Mediterranean Neocomian belemnites, part 1: Río Argos sequence (province of Murcia, Spain): the Berriasian-Valanginian and the Hauterivian-Barremian boundaries

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Keywords: Belemnites, Neocomian, Spain.
In the Río Argos sequence (Murcia, SE Spain) belemnites were collected in ammonite controlled Lower Cretaceous strata. The calibration towards ammonite biozones gives the opportunity to specify the biostratigraphical ranges of belemnites in the (western) Mediterranean. Emphasized are the Berriasian- Valanginian and Hauterivian-Barremian boundary intervals.
Three new species and two possible new species are described under open nomenclature: *Castellanibelus* sp. A, *Duvalia* sp. A, *Duvalia* sp. B, *Duvalia* sp. indet. nov. ? and *Duvalia* aff. *deeckei*.
A provisional framework for future detailed biostratigraphical zonation by means of belemnites is given for the western Tethyan Basin.

Contents

Introduction

Only sporadic references to Early Cretaceous belemnites of the Iberian Peninsula can be found in the literature (Haime, 1855; Hermite, 1879; Mallada, 1887; Kilian in Bertrand & Kilian, 1889; Nicklès, 1891; Douvillé, 1906; Fallot, 1922; Bataller, 1950; Almelo & de la Revilla, 1957; Colmenero et al., 1974; Lillo Bevia, 1975). Moreover, detailed biostratigraphical data of belemnites, i.e. correlation to ammonite biozones or chronozones, have never been published to the authors knowledge. As a result the understanding of the accurate vertical distribution of belemnites is rather scarce in the (western) Mediterranean Early Cretaceous.

In the Río Argos section the opportunity to calibrate belemnite findings with ammonite stratigraphical data is present. As the lithological columns are already published (Hoedemaeker, 1982, 1994; Hoedemaeker & Leereveld, 1995) they are not depicted again in detail. Only the specific parts of the sequence that were treated are figured.

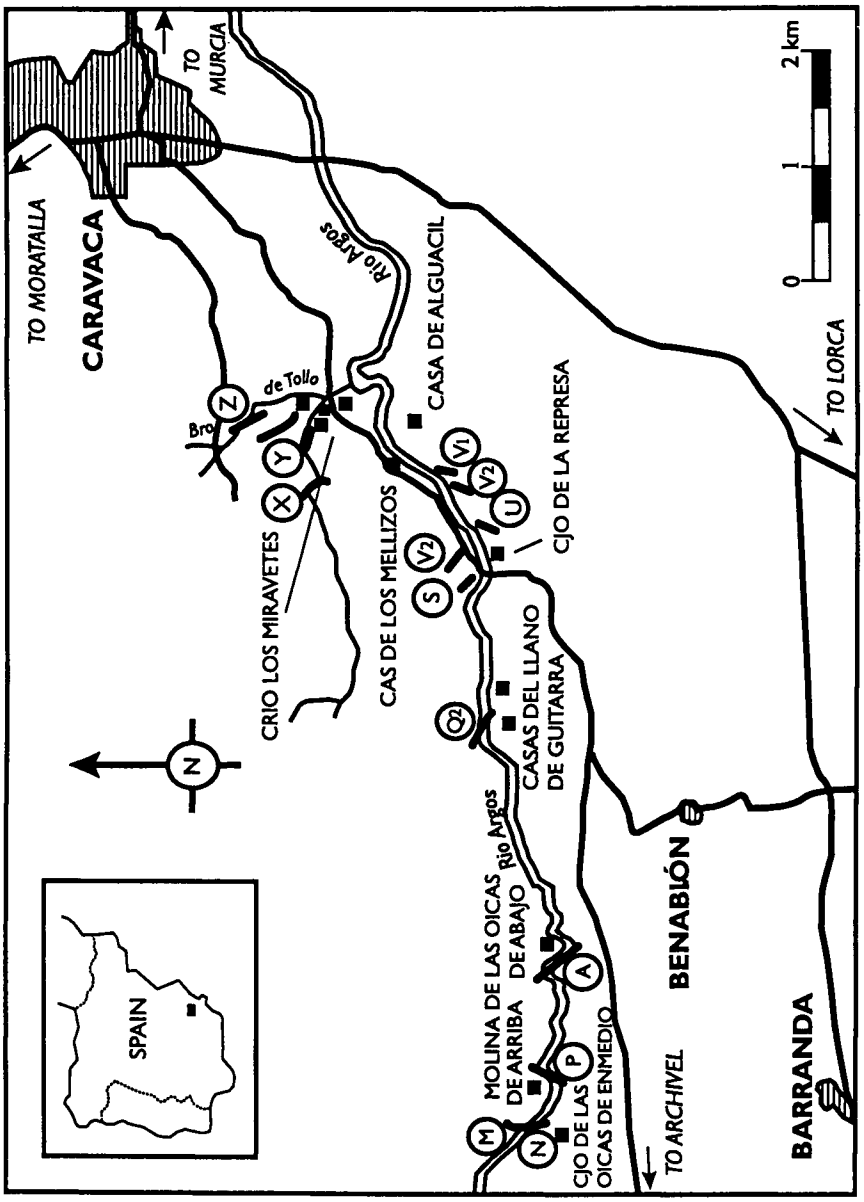

Fig. 1. Geographical map of the Río Argos area. Capitals show position of the different sections. From Hoedemaeker & Leereveld (1995). Section Z to Y (X-numbers correlate to Y-numbers, they represent the same beds in two parallel sections). These sections represent the Jurassic-Cretaceous transition upto the Early Valanginian. The Hauterivian-Barremian boundary is represented by section A, V and Q2.

In the Río Argos area (Fig. 1) an on ammonites based biostratigraphical framework was made and stratigraphical columns were constructed for twenty-five sections that cover the whole (c. 1500 m) Argos sequence (Hoedemaeker, 1982; Hoedemaeker & Leereveld, 1995), i.e. Tithonian to Cenomanian strata. Hoedemaeker (1982) published updated ammonite stratigraphical data from upper Tithonian, Berriasian and lower Valanginian strata, from the Hauterivian- Barremian boundary deposits (Hoedemaeker, 1994) and integrated stratigraphical data (bio- and sequence stratigraphy) for the complete Early Cretaceous (Hoedemaeker & Leereveld, 1995; Leereveld, 1995). In these papers, dinoflagellate cysts, calpionellids, nannofossils, and planktonic foraminifera are calibrated against ammonite bio- or chronozones.

Acknowledgements

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Geological context and material

The investigated material is collected from strata of Early Cretaceous age along the Río Argos near Caravaca (province of Murcia, SE Spain; Fig. 1). The sequence is well exposed along the meandering Río Argos and its tributaries. The sediments appear as a monotonous rhythmic alternation of grey marlstone beds and light grey, marly limestone beds. Macrofossils, mainly ammonites and aptychi, are relatively frequent. Belemnites and to a lesser extent brachiopods, echinoids, burrows (especially *Zoophycos*), and bivalves, can sporadically be found.

So far 93 belemnite guards were collected in various states of preservation from the limestone beds (in situ) and from the marly beds (both in situ and not; Figs. 2-3).

Special attention has been paid to the Berriasian-Valanginian boundary (sections Y and Z, in and near the Barranco de Tollo; Fig. 2) and to the Hauterivian-Barremian boundary (sections A, V and Q2, in the Río Argos; Fig. 3), simply because so far the strata in between hardly yielded any belemnites. The lithological columns are grossly simplified. Depicted are lithological units which predominantly represent marly (lowstands), calcareous (highstands) or rhythmic calcareous-marly intervals.

Methods and taxonomic part

Generally the identification of belemnites depends upon the hard parts of incomplete fossils that are found, i.e. guards and phragmocones. Phragmocones are extremely rare in the sediments of the Río Argos sequence. Some were found near the Berriasian-Valanginian boundary, but not in connection with a guard.

In the study of the guards of belemnites quantitative taxonomical criteria were set up by authors like Krimholz (1939, fide Pugaczewska, 1961) and Pugaczewska (1961). These quantitative data (Fig. 4) are obtained by using the following parameters:

Ic compression-index (= Hx/Lx), in which H is the height of the guard and L the width of the guard at a certain point x. At maximum diameter x = m. At the alveolar opening x = a
Id dilatation-index (= R/Hm), in which R is the total preserved length of the guard
Igr growth-index (= Sa/La), in which Sa is the distance from the apex to the groove
a length of alveolus
s length of groove
ap length of apical part
pa length of post-alveolar region
α alveolar angle in the posterior part

The following terms which describe the flattening of a guard are used in the text: Compressed (Ic > 0), in lateral flattening (e.g. in *Duvalia*). Depressed (Ic < 0), in dorso-ventral flattening (e.g. in *Castellanibelus, Rhopaloteuthis, Hibolithes*).

Taxonomical citations can be found in Combémorel, 1973, 1988; Challinor, 1989; among others.

The qualitative approach is based upon all morphological criteria, i.e. measurable and not measurable (Jeletzky, 1966; among others). Modern taxonomy is based upon the integration of quantitative taxonomy (statistics) and qualitative taxonomy (description), see: Stoyanova-Vergilova (1970), Combémorel (1973, 1988), Mutterlose (1978), Ali-Zade (1988), Weiss (1991), Vašíček et al. (1994), etc.

Species are depicted on Pls 1-6. An alphabetic index is provided. The material is stored in the collection of the Nationaal Natuurhistorisch Museum (National Museum of Natural History), Leiden, The Netherlands, under numbers RGM 345 200 - 345 292.

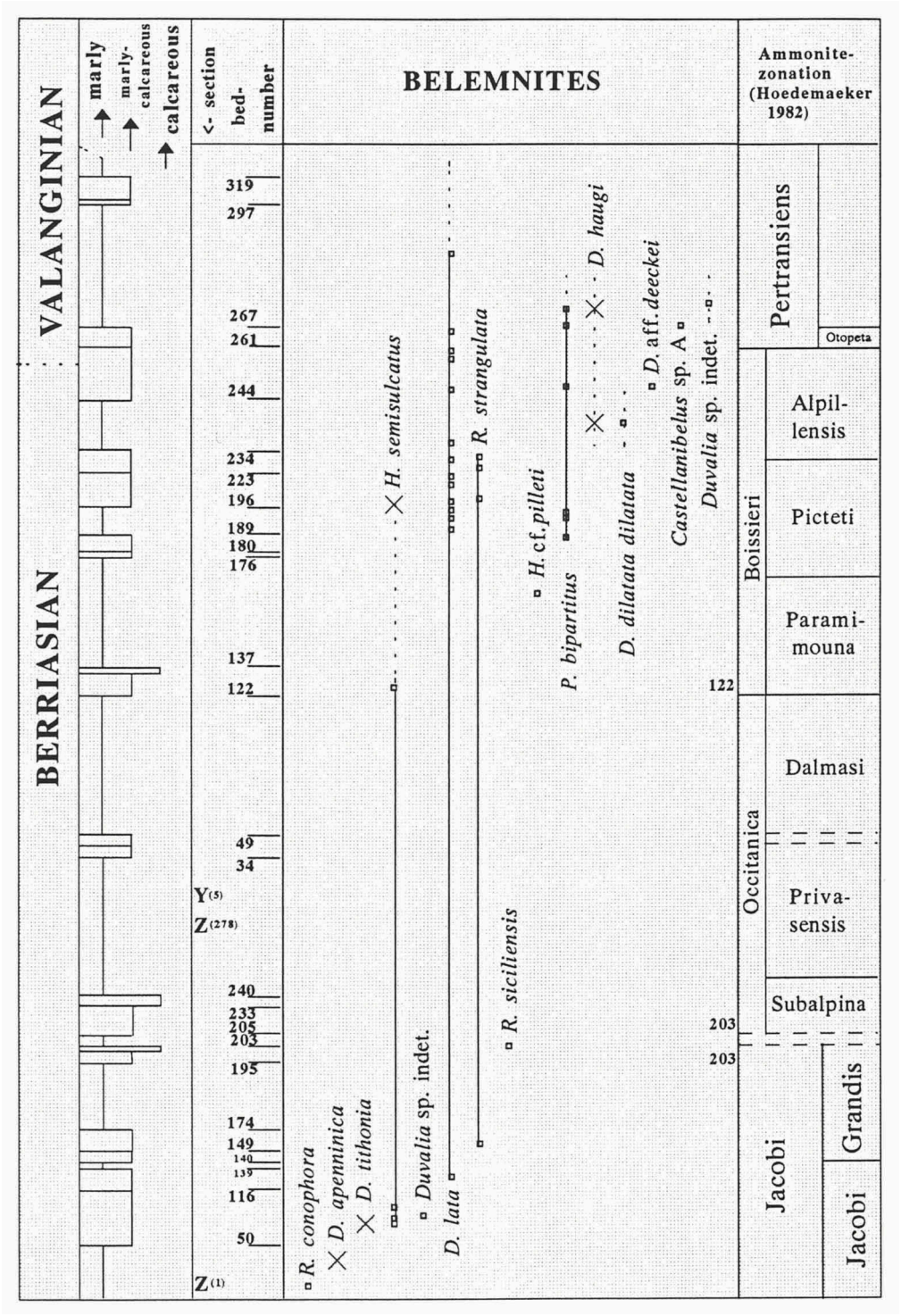
Systematic section

Genera and species are used in the context as indicated in Riegraf (1995), except for *Castellanibelus* and *Hibolithes*. See discussion below.

Contrary to the opinion of Stoyanova-Vergilova (1963), Ali-Zade (1988) and Barskov & Weiss (1992), adopted by Riegraf (1995), *Castellanibelus* Combémorel, 1972 is herein not used as a junior synonym of *Curtohibolites* Stoyanova-Vergilova, 1963. Both genera occur in clearly separated stratigraphical intervals. *Castellanibelus* is currently known from Tithonian to lower Valanginian strata and *Curtohibolites* from lower Barremian (and maybe upper Hauterivian) strata. Thus a possible phylogenetic link remains uncertain. The present knowledge indicates the possibility of iterative evolution of the two genera from the *Hibolithes* stock.

The assignment of *Castellanibelus orbignyanus* to *Conobelus* Stolley, 1919 (e.g. Kab-

Fig. 2. Depicts the position of the collected belemnites within the Berriasian-Valanginian sections Z and Y from the Río Argos sequence. Bed-numbers and ammonite zones are indicated (modified from: Hoedemaeker, 1982). Solid lines: distribution in section (X, Y and Z). Broken lines: tentative distribution due to uncertain determination (indicated by crosses) or not in situ findings. Recent investigations in the Río Argos sequence indicate the *Otopeta* Zone to be part of the *Pertransiens* Zone. As a result the status of the *Otopeta* Zone is lowered to *Otopeta* Horizon.


BERRIASIAN
VALANGINIAN
marly
marly-calcareous
calcareous
<- section
bed-number
BELEMNITES
Ammonite-zonation (Hoedemaeker 1982)
319
297
267
261
244
234
223
196
189
180
176
137
122
49
34
Y(5)
Z(278)
240
233
205
203
195
174
149
140
139
116
50
Z(1)
R. conophora
D. apenninica
D. tithonia
H. semisulcatus
Duvalia sp. indet.
D. lata
R. strangulata
R. siciliensis
H. cf. pilleti
P. bipartitus
D. haugi
D. dilatata dilatata
D. aff. deeckei
Castellanibelus sp. A
Duvalia sp. indet.
122
203
203
Pertransiens
Otopeta
Boissieri
Alpil-lensis
Picteti
Parami-mouna
Occitanica
Dalmasi
Priva-sensis
Subalpina
Jacobi
Grandis
Jacobi

anov, 1960) is erroneous, as *Conobelus* is a junior synonym of *Rhopaloteuthis* Lissajous, 1915 and as such it belongs to the family Duvaliidae Pavlow, 1914.

Furthermore is *Hibolithes subfusiformis* (Raspail) erroneously placed within the genus *Neohibolites* by Riegraf (1995: 95).

Class Cephalopoda Cuvier, 1794
Subclass Coleoidea Bather, 1888
Order Belemnoidea Gray, 1849
Suborder Belemnitida Gray, 1849
Family 'Cylindroteuthidae' Stolley, 1919
Genus *Castellanibelus* Combémorel, 1972

Type species — *Belemnites orbignyanus* Duval-Jouve, 1841.

Description — Guards of intermediate length (27-56 mm). Overall depressed (Im = 0.77-0.99). Maximum outline in the posterior part of the guard, near the apex, situated near the end of the alveolar groove. The alveolar groove is shallow, rounded and rather wide compared to its depth. The alveolar groove extends over the larger part of the guard. Apex generally mucronate and orientated on the dorsal side. Alveolus, rather shallow, upto one-third of the total length of the guard. Alveolar angle varies from 15 to 18° (Combémorel, 1972: 80). Generally the alveolar opening is subrounded but still depressed. The lateral sides are subparallel. The largest width is in the point of maximum diameter and diminishes slightly towards the anterior part of the guard, thus towards the alveolar opening. Lateral lines are visible in young and adolescent specimen. They are situated just above the middle of the flanks, on the dorso-lateral side.

Range — *Castellanibelus* is found in Tithonian to lowermost Late Valanginian strata of the Tethyan Realm.

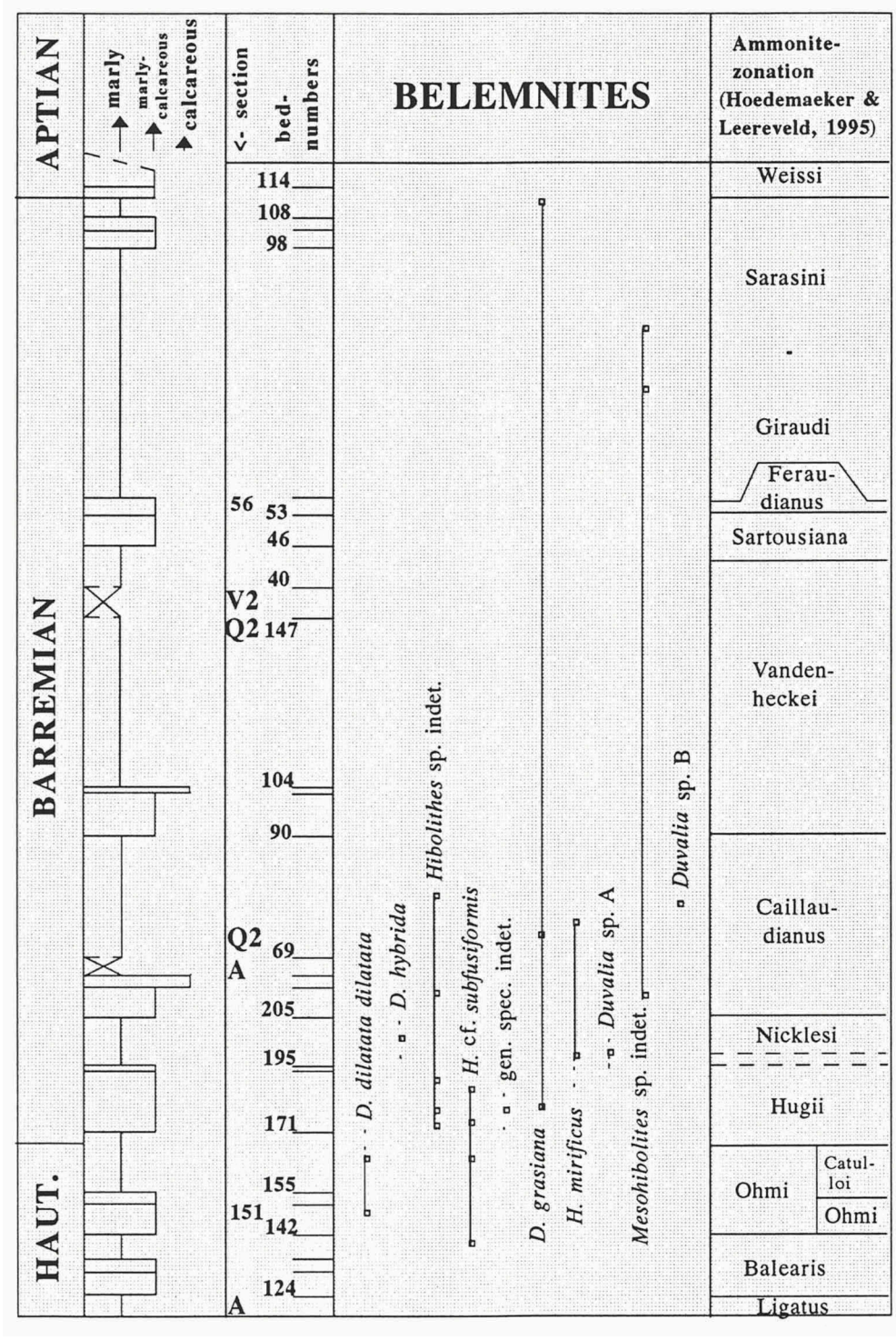
Castellanibelus sp. A
Pl. 3, figs. 7-8.

Material — One complete guard (RGM 345 320).

Diagnosis — Club-shaped guard with ventral groove and ventro-lateral swellings in the posterior part of the guard.

Description — A club-shaped, depressed guard with a long clear but shallow groove. The width of the groove is larger as compared to the depth. The apex is mucronate and in a ventral position. Depressed throughout the guard but more markedly towards the apical part. Alveolar part subrounded in cross-section, but still depressed. Alveolus (c. 15 mm) short compared to the length of the groove (37 mm). At 2/3 of the apex, two ventro-lateral swellings can be observed upto the apex. This results in a rounded pentagonal-like cross-section. The swellings disappear near the end of the groove. No lateral lines can be observed.

Fig. 3. Depicts the position of the collected belemnites within the Hauterivian-Barremian sections A, V and Q2 from the Río Argos sequence. Bed-numbers and ammonite zones are indicated (from: Hoedemaeker, 1994; Hoedemaeker & Leereveld, 1995). Solid lines: distribution in section (A, Q and V). Broken lines: tentative distribution due to uncertain determination (indicated by crosses) or not in situ findings.


APTIAN
BARREMIAN
HAUT.
marly
marly-calcareous
calcareous
<- section
bed-numbers
114
108
98
56
53
46
40
V2
Q2 147
104
90
Q2
A 69
205
195
171
155
151 142
124
A
BELEMNITES
D. dilatata dilatata
D. hybrida
Hibolithes sp. indet.
H. cf. subfusiformis
gen. spec. indet.
D. grasiana
H. mirificus
Duvalia sp. A
Mesohibolites sp. indet.
Duvalia sp. B
Ammonite-zonation (Hoedemaeker & Leereveld, 1995)
Weissi
Sarasini
Giraudi
Feraudianus
Sartousiana
Vandenheckei
Caillaudianus
Nicklesi
Hugii
Ohmi
Catulloi
Ohmi
Balearis
Ligatus

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Ig
345 320	52	15	8.0	8.3	0.96	8.8	9.3	0.95	5.57	1.81

Comparison — This species differs from *C. orbignyanus* by the less deep alveolus and by the absence of ventro-lateral swellings in the latter.

Stratigraphical distribution — Base of Pertransiens Zone, bed: Y267.

Range — Compare Fig. 5.

Geographical distribution — SE Spain (this paper).

Remarks — *C. orbignyanus* is currently known from Tithonian to lower Late Valanginian strata of France, ?Switzerland and ?Tunisia.

Genus *Hibolithes* Denys de Montfort, 1808

Type species — *Belemnites hastatus* Denys de Montfort, 1808 (by original designation and monotypy).

Remarks — The type species of *Hibolithes* is a nomen dubium (cf. Combémorel & Howlett, 1993) and *Hibolithes*, therefore, is invalid. But W. Riegraf (pers. commun., 1996) prepared an application to the International Commission on Zoological Nomenclature, which should decide by their plenary powers that the type species of *Hibolithes* Denys de Montfort, 1808 will be *Belemnites semihastatus* von Münster, 1830, a well defined, widely-distributed Late Jurassic species. This new type species would enable that *Hibolithes* could remain in common use in its traditional sense, without any nomenclatorial confusion.

Description — Quite variable guards in length, outline of the apex, depth of the

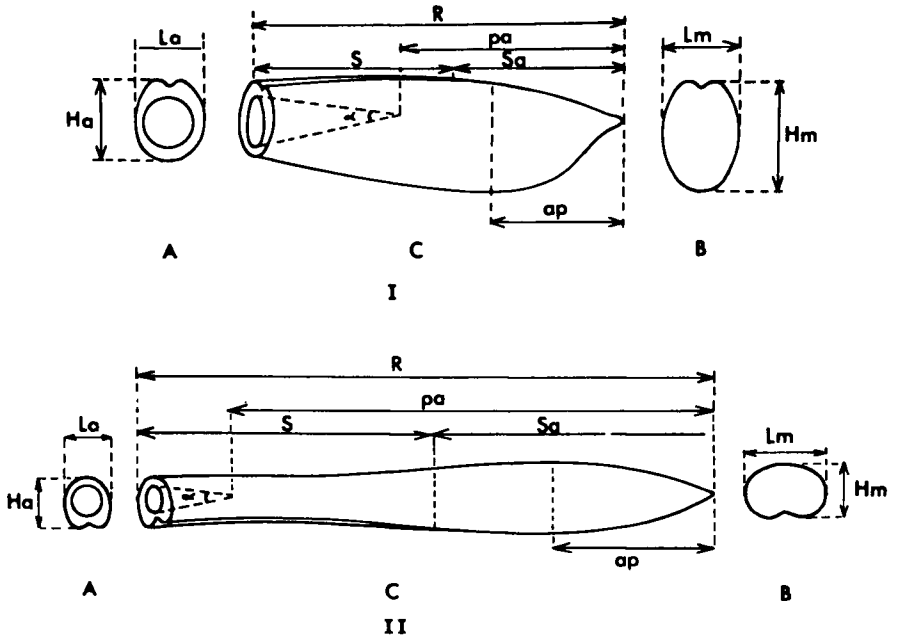


Fig. 4. Depicts the parametres which are used in the text and described above.

alveolus and outline of the guard. Generally, the guards are slender to club- shaped and overall rounded or subrounded with a severe constriction on the anterior side of the guard (tapering towards the alveolus as well to the apex), giving way to the typical clavate or hastate outline and/or profile (cf. Challinor, 1989: 10). The guards can be either slightly depressed or slightly compressed. Maximum cross-section generally close to the apex, in the posterior region of the guard. The alveolar groove is quite variable in length and width and extends generally not over half the length of the guard.

The alveolus is generally very shallow with a variable alveolar-angle. Lateral lines are as often visible as not. If present there are two or sometimes three thin lines visible in the larger part of dorso-lateral side of the guard.

Range — *Hibolithes* is found in Oxfordian to Barremian strata around the world.

Hibolithes mirificus Stoyanova-Vergilova, 1965
Pl. 5, figs. 5-6.

1965a *Hibolites mirificus*, Stoyanova-Vergilova, pp. 151-152, pl. 1, figs. 1-4.
1970 *Hibolites mirificus* Stoyanova-Vergilova — Stoyanova-Vergilova, p. 19, pl. V, figs. 1-4; pl. XXXII, fig. 2.
1989 *Hibolites mirificus* Stoyanova-Vergilova — Michalík & Vašíček, pl. 3, fig. 4.
1994 *Hibolites mirificus* Stoyanova-Vergilova — Vašíček et al., pp. 79-80, pl. 27, figs. 11-12.
1995 *Pseudohibolites mirificus* (Stoyanova-Vergilova) — Riegraf, p. 104.

Material — Two incomplete specimens (RGM 345 268, 345 271).

Description — Medium sized, overall slightly depressed guards with a characteristic club-shaped outline. The guards show a rather strong constriction in the post-alveolar area. The ventral side is slightly flattened, whereas the dorsal side is rounded. Maximum diameter at c. 10-15 mm from the apex. In ventral view the apex is convex whereas in dorsal view it is stronger curved resulting in a pointed to mucronate ventrally placed apex, with a constricted and snouth-like profile (cf. Swinnerton, 1936: ix). The orientation of the mucron is (always ?) to the dorsal side. The lateral areas are slightly inflated. The latter characteristic disappears towards the alveolar side. No groove is preserved in the collected specimens.

RGM	R	Sa	Hm	Lm	Hx	Lx	Icm
345 268	45.2	30.4	7.3	7.9	6.0	6.2	0.92

Comparison — *Hibolithes jaculoides* Swinnerton, 1952 is generally of larger size, hastate and with a relative short groove. The alveolair region is constricted and virtually never parallel sides are noted. This species and its variations occur in specific timeslices during the Valanginian to Barremian in Boreal (E England, NW Germany) as in Tethyan regions (SE France, Carpathians, Bulgaria, Georgia, Turkey, and ?Switzerland).

H. jaculoides var. *torpedinus* Swinnerton, 1952 has no club-shaped outline and the anterior part does not show the almost parallel, post-alveolair to alveolair region.

Hibolithes subfusiformis (Raspail, 1829) is of larger size compared with *H. mirificus* and virtually never parallel sides are noted. The maximum diameter in the posterior

part of the guard is shifted much more anteriorly comparable to *H. mirificus*. The alveolar groove extends well onto the guard in *H. subfusiformis*. The latter shows a more rounded diameter and *H. subfusiformis* is known from Valanginian and Hauterivian strata (probably Barremian also).

Hibolithes krimholzi Stoyanova-Vergilova, 1970 and *H. zlatarskii* Stoyanova- Vergilova, 1965a are much more hastate with the maximum diameter more anteriorly positioned and with an acute to obtuse developed apex. They were collected from Hauterivian-Barremian strata of Bulgaria.

Hibolithes longior Schwetzov, 1913 is of larger size and much more hastate and does never show the characteristic club-shape. It occurs in Valanginian- Hauterivian strata of Bulgaria, Central Carpathians, Georgia, and Ukraine.

Hibolithes sp. 1 in Stoyanova-Vergilova (1965a: pl. II, fig. 2) does show a differently developed apical region, almost attenuated. It occurs in lower Barremian strata.

Hibolithes sp. 2 in Stoyanova-Vergilova (1970: pl. V, fig. 6) has a hastate outline and a straight pointed apex. It occurs in lower Barremian strata.

Hibolithes innae Eristavi, 1955 has an acute apex and does not show the club-shaped apical part and the near parallel anterior side of the guard. It occurs in upper Hauterivian strata of (Bulgaria, Georgia and the Crimea).

Stratigraphical distribution — ? Top Hugii Zone to top Caillaudianus Zone, beds: A183-205 (RGM 345 271); Q71-74 (RGM 345 268).

Range — Early Barremian.

Geographical distribution — Bulgaria (Stoyanova-Vergilova, 1970), Slovakia (Michalík & Vašíček, 1989; Vašíček et al., 1994), SE Spain (this paper).

Remarks — In Stoyanova-Vergilova (1965a: pl. 1, figs. 1-4) we see that the larger specimens show a well developed groove which extends over half the guard.

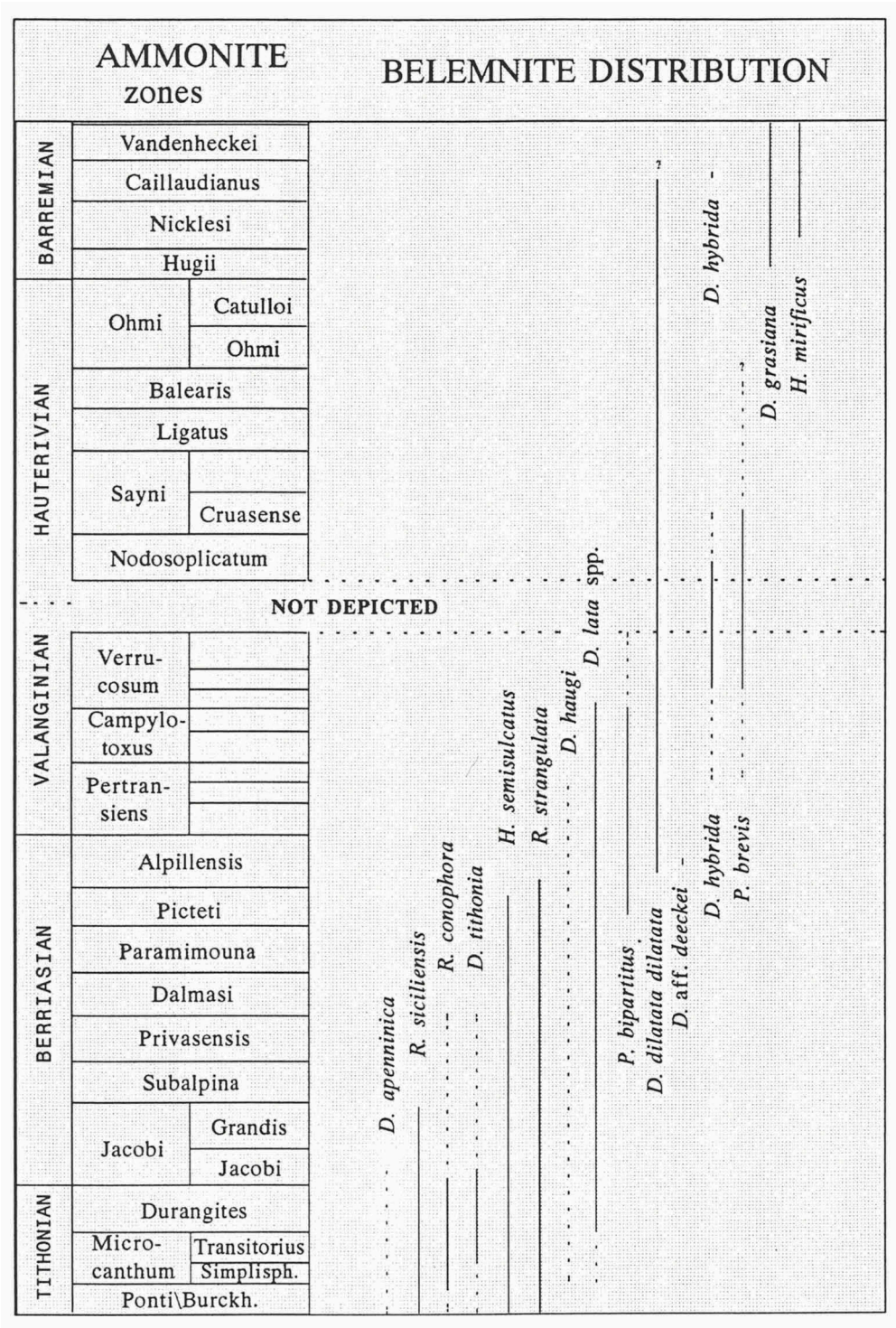
Hibolithes cf. *pilleti* (Pictet, 1868)
Pl. 6, figs. 6-8.

1868 *Belemnites Pilleti* Pictet, pp. 219-220, pl. 36, figs. 7, 8-9(?).
1879 *Belemnites Pilleti* Pictet — Vacek, p. 670.
1880 *Belemnites Pilleti* Pictet — Favre, pp. 18-19, pl. I, figs. 12-13(?).
? 1897 *Belemnites* nov. spec. — Abel, p. 346.
1890 *Belemnites Pilleti* Pictet — Toucas, pp. 573, 590.
1995 *Pseudohibolites pilleti* Pictet — Riegraf, p. 104.

Material — One incomplete guard (RGM 345 238).

Description — The cross-section of the guard is rounded to square. The dorsal area is slightly rounded posteriorly and slightly depressed anteriorly. No groove is visible on the preserved part. The ventral side is rounded anteriorly and flattens towards posteriorly. The flanks are plano-convex resulting in a subrounded to square cross-section. However, in the alveolar area the cross-section of the guard is rounded with a weak depression on the dorsal side. As a result, the cross- section seems to be square to polygonal.

Fig. 5. Depicts the stratigraphical ranges from belemnite species encountered in the Río Argos sequence. Additional information from outside Spain was added. Solid lines: distribution certain. Broken lines: distribution uncertain. Question marks: no further data available.


AMMONITE zones
BELEMNITE DISTRIBUTION
BARREMIAN
Vandenheckei
Caillaudianus
Nicklesi
Hugii
HAUTERIVIAN
Ohmi
Catulloi
Ohmi
Balearis
Ligatus
Sayni
Cruasense
Nodosoplicatum
NOT DEPICTED
VALANGINIAN
Verru-cosum
Campylo-toxus
Pertran-siens
BERRIASIAN
Alpillensis
Picteti
Paramimouna
Dalmasi
Privasensis
Subalpina
Jacobi
Grandis
Jacobi
TITHONIAN
Durangites
Micro-canthum
Transitorius
Simplisph.
Ponti\Burckh.
D. apenninica
R. siciliensis
R. conophora
D. tithonia
H. semisulcatus
R. strangulata
D. haugi
D. lata spp.
P. bipartitus
D. dilatata dilatata
D. aff. deeckei
D. hybrida
P. brevis
D. hybrida
D. grasiana
H. mirificus

RGM	R	Ha	La	Ima	Hx	Lx	Imx
345 238	38	9.2	8.5	1.08	11.4	10.8	1.03

Comparison — The only comparable belemnite that could be found is *H. pilleti*. This species is figured in Pictet (1868) and Favre (1880) and seems to be quite variable. The specimen that is found in the Río Argos sequence is comparable to the specimen figured by Pictet on pl. 36, fig. 7a-c.

Stratigraphical distribution — Top Paramimouna Subzone, bed: Y159-161.

Range — Compare Fig. 5.

Geographical distribution — Austria (?, Abel, 1897: 346, as: *Belemnites* nov. spec. ('eine scharf vierkantige Form'); Vacek, 1879), France (Pictet, 1868; Toucas, 1890), SE Spain (this paper), and Switzerland (Favre, 1880).

Hibolithes semisulcatus (von Münster, 1830)

1830 *Belemnites semisulcatus* — von Münster, pp. 6-7, pl. I, figs. 1-8, 15.
1877b *Belemnites semisulcatus* (Münster) — Favre, pp. 9-10, pl. I, figs. 3-6.
? 1889 *Belemnites (Hibolites) Conradi* — Kilian in Bertrand & Kilian, p. 80, pl. 26, fig. 4.
1922 *Belemnites Conradi* Kilian — de Gregorio, p. 8, pl. I, fig. 12.
e.p. 1922 *Belemnites semisulcatus* Münster — de Gregorio, p. 8, pl. I, figs. 13(?), 16(?), 18(?), 22-23(?), non fig. 19.
1981 *Hibolithes (Hibolithes) hastatus semisulcatus* (Graf zu Münster) — Riegraf, pp. 85-87, pl. 6, figs. 48-49.
1986a *Hibolites semisulcatus* (Münster) — Combémorel & Mariotti, pp. 312- 313, pl. 2, figs. 14-16.
1990 *Hibolites semisulcatus* (Münster) — Combémorel & Mariotti, p. 213, pl.2, figs. 5-10.
1995 *Pseudohibolites semisulcatus* (Graf zu Münster) — Riegraf, p. 105.

Material — Seven guards in different state of preservation (RGM 345 203, 345 223, 345 227, 345 234, 345 242, 345 276, 345 289).

Description — Elongated spindle like, subrounded guards with a straight apical line. The maximum cross-section is posteriorly situated. The alveolar area tends to be elongated with almost parallel sides and subrounded. Towards the apical area the guard flattens in dorso-ventral direction. A clear groove is present and a commissural furrow (RGM 345 223; with a rectilinear base of the slit, cf. Krimholz, 1992) can be observed. However, in some specimens (RGM 345 227) a perpendicularly (cf. Krimholz, 1992) base of the slit can be noted. The alveolar angle varies from 25 to 27°.

RGM	R	Sa	Ha	La	Ica	Hm	Hx	Lx	α
345 223	36	—	10.0	-	—	11.5	—	—	27°
345 227	65	36	9.5	-	—	11.3	—	—	25°
345 234	53	—	10.1	9.2	1.04	—	13.8	14.0	—
345 289	41	—	10.5	-	—	—	10.5	9.1	27°

Comparison — Differs from *Hibolithes subfusiformis* in the development of the alveolar fissure (?) and the extension of the ventral groove. Also the stratigraphical occurrence is different (Valanginian to Barremian).

Hibolithes jaculoides has a different stratigraphical distribution (Valanginian-Hauterivian (Barremian)), generally a longer guard, relative shorter alveolar groove and

the maximum cross-section of the guard is shifted more posteriorly.

Hibolithes hastatus hastatus Denys de Montfort, 1808 has a longer guard and alveolar-groove (broader compared with *H. semisulcatus*). Moreover the position of the maximum diameter is shifted more anteriorly and the transverse sections as well in the posteriorly as in the anteriorly part are different. Also, the alveolar angle is much smaller (17-19°, cf. Riegraf, 1981).

Hibolithes hastatus elegans Riegraf, 1981 is also posteriorly depressed, has a much more parallel outline, a longer guard and most important a much more slender guard.

Hibolithes conradi Kilian in Bertrand & Kilian, 1889 is probably somewhat more hastate and shows a somewhat broader (?) groove. If we compare the figured specimen of Kilian in Kilian & Bertrand (1889: fig. 4a-b) with Riegraf (1981: fig. 203: this shows also a moderate hastate guard) one would doubt the independant nature of *H. conradi* (cf. Retowski, 1894: 216).

Hibolithes sp. (Combémorel & Mariotti, 1986a: pl. 3, figs. 17-29.) has a shorter groove compared with *H. semisulcatus*, it may even be virtually absent.

Stratigraphical distribution — From the middle of the Jacobi Subzone to the top of the Picteti Subzone, beds: Z80 (RGM 345 227), Z85 (RGM 345 289), Z95 (RGM 345 223), Y121-122 (RGM 345 276), Y122 (RGM 345 234), X196 (RGM 345 242), X216-217 (RGM 345 203).

Range — Compare Fig. 5.

Geographical distribution — Western-Alpes (Kilian, 1891, 1892), Austria (Toula, 1907), Crimea (Retowski, 1894), France (Toucas, 1890; Kilian, 1895), S Germany (von Münster, 1830; von Zittel, 1870), Hungary (Fülöp, 1976), Iran (Bogdanovitch, 1890, fide Combémorel & Mariotti, 1986a), Italy (de Gregorio, 1922; Combémorel & Mariotti, 1986a, 1990), Poland (von Zittel, 1870; Birkenmajer, 1963), Roumania (Badaluta, 1975), Slovakia (von Zittel, 1868), SE Spain (this paper), and Switzerland (Favre, 1877b, 1880).

Remarks — Riegraf (1981) gives a detailed description of this species which he placed within the *Hibolithes hastatus* lineage. Riegraf (1981) found specimens transitional between *H. hastatus hastatus* and *H. semisulcatus*.

H. semisulcatus is already known from Late Oxfordian strata. The representants from Spain show their last occurrence to be within the Berriasian Picteti Zone.

Hibolithes cf. *subfusiformis* (Raspail, 1829)
Pl. 5, figs. 7-8.

1970 *Hibolites* sp. 2 — Stoyanova-Vergilova, p. 22, pl. IV, fig. 6.

Material — Four parts of guards in different state of preservation (RGM 345 248, 345 249, 345 253, 345 255).

Description — Elongated guards with the maximum diameter at about 1/3 from the apex. Apex is sharp (at least in young specimens) and the apical line is straight. Stem region is round (in young specimens) to subround, alveolar part is slightly more compressed compared to the rest of the guard. The groove is well developed, broad, angular and comparable to the groove of *H. subfusiformis*. However, in con-

trast to *H. subfusiformis* it does not run well onto the stem region. Before the beginning of the groove, a marked knick in the ventral area is observed. Lateral lines can be seen at the ventro-lateral sides of juvenile specimens.

RGM	R	Sa	Ha	La	Hm	Lm	Icm	Hx	Lx	Icx
345 248	68	28	7.1	6.5	—	—	—	10.5	11.2	0.94
345 249	52	52	—	—	7.5	7.8	0.96	5.9	6.2	0.95
345 253	77	??	6.2	—	10.9	—	—	9.5	10.0	0.95
345 255	49	49	—	—	7.5	9.0	0.83	8.5	9.5	0.89

Comparison — *H.* cf. *subfusiformis* differs from *H. subfusiformis* in the extension of the groove.

Differs from *Hibolithes* sp. (in: Combémorel & Mariotti, 1986a) by a better developed alveolar groove. It has also a totally different stratigraphical range (Tithonian vs. Hauterivian-Barremian).

Stratigraphical distribution — Top Balearis Zone to middle Hugii Zone, beds: A138-139 (juv., RGM 345 249)), A154-170 (RGM 345 255), A170-178 (RGM 345 253), A184 (alveolar part, RGM 345248).

Range — Compare Fig. 5.

Geographical distribution — Bulgaria (Stoyanova-Vergilova, 1970), SE Spain (this paper).

Genus *Mesohibolites* Stolley, 1919

Type species — *Belemnites minaret* Raspail, 1829.

Description — Guards of various length. Generally depressed at the posterior part of the guard and less depressed, (sub)rounded or compressed in the anterior part of the guard.

Compared with *Hibolithes*, the guards of *Mesohibolites* have generally a much more blunt appearance and are sometimes hastate in profile but less or not at all in outline. The apex is pointed but never mucronate. The alveolar groove is quite variable and extends generally not over half the guard. The alveolus varies from shallow to deep, but is generally deeper compared to the depth of the alveolus in *Hibolithes*. A pseudoalveolus can sometimes be noted.

Range — *Mesohibolites* occurs in Barremian (? Hauterivian) to Aptian strata of the Tethyan and Boreal Realm.

Mesohibolites spp.

Material — A few fragments of apical compressed and alveolar rounded guards are found. However, they could not be determined at the species level.

Occurrence — Caillaudianus Zone to Giraudi/Sarasini Zone.

Family Duvaliidae Pavlow, 1914
Genus *Duvalia* Bayle, 1878

Type species — *Belemnites dilatatus* de Blainville, 1825

Description — Guards of various length, ouline and profile. Generally well compressed guards (Im = 1.00-3.50). Most species show their maximum cross- section to be situated at the posterior part of the guard. However, sometimes at the anterior part of the guard, near or in the alveolar opening.

The alveolar groove is quite variable, in length, depth and width. It may be virtually absent or nearly reach the apex. The base of the groove can be rounded or sharp.

Also, the depth of the alveolus is quite variable and varies from a few millimetres to several centimetres. Generally guards with a long groove show a deep alveolus but not always.

The apex is generally orientated to the dorsal side. It can be pointed, rounded or blunt.

Various cross-sections published in recent years show different growth-stages in duvaloid guards. Some species tend to grow, depending on their age, in dorso- ventral direction followed by grow in lateral direction or vice versa or only in dorso-ventral direction.

Range — *Duvalia* appears in Tithonian to Aptian strata of the Tethyan Realm and sometimes wanders into the Boreal Realm.

Duvalia cf. *apenninica* Combémorel & Mariotti, 1986
Pl. 2, figs. 3-4.

1986a *Duvalia apenninica* — Combémorel & Mariotti, pp. 305-306, pl. 1, figs. 5-7.

Material — One incomplete guard (RGM 345 228).

Description — One incomplete long-drawn strongly compressed guard is preserved. The alveolar area is partly preserved in the specimen and a 32 mm long dorsal furrow can be observed on it. The groove is rather broad but not deep. Both the end of the alveolar part and the onset of the apex are not preserved. The preserved parts are more or less parallel in lateral view. I.e. the dorsal area is straight whereas the ventral side is slightly convex.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id
345 228	49	—	7.9	6.2	1.27	8.8	6.3	1.4	5.57

Comparison — As indicated in Combémorel & Mariotti (1986a) no comparable species have been described in the literature.

Stratigraphical distribution — Base of Jacobi Subzone, bed: Z37 (RGM 345 228).

Range — Compare Fig. 5.

Geographical distribution — Italy (Combémorel & Mariotti, 1986a), SE Spain (this paper).

Remarks — The characteristic convexity of *Duvalia apenninica* in the apical area is not preserved. As a result this specimen is tentatively called *D.* cf. *apenninica*.

Duvalia aff. *deeckei* (Kilian in Bertrand & Kilian, 1889)
Pl. 5, figs. 1-4.

Material — The anterior part of a guard (RGM 345 236).

Description — A robust looking, large guard with a hexagonal cross-section. A broad, very shallow groove is partly preserved. The groove debouches in a clear, markedly flattened area c. 5 mm in width. A dorso-lateral longitudinal rounded ridge can be observed. This results in a hexagonal cross-section.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id
345 236	47	—	18	15	1.20	21.5	17.9	1.20	2.19

Comparison — *Duvalia deeckei* differs from *D. haugi* (Kilian in Bertrand & Kilian, 1889) by a different cross-section. Lateral swellings (or keels) are dorsally placed in *D. deeckei* (hexagonal cross-section) and medio-ventral in *D. haugi* (pentagonal cross-section). The dorsal groove is broad and open, and not clear and sharp. The hexagonal cross-section separates it from other comparable duvaliid guards. *Duvalia* aff. *deeckei* differs from typical *D. deeckei* by its much larger size.

Stratigraphical distribution — In the middle of the Alpillensis Subzone, bed: Y244-251.

Range — Compare Fig. 5.

Geographical distribution — SE Spain (this paper).

Remarks — The general appearance shows affinities with *D. deeckei* but the fragment is not complete enough for specific identification. Moreover, the preserved part is much larger as compared to the original description. It may prove to be a new species.

Dilatata dilatata dilatata (de Blainville, 1825)
Pl. 2, fig. 7; Pl. 4, fig. 4.

* 1825 *Belemnites dilatatus* de Blainville, p. 99, pl. 5, fig. 18; pl. 3, fig. 13a- e(?).
1829 *Belemnites emarginatus* — Raspail, p. 315, pl. 7, figs. 50-51.
1829 *Belemnites mitraeformis* — Raspail, p. 316, pl. 7, fig. 52.
1829 *Belemnites difformis* — Raspail, p. 315, pl. 7, fig. 54.
1829 *Belemnites variegatus* — Raspail, p. 311, pl. 7, fig. 55.
1829 *Belemnites apiculatus* — Raspail, p. 312, pl. 7, fig. 56.
1829 *Belemnites sinuatus* — Raspail, p. 312, pl. 7, figs. 59(?)-60.
1829 *Belemnites spathulatus* — Raspail, pp. 312-313, pl. 7, fig. 61.
e.p. 1840 *Belemnites dilatatus* de Blainville — d'Orbigny, pp. 39-44, pl. 2, figs. 20-21; pl. 3, figs. 4-5; non pl. 2, figs. 1-3 = *Pseudoduvalia polygonalis* (de Blainville, 1827), figs. 4, 6, 8 = *Pseudoduvlia trabiformis* (Duval- Jouve, 1841), figs. 9-15 = *Duvalia binervia* (Raspail, 1829), figs. 18-19 = *Duvalia dilatata binervioides* Stoyanova-Vergilova, 1965, figs. 22-23 = *Duvalia emericii* (Raspail, 1829); non pl. 3, figs. 1-3 = *D. emericii*.
e.p. 1841 *Belemnites dilatatus* de Blainville — Duval-Jouve, pp. 54-58, pl. 4, figs. 3-5, 7-8(?), non fig. 6 = *D. binervia*; non pl. 4, figs. 1-2 = *D. dilatata binervioides*.
e.p. 1848 *Belemnites dilatatus* de Blainville — Quenstedt, p. 393, pl. 31, fig. 20, non fig. 19 = *D. dilatata binervioides*.
? 1858 *Belemnites dilatatus* de Blainville — Pictet & de Loriol, p. 12, pl. I, fig. 6.
e.p. 1878 *Duvalia dilatata* (de Blainville) — Bayle, pl. XXXII, figs. 1-6, non fig. 7 = *D. dilatata binervioides*.
non 1887 *Belemnites dilatatus* de Blainville — Mallada, pp. 6-7, pl. 1 (1882), figs. 12-14 = *D. emericii*, figs. 15-16 = *D. binervia*.
e.p. 1898 *Belemnites (Duvalia) dilatatus* de Blainville — Simionescu, pp. 109- 110, pl. I, fig. 1, non fig. 2.
? 1907 *Duvalia dilatata* (de Blainville) — Karakasch, p. 19, pl. I, figs. 1, 7, 14.

1913 *Belemnites (Duvalia) dilatatus* de Blainville — Kilian, pl. 5, fig. 1.
non 1929 *Duvalia dilatata* (de Blainville) — Barrabé, pl. VIII, fig. 9 = *Duvalia soromarayensis* Combémorel, 1988, fide Combémorel, 1988.
1934 *Duvalia dilata* (de Blainville) (sic!) — Stefanov, p. 221.
non 1935 *Duvalia dilatata* (de Blainville) — Stolley, pp. 66-67, pl. II, figs. 6-7 = *Duvalia ceramensis* Challinor, 1989, fide Challinor, 1989.
? 1936 *Duvalia dilatata* (de Blainville) — Besaire, p. 148, pl. XXIII, fig. 5.
non 1942 *Duvalia dilatata* (de Blainville) — Dacqué, pl. II, fig. 8 (= *D. emericii* (Raspail, 1829)).
1960 *Duvalia dilatata* (de Blainville) — Kabanov, pl. 1, fig. 11.
1964 *Duvalia dilatata* (de Blainville) — Fülöp, pl. XXIX, fig. 5.
1965b *Duvalia dilatata* (de Blainville) — Stoyanova-Vergilova, pp. 191-194, pl. V, fig. 10; pl. VII, figs. 1-3; pl. VIII, figs. 1-2; text-figs. G-I.
1970 *Duvalia dilatata dilatata* (de Blainville) — Stoyanova-Vergilova, pp. 54-55, pl. XXVII, fig. 9; pl. XXIX, figs. 1-5; pl. XXXIII, figs. 5-6.
1973 *Duvalia dilatata dilatata* (de Blainville) — Combémorel, pp. 142-144, pl. 2, fig. 10; pl. 3, figs. 1-5.
1973 *Duvalia dilatata majoriana* Stoyanova-Vergilova — Combémorel, p. 146, pl. 3, fig. 8.
1975 *Duvalia dilatata* (de Blainville) — Lillo Bevia, pp. 387-388, pl. 2, fig. 5; pl. 3, figs. 8-9.
1979 *Duvalia dilatata* (de Blainville) — Combémorel, p. 72, text-fig. 19.
? 1986 *Duvalia dilatata* (de Blainville) — van Diggelen, p. 25, text-fig. 27.1a.
1991 *Duvalia binervia* (de Blainville) — Kakabadze & Keleptrishvili, p. 35, pl. I, fig. 2.
1992 *Duvalia dilatata* (de Blainville) — Barskov & Weiss, text-fig. 6d-e.
1994 *Duvalia dilatata dilatata* (de Blainville) — Vašíček et al., p. 84-85, pl. 29, figs. 1-2.
1994 *Duvalia dilatata dilatata* (de Blainville) — Combémorel et al., p. 54, pl. 1, figs. 1-2.

Material — Three incomplete guards (RGM 345 213, 345 245, 345 252).

Description — A compressed elongated guard with a dorsally placed apex was collected at the base of the Alpillensis Subzone. In lateral view both dorsal and ventral sides are convex. Towards the apex a clear inclination in the rising outline of the ventral side can be noted. The alveolus is not preserved. The overall cross- section is subcircular with two more or less parallel lateral sides. No groove can be observed. Obviously, both the alveolus and the groove are (very) short.

In the upper Hauterivian strata two strongly compressed guards were found. The apex is rounded and orientated towards the dorsal side. In these more mature individuals a bulge can be observed at the dorsal side of the apical region. The dorso-ventral cross-sections vary from elongated subrounded to stretched subrounded.

In general the groove is small and often not observed because it is only present at the very beginning of the alveolar part.

RGM	R	Sa	Hm	Lm	Icm	Id
345 213	42	42	18.1	8.6	2.10	2.32
345 252	50	50	24.3	11.1	2.19	2.06

Comparison — Of the three subspecies of *D. dilatata* that are described in literature only *D. dilatata dilatata* was collected. The subspecies *D. dilatata majoriana* Stoyanova-Vergilova emend. Vašíček et al., 1994 has a much deeper alveolus. *D. dilatata dilatata* and *D. dilatata majoriana* can rather easily be distinguished from *D. dilatata binervioides* Stoyanova-Vergilova, 1965b by the overall dimensions. The latter being much more compressed and mature specimens are of much smaller size.

Stratigraphical distribution — Base to middle Alpillensis Subzone and base of Ohmi Subzone to top of Catulloi Subzone, beds: Y234-244 (RGM 345 213); A144-145 (RGM 345 245) and A154-170 (RGM 345 252).

Range — Compare Fig. 5.

Geographical distribution — Algeria (Oppel, 1865), Austria (Uhlig, 1882), Bulgaria (Stefanov, 1934; Tzankov, 1937; Koen, 1946; Stoyanova-Vergilova, 1965b, 1970), N Caucasus (Kabanov, 1960), Crimea (Karakasch, 1907; Kabanov, 1960; Barskov & Weiss, 1992), S Germany (Winkler, 1868; Uhlig, 1882), France (Combémorel, 1973; a.o.), Hungary (Fülöp, 1958, 1964), Italy (Travaglia, 1880; Combémorel et al., 1994), Poland (Lefeld, 1974), Roumania (Simionescu, 1898), Slovakia (Michalík & Vašíček, 1989; Vašíček et al., 1994), Spain (Hermite, 1879; Mallada, 1887; Nicklès, 1891; Colmenero et al., 1974; Lillo Bevia, 1975; this paper), Switzerland (de Loriol, 1861), and Tunisia (Pervinquière, 1907; Memmi, 1981).

Duvalia grasiana (Duval-Jouve, 1841)

? 1829 *Belemnites convexus* — Raspail, p. 312, pl. 7, fig. 57 (nom. oblitum).
1841 *Belemnites Grasianus* Duval-Jouve, p. 63, pl. 7, figs. 1-3.
1883 *Belemnites Grasi* Duval-Jouve — Uhlig, p. 174, pl. I, figs. 5-6, 11 (nom. vanum).
1907 *Duvalia Grasi* (Duval-Jouve) — Karakasch, pp. 19-20, pl. I, figs. 2-5 (nom. vanum).
1911 *Duvalia grasiana* (Duval-Jouve) — Stolley, pp. 68-72, pl. VII, figs. 1-12; pl. VIII, figs. 1-19.
1913 *Belemnites (Duvalia) grasianus* Duval-Jouve — Kilian, pl. 5, fig. 9; pl. 12, fig. 2.
1942 *Duvalia grasiana* (Duval-Jouve) — Dacqué, pl. II, fig. 7; pl. XIII, figs. 4-5.
? 1959 *Duvalia grasiana* (Duval-Jouve) — Khalilov, pp. 49, 52, 54, pl. I, fig. 4.
1960 *Duvalia grasiana* (Duval-Jouve) — Kabanov, pl. I, fig. 9.
1964 *Duvalia lata* (de Blainville) — Fülöp, pl. XVII, figs. 9, 12; pl. XVIII, fig. 10.
1964 *Duvalia grasiana* (Duval-Jouve) — Fülöp, pl. XVII, fig. 7.
1965b *Duvalia grasiana* (Duval-Jouve) — Stoyanova-Vergilova, pp. 202-204, pl. IV, figs. 1-3, 4(?), 5-8 and text-fig. P.
1968 *Duvalia grasiana* (Duval-Jouve) — Wiedmann & Dieni, pp. 160-161, pl. XVII, fig. 2.
1970 *Duvalia grasiana* (Duval-Jouve) — Kotetishvili, pp. 106-107, pl. XX, fig. 5.
1970 *Duvalia grasiana* (Duval-Jouve) — Stoyanova-Vergilova, p. 57, pl. XXXI, figs. 1-3, 4(?), 5-7; pl. XXXIII, fig. 2.
1972 *Duvalia grasiana* (Duval-Jouve) — Ali-Zade, pp. 132-133, pl. II, fig. 11; pl. III, figs. 5-6(?).
1973 *Duvalia grasiana* (Duval-Jouve) — Combémorel, pp. 149-151, pl. 4, figs. 4-5.
1973 *Duvalia grasiana* (Duval-Jouve) — Nazarishvili, pp. 81-82, pl. 7, figs. 19-21.
1975 *Duvalia* cf. *binervia* (Raspail) — Lillo Bevia, p. 388, pl. II, figs. 6-7.
1979 *Duvalia grasiana* (Duval-Jouve) — Mutterlose, pl. 1, fig. 4.
1980 *Duvalia graziana* (Duval-Jouve) (sic!) — Jeletzky, pl. I, fig. 1a-h; pl. II, fig. 1a-d; pl. III, fig. 1a-d; pl. IV, fig. 2a-c.
1987 *Duvalia grasiana* (Duval-Jouve) — Mutterlose, pl. 2, figs. 1, 2, 6.
1988 *Duvalia grasiana* (Duval-Jouve) — Ali-Zade, p. 392, pl. I, fig. 8.
1989 *Duvalia grasiana* (Duval-Jouve) — Conte, p. 28, figs. a-b.
1989 *Duvalia grasiana* (Duval-Jouve) — Michalík & Vašíček, pl. 2, fig. 4.
1992 *Duvalia grasiana* (Duval-Jouve) — Barskov & Weiss, text-fig. 6a.
1994 *Duvalia grasiana* (Duval-Jouve) — Vašíček et al., p. 87, pl. 30, figs. 3-6.

Material — Two nearly complete guards and one part of a guard (RGM 345 260, 345 263, 345 267).

Description — Guards with usually a broad, relative deep groove that runs

towards the apical part of the guard. The dorsal and ventral sides are convex, the ventral-side being more curved. The apex is pointed. The lateral sides are convex to plano-convex. The transverse cross-section is rounded, being more rhombic towards the alveolar side and more elongated rounded towards the apex. The maximum cross-section is situated near the end of the groove towards the apical part of the guard. The alveolus is very deep, extending halfway the guard.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id
345 260	63	??	15.4	11.7	1.32	17.8	13.6	1.31	3.54
345 267	25	13	11.5	7.9	1.46	—	—	—	—

Comparison — Major difference with *Duvalia lata* is the extension of the alveolus and the stratigraphical occurrence. The alveolus is much deeper in *D. grasiana* as compared with *D. lata* (see Stoyanova-Vergilova, 1965b: text-fig. P). *Duvalia grasiana* occurs in Barremian to Aptian strata whereas *D. lata* is known from Tithonian to Valanginian (Hauterivian) strata.

Stratigraphical distribution — Base Hugii Zone to Sarasini/Weissi Zone, beds: A177-178 (RGM 345 260); Q69-74 (RGM 345 267); V105-112 (RGM 345 263).

Range — Compare Fig. 5.

Geographical distribution — Algeria (Pervinquière, 1907), Azerbaijan (Khalilov, 1959; Ali-Zade, 1988), Bulgaria (Stoyanova-Vergilova, 1965b, 1970), N Caucasus (Kabanov, 1960; Ali-Zade, 1988), Crimea (Karakasch, 1907; Kabanov, 1960; Ali-Zade, 1988; Barskov & Weiss, 1992), N Germany (Stolley, 1911; Mutterlose, 1979, 1987), Georgia (Kotetishvili, 1970; Ali-Zade, 1988; Keleptrishvili, 1990), France (Hébert, 1871; Combémorel, 1973; a.o.), Hungary (Fülöp, 1964); Italy (Rodighiero, 1919; Wiedmann & Dieni, 1968), Madagascar (Combémorel, 1973), Slovakia (Michalík & Vašíček, 1989; Vašíček et al., 1994), SE Spain (this paper), Switzerland (Ooster, 1863), Tunisia (Pervinquière, 1907; Memmi, 1981), and Turkey (cf., Doyle & Mariotti, 1991).

Remarks — As stated in Wiedmann & Dieni (1968) the variety *Duvalia grasiana* var. *schwetzovi* Eristavi, 1957 is an endmember of the quite variable *D. grasiana*. The variation *schwetzovi* can be recognized because of the rhomboidal cross-section, due to lateral keels.

Barskov & Weiss (1992) consider *D. grasiana* as a direct descendant from *D. lata*.

Duvalia cf. *haugi* (Kilian in Bertrand & Kilian, 1889).
Pl. 6, fig. 5.

1889 *Belemnites (Duvalia) Haugi* — Kilian in Bertrand & Kilian, p. 636, pl. XXVII, fig. 1.
1895 *Belemnites (Duvalia) Haugi* Kilian — Kilian, p. 679.

Material — Two largely incomplete specimens (RGM 345 215, 345 220).

Description — Guards with a characteristic pentagonal cross-section and a small clear groove, with a rounded base. Both the dorsal and the ventral side are subrounded in cross-section. The lateral sides are rounded but with a clear angle. Longitudinal extensions are placed on the dorsal side of the guards. The overall cross-section is thus pentagonal with the ventral seide being slightly elongated compared to the dorsal side.

Stratigraphical distribution — Alpillensis Zone to middle Pertransiens Subzone, beds: X234-244 (RGM 345 215), Y267-274 (RGM 345 220).

Range — Compare Fig. 5.

Geographical distribution — France (Kilian, 1895), Spain (Kilian in Bertrand & Kilian, 1889; this paper).

Remarks — The collected parts have the general characteristics of *D. haugi*, but are not complete enough to ensure a certain identification.

Duvalia hybrida (Duval-Jouve, 1841)
Pl. 4, fig. 5.

? 1829 *Belemnites amorphus* — Raspail, p. 314, pl. 7, fig. 49 (nom. oblitum).
? 1829 *Belemnites formosus* — Raspail, p. 311, pl. 7, fig. 58 (nom. oblitum).
e.p. 1841 *Belemnites hybridus* Duval-Jouve, pp. 51-54, pl. 3, figs. 1(?), 2, 3(?), 4(?). 5, 7-8, 15(?), 16(?), non figs. 6, 9-14 = *D. binervia*.
1858-1869 *Belemnites binervius* Raspail — Pictet & Campiche, p. 109, pl. XIII, fig. 12.
non 1878 *Duvalia hybrida* (Duval-Jouve) — Bayle, pl. XXXII, figs. 8-13 = *D. binervia*.
? 1907 *Duvalia crimica* — Karakasch, p. 20. pl. 1, fig. 8.
? 1965b *Duvalia crimica* Karakasch — Stoyanova-Vergilova, p. 205, pl. VII, fig. 4.
1965b *Duvalia hybrida* (Duval-Jouve) — Stoyanova-Vergilova, pp. 190-191, pl. VIII, fig. 5, text-fig. F.
1965b *Duvalia binervia* (Raspail) — Stoyanova-Vergilova, pp. 187-190, pl. V, fig. 2, text-fig. Db.
1970 *Duvalia hybrida* (Duval-Jouve) — Stoyanova-Vergilova, p. 54, pl. XXX, fig. 7; pl. XXXIII, fig. 9.
1970 *Pseudoduvalia polygonalis* (de Blainville) — Stoyanova-Vergilova, p. 59, pl. XXVII, fig. 4.
? 1970 *Pseudoduvalia crimica* (Karakasch) — Stoyanova-Vergilova, pp. 60-61, pl. XXXI, fig. 9.
1970 *Duvalia binervia* (Raspail) — Stoyanova-Vergilova, p. 53, pl. XXVII, fig. 2; pl. XXXIII, fig. 11.
? 1972 *Duvalia crimica* (Karakasch) — Ali-Zade, pp. 133-134, pl. II, fig. 10.
1973 *Duvalia hybrida* (Duval-Jouve) — Combémorel, pp. 148-149, pl. 4, figs. 2-3.
1994 *Duvalia hybrida* (Duval-Jouve) — Vašíček et al., p. 87, pl. 29, figs. 10-12.

Material — One neraly complete guard (RGM 345 250).

Description — A compressed elongated guard with near parallel dorsal and ventral sides. The cross-section in the anterior part is rhomboidal. A blunt apex is preserved, orientated to the dorsal side. The maximum cross-section is situated in the alveolar region where a small bulge can be observed at the dorsal side. A second bulge can be observed near the apex. However, the latter is not well developed in this specimen. The lateral sides are convex and do show the maximum cross-section near the apical side of the guard. No groove is preserved, but the remains of a dorsal keel-like extension can be observed in the laveolar region. The apical line is plano-convex.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Igr
345 250	55	44	16.7	10.5	1.59	17.0	11.9	1.43	3.24	4.19

Comparisson — *Duvalia crimica* Karakasch, 1907 is quite comparable to *D. hybrida*. Contrary to the opinion of Stoyanova-Vergilova (1970) who compares this specimen to *Pseudoduvalia polygonalis* (de Blainville, 1825), it is in the author's vision identical or very close to *D. hybrida* (probably in the variation range of the highly variable *D. hybrida*). This is based upon the description and the pictures in Stoyanova-Vergilova (1965b, pl.VII, fig.4) from this material.

Stratigraphical distribution — Boundary interval of the Hugii and Nicklesi Zones, bed: A195-205c.

Range — Compare Fig.5.

Geographical distribution — Bulgaria (Stoyanova-Vergilova, 1965b, 1970; Late Hauterivian), France (Combémorel, 1973; a.o. (up to the Early Hauterivian), Slovakia (Vašíček et al., 1994), SE Spain (this paper; earliest Barremian) and Switzerland (Pictet & campiche, 1858-1860).

Remarks — *Pseudoduvalia* spp. and *D. hybrida* do probably show a phylogenetic relation.

Duvalia lata (de Blainville, 1825)
Pl. 1, figs. 1-4.

*1825	*Belemnites latus* de Blainville, p. 121, pl. 5, fig. 10.
e.p. 1840	*Belemnites latus* de Blainville — d'Orbigny, pp. 48-50, pl. 4, figs. 4-8, non figs. 1-3 = *Rhopaloteuthis conica* (de Blainville, 1825).
e.p. 1841	*Belemnites latus* de Blainville — Duval-Jouve, pp. 61-62, pl. 6, figs. 1(?), 2-3, 5, 6-11(?), non fig. 4 = *R. conica*.
1858	*Belemnites latus* de Blainville — Pictet & de Loriol, pp. 11-12, pl. Ibis, figs. 9-10, 11(?).
1858-1860	*Belemnites latus* de Blainville — Pictet & Campiche, pp. 106-107, pl. XIII, figs. 10-11.
1867	*Belemnites latus* de Blainville — Pictet, pp. 53-54, pl. 8, fig. 1.
1868	*Belemnites latus* de Blainville — Pictet, pp. 216-217, pl. 36, figs. 1-2.
1878	*Duvalia lata* (de Blainville) — Bayle, pl. XXXI, figs. 3-8.
1887	*Belemnites latus* de Blainville — Mallada, pp. 7-8, pl. 1(1882), figs. 17-18.
1902	*Belemnites (Duvalia) lata* (de Blainville) var. *constricta* Uhlig, pp. 18-19, pl. I, fig. 4.
1907	*Duvalia lata* (de Blainville) var. *zeugitana* Pervinquière, pp. 404-405, fig. 157.
non 1935	*Duvalia lata* (de Blainville) — Stolley, pp. 67-68, pl. II, fig. 8 = *Duvalia robusta* Challinor, 1989, fide Challinor, 1989.
1942	*Duvalia lata* (de Blainville) — Dacqué, pl. V, figs. 5-6; pl. VIII, fig. 8.
? 1946	*Duvalia lata* (de Blainville) — Tzankov, pl. XVII, figs. 7-8.
? 1958	*Duvalia lata* (de Blainville) — Krimholz, p. 161, pl. LXVIII, fig. 8.
1960	*Duvalia lata* (de Blainville) — Kabanov, pl. 1, fig. 8.
1960	*Duvalia lata constricta* (Uhlig) — Kabanov, pl. 1, fig. 10.
e.p. 1964	*Duvalia lata* (de Blainville) — Fülöp, pl. XII, fig. 10; non pl. XVII, figs. 9, 12 nec pl. XVIII, fig. 10 = *Duvalia grasiana* (Duval-Jouve, 1841).
1965b	*Duvalia lata* (de Blainville) — Stoyanova-Vergilova, pp. 184-185, pl. I, figs. 1-3.
1965b	*Duvalia lata constricta* (Uhlig) — Stoyanova-Vergilova, pp. 185-186, pl. VIII, figs. 3-4.
1967	*Duvalia lata* (de Blainville) — Kabanov, pl. I, fig. 6; pl. III, fig. 8; pl. V, fig. 2.
1967	*Duvalia constricta* (Uhlig) — Kabanov, pl. III, fig. 6 (nom. vanum).
1970	*Duvalia lata lata* (de Blainville) — Stoyanova-Vergilova, p. 51, pl. XXVI, figs. 1-3; pl. XXXII, fig. 19.
1970	*Duvalia lata constricta* (Uhlig) — Stoyanova-Vergilova, p. 52, pl. XXVI, figs. 4-5.
1972	*Duvalia lata* (de Blainville) — Ali-Zade, pp. 130-131, pl. II, figs. 3-4; pl. III, figs. 1-4.
1973	*Duvalia lata* (de Blainville) — Combémorel, pp. 137-139, pl. 1, figs. 1-8.
1973	*Duvalia lata lata* (de Blainville) — Nazarishvili, pp. 82-83, pl. 7, figs. 22-23.
1973	*Duvalia lata constricta* (Uhlig) — Nazarishvili, pp. 83-85, pl. 7, figs. 24-26.
1975	*Duvalia lata* (de Blainville) — Lillo Bevia, p. 387, pl. 2, fig. 4; pl. 3, figs. 10- 11.
1979	*Duvalia lata* (de Blainville) — Combémorel, p. 70, text-fig. 16.
? 1979	*Duvalia lata* (de Blainville) — Mutterlose, pp. 124-125, pl. 1, fig. 3.
1986	*Duvalia lata* (de Blainville) — van Diggelen, p. 25, text-fig. 27.2.
1988	*Duvalia lata* (de Blainville) — Ali-Zade, pp. 391-392, pl. 1, fig. 7.

1988 *Duvalia lata lata* (de Blainville) — Horák, pp. 61-62, pl. I, fig. 1.
1988 *Duvalia lata constricta* (Uhlig) — Horák, pp. 62-63, pl. II, fig. 1.
1988 *Duvalia lata* (de Blainville) — Klein, pl. 7, fig. 1.
1991 *Duvalia lata* (de Blainville) — Doyle & Mariotti, pp. 362-363, pl. 4, fig. 8.
1992 *Duvalia lata* (de Blainville) — Barskov & Weiss, text-fig. 6b.
1994 *Duvalia lata constricta* (Uhlig) — Vašíček et al., p. 84, pl. 28, figs. 1-2.

Material — Eighteen specimens in different state of preservation (RGM 345 200, 345 202, 345 205, 345 216, 345 221-222, 345 225, 345 231-233, 345 237, 345 239-241, 345 277-278, 345 283-284).

Description — Guards with the characteristic duvaliid outline. The dorsal side is convex parallel whereas the ventral side is convex. Towards the pointed to '-mucronate' apex a clear increase in the rising outline of the ventral side can be noted in all specimens, including the adolescent guards.

The dorsal groove is clear, broad and subrounded at the base. It runs over the larger part of the guard approximately untill the point of the maximum diameter in the cross-section. At this point the groove disappears gradually.

The apex is clearly orientated towards the dorsal side.

The lateral sides are parallel to convex. In large individuals a ventral bulge can be observed near the place of the maximal cross-section in the transverse section. It runs onto the lateral sides of the ventral area. The alveolus is relative undeep compared to the length of the groove. The alveolar side is subrounded in cross-section. Lateral lines can be observed in juvenile specimens.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Igr
345 200	76	12	14.8	8.9	1.66	15.0	9.0	1.67	5.07	1.35
345 202	64	29	19.8	15.4	1.29	26.1	16.6	1.57	2.45	1.88
345 225	43	—	15.3	8.8	1.74	15.5	9.0	1.72	2.77	—
345 232	58	25	15.0	9.2	1.63	19.0	13.2	1.44	3.05	2.72
345 239	73	29	17.1	13.2	1.3	22.9	16.3	1.40	3.19	2.2
345 240	36	11.5	9.3	6.0	1.55	10.4	6.6	1.58	3.46	1.92
345 277	55	27	—	14.0	—	23.0	16.3	1.41	2.39	1.93
345 283	27	6	—	—	—	11.4	7.9	1.44	2.37	—

Comparison — *D. lata* is comparable to *D. grasiana*. However, the latter species has a much deeper alveolus. It also shows a totally different stratigraphical range (Barremian-Aptian).

D. aesinensis Combémorel & Mariotti (1986a) is much more slender as is *D. ensifer* (Oppel, 1865), compared with *D. lata*.

Stratigraphical distribution — Top Jacobi Subzone to middle Pertransiens Zone, beds: Z131 (RGM 345 225); Y189-190 (RGM 345 277-278), Y191-195 (RGM 345 239), Y201-207 (RGM 345 283), Y209-212 (RGM 345 284), Y218 (RGM 345 233), X219 (RGM 345 202), X229 (RGM 345 205); Y233-235 (RGM 345 232), X244-249 (RGM 345 241); X258 (RGM 345 240), Y261b (RGM 345 216); Y262 (RGM 345 200), Y266-266b (RGM 345 237), Y266-300 (RGM 345 231), Y267-274 (RGM 345 221-222).

Range — Compare Fig. 5.

Geographical distribution — Algeria (Bayle & Ville, 1854; Coquand, 1867; Pomel,

1889), W Alpes (Kilian, 1891, 1892), Austria (von Richthofen, 1862; Uhlig, 1882; Vacek, 1879), Azerbaijan (Ali-Zade, 1960, 1972, 1988; Berriasian- Hauterivian), Bulgaria (Stefanov, 1934; Koen, 1946; Stoyanova-Vergilova, 1965b, 1970; Valanginian-Early Hauterivian, E Caucasus (Khalilov, 1971), N Caucasus (Krimholz, 1958; Kabanov, 1960), Crimea (Favre, 1877a; Retowski, 1894; Karakasch, 1907; Ali-Zade, 1988; Barskov & Weiss, 1992), France (Pictet, 1867; Hébert, 1867, 1871; Toucas, 1890; Combémorel, 1973; a.o.), Georgia (Ali-Zade, 1988; Keleptrishvili, 1990 (Valanginian-Hauterivian), Southern-Germany (Schlosser, 1893), Great Britain (?, Mutterlose, 1979), Hungary (Fülöp, 1964, (Valanginian-Barremian), Italy (Zigno, 1849), Madagascar (?, Combémorel, 1973), Poland (Ali-Zade, 1988), Roumania (Stefanescu, 1897; ex gr., Simionescu, 1898), Slovakia (Horák, 1988; Michalík & Vašíček, 1989; Vašíček et al., 1994), Spain (Mallada, 1882; Kilian in Bertrand & Kilian, 1889; Fallot, 1922; Lillo Bevia, 1975; this paper), Switzerland (Lory, 1857; Pictet & de Loriol, 1858; Pictet & Campiche, 1858-1860; Ooster, 1863; Gilliéron, 1873), Tunisia (Memmi, 1981; Pervinquière, 1907), and Turkey (Doyle & Mariotti, 1991).

Remarks — *D. lata* together with *Berriasibelus exstinctorius* (Raspail, 1829) is collected and described from the Boreal Realm by Mutterlose (1979). These specimens are found in sediments comparable to the upper part of the Nodosoplicatum Zone and lowerpart of the Sayni Zone from the Tethyan Realm.

Different subspecies are described from *D. lata*, i.e. *D. lata lata* (in: Stoyanova-Vergilova, 1970 = *D. lata* var. *lata*, in: Combémorel, 1973), *D. lata constricta* Uhlig, 1902 (= *D. lata* var. *constricta*, in: Combémorel, 1973) and *D. lata zeugitana* Pervinquière, 1907 (= *D. lata* var. *zeugitana*, in: Combémorel, 1973). In the view of Combémorel (1973) these are no more than intraspecific variations because he has collected them from the same stratigraphical population. The 'endmembers' are on the one hand *D. lata* and on the other hand *D. lata constricta*. This opinion is shared by Doyle & Mariotti (1991).

D. lata constricta has the following characteristics: less profound alveolus, a less cylindrical form and a characteristic constriction of the guard in the anterior part (derivation of name). This would be sufficient enough to separate them as subspecies rather than a variation in the view of Vašíček et al. (1994).

Moreover, in the sediments of the Río Argos (near Caravaca) specimens of the *D. lata* group are found which are even more slender compared with *D. lata lata* and probably comparable to Paquier's (1900, p. 461) *Duvalia* cf. *lata* from the Dalmasi Zone. Their compressional index (Ic) is comparable to *Duvalia guillantona* Besaire emend. Combémorel, 1988 (Valanginian or Middle Aptian of Madagascar). They differ from *D. lata* by the absence of the constriction in the alveolar region, showing more parallel sides, upto the apical area and possessing a longer dorsal groove.

Duvalia cf. *tithonia* (Oppel, 1865)

1865 *Belemnites tithonius* Oppel, p. 545.
1868 *Belemnites tithonius* Oppel — von Zittel, p. 37, pl. I. figs. 12-13.
1868-1876 *Belemnites tithonius* Oppel — Gemmellaro, p. 20, pl. III, figs. 6-7.
1870 *Belemnites tithonius* Oppel — von Zittel, p. 29, pl. 25, fig. 6 (partim, non fig. 7).
1880 *Belemnites tithonius* Oppel — Favre, pp. 19-20, pl. 1, figs. 18-19.
1894 *Belemnites tithonius* Oppel — Retowski, pp. 221-222, pl. XIV, figs. 3-4.

1900 *Duvalia tithonia* (Oppel) — Paquier, p. 430.
non 1922 *Belemnites tithonius* Oppel — de Gregorio, p. 8, pl. I, fig. 11.
1932 *Duvalia tithonia* (Oppel) — Krimholz, pp. 43-44, pl. II, figs. 45-48.
1965 *Polygonalia polygonalis* (de Blainville) — Ali-Zade, p. 64.
1972 *Pseudoduvalia tithonius* (Oppel) — Ali-Zade, p. 114.
1986b *Duvalia tithonica* (Oppel) — Combémorel & Mariotti, p. 36-39, text- fig. 2 (nom. nullum).
1990 *Duvalia tithonica* (Oppel) emend. von Zittel, 1868 — Combémorel & Mariotti, p. 211, pl. 1, fig. 6 (nom. nullum).
1992 *Pseudoduvalia tithonica* (Oppel) — Barskov & Weiss Weiss, p. 61.

Material — One incomplete specimen (RGM 345 287).

Description — The preserved anterior part shows the characteristic cross- section of *D. tithonia* with an inverse convex ventral (excavated, in: Combémorel & Mariotti, 1986b) side and a flattened dorsal side.

Comparison — It is in some way comparable to Pseudoduvalia polygonalis as described by Combémorel & mariott (1986b) but differs in various ways, among others by the larger dimension of D. tithonia and the different cross- sections throughout the guard. See Combémorel & Mariotti (1986b: 38) for more details.

Stratigraphical distribution — Jacobi Subzone, bed: Z76-78.

Range — Compare Fig. 5.

Geographical distribution — E Caucasus (Khalilov, 1971), Crimea (Retowski, 1894; Krimholz, 1932; Barskov & Weiss, 1992), France (Toucas, 1890; Paquier, 1900), Hungary (von Zittel, 1868; ?, Fülöp, 1976), Italy (von Zittel, 1868; Gemmellaro, 1868-1876; Combémorel & Mariotti, 1986b, 1990), Slovakia (Remeš, 1897, 1902), SE Spain (this paper), Switzerland (Favre, 1880), Turkey (Doyle & mariotti, 1991), and Tunisia (Memmi & Salaj, 1975).

Remarks — The preserved part is not complete enough to assure a positive determination thus it is tentativelly called *D.* cf. *tithonia.*

Duvalia sp. A
Pl. 4, figs. 1-2.

Material — One guard in which the alveolar region is not preserved (RGM 345 266).

Diagnosis — Anteriorly extremely compressed guard. Posteriorly swollen with a bulge like expulsion at the dorsal side.

Description — A characteristic duvaliid guard without any sign of a groove. The apex is pointed and orientated at the dorsal side. The dorsal side is somewhat more pronounced compared to the ventral side as the result of a small bulge. The lateral sides are slidly compressed in the stem region and very strongly in the anteriorly region. The alveolar part is not preserved.

RGM	R	Sa	Hx	Lx	Ica	Hm	Lm	Icm	Id
345 266	52	52	10.4	3.8	2.74	18.5	10.6	1.75	2.81

Comparison — The dorso-ventral section can be compared with *Duvalia emericii* (Raspail, 1829), but the bulge is not as pronounced as in the latter, resulting in a diffe-

rent cross-section. *D. emericii* is of larger size and shows a clear groove in the alveolar area. Moreover, these species do not share the same stratigraphical position as *D. emericii* is a typical representant of the Valanginian fauna.

The general outline of the described specimen can be compared with *Duvalia binervia* (Raspail, 1829), *Duvalia sakalava* Besaire, 1930 (Neocomian of Madagascar) and *Duvalia ceramensis* Challinor, 1989 (Valanginian of Misool, Irian Jaya) but differs in the larger size, and in the absence of the characteristic lateral grooves by the latter three species. Moreover, they lack the extreme constriction within the anterior end.

Stratigraphical distribution — Around the boundary of the Hugii and Nicklesi Zones, bed: A192-198.

Range — Compare Fig. 5.

Geographical distribution — SE Spain (this paper).

Remarks — The anterior part is slightly exfoliated. However, the extreme flattening is undoubtly not the result of this exfoliation.

Duvalia sp. B
Pl. 4, figs. 3, 6.

Material — One guard (RGM 345 264).

Diagnosis — Medium sized guard with characteristic depressions in the apical area. Relatively short dorsal groove which debouches posteriorly in a shallow zone. The extension of the alveolus is short compared to the length of the groove.

Description — The specimen shows a rather characteristic development in the apical area. Two longitudinal incisions run from the apex towards the point of maximum diameter. The apex is compressed, pointed and dorsally placed. The alveolar part of the guard is not completely preserved. The alveole runs for c. 9 mm into the guard, the alveolar angle is 25° (dorso-ventrally). The groove is clear but not deep and can be followed for 12 mm before debouching in a 6 mm long shallow zone in which the groove disappears. The dorsal and ventral sides diverge towards the apex. The dorsal side reaches its maximum divergation at the point of maximum diameter. The ventral side well before it. The lateral sides are almost parallel (slightly hastate outline in dorsal view) untill the area in which the apical incisions start, somewhere between the point where the ventral and dorsal side have their maximum divergation.

The apical line is plano-convex, orientated to the ventral side with a small steepening at the point of maximum diameter, resulting in a short but obvious rise towards the apex. So the apical line is skewed towards the apex. The cross-section in the alveolar area shows a stretched rounded rhomboid. From an apical view the ventral side is much more bulged compared to the dorsal side.

RGM	R	pa	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Igr
345 264	50	41	38	15.3	10.3	1.49	18.1	11.0	1.65	2.76	3.7

Comparison — In *Duvalia grasiana* and *D. grasiana* var. *schwetzovi* the dorsal groove is much longer and the alveolus is much deeper. Stolley (1911) showed that *D. grasiana* is quite variable. One specimen described by Stolley (pl. VIII, fig. 11) as an aborant

specimen is somewhat comparable our specimen but differs in the apparent constriction in the alveolar part of the guard, the absence of a clear bulge in the posterior apical region.

Our material differs from *Duvalia hybrida* and *D. crimica* in the development of the dorsal groove, the position of the maximum cross-section and the presence of a ventral bulge. It differs from *D. satelles* Barskov & Weiss, 1992 (Barremian-Aptian of Crimea) by a different transverse cross-section in the apical area, shorter groove and less profound alveolus.

The specimen differs from *Duvalia laniraensis* Combémorel, 1988 (Late Hauterivian of Madagascar) by the overall size. Especially the hight of the guard is much less and the transverse section in the apical area is much more compressed. *D. soromarayensis* Combémorel, 1988 (Hauterivian of Madagascar) has a much less profound alveolus and the overall shape is different, especially as the maximal cross-section of the latter is found in the anterior part.

Stratigraphical distribution — Top Caillaudianus Zone, bed: Q74.

Range — Compare Fig. 5.

Geographical distribution — SE Spain (this paper).

Remarks — It could be an infraspecific variation of *D. grasiana*.

Duvalia sp. nov.? indet.
Pl. 2, figs. 5-6.

Material — One specimen (RGM 345 290).

Diagnosis — Extremely compressed duvaliid guard.

Description — The specimen shows the characteristic duvaliid compression, quite strong in this example, of the guard with a dorsal orientated compressed apex. Unfortunately the alveolar side is not completely preserved. As a result the alveolus is not present nor is the alveolar opening.

RGM	R	Hm	Lm	Icm	Id
345 290	49	15.1	8.9	1.7	3.25

Comparison — The specimen differs from *Duvalia lata* and *D. ensifer* by the much stronger compression. In *D. ensifer* and *D. haugi* the dorsal groove extends over 2/3 of the guard and the cross-section is not oval but subrhomboidal.

Duvalia aesinensis Combémorel & Mariotti, 1986a has a more parallel outline and a much smaller height. Our material differs from *D. guillantona* by the absence of an anterior incision, less deep alveolus (?), the position of the apex, and the nature of the apex.

Duvalia esbus (de Gregorio, 1886) appears to be stronger compressed and shows a more constricted anterior area.

Stratigraphical distribution — Jacobi Subzone, bed: Z85-87.

Range — Compare Fig. 5.

Geographical distribution — SE Spain (this paper).

Remarks — It is probably a new species, which is however, not sufficiently preserved.

Genus *Pseudobelus* de Blainville, 1825.

Type species — *Pseudobelus bipartitus* de Blainville, 1825

Description — Very elongated, slightly hastate guards which show a typical incision in profile which gives way to the characteristic eight-shaped cross-section. The guards are of small to moderate length. Generally slightly compressed guards, sometimes depressed (Im = 0.89 - 1.67). Small guards show often a spindle-shaped profile. Alveolar groove very short (roughly upto one- third of the length of the guard) compared to the length of the guard. Sometimes two dorsal alveolar grooves can be observed. Alveolus shallow to very shallow.

Range — *Pseudobelus* appears in Tithonian to Hauterivian (?Barremian) strata of the Tethyan Realm.

Pseudobelus bipartitus de Blainville, 1825
Pl. 6, figs. 1-2.

1825	*Pseudobelus bipartitus* de Blainville, p. 113, pl. 5, fig. 19.
e.p. 1840	*Pseudobelus bipartitus* de Blainville — d'Orbigny, pp. 45-47, pl. 3, figs. 6, 7, non figs. 8-12 = *Pseudobelus brevis* Paquier, 1900.
e.p. 1841	*Pseudobelus bipartitus* de Blainville — Duval-Jouve, pp. 41-42, pl. 1, fig. 1(?), 2, 7(?), 8(?), non figs. 3, 5-6 = *P. brevis*; nec fig. 4 = *P.* cf. *giziltchaensis* Ali-Zade, 1961.
? 1848	*Pseudobelus bipartitus* de Blainville — Quenstedt, p. 393, pl. 32, fig. 1-2.
e.p. 1858	*Pseudobelus bipartitus* de Blainville — Pictet & Loriol, pp. 2-4, pl. Ibis, figs. 1- 3(?), non figs. 4-5.
1887	*Pseudobelus bipartitus* de Blainville — Mallada, pp. 5-6, pl. 1 (1882), fig. 9, 10, 11(?).
non 1897	*Pseudobelus bipartitus* de Blainville — Remeš, p. 228.
non 1902	*Pseudobelus* cf. *bipartitus* de Blainville — Remeš, p. 214, pl. XX, figs. 42-43.
? 1906	*Pseudobelus* cf. *bipartitus* de Blainville — Bogdanovitch, p. 125, pl. VII, fig. 21.
1942	*Pseudobelus bipartitus* de Blainville — Dacqué, pl. VI, fig. 9.
? 1958	*Pseudobelus bipartitus* de Blainville — Krimholz, p. 161, pl. LXVIII, fig. 7.
1960	*Pseudobelus bipartitus* de Blainville — Kabanov, pl. 1, fig. 12.
1964	*Pseudobelus bipartitus* de Blainville — Fülöp, pl. XIV, fig. 14.
1967	*Pseudobelus bipartitus* de Blainville — Gustomesov, pp. 130-131, pl. II, fig. 5.
1970	*Pseudobelus bipartitus* de Blainville — Stoyanova-Vergilova, pp. 61-62, pl. XXVIII, fig. 9.
non 1972	*Pseudobelus bipartitus* de Blainville — Ali-Zade, pp. 128-129, pl. I, figs. 5-6; pl. II, fig. 12 = *P. brevis*.
1973	*Pseudobelus bipartitus* de Blainville — Combémorel, pp. 160-161, pl. 5, figs. 8-9.
1979	*Pseudobelus bipartitus* de Blainville — Combémorel, p. 74, text-fig. 23.
non 1986	*Pseudobelus bipartitus* de Blainville — van Diggelen, p. 25, text-fig. 26.2 = *P. brevis*.
1988	*Pseudobelus bipartitus* de Blainville — Ali-Zade, p. 391, pl. 1, fig. 3.
1988	*Pseudobelus bipartitus* de Blainville — Horák, p. 67, pl. I, fig. 2.
1991	*Pseudobelus bipartitus* de Blainville — Kakabadze & Keleptrishvili, pp. 36-37, pl. I, fig. 5.

Material — Eight largely incomplete specimens and one nearly complete specimen (RGM 345 201, 345 206, 345 209-210, 345 214, 345 217, 345 219, 345 235, 345 279).

Description — Elongated subrounded guards with clear and characteristic longitudinal incisions. These incisions give way to an eight-shaped cross-section. The incisions vary from moderate to deep, probably depending on age. The more juvenile, the deeper the lateral incision is.

The guard is smooth with overall parallel sides. Usually, the apex is situated in

the middle of the guard, sometimes slightly to the dorsal side. The dorsal groove is clear and varies in length.

RGM	R	Sa	Hm	Lm	Icm	Id
345 201	73	52	6.3	5.1	1.24	11.59
345 206	109	48	11.1	9.0	1.23	9.82

Comparison — See *Pb. brevis* below.

Stratigraphical distribution — Base Picteti Subzone to base Pertransiens Subzone, beds: Y186-189 (RGM 345 235), Y189-190 (RGM 345 279), X229 (RGM 345 206), X231 (RGM 345 209-210), Y247-248 (RGM 345 214); Y262 (RGM 345 201), Y267-267a (RGM 345 217), Y267- 274 (RGM 345 219).

Range — Compare Fig. 5.

Geographical distribution — Austria (?, von Richthofen, 1862; Vacek, 1879), Azerbaijan (Ali-Zade, 1960, 1988; Valanginian-Hauterivian), Bulgaria (Stoyanova-Vergilova, 1970; Hauterivian), E Caucasus (?, Bogdanovitch, 1906; Khalilov, 1971), N Caucasus (Ali-Zade, 1988), Crimea (Kabanov, 1960; Ali-Zade, 1988), France (Hébert, 1871; Combémorel, 1973; a.o.), Georgia (Krimholz, 1958; Ali-Zade, 1988; Keleptrishvili, 1990), S Germany (Schlosser, 1893), Hungary (Fülöp, 1958, 1964), Italy (Zigno, 1849; Ali-Zade, 1988), Poland (Uhlig, 1888), Roumania (Simionescu, 1898; Patrulius & Avram, 1976; Patrulius et al., 1976), Slovakia (Horák, 1988; Vašíček et al., 1994), Spain (Mallada, 1887; Douvillé, 1906; this paper), Switzerland (?, Pictet & de Loriol, 1858; pars, Gilliéron, 1873; Ooster, 1863), and Tunisia (Memmi, 1981; ?, Pervinquière, 1907).

Pseudobelus brevis Paquier, 1900
Pl. 6, figs. 3-4.

e.p. 1840	*Pseudobelus bipartitus* de Blainville — d'Orbigny, pp. 45-47, pl. 3, figs. 8-12, non figs. 6-7.
e.p. 1841	*Pseudobelus bipartitus* de Blainville — Duval-Jouve, pp. 41-42, pl. 1, figs. 3-6, non fig. 2.
? 1861	*Pseudobelus bipartitus* de Blainville — de Loriol, p. 20, pl. 1, fig. 4.
? 1868	*Pseudobelus bipartitus* de Blainville — Winkler, p. 24, pl. 4, fig. 4.
? 1887	*Pseudobelus bipartitus* de Blainville — Mallada, pp. 5-6, pl. 1 (1882), fig. 11.
1900	*Pseudobelus bipartitus* de Blainville mut. *brevis* Paquier, p. II. (pl. I, fig. 3, 5, 6; in: Duval-Jouve, 1841).
e.p. 1961	*Pseudobelus giziltchaensis* — Ali-Zade, pp. 495-497, pl. 1, fig. 1.
1972	*Pseudobelus bipartitus* de Blainville — Ali-Zade, pp. 128-129, pl. I, figs. 5-6; pl. II, fig. 12.
1973	*Pseudobelus brevis* Paquier — Combémorel, pp. 162-163, pl. 5, figs. 10-14.
1979	*Pseudobelus brevis* Paquier — Combémorel, p. 74, text-fig. 24.
1986	*Pseudebelus bipartitus* de Blainville — van Diggelen, p. 25, text-fig. 26.2.
1986	*Pseudebelus brevis* Paquier — van Diggelen, p. 25, text-fig. 26.3.
1988	*Pseudobelus brevis* Paquier — Klein, pl. 7, fig. 6.
1994	*Pseudobelus brevis* Paquier — Vašíček et al., pp. 88-89, pl. 27, figs. 5-6; pl. 29, figs. 5- 6.

Material — One incomplete specimen consisting of the apical part (RGM 345 269).

Description — An elongated, relative small guard with a pointed apex, more or less in the plane of symmetry. The characteristic eight-shape of the dorso-ventral cross-section is caused by deep lateral incisions. They run from the alveolar side to the apical side, sometimes even onto the apex. The apex may be slightly shifted

towards the dorsal side. The guards are always, but in varying intensity, striated or with a grainy surface.

Comparison — *P. brevis* differs from *P. bipartitus* in two ways: the guard is shorter and the surface is not smooth in *P. brevis*. It differs from *P. giziltchaensis* (described from Late Valanginian- Hauterivian deposits in Azerbaidjan, Crimea and Ukraine by Ali-Zade, 1961) by a parallel outline and not being spindle-like.

Stratigraphical distribution — Base of the Cruasense Subzone, bed: A53.

Range — Compare Fig. 5.

Geographical distribution — Caucasus (Ali-Zade, 1961, 1972), S Germany (?, Winkler, 1868; ?, Uhlig, 1882), France (Paquier, 1900; Combémorel, 1973; a.o.), Italy (near Asiago, Veneto; pers. obs.), Slovakia (Michalík & Vašíček, 1989; Vašíček et al, 1994), SE Spain (Mallada, 1882; this paper), Switzerland (?, de Loriol, 1861; pars, Gilliéron, 1873), and Tunisia (Memmi, 1981).

Remarks — Spindle-like *P. brevis* are known from the Hauterivian of SE France. In the view of Combémorel they are intra-specific variations of *P. brevis*, indicating *P. giziltchaensis* to be a junior-synonym of *P. brevis*. However, these forms are not known from sediments older than topmost Early Valanginian. Contrary *P.* (cf.) *giziltchaensis* is collected from lower Berriasian strata in the Outer Carpathians by Vašíček et al. (1994).

Genus *Rhopaloteuthis* Lissajous, 1915

Type species — *Belemnites sauvanausus* d'Orbigny, 1842.

Description — Generally medium sized, plump, sometimes slightly elongated guards. Cross-sections show compressed or (sub)rounded guards. Normally the area with the largest cross-section is situated in the posterior part of the guard. Thus generally the alveolar area shows a slightly constricted area. The alveolar groove varies, but reaches generally upto the half of the guard. However, sometimes the alveolar groove reaches onto the apex. The groove can either be thin or broad. The alveolus varies from deep to very deep. The apex can either be blunt, pointed or mucronate.

Rhopaloteuthis occurs in Callovian to lower Late Valanginian strata of the Tethyan Realm.

Rhopaloteuthis conophora (Oppel, 1865)
Pl. 2, figs. 1-2.

1865 *Belemnites conophorus* Oppel, p. 546.
1868 *Belemnites conophorus* Oppel — von Zittel, pp. 34-35, pl. 1, figs. 1-5.
? 1868-1876 *Belemnites conophorus* Oppel — Gemmellaro, pp. 21-22, pl. III, figs. 10-11.
1880 *Belemnites conophorus* Oppel — Favre, pp. 10-11, pl. I, fig. 1.
e.p. 1922 *Belemnites conophorus* Oppel — de Gregorio, p. 7, pl. I, figs. 9-10(?), non fig.17 = *Diplobelus belemnitoides* (von Zittel, 1868).
1932 *Conobelus conophorus* (Oppel) — Krimholz, p. 42, pl. II, figs. 40-41.
1958 *Conobelus conophorus* (Oppel) — Krimholz, p. 161, pl. LXVIII, fig. 6.
1966 *Rhopaloteuthis conophora* (Oppel) — Jeletzky, p. 115.
1972 *Conobelus gemmelaroi* (von Zittel) — Stoyanova-Vergilova, pl. I, fig. 4.
1980 *Conobelus (Conobelus) conophorus* (Oppel) — Jeletzky, pl. VI, fig. 1a-e.
1986a *Rhopaloteuthis conophorus* (Oppel) (sic!) — Combémorel & Mariotti, pp. 306-307, pl. 1, figs. 8-10.

Material — One nearly complete guard (RGM 345 226).

Description — Sausage-like thick well-rounded to very weakly depressed guards with a rounded apex and a clear, shallow and relative broad, dorsal groove. The groove reaches almost onto the apex. The end of the groove is well after the beginning of the alveole.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Igr
345 226	40	>10	12.0	12.3	0.98	12.2	12.6	0.97	3.28	>0.81

Comparison — Differs from other *Rhopaloteuthis* species by its well-rounded and 'fat' appearance. *Rhopaloteuthis conica* (de Blainville) is generally larger, with a pointed apex, well developed alveolar groove and a guard that tapers from the anterior to the posterior side.

Stratigraphical distribution — Base of Jacobi Subzone, bed: Z10 (RGM 345226).

Range — Compare Fig. 5.

Geographical distribution — Austria (Abel, 1897), Bulgaria (Stoyanova-Vergilova, 1972), Crimea (Retowski, 1894; Krimholz, 1931, 1958), France (Toucas, 1890), Hungary (?, Koch, 1909, fide Fülöp, 1976)), Italy (Combémorel & Mariotti, 1986a), Slovakia (Remeš, 1897, 1902), Spain (Kilian in Bertrand & Kilian, 1889; Fallot, 1922; this paper), Switzerland (Favre, 1880).

Rhopaloteuthis siciliensis Combémorel & Mariotti, 1986
Pl. 3, figs. 1-2.

1868-1876 *Belemnites gemmellaroi* von Zittel — Gemmellaro, p. 22, pl. III, figs. 8-9.
1880 *Belemnites gemmellaroi* von Zittel — Favre, p. 11, pl. I, fig. 2.
? 1890 *Belemnites orbignyanus* Duval-Jouve var. *jouvei* — Toucas, pl. I, fig. 3.
1986a *Rhopaloteuthis siciliensis* Combémorel & Mariotti, pp. 308-309, pl. 1, fig. 11.
1990 *Rhopaloteuthis siciliensis* — Combémorel & Mariotti, pp. 311-312, pl. 1, figs. 8-10.

Material — One complete guard (RGM 345 229).

Description — A depressed, claviform guard with a pointed apex and a fine but clear groove. Both ventral and dorsal areas are convex with a depression near the end of the alveolus. The lateral sides are convex. The maximum cross-section is near the apex, situated between the end of the groove and the apex, but shifted towards the end of the groove. The apex is placed slightly towards the dorsal side of the guard. Throughout the guard the cross-section is subcircular. The end of the groove is situated well before the end of the alveolus. The apical line is shifted slightly towards the ventral side of the guard.

RGM	R	Sa	Ha	La	Ica	Hm	Lm	Icm	Id	Igr
345 229	44	19	7.0	7.3	0.96	9.0	8.8	1.02	4.89	2.60

Comparison — Combémorel & Mariotti (1986a: 309) describe the affinities with *R. argoviana* (Mayer, 1862) and *R. sauvanausa* (d'Orbigny) (= *R. sauvanaui* in Combémorel & Mariotti, 1986a). It differs from the first by a shorter and more slender guard and from the second by a more rounded cross-section. Moreover, both *R. argoviana* and *R.*

sauvanausa are known from the (Early) Oxfordian.

Stratigraphical distribution — Top Grandis Subzone, bed: Z202.

Range — Compare Fig. 5.

Geographical distribution — France (Toucas, 1890), Italy (Combémorel & Mariotti, 1986a, 1990), SE Spain (this paper), Switzerland (Favre, 1880).

Rhopaloteuthis strangulata (Oppel, 1865)
Pl. 3, figs. 3-6.

1865 *Belemnites strangulatus* Oppel — p. 545, not figured.
1868 *Belemnites strangulatus* Oppel — von Zittel, pp. 35-36, pl. 1, figs. 6-7.
1880 *Belemnites strangulatus* Oppel — Favre, pp. 12-13, pl. I, figs. 3-5.
? 1890 *Belemnites orbignyanus* Duval-Jouve var. *suborbignyi* — Toucas, p. 588, pl. I, fig. 2.
? 1922 *Belemnites strangulatus* Oppel — de Gregorio, p. 8, pl. I, fig. 15.
1932 *Conobelus strangulatus* (Oppel) — Krimholz, p. 43, pl. II, figs. 42-44.
1946 *Conobelus strangulatus* (Oppel) — Tzankov, pl. IX, fig. 8.
1972 *Conobelus strangulatus* (Oppel) — Stoyanova-Vergilova, pl. I, figs. 5-6.
1976 *Conobelus strangulatus* (Oppel) — Patrulius & Avram, pl. X, fig. 22.
1986a *Rhopaloteuthis strangulatus* (Oppel) (sic!) — Combémorel & Mariotti, pp. 307-308, pl. 1, figs. 12-15.
1991 *Conobelus (Coctebelus) strangulatus* (Oppel) — Weiss, p. 26.
1995 *Belemnites strangulatus* Oppel — Riegraf, p. 118.

Material — Five incomplete specimens (RGM 345 204, 345 207-208, 345 285, 345 292).

Description — Well rounded to weakly depressed guards with a clear, relatively broad but shallow groove and a mucronate apex. The end of the groove and the beginning of the alveolus are relatively close. The apex is placed towards the dorsal side. In the ventral side an increasing convexity is observed towards the apex. The apical line is convex and skewed towards the apex but the inclination towards the apex is rather moderate.

RGM	R	Sa	Ha	La	Hm	Lm	Hx	Lx	Icx	α
345 207	39	19	—	11.0	—	11.0	—	—	—	16°
345 208	21	21	10.5	10.0	—	—	10.9	11.2	0.97	14°
345 285	30	13	—	—	9.3	9.9	—	—	—	18°
345 292	37	12	—	—	9.5	—	9.1	9.3	0.98	16°

Comparison — Combémorel & Mariotti (1986a) compare *R. strangulata* with *R. conophora* from which it differs in its smaller and more slender size. Moreover, the depth of the alveolus is less profound in *R. strangulata* as compared with *R. conophora.*

R. siciliensis shows a constriction in the anterior part of the guard contrary to *R. strangulata.*

Differs from *Castellanibelus* and *Curtohibolites* by the position of the alveolar groove; ventrally placed in *Castellanibelus* and *Curtohibolites*, while, dorsally placed in *Rhopaloteuthis.*

Stratigraphical distribution — Grandis Subzone to extreme base Alpillensis Subzone, beds: Z152-168 (RGM 345 292); Y209-212 (RGM 345 285), X225-226 (RGM 345 204), X230 (RGM 345 207-208).

Range — Compare Fig. 5.

Geographical distribution — Bulgaria (Stoyanova-Vergilova, 1972), Crimea (?, Retowski, 1894; Krimholz, 1932), Hungary (?, Koch, 1909, fide Fülöp, 1976)), Italy (Combémorel & Mariotti, 1986a), Roumania (Patrulius & Avram, 1976), Slovakia (von Zittel, 1868 (= *R.* aff. *conica*, fide Remeš, 1897: 223); Remeš, 1902), Spain (Kilian in Bertrand & Kilian, 1889; this paper), and Switzerland (Favre, 1880).

Alphabetical species index

Species known so far only from Spain are indicated with an asterix.

* *Castellanibelus* sp. A
Duvalia cf. *apenninica* Combémorel & Mariotti, 1986a
* *Duvalia* aff. *deeckei* (Kilian in Bertrand & Kilian, 1889)
Duvalia dilatata dilatata (de Blainville, 1825)
Duvalia grasiana (Duval-Jouve, 1841)
* *Duvalia* cf. *haugi* (Kilian in Bertrand & Kilian, 1889)
Duvalia hybrida (Duval-Jouve, 1841)
Duvalia lata (de Blainville, 1825)
Duvalia cf. *tithonia* (Oppel, 1865)
* *Duvalia* sp. A
* *Duvalia* sp. B
* *Duvalia* sp. nov. indet.
Hibolithes mirificus Stoyanova-Vergilova, 1965a
Hibolithes cf. *pilleti* (Pictet, 1868)
Hibolithes semisulcatus (von Münster, 1830)
Hibolithes cf. *subfusiformis* (Raspail, 1829)
Mesohibolites spp.
Pseudobelus bipartitus de Blainville, 1825
Pseudobelus brevis Paquier, 1900
Rhopaloteuthis conophora (Oppel, 1865)
Rhopaloteuthis siciliensis Combémorel & Mariotti, 1986a
Rhopaloteuthis strangulata (Oppel, 1865)

Belemnite zonation

Belemnite zonations for the Early Cretaceous of the Tethyan area are not yet well established. Several reasons can be given. The apparent long stratigraphical ranges of most belemnite species (Fig. 5) and the lack of exact stratigraphical data (i.e. in situ findings; bed-to-bed collecting) are among the most important ones. Moreover, generally belemnites seem to occur rather sporadically in the investigated sediments. Some species seem to survive resp. occur in certain regions whereas they have already vanished in other regions.

Despite the rather rich fauna from e.g. SE France, an attempt to make a zonational scheme has never been made.

In the Carpathians, Vašíček et al. (1994) have made an attempt towards a provisional zonation based upon belemnites (Late-Hauterivian to Albian) and Keleptrishvili (1990: Valanginian to Albian) in Georgia.

From the different sources which were available to the author it was obvious that most of the papers did not deal with bed-by-bed collecting of the belemnite species in ammonite controlled sections. Thus a practically useful scheme has to be established in sections with well described faunas and bed-to-bed collected faunas that are conclusive towards their position in the earth- history and thus with well defined ammonite chronozones (in Hoedemaeker, 1982 and Hoedemaeker & Leereveld, 1995) the ammonite zones are ment to be Oppel-zones (Oppel, 1856: 3*; = Chronozones). In the Río Argos sequence ammonite-zonations, sequence stratigraphical and biostratigraphical data from nannofossils are available.

The data which were obtained on the basis of the collected belemnites, together with data from the literature (e.g. Favre, 1880; Bertrand & Kilian, 1889 and 1895; Toucas, 1890; Combémorel, 1973, 1979; Riegraf, 1981; Combémorel & Mariotti, 1986a,b, 1990; Michalík & Vašíček, 1987; Keleptrishvili, 1990; Vašíček et al., 1994) and unpublished data from my own collection, show that it is possible to make a provisional framework for future detailed zonation by means of belemnites (Figs. 5-6). Species that are thought to occur throughout the Mediterranean basin are chosen in this tentative framework.

Four species, viz. *H. semisulcatus* (von Münster), *D. lata* (de Blainville), *D. dilatata dilatata* (de Blainville), and *D. grasiana* (Duval-Jouve), are chosen to represent superbiozones (cf. Salvador, 1994) within the strata of Late Jurassic to Early Cretaceous age. Superzones or zones placed between quotation marks are not yet officially defined because they are based upon data from the Río Argos sequence.

The boundary between the oldest 'superzone' (*H. semisulcatus* Superzone) and the base of the next 'superzone' (*D. lata* Superzone) which is not present in the investigated part of the Río Argos sequence is provisionally placed near the Early/Late Tithonian boundary.

The top of the *H. semisulcatus* 'Superzone' is probably characterised by *D. ensifer* (Oppel). Within the tentative zone of *D. ensifer* is situated the last occurrence (= LO) of *Rhaphibelus acicula* (von Münster) and probably the first occurrence (= FO) of *Pseudobelus datensis* (Favre), *D. apenninica* (Combémorel & Mariotti), *Hibolithes conradi* Kilian and *Hibolithes pilleti* (Pictet).

Duvalia lata 'Superbiozone'

Definition — The base is defined by the FO of *D. lata*. The top is defined by the first occurrence of *D. dilatata dilatata* near the base of the Alpillensis Zone.

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* Oppel, 1856: 3. 'Es wurden immer bloss ganze Schichtengruppen mit einander parallelisirt, nicht aber gezeigt, dass ein jeglicher Horizont, der an dem einen Orte durch eine Anzahl für ihn constanter Species markirt wird, auch in der entferntesten Gegend mit derselben Sicherheit wieder zu finden sei. Diese Aufgabe ist zwar eine schwierige, aber nur durch ihre Erfüllung kann eine genaue Vergleichung ganzer Systeme gesichert werden. Es wird dabei nöthig gemacht, mit Hintansetzung der mineralogischen Beschaffenheit der Schichten, die verticale Verbreitung jeder einzelnen Species an den verschiedensten Orten zu erforschen, hernach diejenigen Zonen hervorzuheben, welche durch stetes und alleiniges Auftreten gewisser Arten sich von den angrenzenden als bestimmte Horizonte absondern. Man erhält dadurch ein ideales Profil, dessen Glieder gleichen Alters in den verschiedenen Gegenden immer wieder durch dieselben Arten characterisirt werden.'

Calibration — Ammonites: upper part (?) of Fallauxi Zone to base Alpillensis Zone.

Type section — Not yet assigned.

Age — ?late Tithonian-latest Berriasian.

Remarks — The top is characterised by the LO of *R. strangulata* (Oppel), *H. semisulcatus* (von Münster) and the FO of *P. bipartitus* de Blainville and *D. dilatata dilatata* (de Blainville). De FO of *D. lata* is not yet well understood. However, literature data show it be near the baoundary between the Early and Late Tithonian.

The *Duvalia lata* 'Superzone' can probably be divided into three biozones, but good stratigraphical data are lacking in the literature. The lower part could be characterized by *D. tithonia* (Oppel), probably useful as a marker (cf. Combémorel & Mariotti, 1986b) for the Late Tithonian- Earliest Berriasian. *R. strangulata* could be characteristic for the Middle to Late Berriasian (Subalpina Zone to Paramimouna Zone). The uppermost part of the Late Berriasian (Picteti Zone) is characterized by the FO of *P. bipartitus*.

From these three zones the last one can be characterized and will be formally introduced, the other two zones can be characterized, however, exact stratigraphical position in relation to ammonite zones can not be given yet.

Within the tentative zone of *Duvalia tithonia* is probably situated the LO of *D. apenninica, P. datensis* and *Diplobelus* spp. Besides the FO of *Castellanibelus orbignyanus* (Duval-Jouve), *Berriasibelus exstinctorius* (Raspail) and *Rhopaloteuthis conica* (de Blainville).

The tentative zone of *Rhopaloteuthis strangulata* is characterized by the LO of *R. siciliensis* and *H. conradi* near the base. Furthermore some species have probably their last occurrence near the top of this 'zone' or within the *Pseudobelus bipartitus* Zone, i.e.: *H. pilleti, D. ensifer, D. tithonia,* and *R. conophora.*

Pseudobelus bipartitus Biozone

Definition — The interval from the FO of *P. bipartitus* in bed Y186 to the FO of *D. dilatata dilatata* in bed Y234.

Calibration — Ammonites: Picteti Zone - basinal Alpillensis Zone.

Age — Latest Berriasian.

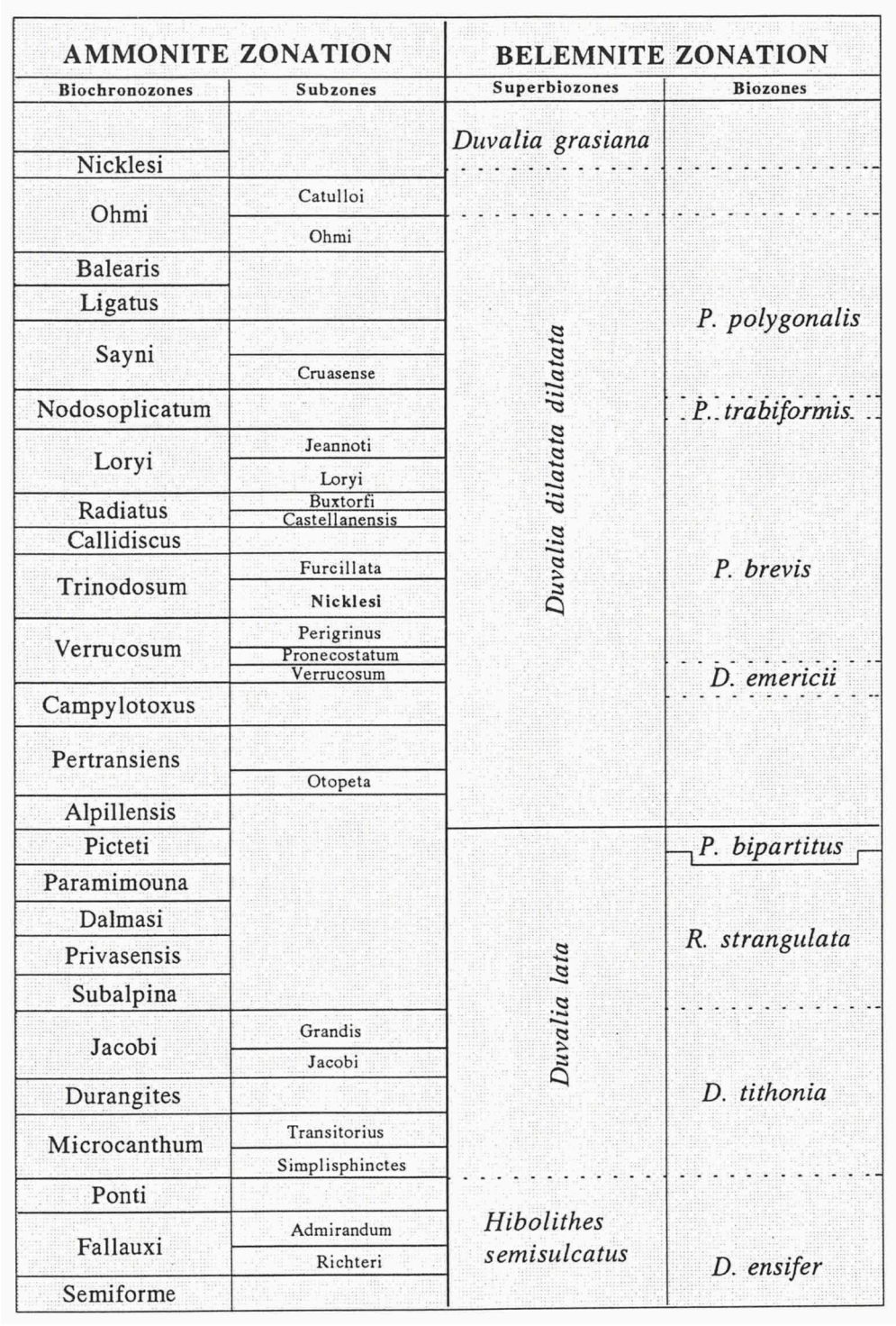
Remarks — FO of *P. bipartitus,* LO of *R. strangulata* and *H. semisulcatus.*

Duvalia dilatata dilatata Superbiozone

Definition — The base of the superzone is defined by the FO of *D. dilatata dilatata* in bed Y234. The top of the superzone is defined by the FO of *D. grasiana.*

Calibration — Ammonites: base Alpillensis Zone to top Catulloi Subzone or base Hugii Zone.

Fig. 6. Belemnite zonation scheme. This zonation scheme is in state of the art. The Superzones are introduced formally where as the zones are tentative with the exception of the *Pseudobelus bipartitus* Zone. Early Cretaceous Ammonite-zones are adopted and slightly modified from Hoedemaeker & Company (1993). Broken lines indicate uncertainties within the framework. The essence of the scheme is based on the first occurrences of species mentioned (as far as known to the author).


AMMONITE ZONATION
BELEMNITE ZONATION
Biochronozones
Subzones
Superbiozones
Biozones
Nicklesi
Ohmi
Catulloi
Ohmi
Balearis
Ligatus
Sayni
Cruasense
Nodosoplicatum
Loryi
Jeannoti
Loryi
Radiatus
Buxtorfi
Castellanensis
Callidiscus
Trinodosum
Furcillata
Nicklesi
Verrucosum
Perigrinus
Pronecostatum
Verrucosum
Campylotoxus
Pertransiens
Otopeta
Alpillensis
Picteti
Paramimouna
Dalmasi
Privasensis
Subalpina
Jacobi
Grandis
Jacobi
Durangites
Microcanthum
Transitorius
Simplisphinctes
Ponti
Fallauxi
Admirandum
Richteri
Semiforme
Duvalia grasiana
Duvalia dilatata dilatata
Duvalia lata
Hibolithes semisulcatus
P. polygonalis
P. trabiformis
P. brevis
D. emericii
P. bipartitus
R. strangulata
D. tithonia
D. ensifer

Age — Latest Berriasian-latest Hauterivian/earliest Barremian.

Remarks — The top is characterized by the FO of *D. grasiana, H. mirificus* Stoyanova- Vergilova and *Mesohibolites* spp. and the LO of *D. dilatata binervioides* Stoyanova-Vergilova and *D. binervia* (Raspail).

The *Duvalia dilatata dilatata* Superzone can probably be divided into several biozones and biosubzones, especially the base is characterized by various FO's and acmes of species that are found throughout the Tethyan Basin. However, the exact stratigraphical extension of most of these species is not known. More or less successive associations are: *D. emericii* (Raspail), *D. dilatata binervioides, D. hybrida* (Duval-Jouve); *P. brevis* Paquier, *D. binervia, H. subfusiformis* (Raspail), *V. pistilliformis* (de Blainville); *H. jaculoides* Swinnerton, *H. prodromus* (Schwetzov) and *H. longior* (Schwetzov).

Thus we could divide the latest Berriasian-earliest Barremian into three stratigraphically important intervals. These intervals are characterized by: the oldest (basinal Alpillensis Zone to basinal Verrucosum Zone) by the income of the *D. emericii* with relative short stratigraphical range and long ranging species like: *D. dilatata dilatata, D. hybrida, D. binervia*, etc.

The youngest part is characterized by *Pseudoduvalia* species and the appearance of numerous *H. jaculoides* (top (?) Nodosoplicatum Zone to Ohmi Zone) as is known from the Boreal area. Together with the LO of *D. dilatata binervioides, P. brevis, P. trabiformis* and *P. sicyoides.*

In between we note several long ranging species: *P. brevis, D. binervia*, and *D. dilatata*. Moreover, the occurrence of *'Combemorelites'* spp. (i.e. *Hibolithes rogeri* (Delattre), *'H. mariae'* (Gayte, 1984: 103, invalid (mascr.-name)), *H. krimholzi* (Stoyanova-Vergilova), a.o.), and, the FO (?) of *'D. gervaisiana'* (de Rouville)*, *D. dilatata majoriana* Stoyanova-Vergilova, *P. sicyoides*, and *D. crimica* (Karakasch).

Duvalia grasiana 'Superbiozone'

Definition — The base is defined by the FO of *D. grasiana.* The top of this zone is not yet defined.

Calibration — Ammonites: base Hugii Zone. The top may be represented by the FO of *Neohibolites ewaldi* (von Strombeck) near the base of the Tuarkyricus Zone.

Type section — Not yet defined.

Age — Earliest Barremian-(?)latest Barremian/early Aptian.

The available literature data for the occurrence of the *Neohibolites ewaldi-wollemani*

* cf. Riegraf (1995: 110) an invalid species (nom. nudum). Nevertheless sometimes used to indicate the Valanginian-Hauterivian boundary. This species has been described by de Rouville (1872: 729) as: 'espèce remarquable par sa forme et qu'on ne trouve pas dans la partie supérieure des marnes'). According to the stratigraphical description by de Rouville (pp. 730-731) it is found above the marls with *D. emericii* and accompanied by some small *P. bipartitus* (= *P. brevis*), many *D. dilatata* and very large amounts of *'Hibolithes/Vaunagites'*- types of belemnites.
In Paquier (1900: 475) *'D. gervaisiana'* is mentioned from the 'marnes valangiennes supérieur' as 'exemplaires assez typique'. This includes probably the (*Campylotoxus*)-*Verrucosum* Zone to part of the *Radiatus/Loryi* Zone.

lineage (compare Boreal zonational scheme, Mutterlose, 1990) show a shift towards older strata in the Tethyan sediments compared to the Boreal distribution, at least in the species: *N. ewaldi* (von Strombeck, 1861), *N. clava* Stolley (1911), and *N. inflexus* Stolley (1911). *N. wollemani* Stolley (1911) seems to be concordant with the Boreal data.

Generally, the Aptian sediments show a mixed fauna of *Neohibolites*, *Mesohibolites* and *Parahibolites* species. *Neohibolites* is, however, the dominant genus, as in the Albian. Sporadically *Pseudoduvalia* occurs.

Literature data from the Albian towards the Cenomanian are less conclusive, generally due to the lack of well controlled belemnite findings. Normally, the sediments show a fauna consisting of a mixture of *Neohibolites* and *Parahibolites*. The index species from the Boreal zonation are present, except for *N. oxycaudatus* Spaeth (1971). Basinal Albian sediments show a mixture of *N. strombecki* (Müller, 1895) - *N. minor* Stolley (1911). Whereas topmost Albian sediments show *N. praeultimus* Spaeth (1971). Thus the *Neohibolites strombecki-praeultimus* lineage is well represented, but the stratigraphical extension of the species is not yet well understood. E.g. *N. strombecki* and *N. minor* are known from the Late Aptian already (Bulgaria, Sardinia), contrary to their distribution in the Boreal-Atlantic area. The genera *Mesohibolites* and the family Duvaliidae are represented no longer in the Albian sediments of the Mediterranean basin.

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All species are figured 1.6 × their natural size, unless otherwise stated.

Plate 1

Figs. 1-4.
1. *Duvalia lata*: Y191-195, Picteti Zone; RGM 345 239; alveolar side; 2. *Duvalia lata*: X258, Otopeta Zone; RGM 345 240; alveolar side; 3. *Duvalia lata*: X258, Otopeta Zone; RGM 345 240; right lateral side; 4. *Duvalia lata*: Y191-195, Picteti Zone; RGM 345 239; right lateral side.

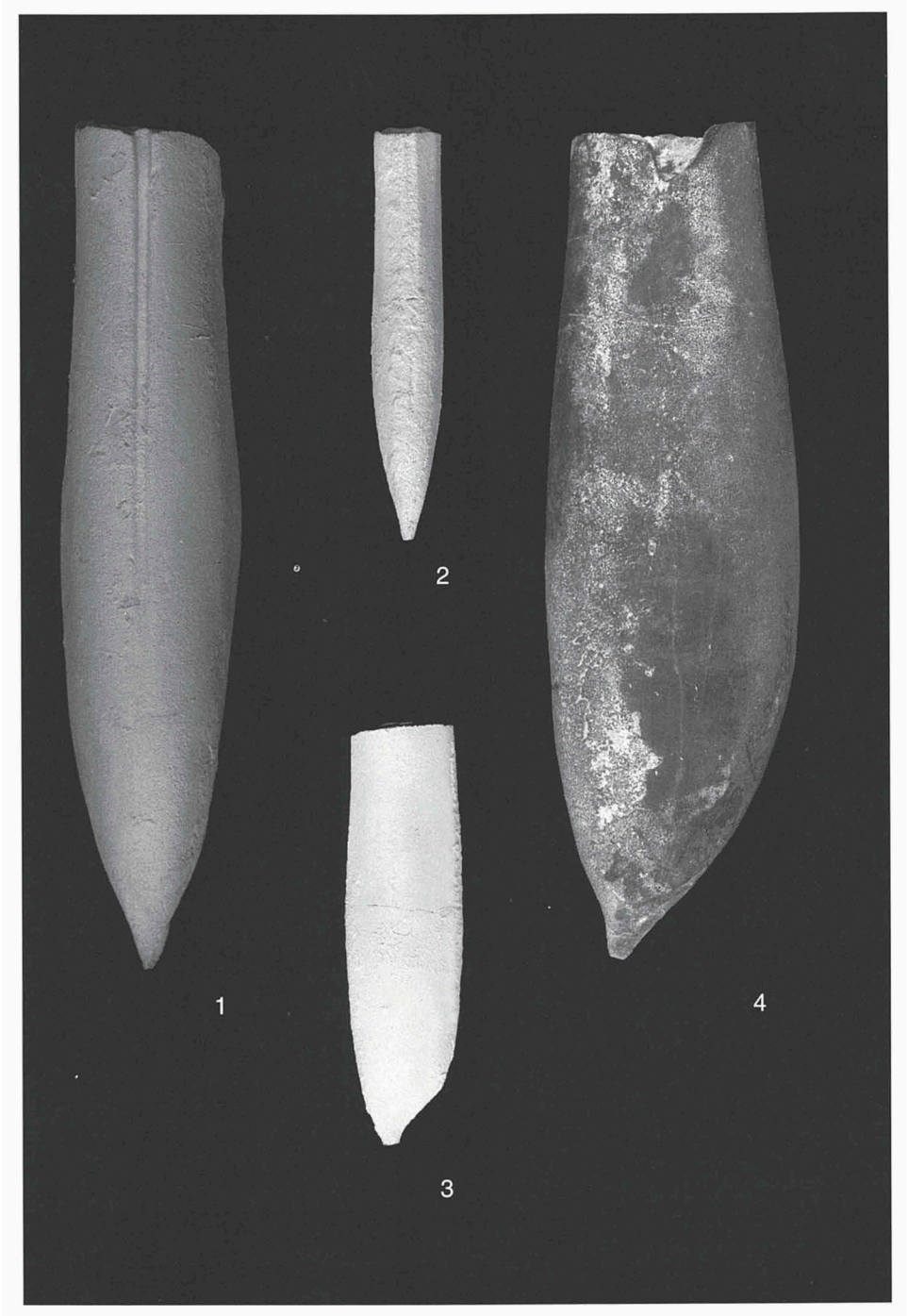
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Plate 2

Figs. 1-7.

1. *Rhopaloteuthis conicus*: Z10, Jacobi Subzone; RGM 345 226; alveolar side; 2. *Rhopaloteuthis conicus*: Z10, Jacobi Subzone; RGM 345 226; right lateral side; 3. *Duvalia* cf. *apenninica*: Z37, Jacobi Subzone; RGM 345 228; alveolar side; 4. *Duvalia* cf. *apenninica*: Z37, Jacobi Subzone; RGM 345 228; right lateral side; 5. *Duvalia* sp. nov. spec.? indet.: Z85-87, Jacobi Subzone; RGM 345 290; alveolar side; 6. *Duvalia* sp. nov. spec.? indet.: Z85-87, Jacobi Subzone; RGM 345 290; right lateral side; 7. *Duvalia dilatata dilatata*: X234-244, Alpillensis Zone; RGM 345 213; right lateral side.

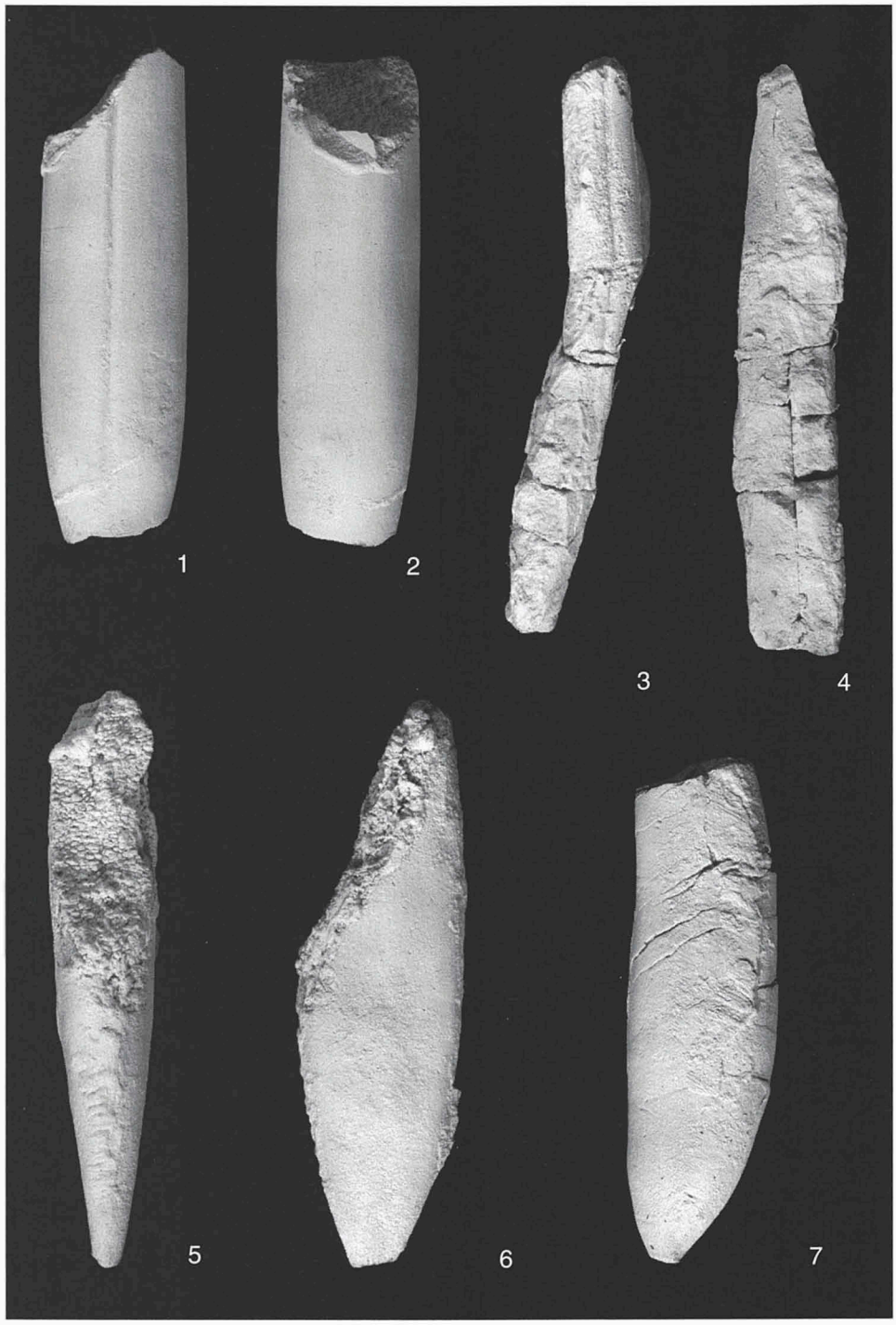
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Plate 3

Figs. 1-8.

1. *Rhopaloteuthis siciliensis*: Z202, Grandis Subzone; RGM 345 229; alveolar side; 2. *Rhopaloteuthis siciliensis*: Z202, Grandis Subzone; RGM 345 229; right lateral side; 3. *Rhopaloteuthis strangulatus*: Z152-168, Grandis Subzone; RGM 345 292; alveolar side; 4. *Rhopaloteuthis strangulatus*: Z152-168, Grandis Subzone; RGM 345 292; right lateral side; 5. *Rhopaloteuthis strangulatus*: X230, Alpillensis Zone; RGM 345 207; alveolar side; 6. *Rhopaloteuthis strangulatus*: X230, Alpillensis Zone; RGM 345 207; cross-section in lateral plane; 7. *Castellanibelus* sp. A: Y267, Pertransiens Zone; RGM 345 230; alveolar side; 8. *Castellanibelus* sp. A: Y267, Pertransiens Zone; RGM 345 230; right lateral side.

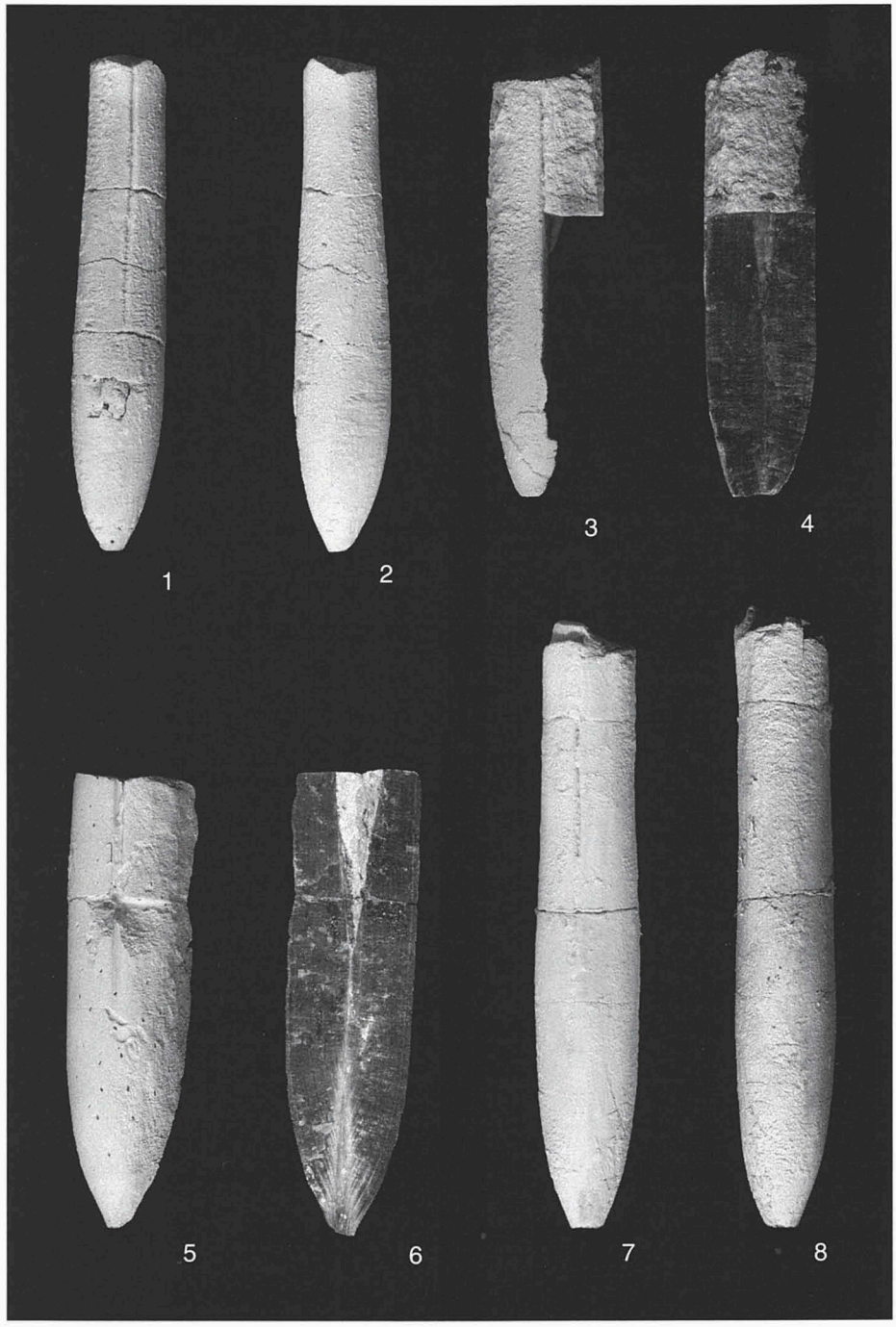
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Plate 4

Pls. 1-6.

1. *Duvalia* sp. A: Q41-50, Hugii-Nicklesi Zone; RGM 345 266; alveolar side; 2. *Duvalia* sp. A: Q41-50, Hugii-Nicklesi Zone; RGM 345 266; right lateral side; 3. *Duvalia* sp. B: Q74, Caillaudianus Zone; RGM 345 264; left lateral side; 4. *Duvalia dilatata dilatata*: W36-46, Catulloi Subzone; RGM 345 252; left lateral side; 5. *Duvalia hybrida*: W90-111, Hugii-Nicklesi Zone; RGM 345 250; right lateral side; 6. *Duvalia* sp. B: Q74, Caillaudianus Zone; RGM 345 264; alveolar side.

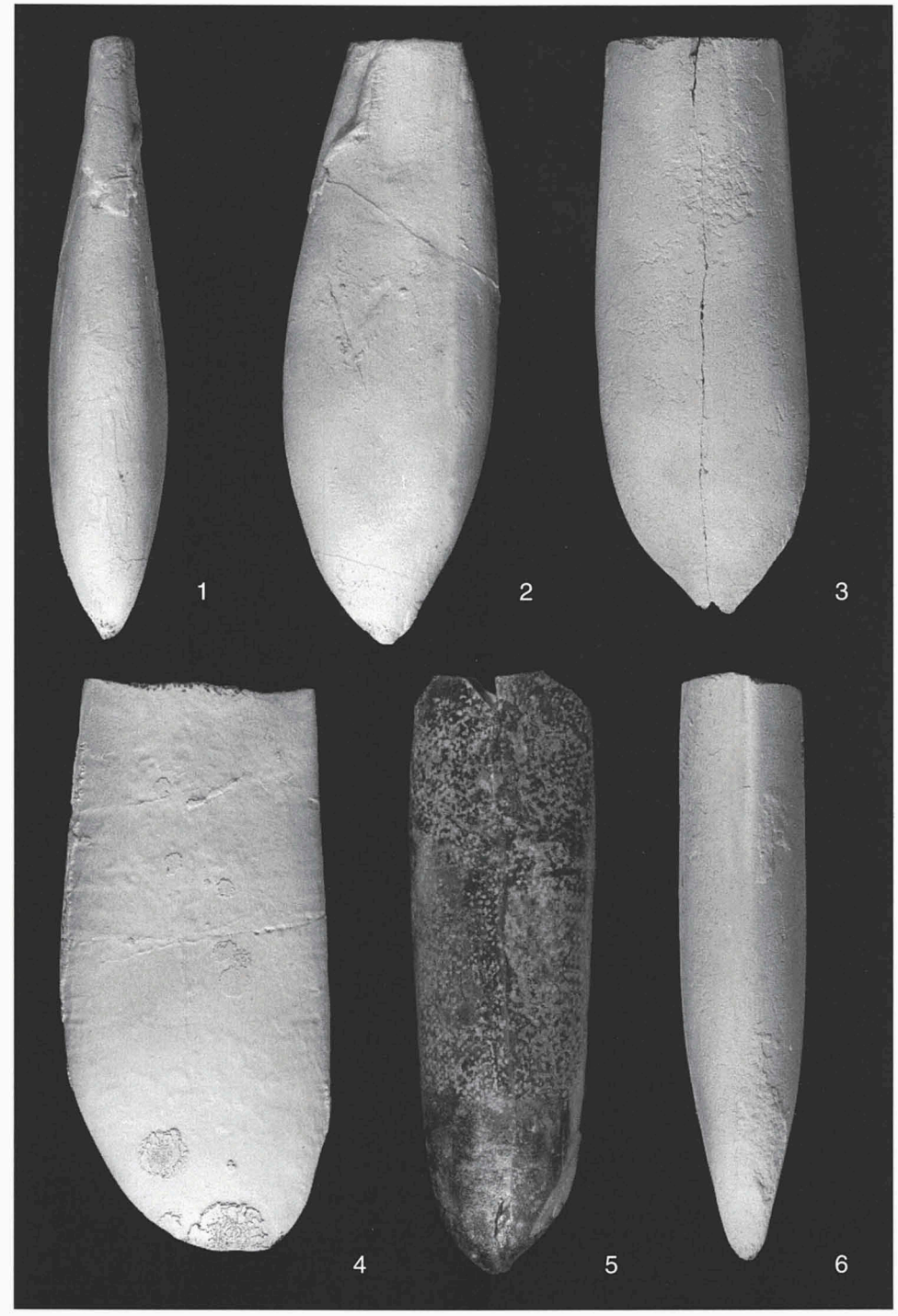
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Plate 5

Pls. 1-8.

1. *Duvalia* aff. *deeckei*: Y244-251, Alpillensis; RGM 345 236; alveolar side; 2. *Duvalia* aff. *deeckei*: Y244-251, Alpillensis; RGM 345 236; cross-section in alveolar area; 3. *Duvalia* aff. *deeckei*: Y244-251, Alpillensis; RGM 345 236; cross-section in posterior part of guard; 4. *Duvalia* aff. *deeckei*: Y244-251, Alpillensis; RGM 345 236; right lateral side; 5. *Hibolithes mirificus*: Q71-74, Caillaudianus; RGM 345 268; alveolar side (× 0.8); 6. *Hibolithes mirificus*: Q71-74, Caillaudianus; RGM 345 268; right lateral side (× 0.8); 7. *Hibolithes* cf. *subfusiformis*: W46-56, Catulloi-Hugii Zone; RGM 345 253; dorso-ventral cross-section (× 0.8); 8. *Hibolithes* cf. *subfusiformis*: W26-27, Balearis Zone; RGM 345 249; right lateral side.

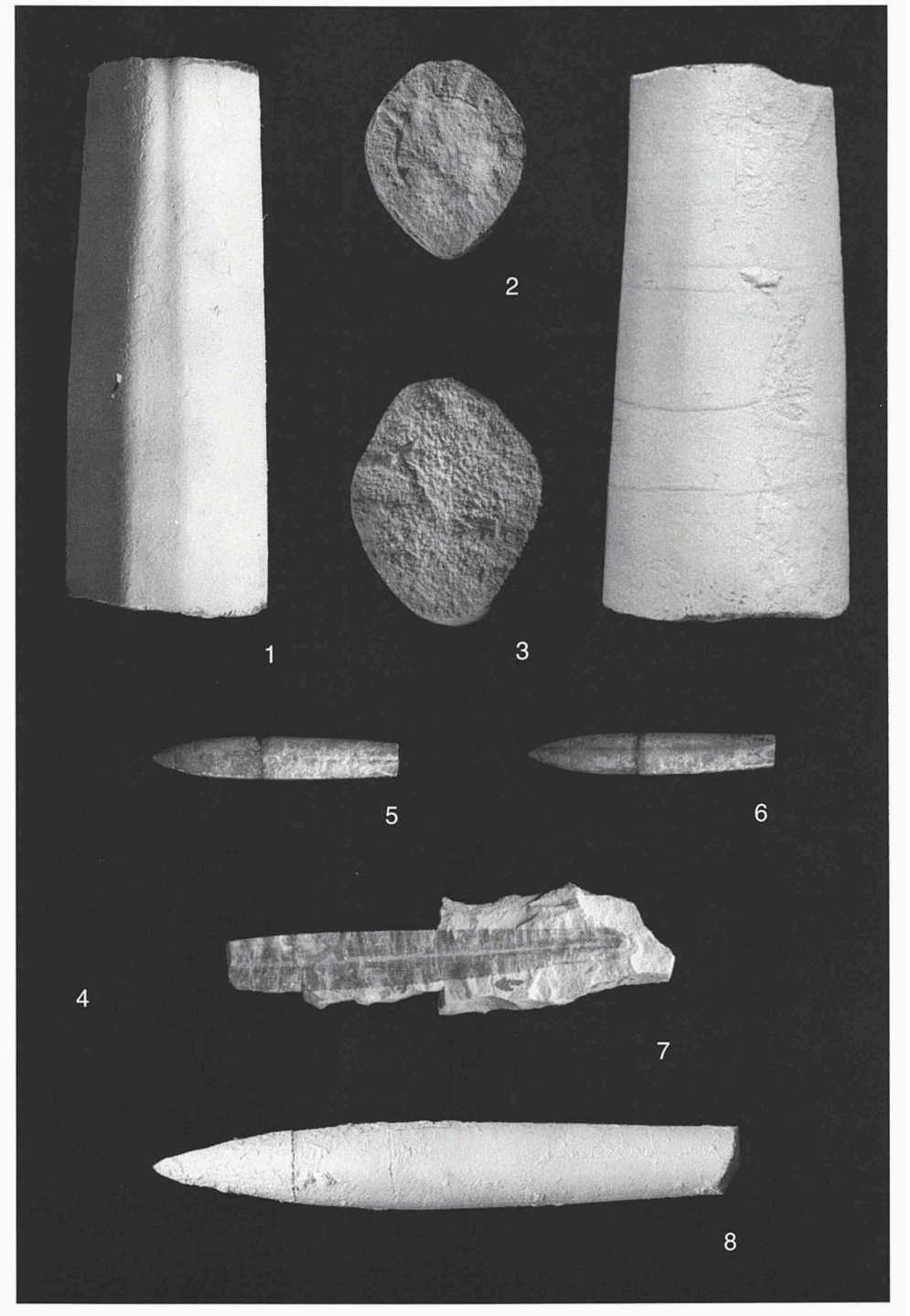
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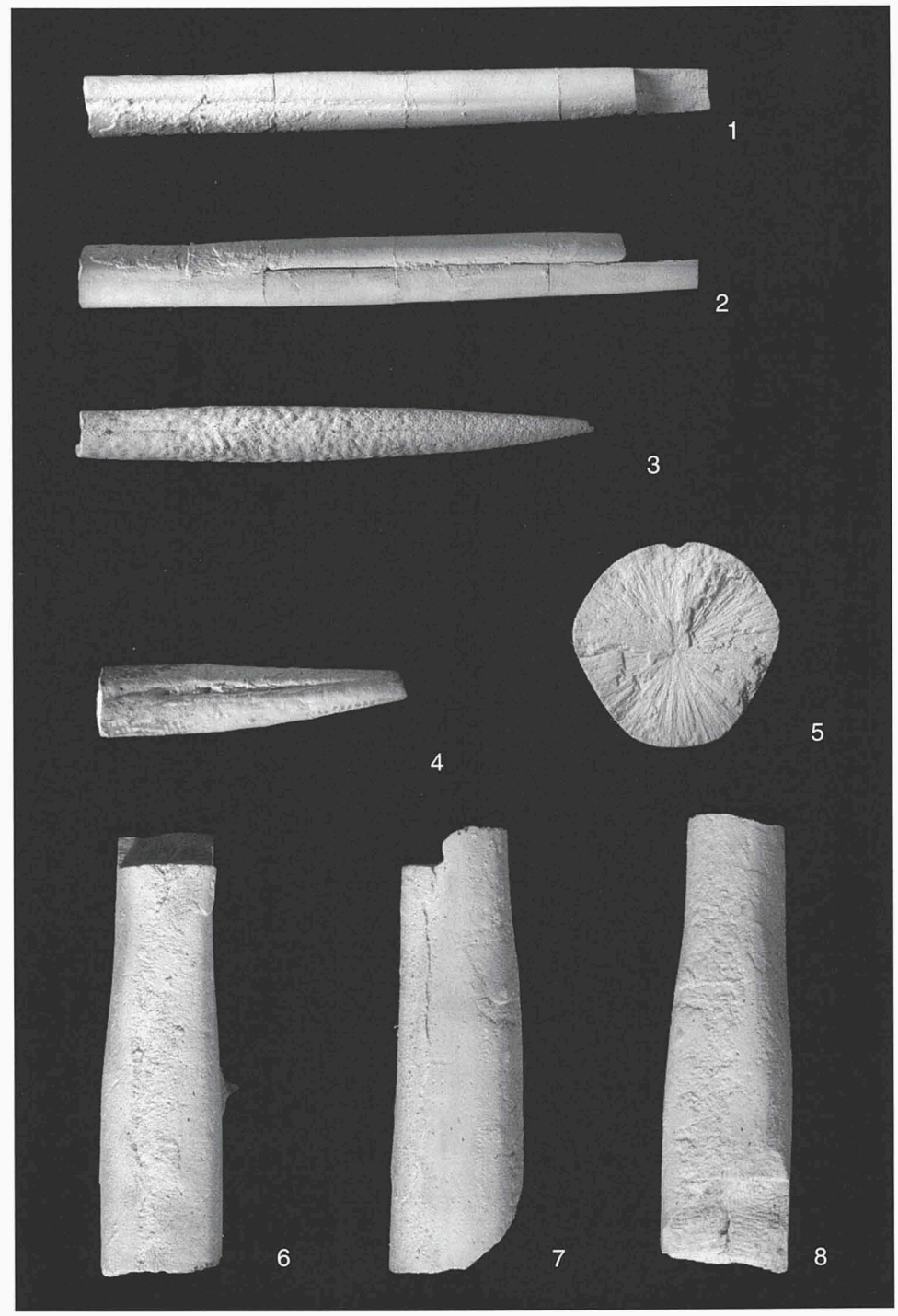
Plate 6

Pls. 1-8.

1. *Pseudobelus bipartitus*: X229, Picteti Zone; RGM 345 206; alveolar side (× 0.8); 2. *Pseudobelus bipartitus*: X229, Picteti Zone; RGM 345 206; left lateral side (× 0.8); 3. *Pseudobelus brevis*: Collet des Boules, Peyroules, France; B6-7, Sayni Zone; no. 1114; 4. *Pseudobelus brevis*: A53, Cruasense Subzone; RGM 345 269; left lateral side; 5. *Duvalia* cf. *haugi*: Y267-274, Pertransiens Zone; RGM 345 220; cross section in anterior part of the guard; 6. *Hibolithes* cf. *pilleti*: Y159-161, Paramimouna Zone; RGM 345 238; alveolar side; 7. *Hibolithes* cf. *pilleti*: Y159-161, Paramimouna Zone; RGM 345 238; left lateral side; 8. *Hibolithes* cf. *pilleti*: Y159-161, Paramimouna Zone; RGM 345 238; ventral side.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