

# LOWER CRETACEOUS TEREBRATULIDAE FROM SOUTH-WESTERN MOROCCO AND THEIR BIOGEOGRAPHY

by FRANK A. MIDDLEMISS

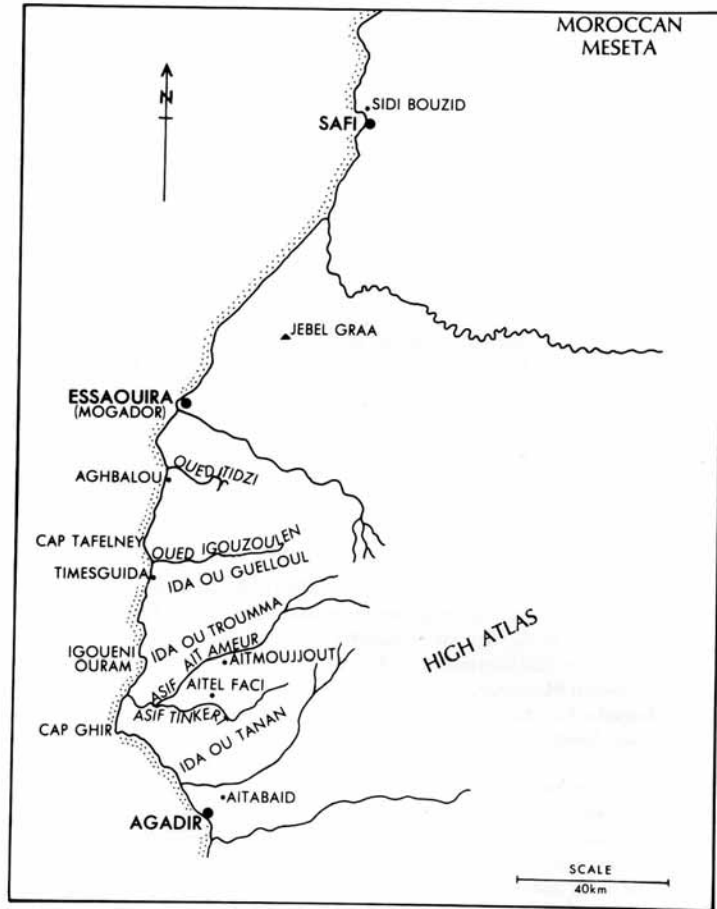
**ABSTRACT.** The terebratulid brachiopods contained in the Gentil and Whitaker Collections from the Lower Cretaceous of south-west Morocco have been revised. Although the majority of the species are confined to south-west Morocco, the affinities of the fauna are with the faunas of the shallow marine regions bordering Tethys, such as the Jura region, eastern Spain, the Crimea, and the northern Caucasus; the Tethyan pygopid brachiopods characteristic of the Rif in northern Morocco are almost absent. The fauna thus constitutes a Jura-type assemblage situated on the southern side of Tethys. In the systematic section a new genus *Paraboubeithyris* is erected; also seven new species: *Loriolithyris melaitensis*, *L. marocensis*, *Boubeithyris tibourrensis*, *B. pleta*, *Paraboubeithyris plicae*, *Kutchithyris kennedyi*, and *Juralina ecruensis*. The genera *Kutchithyris* and *Juralina*, previously described from the Jurassic, are shown to have survived into the Lower Cretaceous. *Terebratula subsella* Leymerie is referred to *Kutchithyris*.

THIS paper consists mainly of a revision of the terebratulids contained in two important collections, the Gentil Collection in the Collection de Paléontologie of the Université Pierre et Marie Curie, Paris, and the Whitaker Collection in the British Museum (Natural History), London. All the specimens came from the Lower Cretaceous (Berriasian to Aptian inclusive) of an area at the seaward end of the High Atlas in south-western Morocco, extending some 40 kilometres inland between Agadir in the south, Essaouira (Mogador) in the centre, and Safi in the north.

Louis Gentil, who was born at Algiers in 1868 and died in Paris in 1925, was a pioneer in the study of the geology of Morocco. His first major contribution was the exploration of the Tafna basin. Later he became a member of the Segonzac exploratory mission to the Atlas Mountains and eventually head of the mission. He was the author of numerous publications, particularly on the geology of the Atlas, almost up to the time of his death including, most notably, the first geological map of Morocco, which appeared in 1923. J. J. S. Whitaker was not a geologist but a Christian missionary who worked in Morocco during the early years of this century. His collection was made at one locality only (see p. 519 below) and very probably on one occasion. Figured specimens are in the British Museum (Natural History) (BM) or the Collection de Paléontologie, Université Pierre et Marie Curie, Paris (Gentil Coll.).

## THE LOWER CRETACEOUS OF SOUTH-WESTERN MOROCCO

The Lower Cretaceous geology of the area was described by Roch (1930) and that of the southern part by Ambroggi (1963); Gigout (1951) included the extreme northern part, around Safi, in his survey; Ager (1974) gave a brief summary in English. All agree that south-western Morocco was, in Lower Cretaceous times, a marine depositional basin opening westwards towards the ocean, cut off from the marine deposits of the same age, but quite different lithofacies and fauna, in the Rif arc to the north by the interposition of the positive block of the Moroccan Meseta and from the marine area of the Algerian high plateaux by the emergent central massif of the High Atlas. At each stage of the Lower Cretaceous the most fully marine conditions, presumably indicating the deepest water, are found in the extreme west, around Cap Ghir and northwards to the neighbourhood of Cap Tafelney. Passing north-eastwards, eastwards, and south-eastwards from this region one finds increasingly



TEXT-FIG. 1. Locality map of south-west Morocco.

shallow-water lithofacies and biofacies and, usually within 40 or 50 kilometres, non-marine deposits.

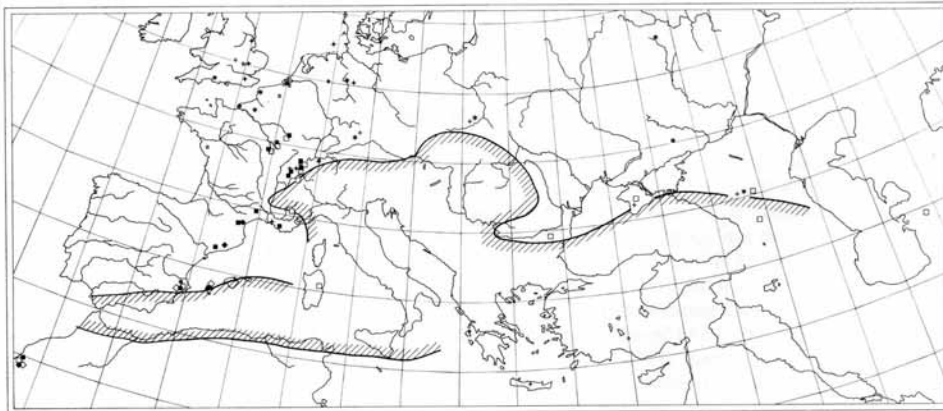
The deep-water facies around Cap Ghir consists of green marls and marly limestones with ammonites. These pass eastwards into the more sandy and calcareous beds, with brachiopod and mollusc faunas, of what Roch significantly calls a 'jurassian facies'. These pass eventually into sub-continental red beds. The lithological succession differs markedly from the monotonous lithofacies of the 'bathyal' Lower Cretaceous, seen in the Rif and the Betic region, and has a general resemblance to the successions seen in the Pre-Betic zone of Spain, north-east Spain (Sitges), east-central Sardinia, Provence, and Portugal. It exhibits a very striking difference from these, however, in the absence of the massive urgonian limestones, which are characteristically developed in the Barremian and Aptian of those regions, and of the rudists. In these respects, the south-west Moroccan succession is most comparable to the Lower Cretaceous of central Texas and parts of Coahuila (Mexico). The Aptian,

as in northern Spain and England, is transgressive, the Gargasian overlapping the earlier divisions on to the flanks of the High Atlas. To the south lies the coastal Cretaceous basin of Tarfaya, at first sight similar in situation to the Agadir-Essaouira basin, but here the earlier part of the Cretaceous is non-marine, marine sedimentation starting only with the Apto-Albian (Choubert *et al.* 1967).

#### PALAEOBIOGEOGRAPHICAL RELATIONSHIPS OF THE TEREBRATULID FAUNA

*Endemicity.* The fauna contains a high proportion of endemic species: of the eleven species described eight are new and seven of these are so far known only from south-west Morocco. This is not unusual. The terebratulids tend to produce local, allopatric species. For example, of the sixteen terebratulid species in the English Aptian thirteen are known only in south and south-central England, of which three occur at one locality only (Middlemiss 1959). I have recently (Middlemiss 1979) pointed to the contrast between such local species and widespread species such as (in the Moroccan fauna) *Loriolithyris valdensis* and suggested that these differences were probably due to differing lengths of the free-swimming larval stage. Evidence for the palaeobiogeographical relationships of the fauna comes mainly from the occurrence elsewhere of the widespread species but also from the taxonomic relationships of the local species.

*Loriolithyris. L. valdensis* is the most widespread species of this genus, occurring in the Lower Cretaceous of eastern Spain (and the Balearic Islands), Sardinia, southern France, the Jura, south-east Paris Basin, north-east Bulgaria, the Crimea, northern Caucasus, Kopet Daga, and perhaps Algeria. *L. russillensis* shares the western part of this distribution—eastern Spain, the Balearic Islands, southern France, the Jura, and south-east Paris Basin. *L. melaitensis* and *L. marocensis* are local offshoots from the stock, not at present known outside the south-west Moroccan basin.



TEXT-FIG. 2. Palaeobiogeographical relationships of the Lower Cretaceous terebratulids of south-west Morocco. Distribution of south-west Moroccan Lower Cretaceous species which occur elsewhere: ■ *Loriolithyris russillensis*, □ *Loriolithyris valdensis*, ◆ *Cyrtothyris middlemissi*, ◇ *Kutchithyris kennedyi*. Distribution of other Lower Cretaceous species of *Cyrtothyris*: +. Distribution of Aptian-Cenomanian species of *Boubeithyris*: ☆. Generalized occurrence of *Kutchithyris subsella* in the Upper Jurassic and Lower Cretaceous: \*. Generalized occurrence of Jurassic species of *Juralina*: +. Generalized boundary of the Tethyan pygopid fauna shown by diagonal shading.

*Boubeithyris* and *Paraboubeithyris*. The three species here ascribed to these genera are all local to south-west Morocco but the genus *Boubeithyris*, of which *Paraboubeithyris* is perhaps a specialized development, is represented by a species in the Aptian of the Jura, by two species in the Albian of England and by one species in the Cenomanian of Belgium and western France.

*Cyrtothyris*. *C. middlemissi*, the south-west Moroccan species, is known also in eastern Spain and southern France. The genus is more widespread, being represented by species in the early Cretaceous of north Germany, north-east England, and east Greenland and the Aptian of the Jura and southern France. Imlay's species *Terebratula sillimani* and *T. tamaulipana* (Imlay 1937), from the Valanginian-Hauterivian of northern Mexico, probably belong to this genus.

*Kutchithyris*. *K. brivesi* is a highly distinctive form confined to south-west Morocco but *K. kennedyi* is known also in the Lower Cretaceous of eastern Spain, the Balearic Islands, and southern France, the southern part of the same distribution area as *L. russillensis*. Other species of the genus are found in the Middle Jurassic of India and, according to Buckman (1918), Europe. I here refer *Terebratula subsella* Leymerie to this genus. This species has a widespread occurrence in the Upper Jurassic of Europe and is known (but undescribed) in the Lower Cretaceous of eastern Spain.

*Juralina*. This genus, as interpreted by recent authors (especially Boullier 1976), occurs in the Upper Jurassic of a wide area of Europe north of the Alps from England to Russia and also of Crete (*J. immanis*—see Bonneau, Beauvais, and Middlemiss 1975) and Sicily (Boullier 1976). *J. ecruensis* is the first species of the genus to be described from the Cretaceous.

*Discussion*. The Lower Cretaceous terebratulids of Europe can be divided into three geographical faunas: the boreal fauna in the north, the Tethyan fauna with its distinctive Pygopinae, and between them the Jura fauna. The last is so named after the area in which the fauna is richest and best known, but the character of the Jura fauna is essentially that of a neritic assemblage occupying an optimum situation on the border of the deeper-water Tethyan region and extending approximately parallel to the border of Tethys from the Iberian Peninsula eastwards to Turkmenistan. In this sense, the Lower Cretaceous fauna of south-west Morocco falls into place as an extension of the Jura fauna to the south of the Tethyan fauna which is so strongly developed in the Rif.

The affinities of our terebratulids are essentially with the Jura brachiopod fauna. This is generally true of the cephalopods listed and figured by Roch, Ambroggi, and Gigout. Characteristic Tethyan genera such as *Lytoceras* (Valanginian-Hauterivian), *Phylloceras* (Hauterivian), *Desmoceras* (Barremian), *Pulchellia* (Barremian), *Duvalia* (Valanginian), *Hibolites* (Valanginian) occur but are almost confined to the deep-water region of the extreme west. Further east the cephalopods are noted by Roch as being of 'Jura type' and include such genera as *Acanthodiscus* and *Leopoldia*. There is scarcely a trace in the pre-Aptian Cretaceous of the Tethyan pygopines which characterize the Rif and the Betic region (Geyssant 1966). The 'jurassian' affinities of the faunal facies were clearly recognized by Roch and Gignoux (1955). Ager (1974) has recorded the discovery of *Nucleata* cf. *jacobi* in the Aptian or Albian near Tamzargout. This seems to be the only recorded occurrence of pygopine brachiopods in the Lower Cretaceous of south-west Morocco—a feeble sign of southward 'Tethyan spread' simultaneous with those transgressions which were causing northward movement of southern species into north Spain, England, and north Germany (Middlemiss 1979). The specimen from Safi figured by Gigout (1951, pl. 9, figs. 35–38) as *T. euthymi* is a terebratellidine related to '*Terebratula*' *moreana* d'Orbigny.

*Kutchithyris*, in the Lower Cretaceous, does not occur north of southernmost France and is one of those sub-Tethyan forms (Middlemiss 1979) which are sensitive indicators of the advance and retreat of the Tethyan fauna. *K. subsella* shows this well. In the Oxfordian, a period of major expansion of the Tethyan fauna (Arkell 1956), it is found throughout a large part of central Europe—England, northern France, northern and south-western Germany, southern Poland, the Russian Platform. By Kimmeridgian times it extended no further north than the Boulonnais. The Volgian saw a further southward retreat to the Pays de Bray, its place in England and the Boulonnais being taken by boreal forms. In the Lower Cretaceous it has so far been found only in the Pre-Betic region of Spain, on the

margin of Tethys. *Juralina* may also be a sub-Tethyan genus whose history is possibly similar to that of *K. subsella*.

Reconstruction of plate positions as they were in Lower Cretaceous times shows the area of the Jura faunas as much more linear than it is now. Provence, eastern Spain, Sardinia, the Balearic Islands, and south-west Morocco form a linear belt which, extended westwards, would include the western Gulf region of the U.S.A. and the northern parts of Mexico. The neritic Lower Cretaceous of these latter regions is in this sense an extension of the area of the Jura fauna. Unfortunately brachiopods are rare but Imlay (1940) remarked of the Neocomian faunal assemblage of northern Mexico that it was remarkably similar to that of France, England, and Switzerland and belonged decidedly to the 'Mediterranean' province. His species *T. coahuilensis* is certainly close to and probably synonymous with *Sellithyris carteroniana* d'Orbigny, one of the most characteristic Jura species. It seems a reasonable forecast that neritic Lower Cretaceous brachiopod assemblages of 'Jura fauna' affinities will some day be found in the south-eastern or Gulf continental shelf deposits of the U.S.A. or the north-western continental shelf deposits of Africa. Unfortunately those of the offshore part of the Tarfaya basin have yielded no brachiopods.

#### STRATIGRAPHIC AGES OF SPECIMENS IN THE WHITAKER AND GENTIL COLLECTIONS

Whitaker left no record of the age of the strata from which he made his collection and it has not so far proved possible to trace the exact locality. All the specimens were obtained from one locality, recorded as: 'Ecrú, Mogador, Morocco. 500 ft. on plateau edge of 1000 ft. elevation'. The age can only be assessed on the internal evidence of the fauna and appears to be either Hauterivian or Barremian. The species represented all occur elsewhere in south-west Morocco in both the Hauterivian and the Barremian, whereas not all occur in the Valanginian or Aptian.

Four species are represented in the Whitaker Collection, in the following numbers: *Loriolithyris russillensis*, 57; *L. valdensis*, 39; *Juralina ecrúensis*, 46; *Kutchithyris kennedyi*, 1. The predominance of *L. russillensis* would suggest, on analogy with the occurrence of the species in Switzerland and France, a Barremian age. The distribution of these four species in the Gentil Collection is as follows:

<i>L. russillensis</i>	Hauterivian	7	<i>J. ecrúensis</i>	Valanginian	25
	Barremian	39		Hauterivian	2
	Aptian	9		Barremian	15
<i>L. valdensis</i>	Valanginian	25	<i>K. kennedyi</i>	Hauterivian	2
	Hauterivian	63		Barremian	1
	Barremian	104			
	Aptian	16			

In general these statistics again support a Barremian age for the Whitaker Collection but they may reflect nothing more than the accidents of collection.

I have followed stratigraphic ages given on the labels of the Gentil Collection because it was not possible to check each locality in the field, but there are some arguments supporting the general validity of these labels, even though there must be a number which are wrong. Analysis of all the localities given on the labels shows that all the specimens from any one locality are assigned consistently either to a single stage or to two, or rarely three, adjacent stages. Thus a logical series of localities can be set out, ranging from those credited with yielding only Berriasian and Valanginian fossils to those credited with yielding fossils only of Clansayesian age.

## SYSTEMATIC PALAEONTOLOGY

Order TEREBRATULIDA Waagen, 1883  
 Suborder TEREBRATULIDINA Waagen, 1883  
 Superfamily TEREBRATULACEA Gray, 1840  
 Family TEREBRATULIDAE Gray, 1840  
 Subfamily SELLITHYRIDINAE Muir-Wood, 1965

*Remarks.* *Loriolithyris* and *Boubeithyris* are closely related sellithyridine genera. The corniced hinge plates which are the most distinguishing feature of *Boubeithyris* are essentially the same in detailed structure as the piped hinge plates of *Loriolithyris*. Both genera essentially have *small* crural bases (attached to the inner edges of the hinge plates) which become encased in successive layers of secondary skeletal tissue (Pl. 60, fig. 2; Pl. 61, figs. 2, 3). The function of this is presumably to strengthen the junction of hinge plates and crural bases. These structures are not inner hinge plates, which some authors claim to be present in *Terebratula*, although Muir-Wood (1965, p. H775) denies their presence in that genus, because they show no sign of having taken part in any way in the attachment of the dorsal pedicle muscles. *Boubeithyris* and *Loriolithyris* differ mainly in the shape of the hinge plates—concave and corniced in *Boubeithyris*, concave to sigmoid and piped in *Loriolithyris*. Externally *Boubeithyris* is distinguished especially by the close spacing of the plicae of the anterior commissure. Both differ from *Sellithyris* in having accessory structures (cornicing or piping) on the hinge plates and in their much less pentagonal external form.

*Paraboubeithyris* has an internal structure which is closely related to that of *Boubeithyris*. Externally *P. plicae* looks different at first sight from *Boubeithyris* spp. but similarities include the convex cardinal slopes, small size of the median sinus, and the late development of folding. The external differences, however, seem too great to allow the species to be included in *Boubeithyris*. *P. plicae* is here regarded as a specialized local offshoot from the *Boubeithyris* stock.

## Genus LORIOLITHYRIS Middlemiss, 1968

*Type species.* *Terebratula russillensis* de Loriol, 1866.

*Species included.* *T. russillensis* de Loriol, *T. valdensis* de Loriol, *L. melaitensis* nov., *L. marocensis* nov. Range: Berriasian to Aptian.

## EXPLANATION OF PLATE 55

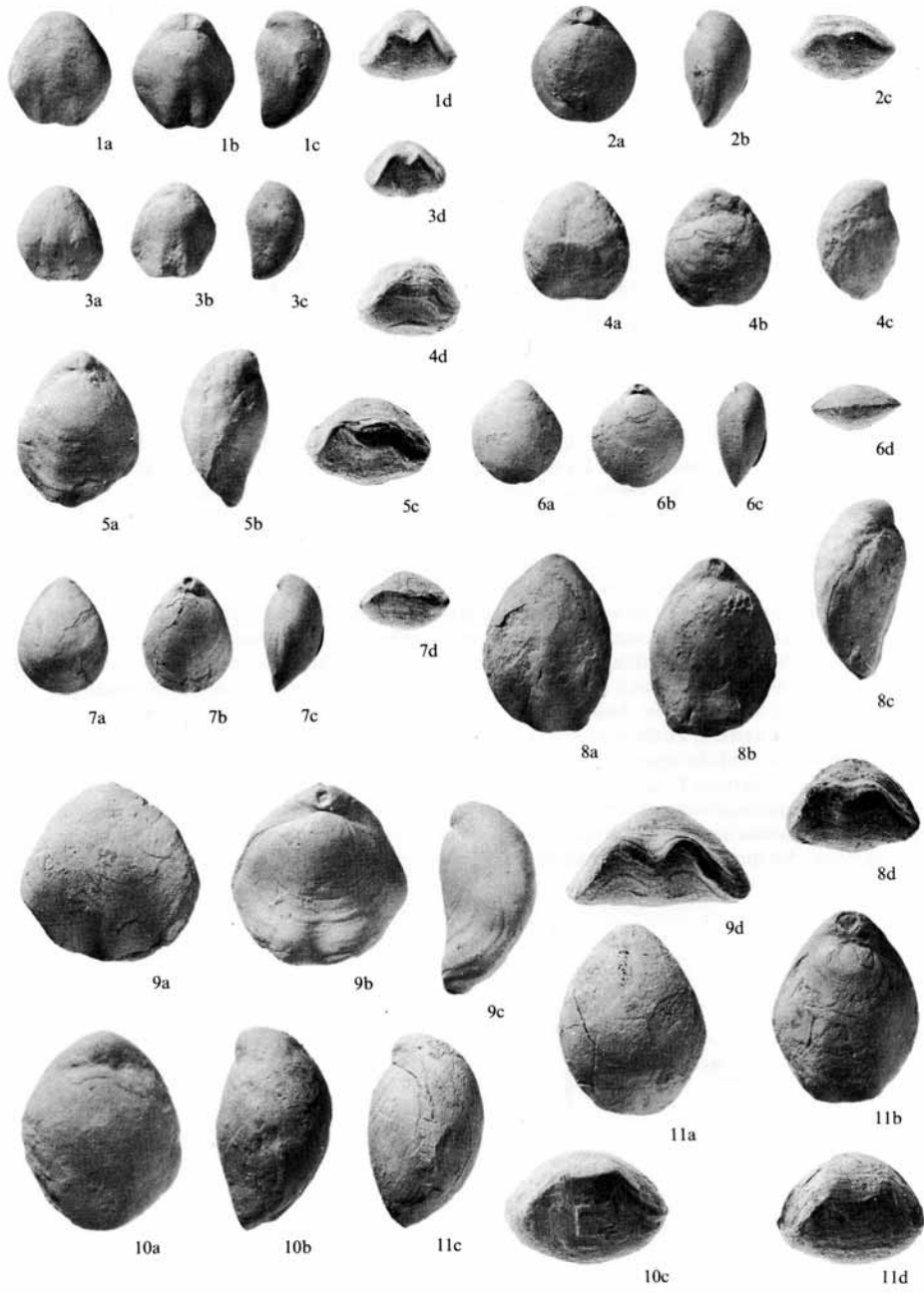
Figs. 1-4. *Loriolithyris russillensis* (de Loriol). Whitaker Coll. 1a-d, typical form, plaster cast of specimen sectioned (see text-fig. 5), BM BB 76544. 2a-c, wide *latifrons*-like form, plaster cast of specimen sectioned (see text-fig. 7), BM BB 76552. 3a-d, small sharply folded form, plaster cast of specimen sectioned (see text-fig. 6) BM BB 76543. 4a-d, thick *latifrons*-like form, BM B 17293.

Figs. 5-9. *Loriolithyris valdensis* (de Loriol). 5a-c, typical form, plaster cast of specimen sectioned (see text-fig. 11), BM BB 76545. Whitaker Coll. 6a-d, juvenile rectimarginate form, BM BB 76546, Whitaker Coll. 7a-d, juvenile incipiently biplicate form BM BB 76549, Whitaker Coll. 8a-d, elongate adult form, BM BB 76554, Whitaker Coll. 9a-d, wide adult form, S.546/1/12, Gentil Coll., Upper Hauterivian, loc. unknown.

Fig. 10a-c. *Loriolithyris melaitensis* sp. nov. Plaster cast of specimen sectioned (see text-fig. 12), S.556/1, Gentil Coll., Hauterivian, Tizi Ouarioum.

Figs. 11a-d. *Loriolithyris melaitensis* sp. nov. Holotype, S.556/2, Gentil Coll., Barremian, Ait Ben Melait, Ida ou Guelluil.

All natural size.



MIDDLEMISS, Cretaceous Terebratulidae

*Loriolithyris russillensis* (de Loriol)

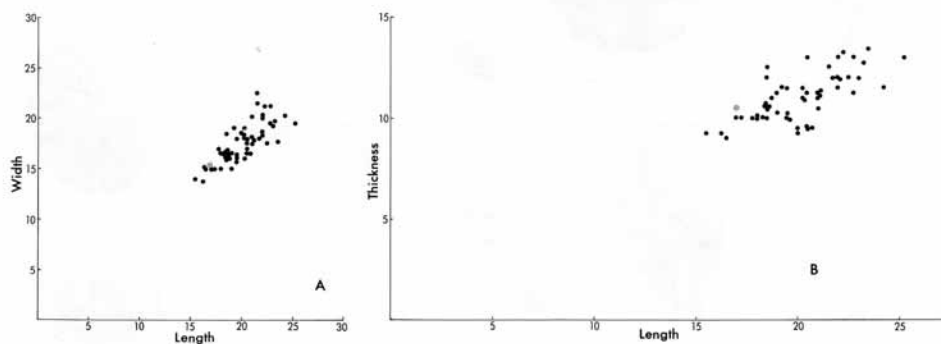
Plate 55, figs. 1-4; text-figs. 3-7

- \*1866 *Terebratula russillensis* de Loriol, p. 88, pl. E, figs. 12-15.  
 1867 *Terebratula russillensis* de Loriol, p. 393, pl. C, figs. 28-31.  
 1869 *Terebratula russillensis* de Loriol, p. 28, pl. 4, fig. 1.  
 v1872 *Terebratula russillensis* de Loriol; Pictet, p. 68, pl. 202, figs. 1-8.  
 v1872 *Terebratula latifrons* Pictet, p. 67, pl. 201, figs. 16-17.  
 ?1964 *Sellithyris (?)russillensis* (de Loriol); Ager, p. 340.  
 non 1966 *Sellithyris russillensis* (de Loriol); Bogdanova and Lobacheva, p. 53, pl. 5, figs. 5-6.  
 v1968 *Loriolithyris russillensis* (de Loriol); Middlemiss, p. 176, pl. A, figs. 1-4.

*Lectotype*. Muséum d'Histoire Naturelle, Geneva (Pictet Collection), no. CB 1520. Designated Middlemiss 1968. Fig. Pictet and de Loriol 1872, pl. 202, fig. 4; from the urgonian of La Russille, Vaud, Switzerland.

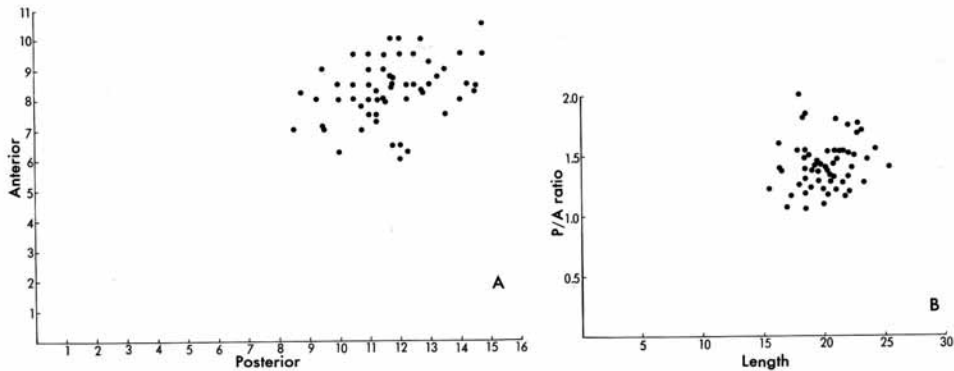
*Material*. Fifty-seven specimens from the Whitaker Collection. About fifty-five specimens in the Gentil Collection.

*Remarks*. Specimens from Morocco tend to be wider and thinner, in relation to length, than the typical members of the species from La Russille and Orgon and many have the characters of the form described by Pictet (1872) as *Terebratula latifrons*. I have previously (Middlemiss 1968a) believed the latter form to be a variety of *Loriolithyris russillensis* and experience of the Moroccan fauna has reinforced this belief. Forms from the Jura region which Pictet recognized as *T. latifrons* (Geneva Museum) are distinct because of their decidedly small umbones and foramina, not because of their wide depressed shape. They usually display well-developed *russillensis*-like folding of the shell and as regards shape there seems to be a complete gradation between the two species. In both south-west France and south-west Morocco forms apparently referable to *L. russillensis* show continuous variation, in the same assemblages, into other forms with the same characters except for the proportions of shell shape, which are those of *T. latifrons*. The forms with decidedly small umbones and foramina do not occur in these regions. The internal skeletal arrangements revealed by serial sectioning are the same in all these forms: the concave piped hinge plates, situated close to the floor of the brachial valve, and the sigmoid passage from inner socket ridge to hinge plate, are unmistakable. Pictet records his typical *T. latifrons* forms only from the Upper Valanginian of Villers-le-Lac and Vesency. *L. russillensis* was apparently a species-group very variable in proportions of length, width, and thickness, some members of which, in part of the Jura region and for a short time in the Upper Valanginian, became locally sufficiently differentiated to deserve recognition as a subspecies '*latifrons*'.



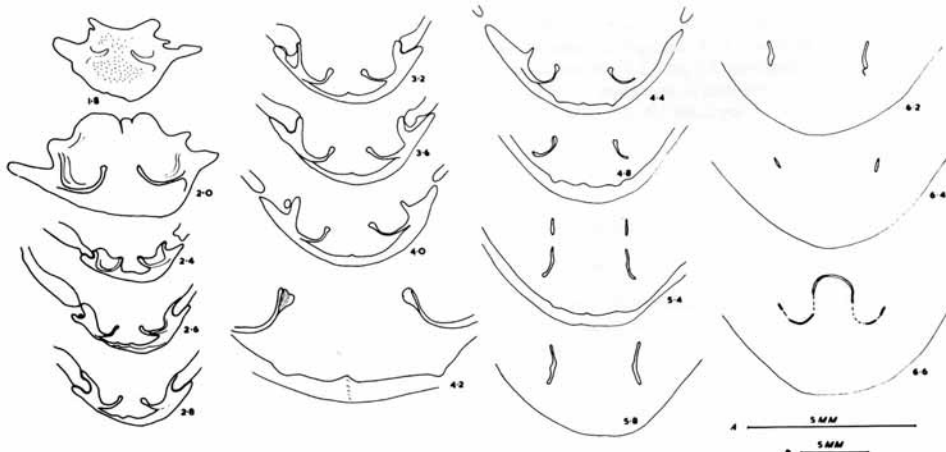
TEXT-FIG. 3. Scatter diagrams of relationships of width to length and thickness to length in *Loriolithyris russillensis* from the Whitaker Collection.





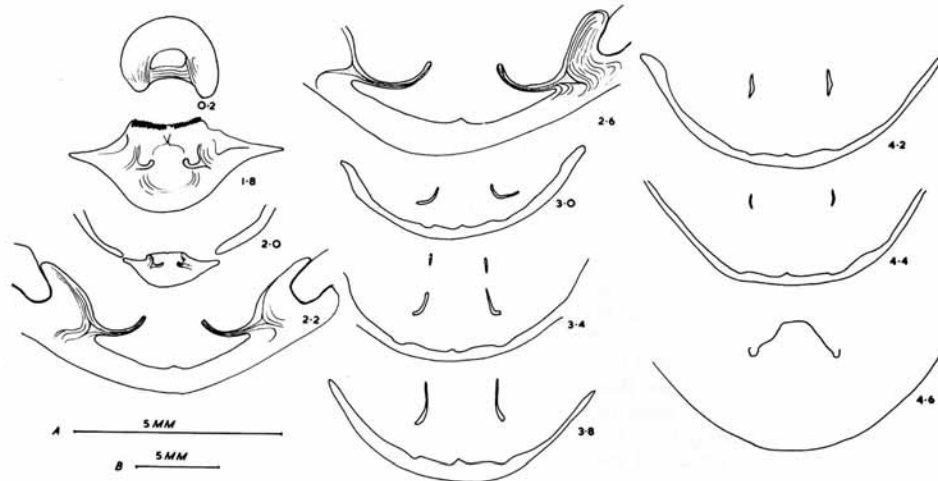
TEXT-FIG. 4. Scatter diagrams of the posterior/anterior ratio in *Loriolithyris russillensis* from the Whitaker Coll.

The main differences between this species and *L. valdensis* are that *L. valdensis* is longer in relation to both width and thickness and has a higher P/A ratio than *L. russillensis*. These points are graphically illustrated, as far as the Moroccan specimens are concerned, in text-figs. 3, 4, 8, 9, and 10. Internally, a point of distinction is that in *L. russillensis* the hinge plates are close to, or even in part in contact with, the floor of the brachial valve, whereas in *L. valdensis* they are raised clearly above the floor of the valve for their whole width. It can be added that, internally, *L. russillensis* has a very short loop, little more than 1 mm from the crural processes to the transverse band in adult shells. Unfortunately it is characteristic of species of *Loriolithyris* that the transverse band is delicate and seldom preserved and I have never yet seen this structure in *L. valdensis*.



TEXT-FIG. 5. Transverse sections through a small, strongly folded specimen of *Loriolithyris russillensis*. Sections 1.8 and 2.0 are enlarged in order to show the shape of the juvenile hinge plates enclosed within the cardinal process (punctate tissue is stippled in section 1.8). Section 4.2 is enlarged in order to show the structure of the piped hinge plates. BM BB 76544, Whitaker Coll. A—scale for sections, 1.8, 2.0 and 4.2. B—scale for the remaining sections.

*Distribution.* Ager (1964) claims this species in the Berriasian of the southern Jura and Pictet (1872) notes it in the Valanginian of Sainte-Croix (Vaud). It certainly occurs in the Hauterivian of Vaud, Doubs, Haute-Marne, and Yonne and of Les Corbières (Aude). It is at its most abundant, however, in the Barremian of Vaud, Jura, the south-east Paris Basin, Bouches-du-Rhône, Gard, Aude, eastern Spain, and Ibiza. It occurs very rarely in the Aptian of Aude. In south-west Morocco it ranges from the Hauterivian to Aptian inclusive.



TEXT-FIG. 6. Transverse sections through a small, strongly folded specimen of *Loriolithyris russillensis* to show the short loop. Section 1.8 is enlarged in order to show the shape of the juvenile hinge plates enclosed in the cardinal process. Sections 2.2 and 2.6 are enlarged in order to show the primary hinge plates (stippled). The maximum height of the crural processes is seen in section 3.4. BM BB 76543, Whitaker Coll. A—scale for sections 1.8, 2.2, and 2.6. B—scale for the remaining sections.

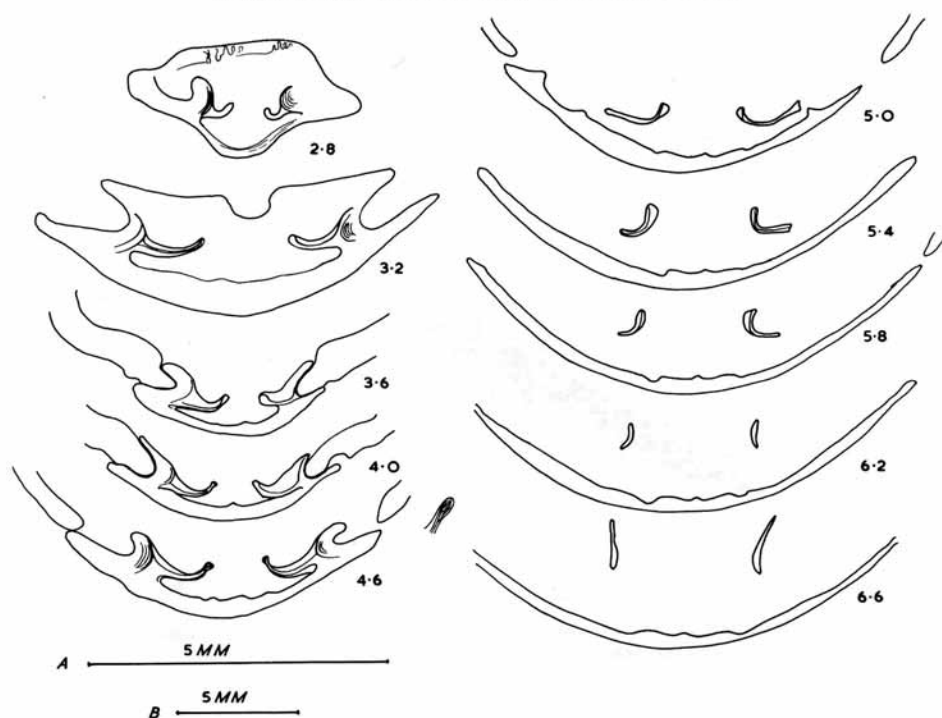
*Loriolithyris valdensis* (de Loriol)

Plate 55, figs. 5-9; text-figs. 8-11

- v\*1868 *Terebratula valdensis* de Loriol, p. 52, pl. 4, figs. 9-12.
- v1872 *Terebratula valdensis* de Loriol; Pictet, p. 66, pl. 201, figs. 11-15.
- non 1939 *Terebratula valdensis* var. *kentugajensis* Moisseev, p. 200, pl. 2, fig. 6.
- 1960 '*Terebratula*' *valdensis* de Loriol; Smirnova, p. 374, pl. 1, fig. 1.
- pars 1966 *Selliithyris valdensis* (de Loriol); Bogdanova and Lobacheva, p. 55, pl. 5, fig. 7 (*non* pl. 7, fig. 11).
- v1968 *Loriolithyris valdensis* (de Loriol); Middlemiss, p. 182, pl. A, fig. 5.
- 1972 *Selliithyris valdensis* (de Loriol); Smirnova, p. 81, pl. 7, fig. 5.
- v1975 *Loriolithyris valdensis* (de Loriol); Dieni and Middlemiss, p. 182, pl. 36, figs. 9-10.

*Lectotype.* Muséum d'Histoire Naturelle, Geneva (Arzier Collection), no. CB 1505. Designated Middlemiss 1968. Fig. de Loriol 1868, pl. 4, figs. 9a-d, from Bed B, Valanginian, Arzier Quarry, Vaud, Switzerland.

*Material.* Thirty-nine specimens in the Whitaker Collection. About 200 specimens in the Gentil Collection. Eight specimens from Barremian or Aptian, Tizi ou Elma, Agadir (D.V. Ager Collection).

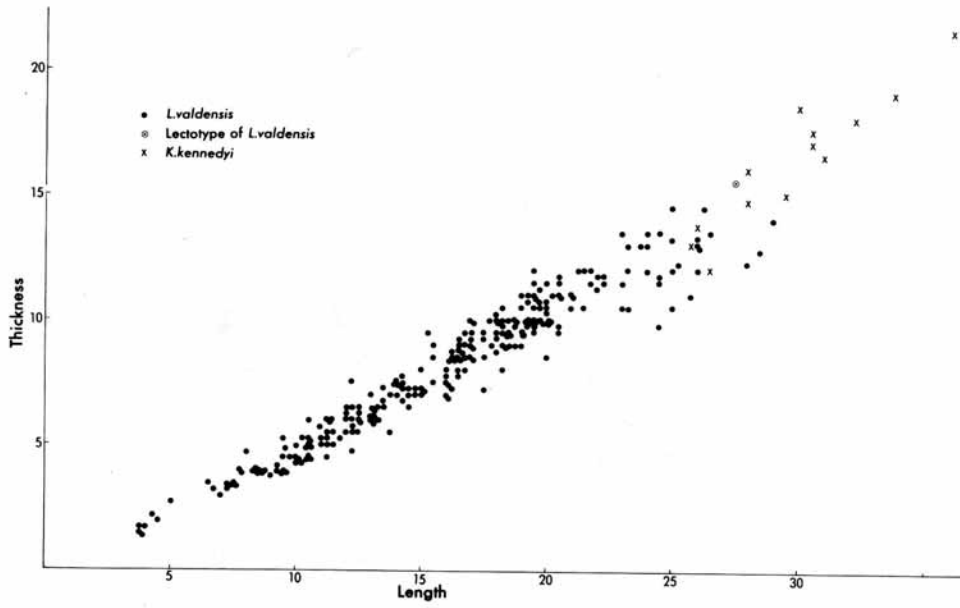


TEXT-FIG. 7. Transverse sections through a broad, *latifrons*-like specimen of *Loriolithyrus russillensis*. Sections 2.8 and 3.2 are enlarged in order to show the shape of the juvenile hinge plates. The structure of the piped inner margin of the hinge plate is enlarged at section 4.6 (see plate 60, fig. 5). The transverse band was not preserved in this specimen. BM BB 76552, Whitaker Coll. A—scale for sections 2.8, 3.2, and 4.6 (inset). B—scale for the remaining sections.

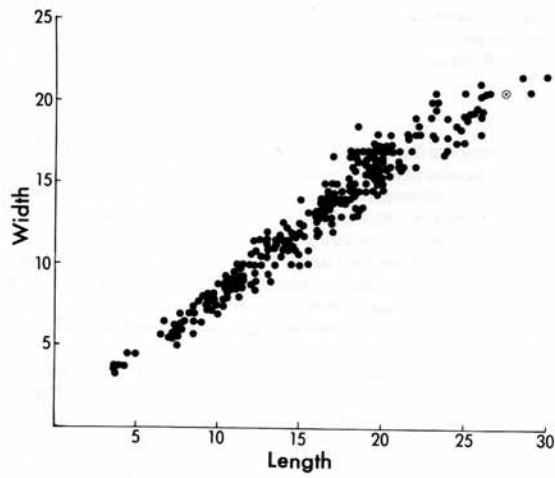
*Description.* Text-figs. 8 and 9 compare the thirty-nine specimens in the Whitaker Collection with a collection of 227 specimens made at the type locality of Arzier by Monsieur Roessinger and preserved at the Geneva Natural History Museum. The isometric development of length and width is well shown in text-fig. 9. Thickness in relation to length develops allometrically, although with a very small differential growth ratio (text-fig. 8). Text-fig. 10 shows that the P/A ratio develops allometrically with a very wide range of variation (about double the width of that shown by *Sellithyrus sella* from the Isle of Wight Aptian (Middlemiss 1968b, fig. 9)). The smallest shells, less than 5 mm in length, are subcircular in ventral profile but posterior length increases allometrically with growth, at the expense of anterior length. There is a marked tendency for Moroccan specimens to have a lower P/A ratio, i.e. to have a relatively greater anterior length than those from the type area; in this respect the lectotype has an anomalous position.

The anterior commissure remains rectimarginate until the shell is about 12 mm in length. It then passes through a well-marked uniplicate stage until the shell reaches a length of about 16 mm, after which plicae and sinuses are rapidly developed, shells from 17 mm upwards being normally sulcinate. The episulcate stage is occasionally seen at Arzier but is very rare in Morocco.

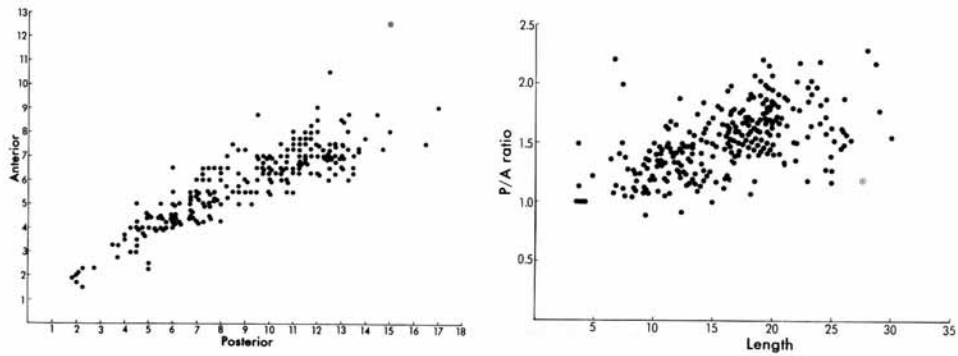
*Remarks.* Differences between this species and *L. russillensis* were discussed above. Roch remarks on the abundance of this species in the Valanginian and Barremian of south-west Morocco, especially in the Barremian of Jebel Graa and Aghbalou.



TEXT-FIG. 8. Scatter diagrams of the relationship of thickness to length in *Loriolithyris valdensis* (Arzier and Whitaker Colls.) and *Kutchithyris kennedyi* (all available specimens).



TEXT-FIG. 9. Scatter diagram of the relationship of width to length in *Loriolithyris valdensis* (Arzier and Whitaker Colls.).



TEXT-FIG. 10. Scatter diagrams of the posterior/anterior ratio in *Loriolithyris valdensis* from Arzier.

*Distribution.* Berriasian and Valanginian of Vaud and Haute-Savoie; Valanginian and Hauterivian of the south-east Paris Basin; Valanginian of Georgia and Hauterivian of the northern Caucasus (Smirnova 1972); Neocomian of the Kopet Daga (Bogdanova and Lobacheva 1966); Hauterivian of north-east Bulgaria. Valanginian and Hauterivian of eastern Spain; Barremian of Basses-Alpes and Alpes-Maritimes. Aptian of La Presta (Neuchâtel). In south-west Morocco the range is Valanginian to Aptian inclusive.



TEXT-FIG. 11. Transverse sections through *Loriolithyris valdensis*. Sections 2.8-4.4 are enlarged in order to show the shape of the juvenile hinge plates enclosed within the cardinal process and the structure of the crural bases within the piped inner margins of the hinge plates. Maximum development of the crural processes is seen in section 7.2. The transverse band was not preserved in this specimen. BM BB 76545, Whitaker Coll. A—scale for sections 2.8-4.4. B—scale for the remaining sections.

*Loriolithyris melaitensis* sp. nov.

Plate 55, figs. 10, 11; text-fig. 12

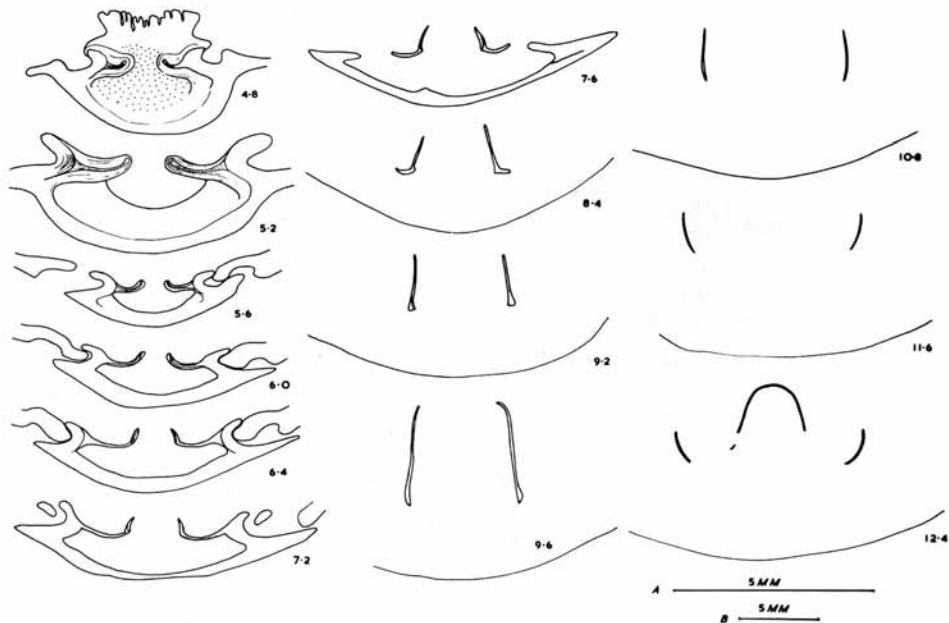
v1951 *Terebratula salevensis* de Loriol; Gigout, p. 360, pl. 9, figs. 15-18.

*Types.* Holotype, Gentil Collection specimen no. S.556/2, from the Barremian of Ait Ben Melait. Dimensions: L 31, W 28.5, T 18.5. Paratype, Gentil Collection specimen no. S.556/1 (locality as holotype).

*Material.* Ten specimens in the Gentil Collection; nine from the Hauterivian of Tizi Ouaroum, one from the Barremian of Ait Ben Melait, Ida ou Guelluill.

*Diagnosis.* *Loriolithyris* of elongate oval ventral profile, becoming thick in adult stage (thickness nearly equal to width); P/A ratio slightly more than 1. Valves equally convex. Umbo suberect. Foramen mesothyrid, attrite, slightly labiate. Beak ridges rounded. Symphytium very short, but visible. Lateral commissure strongly arched; anterior commissure sulciphate. Shell not folded except at extreme anterior. Small pedicle collar present. Hinge plates concave, piped. Crural bases well developed. Crural processes slightly incurved. Transverse band high-arched, rounded.

*Remarks.* The thick, well-filled appearance of the shell, the arched lateral commissure, and the relative lack of folding give this species a superficial resemblance to *Tropeothyris salevensis* (de Loriol) and it is likely that Ambroggi's (1963) record of *T. salevensis* in both Lower and Upper Barremian of south-west Morocco refers to this species.



TEXT-FIG. 12. Transverse sections through *Loriolithyris melaitensis*. Section 4.8 is enlarged in order to show the shape of the juvenile hinge plates enclosed within the cardinal process and the boundary between punctate tissue (stippled) and impunctate laminated tissue. Section 5.2 is enlarged in order to show the primary hinge plates (stippled). The crural bases, unusually large for *Loriolithyris*, are well shown in sections 6.4-7.6. Section 9.6 shows the maximum development of the crural processes. S.556/1, Gentil Coll., Hauterivian, Tizi Ouaroum.

A—scale for sections 4.8 and 5.2. B—scale for the remaining sections.

It is distinguished from other species of *Loriolithyris* especially by the unusually large size of the crural bases attached to the inner edges of the hinge plates (text-fig. 12), but also by its external appearance.

*Distribution.* Hauterivian and Barremian of south-west Morocco.

*Loriolithyris marocensis* sp. nov.

Plate 56, figs. 1, 2; text-fig. 13

*Types.* Holotype, Gentil Collection specimen no. S.547/2; age given as Upper Hauterivian (locality unknown). Dimensions: L 49.75, W 32, T 26.25. Paratype, Gentil Collection specimen no. S.547/1.

*Material.* Sixteen specimens in the Gentil Collection: four from the Hauterivian (including Oued Tidzi), two from the Barremian, Chaine d'Azour, ten from the Barremian of Oued Aghbalou.

*Diagnosis.* Elongate *Loriolithyris*, attaining large size; P/A ratio slightly more than 1. Valves equally convex. Umbo erect. Foramen mesothyrid, labiate. Beak ridges rounded. Symphytium hidden in adult stage. Lateral commissure very strongly arched. Anterior commissure sulciphate with shallow median sinus, rarely episulcate. Shell folded only at extreme anterior, marked by strong concentric growth ridges. Small pedicle collar present.



TEXT-FIG. 13. Transverse sections through *Loriolithyris marocensis*. Sections 5.6 and 6.0 are enlarged in order to show the detailed structure of the cardinal process, with juvenile primary hinge plates (fine stipple) surrounded by laminated thickening and the body of the cardinal process infilled with punctate skeletal tissue (coarse stipple). Section 6.4 is enlarged to show the primary hinge plates (stippled). Maximum development of the crural processes is seen in section 11.2. Note the height of the transverse band above the floor of the valve in section 14.4. S.547/1, Gentil Coll., Hauterivian, locality unknown. A—scale for sections 5.6, 6.0, and 6.4. B—scale for the remaining sections.

Hinge plates initially concave, becoming rounded L-shaped, piped. Cardinal process extends along the hinge plates, leaving small dorsal umbonal cavity. Transverse band high-arched, with somewhat pointed crest, high above floor of valve.

*Remarks.* As all the specimens available are fully adult or gerontic little can be said about the ontogeny, except that biplication of the anterior commissure and folding of the shell appear to develop very late. *L. marocensis* differs from most species of the genus in the large size attained when adult and the massive, little-folded form of the shell; in those respects it is nearest to *L. melaitensis* but differs markedly from that species in its internal structures: *L. melaitensis* is distinguished by the large size of its crural bases whereas in *L. marocensis* the crural bases are small and enclosed within the piped edge of the hinge plate as usual in *Loriolithyris*. *L. marocensis* is also distinct from other species of the genus in the L-shape developed by the hinge plates as seen in transverse section (text-fig. 13). Another Moroccan Lower Cretaceous species which closely resembles *L. marocensis* is *Cyrtothyris middlemissi*; the latter is broader in relation to length, and has a less erect umbo, and lacks the loriolithyrid boldly arched lateral commissure of *L. marocensis*, besides the internal differences.

*Distribution.* Hauterivian and Barremian of south-west Morocco.

#### Genus BOUBEITHYRIS Cox and Middlemiss, 1978

*Type species.* *Terebratula boubei* d'Archiac, 1847.

*Species included.* *T. boubei* d'Arch. *Boubeithyris buzzardensis* Cox and Middlemiss, *B. tibourrensis* nov., *B. pleta* nov. Range: Hauterivian?, Barremian to Cenomanian.

#### *Boubeithyris tibourrensis* sp. nov.

Plate 56, figs. 3, 4; text-fig. 14

*Types.* Holotype, Gentil Collection specimen no. S.548/2/1, from Butte de Tibourr'm; labelled Aptian (more likely Barremian). Dimensions: L 20.5, W 16.25, T 12.5. Paratype, Gentil Collection specimen no. S.552/3/1, Barremian, Tibourr'm.

*Material.* Two specimens in the Gentil Collection from Butte de Tibourr'm, one labelled Aptian, the other Barremian.

*Diagnosis.* *Boubeithyris* regularly oval as seen in ventral profile, apart from short straight anterior (between the lateral plicae). Valves equally convex. P/A ratio slightly greater than 1. Umbo suberect; beak ridges moderately well defined. Foramen mesothyrid, marginate, slightly telate. Lateral commissure arched. Anterior commissure sulcinate; lateral plicae close together; median sinus narrow. Plication reflected by small folds and sulci in extreme anterior part of brachial valve only. Hinge plates thin, concave, piped to strongly corniced. Inner socket

#### EXPLANATION OF PLATE 56

Figs. 1, 2. *Loriolithyris marocensis* sp. nov. 1a-d, holotype, S.547/2 Gentil Coll., Upper Hauterivian, loc. unknown. 2a-c, plaster cast of specimen sectioned (see text-fig. 13), S.547/1, Gentil Coll., Upper Hauterivian, loc. unknown.

Figs. 3, 4. *Boubeithyris tibourrensis* sp. nov. 3a-d, holotype, S.548/2/1, Gentil Coll., Barremian or Aptian, Butte de Tibourr'm. 4a-c, plaster cast of specimen sectioned (see text-fig. 14), S.522/2/1, Gentil Coll., Barremian, Tibourr'm.

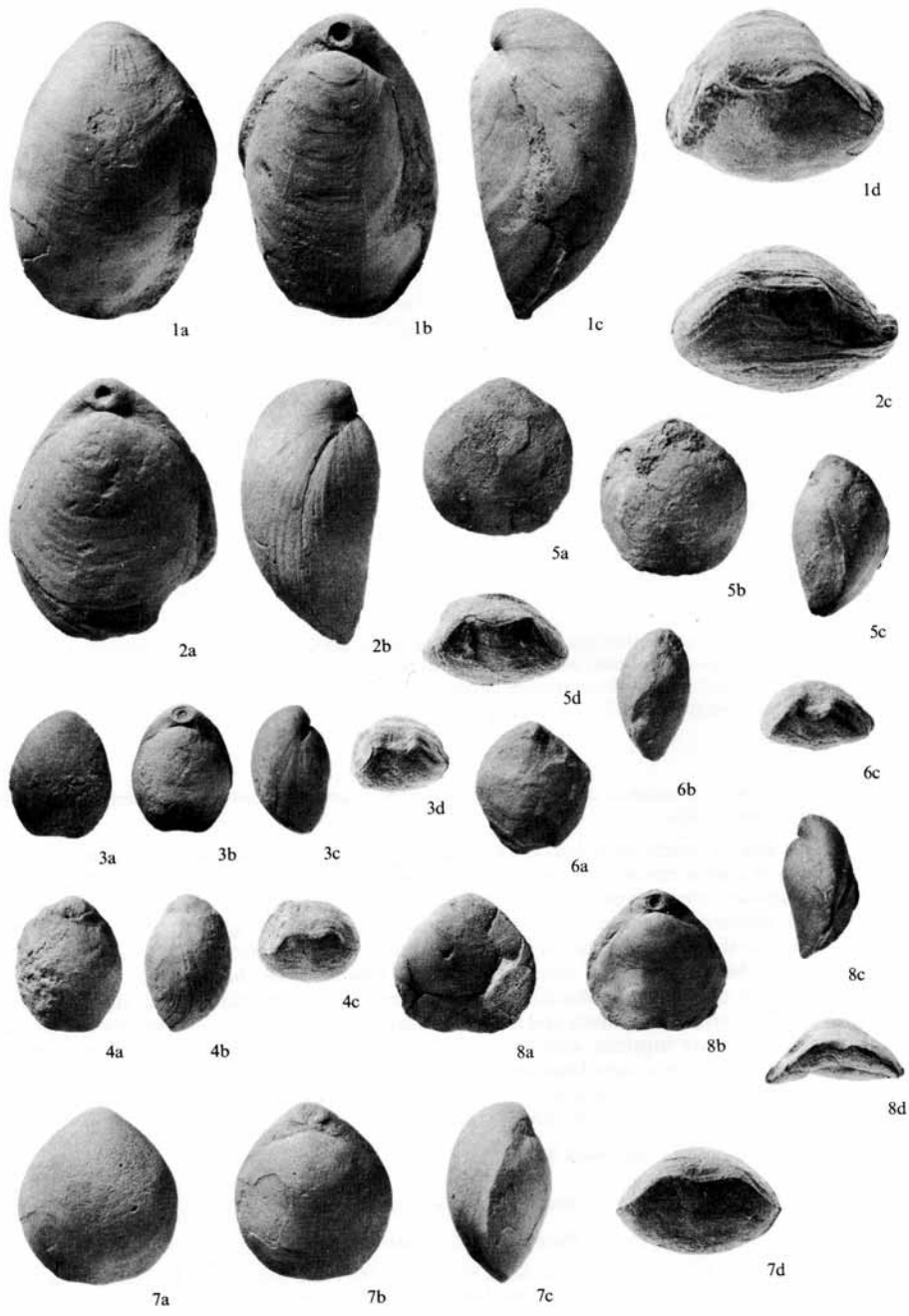
Figs. 5, 6. *Boubeithyris pleta* sp. nov. 5a-d, holotype, S.553/3, Gentil Coll., Barremian, Sidi Bou Rjaa. 6a-c, plaster cast of specimen sectioned (see text-fig. 15), S.553/1, Gentil Coll., Barremian, Sidi Bou Rjaa.

Fig. 7a-d. *Boubeithyris pleta* sp. nov. Large typical specimen, S.557/6, Gentil Coll., Barremian, Igueni Ouram.

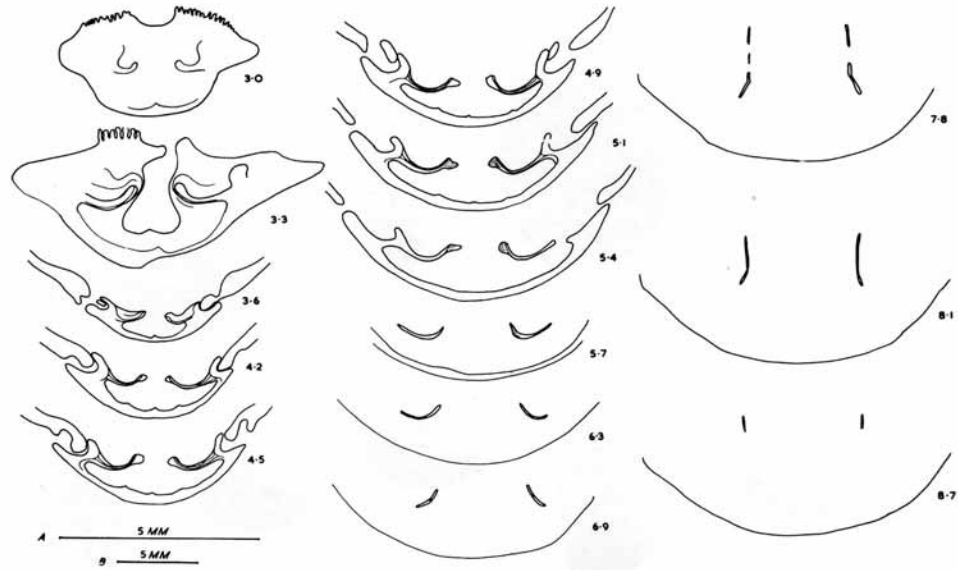
Fig. 8. *Paraboubeithyris plicae* gen. et sp. nov. 8a-d, holotype, S.548/1/3, Gentil Coll., Barremian, Vallee Asif Ait Ameur.

All natural size.





MIDDLEMISS, Cretaceous Terebratulidae



TEXT-FIG. 14. Transverse sections through *Boubeithyris tibourensis*. Sections 3.0 and 3.3 are enlarged to show the initial shape of the juvenile hinge plates within the cardinal process. Cornicing of the hinge plates is best seen in sections 4.2–5.4. Section 7.8 shows the maximum development of the crural processes. The transverse band was not preserved in this specimen. S.552/2/1, Gentil Coll., Barremian, Tibouren'm. A—scale for sections 3.0 and 3.3 B—scale for the remaining sections.

ridges narrow. Accessory articulation slightly developed. Euseptoidum short, confined to posterior part of hinge plates, flanked by lateral ridges.

*Remarks.* This species closely resembles the type species in general shape, the close-set lateral plicae being particularly characteristic of both species. *B. tibourensis* differs from *B. boubei* in being more oval, less pentagonal, in ventral profile and somewhat more convex in lateral profile. Like *B. boubei*, it differs from *B. buzzardensis* in being narrower and thicker, having a higher P/A ratio and folding almost confined to the brachial valve. Internally the hinge plates are more deeply concave and the cornice-structure better developed than in either *B. boubei* or *B. buzzardensis*. A species of *Boubeithyris* which occurs in the Aptian of the Jura region, so far undescribed, differs from *B. tibourensis* in being still more convex and in having a lateral commissure still more strongly arched, lateral plicae even closer together, and a longer symphytium. Although only two specimens are available, this species is important because it extends back to the Barremian the time-range of the typical oval form of *Boubeithyris*, which can thence be traced through the undescribed Aptian species from the Jura to *B. boubei* itself in the Albian and Cenomanian.

*Distribution.* Barremian of south-west Morocco.

*Boubeithyris pleta* sp. nov.

Plate 56, figs. 5–7; text-fig. 15

*Types.* Holotype, Gentil Collection specimen no. S.553/3, from the Barremian of Sidi Bou Rjaa, Oued Tidzi. Dimensions: L 25.5, W 23.75, T 15. Paratypes, Gentil Collection specimens S.553/1 (age and locality as holotype) and S.557/6, Barremian, Igueni Ouram.

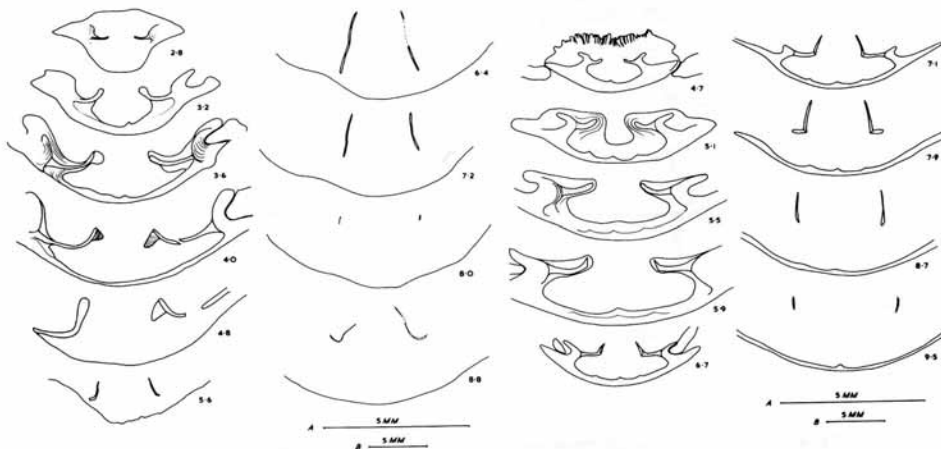
*Material.* Twenty-one specimens in the Gentil Collection.

*Name.* Latin *pleta*, 'filled', from the well-filled appearance of the shell.

*Diagnosis.* *Boubeithyris* almost as broad as long, with thickness less than two-thirds of width. Subcircular in ventral profile. Valves equally convex. P/A ratio about 1. Umbo short, suberect. Beak ridges rounded. Foramen mesothyrid, attrite. Lateral commissure arched. Anterior commissure sulcinate; median sinus low. Shell little folded. Hinge plates concave, piped to strongly corniced. Euseptoidum short and weak. Transverse band moderately high.

*Remarks.* In external appearance this species could be taken for a sulcinate species of *Sellithyris* but the extremely gentle folding imparts to the shell a tumid or 'well-filled' appearance which is distinctive; also the ventral profile is less pentagonal than in most species of *Sellithyris*, even *S. deningeri* which is a particularly rounded species of that genus. It differs from other species of *Boubeithyris* mainly in being relatively wide and flat in comparison with its length and in the wider spacing of the plicae of the anterior commissure.

*Distribution.* Hauterivian(?) and Barremian of south-west Morocco.



TEXT-FIG. 15. Transverse sections through *Boubeithyris pleta*. Sections 2.8-4.8 are enlarged to show details of the structure of the hinge plates and of the cornicing. Maximum height of the crural processes is seen in section 6.4. S.553/1, Gentil Coll., Barremian, Sidi Bou Rjaa. A—scale for sections 2.8-4.8. B—scale for the remaining sections.

#### Genus PARABOUBEITHYRIS gen. nov.

*Type species.* *Paraboubeithyris plicae* sp. nov.

*Diagnosis.* Ventral profile rounded pentagonal, as wide as, or wider than, long. Depressed. P/A ratio slightly more than 1. Umbo suberect to erect. Beak ridges rounded. Foramen mesothyrid, marginate, becoming labiate. Lateral commissure strongly arched. Anterior commissure deeply uniplicate, or sulcinate with very small median sinus. Brachial valve has a strong median fold extending from the umbonal region to the anterior; corresponding to a deep, wide sulcus in the anterior half of the pedicle valve. Hinge plates concave, thin, sharply differentiated from the inner socket ridges; piped to strongly corniced. Transverse band high-arched. Euseptoidum weak, flanked by two low lateral ridges.

*Paraboubeithyris plicae* sp. nov.

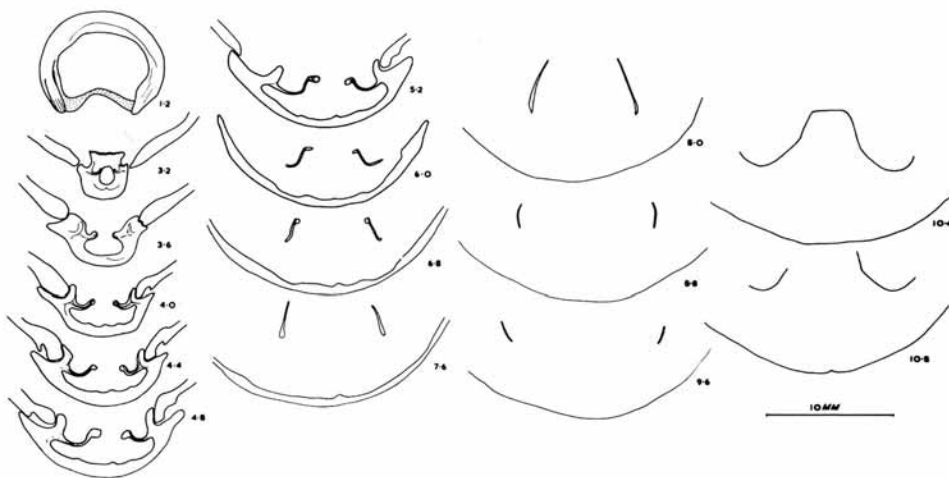
Plate 56, fig. 8; Plate 57, figs. 1-3; text-fig. 16

*Types.* Holotype, Gentil Collection specimen no. S.548/1/3, from the Barremian of the Vallée Asif Ait Aneur. Dimensions: L 22, W 22.5, T 10. Paratypes, Gentil Collection specimens S.546/1/1, S.546/1/2, and S.546/1/3; age given as Upper Hauterivian (locality unknown).

*Name.* Genitive of Latin *plica*, 'a fold'.

*Material.* Thirty-three specimens in the Gentil Collection, of which ten are from the Barremian of Vallée Asif Ait Aneur and twelve from the Barremian of Ida ou Tanan, the remainder being unlocated.

*Description.* This species has a deep and dramatic uniplication, especially in the more gerontic specimens. Some of the smaller specimens have a very small median sinus, so that the anterior commissure is strictly sulcate, but the sinus is always extremely small and usually *asymmetrically* placed. We lack juvenile representatives of the



TEXT-FIG. 16. Transverse sections through *Paraboubeithyris plicae*. Section 1.2 shows the pedicle collar (stippled). Section 3.2 shows a dorsal umbonal cavity. The corniced hinge plates are well seen in sections 4.8 and 5.2. S.546/1/1, Gentil Coll., Hauterivian, locality unknown.

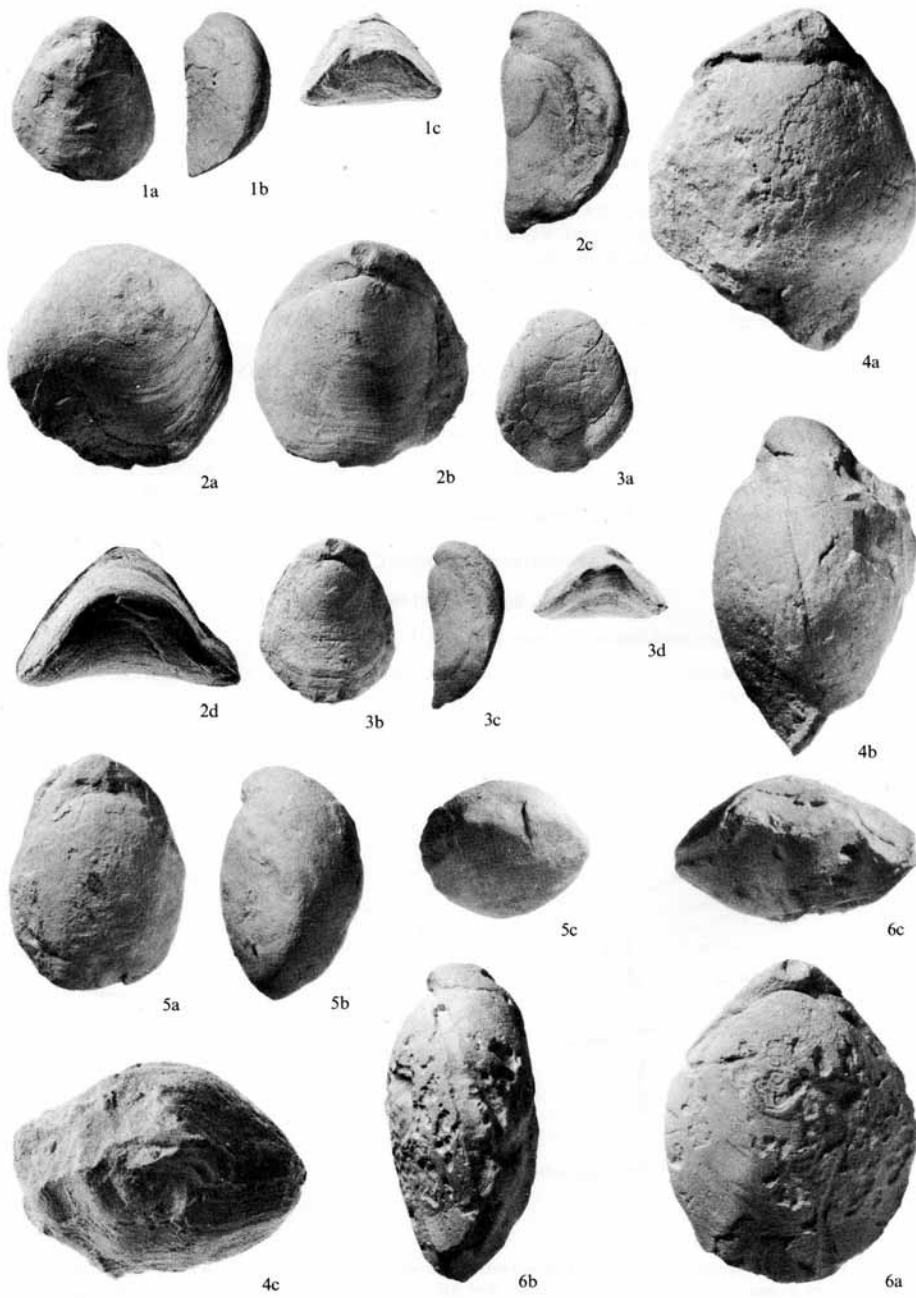
## EXPLANATION OF PLATE 57

Figs. 1-3. *Paraboubeithyris plicae* gen. et sp. nov. 1a-c, plaster cast of specimen sectioned (see text-fig. 16), S.546/1/1, Gentil Coll., Upper Hauterivian, loc. unknown. 2a-d, adult but uniplicate form, S.546/1/2, Gentil Coll., Upper Hauterivian, loc. unknown. 3a-d, elongate form showing incipient biplication, S.546/1/3, Gentil Coll., Upper Hauterivian, loc. unknown.

Fig. 4a-c. *Cyrtothyris middlemissi* (Calzada), plaster cast of specimen sectioned (see text-fig. 18), BM BB 76564, D.V. Ager Coll., Aptian, Ait Abaid, Agadir.

Figs. 5, 6. *Cyrtothyris middlemissi* (Calzada). 5a-c, plaster cast of specimen sectioned (see text-fig. 17), BM BB 76565, Calzada Coll., Aptian, La Roqueta, Spain. 6a-c, BM BB 76566, Calzada Coll., Albian, Peracals, Spain.

All natural size.



MIDDLEMISS, Cretaceous Terebratulidae

species but specimens in the Gentil Collection indicate that the sinus appears late, following juvenile rectimarginate and uniplicate stages, when the shell has attained a length of about 15 mm, and is then lost again in the gerontic stage. Some individuals show no sign of biplication, however.

*Remarks.* This species is almost certainly the form that both Roch and Ambroggi identified as *Terebratula collinaria* d'Orbigny, which it resembles in general shape. The principal differences between these two species are (a) *T. collinaria* is always uniplicate, never biplicate; (b) the cardinal slopes of *T. collinaria* tend to be concave in dorsal profile, with a sharply produced umbo, those of *P. plicae* are convex, with an umbo which does not protrude beyond the curve of the cardinal slopes; (c) *T. collinaria* has relatively flat hinge plates with no trace of the corniced structure characteristic of *Paraboubeithyris*.

*Distribution.* Barremian of south-west Morocco.

Subfamily RECTITHYRIDINAE Muir-Wood, 1965

Genus CYRTOTHYRIS Middlemiss, 1959

*Type species.* *Terebratula depressa* var. *cyrta* Walker, 1868.

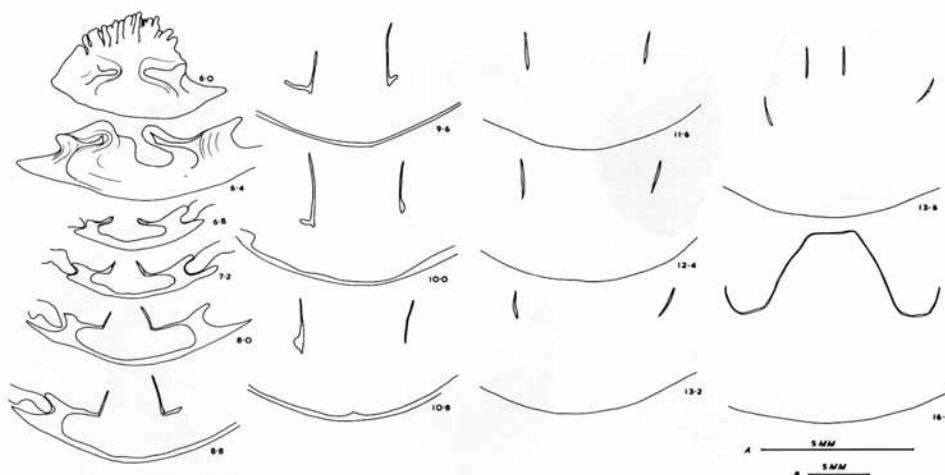
*Species included.* *T. depressa* var. *cyrta* Walker, *T. depressa* var. *uniplicata* Walker, *T. depressa* var. *cantabridgiensis* Walker, *T. seeleyi* Walker, *T. dallasi* Walker, *Cyrtothyris middlemissi* Calzada, *C. cyrta arminiae* Middlemiss, '*Cyrtothyris*' *maynci* Owen. Range: Valanginian to Albian.

*Cyrtothyris middlemissi* Calzada

Plate 57, figs. 4-6; text-figs. 17, 18

\*1972 *Cyrtothyris middlemissi* Calzada, p. 66, fig. 1.

*Holotype.* Geological Museum of the Seminario de Barcelona, specimen no. 23.346, from the Aptian of La Roqueta, Garraf, Barcelona.



TEXT-FIG. 17. Transverse sections through *Cyrtothyris middlemissi*. Sections 6.0 and 6.4 are enlarged to show the initial horizontal cuneate shape of the hinge plates. BM BB 76565, Coll. S. Calzada, Aptian, La Roqueta, Spain.

A—scale for sections 6.0 and 6.4. B—scale for the remaining sections.



TEXT-FIG. 18. Transverse sections through *Cyrtothyris middlemissi*. Maximum height of the crural processes is seen at 16.4. BM BB 76564, Coll. D. V. Ager, Aptian, Ait Abaid, Agadir, Morocco.

**Material.** Nineteen specimens in the Gentil Collection (seventeen from the Clansayesian of Sidi Bou Rjaa, one from the Clansayesian of Imi ou Tanant, one from the Aptian of Ait Moujjout). Three specimens from probable Aptian, Ait Abaid, north-east of Agadir (Ager Collection). Also nineteen other specimens: three from the Aptian of La Roqueta (Calzada Collection); four from the Upper Aptian, Plan de Coloubret, Taura, Aude (Charrière Collection); six from the Aptian of Combe Longue, Taura, Aude; two from the Albian of Peracals, Lerida, Spain (Calzada Collection); four from the Albian of Pic du Seigneur, Tuchan, Aude (Debuyser Collection).

**Original diagnosis** (after Calzada 1972). Large forms (maximum L 53, W 36, T 24; L/W ratio 1.1–1.6; L/T ratio 1.7–2.1) of subpentagonal to oval ventral profile. Maximum width and thickness in middle of length. Valves convex, pedicle valve much more so than brachial valve. Valves may show folding (but this character is very variable). Lateral commissure inclined ventralwards at about 20° and arched. Anterior commissure uniplicate to slightly sulcinate. Umbo wide, massive, suberect to erect. Foramen wide, labiate, circular, mesothyrid. Interareas somewhat concave; beak ridges moderately rounded. Deltoidal plates small but visible, fused into a symphytium. Growth lines visible. Hinge plates concave, somewhat clubbed, becoming anteriorly persistently virgate or even V-shaped. Angle between the crural bases and the crural rami 70°–100°. Loop strongly recurved in a posterior direction so that no one serial section includes the whole of the arch of the transverse band.

**Remarks.** Specimens from Morocco and from the Albian of north-east Spain exceed Calzada's stated maximum width (up to 43 mm); nevertheless all specimens available fall into the range of L/W ratios given in his diagnosis. On the other hand specimens from both areas, and including the type locality, fall outside the range of L/T ratios given (extremes are specimen MDA 2/1, from Morocco, 1.57 and CaP2, from the Albian of Peracals, 2.12). Calzada understates the plication of the anterior commissure, which is normally gently sulcinate in the adult stage. The foramen should be described

as strongly marginate, labiate in the adult stage. The wide triangular shape of the loop and the strong recurvature of the transverse band are generic features in *Cyrtothyris* (Middlemiss 1976).

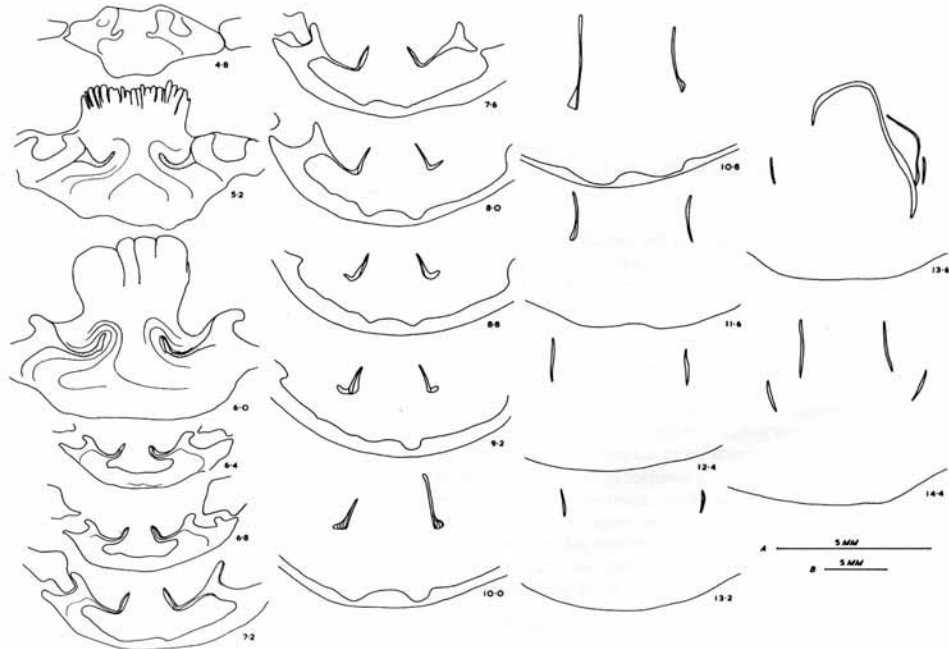
*Distribution.* Aptian of Aude and north-eastern Spain; Aptian (including Clansayesian) of south-western Morocco; Albian of Aude and north-eastern Spain.

Subfamily uncertain  
Genus *KUTCHITHYRIS* Buckman, 1918

*Type species.* *Terebratulula acutiplicata* Kitchin, 1900.

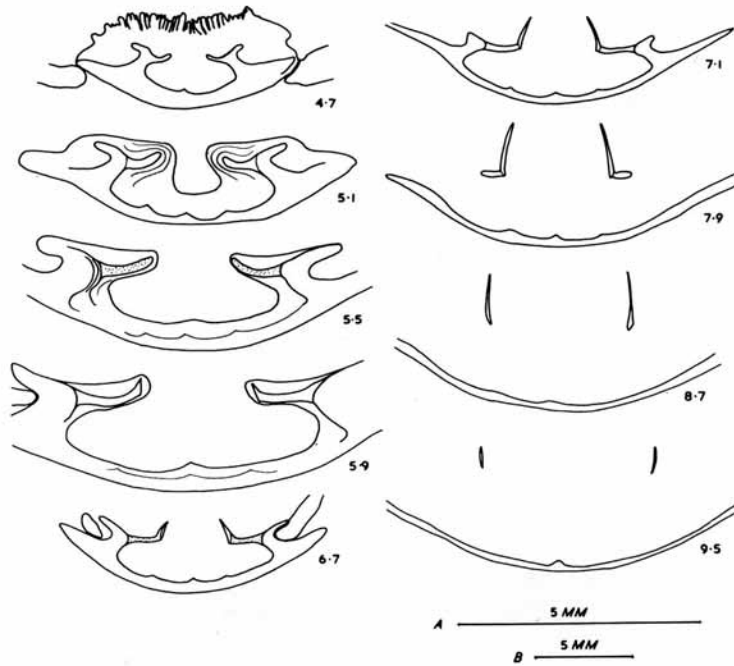
*Original definition* (Buckman 1918). 'Permesothyrid (beak stout, broad, quite short, thickened with callus, obliquely truncate, foramen large, circular, attrite, close to umbo, symphytium very short); morphogeny, biconvex to strongly sulcinate; muscle-tracks obliterated posteriorly, not reaching far down valves, rather sharply divergent, starting not from the umbo but from about midway of the posterior half of the shell, showing little more than scars; dorsal septum feeble—ovarian areas large, mammillate on cast. The muscle scars posteriorly obliterated and diverging from a point well removed from the umbo, the short beak with little exposure of symphytium: these characters at once distinguish the genus.'

*Diagnosis.* Umbo suberect to incurved. Foramen mesothyrid to epithyrid; may be slightly labiate. Development of anterior commissure uniplicate to sulcinate, more rarely to episulcate. Hinge plates wide, concave, flattening anteriorly, very little differentiated from the laterally deflected inner socket ridges. Crural bases low where attached to hinge plates, rapidly elongating anteriorly and passing into high, thin, slightly flanged crural



TEXT-FIG. 19. Transverse sections through *Kutchithyris acutiplicata* (type species of the genus). Sections 4.8-6.0 are enlarged in order to show details of the structure of the cardinal process. The crural bases first appear at 6.0. The transverse band at 13.6 is broken and partially displaced. BM 52420, Putchum Group (Upper Jurassic), Jumara, Kutch, India. A—scale for sections 4.8-6.0. B—scale for the remaining sections.



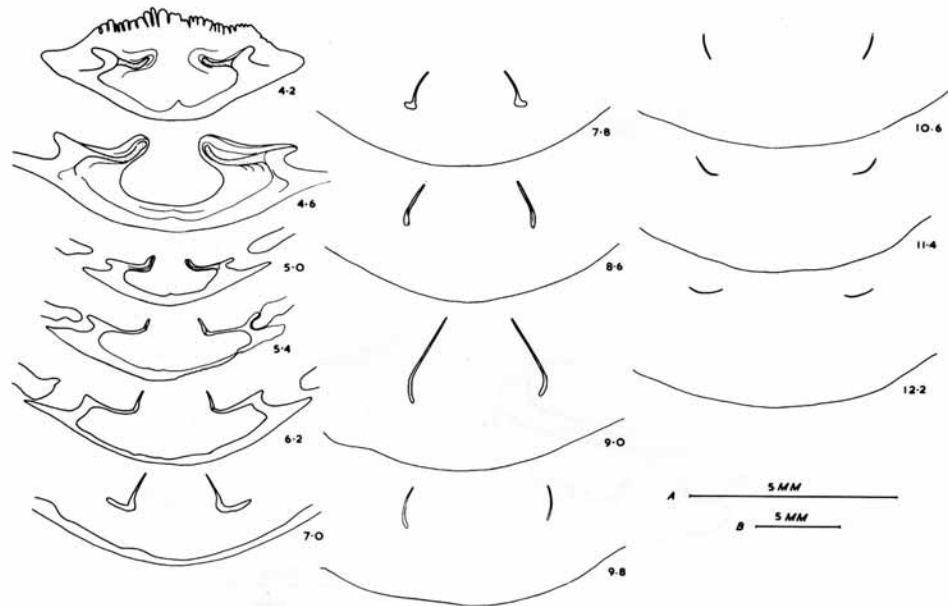


TEXT-FIG. 20. Transverse sections through *Kutchithyris subsella*. Sections 4.7–5.9 are enlarged to show the initial shape of the hinge plates at 4.7 and 5.1, the primary hinge plates (stippled) at 5.5, and the first appearance of the crural bases at 5.9. Maximum height of the crural processes is seen at 7.9. The transverse band was not preserved in this specimen. BM BB 76555, Kimeridgian, Le Havre, France. A—scale for sections 4.7–5.9. B—scale for the remaining sections.

processes. Hinge plates and crural processes usually clubbed. Descending lamellae thin. Transverse band high-arched, ogival. Euseptoidum present but usually weak; may be bounded by two low euseptoidum-like ridges bounding the adductor impressions.

*Remarks.* The species here ascribed to this genus differ one from another considerably in external proportions, from the highly convex globular form of *Kutchithyris brivesi*, through the pentagonal ventral profile of *K. acutiplicata* and *K. subsella* to the elongate form of *K. kennedyi*. They are linked, however, by close similarity in the internal characters, especially those of the hinge plates, inner socket ridges, and crural bases. Buckman erected the genus *Kutchithyris* mainly to accommodate six species from the Bathonian and Callovian of India previously established by Kitchin but he also included two European species of Deslongchamps and two newly established species of his own from the English Great Oolite (Bathonian) of Bradford-on-Avon, *K. fulva* and *K. egregia*.

I here refer to *Kutchithyris* the species *T. subsella* Leymerie, a familiar Upper Jurassic species in Europe, which has been previously referred to *Sellithyris* by Barczyk (1969). I exclude it from *Sellithyris* mainly because of the lack of differentiation between hinge plates and inner socket ridges, the detailed form of the hinge plates (as seen in transverse section they are like hockey sticks), and the form of the crural processes; these are features which it shares with other species of *Kutchithyris*. *K. subsella* survived into the Lower Cretaceous and occurs in the Upper Valanginian of La Querola



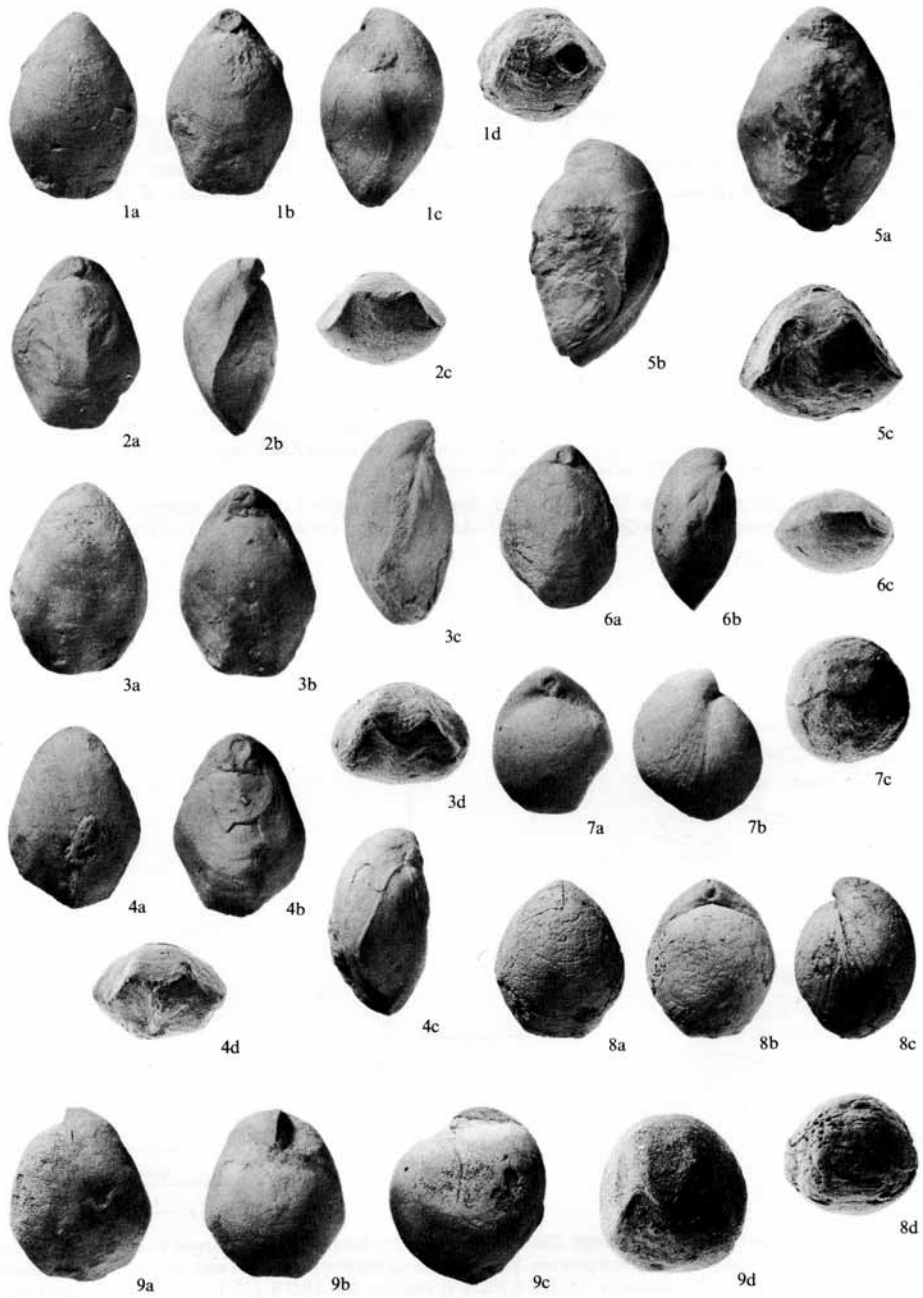
TEXT-FIG. 21. Transverse sections through *Kutchithyris subsella*. Sections 4.2 and 4.6 are enlarged to show detail of the primary hinge plates. The crural bases are first seen at 5.0. The crural processes are at their maximum height at 9.0. The transverse band was not preserved in this specimen. BM BB 76558, Coll. M. Durand Delga, Niveau 14A, Valanginian, La Querola, Spain. A—scale for sections 4.2 and 4.6. B—scale for the remaining sections.

#### EXPLANATION OF PLATE 58

Figs. 1-6. *Kutchithyris kennedyi* sp. nov. 1a-d, holotype, BM BB 76556, Y. Champetier Coll., Hauterivian or Barremian, Oliva, Valencia, Spain. 2a-c, plaster cast of specimen sectioned (see text-fig. 23), BM BB 76557, Y. Champetier Coll., Hauterivian or Barremian, Oliva, Valencia, Spain. 3a-d, BM BB 76559, Durand Delga Coll., Valanginian, La Querola, Alicante, Spain. 4a-c, typical specimen, BM BB 76562, W. J. Kennedy Coll., Lower Barremian, Les Moulins, Mont Chauve, Nice, France. 5a-c, large adult specimen, plaster cast of specimen sectioned (see text-fig. 24), BM BB 76561, Y. Rangheard Coll., ?Hauterivian, Punta Torreta, Ibiza. 6a-c, plaster cast of specimen sectioned (see text-fig. 22), S.552/1/1, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen.

Figs. 7-9. *Kutchithyris brivesi* (Roch). 7a-c, plaster cast of specimen sectioned (see text-fig. 26), S.549/2, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen. 8a-d, uniplicate specimen, S.549/3, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen. 9a-d, gerontic episulcate specimen, S.549/4, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen.

All natural size.



MIDDLEMISS, Cretaceous Terebratulidae

north of Alcoy, Alicante, Spain (Durand Delga Collection). The other Cretaceous species of the genus, which are described here, are new.

*Species included.* Bathonian: *T. hypsogonia* Kitchin, *T. acutiplicata* Kitchin, *T. propinqua* Kitchin, *T. circumdata* Deslongchamps, ?*K. fulva* Buckman, ?*K. egregia* Buckman. Callovian: *T. aurata* Kitchin, *T. jooraensis* Kitchin, ?*T. longicarinata* Kitchin, *T. subcanaliculata* Deslongchamps. Oxfordian to Valanginian: *T. subsella* Leymerie. Valanginian to Barremian: *K. kennedyi* nov., *K. brivesi* (Roch).

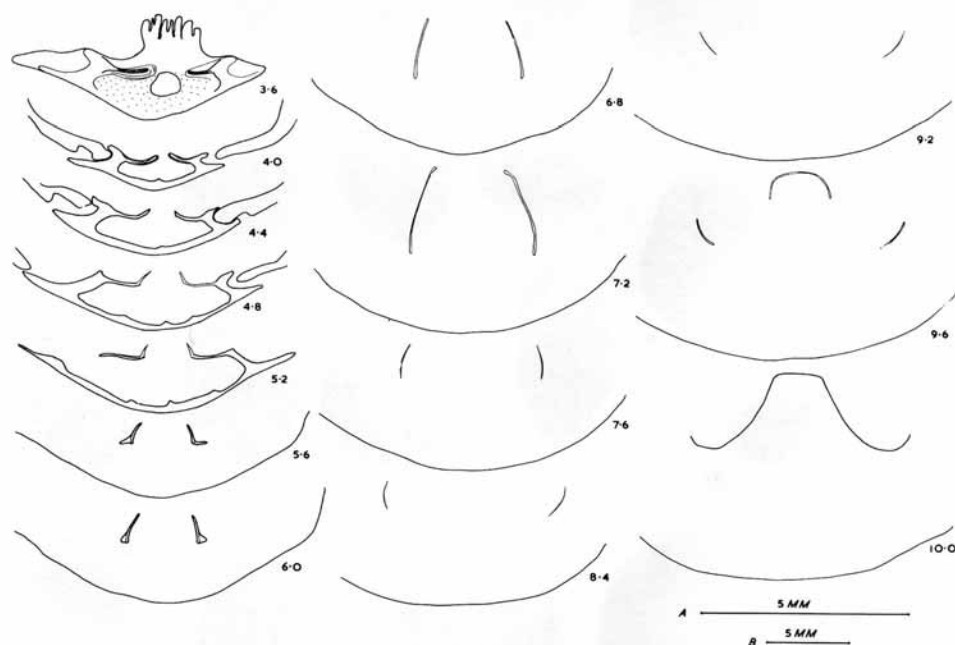
*Range of the genus.* Bathonian to Barremian.

*Kutchithyris kennedyi* sp. nov.

Plate 58, figs. 1-6; text-figs. 22-24

*Types.* Holotype, BM BB 76556, from Oliva, Valencia, Spain (Champetier Collection). The horizon is dubious but is probably Hauterivian or Barremian. Dimensions: L 30, W 20, T 18.5. Paratypes. BM BB 76557, Oliva, Valencia, Spain; BM BB 76559, Upper Valanginian, La Querola, Alicante, Spain; BM BB 76561, Punta Torreta, Ibiza; BM BB 76562 and 76563, Lower Barremian, Mont Chauve, Alpes Maritimes, France; Gentil Collection S.552/1/1, Hauterivian, Ifrech Oued Igouzoulen, Morocco.

*Material.* Three specimens from Oliva, Valencia, Spain (Champetier Collection, horizon uncertain). Five specimens from niveau 14A at La Querola, north of Alcoy, Alicante, Spain (Busnardo and Durand Delga 1960)



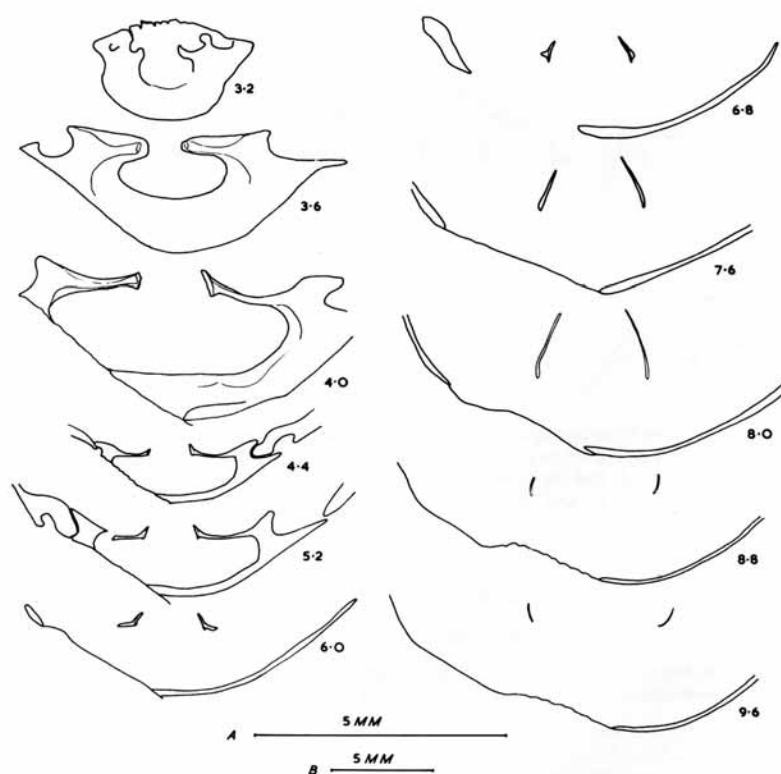
TEXT-FIG. 22. Transverse sections through *Kutchithyris kennedyi*. Section 3.6 is enlarged to show the juvenile primary hinge plates within the cardinal process. The crural bases are first seen at 4.4 and maximum development of the crural processes at 7.2. Sections 3.6-6.0 S.552/1/1; sections 6.8-10.0 S.552/1/2. Both specimens Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen. A—scale for section 3.6. B—scale for the remaining sections.

(Durand Delga Collection, probably Valanginian). Two specimens from the Lower Barremian of a stream section 800 m north of Les Moulins, east of Mont Chauve, north of Nice, Alpes Maritimes (Kennedy Collection). One specimen from Ecrú, Morocco (Whitaker Collection). One specimen from Punta Torreta, Ibiza (Rangheard Collection, probably Hauterivian). Four specimens in the Gentil Collection (three from the Hauterivian of Ifrech Oued Igouzoulen, one from the Barremian of Asif Ait Ameur).

*Name.* Named after Dr. W. J. Kennedy, who supplied some of the specimens.

*Diagnosis.* *Kutchithyris* of elongate oval ventral profile (width about 0.7 length); thickness more than half length. P/A ratio 1.3–1.6. Umbo suberect to erect in adults. Symphytium very short or invisible. Foramen mesothyrid, labiate. Beak ridges rounded. Anterior commissure sulcinate to episulcate. Folding of the shell, corresponding to the plicae and sinuses of the commissure, weak and confined to the anterior third of the shell except in gerontic stage.

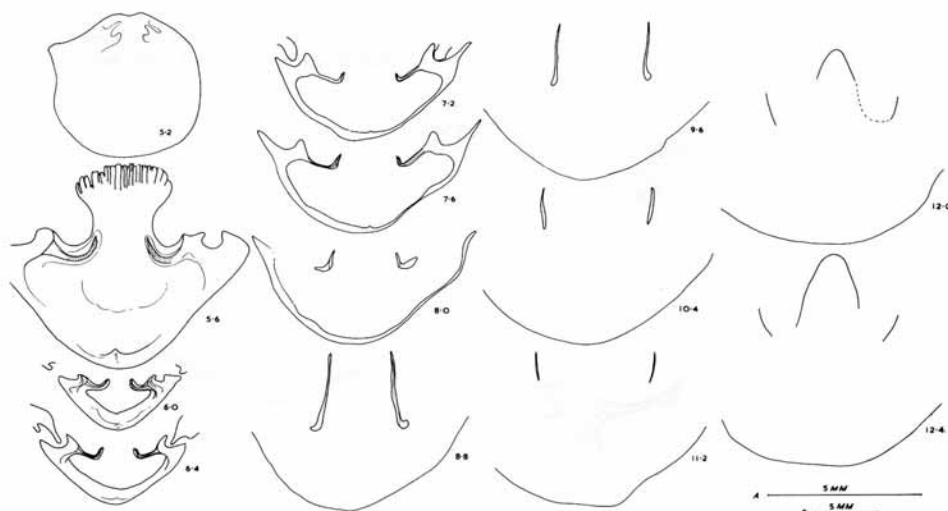
*Description.* Because of the few specimens available little can be said about the ontogeny of this species except that the width/length ratio appears to be isometric and to remain constant during growth at a little less than 0.7, whereas the thickness/length ratio is allometric.



TEXT-FIG. 23. Transverse sections through *Kutchithyris kennedyi*. Sections 3.2–4.0 are enlarged in order to show the juvenile hinge plates within the cardinal process (at 3.2) and the crural bases (at 3.6 and 4.0). Maximum height of the crural processes is seen at 8.0. The transverse band was not preserved in this specimen. BM BB 76557, Coll. Y. Champetier, Oliva, Spain. A—scale for sections 3.2–4.0. B—scale for the remaining sections.

*Remarks.* This species is easily distinguished from other members of *Kutchithyris* by its elongate form. The species with which it is most likely to be confused is *Loriolithyris valdensis*. *K. kennedyi* is thicker in relation to its length than *L. valdensis*, because the differential growth ratio of this character is slightly bigger, giving the allometric distribution a slightly steeper slope (fig. 8). In addition, the brachial valve of *K. kennedyi* is slightly concave in anterior third, that of *L. valdensis* uniformly convex in lateral view. Internally the characters of the hinge plates, inner socket ridges, and crural bases are all quite different in the two species.

*Distribution.* ?Valanginian of south-east Spain; Hauterivian and Barremian of south-west Morocco; ?Hauterivian of Ibiza; Lower Barremian of south-east France.



TEXT-FIG. 24. Transverse sections through a large, adult specimen of *Kutchithyris kennedyi*. Sections 5.2 and 5.6 are enlarged to show the juvenile hinge plates (at 5.2) and the primary hinge plates (stippled at 5.6). The crural bases are already visible at 5.6. BM BB 76561, Coll. Y. Rangheard, Punta Torreta, Ibiza. A—scale for sections 5.2 and 5.6. B—scale for the remaining sections.

*Kutchithyris brivesi* (Roch)

Plate 59, figs. 1, 2; text-figs. 25, 26

v\*1930 *Terebratula brivesi* Roch, p. 259, pl. 22, figs. 12–13.

v1951 *Terebratula brivesi* Roch; Gigout, p. 361, pl. 9, figs. 27–34.

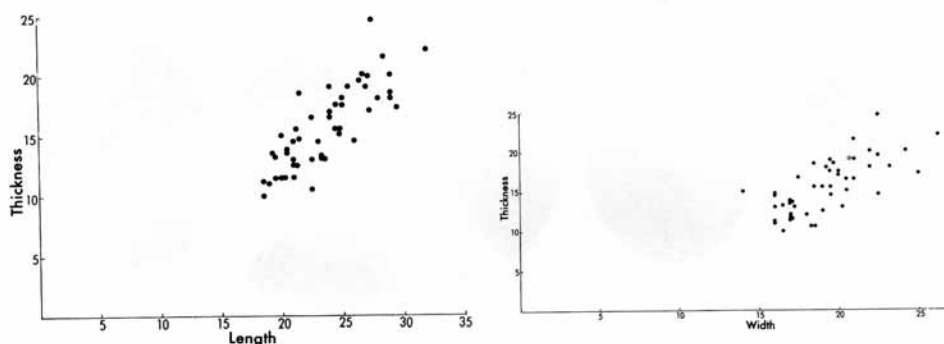
*Lectotype.* Roch figured two specimens but there is confusion in the numbering of the figures; figs. 12a and 13b represent one specimen, figs. 12b and 13a the other. The specimen represented by figs. 12a and 13b is here chosen as lectotype. It is in the collection of the Service de la Carte Géologique du Maroc at Rabat, bearing the number Ci 55, and is from the Valanginian of Zauouia Embarek des Ida ou Troumma. The label describes it as 'Coll. E. Roch' but Roch in his caption gives it as 'Brives Coll.'

*Paratypes.* The specimen figured by Roch as figs. 12b and 13a (at Rabat, bearing the same number as the lectotype and from the same horizon and locality). A specimen in the Roch Collection at Rabat bearing number P 62 and coming from the Berriasian of Dar Caid Tizirin. Six specimens in the Roch Collection at Rabat bearing the

number P 50 and coming from the Valanginian of Oued Igoulouzen. The following specimens in the Gentil Collection: S.549/1, S.549/2, S.549/3, S.549/4, S.549/5, S.559/1, all labelled Hauterivian, Ifrech-Oued-Igoulouzen. The two specimens figured by Gigout (both numbered 720 in the Gigout Collection, Université Mohamed V, Rabat).

**Material.** Nine specimens from the Roch Collection (detailed above). Forty-eight specimens from the Gentil Collection (forty-five labelled Hauterivian of Ifrech-Oued-Igoulouzen; three labelled Barremian, Chaîne d'Azour).

**Diagnosis.** *Kutchithyris* highly obese in lateral profile, oval in ventral profile. P/A ratio slightly more than 1. Brachial valve more convex than pedicle valve. Umbo erect to incurved. Symphytium very short to invisible. Foramen mesothyrid, labiate in older individuals. Beak ridges rounded. Lateral commissure arched. Anterior commissure rectimarginate to sulcinate or episulcate. Shell tumid and little folded, or not folded. Euseptoidum well developed in the region of the hinge plates and flanked by two lateral ridges.



TEXT-FIG. 25. Scatter diagrams of the relationships of thickness to length and thickness to width in *Kutchithyris brivesi* (Gentil Coll.).

**Description.** The growth of this species is accompanied by rapid increase in the thickness/length ratio. In the most adult individuals thickness can exceed width. The smallest specimens available (L 18.5) are either rectimarginate or gently uniplicate but the later development of the commissure is the most variable character of the species. Some specimens of 29 mm in length are clearly and deeply uniplicate, while other specimens of similar size are sulcinate or, rarely, episulcate. In other specimens again a clearly episulcate commissure is developed at a shell length of as little as 19.5 mm.

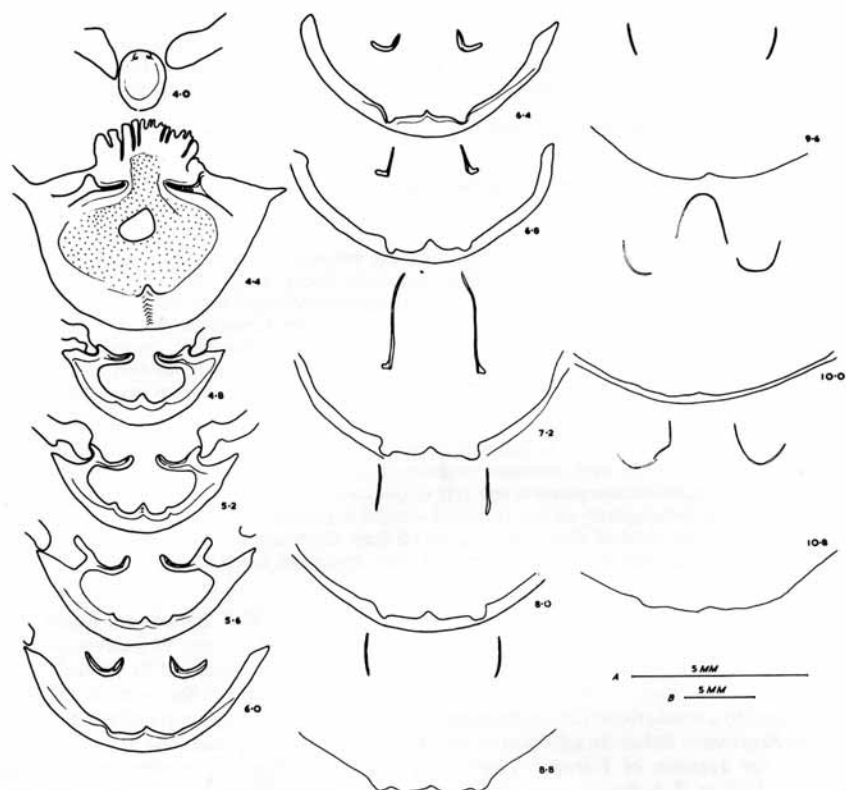
**Remarks.** This species is distinguishable at once from other species of *Kutchithyris* and from all the other species considered here by its globular form and the tumid appearance of both valves. Internally it differs from other species of *Kutchithyris* in having a well-developed, although short, euseptoidum. Both Roch and Gigout underestimate the plication which the anterior commissure may show in this species. Roch states: 'La commissure frontale est pratiquement droite, sauf deux petits plis à peine marqués.' According to Gigout: 'Commissure frontale droite ou très légèrement convexe vers la petite valve.' The larger specimens (L 25.5) in Roch's own collection, however, are strongly uniplicate. The form of the anterior commissure of the larger specimens in the Gentil Collection is very variable, suggesting that Roch and Gigout may have seen only small, relatively juvenile specimens such as the lectotype. Roch, Gigout, and Ambroggi all give the main occurrence of this species as of Valanginian age, Roch and Ambroggi recording some also from the Berriasian, whereas the great majority of the Gentil Collection specimens are labelled Hauterivian, with a few labelled Barremian. It is possible that strong sulcination or episulcation was developed in this species only after the Valanginian. The unity of the species is demonstrated by the remaining

PLATE 59



MIDDLEMISS, Cretaceous Terebratulidae





TEXT-FIG. 26. Transverse sections through *Kutchithyris brivesi*. Section 4.4 is enlarged to show detail of the structure of the cardinal process. The crural bases are first seen at 4.8. The crural processes are at their maximum height at 7.2. S.549/2, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen. A—scale for section 4.4. B—scale for the remaining sections.

## EXPLANATION OF PLATE 59

Figs. 1, 2. *Kutchithyris brivesi* (Roch). 1a-d, juvenile but incipiently biplicate specimen, S.549/5, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen. 2a-d, adult but uniplicate specimen, S.559/1, Gentil Coll., Hauterivian, Ifrech-Oued-Igouzoulen.

Figs. 3-7. *Juralina ecruens* sp. nov. 3a-d, holotype, BM BB 76547, Whitaker Coll. 4a-d, typical uniplicate form, BM BB 76548. 5a-d, plaster cast of specimen sectioned (see text-fig. 28), BM BB 76550. 6a-d, juvenile specimen, BM BB 76551. 7a-d, elongate adult form, BM BB 76553.

All natural size.

characters both external and internal. A specimen from Roch's collection (from the Valanginian of Oued Igouzoulen) was serially sectioned and differed slightly from the Gentil specimen shown in text-fig. 26 in having hinge plates less concave in their earlier stages, a less developed euseptoidium, and in lacking any clubbed thickening of the hinge plates and crural processes. These are signs of immaturity, confirming that the specimens described by Roch were comparatively juvenile.

*Distribution.* Berriasian to Barremian of south-west Morocco.

#### Genus JURALINA Kyansep, 1961

*Type species.* *Juralina procerus* Kyansep.

*Original diagnosis* (from Kyansep 1961). 'Shell plano-convex to biconvex. Anterior commissure rectimarginate to uniplicate. Umbo massive, straight to erect. Deltidium high. Socket ridges high. Cardinal process well developed and separated from the floor of the dorsal valve. Hinge plates divided, very narrow, in close proximity to the socket ridges. Crural bases given off ventrally from the hinge plates. Crura narrow, with well-developed, sharp-pointed crural processes. Loop about one-third of the length of the dorsal valve, triangular, with arched transverse band. Pedicle collar shaped like a ring valve. Hinge teeth massive, without denticulae. Adductor muscle impressions oval triangular, narrowing to fine lines posteriorly. Euseptoidium small. Shell smooth, punctate.'

*Emended diagnosis.* Shell plano-convex to biconvex, depressed (thickness/length ratio low), subcircular in ventral profile. Umbo straight to erect. Foramen mesothyrid, slightly labiate. Lateral commissure oblique to arched; anterior commissure rectimarginate to squarely uniplicate or slightly sulcinate. Cardinal process well developed. Hinge plates rectangularly virgate (that is, L-shaped in cross-section with an inner lamina at right angles to the outer lamina); clubbed. Crural bases given off from the anterior ventral extremities of the hinge plates. Crural processes high, sharp-pointed, incurved at their extremities. Loop broad; transverse band high-arched, arcuate to trapezoidal.

*Remarks.* Kyansep considered that his new genus strongly resembled *Lobothyris* Buckman but *Juralina* differed in having very narrow hinge plates, high socket ridges, and well-developed crural processes, in lacking a septum to its pedicle collar, and in the elliptical shape of its ventral umbonal cavity. Boullier (1976) has, however, pointed out several additional differences. Kyansep also correctly pointed to a marked external resemblance, but equally marked internal differences, between *Juralina* and *Rectithyris* Sahnii. In addition to his new species, Kyansep included in *Juralina* several species from the Jurassic of Europe: *Terebratula rauraca* Rollier, *T. repelliniana* D'Orbigny, *T. censoredensis* Rollier, *T. bullingdonensis* Rollier, *T. cotteai* Douvillé, and *T. moravica* Glocker. Of these, *T. moravica* was referred to a new genus *Weberithyris* by Smirnova (1969). In her discussion of the genus Boullier (1976) rejects affinities with *Lobothyris*, *Weberithyris*, *Trapeothyris* Smirnova, and *Postepithyris* Makridin but finds considerable resemblance to *Cyrtothyris* Middlemiss. Boullier added three more previously established species—*T. bauhini*, *T. valfinensis*, and *T. subformosa*.

Barczyk (1969) added the following species from Upper Jurassic rocks of the Holy Cross Mountains of Poland to *Juralina*: *T. insignis insignis* Schübler, 1830, *T. insignis maltonensis* Opperl, 1858, *T. immanis immanis* Zejszner, 1856, *T. immanis speciosa* Schlosser, 1882. Of these, Boullier (1976) has since referred *T. insignis* var. *maltonensis* Opperl to the genus *Galliennithyris* as *G. maltonensis*.

I introduced the terms inner and outer lamina in 1959 and defined them as follows: 'A virgate hinge plate is divisible into two parts, the outer lamina from the socket ridge to the virgation and the inner lamina on the inner (median) side of the virgation.' The accompanying figure (Middlemiss 1959, text-fig. 1j), however, showed cuneate hinge plates with large crural bases. Because of this confusion I later withdrew the terms inner lamina and outer lamina (Dieni *et al.* 1975; Middlemiss 1976). Now that more is known about the detailed structure of terebratulid hinge plates (Cox and Middlemiss 1978) the terms are seen to be useful in their original sense and I use them here.

*Species included.* *J. procerus* Kyansep, *?Terebratula rauraca* Rollier, *?T. repelliniana* d'Orbigny, *J. graciosa* Kyansep, *?T. censoredensis* Rollier, *T. bullingdonensis* Rollier, *J. naklivkini* Kyansep,

*T. cotteaudi* Douvillé, *J. babugani* Kyansep, *J. carus* Kyansep, *T. bauhini* Etallon, *T. valfinensis* de Loriol, *T. subformosa* Rollier, *J. ecruensensis* nov.

*Range of the genus.* Middle Oxfordian to Barremian.

*Juralina ecruensensis* sp. nov.

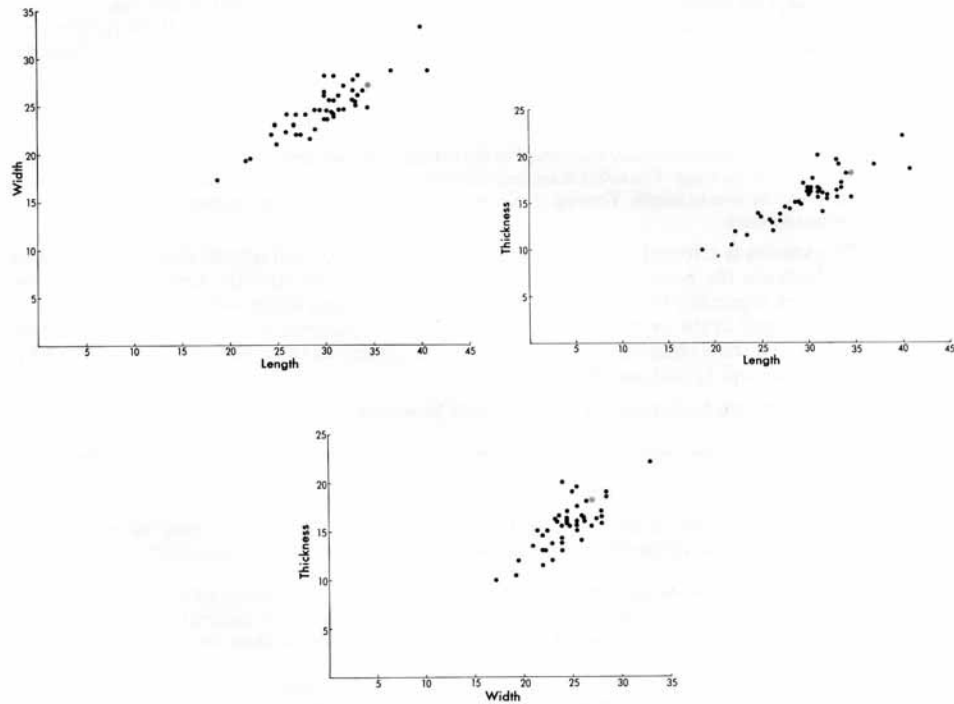
Plate 59, figs. 3–7; text-figs. 27, 28

*Types.* Holotype, BM BB 76547, Whitaker Collection. Dimensions: L 34.5, W 27, T 18. Paratypes: Whitaker Collection specimens BM B 17273, B 17277, BB 76548, BB 76550, BB 76551, BB 76553.

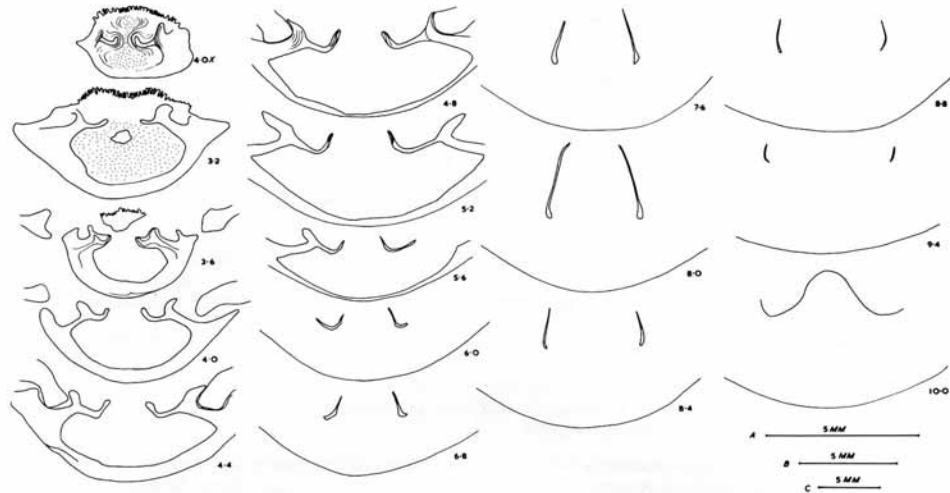
*Material.* Forty-six specimens in the Whitaker Collection. Forty-two specimens in the Gentil Collection (twenty-five from the Berriasian or Valanginian of Tinirt Ait Ameur, two from the Hauterivian of an unnamed locality, three from the Barremian of Igueni Ouram, twelve from the probable Barremian of Oued Aghbalou).

*Diagnosis.* *Juralina* of subcircular to oval ventral profile; maximum width about the mid-line; valves equally convex. Umbo erect. Foramen mesothyrid, marginate, becoming labiate. Beak ridges rounded. Symphytium short, hidden in adult stage. Shell smooth, with faint growth lines. Lateral commissure oblique to arched. Anterior commissure rectimarginate to squarely uniplicate or slightly sulcinate. Euseptoidium absent or negligible. Transverse band high-arched, rounded.

*Description.* Juvenile specimens resemble the adults except in being rectimarginate. At a length of about 22 mm the characteristic adult uniplicate commissure begins to develop. In adults over about 30 mm in length the



TEXT-FIG. 27. Scatter diagrams of the relationships of simple dimensions in *Juralina ecruensensis* (Whitaker Coll.).



TEXT-FIG. 28. Transverse sections through *Juralina ecruensis*. The first two sections (upper left) are enlarged in order to show detail of the structure of the cardinal process. Sections 3.6-5.2 are enlarged to show the form of the hinge plates and of the crural bases. Maximum height of the crural processes is seen at 8.0. BM BB 76550 except that 4.0x is from BM B 17273 and 3.2 from BM B 17277 as these showed better the details of the cardinal process (Whitaker Coll.). A—scale for sections 3.2 and 4.0x. B—scale for sections 3.6-5.2. C—scale for the remaining sections.

uniplica may be angular, the commissure horizontal in the centre; or it may develop a gentle sinus in the centre, giving a slightly sulcinate stage. The other main gerontic development is that the foramen becomes labiate in specimens over about 30 mm in length. Text-fig. 27 shows that there are a few long, narrow variants and others that are exceptionally thick.

*Remarks.* This species is referred to *Juralina* because of (a) its external appearance, the distinctive elements of which are the biconvex but moderately depressed form and the erect umbo; (b) the internal characters, especially the L-shaped form of the hinge plates in transverse section, with the crural bases developed in the extreme ventral tips of the inner laminae in the anterior parts of the hinge plates only. All these characters appear closely comparable to those described and figured by Kyansep (1961), Barczyk (1969), and Boullier (1976).

*Distribution.* Valanginian to Barremian of south-west Morocco.

#### EXPLANATION OF PLATE 60

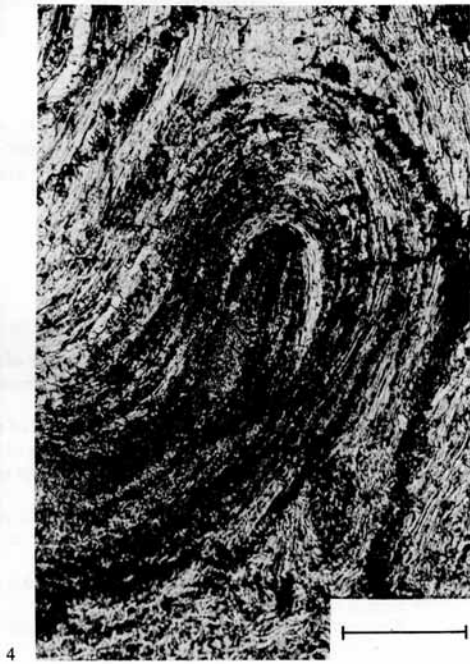
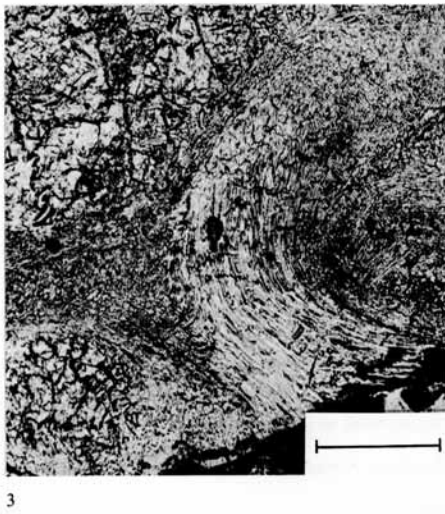
Fig. 1. *Loriolithyris melaitensis* sp. nov. Section 4.8 of text-fig. 12 photographed to show the shape of the juvenile hinge plates and the distinction between punctate and inpunctate skeletal tissue within the cardinal process.

Fig. 2. *Loriolithyris marocensis* sp. nov. Part of section 6.0 of text-fig. 13 photographed to show the primary piped hinge plate with its secondary clubbed thickening and the structure of the cardinal process.

Fig. 3. *Boubeithyris pleta* sp. nov. Part of section 4.0 of text-fig. 15 enlarged to show the detailed structure of the junction between hinge plate and inner socket ridge.

Fig. 4. *Kutchithyris acutiplicata* (Kitchin). Part of section 6.0 of text-fig. 19 enlarged to show the primary hinge plate with its clubbed thickening and the incipient crural base, all enclosed within the cardinal process.

Linear scale = 2 mm.



MIDDLEMISS, Cretaceous Terebratulidae

TEREBRATULID SPECIES OF MORE DOUBTFUL OCCURRENCE IN THE  
LOWER CRETACEOUS OF SOUTH-WEST MOROCCO

*Terebratula sueuri* Pictet is recorded by Gigout from the Valanginian and Hauterivian at Safi and by both Roch and Ambroggi from the Barremian. *T. sueuri* is a Jura species which is also found rarely in the Hauterivian of the Lower Saxon Basin. Three specimens in the Gentil Collection, S.544/1 (from Safi), S.547/2/1, and S.547/2/2 (both from the Barremian of Ait el Faci) have a close external resemblance to this species and probably represent the form to which the name was applied by previous authors. Serial sectioning proved these to be an undescribed species of terebratellid, which also occurs in the Jura region (Collections of the Institut de Géologie, Neuchâtel). Gigout's figured specimen (Gigout 1951, pl. 9, figs. 19-22) has a well-developed dorsal median septum and is almost certainly the same terebratellid species. The occurrence of these two externally similar but quite unrelated species together in the Jura region is a good example of homochronous homoeomorphy.

*Terebratula collinaria* d'Orbigny is recorded by both Roch and Ambroggi from the Hauterivian and Barremian and by Roch from the Valanginian also. The records probably refer to *Paraboubeithyris plicae*, although the Gentil Collection contains specimens of this species only from the Barremian.

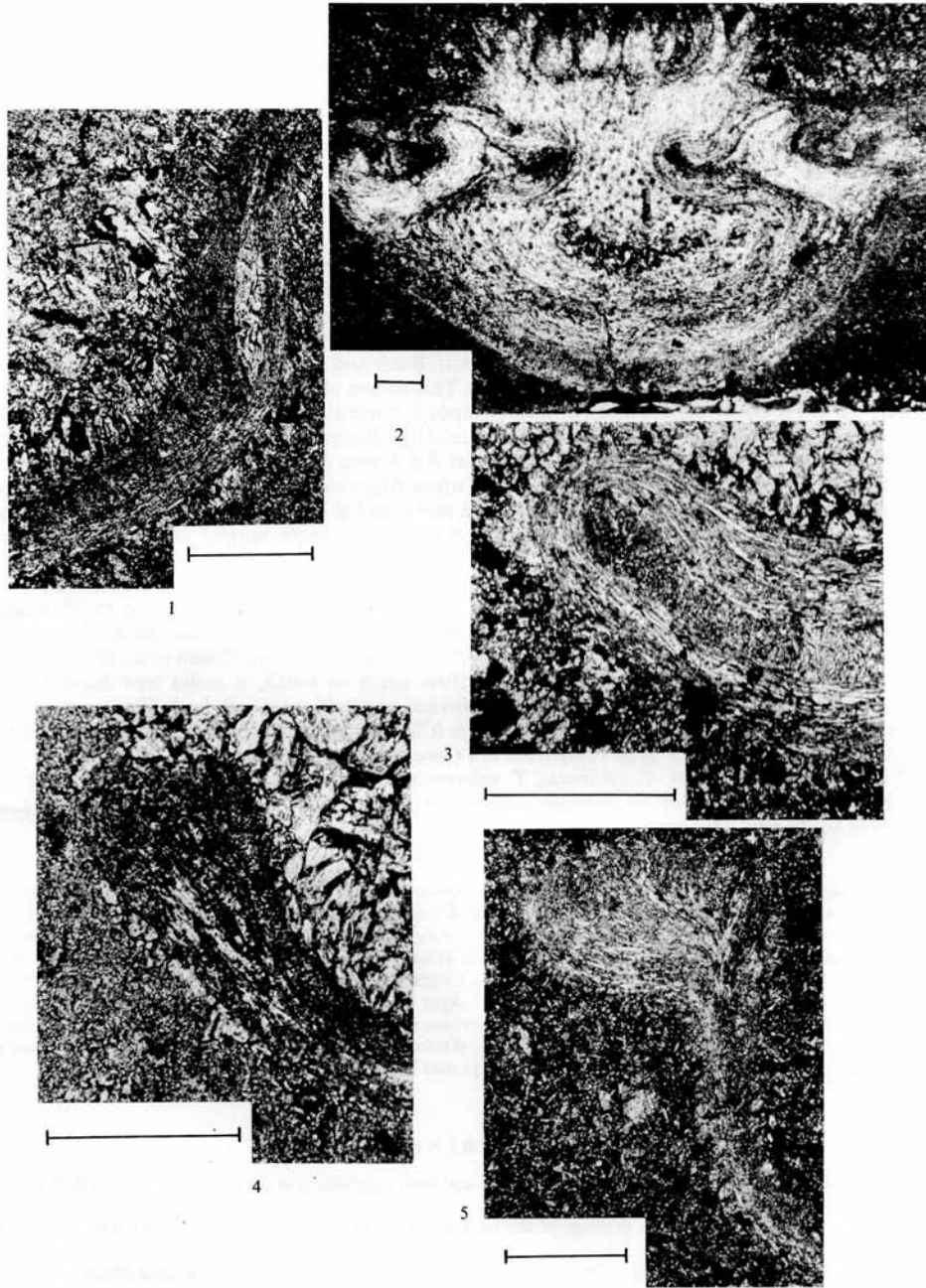
*Tropeothyris salevensis* (de Loriol). This is recorded by Gigout from the Valanginian of the environs of Safi and by Ambroggi from the Barremian of his area. On first viewing the collections I referred to *T. salevensis* the specimens which I have here named *Loriolithyris melaitensis*; Gigout's figured specimen (Gigout 1951, pl. 9, figs. 15-18) is apparently similar to these externally except that it is a gerontic specimen. The records probably refer to *L. melaitensis*.

*Moutonithyris moutoniana* (d'Orbigny) is recorded by Roch from the Barremian and by Gigout from the 'Neocomian' and Aptian of Safi and Sidi Bou Zid. Although Gigout gives in synonymy Pictet's (1872) figure of the species, not d'Orbigny's original, his own figured specimen looks reasonably convincing (Gigout 1951, pl. 9, figs. 23-26). In the Gentil Collection are four specimens from the Hauterivian of Oued Tidzi, one from the Hauterivian of Ifrech Oued Igoulouzen, four from the Barremian of Ait el Faci, and seven from the Barremian of Asif Ait Ameur which are probably this species. *M. moutoniana* is a sub-Tethyan species of very widespread occurrence throughout the Lower Cretaceous (see Middlemiss 1976, 1979) and it would indeed be surprising if some specimens were not to be found in south-west Morocco.

EXPLANATION OF PLATE 61

- Fig. 1. *Loriolithyris melaitensis* sp. nov. Section 6.8 of specimen S.556/1 (not included in text-fig. 12) enlarged to show the development of the crural base with secondary clubbing. The primary hinge plate has a cuneate relationship to the crural base.
- Fig. 2. *Loriolithyris melaitensis* sp. nov. Section 4.8 of text-fig. 12 photographed to show the internal structure of the cardinal process, especially the distribution of punctate and impunctate skeletal tissue. The juvenile primary hinge plates have a secondary clubbed thickening which was deposited prior to the incorporation of the hinge plates into the cardinal process.
- Fig. 3. *Loriolithyris melaitensis* sp. nov. Section 5.2 of text-fig. 12 enlarged to show the primary hinge plate surrounded by secondary tissue and the first sign of development of the crural base within the piped inner margin of the hinge plate.
- Fig. 4. *Loriolithyris russillensis* (de Loriol). Section 4.6 of text-fig. 7 enlarged to show the structure of the piped inner margin of the hinge plate.
- Fig. 5. *Paraboubeithyris plicae* gen. et sp. nov. Part of section 4.8 of text-fig. 16 enlarged to show the structure of the corniced inner margin of the hinge plate.

Linear scale = 2 mm.



MIDDLEMISS, Cretaceous Terebratulidae

*Sellithyris carteroniana* (d'Orbigny) is recorded by Roch from the Berriasian and the Barremian, by Gigout from the Valanginian (of Safi) and by Ambroggi from the Hauterivian. In the Gentil Collection there is one specimen from Tinirt Ait Ameer (probably Hauterivian) which has some resemblance to *S. carteroniana* in being obese, equidimensional, and strongly episulcate but the resemblance is closer, in fact, to the Algerian variety or subspecies of *S. sella* (see below). The same can be said of Gigout's figured specimen (Gigout 1951, pl. 9, figs. 11-14). *S. carteroniana* is an interesting species from the palaeobiogeographical point of view as (a) it is a characteristic member of the Jura fauna which is also found in north Germany during the time of the Valanginian-Hauterivian transgression (Middlemiss 1976, 1979) and (b) *Terebratula coahuilensis* of the Neocomian of northern Mexico is probably synonymous with it. In view of my thesis of the Jura affinities of the south-west Moroccan fauna the occurrence of this species would be significant. Unfortunately there is no evidence that all the records do not refer to *S. sella*, although some may refer to *Boubeithyris pleta*.

*Sellithyris sella* (J. de C. Sow) is recorded by both Roch and Ambroggi from the Barremian and Gargasian and by Roch from the Bedoulian also. This almost ubiquitous Lower Cretaceous species would be expected to occur in south-west Morocco, especially as an undescribed form of it is certainly known from the Lower Cretaceous of the High Plateaux region of Algeria. In the Gentil Collection are twenty-three specimens from Tinirt Ait Ameer (labelled Berrisian-Valanginian but more likely Hauterivian) which appear to be this obese Algerian variety of the species. There is also one specimen from the Hauterivian of Oued Tidzi, one from the Barremian of Ida ou Troumma, and two from the Barremian of Tibourr'm; these resemble the more normal somewhat depressed Neocomian form of the species.

*Moutonithyris dutempleana* (d'Orbigny). This almost ubiquitous Albian species is recorded by both Roch and Ambroggi from both the Clansayesian and the Albian. Its occurrence in the Albian would not be surprising. Doubts are raised, however, by two circumstances: (a) *M. dutempleana* is very rare in the Clansayesian and known certainly from that stage only in Sardinia (Dieni *et al.* 1975). On the other hand if, as is likely, the species spread from south to north, it could well occur in the Clansayesian of Morocco. (b) *Cyrtothyris middlemissi* certainly occurs in both Clansayesian and Albian and is easily mistaken for *M. dutempleana* (Calzada 1972, p. 66). The specimen figured by Gigout (1951, pl. 13, figs. 5-8) as *T. biphacata* is a *Concinnithyris cf. obesa*.

To summarize: *T. sueuri*, *T. collinaria*, *T. salevensis*, *T. carteroniana*, and *M. dutempleana* have probably been misidentified by previous authors. *M. moutoniana* and *S. sella* probably do occur rarely in south-west Morocco.

*Acknowledgements.* I particularly thank Mr. E. F. Owen (British Museum, Natural History), Monsieur D. Pajaud and his staff at the Université Pierre et Marie Curie, and Monsieur J-P. Thieuloy (Grenoble). I thank Mademoiselle S. Willefert (Service de la Carte Géologique du Maroc, Rabat) for her help in locating and sending to me specimens from the Roch Collection; also the Head of the Laboratoire de Géologie-Paléontologie, Université Mohamed V, Rabat, and Monsieur G. Cogné for lending me specimens figured by Gigout. Additional specimens were lent by: Professor D. V. Ager (Swansea), Señor S. Calzada Badia (Barcelona), Monsieur Y. Champetier (Nancy), Monsieur A. Charrière (Paris), Monsieur M. Debuyser (Paris), Professor M. Durand Delga (Toulouse), Dr. W. J. Kennedy (Oxford), Monsieur E. Lanterno (Geneva), Monsieur Y. Rangheard (Besançon), Dr. J. Remane (Neuchâtel), and Monsieur Weidmann (Lausanne).

#### REFERENCES

- AGER, D. V. 1974. The western High Atlas of Morocco and their significance in the history of the North Atlantic. *Proc. geol. Ass., Lond.* **85**, 23-41, London.  
 — and EVAMY, B. D. 1964. The geology of the southern French Jura. *Ibid.* **74** (for 1963), 325-355, pl. 9, London.  
 AMBROGGI, R. 1963. Étude géologique du versant méridional du Haut Atlas occidental et de la Plaine du Souss. *Notes et Mém. Serv. géol. Maroc*, **157**, 321 pp., 181 figs., Rabat.



- ARKELL, W. J. 1956. *Jurassic Geology of the World*, Edinburgh.
- BARCZYK, W. 1969. Upper Jurassic terebratulids from the Mesozoic border of the Holy Cross Mountains in Poland. *Pr. Muz. Ziemi*, **14**, 1-82, pls. 1-18, Warsaw.
- BOGDANOVA, T. N. and LOBACHEVA, S. V. 1966. Neocomian Fauna of the Kopet-Daga. *Min. Geol. U.S.S.R., Inst. Econ. Sci. Leningrad*, n.s. **130**, 1-140, pls. 1-13, Leningrad. [In Russian.]
- BONNEAU, M., BEAUVAIS, L. and MIDDLEMISS, F. A. 1975. L'unité de Miamou (Crète-Grèce) et sa macrofaune d'âge Jurassique supérieur (Brachiopodes, Madréporaires). *Ann. Soc. géol. Nord*, **94** (for 1974), 71-85, pls. 10-11, Lille.
- BOULLIER, A. 1976. *Les terebratulides de l'Oxfordien du Jura et de la bordure sud du Bassin de Paris*. Thesis, Besançon.
- BUCKMAN, S. S. 1918. The Brachiopods of the Namyau Beds, northern Shan States, Burma. *Pal. Indica*, n.s. **3** (for 1917), Mem. no. 2, 1-254, pls. 1-21, Calcutta.
- BUSNARDO, R. and DURAND-DELGA, M. 1960. Données nouvelles sur le Jurassique et le Crétacé inférieur dans l'est des Cordillères Bétiques (Regions d'Alcoy et d'Alicante). *Bull. Soc. géol. Fr.* (7), **2**, 278-287, Paris.
- CALZADA, S. 1972. *Cyrtothyris middlemissi*, n. sp. del Aptiense de Garraf (Barcelona). *Acta geol. Hisp.* **7**, 66-68, 2 figs., Barcelona.
- CHOUBERT, G., FAURE-MURET, A. and HOTTINGER, L. 1967. Aperçu géologique du bassin cotier de Tarfaya. *Notes Mém. Serv. géol. Maroc*, **175** (1), 7-106, Rabat.
- COX, MARGARET M. and MIDDLEMISS, F. A. 1978. Terebratulacea from the Cretaceous Shenley Limestone. *Palaeontology*, **21**, 411-441, pls. 40-42, figs. 1-13, London.
- D'ARCHIAC, A. 1847. Rapport sur les fossiles du Tourtia. *Mém. Soc. géol. Fr.*, (2) **2**, 291-351, pls. 13-25, Paris.
- DIENI, I., MIDDLEMISS, F. A. and OWEN, E. F. 1975. The Lower Cretaceous Brachiopods of east-central Sardinia. *Bol. Soc. Pal. Ital.* **12** (for 1973), 166-216, pls. 32-38, Modena.
- GEYSSANT, JEANNINE. 1966. *Glossothyris* et *Pygope* (Terebratulidae)—essai de répartition de ces espèces dans la domaine méditerranéen. *Notes Serv. géol. Maroc*, **26**, 75-98, pls. 1-3, figs. 1-7, 8 tables, Rabat.
- GIGNOUX, M. 1955. *Stratigraphic Geology* (English edn.), San Francisco.
- GIGOUT, M. 1951. Études géologiques sur la Meseta marocaine occidentale (arrière-pays de Casablanca, Mazagan et Safi). *Notes Mém. Serv. géol. Maroc*, **86**, 1-507, pls. 1-18, Rabat.
- IMLAY, R. W. 1937. Lower Neocomian fossils from the Miquihuana region, Mexico. *J. Palaeont.* **11**, 552-574, pls. 70-83, Menasha.
- 1940. Neocomian faunas of northern Mexico. *Bull. G. S. Amer.* **51**, 117-190, pls. 1-21, New York.
- KYANSEP, N. P. 1961. Terebratulids of the Lusitanian Beds of the Lower Kimmeridgian of the south-west Crimea. *Akad. Nauk. U.S.S.R.* **8**, 1-101, 8 pls., Moscow. [In Russian.]
- LORIOU, P. DE. 1866. *Description de fossiles de l'oolite corallienne, de l'étage valangien et de l'étage urgonien du Mont Salève*, Geneva.
- 1867. In FAVRE, A. *Recherches géologiques dans la Savoie*, Paris and Geneva.
- 1868. Monographie des couches de l'étage valangien des Carrières d'Arzier (Vaud). *Matér. pour Paléont. suisse*, ser. 4, Geneva.
- and GILLIÉRON, V. 1869. Monographie paléontologique et stratigraphique de l'étage urgonien inférieur du Landeron (Neuchâtel). *Mem. Soc. helv. Sc. nat.* **23** (5), 1-123, pls. 1-18, Zürich.
- MIDDLEMISS, F. A. 1959. English Aptian Terebratulidae. *Palaeontology*, **2**, 94-142, pls. 15-18, London.
- 1968a. Brachiopodes du Crétacé inférieur des Corbières orientales (Aude). *Ann. Paléont. (Invert.)*, **54**, 173-197, pls. A-C, Paris.
- 1968b. Observations on the ontogeny of the brachiopod *Sellithyris sella*. *Bull. Ind. geol. Ass.* **1**, 1-17, pl. 1, Chandigarh.
- 1973. The geographical distribution of Lower Cretaceous Terebratulacea in western Europe. In CASEY, R. and RAWSON, P. F. (eds.). *The boreal Lower Cretaceous: Geol. J. Spec. Issue* no. 5, 110-129, Liverpool.
- 1976. Lower Cretaceous Terebratulidina of northern England and Germany and their geological background. *Geol. Jb.* **A30**, 21-104, pls. 1-11, Hanover.
- 1979. Boreal and Tethyan brachiopods in the European early and middle Cretaceous. *Kreide Europas* IUGS ser. A.
- MUIR-WOOD, H. M. 1965. In MOORE, R. C. (ed.). *Treatise on Invertebrate Paleontology*, pt. H, New York.
- PICQUET, F.-J. and LORIOU, P. DE. 1872. Description des fossiles du terrain crétacé des environs de Sainte-Croix, pt. 5. *Matér. pour la Paléont. suisse* (6), Geneva.
- ROCH, E. 1930. Études géologiques dans la région méridionale du Maroc occidentale. *Notes et Mém. Serv. Mines Maroc*, **9**, 1-542, pls. 1-26, Macon.

- SMIRNOVA, T. N. 1960. Brachiopoda. In DRUSHCHITZ, V. V. and KUDRIAVCHEVA, M. P. *Atlas of the Lower Cretaceous Fauna of the northern Caucasus and Crimea*. Trudy, VNII Gaz., 370-387, 6 pls., Moscow. [In Russian.]
- 1969. A new terebratulid genus from the Tithonian-Valanginian. *Pal. Zh.*, 3, 144-146, Moscow. [In Russian.]
- 1972. Brachiopods from the Crimea and northern Caucasus. *Akad. Nauk. U.S.S.R.* 140 pp., 13 pls., Moscow. [In Russian.]

Typescript received 5 March 1979

Revised typescript received 15 November 1979

F. A. MIDDLEMISS  
Department of Geology  
Queen Mary College  
Mile End Road  
London