

ISSN 0375 - 7633

Bollettino

della

Società Paleontologica Italiana

Pubblicato sotto gli auspici e col contributo
del Consiglio Nazionale delle Ricerche

Volume 41, n. 1, 2002

MUCCHI - MODENA

Upper Callovian - Middle Oxfordian belemnite assemblage from Monte Kumeta (Jurassic of western Sicily, Italy)

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KEY WORDS – *Cephalopoda, Belemnites, Systematics, Biostratigraphy, Tethys, Upper Callovian, Middle Oxfordian, Western Sicily.*

ABSTRACT – A belemnite assemblage, was collected from Upper Callovian to Middle Oxfordian beds of the Rosso Ammonitico Inferiore at Monte Kumeta (Palermo, southern Italy). Abundant *Duvalia Bayle, 1878* and *Hibolithes Montfort, 1808*, characteristic of the western Tethys, were found with *Belemnopsis Bayle, 1878*, *Rhopaloteuthis Lissajous, 1915* and *Pseudobelus de Blainville, 1827*. The following species were recognised: *Hibolithes hastatus Montfort, 1808*, *Hibolithes sp. aff. H. beyrichi Oppel, 1857*, *Belemnopsis latesulcatus (Voltz) in Thurmann, 1832*, *Duvalia monsalvensis (Gillieron, 1873)*, *D. neyrivensis (Favre, 1876)*, *D. didayana (d'Orbigny, 1842)*, *D. dumortieri (Oppel, 1865)*, *Rhopaloteuthis sauvanausa (d'Orbigny, 1842)*, *R. argoviana (Mayer, 1863)*, *Pseudobelus coquandus (d'Orbigny, 1842)*. In addition *Belemnopsis sp. 1* and *Rhopaloteuthis sp. 1* are present and retained in open nomenclature.

This assemblage allows new stratigraphic considerations for the Middle - Late Jurassic of central and southern Italy.

RIASSUNTO – [Belemniti dell'intervallo Calloviano superiore – Oxfordiano medio del Monte Kumeta (Giurassico della Sicilia occidentale, Italia)] – Un'associazione a belemniti, raccolta da sedimenti medio Giurassici (Calloviano superiore – Oxfordiano medio), si caratterizza per la presenza di abbondanti esemplari di *Duvalia Bayle, 1878* e *Hibolithes Montfort, 1808*, forme tipiche della Tetide occidentale, associate a *Belemnopsis Bayle, 1878*, *Rhopaloteuthis Lissajous, 1915* e *Pseudobelus de Blainville, 1827*. A livello specifico sono state riconosciute: *Hibolithes hastatus Montfort, 1808*, *Hibolithes sp. aff. H. beyrichi Oppel, 1857*, *Belemnopsis latesulcatus (Voltz) in Thurmann, 1832*, *Duvalia monsalvensis (Gillieron, 1873)*, *D. neyrivensis (Favre, 1876)*, *D. didayana (d'Orbigny, 1842)*, *D. dumortieri (Oppel, 1865)*, *Rhopaloteuthis sauvanausa (d'Orbigny, 1842)*, *R. argoviana (Mayer, 1863)*, *Pseudobelus coquandus (d'Orbigny, 1842)*. Inoltre sono state riconosciute *Belemnopsis sp. 1* e *Rhopaloteuthis sp. 1* che rimangono in nomenclatura aperta.

L'associazione consente nuove considerazioni sulla importanza stratigrafica di queste forme per il Giurassico medio e superiore dell'Italia centrale e meridionale.

INTRODUCTION

The purpose of this paper is to describe an Upper Callovian – Middle Oxfordian belemnite association and to discuss its biostratigraphical and palaeobiogeographical implications. The investigated specimens were collected from an 80 cm thick laminated level in a single outcrop located near the top of Monte Kumeta, SE of the Piana degli Albanesi village (Palermo, southern Italy) (Text-fig. 1).

This is the first Upper Callovian - Middle Oxfordian belemnite assemblage from southern Italy to be described and is probably the only assemblage to come from a single site in the western Tethys.

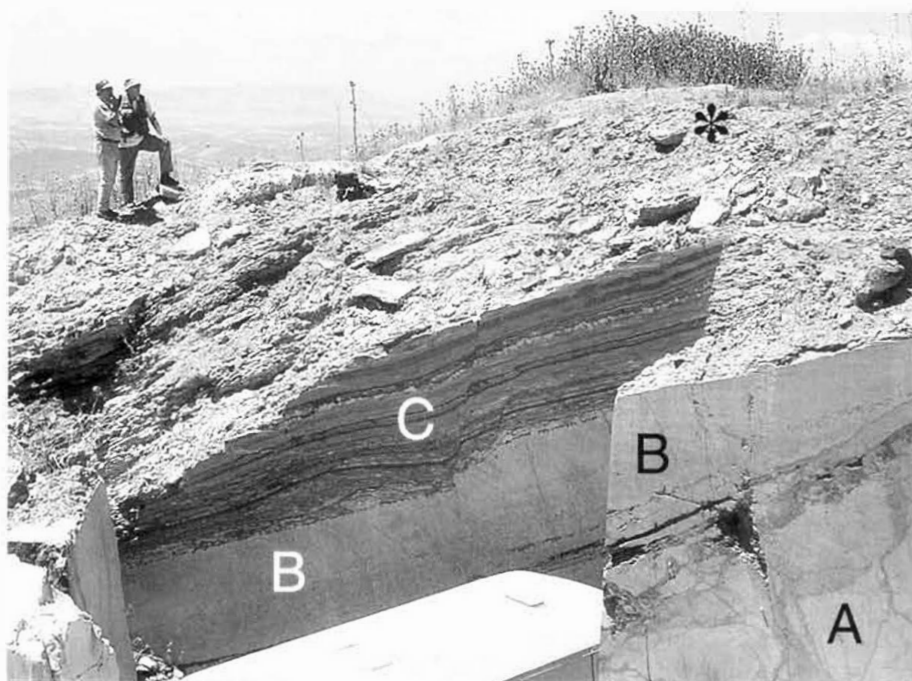
GEOLOGICAL SETTING

The investigated fauna was collected between 1997 and 2001 in a sequence cropping out in an active quarry (Text-fig. 2), near the top of Monte Kumeta, in the southern part of the Palermo Mountains (western Sicily). The mountain is the uppermost portion of an E-W trending ridge, about 20 km long, belonging to a major structural unit of the Sicilian-Maghrebian chain. This ridge derives from the Neogene deformation of a wide palaeogeographic domain that in the Mesozoic was part of the African passive margin, and defined by different names (Trapanese, Saccense, Imerese, Panormide Domains, etc. see Catalano & D'Argenio, 1982a).

Among the Jurassic outcrops of the Trapanese Domain, Monte Kumeta offers a good example of the complex tectonic and sedimentary evolution of a pelagic stepped escarpment adjacent to a structural



Text-fig. 1 - Location map of Monte Kumeta area.



Text-fig. 2 - General view of the Rosso Ammonitico Inferiore unit in the Cerniglia quarry at Monte Kumeta A) Calcare a Crinoidi unit; B) pseudonodular limestone and pink wavy cross-bedded limestone (RALa, b); C) red pseudonodular marly limestone (RALc); * belemnite bearing nodular marls (RALd).

high. The area is well known in the geological literature (Catalano & D'Argenio, 1982a, b; Catalano *et al.* 1993, 1996; Di Stefano 1990; Di Stefano & Mindszenty, 2000). More strictly stratigraphy-oriented papers include those by Catfish (1966), Mascle (1979), Wendt (1963, 1969). As well as other domains in the Tethys, after the Early Jurassic break-down of a prolific carbonate platform, it was drowned to become a pelagic environment, further subdivided into more or less depressed areas frequently connected by steep (non depositional) or gentle (depositional) escarpments.

The Jurassic sequences cropping out in the Monte Kumeta area have been known for a long time for the fossil assemblages and the interesting complexity of the apparent rock body geometries and reports. These geometries fit well with the palaeostructural schemes (Abate *et al.*, 1982) in which intensive synsedimentary, mainly extensional, Jurassic tectonics is stressed. This type of sequence characterizes all the basin/platform systems causing the genesis of different types of unconformable contacts. In this area the main unconformity is that between "bahamian" platform limestone (Inici Formation) and different pelagic terms (Rosso Ammonitico after Di Stefano & Mindszenty, 2000) but minor unconformities within these rock bodies are also frequent. The complex facies relationships, the depositional geometries, hiatuses and the precise multi-element biostratigraphic calibration of the events have provided detailed knowledge of the timing and mode of the evolution of the area (Mariotti *et al.*, 2001).

A peculiar element of the stratigraphy of Monte Kumeta, which palaeogeographically behaves as a morpho-structural high (pelagic carbonate platform

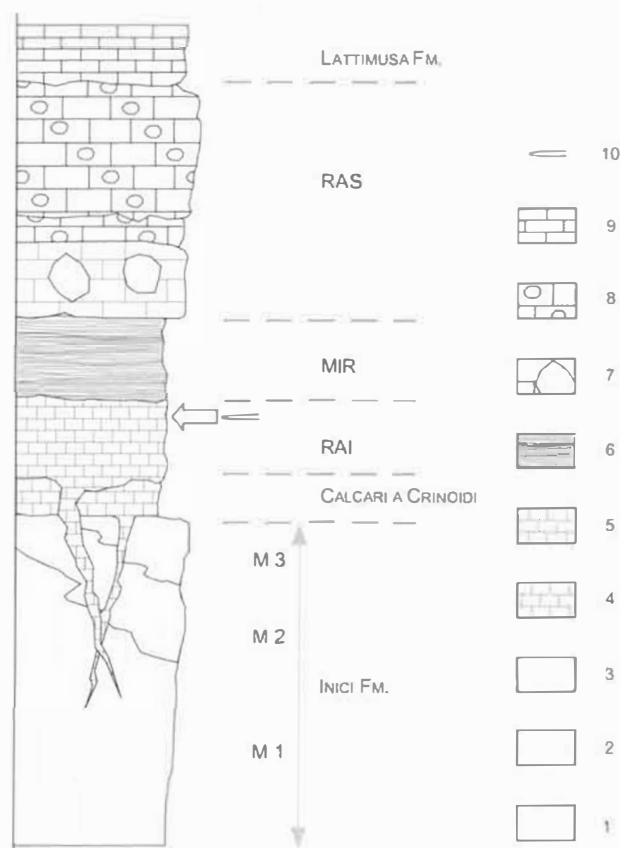
sensu Santantonio, 1994), is the lack of a thin succession conformably overlying peritidal limestone. This absence represents, in similar palaeostructural situations (Southern Alps, Umbria-Marche-Sabina Apennines, Saccense Domain), the marker of the drowned platform-top on faulted blocks (condensed pelagic facies *sensu* Santantonio, 1993).

In the studied outcrop, angular unconformities, discontinuous sediment distribution and strong thickness reduction of pelagic units, over the irregular basement, prevail, that seem to correspond to the typical characters of the submarine slope zone (composite pelagic facies association *sensu* Santantonio, 1993). Consequently they would indicate deposition related to a tilted block, either corresponding to its eroded ridge or, more probably, to its flanks. The second alternative was in the end preferred because of the presence of clastic deposits of local derivation (Mariotti *et al.*, 2001).

THE JURASSIC SECTION OF MONTE KUMETA

The Monte Kumeta sequences were recently described (Di Stefano & Mindszenty, 2000; Di Stefano & Mallarino, in press; Di Stefano *et al.*, in press) providing great detail of their complex relationships (Text-fig. 3); thus only a brief synthesis is given here.

The Jurassic part of the sequence was organised into four main units (Inici Formation, Calcare a Crinoidi, Rosso Ammonitico and Lattimusa Formation, *pars*) and subsequently the Rosso Ammonitico was split into three informal units named as Rosso Ammonitico Inferiore (RAI), Membro Intermedio Radiolaritico



Text-fig. 3 - Schematic columnar section of the Jurassic sequence at Monte Kumeta. 1) Peritidal cyclothems; 2) oolitic skeletal limestone; 3) peloidal skeletal grainstones and packstones; 4) crinoidal limestone; 5) reddish condensed limestone; 6) bedded cherts and radiolarian-rich marls; 7) nodular limestone with megabreccias; 8) nodular limestone; 9) calpionellid bearing calcilitites; 10) belemnite bearing beds.

(MIR) and Rosso Ammonitico Superiore (RAS) (see below for detailed description).

The oldest sediments cropping out are peritidal to open-shelf limestone and dolostones (Inici Formation) of lower to mid Early Jurassic in age, characterized by neptunian dykes with polyphase fillings. Three main lithofacies associations were recognized in the Inici Formation, from the base: Inici M1, peritidal cyclothems (>300 m), Inici M2, oolitic-skeletal limestone and Inici M3 peloid-skeletal grainstones and packstones (Early Pliensbachian).

A white to pink crinoidal limestone, the Calcari a Crinoidi unit, unconformably succeeds the Inici Formation. This unit, Pliensbachian p. p., characterized by a prismatic geometry, also fills the first generation of neptunian dykes (Di Stefano & Mallarino, in press; Di Stefano *et al.*, in press). The top of this unit is characterised by a dissolution surface with pinnacles coated by a ferromanganese crust. Its genesis is related to complex changes in seawater chemistry (Di Stefano & Mindszenty, 2000).

The overlying sediments, late Early Jurassic – Tithonian p. p. in age, are subdivided into three units (Di Stefano & Mindszenty, 2000; Di Stefano & Mallarino, in press; Di Stefano *et al.*, in press):

- a) a lower unit (RAI) consisting of up to 6 m of massive, reddish condensed limestone ranging Toarcian to Oxfordian p. p. This unit filled the depressions of the irregular substrate made of the Inici Formation and Calcari a Crinoidi unit;
- b) an intermediate cherty unit (MIR) characterized by varicoloured, 0 to 15 m thick, bedded cherts and radiolarian-rich marls of Late Oxfordian – Earliest Kimmeridgian age (Mariotti *et al.*, 2001);
- c) an upper unit (RAS) consisting of 10 to 15 m thick reddish nodular limestone and *Saccocoma*-limestone of Kimmeridgian – Early Tithonian age, locally with intraformational unconformities, megabreccias, pebbly mudstones, and slumps.

Upper Tithonian – Neocomian calpionellid-bearing cherty calcilitites (“Lattimusa” Auct.) and Lower Cretaceous to Eocene marls and calcilitites (Hybla Formation and Scaglia = Amerillo Formation) follow upward.

In the RAI unit Di Stefano *et al.* (in press) recognize four lithofacies:

- 1) RAIa, “Red pseudonodular cephalopod limestone”, consisting of dark red to red calcilitite containing abundant ammonites, fragments of *Bositra*, radiolarians, mollusc fragments and benthic foraminifers. It is possible to recognize three subunits separated by thin Mn-oxide-coated bedding planes corresponding to the Humphriesianum, Garantiana, and Parkinsoni Zones;
- 2) RAIb, “Pink wavy cross-bedded limestone”, characterized by alternating laminae of coarser and finer bioclastic grain/pack/wackestone with *Bositra*, other mollusc fragments, foraminifers, ostracods, *Globochaete*, ammonites, gastropods and echinoderm fragments. The upper portion of RAIb is marked by the presence of a Late Bathonian (*Retrocostatum* Zone) fauna;
- 3) RAIc, “Red pseudonodular marly limestone”, a reddish calcilitite characterized by a pseudonodular texture derived from early diagenetic nodules, ammonite moulds and bioturbation traces. The fossil content is represented by radiolarians, benthic foraminifers and mollusc and echinoderm fragments. Several bed-parallel goethitic marl intercalations characterize the unit whose upper portion is rich in large ammonites of Middle Callovian (Anceps Zone) age, and marked by a series of Mn-coated condensation horizons. A thin and discontinuous Mn-oxide crust separates this unit from the succeeding one;
- 4) RAI d, “Red/grey nodular marls”, marly calcilitite showing slump structures and pebbles and with a rich fossil content characterized by belemnites, aptrychi, corals, crinoids, rhyncholites and echinoderm fragments. The belemnite assemblage investigated here was collected from this interval (Text-fig. 4).

SYSTEMATICS

PREVIOUS WORKS

Belemnite assemblages from Callovian - Oxfordian beds have never been described from central and southern Italy. It is thus worth mentioning past authors such as de Blainville (1827), d'Orbigny (1842-49), Favre (1875, 1876), Gilliéron (1873), de Loriol (1900, 1902) and Lissajous (1912, 1915, 1925), who described, figured and discussed belemnites from the Middle and Upper Jurassic of Switzerland and France. All the taxa here investigated were calibrated with ammonite biostratigraphy by them. Even if today their descriptions are defective according to the ICZN rules (1999), we must positively consider their studies and the attempt they made to use these fossils in biostratigraphy. Since this pioneering work only two authors have investigated belemnites of the perimediterranean area from the taxonomic, stratigraphical and evolutionary point of view: Pugaczewska (1961) described and discussed belemnites from Middle Jurassic beds of Poland; Riegraf (1980, 1981), carrying on the belemnite revision begun by Schwegler (1965), completed the biostratigraphical, evolutionary and palaeobiogeographical study of Jurassic belemnites of south-western Germany.

The systematic arrangement adopted here is mainly based on that proposed by Doyle, Donovan & Nixon (1994); although the more recent works of Riegraf (1995) and Riegraf, Janssen & Schmitt-Riegraf (1998) open some systematic problems that will need some time for resolution.

TAXONOMY

The terminology herein used is derived from Stevens (1965), Doyle & Kelly (1988) and Combémorel (1988). Individual descriptions also include size measurements in the cases of complete or almost complete specimens. All measures are in millimetres.



Text-fig. 4 - Belemnite bearing marls.

Estimated values for incomplete specimens are marked by a (*). Dimensional adjectives are used as in Doyle & Kelly (1988); the terms small, medium and large, related to the length of the rostrum (L), are respectively referred to $L < 80$ mm, L between 80 and 110 mm and $L > 110$ mm.

Abbreviations as in Mariotti (in press): L , total preserved length; D_v , dorso-ventral diameter at alveolar opening; D_l , lateral diameter at alveolar opening; $D_{v_{max}}$, maximum ventral diameter; $D_{l_{max}}$, maximum lateral diameter; X , length from apex to D_{max} ; I_c , compression index, used for the Duvaliidae, the ratio between dorso-ventral diameter and lateral diameter, calculated at the level of the alveolar opening (I_{ca}), and at the level of the maximum dorso-ventral diameter (I_{cm}); I_d , depression index, used for the Belemnopseidae, the ratio between lateral diameter and dorso-ventral diameter calculated at the level of the alveolar opening (I_{da}), and at the level of the maximum lateral diameter (I_{dm}).

All the collected specimens are housed in the Palaeontological Museum of the Dipartimento di Scienze della Terra of the University "La Sapienza" of Rome, and are curate with the collection number NS 20/...

Some of the species described herein are poorly known as their original descriptions made at the end of the nineteenth century were poor and the illustrations in the original papers were just drawings. Some forms subsequently described still present nomenclatural problems. Moreover the studied belemnite assemblage, typical of Upper Callovian - Middle Oxfordian levels, is unique because was collected from a single outcrop, from beds with a total thickness of less than one metre.

Class CEPHALOPODA Cuvier, 1794

Subclass COLEOIDEA Bather, 1888

Order BELEMNITIDA Gray, 1849

Suborder BELEMNOPSEINA Jelezky, 1965

Family BELEMNOPSEIDAE Naef, 1922

Remarks - *Hibolithes* Montfort, 1808 and *Belemnopsis* Bayle, 1878 are the two best known genera of this family. The question of the distinction between them was raised for the first time by Lissajous (1925). This author's opinion was that *Belemnopsis* comprised two groups (*Hibolithes* and *Belemnopsis*) and that they had been incorrectly separated.

Subsequently this problem was also discussed by other authors. Mutterlose (1992) describing the genus *Belemnopsis* underlines how the two genera are close each other but states that they differ because *Hibolithes* has a pronounced hastate rostrum with a shorter less prominent ventral groove. Recently Doyle & Pirrie (1999, p. 424) affirm that "the overall morphology of *Belemnopsis* shows a number of subtleties which suggest that a detailed analysis of the group as a whole is necessary." They distinguish the Middle Jurassic specimens from the subsequent ones: the former possess a

depressed cross section and hastate outline, the latter a compressed cross section and cylindrical shape.

Here Mutterlose's (1992) subdivision is applied; consequently the specimens with a clearly hastate rostrum, a ventral groove limited to the anterior half of the rostrum, or at its maximum not reaching the apex, and a usually circular, sometimes depressed transverse section, are ascribed to the genus *Hibolithes*. In contrast, the specimens characterized by a cylindrical rostrum, a transverse section markedly depressed in the apical and stem regions, compressed in the alveolar region and a ventral alveolar groove extending up to the apex are included in *Belemnopsis*. Nevertheless the existence of forms with transitional characters is confirmed and in investigating the morphological characters of some western Tethyan rostra of *Hibolithes* and *Belemnopsis*, it is possible to observe that they are similar to those, coeval or not, of the Indonesian or South Pacific rostra. This seems a quite important argument due to the attribution to *Hibolithes* or to *Belemnopsis* of these forms, at the Late Oxfordian (the time of its assumed eastward emigration), has profound implications in palaeobiogeographical models and in biostratigraphical schemes.

Sometime biogeographical and biostratigraphical disjunctions are considered as taxonomically distinctive characters at species or at genus level. Only with regard to some widespread and long ranging taxa such as *Rhopaloteuthis sauvanausa* or *Hibolithes hastatus* that have been recorded from different geographical and stratigraphical levels from the first palaeontological studies onwards, do these obstacles seem to be overcome.

The uncertainty of a clear distinction between these two genera means that a revision of their evolutionary history is needed. Therefore to make progress in this field and to clarify in detail their geographical and stratigraphical distribution, primary descriptive papers are urgently needed. It would probably be better to try first to closely adhere to the original description of these taxa, leaving open for the moment the nomenclatural problems, and collect original data. Only after a synthesis of such new data will it be possible to scientifically analyse the results and determine their biostratigraphical and palaeobiogeographical implications.

Genus *HIBOLITHES* Montfort, 1808

Type species – *Hibolithes hastatus* Montfort, 1808. According to Riegraf, Janssen & Schmitt-Riegraf (1998, p. 149): "Type species is a *nom. dub.*; ICZN pending: validation with type species *Belemnites semisulcatus* Münster, 1830". Until the question is officially settled it seems useful to consider *Hibolithes hastatus* Montfort, 1808 as the type species.

Diagnosis – Elongated, slender and hastate rostrum. Symmetrical outline and profile. Maximum transverse diameter usually at the posterior region, near the apex. Transverse section usually circular, sometimes depressed in the posterior region and at

the mid point of the rostrum, sometime compressed in the alveolar region. Shallow, wide ventral groove limited to the anterior half of rostrum. Well evident lateral lines (Doppellinien). Central apical line.

Stratigraphical range and geographical distribution – Bajocian to Aptian of Europe, Africa, Madagascar, Pakistan, India, Tibet, south-eastern Asia, New Zealand, Australia, western Antarctica, South and North America.

HIBOLITHES HASTATUS Montfort, 1808

Pl. 1, figs. 1-6

1808 *Hibolithes hastatus* MONTFORT, p. 387.

1827 *Belemnites hastatus* (Montfort) - de BLAINVILLE, p. 71, pl. 2, figs. 4-5; pl. 5, fig. 3.

1981 *Hibolithes (Hibolithes) hastatus hastatus* (Montfort) - RIEGRAF, pp. 81-84, text-figs. 199-201; pl. 6, figs. 45-47 (*cum syn.*).

Material – Three well preserved adult specimens (NS 20/1189, /1190, /1191), four sub-adult (NS 20/1192, /1193, /1194, /1195), two juvenile specimens (NS 20/1196, /1197), nine sub-adult specimens lacking the alveolus (NS 20/1198, /1199, /1200, /1201, /1202, /1203, /1204, /1205, /1206), eight juvenile specimens lacking the alveolus (NS 20/1207, /1208, /1209, /1210, /1211, /1212, /1213, /1214) four fragments of alveolar, stem and apical regions (NS 20/1215, /1216, /1217, /1218).

Description – The large-sized rostrum is typically hastate and slender with a narrowing at the beginning of the alveolus and an inflation in its proximal portion.

The outline is symmetrical and hastate with its maximum diameter (DI_{max}) at about one third of the length from the apex. The profile is symmetrical and hastate; the maximum dorso-ventral diameter (Dv_{max}) is at one third of the length from the apex. The transverse section is slightly compressed in the alveolar region becoming slightly depressed in the stem and apical regions. A ventral groove extends from the alveolar opening to the apical region. Proximally it is narrower with angular edges that become more rounded in the posterior portion where the groove is less deep and wider as a shallow depression. Two lateral lines run on each flank. The apex is acute, slightly mucronate in the adult specimens.

Dimensions

NS 20/	L	DI_{max}	Dv_{max}	DI	Dv	x	I_{dm}	I_{da}
1189	150.0	16.5	13.5	11.0	12.0	41.0	1.22	0.91
1190	144.5*	18.1	15.8	12.3	10.7	—	1.45	1.15
1191	130.0*	13.9	11.5	9.7	10.2	—	1.21	0.95
1192	87.6	8.1	6.8	5.5	4.9	33.5	1.19	1.12
1194	91.0*	10.0	9.3	6.5	6.5	—	1.09	1.00
1196	54.3	8.0	7.1	4.7	4.3	19.0	1.13	1.09
1197	41.2	5.0	4.5	2.7	2.5	15.0	1.11	1.08
1201	108.3	8.2	8.2	—	—	33.0	1.00	—

Remarks – The specimens investigated here are very similar to those known in the literature (de Blainville, 1827; Favre, 1876; Lissajous, 1925; Pugaczewska, 1961; Riegraf, 1981). *Hibolithes semihastatus* is the species closest to *Hibolithes hastatus*, but the latter possesses a shorter groove and a less clavate rostrum.

Occurrence – Upper Callovian to Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). Favre (1876) affirms that *Hibolithes hastatus* is the most widespread species in the Callovian and Oxfordian rocks of Switzerland. d'Orbigny (1842-49) asserts that this is the most characteristic species of Lower Oxfordian beds in France, and records it also in Spain. Pugaczewska (1961) recorded that this is a widespread species in the Bathonian - Oxfordian of Poland; additionally she records it in Germany, France, England, Switzerland, Austria, Portugal, Spain, Algeria, Caucasus, Russia, Arabia, India and Madagascar. Riegraf (1981) records it in Oxfordian sediments of south-western Germany.

HIBOLITHES sp. aff. H. BEYRICHI Oppel, 1857
Pl. 2, figs. 1-2

Material – Three almost complete rostra (NS 20/1295, /1296, /1297), four specimens lacking the alveolar region (NS 20/1298, /1299, /1300, /1301), one long fragment of the stem region (NS 20/1302), one specimen lacking the apical region (NS 20/1303) and five fragments of the stem region (NS 20/1304, /1305, /1306, /1307, /1308).

Description – The large-sized rostrum is characteristically very slender. The outline is symmetrical and very weakly hastate. The maximum lateral diameter (D_{max}) occurs at one third of the total length from the apex. The profile is symmetrical, cylindrical to slightly hastate. Two long lateral lines run on each flank to nearly the apex. The transverse section is circular, sometime very little compressed near the alveolar opening. The ventral furrow is narrow and shallow ending a little beyond the mid-length of the rostrum. The apical region is slender and sharply pointed.

Dimensions

NS 20/	L	D_{max}	D_{vent}	DI	Dv	x	I_{dn}	I_{da}
1295	131.5	5.4	5.3	4.2	3.8	33.0	1.02	1.10
1296	114.3	6.7	6.5	3.8	4.1	30.0	1.03	0.93

Remarks – The specimens investigated possess a characteristically long and slender rostrum with a circular transverse section. The only specimens with which these can be related, are those described, figured and ascribed to *Hibolithes beyrichi* by Pugaczewska (1961). The same species was also described and figured by Riegraf (1980) as *Belemnopsis (Longibelelemnopsis) beyrichi* and successively ascribed to *Longibelelemnopsis* by Riegraf, Janssen & Schmitt-Riegraf (1998). The specimens studied, although showing some affinities with the specimens figured by Pugaczewska (1961), differ from them in a more marked hastation of the apical region and in a clearly longer groove.

The attribution to *Hibolithes* is based on profile and outline both symmetrical and slightly hastate, on circular cross section and on the groove length. The investigated specimens are not comparable to any known species but they were not so well preserved and numerous enough to establish a new species.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy).

Genus BELEMNOPSIS Bayle, 1878

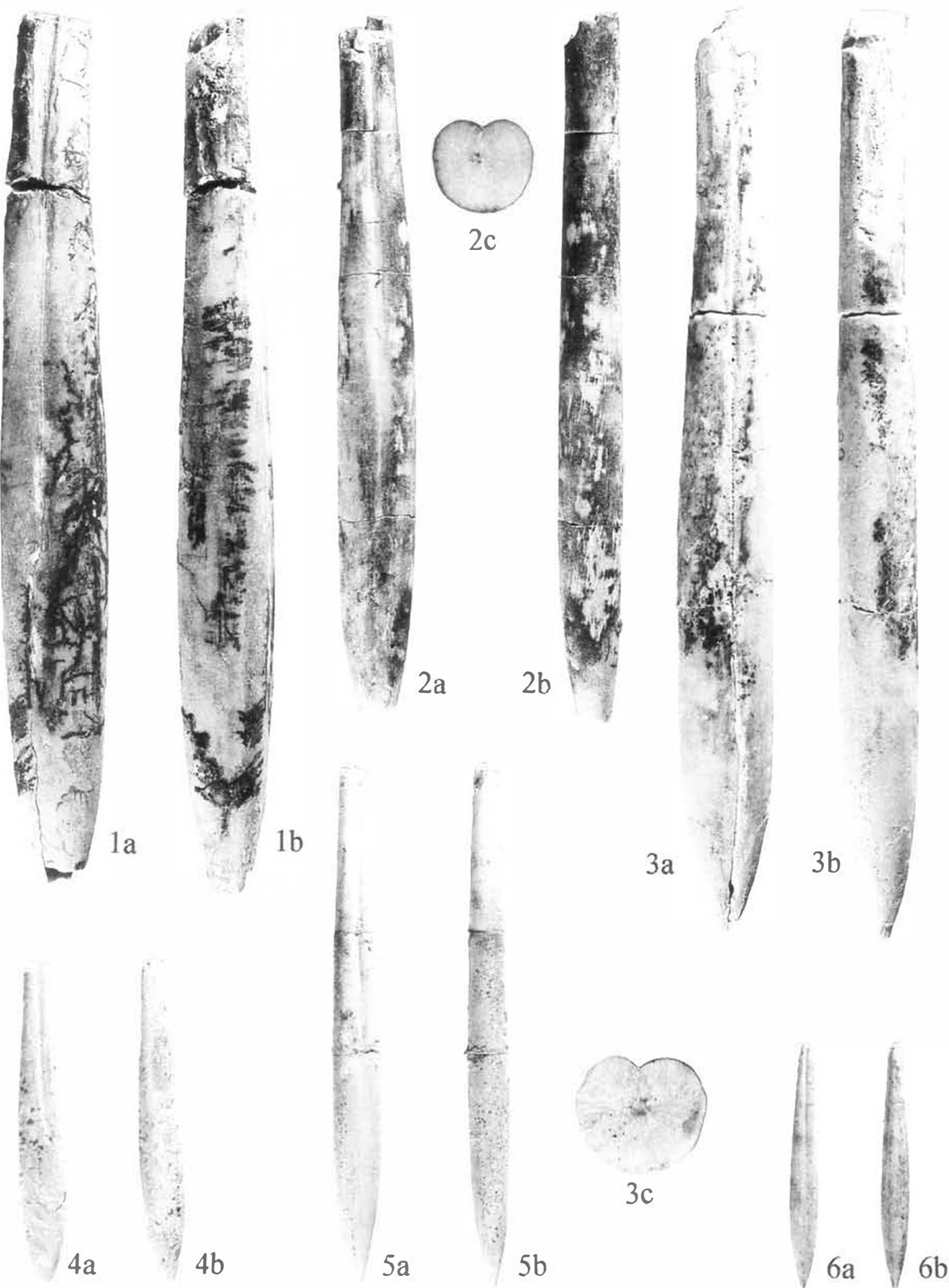
Type species – *Belemnites sulcatus* Miller, 1823, by subsequent designation (Douville, 1879). Recently Riegraf, Janssen & Schmitt-Riegraf (1998) questioned the validity of the genus *Belemnopsis* and its type species *Belemnites sulcatus* Miller. However, it is maintained in this paper, mainly following the classification of Doyle, Donovan & Nixon (1994).

Diagnosis – Cylindrical to hastate, elongate rostrum. Outline symmetrical. Profile asymmetrical. Acute apex. Transverse section usually depressed in the apical and stem regions, compressed in the alveolar region. Broad, ventral alveolar groove extending up to the apex. Apical line ventrally eccentric. Lateral lines rarely present.

Stratigraphical range and geographical distribution – Bajocian to lowermost Hauterivian of Europe, Africa, Madagascar, Pakistan, India, Tibet, South East Asia, Australia, New Zealand, western Antarctica and South America. In Italy the genus is known from beds of Early Kimmeridgian age at Campo al Bello and from Bajocian beds at Sasso di Pale (Central Apennines; Mariotti, 1994; in press).

EXPLANATION OF PLATE 1

Figs. 1-6 – *Hibolithes hastatus* Montfort, 1808. 1) Adult specimen, NS 20/1190: 1a) ventral view, ($\times 1$), 1b) left side, ($\times 1$); 2) adult specimen NS 20/1191: 2a) ventral view, ($\times 0.9$), 2b) left side ($\times 0.9$), 2c) transverse section, ($\times 2$); 3) adult specimen, NS 20/1189: 3a) ventral view, ($\times 1$), 3b) right side, ($\times 1$), 3c) transverse section, ($\times 2$); 4) juvenile specimen, NS 20/1196: 4a) ventral view, ($\times 1$), 4b) left side, ($\times 1$); 5) sub-adult specimen, NS 20/1192: 5a) ventral view, ($\times 1$), 5b) right side, ($\times 1$); 6) juvenile specimen, NS 20/1197: 6a) ventral view, ($\times 1$), 6b) left side, ($\times 1$).



BELEMNOPSIS LATESULCATUS (Voltz) in Thurmann, 1832
Pl. 2, figs. 3-6

- 1832 *Belemnites latesulcatus* (Voltz) - THURMANN, p. 27.
1845 *Belemnites latesulcatus* d'ORBIGNY, p. 301, pl. 50, figs. 3-8.
1846-1849 *Belemnites semihastatus depressus*, QUENSTEDT, p. 440, pl. 29, figs. 12-19.
1893 *Belemnites (Hibolites) latesulcatus* (Voltz) - RICHE, pp. 327-328, pl. II, figs. 13-17.
1902 *Belemnites (Hibolites) latesulcatus* (d'Orbigny) - de LORIOI, pp. 8-9, pl. I, figs. 8-11.
1910 *Belemnites latesulcatus* (Voltz) - BENECKE, pp. 129-132, text-fig. 1.
1912 *Belemnites (Hibolites) latesulcatus* (d'Orbigny) - LISSAJOUS, p. 15, pl. 2, figs. 7-8.
1920 *Hibolites latesulcatus* (Voltz) - BULLOW-TRUMMER, p. 145.
1925 *Belemnopsis latesulcatus* (d'Orbigny) - LISSAJOUS, p. 105.
1961 *Belemnopsis latesulcatus* (d'Orbigny) - PUGACZEWSKA, pp. 150-153, text-fig. 14; pl. XI; pl. XII, fig. 1.

Material – Four adult specimens (NS 20/1273, /1274, /1275, /1276), one juvenile specimen (NS 20/1284), three specimens lacking the alveolar region (NS 20/1277, /1278, /1279), four apical regions (NS 20/1280, /1281, /1282, /1283).

Description – The medium-sized rostrum is slender and characteristically little hastate. The outline is symmetrical, cylindrical to little hastate. The ventral surface is flattened with the maximum diameter ($D_{l_{max}}$) at about the half of the rostrum in adult specimens and a little less than one third in the juvenile forms. The profile is symmetrical, cylindrical to very slightly hastate. The transverse section is depressed along the entire length of the rostrum. Two faintly visible lateral lines run along each flank. A ventral well developed groove extends backward from the alveolar opening, terminating near the apex; in the apical region it becomes shallow expanding. The apical region is relatively short and pointed.

Dimensions

NS 20/	L	$D_{l_{min}}$	$D_{v_{max}}$	DI	Dv	x	I_{dim}	I_d
1274	77.0	12.0	9.7	10.3	9.2	33.0	1.24	1.12
1275	68.0	11.8	10.0	8.8	8.8	29.0	1.36	1.00
1277	65.0*	11.4	9.3	—	—	32.0	1.22	—
1284	50.8	6.8	5.7	5.8	5.2	21.3	1.19	—

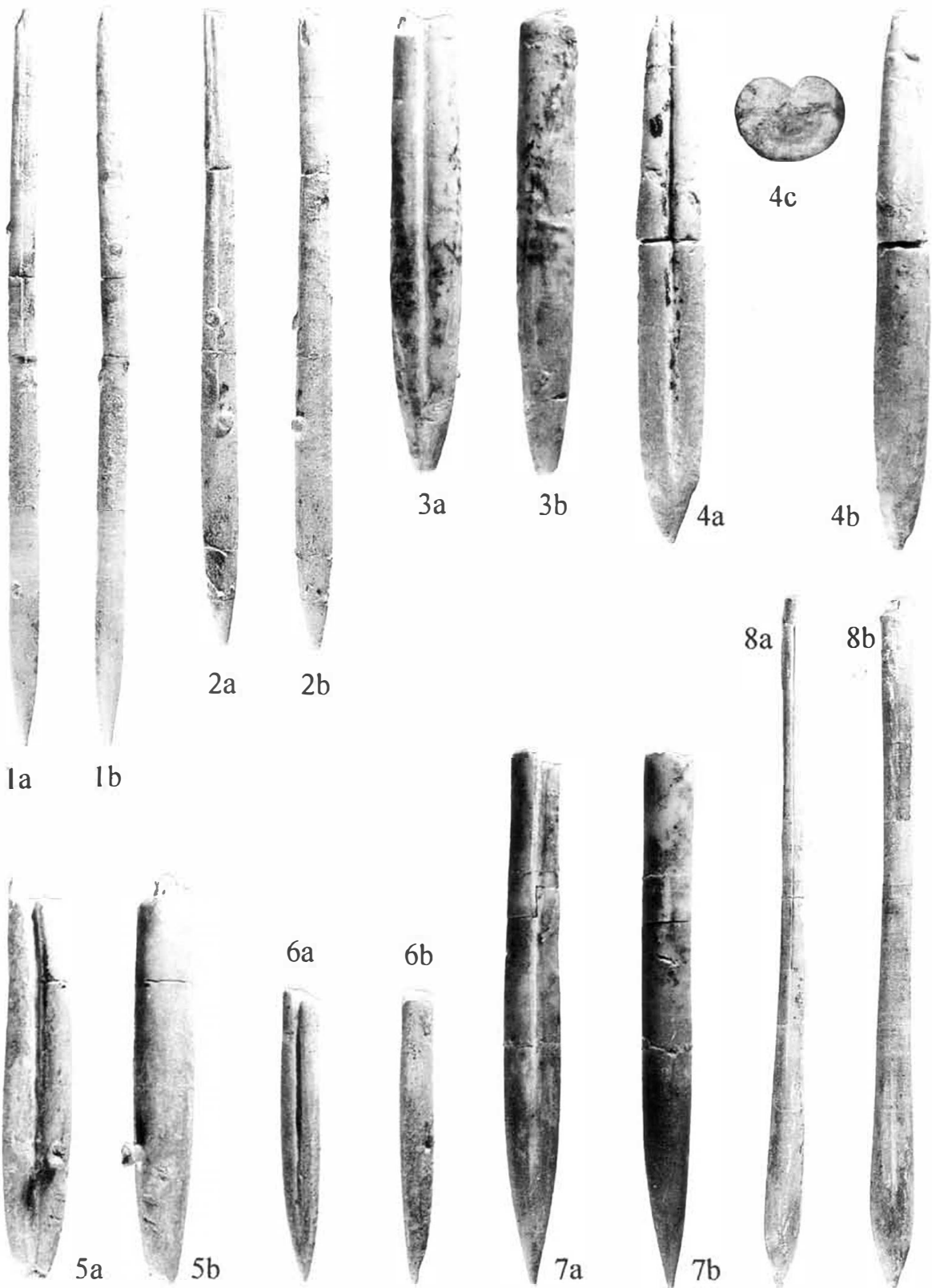
Remarks – The funny and interesting history of this name, as reported by Benecke (1910) is the following: Voltz probably gave his name as author only to the fragmentary specimens figured in Benecke (1910, fig. 1) because they were the unique belemnites stored in an unspecified "city collection". These specimens were defined as *Belemnites latesulcatus* Voltz and so they can be considered to include the original material. Voltz never published his name as the author of the species; nevertheless the name *Belemnites latesulcatus* Voltz in lit. as quoted by Bronn (1848, Index I, p. 152, *fide* Benecke, 1910) was known and has been frequently cited in the literature since 1832, (e.g. in Thurmann, 1832; Thirria, 1883 and Mandelsloh, 1835). Since the "Essay" of Thurmann was published in 1832 and in the "Observations sur les Bélemnites" of Voltz (1830) *Belemnites latesulcatus* was not cited, Benecke (1910) considered it probable that Voltz gave the name to his belemnites between 1830 and 1832. The same author believed that d'Orbigny (1845) probably created the name *latesulcatus* in autonomous way. The figures of d'Orbigny were never published, and what he intended with the name *Belemnites latesulcatus* was known only by Riche (1893). In the opinion of Benecke (1910) it is correct to write *Belemnites latesulcatus* as French and Swiss authors did, adding the attribution Voltz non d'Orbigny.

Belemnites latesulcatus has some very characteristic features, such as a little hastation, a long groove almost to the apex and an always depressed cross section that allows clear distinction of this species from the closely related *Hibolites semihastatus*.

Occurrence – Upper Callovian-Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It is recorded from Upper Callovian beds of the *Quenstedtoceras lamberti* Zone at Lupieu (Ain), Montrevel (Jura) and Valfin-sur-Valouze (Jura) (Riche, 1893). D'Orbigny (1845) found it in the lower beds of the Oxfordian (Jura bernois), de Loriol (1902) from the "*Phol. exaltata* beds" at Andelot-en-Montagne, Gevingey, Arc-sous-Montenot, Dramelay, la Billode. Benecke (1910) from Oxfordian of Monte Terrible. Lissajous (1912) recorded it from the Upper Callovian of the *Quenstedtoceras lamberti* Zone of the "Jurassique maconnais". Pugaczewska (1961) collect-

EXPLANATION OF PLATE 2

- Figs. 1-2 - *Hibolites* sp. aff. *H. beyrichi* (Oppel, 1857). 1a) ventral view, ($\times 0.9$), 1b) left side, ($\times 0.9$), NS 20/1295; 2a) ventral view, ($\times 0.9$), 2b) left side, ($\times 0.9$), NS 20/1296.
Figs. 3-6 - *Belemnopsis latesulcatus* Voltz in Thurmann, 1832. 3a) ventral view, ($\times 1$), 3b) left side, ($\times 1$), NS 20/1274; 4a) ventral view, ($\times 1$), 4b) left side, ($\times 1$), 4c) transverse section, ($\times 2$), NS 20/1273; 5a) ventral view, ($\times 1$), 5b) left side, ($\times 1$), NS 20/1275; 6) juvenile specimen, NS 20/1284, 6a) ventral view, ($\times 0.9$), 6b) left side, ($\times 0.9$).
Fig. 7 - *Belemnopsis* sp. 1. 7a) ventral view, ($\times 1$), 7b) right side, ($\times 1$), NS 20/1285.
Fig. 8 - *Duvalia didayana* (d'Orbigny, 1842). 8a) dorsal view, ($\times 0.9$), 8b) left side, ($\times 0.9$), NS 20/1266.



ed it from Bathonian and Callovian horizons in Poland.

BELEMNOPSIS sp. 1

Pl. 2, fig. 7

Material – One adult specimen (NS 20/1285), one long stem region (NS 20/1286) eight fragments of apical region (NS 20/1287, /1288, /1289, /1290, /1291, /1292, /1293, /1294).

Description – The rostrum is slender and medium-sized. The outline is symmetrical and very slightly hastate. The maximum transverse inflation (DI_{max}) occurs at a little more than one third of the total length of the rostrum from the apex. The apical region is elongate ending with a sharp point. Anterior of the widest point the sides converge very slightly up to the beginning of the alveolar region. The transverse hastation is very slight. The profile is symmetrical and cylindrical. The apex is centrally placed. The transverse section of the stem and apical regions are depressed, anteriorly the cross section becomes a little compressed. The apical region is long and sharp. A median ventral groove, extending from the alveolar opening to one sixth from the apex, attains a maximum depth of 1 mm and a maximum width of 3 mm. Lateral lines are present on each flank.

Dimensions

NS 20/	L	DI_{min}	Dv_{min}	DI	Dv	x	I_{min}	I_{max}
1285	89.0	9.6	8.3	8.4	8.5	33.0	1.57	0.98

Remarks – These specimens show the typical characteristics allowing them to be ascribed to the genus *Belemnopsis*. The length of the groove, the long and slender apical region and the slightly hastate profile distinguish these specimens from already known forms. The material, even though well preserved, is not enough to establish a new species.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy).

Family DUVALIIDAE Pavlow, 1914

Genus DUVALIA Bayle, 1878

Type species – *Belemnites dilatatus* de Blainville, 1827, by subsequent designation (Douville, 1879).

Diagnosis – Small to large sized, more or less strongly compressed rostrum. Alveolar dorsal groove. Outline symmetrical. Profile asymmetrical. Two lateral lines (Doppellinien) on each flank. Apex short, sometimes mucronate or rounded.

Remarks – Riegraf (1981) re-established the genus *Produvalia* and used *Belemnites monsalvensis* Gillieron, 1873 as type species, using the name *Produvalia* established by Schwegler (1949) but *nomen nudum*. Doyle, Donovan & Nixon (1994) maintained the genus *Produvalia* Schwegler, 1949 believing that the species *Belemnites argoviensis* cited by Schwegler (1949) could be considered as type species. According to Riegraf, Janssen & Schmitt-Riegraf (1998, p. 264), the question of suppression of this genus is pending with the ICZN. As some species (*Duvalia monsalvensis*, *D. didayana*, *D. neyrivensis* and *D. dumortieri*), that were ascribed by Riegraf, Janssen & Schmitt-Riegraf (1998) to *Produvalia* Riegraf, are investigated here it is preferable, while waiting for resolution of this problem by the International Commission on Zoological Nomenclature, to refer these species to the genus *Duvalia*.

Stratigraphical range and geographical distribution – *Duvalia* is a widespread Tethyan genus from Kimmeridgian-Early Aptian times and is rarer in the Middle Jurassic and Oxfordian. *Duvalia disputabilis*, from Poland (Pugaczewska, 1961), and *Duvalia rhopaliformis*, from Madagascar (Combémère, 1988), are the only known Bathonian records. The youngest species, *D. rafarae*, was collected from the Turonian of Madagascar (Combémère, 1988). The only species recorded outside the Tethyan Realm is *Duvalia grasiana* from the middle Late Aptian of north-western Germany (Mutterlose, 1988, 1990, 1992, 1998).

DUVALIA DIDAYANA (d'Orbigny, 1842)

Pl. 2, fig. 8

- 1842 *Belemnites Didayanus* d'ORBIGNY, pp. 126-127, Pl. XX, figs. 1-5.
 1863 *Belemnites Didayanus* d'Orbigny - VILANOVA & PIERA, pl. 9, fig. 9, *sede* Lissajous, 1925.
 1994 *Duvalia didayana* (d'Orbigny) - COMBÉMÈRE & FISHER in FISHER, pp. 19-20, pl. 4, figs. 4-5.

Material – Eight complete specimens (NS 20/1266-72, /1351), six juvenile specimens (NS 20/1326-31), three adult specimens lacking the alveolus (NS 20/1323-25), fourteen specimens lacking the alveolar region and a portion of the stem (NS 20/1332-45), one juvenile specimen without apex ((NS 20/1346), one stem region ((NS 20/1347), three specimens lacking the alveolar region (NS 20/1348-50) and one very juvenile specimen (NS 20/1352).

Description – The large sized rostrum is very slender and compressed (i_{cm} 0.66 to 0.87, i_a 0.64 to 0.78). The compression is more accentuated in the stem and apical regions. The outline is symmetrical and hastate. The maximum lateral diameter (DI_{max}) is placed at the posterior portion of the rostrum in the proximity of the apex, so the outline has a characteristic clavate aspect. The flanks show a convergent

trend for the entire alveolar region, becoming almost parallel or moderately divergent in the long stem region, finally becoming very quickly convergent in the apical region. The profile is hastate and asymmetrical. The asymmetry is due to the more accentuated ventral side in the apical region. A weak depression runs along the flanks from the end of the alveolar region nearly to the apex; it is more accentuated and marked by lateral lines in the apical region. A dorsal alveolar groove extends from the alveolar opening as far as the beginning of the apical region. The latter is short and ends in a sharp, sometimes mucronate, apex. The phragmocone penetrates for about one fifth of the length of the rostrum. The transverse section is compressed with rounded edges and a more developed ventral side. Alveolar angle about 20°.

Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _{dc}	I _{ds}
1266	124.8	6.9	7.9	4.8	6.3	16.2	0.87	0.76
1267	111.0	6.2	7.6	5.1	6.6	21.0	0.81	0.77
1268	115.0	5.2	7.7	3.6	4.7	23.7	0.67	0.76
1272	92.0	5.6	7.1	4.0	5.3	22.0	0.79	0.75
1327	74.6	6.1	9.2	3.9	5.0	15.0	0.66	0.78
1328	61.0	5.1	6.8	3.0	3.9	15.7	0.75	0.77

Remarks – This species is extremely slender and with a long dorsal groove; these features distinguish *Duvalia didayana* from *D. monsalvensis* and *D. neyrivensis*. In fact the former has a clearly more robust and shorter rostrum and a shorter groove; the latter, even though characterized by a long and slender rostrum, possesses a shorter groove and a little more robust rostrum.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). Elsewhere, this species is only known from Oxfordian beds at Rians and Châtillon-sur-Seine (France, d'Orbigny, 1842-49).

DUVALIA DUMORTIERI (Oppel, 1865)

Pl. 3, figs. 1-2, 5

1865 *Belemnites Dumortieri* OPPEL, p. 313

1876 *Belemnites Dumortieri* OPPEL - DUMORTIER & FONTANNES, pp. 31-33, pl. IV, figs. 8, 10, not fig. 9.

1897 *Belemnites Dumortieri* OPPEL - ROMAN, p. 5, pl. I, fig. 8.

no 1981 *Produvalia (Produvalia) dumortieri* (Oppel) - RIEGRAF, p. 114, text-figs. 244-245; pl. 8, fig. 85.

Material – Five complete adult specimens (NS 20/1309, /1314, /1320-22), three sub-adult specimens (NS 20/1310, /1313, /1315) and six juvenile specimens (NS 20/1311-12, /1316-19).

Description – The small sized rostrum is stout and compressed (I_{cm} 0.75 to 0.92, I_{ca} 0.77 to 0.93). The outline is symmetrical and hastate. The maximum

lateral diameter (DI_{max}) is placed at the posterior portion of the rostrum. The hastate outline is caused by the very gradual widening of the sides, starting from the alveolar opening, up to about the three quarters of the total length; they then converge rapidly in the apical quarter. The profile is hastate and markedly asymmetrical. The asymmetry is due to the more accentuated ventral side in the apical region where the rostrum narrows very quickly, causing a clavate aspect to the posterior part. A weak depression runs along each flank from the end of the alveolar region almost to the apex. A dorsal alveolar groove extends along all the alveolar region to the beginning of the apical region, which is short and ends with an obtuse and mucronate apex. The phragmocone penetrates for about one third of the length of the rostrum in the adult specimens and for about one half in the juvenile specimens. The transverse section is compressed with rounded edges. Alveolar angle about 18°.

Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _{dc}	I _{ds}
1309	66.3	13.0	14.3	9.9	10.6	25.7	0.91	0.93
1310	55.2	10.5	12.2	9.6	10.5	22.6	0.86	0.91
1314	64.3	10.5	13.0	8.0	10.9	24.6	0.81	0.73
1315	53.0	10.0	11.6	8.7	9.5	21.7	0.86	0.91
1318	46.4	8.9	11.9	8.5	10.4	16.5	0.75	0.82
1319	48.0	10.8	11.7	7.8	9.5	18.6	0.92	0.82

Remarks – This species was erected by Oppel (1865) without designation of the holotype. In our opinion Oppel did not intend to select a type but only to compare its material with some other figures, in fact in his description a simple comparison was made with a figure of *Belemnites latus* (= *Duvalia lata*) as in Quenstedt (1849, p. 452, pl. XXX, fig. 13), not to establish a type, as believed by some authors, but only to compare the two morphologies. Subsequently Dumortier & Fontannes (1876) described and figured some specimens coming from the same locality from which Oppel's material came and named them as *Belemnites dumortieri* Oppel. According to Lissajous (1925), Oppel (1865) chose the figure of a Cretaceous specimen and so the species would be invalid; that author suggested that it would have been better to select the Dumortier & Fontannes (1876) figures. All the authors, that successively studied or reported the species, accepted as author Oppel. If we consider that Dumortier & Fontannes (1876) described and figured firstly the species, the correct name group might be *Duvalia dumortieri* Dumortier & Fontannes, 1876. This question is still open and requires a specific study although the taxon is clearly recognizable.

Duvalia monsalvensis is the species closest to *D. dumortieri*. *D. dumortieri* differs clearly in a shorter, stout and clavate rostrum, in a longer groove and in a larger alveolar opening.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It has also been recorded from the *Gregoryceras transversarium* Zone at Crussol (Ardèche), (Oppel, 1865), from Oxfordian sediments of the “*Terebratula impressa* Zone” at Crussol, Bouchard (Ardèche) and les Pênes (Ain) (Dumortier & Fontannes, 1876).

DUVALIA MONSALVENSIS (Gillieron, 1873)

Pl. 3, figs. 3-4, 6-7

- 1873 *Belemnites monsalvensis* GILLIERON, p. 202, pl. 8, figs. 5-7.
 1873 *Belemnites* cf. *Didayanus* GILLIERON, p. 198, pl. 8, figs. 3-4.
 1875 *Belemnites voironensis* Gillieron - FAVRE, p. 15, pl. I, fig. 4.
 1876 *Belemnites monsalvensis* Gillieron - FAVRE, p. 22, pl. I, fig. 11.
 1876 *Belemnites Dionysii* FAVRE, p. 24, pl. IV, figs. 1-3.
 1876 *Belemnites Dumortieri* Oppel - DUMORTIER & FONTANNES, p. 31, pl. IV, fig. 9.
 no 1902 *Belemnites* cf. *monsalvensis* Gillieron - de LORIOU, p. 14, pl. I, fig. 13.
 1981 *Produvalia (Produvalia) monsalvensis* (Gillieron) - RIEGRAF, p. 112, text-figs. 241-243; pl. 8, figs. 82-84.
 1981 *Produvalia (Produvalia) dumortieri* (Oppel) - RIEGRAF, p. 114, text-figs. 244-245; pl. 8, fig. 85.

Material – One almost complete rostrum of an adult specimen (NS 20/1218); fourteen sub-adult specimens (NS 20/1219, /1220, /1222-27, /1234, /1235, /1238-41); seventeen juvenile specimens (NS 20/1221, /1228-33, /1236, /1237, /1242-48, /1265), eleven adult specimens lacking the alveolar region (NS 20/1249-59) and five fragments of apical region of adult specimens (NS 20/1260-64).

Description – The medium-sized rostrum is robust, clearly compressed throughout its length. The outline is symmetrical and weakly hastate, the maximum lateral diameter (DI_{max}) occurs at a little more than one third of the total length from the apex. The profile is asymmetrical and hastate. The asymmetry is due to an almost straight dorsum in contrast to the more convex venter, overall in the apical region. In the juvenile specimens the profile is more asymmetric and clavate. A narrow, dorsal, alveolar groove usually extends just up to the mid-point of the rostrum. The flanks are flattened, sometimes marked by a slight

depression. In the juvenile specimens a depression, more accentuated in the apical region, is present on each flank, this depression changes in a flattened area in the apical region in the sub-adult specimens. The transverse section is elliptical anteriorly and rectangular with rounded angles posteriorly. The phragmocone penetrates approximately for one quarter into the rostrum. The alveolar angle is about 18°. The apical line is almost central.

Dimensions

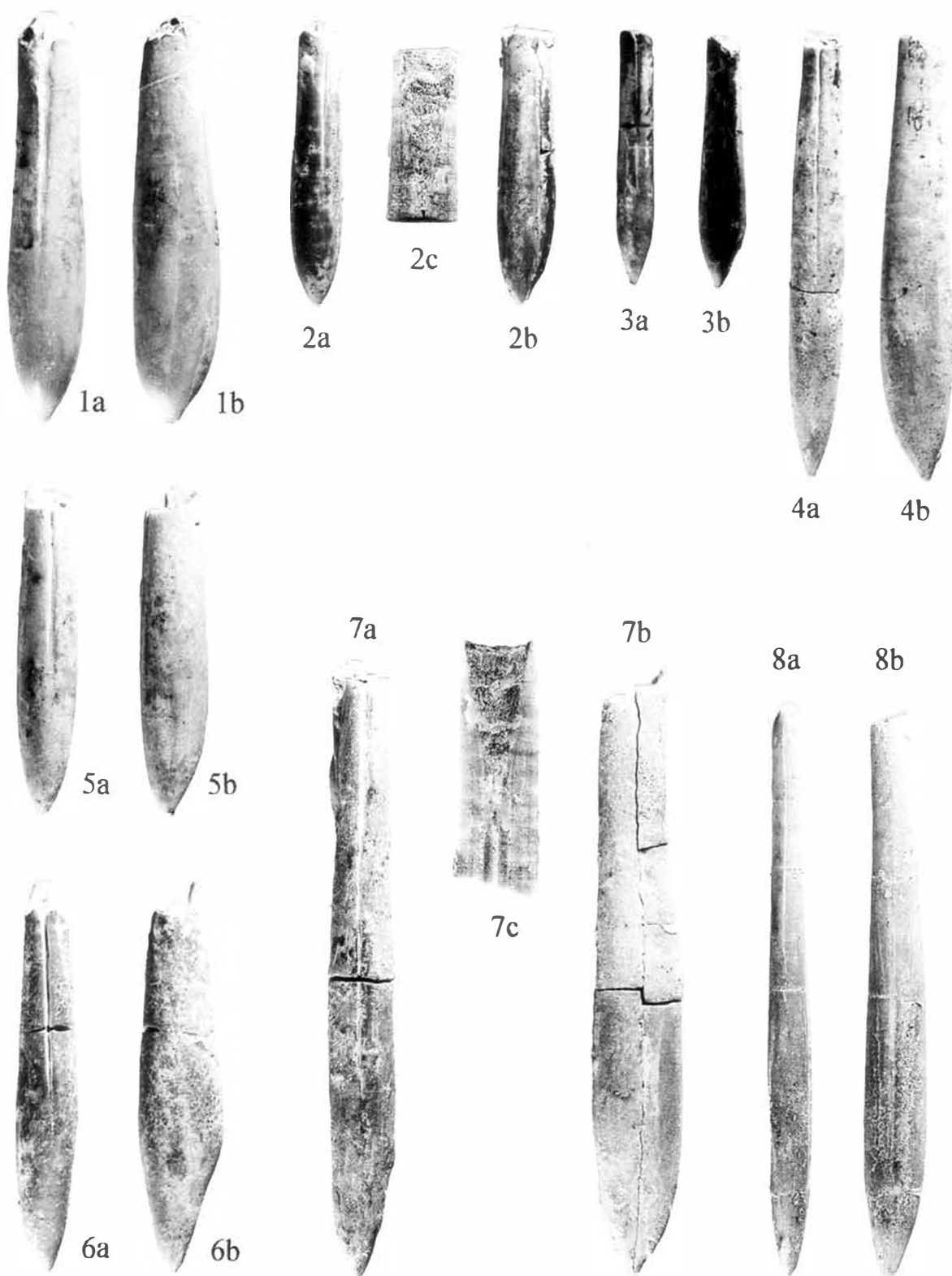
NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _{ext}	I _{ch}
1218	106.7	11.0	15.8	8.1	10.8	23.5	0.70	0.75
1220	89.3	8.8	12.0	5.4	6.4	24.0	0.73	0.84
1228	53.0	6.2	7.1	3.7	4.6	15.0	0.87	0.80
1229	58.0	6.3	9.3	5.5	6.3	16.0	0.68	0.87
1234	60.7	7.1	8.4	3.9	5.2	17.2	0.84	0.75
1236	44.4	7.8	9.1	7.1	7.9	16.2	0.86	0.90
1237	37.1	5.0	6.8	3.4	4.5	11.4	0.73	0.75
1239	69.0	7.2	9.8	6.0	7.9	18.6	0.73	0.76

Remarks – This is the most common species in the outcrop studied and all its growth stages are present. The majority of the specimens figured in literature are juvenile forms. Lissajous (1925, p.81) affirmed that the specimens described and figured for the first time by Favre (1876) as *Belemnites Dionysii* are a “variété grêle” of *Duvalia monsalvensis*. The only figured adult specimen is in Favre (1876, pl. IV, fig. 1) and it is very similar to the specimens investigated here. The closest related species are *Duvalia dumortieri*, *D. neyrivensis* and *D. voironensis*. As already stated by Lissajous (1925) *D. dionysii* and *D. voironensis* are forms that may be ascribed to *Duvalia monsalvensis*. *D. dumortieri* differs in having a markedly shorter and stouter rostrum and in a clearly shorter groove. *D. neyrivensis* possesses a longer slender clavate rostrum and a shorter groove.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It is also recorded from beds of the *Gregoryceras transversarius* Zone in Monsalvens (Alps of Fribourg, Gillieron, 1873; Favre, 1876) and in Plagnère, Prayouds, Riondinaire, vie de Neyrive (Switzerland, Favre, 1876), from the Oxfordian sediments at

EXPLANATION OF PLATE 3

- Figs. 1-2, 5 - *Duvalia dumortieri* (Oppel, 1865). 1) Adult specimen, NS 20/1309: 1a) dorsal view, (× 1), 1b) right side, (× 1); 2) juvenile specimen, NS 20/1311: 2a) dorsal view, (× 1), 2b) right side, (× 1), 2c) longitudinal section of the alveolar region, (× 1.5); 5) sub-adult specimen, NS 20/1315: 5a) dorsal view, (× 1), 5b) right side, (× 1).
 Figs. 3- 4, 6-7 - *Duvalia monsalvensis* (Gillieron, 1873). 3) juvenile specimen, NS 20/1221: 3a) dorsal view, (× 1), 3b) right side, (× 1); 4) sub-adult specimen, NS 20/1220: 4a) dorsal view, (× 1), 4b) left side, (× 1); 6) sub-adult teratologic specimen, NS 20/1222: 6a) dorsal view, (× 1), 6b) right side, (× 1); 7) adult specimen, NS 20/1218: 7a) dorsal view, (× 0.9), 7b) right side, (× 0.9), 7c) longitudinal section of the alveolar region, (× 1.5).
 Fig. 8 - *Duvalia neyrivensis* (Favre, 1876). 8a) dorsal view, (× 0.9), 8b) right side, (× 0.9), NS 20/1354.



Voirons (Savoie, Favre, 1875), from Crussol, Bouchard (Ardèche), les Pènes (Ain) (Dumortier & Fontannes, 1876), from the middle part of Lower Oxfordian at Stoberg near Blumberg/Wutach and Lower Oxfordian of Reichenbach near Nusplingen (west-southern Germany; Riegraf, 1981). Some specimens of the Lissajous collection are presently housed at the Museum of the Claude-Bernard University in Lyon; they come from Oxfordian marls of Crussol (Ardèche, south-eastern France).

DUVALIA NEYRIVENSIS (Favre, 1876)

Pl. 3, fig. 8; Pl. 4, fig. 1

1876 *Belemnites Neyrivensis* FAVRE, pp. 23-24, pl. 1, fig. 15.

Material – Four adult almost complete specimens (NS 20/1354-57), one juvenile complete specimen (NS 20/1381) and twenty-six specimens lacking the alveolar region (NS 20/1358-80, /1382-84).

Description – The large sized rostrum is slender and compressed (I_m 0.63 to 0.81, I_a 0.63 to 0.86). The outline is symmetrical and hastate. The maximum lateral diameter (DI_{max}) is placed at one quarter of the total length from the apex. The flanks converge from the alveolar opening to the tip of the alveolus, and then they diverge moderately as far as the beginning of the apical region. The profile is hastate and asymmetrical. The more inflated ventral side causes this asymmetry. The flanks are flattened more in the posterior half of the rostrum and in this portion are run by a broad and weak depression. A dorsal alveolar groove extends from the alveolar opening to half of the length of the rostrum. The apical region is short and ends with a mucronate point. The phragmocone penetrates for about one fifth of the length. The transverse section is compressed with rounded edges. The alveolar angle is about 20°.

Dimensions

NS 20/	L	DI_{max}	Dv_{max}	DI	Dv	x	I_m	I_a
1354	99.0	7.0	11.0	5.2	7.3	27.0	0.63	0.71
1355	124.0	9.1	12.1	7.7	8.9	27.2	0.75	0.86
1356	105.0	7.7	10.8	—	—	24.2	0.71	—
1357	101.6	8.6	12.2	6.3	9.5	27.5	0.70	0.66
1358	94.0*	9.5	12.4	—	—	25.0	0.77	—
1359	89.0*	8.2	11.3	—	—	29.8	0.72	—
1381	76.0	5.9	7.3	4.1	6.5	20.5	0.81	0.63

Remarks – The only species to which it is possible to confuse *Duvalia neyrivensis* is *Duvalia didayana*. The latter is very similar but has a markedly more slender rostrum and a very much longer groove distinguishes it from *D. neyrivensis*.

Occurrence – Upper Callovian-Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It was

also recorded from Oxfordian sediments at Neyrive (Favre, 1976). In the collection of the Museum of the Earth Department of the University Claude-Bernard of Lyon is stored a specimen coming from Upper Oxfordian beds of the base of the *Epipeltoceras bimammatum* Zone at Chassagnes (Ardèche, south-eastern France).

Genus RHOPALOTEUTHIS Lissajous, 1915

Type species – *Belemnites sauvanaus* d'Orbigny, 1842.

Diagnosis – Small sized hastate rostrum. Symmetrical and hastate outline. Symmetrical to very slightly asymmetrical hastate profile. Circular to sub-quadrant transverse section. Dorsal alveolar groove. Apical line slightly eccentric, alveolus penetrating one quarter to one half of the total length. Weak lateral lines on each flank.

Stratigraphical range and geographical distribution – Bathonian to Tithonian of the Mediterranean area and southern Europe.

RHOPALOTEUTHIS ARGOVIANA (Mayer, 1863)

Pl. 4, figs. 2-3

1849 *Belemnites hastatus impressae* QUENSTEDT, p. 447, figs. 36-37, not figs. 38-39.

1863 *Belemnites argovianus* MAYER, p. 193.

1875 *Belemnites argovianus* MAYER - FAVRE, p. 14, pl. VI, figs. 2-3.

1876 *Belemnites argovianus* MAYER - FAVRE, p. 18, pl. I, fig. 7.

1902 *Belemnites (Hibolites) argovianus* MAYER - de LORIOI, p. 10, pl. I, figs. 16-17.

1925 *Rhopaloteuthis argovianus* (Mayer) - LISSAJOUS, pp. 55-56.

1961 *Rhopaloteuthis argovianus* (Mayer) - PUGACZEWSKA, p. 193, pl. 6, figs. 1-3.

1981 *Produvalia (Pachyduvalia) argoviana* (Mayer) - RIEGRAF, pp. 107-108, text-figs. 235-236; pl. 8, fig. 77.

Material – Five complete specimens (NS 20/1388-92) and some fragments of alveolar and apical regions.

Description – The small-sized rostrum has a symmetrical, cylindrical or very slightly hastate outline and a symmetrical to very slightly asymmetrical and hastate profile. The transverse section maintains a sub-circular shape for all the length of the rostrum. The flanks are incised by lateral lines and are not always discernible. From the alveolar opening the flanks run parallel for two thirds of the length; they successively taper rapidly ending in a mucronate dorsally eccentric point. The alveolus penetrates one third of the total length.

Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _{top}	I _{ap}
1388	35.0	7.7	8.4	8.0	8.1	15.3	0.92	0.99
1389	36.5	9.0	9.3	9.2	9.1	15.8	0.97	1.01
1390	36.0	8.6	8.6	8.0	7.8	14.0	1.00	1.02
1391	30.2	6.6	6.9	5.9	6.0	13.7	0.98	0.98
1392	43.4	6.1	6.6	6.0	6.2	15.7	0.92	0.97

Remarks – *Rhopaloteuthis sauvanausa* is the closest species to *Rhopaloteuthis argoviana*. The main characteristics that allow distinction of *R. argoviana* from the above mentioned species is a shorter and less hastate rostrum.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It is recorded also from beds of the *Epipeltoceras bimammatum* Zone at Birminsdorf and Voiron, from beds of the *Sireblites tenuilobatus* Zone at Lémenc and Monsalvens, from Oxfordian limestone at the Hongrin Valley (Favre, 1875, 1876). de Loriol (1902) found it in the "*Ammonites*" *arolicus* Zone beds at St. Sorlin. Pugaczewska (1961) recorded it in Lower Oxfordian horizons in Poland and Riegraf (1981) in the Lower Oxfordian, ("*cautisnigrae*-Zone, *transversarium*-Schichten", p. 108), in southern Germany. Some specimens of the Lissajous' collection, stored at the Museum of the Earth Department of the Claude-Bernard University in Lyon, come from Lower Oxfordian beds at Crussol (Ardèche) and from Oxfordian beds at Authoison (Haute Saône).

RHOPALOTEUTHIS SAUVANAUSA (d'Orbigny, 1842)
Pl. 4, figs. 4, 7

- 1842 *Belemnites sauvanaus* d'ORBIGNY, pp.128-130, pl. XXI, figs. 1-10.
1925 *Belemnites sauvanaus* d'Orbigny - LISSAJOUS, pp. 41-43, 131, text-fig. 23.
1961 *Rhopaloteuthis sauvanaus* (d'Orbigny) - PUGACZEWSKA, pp. 194-195, pl. VI, figs. 7-9.
1988 *Rhopaloteuthis sauvanaus* (d'Orbigny) - COMBÉMOREL, pp. 140-141, pl. 23, fig. 12.
1994 *Rhopaloteuthis sauvanausa* (d'Orbigny) - COMBÉMOREL & FISCHER in FISCHER, p. 20, pl. 3, fig. 4.

Material – Two adult (NS 20/1385, /1387) and one juvenile specimen (NS 20/1386).

Description – The small-sized rostrum is stout and clearly hastate. The outline is symmetrical and hastate; the maximum lateral diameter (DI_{max}) is at one third of the total length from the apex. The profile is slightly asymmetrical and hastate. The maximum diameter (Dv_{max}) at one third of the total length from the apex. The asymmetry is due to a more inflated ventral side at the apical region. The transverse section is circular, at the alveolar region, to sub-quadrate in the stem and apical regions. A dorsal deep alveolar groove runs as far as the maximum diameter of the

rostrum. The apical line is very slightly eccentric. The alveolus penetrates one third of the total length. Weak lateral lines are present on each flank. The apex is mucronate and dorsally eccentric.

Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _{top}	I _{ap}
1385	51.7	7.4	8.3	7.3	7.3	15.3	0.89	1.00
1386	37.1	7.2	8.0	6.3	6.5	14.0	0.90	0.97
1387	56.5	8.0	9.0	8.3	8.4	16.2	0.88	0.99

Remarks – This is certainly the most common species of the genus *Rhopaloteuthis* in the Oxfordian Tethyan sediments. *R. argoviana* is the closest species to *R. sauvanausa*, but the latter has a characteristically longer rostrum and a less hastate outline and profile. Some juvenile forms of *Duvalia monsalsvensis* can be similar, but their compressed transverse section distinguishes them clearly.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). Additionally it is known from Lower Oxfordian sediments of Germany, France, Switzerland, Portugal, Algeria, India, Madagascar and Upper Callovian-Lower Oxfordian of Poland (Pugaczewska, 1961). Combémoré (1988) recorded this species from Lower Oxfordian beds in Madagascar with *Putealiceris* corresponding to the Early Mariae Zone of Tethyan Europe. Doyle & Mariotti (1991) recorded this species in Oxfordian beds of north-western Anatolia (Turkey).

RHOPALOTEUTHIS sp. 1
Pl. 4, fig. 5

Material – One complete, well preserved specimen (NS 20/1393).

Description – The small-sized rostrum is stout. The outline is symmetrical and cylindrical; it is possible to observe only an imperceptible narrowing at the level of the protoconch. The maximum lateral diameter (DI_{max}) is at the mid point of the rostrum. The profile is asymmetrical and very little hastate with a very slight narrowing at the alveolar opening. The asymmetry is caused by a more evident inflation of the venter with respect to the almost straight dorsum. The maximum dorso-ventral diameter (Dv_{max}) is at the half of length of the rostrum. The apex is obtuse with a mucronate dorsally-eccentric point. The transverse section is circular to sub-quadrate because of the lateral flattening. A moderately deep and narrow dorsal groove extends along half of the rostrum. Lateral lines in the form of a very slight depression are present on each flank.

Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _m	I _a
1393	58.0	12.8	13.1	12.8	12.7	26.0	0.98	1.01

Remarks – The almost circular transverse section, the asymmetry of the profile, the obtuse and mucronate apex and the lateral depressions allow this specimen to be ascribed to *Rhopaloteuthis*. The minor hastation in outline and profile is a character that does not seem to be present in any previously described taxon of this genus. The only closely related species is *Rhopaloteuthis conophora*, present in the Lower Tithonian beds of the western Tethys, but it differs in having a longer groove, rounded flanks and a shorter apical region. Only one specimen was collected so it has not been possible to erect a new species.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy).

Genus PSEUDOBELUS de Blainville, 1827

Type species – *Pseudobelus bipartitus* de Blainville, 1827

Diagnosis – Small-sized rostrum, outline symmetrical and hastate, profile asymmetrical and hastate, a well marked lateral groove on each flank, transverse section compressed, sub-quadrate to pyriform (8-shaped), acute and eccentric, sometime mucronate apex.

Stratigraphical range and geographical distribution – From the Bathonian to Hauterivian of south-western Germany, France, Switzerland, Italy, Balkans, Poland, Caucasus, North Africa, Madagascar.

PSEUDOBELUS COQUANDUS (d'Orbigny, 1842)
Pl. 4, fig. 6

- 1842 *Belemnites Coquandus* d'ORBIGNY, p. 130, pl. 21, figs. 11-18.
1871 *Belemnites Coquandus* d'Orbigny - DUMORTIER, p. 23, pl. 2, figs. 25-26, not figs. 21-24.

- 1920 *Hibolites Coquandus* d'Orbigny - BÜLOW-TRUMMER, p. 138.
1961 *Pseudobelus coquandus* (d'Orbigny) - PUGACZEWSKA, p. 199, Pl. IV, figs. 1-5.
1977 *Quasihastites coquandus* (d'Orbigny) - GUSTOMESOV, 115, pl. 1, fig. 6.
1994 *Pseudobelus coquandus* (d'Orbigny) - COMBÉMOREL & FISHER in FISHER, p. 20, pl. 4, figs. 2-3.

Material – One specimen lacking the alveolar region (NS 20/1394).

Description – The small-sized rostrum has a symmetrical and slightly hastate outline and a markedly asymmetrical and hastate profile. The maximum diameters (DI_{max} and Dv_{max}) are both near the apex giving such a characteristic clavate shape to the rostrum. The asymmetry is caused by a stronger convexity of the venter. A well incised groove extends on each flank. The transverse section is sub-quadrate with a larger venter; the incisions of the lateral grooves give a characteristic 8-shaped outline. The apical region is short ending with a mucronate and eccentric point.

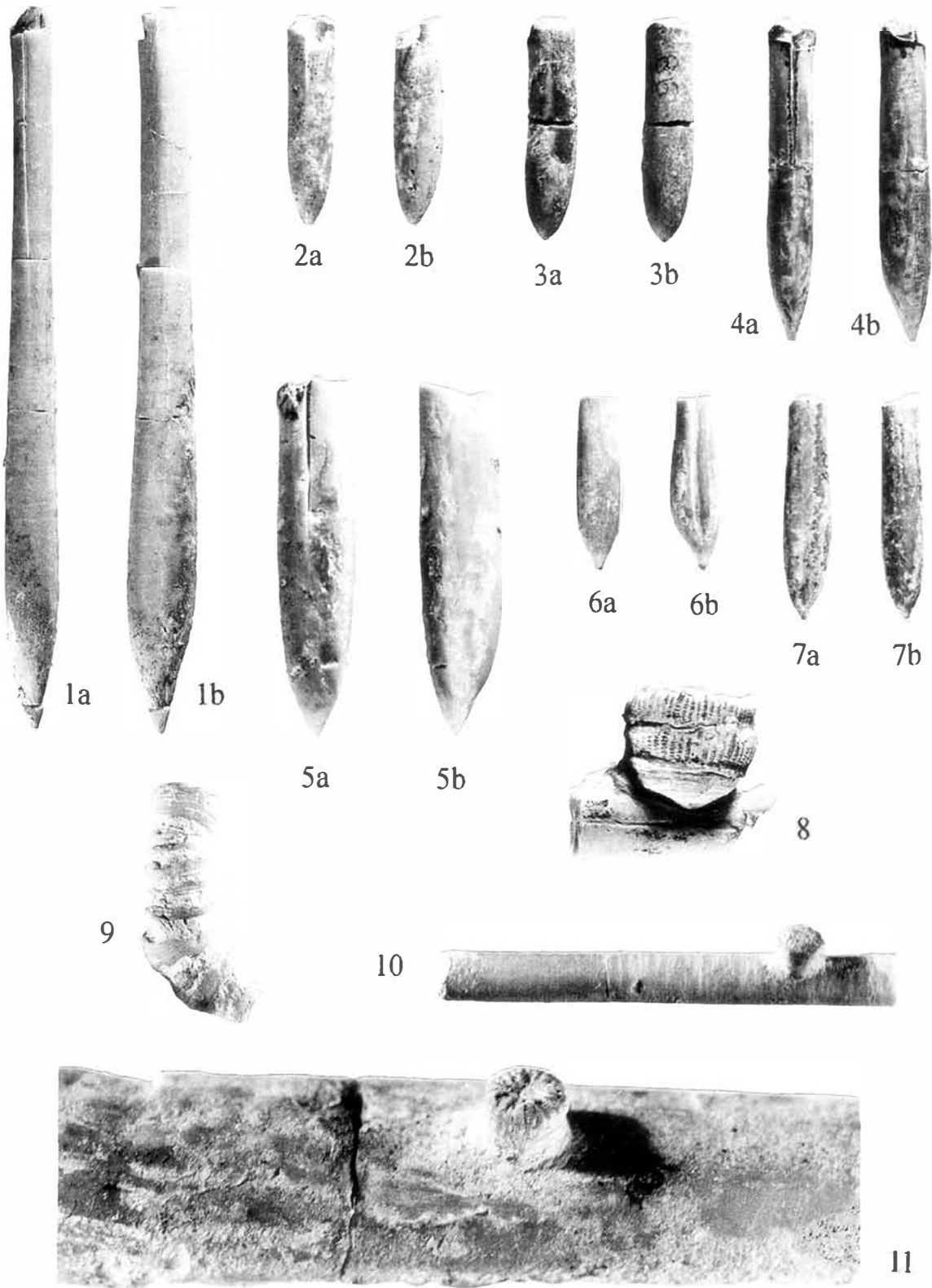
Dimensions

NS 20/	L	DI _{max}	Dv _{max}	DI	Dv	x	I _m	I _a
1394	29.0*	7.4	8.3	—	—	14.0	0.89	—

Remarks – *Belemnites coquandus* d'Orbigny was ascribed by Bülow-Trummer (1920) to the genus *Hibolites*; successively Naef (1922), Lissajous (1925) and Pugaczewska (1961) ascribed it to the genus *Pseudobelus* of the family Duvaliidae Pavlow, 1914. Gustomesov (1977) established the new genus *Quasihastites*, of the family Belemnopseidae Naef, 1922, establishing as type species *Belemnites coquandus* d'Orbigny. Instead Combémoré & Fischer (in Fischer, 1994) confirm the attribution of *Belemnites coquandus* to the family Duvaliidae both for the compressed rostrum and for the presence of deep lateral grooves. The attribution of this species to *Pseudobelus* is here accepted both for the general shape of outline

EXPLANATION OF PLATE 4

- Fig. 1 - *Duvalia neyrivensis* (Favre, 1876). 1) Adult specimen, NS 20/1355: 1a) dorsal view, (× 0.9), 1b) right side, (× 0.9).
Figs. 2-3 - *Rhopaloteuthis argoniana* (Mayer, 1863). 2a) dorsal view, (× 1), 2b) right side, (× 1), NS 20/1388; 3a) dorsal view, (× 1), 3b) right side, (× 1), NS 20/1390.
Figs. 4, 7 - *Rhopaloteuthis sauvanausa* (d'Orbigny, 1842). 4) adult specimen, NS 20/1385: 4a) dorsal view, (× 1), 4b) right side, (× 1); 7) juvenile specimen, NS 20/1386: 7a) dorsal view, (× 1), 7b) right side, (× 1).
Fig. 5 - *Rhopaloteuthis* sp. 1, 5a) dorsal view, (× 1), 5b) right side, (× 1), NS 20/1393.
Fig. 6 - *Pseudobelus coquandus* (d'Orbigny, 1842). 6a) dorsal view, (× 1), 6b) right side, (× 1), NS 20/1394.
Fig. 8 - A small rostrum colonized by a coral of the discoidal morphological type. Notice the coral diameter clearly larger than the belemnite width (× 2).
Fig. 9 - The conical morphological type of coral (× 2).
Fig. 10 - A black coated rostrum colonized by a coral, this last one is not interested by the black cover (× 2).
Fig. 11 - Enlargement of fig. 10 (× 2).



and profile and for the presence of the lateral grooves, in fact it is known that no *Hibolites* species possess such deeply incised lateral grooves, compressed transverse section and asymmetric profile caused by a more marked convexity of the venter.

Occurrence – Upper Callovian - Middle Oxfordian beds at Monte Kumeta (Sicily, southern Italy). It is recorded in Callovian and Oxfordian beds of Poland Pugaczewska (1961) and Oxfordian horizons in France (d'Orbigny, 1842-49).

TAPHONOMY

An enormous number (many hundreds) of belemnite rostra, often well preserved, were collected in a true belemnite "nest", from a lens-shaped densely laminated shale, nearly 80 cm thick bed. The belemnite assemblage is the same in every level of the shale and does not show mixing phenomena although it has been evidently reworked *in situ* (see below). All the rostra are parallel to the surface of the beds and frequently also iso-oriented (Text-fig. 5). Some centimetre thick laminae are characterized at places by an exceptional mass of rostra. It is also worth of note that the same sediment includes a very diversified and rich assemblage including foraminifers, rhyncholites (many forms of the genera *Hadrocheilus*, *Leptocheilus* and *Gonatocheilus*), aptychi (*Lamellaptychus* and *Laevaptychus*), echinoderm sand sized debris, crinoids (roots, columnar plates and Phyllocrinid calyces), fragmentary irregular echinoids (large plates) and shark teeth.

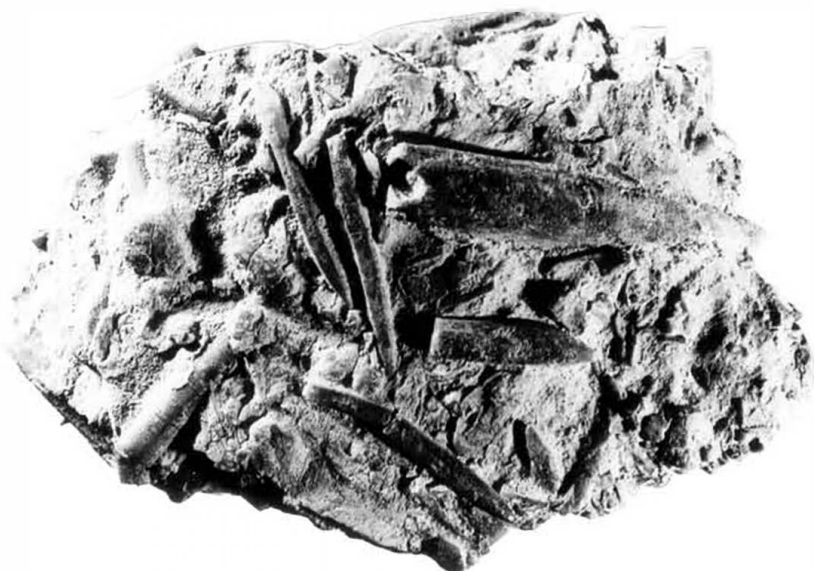
These local enrichments were probably caused by a sediment selection originated from a slump that also caused the packing of several rostra that closely packed against each other, presenting pressure-solu-

tion phenomena. Most of the belemnites are cracked but frequently it has been possible to assemble the fragmented rostra, although very long and slender. It is thus evident that the slump caused the slide of the belemnite bearing layers for a short distance, probably a few metres, and without strong energy.

Several rostra have been colonised by corals, and three (and in few cases four) corals are often present on a single rostrum, demonstrating the presence of an environment suitable for these organisms. The coral assemblage consists of several specimens and is however oligotypic, only solitary forms being present and probably ascribable to two taxa. The morphological characteristics can be summarized into two types: conic-shaped and discoid (Pl. 4, figs. 8-9).

Settling behaviour can be evaluated considering that frequently larger corals grew beyond the belemnite diameter and that corals on the same rostrum show different growth stage with the same orientation. All that considered we can draw a scenario in which belemnites were flat lying on a muddy surface along the non-depositional escarpment. These were very probably the only hard surfaces emerging from the mud and thus were selected for an active colonization by coral larvae present in a presumably large number in the sea water. These rostra remained stable for a quite long time; additionally the period of starved sedimentation must have lasted a time long enough to allow the growth of the corals.

Up to now no investigation has been made on the coral assemblage and obviously it is not possible to attempt any refined palaeoecological analysis. It is, however, useful to remember that sequences typical of structural highs characterized by the presence of solitary and colonial corals are recorded in the Central Apennines (Nicosia & Pallini, 1977; Mariotti *et al.*, 1979; Santantonio, Galluzzo & Gill, 1996).



Text-fig. 5 - Belemnite nest, notice the rostra accumulation ($\times 0.85$).

It is also worth noting that the same conditions were ascribed to the sedimentary environment from which were found the rostra, heavily bored by Acrotoracic cirripedes, coming from sequences typical of structural highs in the Central Apennines (Mariotti & Matteucci, 1989; Mariotti in press) while, in the studied material the rostra were never bioeroded. These apparently contrasting data cannot yet be interpreted, nevertheless they allow an important consideration, that is that some still indecipherable environmental or early diagenetic reasons, that are not recorded into the sediments (or not more recognizable), controlled the presence and the alternative activity of corals and cirripedes.

Many specimens were covered by a black film, probably related to the Mn-coated horizons of the underlying unit, and subsequently by an argillaceous cover. When these "black" rostra are colonized by corals (Pl. 4, figs. 10-11) the corals are never covered. This could be interpreted as providing evidence that when corals colonised the rostra the latter had to be already coated and thus had crossed various stratinomic phases, namely burial, early lithification, coating and reexhumation.

BIOSTRATIGRAPHICAL REMARKS

The examined belemnites were collected from beds of the "Red/grey nodular marls (RAId)" lithofacies of the Rosso Ammonitico Inferiore. These sediments lie on a reddish calcilutite whose top is particularly rich in ammonites and invested by a series of Mn-coated condensation horizons. The ammonites collected from this surface indicate the Middle Callovian (Anceps Zone) (Di Stefano *et al.*, in press). In parallel to the systematic belemnite study other researches began on radiolarians and calcareous nannoplankton present both in the belemnite beds and in the succeeding "Membro Intermedio Radiolaritico" unit (Mariotti *et al.*, 2001). The resulting data fit well with biostratigraphical data related to the belemnites that range from Late Callovian to Middle Oxfordian.

Hibolites hastatus is recorded from Bathonian-Oxfordian beds, but its most significant presence is in Early Oxfordian. *Duvalia didayana* and *D. neyrivensis* occur at various Oxfordian levels so they are less stratigraphically meaningful. *D. dumortieri* was found respectively in beds of the Lower and Middle Oxfordian. *Rhopaloteuthis sauvanasa* is a characteristic form of Late Callovian-Early Oxfordian; however, *R. argoviana* is recorded almost exclusively from the Lower Oxfordian beds. Lastly *Belemnopsis latesulcatus* is present principally in Upper Callovian sediments, only once has it been found in Lower Oxfordian strata. In conclusion the most significant forms are *Belemnopsis latesulcatus*, *Rhopaloteuthis sauvanasa* and *R. argoviana* that permit to date the belemnite bearing levels as of Late Callovian-Middle Oxfordian age.

These data can be joined with the other Italian findings to evidence their stratigraphical meaning,

the following list includes all the Jurassic and Cretaceous outcrops with the related belemnite assemblage known in central and southern Italy (Combémol & Mariotti, 1986a, b, 1990; Combémol, Mariotti & Spaeth, 1994; Combémol *et al.*, 1994; Mariotti, 1994, in press).

CENTRAL ITALY

- 1 - Valdorbis (Perugia), basinal sequence, *Acrocoelites* (*Odontobelus*) *subtricusissus* Late Toarcian (Pseudoradiosa Zone); *Passaloteuthis* sp. Pliensbachian/Toarcian boundary; *Acrocoelites* (*Acrocoelites*) *subtenuis*, Early Toarcian;
- 2 - Gualdo Tadino (Perugia), *Passaloteuthis* cf. *milleri*, Late Pliensbachian-Early Toarcian, *Passaloteuthis* sp., Late Pliensbachian/Toarcian, *Acrocoelites*, *Simpsonibelus*, Toarcian;
- 3 - Tivoli (Roma), olistromal deposits, slumpings and resedimented material coming from a near slope, *Acrocoelites* (*Praepachyteuthis*) *ilminsterensis*, *Simpsonibelus expansus* and *Acrocoelites* (*Odontobelus*) sp., Early Toarcian (Serpentinus Zone);
- 4 - Sasso di Pale (Perugia), *Belemnopsis*, Early Bajocian (Humphriesianum Zone);
- 5 - Campo al Bello (Pesaro), *Hibolites semisulcatus*, *H. pignattii*, *Acutibelus* sp. cf. *acuariformis*, *Belemnopsis neronensis*, *Duvalia matteuccii*, *D. nicosiai*, *D. pallinii*, *D. raymondi* and *Rhopaloteuthis massimoi*, Early Kimmeridgian;
- 6 - Serra San Quirico (Ancona), *Duvalia ensifer*, *D. apenninica*, *D. aesinensis*, *Pseudobelus zeuschneri*, *P. datensis*, *Pseudobelus* sp., *Rhopaloteuthis conophorus*, *R. strangulatus*, *R. siciliensis*, *Quiricobelus italicus*, *Hibolites* cf. *semisulcatus*, Early Tithonian (Ponti Zone);
- 7 - Pieia (Pesaro), *Hibolites* sp., *Duvalia* sp., Early Tithonian;
- 8 - Porcarella (Ancona), *Duvalia tithonica*, Late Tithonian.

SOUTHERN ITALY

- 1 - Cozzo di Mastro Pasquale (Cosenza), *Megateuthis* sp., *Holcobelus trauthi*, *Belemnopsis* sp., Late Aalenian-Early Bajocian;
- 2 - Magaggiaro Mt. (Agrigento), *Hibolites semisulcatus*, Early Tithonian; *Duvalia lata lata*, Early Valanginian;
- 3 - Monte Kumeta (Palermo), *Hibolites hastatus*, *Hibolites* sp. aff. *H. beyrichi*, *Belemnopsis latesulcatus*, *Belemnopsis* sp. 1, *Duvalia didayana*, *D. dumortieri*, *D. monsalvensis*, *D. neyrivensis*, *Rhopaloteuthis argoviana*, *R. sauvanasa*, *Rhopaloteuthis* sp. 1, *Pseudobelus coquandus*, Late Callovian - Middle Oxfordian;
- 4 - Guidaloca (Trapani), *Duvalia dilatata dilatata*, *Duvalia* sp. cf. *Duvalia dilatata binervioris* and *Duvalia* sp., Upper Valanginian-Hauterivian.
- 5 - Palazzo Adriano (Palermo) and S. Stefano di Quisquina (Agrigento), *Duvalia conica*, Lower Tithonian-Valanginian;

From these stratigraphical data it is possible to make some conclusions.

The Early Jurassic belemnites show the greatest affinity to the European forms and can be directly correlated with them.

At the Aalenian-Bajocian boundary *Belemnopsis*, *Megateuthis* and *Holcobelus* are useful markers, the last marks the passage from a uniform Europe-wide belemnite fauna in the Early Jurassic towards the development of endemism and the establishment of a Tethyan fauna. This apparent biogeographical datum presents major problems in biostratigraphy.

The Upper Callovian - Middle Oxfordian belemnite assemblage studied herein confirms the presence of genera and species up to now only known in Mediterranean Tethys such as *Hibolites*, *Belemnopsis*, *Duvalia*, *Rhopaloteuthis* and *Pseudobelus*. Probably some new taxa are present.

The Early Kimmeridgian assemblage characterised by *Belemnopsis*, *Hibolites*, *Rhopaloteuthis* and *Duvalia* shows the last occurrence of *Belemnopsis* that had just migrated towards the east in the Tethyan area. All the species are different from the Upper Callovian-Middle Oxfordian ones.

The Early Tithonian assemblages are dominated by *Duvalia*, *Pseudobelus*, *Rhopaloteuthis* and *Hibolites*. Some of the species ascribed to these genera are new and all the previously present species disappeared.

The Late Tithonian findings show that the genus *Rhopaloteuthis* disappears, while *Duvalia* is still present with the species *D. tithonica* and *D. conica*.

The Early Cretaceous is characterised by *Duvalia lata lata*, *D. dilatata dilatata*, *Duvalia* sp. cf. *D. dilatata binervioides*, well known and reliable forms calibrated to the Valanginian and Hauterivian.

CONCLUSIONS

Belemnites can be considered good biostratigraphical fossils because they are widespread, fast evolving, largely facies independent, simple to identify and abundant. They are common fossils in Mesozoic sequences and have been used for biozonations overall for the Upper Cretaceous of northern Europe. As regards Jurassic belemnite biozonation of the Mediterranean Tethys only the Toarcian belemnites have been used as biostratigraphical tools for zonal schemes (Stoyanova-Vergilova, 1977; Doyle, 1990, 1992). But as regards Middle and Upper Jurassic of the western Tethys, with the only exception of the papers of Rieggraf (1980, 1981) about Jurassic belemnites of south-western Germany, no tentative zonal scheme was proposed.

As for regards the central and southern Italy three main outcrops were recently investigated (Combémoré & Mariotti, 1986a; Combémoré *et al.*, 1994; Mariotti in press) although they are strongly biased by depositional peculiarities.

In the Umbria-Marche Apennines the richest fossil-bearing layers are unfortunately located on structural highs, and characterized by discontinuous and thin sequences, so the vertical evolution of taxa cannot be completely examined. Almost all the sequences of this type are interrupted by a hiatus ranging from Middle Bajocian to Early Kimmeridgian (Farinacci *et al.*, 1981; Farinacci, 1988; Cecca *et al.*, 1990; Santantonio, 1993; Bartolini & Cecca, 1999; Mariotti in press). Only two belemnite assemblages coming respectively from the Lower Kimmeridgian of Campo al Bello (Mariotti, in press) and the Lower Tithonian of Serra San Quirico (Combémoré & Mariotti, 1986a) are very rich and well calibrated stratigraphically.

In Calabria, at Cozzo di Mastro Pasquale (southern Italy) only a very condensed sequence, deposited on a basement high, has given a belemnite assemblage of Early Aalenian to Middle Bajocian age (Combémoré *et al.*, 1994).

The belemnite assemblage collected from the outcrop of Monte Kumeta is of the same importance, from a stratigraphical point of view, as those of Serra San Quirico, Campo al Bello and Cozzo di Mastro Pasquale.

It is now possible to affirm that all the belemnite assemblages coming from central and southern Italy are the only records with exceptional characteristics, both for the numbers of the forms, and for they were collected from single outcrops well established from the stratigraphical point of view.

Although it is impossible to attempt a zonal scheme basing only on these sporadic data, these records can certainly give useful indications that belemnite biostratigraphy may be attainable.

ACKNOWLEDGEMENTS

I express my cordial thanks to Prof. John Cope, Prof. Massimo Santantonio and Prof. Johannes Pignatti for the critical discussions. I wish to thank the anonymous referees for useful suggestions. My grateful thanks go to Mr. Abel Prieur, conservator of the scientific collections at the Department of Earth Sciences of the Claude-Bernard University in Lyon, and to Dott. Eva Sacchi and Mr. Luciano Spinazzi for the photographs. This paper was supported by the Grants "Sistematica, biostratigrafia e paleobiogeografia dei coleoidi mesozoici" and "Dinamiche deposizionali giurassiche e paleobiologia nel Dominio Saccense (Sicilia sud occidentale)".

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*(manuscript received February 5, 2002
accepted March 5, 2002)*

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