection of BLAINVILLE, erroneously to

be the holotype. This specimen could ultimately serve as a **lectotype** and as such it is treated herein.

***Duvalia superconstricta* sp. nov.**

(Fig. 3.1-6)

- pars 1841 *Belemnites latus* BLAINVILLE var. *subcompressus* DUVAL- JOUVE, Pl. 6, fig. 5.
- 1841 *Belemnites latus* BLAINVILLE var. *prismaticus* DUVAL- JOUVE, Pl. 6, fig. 6.
- pars 1847 *Belemnites latus* BLAINVILLE: ORBIGNY, p. 7-8, Pl. 4, figs. 6-9.
- 1858 *Belemnites latus* BLAINVILLE var. *prismaticus* DUVAL-JOUVE: PICTET & CAMPICHE, p. 107, Pl. XIII, fig. 11a-b.
- pars 1860 *Belemnites latus* BLAINVILLE: PICTET & LORIOU, p. 11-12, Pl. Ibis, fig. 11a-b.
- 1992 *Duvalia lata* (BLAINVILLE): WEISS, Pl. VI, fig. 5.

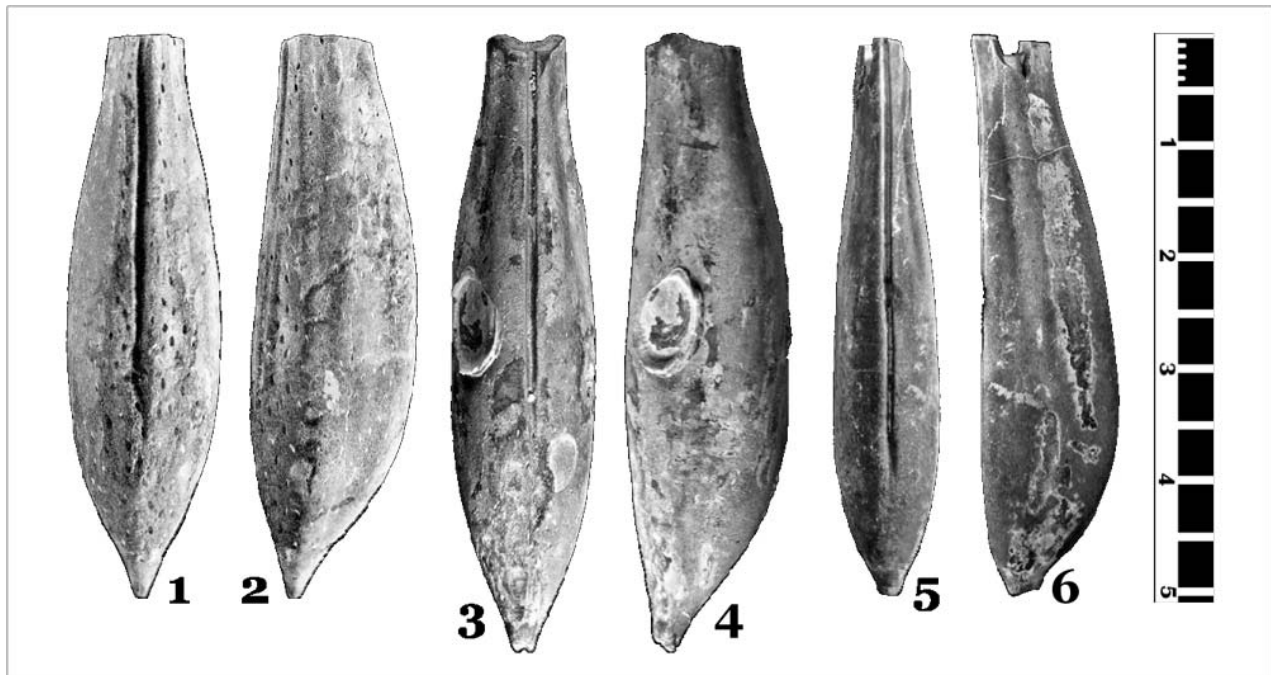


Figure 3: 1-2. *Duvalia superconstricta* sp. nov. [HT], RGM582349, VGL049a-050; 3-4. *Duvalia superconstricta* sp. nov. [PT], RGM611861, SCX050-051; 5-6. *Duvalia superconstricta* sp. nov. [PT], RGM612723, VBL059-060. All from the Hirsutus Sz. In lateral view (Fig. 3.2, 4, 6), dorsal side to the left. Dorsal view Fig. 3.1, 3, and 5. Scale-bar 5 cm.

Derivation of name: Named after its morphological appearance, being very constricted in the alveolar region.

Holotype: RGM582349 (Fig. 3.1-2).

Type stratum: VGL049a-050, Hirsutus Sz, Neocomiensiformis Zone.

Paratypes: RGM611861, SCX050-051, Hirsutus Sz (Fig. 3.3-4); RGM612723, VBL059-060, Hirsutus Sz (Fig. 3.5-6).

Material: Several tenths of specimens.

Description: Medium sized duvaliid with a strong constriction near the alveolar region, and a typically pear-shaped cross-section in the post-alveolar and parts of the alveolar region. The alveolar region is straight and the alveolus is (very) shallow. The apex is displaced strongly to the dorsal side and thorn-like (indicating a mature stage). The profile is asymmetrically hastate whereas the outline is hastate.

Differential diagnosis: Differs from *D. constricta* UHLIG, 1902, by its smaller size and much more constricted alveolar region.

Remarks: The species resembles its progenitor *D. constricta* but differs by its smaller size combined with the typical cross-sections of the rostrum, being pear-shaped in parts of the *rostrum solidum* and becoming rounded quadrangular at the opening of the alveolus. Juvenile rostra are comparable to *D. constricta*, being compressed to round and with a relative long alveolar groove.

Stratigraphic occurrence: Hirsutus Sz (Neocomiensiformis Zone).

Geographical occurrence: France, Spain, Switzerland, Ukraine (Crimea), and possibly Hungary.

Duvalia crassa sp. nov.

(Fig. 4.1-9)

pars	1841	<i>Belemnites latus</i> BLAINVILLE var. <i>subcompressus</i> DUVAL-JOUVE, Pl. 6, fig. 3.
	1849	<i>Belemnites latus</i> BLAINVILLE: QUENSTEDT, Pl. 30, fig. 14a-c.
	1860	<i>Belemnites latus</i> BLAINVILLE: PICTET & LORIOU, Pl. Ibis, fig. 9a-b.
	1965	<i>Duvalia lata</i> (BLAINVILLE): STOYANOVA-VERGILOVA, p. 184-185, Pl. I, figs. 1, 2[?], 3.
	1988	<i>Duvalia lata lata</i> (BLAINVILLE): HORÁK, p. 61-62, Pl. 1, fig. 1.
?	1994	<i>Duvalia lata constricta</i> (UHLIG): VAŠIČEK <i>et al.</i> , p. 84, Pl. 28, figs. 1-2.

Derivation of name: Named after its morphological appearance, being quite robust and thick.

Holotype: RGM582367 (Fig. 4.1-3).

Type stratum: Vergol bed VGL086-087 Inostranzewi Sz.

Paratypes: RGM582375, Vergol, VGL096b-097, Platycostatus Sz (Fig. 4.4-6); RGM612896, Vaubelle, VBL084-085 Inostranzewi Sz (Fig. 4.7-9).

Material: Several tens of specimens.

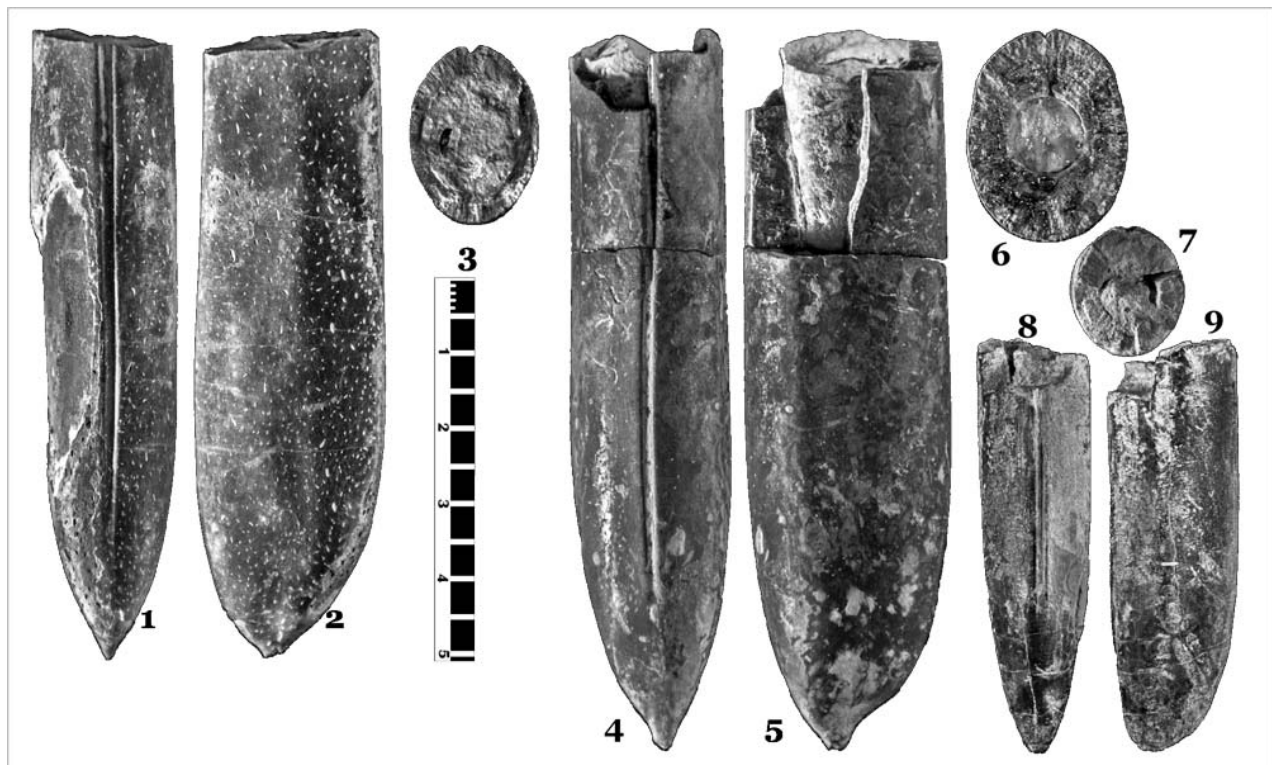


Figure 4: 1-3. *Duvalia crassa* sp. nov. [HT], RGM582367, VGL086-087, Inostranzewi Sz; 4-6. *Duvalia crassa* sp. nov. [PT], RGM582375, VGL096b-097, Platycostatus Sz; 7-9. *Duvalia crassa* sp. nov. (subadult) [PT], RGM612896, VBL084-085, Inostranzewi Sz. Scale-bar 5 cm. In lateral view (Fig. 4.2, 5, 9), dorsal side to the left. Dorsal view Fig. 4.1, 4, and 8. Cross-sections Fig. 4.3 and 7 in the preserved alveolar opening, Fig. 6 at the crack.

Description: A rather robust member of the *D. lata*-group with nearly straight to very slightly constricted profile and outline ("sub-cylindrical"). The dorsal alveolar groove can be traced well into the apical region, being broad and clear. The alveolar cavity is rather deep, extending nearly halfway through rostrum. Cross-sections vary from compressed elliptical to almost round, in general they are rather constant throughout the rostrum but sometimes becoming more rounded towards the apex.

Differential diagnosis: Differs from other species of the *D. lata*-group by its "sub-cylindrical" profile and outline. Some specimens do show some slight constriction of the alveolar region, but never as strong as in *D. constricta* or *D. superconstricta* sp. nov.

Remarks: The species appears similar to *D. constricta* but differs in its less constricted alveolar part. The profile is much straighter, nearly without a ventral constriction in the *rostrum cavum* area, and the same for the outline. As a result the overall morphology is more "robust". Given the uncertainty, whether or not dimorphism is expressed in the morphology of the rostrum, certain specimens that are more "*D.*

lata-like", that is with clear compressed elliptical cross-sections, are for the moment classified as *D. ex gr. lata*.

Stratigraphic occurrence: Latest early Valanginian (Inostranzewi Zone).

Geographical occurrence: Bulgaria, France, Slovakia, Spain, and Switzerland.

***Duvalia binervia*-group:** juvenile rostra with a very short alveolar groove. Cross-sections are highly elliptical, with rounded to angular outline. Mature specimens possess an alveolar groove with variable length but generally short and restricted to the alveolar part. The *rostrum solidum* and *rostrum cavum* are either in line or bended slightly to the ventral side, but in several species the *rostrum cavum* is strongly curved to the dorsal side. The *rostrum cavum* is short. This group first occurs in the earliest late Valanginian and disappears in the earliest Hauterivian. Its progenitor *Duvalia emericii* (RASPAIL, 1829), shows intermediate characteristics between this group and the *D. lata*-group, namely the juvenile rostrum has a well-developed alveolar groove, but its mature outer-morphology is like the *D. binervia*-group, that is with a highly elliptical cross-section.

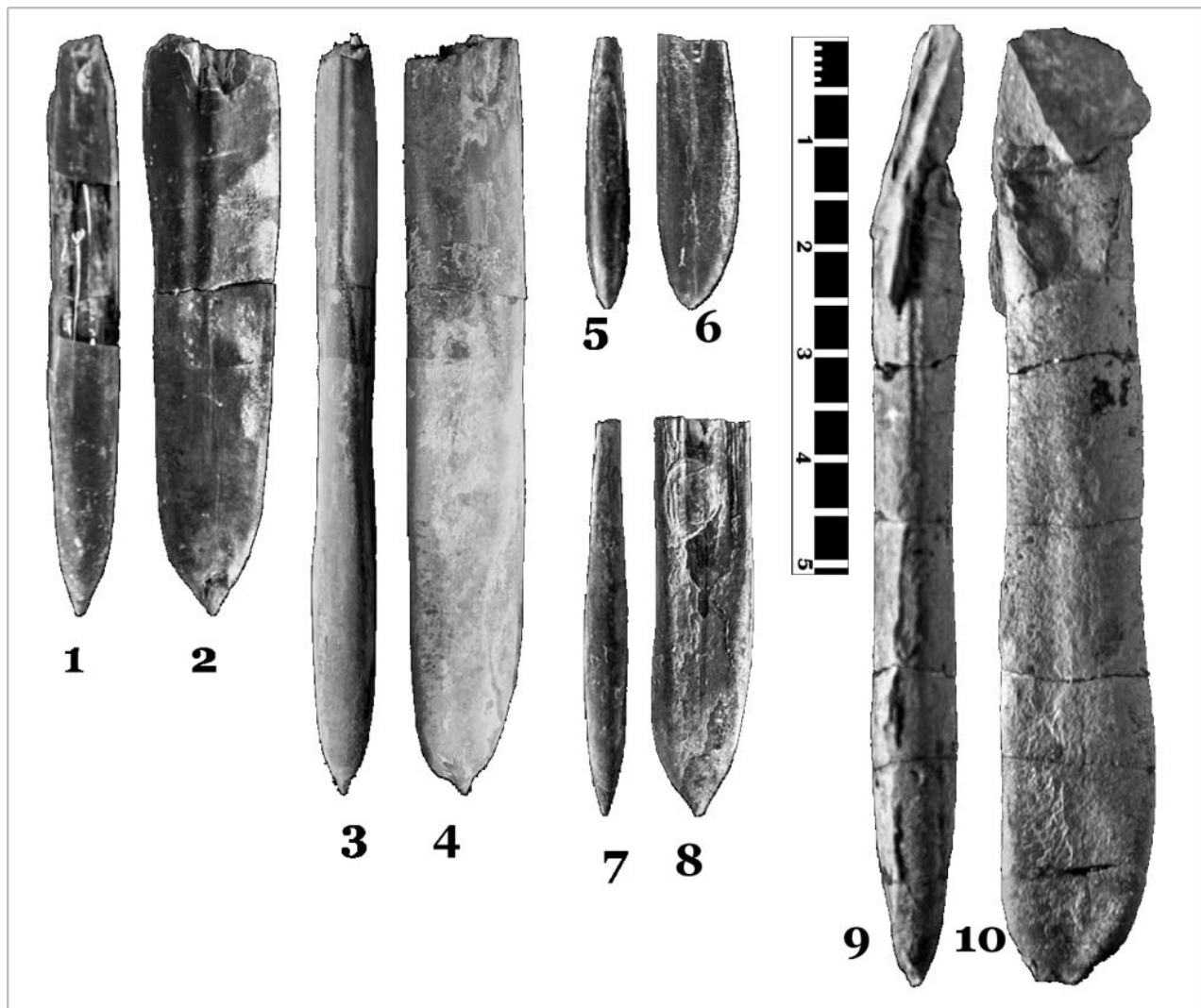


Figure 5: 1-2. *Duvalia elongata* sp. nov. var., RGM561240, VGL122d-e, Pronecostatum Sz; 3-4. *Duvalia elongata* sp. nov. [HT], RGM561350, VGL113-114, Pronecostatum Sz; 5-6. *Duvalia elongata* sp. nov. (juvenile) [PT], RGM561348, VGL113-114, Pronecostatum Sz; 7-8. *Duvalia elongata* sp. nov. (subadult) [PT], RGM561395, VGL110-a, "Neocomiensis" Sz; 9-10. *Duvalia* sp. nov. ? (aff. *elongata*), RGM560596, CHE331, Peregrinus Sz. Scale-bar 5 cm. In lateral view (Fig. 5.2, 4, 6, 8, 10), dorsal side to the left. Dorsal view Fig. 5.1, 3, 5, 7, and 9.

***Duvalia elongata* sp. nov.**

(Fig. 5.1-8)

1840 *Belemnites dilatatus* BLAINVILLE: ORBIGNY, Pl. 2, figs. 16-17.

2002 *Duvalia* aff. *gervaisiana* [ROUVILLE] GAYTE: JANSSEN & CLÉMENT, p. 514, 515, 520.

Derivation of name: Named after its morphological appearance, being very elongated.

Holotype: RGM561350 (Fig. 5.3-4).

Type stratum: Pronecostatum Sz; bed VGL113-114, Vergol section.

Paratypes: RGM561348 (juvenile; Fig. 5.5-6), Vergol, VGL113-114, Pronecostatum Sz; RGM 561395 (subadult; Fig. 5.7-8), Vergol, VGL110-a, "Neocomiensis" Sz.

Material: Several tens of specimens.

Description: Medium sized straight rostrum. The outline is slim, elongated, very weakly hastate to slightly sub-cylindrical. The profile is elongate and somewhat asymmetrical due to its weakly dorsally displaced apex. There is no constriction in the alveolar region. Alveolar groove clear, with rounded base. The alveolus is shallow with the lateral surfaces flattened. The apex is obtuse or weakly pointed, and the lateral surfaces of the apical region are flattened too. Cross-sections are elliptical sub-rounded to angular. Subadult (immature) rostra are comparable in outer-morphology, only being of smaller size.

Differential diagnosis: Some specimens are grouped as *D. aff. elongata* for the moment (see below). Apparently, they occur in slightly younger levels as compared to the nominal species. They show a less flattened alveolar region, and a less straight profile, due to expansion of the alveolar



region, and are of a larger size. Whether or not these differences justify a separation into two separate species is not clear and for the moment these specimens are left in open nomenclature. In addition, besides a different stratigraphic range, the new species differs from the following more-or-less comparable species: *D. gervaisiana* (DUMAS, 1876) is characterized by a ventrally shifted bend in the alveolar part of the rostrum, and a less compressed rostrum. *Duvalia variegata* (RASPAIL, 1829) has a more robust rostrum, more dilatoid (highly elliptical cross-sections) and especially in mature specimens, a more irregular profile. *Duvalia hybrida* (DUVAL-JOUVE, 1841) and *D. hybrida* Auct. are (at least partially) objective synonyms of *D. variegata* and/or *D. binervia* RASPAIL (1829), and part of the type material might actually have been derived from the early Barremian, while *D. binervia* has a leaf-like profile.

Variation: Some specimens from the same stratigraphic interval, herein treated as a variety of the nominal species (Fig. 5.1-2), show a slight expansion of the alveolar region, both laterally as well as in the dorsal/ventral direction, but are otherwise morphologically well comparable to the nominal species (also see the specimen depicted by PICTET & CAMPICHE, 1858, Pl. XIII, fig. 12a-b).

Stratigraphic occurrence: Late Valanginian (Verrucosum Zone *pro parte*, top part of the "Neocomiensis" Sz to Pronocostatum Sz) and the earliest Peregrinus Sz.

Geographical occurrence: France, Spain, and Switzerland.

***Duvalia* sp. nov. ? (aff. *elongata*)**

(Fig. 5.9-10)

Description: Medium sized straight rostrum. The outline is slim, elongate, sub-cylindrical. It shows a less flattened alveolar region, and a less straight outline, due to an expanding alveolar part, as compared to *D. elongata* sp. nov. (see above). The profile is elongated but slightly irregular. There is no constriction in the alveolar region. The dorsal alveolar groove is clear, with a rounded base. The alveolus is short. The alveolar part is laterally slightly expanded. Cross-sections are elliptical, sub-rounded to angular, especially in the alveolar region; it appears to be of larger size when compared to the nominal species.

Material: Four specimens.

Stratigraphic occurrence: Late Valanginian (late Peregrinus Sz).

Geographical occurrence: France (Vocontian Basin), Spain (Tornajo, Baetic Cordillera).

***Duvalia kleini* sp. nov.**

(Fig. 6.1-6)

- | | |
|------|---|
| 1847 | <i>Belemnites binervius</i> RASPAIL: ORBIGNY, Pl. 3, fig. 5. |
| 1898 | <i>Belemnites (Duvalia) dilatatus</i> BLAINVILLE: SIMIONESCU, Pl. I, fig. 2. |
| 1984 | <i>Duvalia valnagensis</i> [sic] n. sp. GAYTE, p. 109-111, Pl. 3, figs. 3-4 [unpublished; <i>nomen nudum</i>]. |
| 1993 | <i>Duvalia</i> n. sp. aff. <i>D. dilatata</i> (BLAINVILLE): AVRAM & GRADINARU, p. 683, Pl. 7, fig. 5a-b. |
| ? | 1993 <i>Duvalia binervia</i> (RASPAIL) n. sp.?: AVRAM & GRADINARU, Pl. 7, fig. 9a-b. |
| ? | 1993 <i>Duvalia binervia</i> (RASPAIL): AVRAM & GRADINARU, Pl. 7, fig. 13a-b. |

Derivation of name: Named after Jaap KLEIN (Vinkeveen, The Netherlands), friend and ammonitologist.

Holotype: RGM361669 (Fig. 6.1-2)

Type stratum: Bed B110 (Nicklesi Subzone, late Valanginian), Tornajo (Spain).

Paratypes: RGM583933 (Fig. 6.3-4), Barranco del Garranchal, bed Y.G35, Nicklesi Sz, and in addition from the Tornajo: RGM361670, bed B112, Nicklesi Sz; RGM361671, bed B117, Furcillata Zone; RGM361672, bed B117, Furcillata Zone; RGM361676, bed B137, Callidiscus Sz, Furcillata Zone, and from France, Vergol (RGM561068; VGL169-a1, Furcillata Zone; Fig. 6.5-6, an immature specimen).

Material: Several tens of specimens.

Description: Laterally strongly compressed, medium-sized rostrum with a leaf-like, strongly asymmetrical profile and hastate outline; dorsal alveolar groove short. *Rostrum solidum* characterised by strong, dorsally orientated bending of the alveolar part.

Differential diagnosis: Differs from *Duvalia oehlerti* HERMITE, 1879, by its much stronger, more abrupt bend of the alveolar region.

Ontogeny: Initially the ontogenetic development is comparable to *D. binervia*. Eventually, subadult specimens start to develop the characteristic dorsal bending of the alveolar part.

Remarks: The manuscript name *D. vaunagensis* is a synonym of the new taxon. Juvenile to immature specimens are virtually indistinguishable between this new species, *D. binervia*, and other closely related species. The specimen figured by FÖZY & JANSSEN (2009, fig. 6I-J; as *D. binervia*) probably belongs to *D. oehlerti*.

Stratigraphic occurrence: Late Valanginian; Peregrinus Zone (Nicklesi Sz) to Furcillata Zone.

Geographical occurrence: France (Nimes-area; Vocontian Basin), Romania, and Spain (Baetic Cordillera).

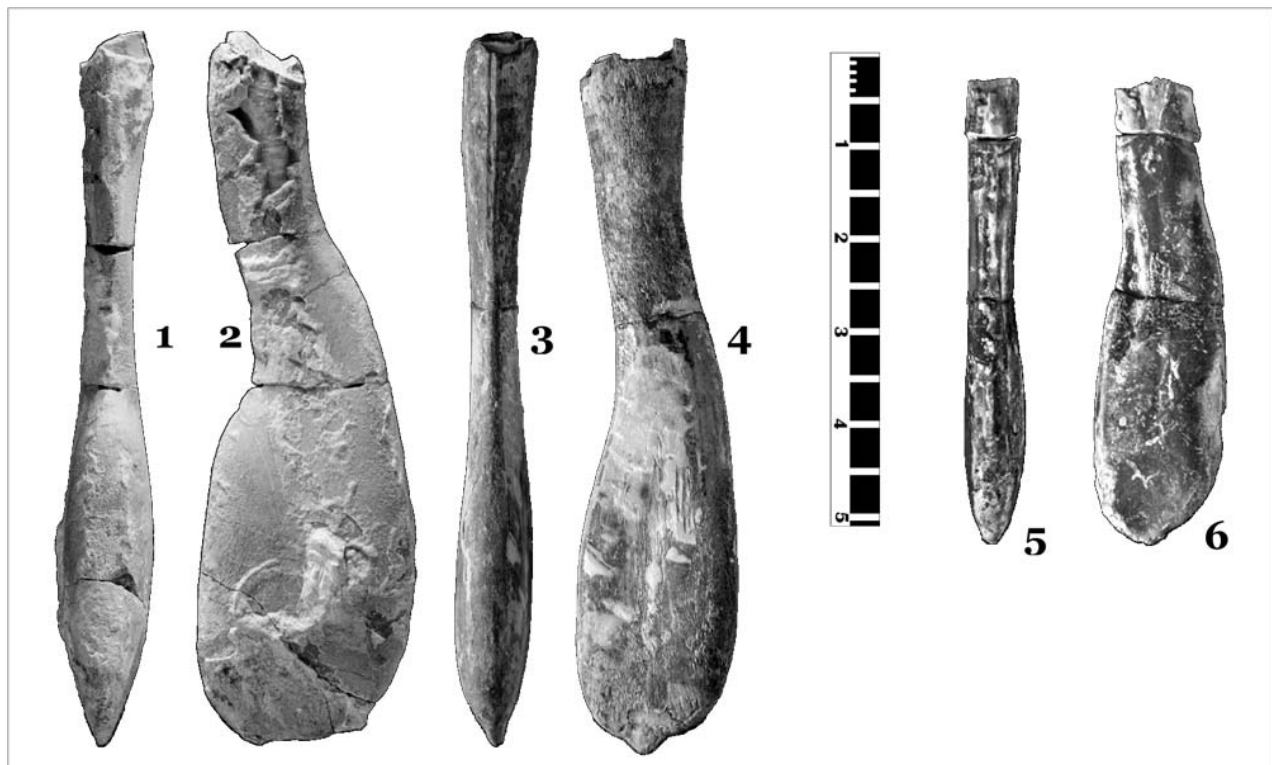


Figure 6: 1-2. *Duvalia kleini* sp. nov. [HT], RGM361669, Tornajo, B110, Nicklesi Sz; 3-4. *Duvalia kleini* sp. nov. [PT], RGM583933, Y.G35top, Nicklesi Sz; 5-6. *Duvalia kleini* sp. nov. [PT] (subadult), RGM561068, VGL169-a1, Furcillata Zone. Scale-bar 5 cm. In lateral view (Fig. 6.2, 4, 6), dorsal side to the left. Dorsal view Fig. 6.1, 3, and 5.

Genus *Castellanibelus* COMBÉMOREL, 1972

Type *Belemnites Orbignyanus* DUVAL-JOUVE, 1841 (OD)

Lectotype: DUVAL-JOUVE, 1841, Pl. 8, figs. 5-6; designated herein.

The type material comes from the Angles-Cheiron region, north of Castellane, but no lectotype has been fixed yet properly. ALI-ZADE (1972, p. 140) indicated two different lectotypes (DUVAL-JOUVE, 1841, Pl. 8, fig. 5-6, and 7) and following STOYANOVA-VERGILOVA (1963) classified it among the Belemnopseidae which was common before the publication of COMBÉMOREL (1972). STOYANOVA-VERGILOVA (1963) included the species within the Barremian *Curtohibolites*, but contrary to the latter genus, *Castellanibelus* is not laterally flattened (compressed) in the posterior (alveolar) part of the rostrum. According to DUVAL-JOUVE (1841, p. 65) it shows little variation and no varieties exist. However, within the stratigraphically collected material there seems to be a (clear) tendency for less dorso-ventrally flattened specimens in younger beds; that is from the late early Valanginian onwards (Inostranzewi Zone), while at the same time specimens also occur with a more or less square cross-section in the alveolar region. Apart from the lectotype, showing a depressed rostrum with a sub-conical outer-morphology, species are apparently much more variable. They show either dorso-ventrally flattened

(depressed) or rounded to square cross-sections. The outline is sub-hastate to sub-conical while the profile is asymmetrically sub-hastate to sub-conical, with the outline of the ventral side generally being more strongly curved. The *rostrum solidum* and *rostrum cavum* are always in line and the apical line is straight, with a dorsal alveolar groove (cf. COMBÉMOREL, 1972) reaching moderately posteriorly to just posteriorly the protoconch.

The difference between *Castellanibelus* and *Conobelus* is not always clear. However, especially the flattened dorsal side, and/or the depressed cross-sections, separate the two genera sometimes. In addition, *Conobelus*, especially in juvenile to immature specimens, can be slightly compressed in the alveolar region, whereas the alveolar groove of *Castellanibelus* generally reaches into the postalveolar region. *Conobelus* is known from the late Jurassic and part of the Berriasian. *Castellanibelus* occurs at least from the latest Berriasian into the earliest late Valanginian, and was probably derived through some conobeloid belemnite.

The genus is abundant in the distal parts of the Vocontian Basin (France) and the Baetic Cordillera (Spain) and occurs only sporadically in the proximal parts of the Vocontian Basin and the Baetic Cordillera (Tornajo).

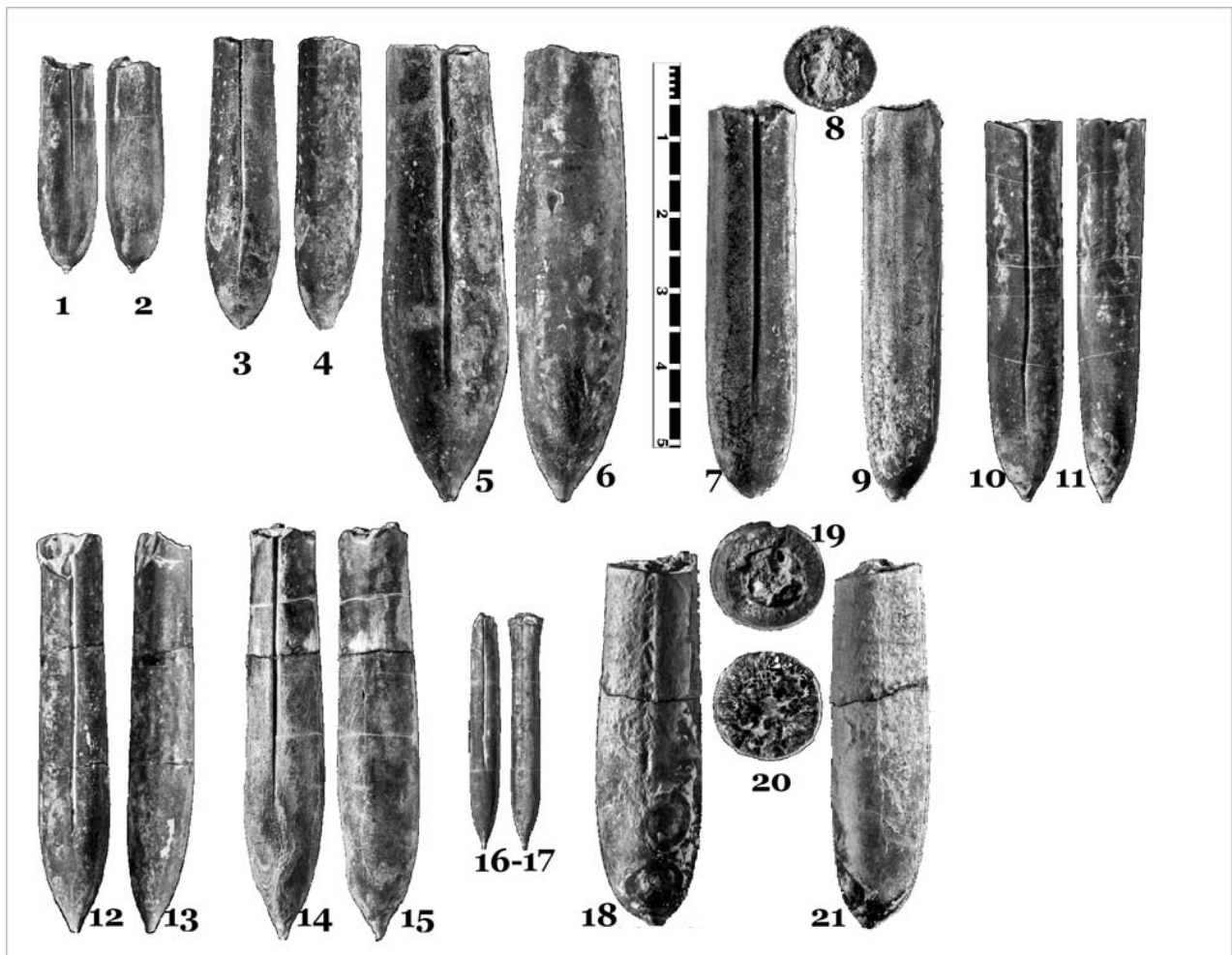


Figure 7: 1-2. *Castellanibelus vaubellensis* sp. nov. (juv./imm.) [PT]; RGM612676, VBL058-059, Hirsutus Sz; 3-4. *Castellanibelus vaubellensis* sp. nov. (immature) [PT], RGM612625, VBL055-056 Hirsutus Sz; 5-6. *Castellanibelus vaubellensis* sp. nov. [HT], RGM612624, VBL052-053, Hirsutus Sz; 7-9. *Castellanibelus orbignyianus* (DUVAL-JOUVE, 1841), RGM612580, VBL045, Hirsutus Sz; 10-11. *Castellanibelus orbignyianus* (DUVAL-JOUVE, 1841), RGM613528, VBL-P08-09, Pertransiens Zone; 12-13. *Castellanibelus picteti* (MAYER, 1866), RGM582211, VGL103a-104, Verrucosum Sz; 14-15. *Castellanibelus picteti* (MAYER, 1866), RGM613150, VBL105-a, Verrucosum Sz; 16-17. *Castellanibelus picteti* (MAYER, 1866) (juv.), RGM613150, VBL105-a, Verrucosum Sz; 18-21. *Castellanibelus picteti* (MAYER, 1866) (gerontic), RGM613018, VBL086, Inostranzewi Sz. Scale-bar 5 cm. In lateral view (Fig. 7.2, 4, 6, 9, 11, 13, 15, 17, and 21), dorsal side to the left. Dorsal view Fig. 7.1, 3, 5, 7, 10, 12, 14, 16, and 18. Cross-sections in Fig. 7.8, 19, and 20.

The specimen figured by VAŠIČEK *et al.* (2009, Fig. 4.12a-b) from the Peregrinus Zone of Serbia, appears to be too young, and is either a reworked specimen or a teratologic hibolitoid, supposing that the temporal distribution of the genus (late Berriasian - earliest late Valanginian) in the investigated areas is correct.

***Castellanibelus vaubellensis* sp. nov.**

(Fig. 7.1-6)

pars	1860	<i>Belemnites Orbignyianus</i> DUVAL: PICTET & LORIOU, p. 8-9, Pl. Ibis, fig. 6.a-b.
non?	1890	<i>Belemnites Orbignyi</i> DUVAL-JOUVE var. <i>Jouvei</i> TOUCAS, p. 588, Pl. XV, fig. 3.
non?	1991	<i>Conobelus (Conobelus) beneckeii</i> NEUMAYR: WEISS, Pl. II, fig. 10.

Derivation of name: After the farm of Vaubelle in the Jabron valley, W of Noyers-sur-Jabron.

Holotype: RGM612624 (Fig. 7.5-6).

Type stratum: Vaubelle, bed VBL052-053, Hirsutus Sz.

Paratypes: RGM612625 (Fig. 7.3-4), Vaubelle, VBL055-056 and RGM612676 (Fig. 7.1-2), Vaubelle, VBL058-059, both specimen from the Hirsutus Sz.

Material: Several tens of specimens.

Description: Robust rostrum, dorso-ventrally flattened (depressed); both profile and outline sub-hastate, apex mucronate, dorsal alveolar groove extending into the postalveolar region well beyond the protoconch. The alveolar groove is rather faint. Immature to juvenile rostra are



morphologically comparable to the adult rostra but for their obvious smaller size.

Differential diagnosis: Differs from all other adult castellanobeloid taxa by its robust and sub-hastate morphology. It differs from *C. orbignyanus* (Fig. 7.7-11) by its less elongated rostrum and more sub-hastate outline. Depression of rostrum comparable to *C. orbignyanus* but typically different from the (well-) rounded cross-sections of *C. picteti* (Ch. MAYER, 1866) (see below).

Remarks: The new species is not rare but does also occur not very regularly. Because of its rather robust hastate appearance it differs from all other castellanobeloid taxa. The dorso-ventral flatness appears to be typical in the earliest Valanginian castellanobeloids. It seems morphologically comparable to *Conobelus* (*Conobelus*) *benneckei* NEUMAYR *sensu* WEISS, 1991, Pl. II, fig. 10). However, the latter specimen according to the author originated from the lower Berriasian. "*Belemnites Orbignyi* DUVAL-JOUVE var. *Jouvei* TOUCAS, 1890" is also morphologically comparable but according to the author occurs in the "Upper Tithonian" (= pars lower Berriasian) of Chomérac (France).

Stratigraphic occurrence: Early Valanginian, Neocomiensiformis Zone (Hirsutus Sz).

Geographical occurrence: France, Spain, and Switzerland.

Castellanibelus picteti
(Ch. MAYER, 1866)

(Fig. 7.12-21)

non	1841	<i>Belemnites Orbignyanus</i> DUVAL-JOUVE, p. 65, Pl. 8, fig. 4, 5-6, 7, 8, 9.
	1866	<i>Belemnites Picteti</i> MAYER, p. 366.
	1887	<i>Hastites (Hibolites) Picteti</i> MAYER: MAYER-EYMAR, p. 11, Pl. I, fig. 16.

Material: The specimen figured in MAYER-EYMAR, 1887, is herein indicated to be the **lectotype**.

Description: More or less elongate rostrum with a round to sometimes angular cross-section at the alveolar opening. Cross-sections become slightly flattened in the posterior apical region, both profile and outline are sub-hastate, and the apex mucronate, alveolar groove generally extending into the post-alveolar region well beyond the protoconch. Immature to juvenile rostra are morphologically comparable to adult rostra but for their obvious smaller size. Gerontic specimens become morphologically much more robust.

Differential diagnosis: Dorso-ventral flattening (depression) of the rostrum is typically (much) less when compared to *C. orbignyanus*. The latter is much more cylindrical to sub-hastate when compared with *C. picteti*. Overall, the outline is never as hastate as in *C. vaubellensis* sp. nov., especially among the mature specimens.

Stratigraphic occurrence: Latest early to earliest late Valanginian (Inostranzewi Sz – Verrucosum Sz), being especially common in the Verrucosum Sz.

Geographical occurrence: France, Morocco, Switzerland.

Family Belemnopseidae NAEF, 1922,
emend. JELETZKY, 1946

Among this family, in the early Valanginian and early late Valanginian "*Hibolites*" dominate. In the Vocontian Basin the hibolitoid *Mirabelobelus* JANSSEN & CLÉMENT, 2002 occurs quite abundantly and regularly but it is only in the late Valanginian that various other genera appear, including *Adiakritobelus* JANSSEN & FÓZY, 2004, and *Vaunagites* COMBÉMOREL & GAYTE, 1981. While "*Hibolites*" become the dominant taxon in the Hauterivian and earliest Barremian, the other genera (*Adiakritobelus* and *Vaunagites*) disappear in the earliest Hauterivian.

Genus "*Hibolites*"
DENYS DE MONTFORT, 1808

Among the Valanginian hibolitoid belemnites several new or unfamiliar species can be distinguished. The earliest Valanginian yields slender elongated hibolitoid belemnites without a clear alveolar groove, identified here as "*H.*" aff. *Pistilliformis* (BLAINVILLE, 1827). They are succeeded by slender elongated hibolitoids with a clear alveolar groove, reaching well beyond the protoconch, "*H.*" *lebresensis* sp. nov. and "*H.*" *laryi* (Ch. MAYER, 1866). The latter species first occurs in the late early Valanginian and disappears in the earliest late Valanginian. Thereafter, Valanginian hibolitoids are dominated by "*H.*" *jaculooides* SWINNERTON, 1937, which occur from around the early/late Valanginian boundary on in the Vocontian Basin, being especially abundant in the upper parts of the Verrucosum Zone.

The stratigraphically collected specimens at least show certain aspects of their outer-morphology to be rather consistent over some time. However, a disadvantage is the scarcity of hibolitoids, at least in the early Valanginian of the Baetic Cordillera as compared to the Vocontian Basin. However, from the earliest late Valanginian onwards, "*H.*" *jaculooides* becomes common in the Baetic Cordillera too.

Among the Tethyan hibolitoids morphological variation, possibly expressed as dimorphism, has been anticipated by GAYTE (1984). While the new species established below, shows a "typical" morphology characterised by an elongated rostrum, many specimens that occur in the same beds show a more "shortened" rostrum, due to a less elongated apical region and *rostrum solidum*. These two morphologies could point to differences in the morphology of these rostra due to sexual dimorphism.

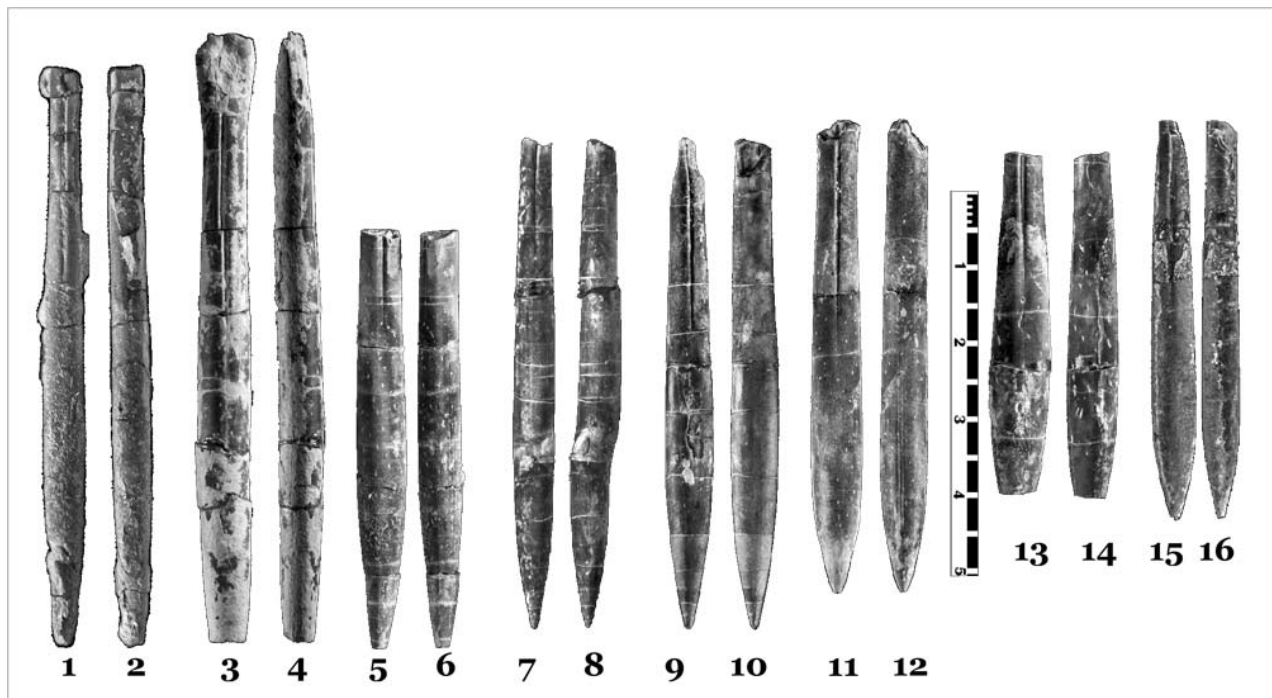


Figure 8: 1-2. "*Hibolithes*" *lebresensis* sp. nov. [HT], RGM543182, GRAU112-113, Inostranzewi Sz; 3-4. "*Hibolithes*" *lebresensis* sp. nov. [PT], RGM345467, LCH094, Subcampylotoxus Sz; 5-6. "*Hibolithes*" cf. *lebresensis* sp. nov., RGM613375, VBL074-075, Subcampylotoxus Sz; 7-8. "*Hibolithes*" *lebresensis* sp. nov. (subadult), RGM613015, VBL085-a, Inostranzewi Sz; 9-10. "*Hibolithes*" *lebresensis* sp. nov. var., RGM613379, VBL075b-076, Subcampylotoxus Sz; 11-12. "*Hibolithes*" *lebresensis* sp. nov. var., RGM613182, VBL082-083, Subcampylotoxus Sz; 13-14. "*Hibolithes*" *laryi* (MAYER, 1866), RGM613445, VBL089, Inostranzewi Sz; 15-16. "*Hibolithes*" *laryi* (MAYER, 1866), RGM561000, ANG301-a, Platycostatus Sz. Scale-bar 5 cm. In ventral view (Fig. 8.2, 4, 6, 8, 10, 12, 14, and 16), ventral side to the left. Ventral view Fig. 8.1, 3, 5, 7, 9, 11, 13, and 15. Dashed line indicates (approximate) position of the protoconch.

"*Hibolithes*" *lebresensis* sp. nov.

(Fig. 8.1-12)

Derivation of name: After the geographical name of the area it was derived from, Grau de Lèbres (SE of Les Allaves, France).

Holotype: RGM543182 (Fig. 8.1-2).

Type stratum: Bed GRAU112-113, Inostranzewi Sz.

Paratype: RGM345467 (Fig. 8.3-4), La Charce, LCH094 (= VGL081), Subcampylotoxus Sz.

Material: Several tens of specimens.

Description: Rostrum slender, elongate, subhastate (with the widest cross-section in the anterior part of the rostrum) both outline as well as profile. Faint but clear ventral groove, extending well into the postalveolar region beyond the protoconch. The depth of the alveolus is less than 1/3 of the length of the alveolar groove. Cross-sections are round to very slightly dorso-ventrally depressed. Apex more or less elongated.

Differential diagnosis: Compared to "*H.*" *laryi* (Fig. 8.13-16), the rostrum is longer - up to twice the length of the latter, and thus more elongated and with a long alveolar groove. The presence of a faint but clear alveolar groove and the overall

more hastate morphology distinguishes it from "*H.*" aff. *pistilliformis*.

Variations: Size differences among the hibolitooids not related to ontogeny, as compared to the new species "typical" morphology, is expressed in an overall shorter rostrum, mainly due to a less elongated apical area. This could point to sexual dimorphism in this species (Fig. 8.9-12).

Stratigraphic occurrence: Late early Valangian (Inostranzewi Zone).

Geographical occurrence: France (Vocontian Basin).

"*Hibolithes*" aff. *pistilliformis* (BLAINVILLE, 1827)

2003 *Hibolites* aff. *pistilliformis* (DE BLAINVILLE): JANSSEN, p. 139-140 (cum syn.).

Description: Rostrum slender elongate, hastate to slightly subhastate (widest cross-section more or less in the middle part of the rostrum), both outline as well as profile. Apparently no trace of ventral alveolar groove. Cross-sections are round to very slightly dorso-ventrally depressed. Apex elongated.

Differential diagnosis: See "*H.*" *lebresensis* sp. nov.



Remarks: The taxon is especially common in the Hirsutus Sz but complete specimens appear to be rare.

Stratigraphic occurrence: Earliest Valanginian (Neocomiensiformis Zone).

Geographical occurrence: France (Vocontian Basin), Spain (Baetic Cordillera), and probably Tunisia.

Discussion

The newly introduced taxa are based on bed-by-bed collection of belemnites, apparently giving the advantage of being able to distinguish chrono-species/associations, *i.e.*, species/assemblages that change more or less gradually over time. This is important, especially among such morphological "nightmarish" taxa as the duvaliids but also in other belemnite genera, bed-by-bed collecting seems preferable.

To complicate matters, the type specimens for some of the distinguished belemnite taxa, are not always easy to place in a (modern) stratigraphic framework, hampering the taxonomical attribution of part of the taxa, especially when these are immature specimens. For instance, the type stratum of *D. binervia* remains rather enigmatic. The latter species originated from the Cheiron area (Fig. 1.C). Recently JANSSEN (2009) has figured supposed topotype specimens from the Nicklesi Sz and Furcillata Zone (late Valanginian). However, most probably these specimens belong to *D. kleini* sp. nov. It now seems that typical *D. binervia* occurs together with *D. elongata* sp. nov. in parts of the Verrucosum and Peregrinus Zones. Juvenile to subadult specimens appear to be virtually indistinguishable (*D. gr. Binervia*), if not at least some part of the alveolar region is preserved. The latter is nearly straight in *D. binervia* but strongly bent in *D. kleini* sp. nov. Also *D. emericii* shows a *rostrum cavum* and *rostrum solidum* in line, which is apparently a trait of the older species of the *binervia*-group, which was inherited from the *D. lata*-group. Stratigraphically younger (sub- and adult) specimens show either a slightly ventrally bent *rostrum cavum*, like in *D. gervaisiana*, or a dorsally bent one.

Another possibility is that duvaliids show sexual dimorphism, and as such *D. binervia* Auct. might be the micro-conch of dimorphic pairs, in which the macro-conch is more easily to typify morphologically. This would imply that the type of *D. binervia* is a mature (sub- or adult) specimen. The latter seems possible, because the larger part of the specimens that have been collected, appear to be of comparable or of slightly larger size as compared to the type species. Larger specimens, often with an irregular outline are also known as *D. hybrida* Auct.; whether these are part of the variation within the macro-conchs is not known yet, but may be likely.

In the *D. lata*-group, there appears to be no such modification of the alveolar region, except for an increasing constriction of that region. However, the stratigraphically younger specimens appear to loose this constriction almost entirely, giving rise to mature near sub-cylindrical morphologies, at least from the Inostranzewi Zone onwards. Like, in the *binervia*-group, dimorphism appears likely. It could be expressed in the outer-morphology of the rostrum (*D. lata* vs. *D. constricta*), especially the flatness of the rostrum but also possibly, the depth of the alveolus.

Castellanibelus, of which the type specimen is likely to be derived from the early Valanginian, is often taxonomically difficult, especially if the rostrum is not fully preserved. The distinguished species are especially unproblematic to identify, if mature specimens are available.

Conclusions

Valanginian duvaliids show high morphological plasticity. Nevertheless, bed-by-bed collections show morphological changes that makes them to some degree suitable for stratigraphic division. A set-back might be that it is not yet fully understood whether or not these duvaliids are sexually dimorphic. However, especially among the *Duvalia binervia* group sexual dimorphism appears likely.

Also *Castellanibelus* so far largely treated as monospecific, other than for some odd and uncertain attributions, show morphological features that can be used stratigraphically. As in the *Duvalia lata* lineage, these morphological changes become apparent in the late early Valanginian. Therefore, on specific level associations of belemnites show changes that have potentially stratigraphical values over wider areas.

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