OSTRACODS FROM THE DOMERIAN AND TOARCIAN OF ENGLAND

by ALAN LORD

ABSTRACT. Marine ostracods from the Middle and Upper Lias are described and their lateral and vertical distribution along the strike from the Dorset to Yorkshire coasts analysed. The composition of the assemblages and the affinities and occurrence of the species are examined, and two new species are described. Ostracod diversity apparently decreased throughout the Margaritatus Zone and few ostracods have yet been found in the Spinatum Zone. However, the Toarcian transgression brought in a new ostracod fauna of Middle Jurassic aspect.

THE Lower Jurassic, particularly in the British Isles, is one of the most neglected periods of Mesozoic and Cenozoic time in the field of stratigraphical palaeontology of the Ostracoda. In this country only eight publications have dealt with Liassic ostracods. That pioneer student of fossil ostracods, T. R. Jones, described Lias species from Yorkshire (1872) and south-west England (1894), and further Yorkshire material was described by Blake (1876). In the past decade, Anderson (1964) has described Rhaetic and Lower Jurassic species particularly from the Bristol and south Wales region and has revised Jones's (1894) work, and Field (1966) has described Hettangian Cytherellidae from the Dorset coast. The present writer has attempted to complete the revision of the older work by re-examining the Yorkshire sections from which Jones (1872) and Blake (1876) obtained their material (Lord 1971*a*), and has begun an analysis of Domerian and Toarcian faunas (Lord 1971*b*, 1972*a*). Also relevant to Lias ostracods are the large number of Triassic faunas described from Europe, the Soviet Union, and elsewhere in the last ten years (see review by Sohn 1968), and numerous publications concerning the Middle Jurassic of which those by R. H. Bate are of particular interest in the British context.

This paper describes the lateral and vertical distribution of Domerian and Toarcian (essentially Middle and Upper Lias of British geologists) ostracods along the strike of the Lower Jurassic outcrop from the Dorset to Yorkshire coasts. The first part is an account of the sampled sections and the distribution of ostracods in them, the second discusses certain species and their affinities, while the final part reviews the material generally within the framework of the north-west European epicontinental seas. The picture obtained is necessarily incomplete because of lack of exposures, natural faunal poverty, and barren samples, particularly in the Midlands. The sample pattern is also far from ideal since what is an areal problem was examined in a linear fashion. Nevertheless, lateral control along the line of strike is good although the answer to many questions probably lies to the east, where any data from subsurface or from submarine outcrops are of especial value. Also important is the work of Curry *et al.* (1970) in the English Channel and Dingle (1971) in the North Sea. To the west of the main outcrop, the Institute of Geological Sciences borehole at Mochras, north Wales contains a remarkable thickness of Lower Jurassic sediments (Wood and Woodland 1968) from which the ostracod faunas will prove of great value.

[Palaeontology, Vol. 17, Part 3, 1974, pp. 599–622, pl. 90.]

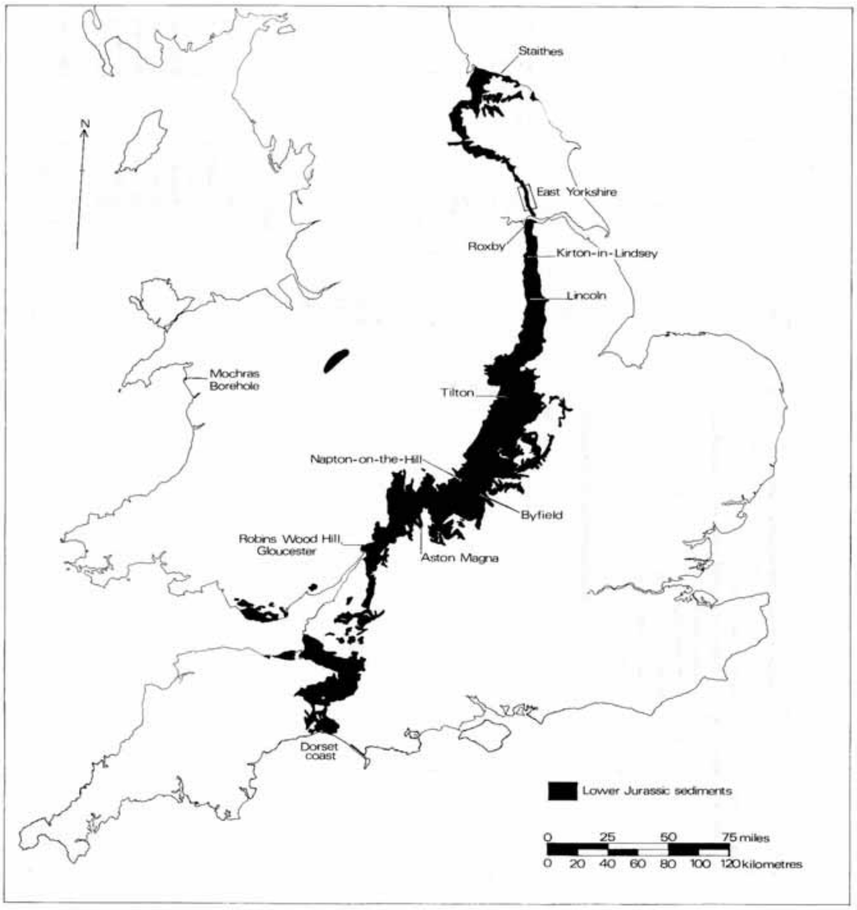
OSTRACOD FAUNAS OF THE SAMPLED SECTIONS

The samples were located as accurately as possible both stratigraphically and regionally, for without this precision any study of the evolution of the faunas or variation within taxa is without value. It is fortunate, therefore, that the Lower Jurassic possesses one of the more sophisticated zonal schemes and there are few sections which cannot be readily zoned with reasonable accuracy. The zonal system of Dean, Donovan and Howarth (1961, emended Howarth, 1964) for the north-west European ammonite province was employed since the present work was regional in concept. 'Domerian' was used because it was a useful division, despite the recommendation of Arkell (1956, p. 8) that the term should be abandoned. The Domerian represents the life span of the amaltheid ammonites (the zones of *Amaltheus margaritatus* and *Pleuroceras spinatum*) and corresponds with Ober Pliensbachian or Lias delta of Hoffmann (1962) and Domérien of Mouterde (1953); it almost corresponds to the English usage of 'Middle Lias'. The outcrop distribution of the Lower Jurassic in England is shown in text-fig. 1, together with the location of the sampled sections.

Dorset. In Dorset, beds of Domerian and Toarcian age are well exposed along the coast near Bridport. The Domerian has been described in some detail by Howarth (1957) and both Domerian and Toarcian by Wilson *et al.* (1958).

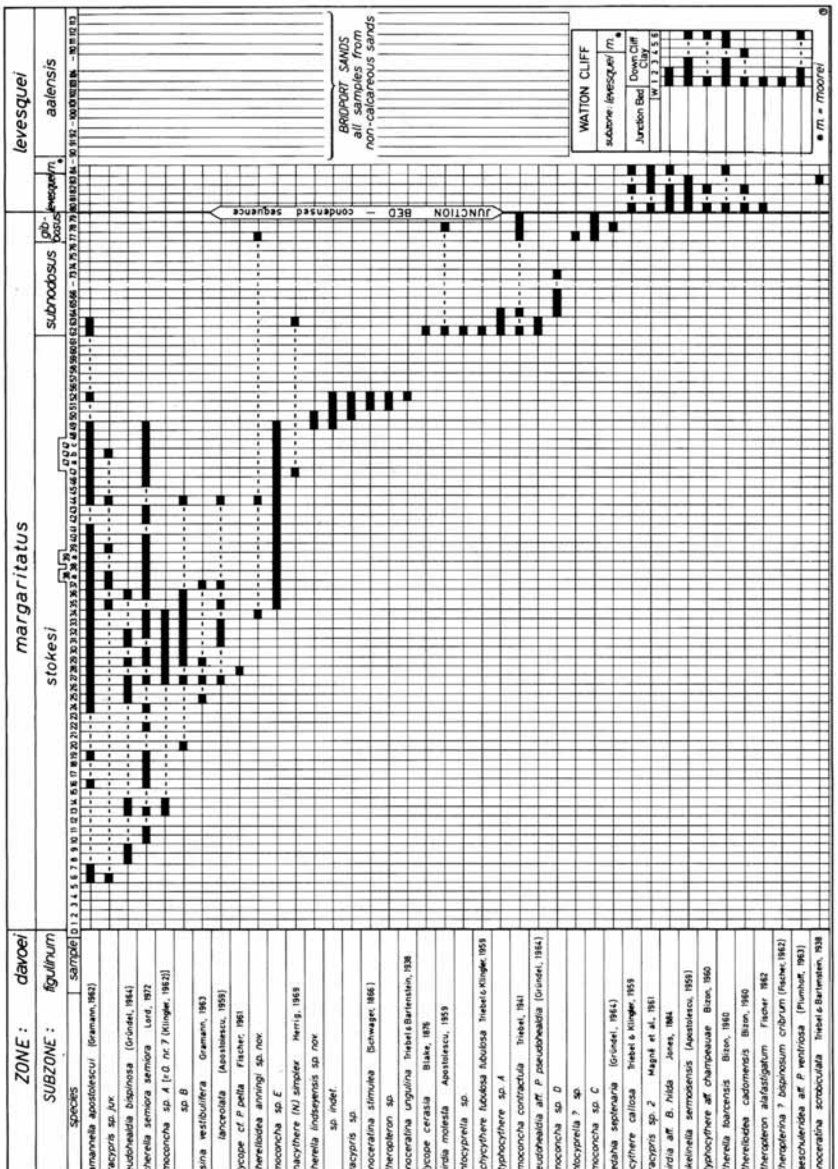
The Domerian and Toarcian beds of the Dorset coast do not always lend themselves to micropalaeontological investigation. Six zones and one subzone, i.e. the upper zone of the Domerian and most of the Toarcian zones, are condensed and represented by a thin bed, up to 7 feet (2 m) thick, of limestones called the Junction Bed. This thin bed is represented by over 450 feet (137 m) of sediment in Yorkshire. Jackson's (1926) small pocket of clay (Tenuicostatum Zone) on the western side of Thorncombe Beacon preserved in a hollow in the Marlstone Rock Bed (the lower, Domerian part of the Junction Bed) could not be located. Not only is a substantial portion of the succession represented by a condensed series of hard limestones, but the top part of the Toarcian consists of the Bridport Sands, sands and sandstones in vertical cliffs both difficult to sample and barren. However, ostracods occurred throughout the lower zone of the Domerian (Margaritatus Zone) which reaches its maximum thickness at outcrop in this country of almost 410 feet (125 m) on the Dorset coast. Ostracods were also obtained from the middle unit of the Toarcian sequence, the Down Cliff Clay. The Domerian part of the Junction Bed, called the Marlstone Rock Bed after that development of the Spinatum Zone in the Midlands, has a non-sequence at the base which can be responsible for the loss of up to half the Apyrenum Subzone (Howarth 1957, p. 192). A non-sequence at the same horizon is known elsewhere and is referred to below.

The Dorset coast succession yielded the most species and individuals found in this investigation and their distributions are shown in text-fig. 2. *Ogmoconcha* dominated the Domerian faunas numerically but *Wicherella semiora semiora* Lord, 1972 occurred commonly in the Stokesi Subzone and *Gramannella apostolescui* Gramann, 1962 was common in both Stokesi and Subnodosus Subzones. The species *Ogmoconcha* sp. E was a consistent faunal element in the upper part of the Stokesi Subzone, i.e. top Eype Clay and lower half of Down Cliff Sands. The latter, however, is very



TEXT-FIG. 1. Lower Jurassic outcrop showing sampled sites.

argillaceous and the disappearance of this species may be facies controlled. Except for *Ogmoconcha contractula* Triebel, 1941 and *Bairdia molesta* Apostolescu, 1959, which occur in both the Subnodosus and Gibbosus Subzones, no less than seven species were restricted to the Subnodosus Subzone. These species have little zonal value; for example *Polycope cerasia* Blake, 1876 ranges from Hettangian to Domerian, and *Trachycythere tubulosa tubulosa* Triebel and Klingler, 1959 is known from many parts of the Pliensbachian. Similarly, three of the six species found in the Gibbosus Subzone were restricted to it on the Dorset coast with *Ogmoconcha* sp. C by far the dominant element; this species closely resembles ostracods from the Gibbosus and



TEXT-FIG. 2. Distribution of ostracod species on the Dorset coast.

Apyrenum Subzones of the Yorkshire coast which are tentatively regarded as the same species and may again be an example of facies control.

The Toarcian of the Dorset coast yielded ostracods from only the lower Down Cliff Clay, since the upper part and much of the Bridport Sands are virtually inaccessible in vertical or near vertical cliffs. The lower part of the Down Cliff Clay from the Junction Bed up was sampled in sections found on Thorncombe Beacon and Watton Cliff, and the species at the two places compared (text-fig. 2). Ostracods were not very numerous; but out of a total of ten species from Thorncombe Beacon and eight from Watton Cliff the following species: *Cytherella toarcensis* Bizon, 1960, *Cytherelloidea cadomensis* Bizon, 1960, *Kinkelinella sermoisensis* Apostolescu, 1959, *Cytheropteron alafastigatum* Fischer, 1962, and *Ektyphocythere* aff. *champeauae* Bizon, 1960, were common to both. Since the two sets of samples are from the same subzone, same type of sediment, stratigraphically similar levels, and the localities are only 500 metres apart the faunal differences seem explicable only in terms of collection failure.

Cotswolds. Northwards along the strike of the Lower Jurassic from the Dorset coast, exposures are limited to small parts of the Domerian and Toarcian. In a primary survey full or relatively large sections with good zonal control are desirable, and so small sections were omitted. The whole of the Domerian is next exposed near Gloucester, north of the Mendip Axis, where the disused brickpit of Robins Wood Hill (SO 836149) was examined. The stratigraphical palaeontology has been recently described by Palmer (1971). Only three out of twenty-four samples contained Ostracoda. Whilst probably due to the very weathered nature of the face, natural faunal paucity cannot be excluded. The fossiliferous samples were from the upper part of the Davoei Zone (*Wicherella semiora semiora* Lord, 1972 and *Ogmoconcha* sp. B) and from the Stokesi Subzone (*W. semiora semiora*, *O.* sp. B, *Gramannella apostolescui* (Gramann 1962), *Trachycythere tubulosa ?seratina* Triebel and Klingler, 1959 and two new cytherurid species). The exact influence of the Mendip Island on faunal movement is impossible to assess. Although certainly variable it was not apparently of major importance. The Gloucester evidence shows a strong connection with the Dorset Domerian fauna even to the extent of the same subspecies of *Wicherella semiora* being present. Howarth (1958, p. xxxvii), using evidence from Kent (1949), concluded that a few miles east of the Mendips there was free north–south access, and the evidence here supports that view. An erosion surface occurs at the base of the Spinatum Zone in the Gloucester area and as a result the Gibbosus Subzone is missing (Palmer 1971). Erosional features are known at about this level from a number of sites between East Yorkshire and Dorset and are cited below.

The Toarcian in the Gloucester area was not sampled because good exposures were lacking. In the south and mid-Cotswolds the Toarcian consists of Cotswold Sands overlain by the condensed Cephalopod Bed, but northwards the facies changes to a full but poorly exposed sequence of clays. These clays could not be sampled and subsurface material is clearly necessary.

In the north Cotswolds at the village of Aston Magna (SP 198356) a brick pit exposes the uppermost beds of the Lower Lias (blue-grey clays of the Davoei Zone) and the lowest beds of the Middle Lias (Domerian) which consists of poorly fossiliferous red-brown sands (McKerrow and Baden-Powell 1953, p. 89). Further up the slope in the village 'ironstone' has been recorded (Arkell 1947, p. 17). This is the Marlstone Rock Bed, now much more ferruginous so that further north at Banbury it is actively quarried. At Aston Magna the junction between the clays and the sands was obscured so that the thicknesses present could not be determined. Although the two samples from the ferruginous Domerian sands were unfossiliferous because of decalcification or very shallow water conditions, or both, samples from the Davoei Zone clays did contain ostracods. The fauna consisted of *Ogmoconcha* species, *Pseudohealdia*, and Ostracode (513) Wicher, 1938. The latter is of particular interest having been recorded from Germany (Wicher 1938; Gramann 1962*b*), from submarine samples from the floor of the North Sea (Dingle 1967), and the writer has found it in the Lower Pliensbachian of Lincolnshire (but not Kirton-in-Lindsey, see below), the Midlands, and the Cotswolds. The species is thought to be related in part to *Wicherella*.

Midlands. North of Banbury and the Marlstone Rock Bed ironstone workings there is an exposure of Lower Toarcian beds in a railway cutting at Byfield (SP 512529) described by Walford (1879) and a section recorded by Beeby Thompson given by Woodward (1893, p. 275). The microfauna is rich and the foraminifera have been described by Barnard (1950). The section is largely overgrown and it was necessary to excavate the face. The zones have not been accurately delimited, but all the Lower Toarcian appears to be present. Dr. M. K. Howarth has kindly commented upon the zonal distribution of the samples. The Falciferum Subzone (Falciferum Zone) contained *Kinkelinella sermoisensis* (Apostolescu 1959) and Gen. indet. ?*bucki* Bizon, 1960; the samples from the Commune Subzone (Bifrons Zone) contained the same two species together with *Cytherella toarcensis* Bizon, 1960, *Kinkelinella* sp. I (Apostolescu, 1959), *Trachycythere tubulosa tubulosa* Triebel and Klingler, 1959, and *T. verrucosa* Triebel and Klingler, 1959. Only two species are common between Byfield and the two sections on the Dorset coast, viz. *C. toarcensis* and *K. sermoisensis*, but since a marked zonal difference exists this is only to be expected. Of particular interest was the occurrence of *Kinkelinella* sp. I and an abundance of specimens closely resembling the species originally named *Procytheridea bucki* Bizon, 1960 which may indicate a close faunal connection with the Paris Basin.

An almost complete sequence of Domerian strata is exposed in a brick pit at Napton-on-the-Hill (SP 456613), like Robins Wood Hill an outlier separated from the main outcrop, but capped by the Marlstone Rock Bed and with no Toarcian present. The pit is at the top of the hill on the north-western side and exposes 72 feet (22 m) of Domerian sediments. The only record is the measured section given by Howarth (1958, p. xi) who proved the presence of the Stokesi and Subnodosus Subzones but not the Gibbosus Subzone. The latter may be represented by the clay bed (Bed 5 of Howarth) immediately below the Marlstone Rock Bed or it may have been removed by pre-Marlstone Rock Bed erosion, for which there is evidence in other sections. The base of the Margaritatus Zone was not seen, the lower part of the section differing from that of Howarth and no liparoceratid ammonites found to prove pre-Domerian strata. Of seventeen samples examined only one, from a shell band, contained ostracods and foraminifera (?Stokesi Subzone, 42 feet (13 m) below Marlstone

Rock Bed). Percolating groundwater probably explains the paucity of microfossils but it is possible that ecological and geographical factors also played a part. The few ostracods found were assigned to *Ogmoconcha* sp. B and *Ogmoconcha* sp. C. Lack of microfossils at this locality and at Robins Wood Hill was critical, since these are the two most complete and best exposed inland sections south of Lincolnshire, and left little to connect the faunas of Lincolnshire with those of Dorset. As a result it was impossible to trace faunal movements or possible provincialism.

The ironstone quarries in the Marlstone Rock Bed around Banbury sometimes expose lowest Toarcian clays at the top, but these proved barren, as did lowest Toarcian paper shales from Tilton-on-the-Hill to the north in the Leicestershire part of the ironstone field. The studied section at Tilton Station cutting (SK 762055) has been described by Hallam (1955). Here the Marlstone Rock Bed is composed of $9\frac{1}{2}$ feet (3 m) of calcareous and ferruginous sandstones overlain by $8\frac{1}{2}$ feet (2·5 m) of ironstone, which is a very ferruginous oolitic limestone. A sample from the sand-rock (Bed 5 of Hallam) yielded ostracods. These specimens, together with a few from Staithes, were the only ostracods found in the Spinatum Zone. For the most part they were heavily encrusted with quartz grains and many specimens were unidentifiable. The species *Trachycythere tubulosa tubulosa* and *T. verrucosa* Triebel and Klingler, 1959 occurred together with new forms which will be described later when more material is available.

Lincolnshire. Immediately south of Lincoln, and 43 miles (69 km) north of Tilton-on-the-Hill is Bracebridge brick pit (SK 971671). Bracebridge has been described by Trueman (1918, pp. 103–104) and Howarth (1958, pp. xi–xii) but the worked part is now small and the lowest beds, formerly seen at the western end, are now obscured by rubbish. Trueman gives a large faunal list which includes foraminifera but no ostracods. The section sampled was about 17 feet (5 m) thick and included Howarths Beds 8, 9, and 10 which belong to the Stokesi and Subnodosus Subzones, but the upper subzone of the Margaritatus Zone, the Spinatum Zone, and the basal part of the Toarcian (Tenuicostatum Zone) were not exposed. This was unfortunate since the Spinatum Zone at Lincoln is in a clay facies. The samples yielded three species of *Ogmoconcha* (*O. contractula* Triebel, 1941, *O.* sp. A, *O.* sp. B) and two of *Pseudohealdia* (*P. bispinosa* and *P. pseudohealdiae* of Gründel 1964), but the higher samples from the Subnodosus Subzone were barren.

At Kirton-in-Lindsey (SE 935005), north of Lincoln, a section of Liassic sediments has been described by Howarth and Rawson (1965). Using amaltheid ammonites to define the Domerian, these authors have proved the presence of 22 feet (7 m) of Davoei Zone clays overlain by 26 feet (8 m) of Domerian clays and Marlstone Rock Bed. In an immediately adjacent pit Toarcian shales (Tenuicostatum and Falciferum Zones) are partially exposed but have suffered prolonged weathering so that most samples were barren. A total of thirteen samples was analysed, the five lowest from the Davoei Zone and the uppermost one from the lower part of the Toarcian (Bed 21 of Howarth and Rawson, Tenuicostatum Zone). The Domerian consists of 18 feet (5·5 m) of Margaritatus Zone sediments (lower 6 feet 4 inches (1·9 m) proved to be Stokesi Subzone, clays above did not yield ammonites) and the Spinatum Zone represented by the lower part of the Marlstone Rock Bed (precise thickness as yet unproved, Marlstone Rock Bed 8 feet (2·4 m) total thickness). As a result of recent work Dr. M. K. Howarth believes that the upper part of the Marlstone in the Midlands should be placed not in the Spinatum Zone but in the Tenuicostatum Zone on the basis of dactylioceratid ammonites found in the top part of the bed. A hard, grey, pebbly, calcareous mudstone (Bed 21) rests on top of, and appears almost continuous with, the Marlstone Rock Bed and contains dactylioceratid ammonites and also ostracods including *Ogmoconcha* (see below); this bed is overlain by weathered shales and paper shales. The Domerian samples were good but Toarcian material was obtained from only one sample; three species were restricted to the Toarcian and seven to the Domerian (Margaritatus Zone), but eight species were common to both Margaritatus and topmost Davoei Zones.

Samples K1–5, Davoei Zone, Figulinum Subzone.

Ogmoconcha contractula Triebel, 1941
Ogmoconcha sp. A
Ogmoconcha sp. B
Ogmoconcha sp. E
Pseudohealdia bispinosa (Gründel 1964)
Pseudohealdia aff. *P. pseudohealdiae* (Gründel 1964)
Liasina vestibulifera Gramann, 1963
Wicherella semiora kirtonensis Lord, 1972

Samples K6–9, Margaritatus Zone. As Samples K1–5 but with the addition of:

Polycope ?pumicosa Apostolescu, 1959
Polycope ?suborbicularis Terquem, 1885
Cytherella lindseyensis sp. nov.
Pontocyprella? sp.
Paracypris sp.
Nanacythere (*Nanacythere*) *simplex* Herrig, 1969
Gen. indet. sp. A

Sample 13, Tenuicostatum Zone (Bed 21 of Howarth and Rawson).

Ogmoconcha sp.
Kinkelinella tenuicostati Martin, 1960
Trachycythere verrucosa Triebel and Klingler, 1959

Some degree of faunal change takes place between the two lower zones, but the faunal break between the Domerian and Toarcian over the sample hiatus of the Spinatum Zone is complete. The ostracod faunal change between Domerian and Toarcian has been well documented by Plumhoff (1967). Usually the genus *Ogmoconcha* has been thought to become extinct in the Spinatum Zone but Plumhoff has shown that the taxon survives into the oldest part of the Toarcian in a number of localities in north-west Europe. The present record of Toarcian *Ogmoconcha* is included in Plumhoff (1967, p. 563). A number of species are common to this locality and the Dorset coast. *Wicherella semiora kirtonensis* is a geographically distinct subspecies from the Dorset form *W. semiora semiora* (Lord 1972*a*), and *Ogmoconcha contractula* is here found in both Davoei and Margaritatus Zones but in Dorset is found only in the upper two subzones of the Margaritatus Zone. The highest Domerian samples (K 10 and K 11) were barren, a phenomenon attributed to leaching of the underlying clays during pre-Spinatum or early Spinatum Zone erosion. As in Dorset and Gloucester there is an erosion surface at the base of the Spinatum Zone Marlstone Rock Bed and also at the next locality of Roxby, near Scunthorpe, and possibly at Napton-on-the-Hill. A large ironstone working at Roxby (SE 914178), 10 miles (16 km) north of Kirton-in-Lindsey, exposes a section of the Lower Jurassic from the Frodingham Ironstone (Sinemurian, Semicostatum, and Obtusum Zones, Hallam 1963) to Toarcian clays with traces of the overlying Middle Jurassic. The Marlstone Rock Bed rests non-sequentially on Davoei Zone clays and it would appear that the Margaritatus Zone sediments, if deposited, were eroded before the deposition of the Marlstone (as at Kirton-in-Lindsey). The Toarcian is thinner at Roxby than at Kirton-in-Lindsey and probably consists only of the Tenuicostatum and Falciferum Zones capped by the Middle Jurassic. These two zones are present at Kirton-in-Lindsey but the unexposed part of the succession beneath the Middle Jurassic may contain higher zones, possibly up to the Bifrons Zone. Both Domerian and Toarcian, however, are showing a general thinning northwards towards the Market Weighton upwarp. Adams (1957) described Toarcian foraminifera from this area from borehole material.

Yorkshire. The Domerian and Toarcian are poorly exposed in East Yorkshire. The Spinatum Zone is proved by a specimen of *Pleuroceras spinatum* from Everthorpe cutting (SE 905320), but there is no convincing record of the Margaritatus Zone (Neale 1958, p. 162). A clay sample from Everthorpe was unfossiliferous. The Toarcian is no longer exposed in East Yorkshire.

The Yorkshire coast and Dorset coast provide the best exposures of the Lower Jurassic in the British Isles, but the former has not received such detailed attention. The most recent account of the Lower Lias is that of Fox-Strangways (1892) and previous to that the work of Tate and Blake (1876). Recently Howarth (1955) has redescribed the Middle Lias but modern work on the Upper Lias is incomplete and restricted to stratigraphical and palaeontological studies by Dean (1954) and Howarth (1962) and sedimentary geochemical work by Gad *et al.* (1969). Much of the Lias is argillaceous but highly lithified and difficult to prepare for microfossils. The results of sampling the Middle Lias (Domerian) along the coast south from Staithes (NZ 783188) have been briefly described (Lord 1971*b*).

The Margaritatus Zone fauna is comparable with Bracebridge particularly in consisting only of the two metacopid genera *Ogmoconcha* (*O. contractula* Triebel, 1941, *O.* sp. B and *O.* sp. C) and *Pseudohealdia* (?*P.* cf. *P. pseudohealdiae* (Gründel 1964)). The Yorkshire fauna, however, is impoverished numerically, a question which has already been discussed in the light of the geochemistry of the sediments (Lord 1971*b*). The Spinatum Zone was disappointing. Only in the Staithes section and Bracebridge do argillaceous sediments suitable for ostracod extraction techniques occur and these yielded a poor fauna at the former site and are now unexposed at the latter. The Toarcian of the Yorkshire coast has yet to be sampled properly, but reconnaissance samples from the various units contained small numbers of cytheracean ostracods.

SYSTEMATIC DESCRIPTIONS

In the following section well-known and illustrated species are not formally described. All specimens are deposited in the collections of the Department of Geology, University of Hull.

Sample Data—full details of sample levels and localities are given in an unpublished pamphlet which has been deposited with the British Library at Boston Spa, Yorkshire, as Supplementary Publication No. SUP 14002 (16 pages). The sample data has been extracted from Lord (unpublished thesis, 1968).

The genus Procytheridea *Peterson, 1954*. The use of the generic name *Procytheridea* in the discussion above refers to the terminology of previous authors and does not imply recognition of the genus in the Lower Jurassic. No Lower Jurassic species found so far would appear to be congeneric with *Procytheridea exempla*, the genotype, although this does not preclude the possibility of the presence of the genus in other parts of the European Jurassic.

The genus Ogmoconcha *Triebel, 1941*. Assessing the degree of shape variation permissible within one species of this genus is a recurrent difficulty and principally for this reason five 'species' have been left in open nomenclature. Text-fig. 3 shows shape differences between typical members of each so-called 'species'. The taxonomy of this group is in a most unsatisfactory state, as an attempt has been made to demonstrate elsewhere (Lord 1972*b*). A single specimen from the *gibbosus* subzone in Dorset resembled *Ledahia septenaria* (Gründel 1964), described from the Domerian of northern Germany (see Malz 1971), but the muscle-scars were poorly preserved.

Order PODOCOPIDA Müller, 1894
Suborder PLATYCOPINA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus CYTHERELLA Jones, 1849
Cytherella lindseyensis sp. nov.

Plate 90, figs. 1–3

Derivato nominis. Lindsey, a Lincolnshire region.

Material. 8 valves, 1 carapace.

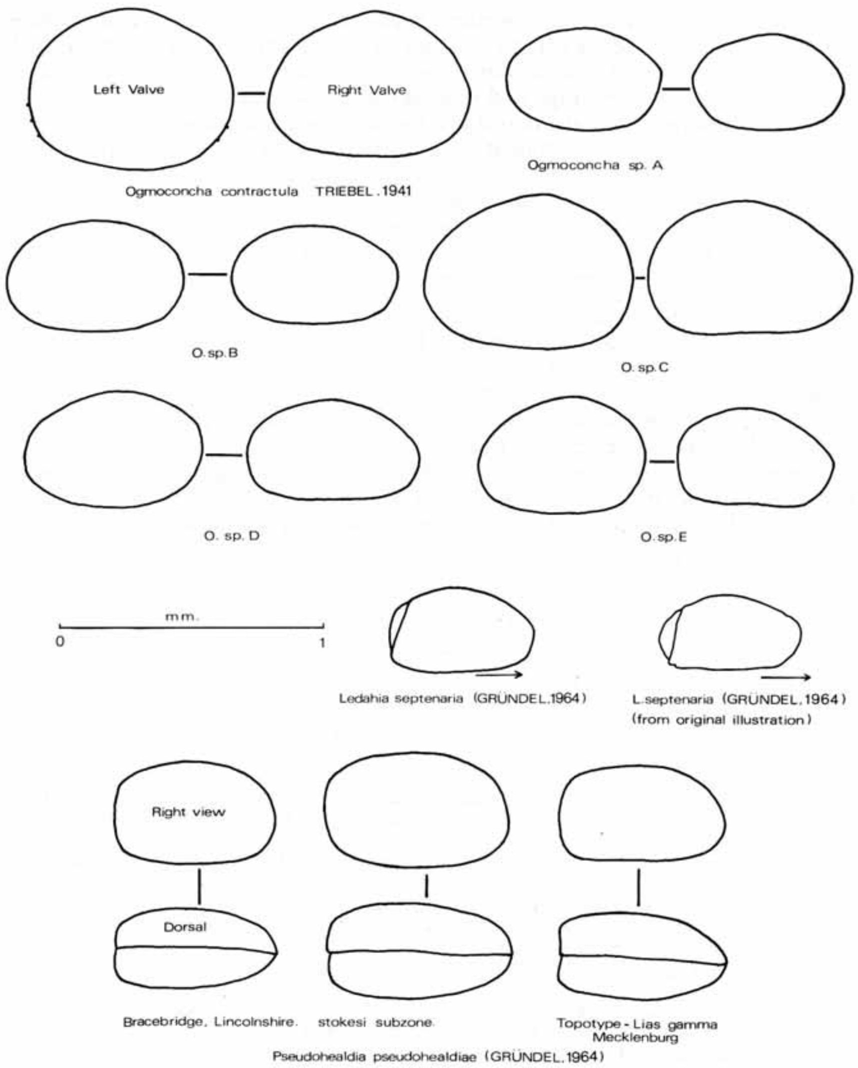
Distribution. Sample K7, Margaritatus Zone, Kirton-in-Lindsey (type locality). Samples D49 and D50, Stokesi Subzone, Down Cliff.

Dimensions.

Sample K7	Length (mm)	Height (mm)	Width (mm)
Holotype, Right valve, female HU.53.J.5	0·875	0·56	0·21
Paratypes, Left valve, female HU.53.J.6	0·85	0·49	0·17
Right valve, male HU.53.J.7	0·83	0·47	0·16

Diagnosis. A species of the genus *Cytherella* with an arched dorsal margin and distinctive shape.

Description. Shape sub-rectangular, elongate. Dorsal margin arched, highest point posterior of mid-length in females; ventral margin rectilinear or may be slightly convex medianly. Anterior margin rounded; posterior margin is slightly angular and



TEXT-FIG. 3. Shape comparison of *Ogmoconcha*, *Ledahia*, and *Pseudohealdia* species.

with an inclined postero-ventral section. Right valve larger than left and overlaps smaller valve all round its margin. Surface of valves smooth and unornamented. Hinge simple, selvage of smaller valve fits into a peripheral groove which runs round margin of right valve. Selvage and complementary selvage groove are most prominently developed along the dorsal margin. Marginal zone simple. Marginal and normal pore canals simple, straight, and sparse. Females swollen posteriorly with greatest height posterior of mid-length. Males are featureless internally but females exhibit three depressions—one large depression posteriorly to accommodate eggs, one ventrally beneath the adductor muscle-scars, and a further concavity, weakly developed, in the antero-dorsal region. Males are lower posteriorly and less inflated. Muscle-scars biserial cytherellid type, composed of two rows of five or six scars.

Remarks. Cytherella is not a common genus in the English Domerian and no species have been described from this sub-stage in Europe. The specimens from Dorset differ slightly from the Lincolnshire type material in their posterior shape in lateral view. This species differs from *Cytherella toarcensis* Bizon, 1960 (from the Upper Toarcian of Calvados) in shape and in the lack of a dorso-median sulcus. *Cytherella lindseyensis* is probably a direct antecedent of *C. toarcensis.*

The depressions described in the female are not comparable to the double posterior depressions found in female *Cytherelloidea* and recently recorded by Bate (1972) in the Australian Cretaceous *Cytherella atypica* since only one depression is situated posteriorly.

Genus CYTHERELLOIDEA Alexander, 1929
Cytherelloidea anningi sp. nov.

Plate 90, figs. 4–5

1961 *Cytherelloidea* sp. 24 Cousin and Apostolescu, p. 429, fig. 2.

EXPLANATION OF PLATE 90

Scanning electron micrographs.

Figs. 1–3. *Cytherella lindseyensis* sp. nov., Margaritatus Zone, Kirton-in-Lindsey, uncoated, ×66. 1, left valve, female, Paratype HU.53.J.6. 2, right valve, male, Paratype HU.53.J.7. 3, right valve, internal, female, Holotype HU.53.J.5.

Figs. 4–5. *Cytherelloidea anningi* sp. nov. Stokesi Subzone, Down Cliff, Dorset coast, uncoated, ×66. 4, right valve, male, Holotype HU.53.J.14. 5, right valve, female, Paratype HU.53.J.15.

Figs. 6–9. *Kinkelinella sermoisensis* (Apostolescu 1959), Lower Toarcian, Byfield, ×66. 6, left valve, HU.55.J.13, carbon coated. 7, right valve, HU.55.J.14, carbon coated. 8, right valve, aluminium coated. 9, right valve internal, aluminium coated.

Fig. 10. *Kinkelinella* sp. I. (Apostolescu 1959), Lower Toarcian, Byfield. Right valve, HU.55.J.23, carbon coated, ×66.

Figs. 11–12. *Ektyphocythere* sp. A, Subnodosus Subzone, Thorncombe Beacon, Dorset coast, aluminium coated, ×66. 11, left valve, HU.57.J.1. 12, right valve, HU.57.J.2.

Figs. 13–15. Gen. indet. sp. A, Margaritatus Zone, Kirton-in-Lindsey, carbon coated, ×66. 13, left valve, female, HU.56.J.26. 14, right valve, female, HU.56.J.27. 15, carapace, male, right view, HU.56.J.28.

Fig. 16. *Ektyphocythere* aff. *champeauae* Bizon, 1960. Levesquei Zone, Down Cliff Clay, Thorncombe Beacon, Dorset coast, Carapace, left view, HU.57.J.6, aluminiun coated, ×66.

Figs. 17–21. Gen. indet. ?*bucki* Bizon, 1960. Lower Toarcian, Byfield, carbon coated, ×66. 17, left valve, male, HU.57.J.7. 18, right valve, male, HU.57.J.10. 19, left valve, female, HU.57.J.12. 20, left valve, interior, female. 21, right valve, female, HU.57.J.13.

LORD, Liassic ostracods

1961 *Cytherelloidea* sp. 24 G. Bizon, p. 436, table 2.
1961 *Cytherelloidea* sp. 24 Champeau, pp. 438, 442, and 443.
1961 *Cytherelloidea* sp. 24 Oertli and Grosdidier, p. 460, table 6.
1962 Ostracod Nr. 107 Klingler, p. 101, pl. 13, fig. 31, table 7.
1963 *Cytherelloidea* sp. 24 Oertli, pls. 13 (ii) and 16 (i).

Derivato nominis, in honour of Mary Anning (1799–1847) of Lyme Regis, an early student of Lias fossils.

Material. 5 valves.

Distribution. Sample D34, D44, and D77 Stokesi and Gibbosus Subzones, Down Cliff.

Dimensions.

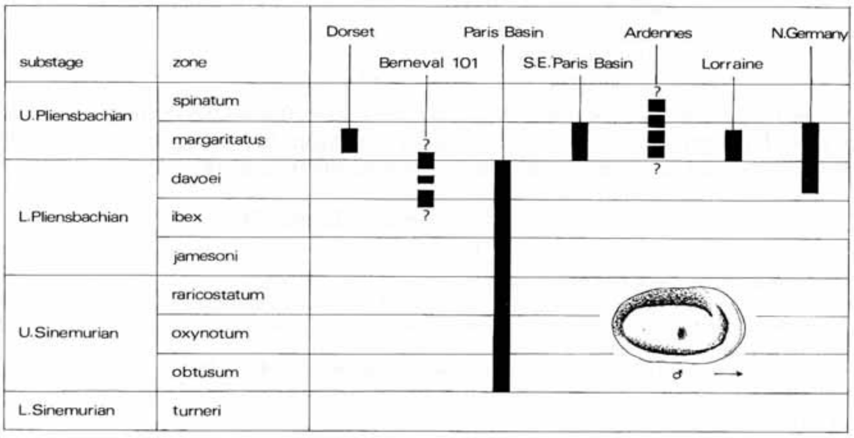
	Length (mm)	Height (mm)	Width (mm)
Holotype,			
Right valve, male (D34) HU.53.J.14	0·64	0·36	0·10
Paratypes,			
Right valve, female (D34) HU.53.J.15	0·76	0·41	0·13
Right valve, male (D77) HU.53.J.16	0·71	0·43	0·12
Left valve, female (D77) HU.53.J.17	0·72	0·43	0·16

Diagnosis. A species of *Cytherelloidea* distinguished by its ornamentation of a single rib which commences near the antero-dorsal margin, runs round the valve parallel to the margins, and terminates slightly below its point of commencement. Distinguished also by pronounced sexual dimorphism.

Description. Shape elongate, rectangular, or sub-rectangular. Sexual dimorphism marked; females larger than males and differ in outline. Dorsal and ventral margins straight but may be slightly convex or concave. Marginal rim present along the anterior and dorsal margins in females and along anterior margin in males. Females inflated posteriorly, posterior margin gently rounded in the dorsal part but more sharply curved in the ventral part. Males are more sharply rounded posteriorly than females, and slightly angular at, or just above, mid-height. Greatest length at mid-height. Dorsal and ventral margins parallel. Maximum width posteriorly in both sexes. Valve surface smooth and ornamented by a single rib which commences close to the antero-dorsal margin and runs completely round the valve parallel to the margins and terminates close to, but on the ventral side of, its starting-point—a single spiral which is almost a closed circle. At the point where it finishes the rib may incline slightly in an antero-ventral direction. This single rib is close to the valve margins but does not border the shell. In the centre of the valve a small depression is sometimes developed which corresponds to the point of attachment of the adductor muscles on the inside of the valve. Details of muscle-scars and pore canals were not visible. Hingement as in *Cytherella*. Female valves infilled so that the two diagnostic posterior cavities, if present, could not be seen.

Remarks. *Cytherelloidea anningi* differs from *C. pulchella* Apostolescu, 1959 in the different rib pattern and *C. pulchella* also possesses a reticulate surface; the present species differs from *C. cadomensis* Bizon, 1960 in its lack of a peripheral inflation.

This species has been described from France and Germany by a number of authors and is notable for its restriction to the Margaritatus Zone for which it forms a useful marker fossil in north-west Europe. The only exception is Oertli and Grosdidier's (1961, p. 460) record of throughout the Upper Sinemurian to the top of the Lower Pliensbachian in the Paris Basin. This is difficult to explain since their small drawing shows a *Cytherelloidea* with a distinctive coiled rib apparently synonymous with the present species. Possibly the species was restricted to the central part of the Paris Basin until the end of the Lower Pliensbachian and then extended its habitat to southern England, the borders of the Paris Basin, and north Germany (text-fig. 4).



TEXT-FIG. 4. Distribution of *Cytherelloidea anningi* sp. nov.

Suborder PODOCOPINA Sars, 1866
Superfamily CYTHERACEA Baird, 1850
Genus *Kinkelinella*
Kinkelinella sp. I (Apostolescu 1959)

Plate 90, fig. 10

This species is easily distinguished from other *Kinkelinella* by virtue of its ornament, which is a pattern of slightly sinuous ribs which run sub-vertically from the dorsal to the ventral margin and which are slightly flexed towards the anterior in the ventral half of the shell, but lack secondary transverse ribs. *Kinkelinella* sp. I occurs in association with *K. sermoisensis* (Apostolescu 1959) (Pl. 90, figs. 6–9) in the Falciferum and Bifrons Zones at Byfield. The two species are figured to demonstrate the contrast in ornamental pattern. *K.* sp. I was originally recorded from the Toarcian (Bifrons Zone) and Aalenian (Aalensis Zone) of the Paris Basin by Apostolescu in 1959 and appears identical with Ostracod 1081 from the Toarcian and Aalenian of south-west Germany (Buck 1954).

Genus EKTYPHOCYTHERE

Ektyphocythere sp. A

Plate 90, figs. 11–12

Material. 1 carapace, 16 valves, and fragments.

Distribution. Samples D62–64—Subnodosus Subzone, Thorncombe Beacon.

Dimensions.

	Length (mm)	Height (mm)	Width (mm)
Left valve (D62) HU.56.J.1	0·62	0·36	0·16
Left valve (D62) HU.57.J.1	0·67	0·36	0·16
Right valve (D62) HU.57.J.2 (broken after photography)	0·64+	0·33	0·16

Remarks. This species resembles *Procytheridea rugosa* Bizon, 1960 from the French Upper Toarcian in its essentially triangular ornament and in shape but differs in being somewhat more rectangular and possessing many more primary ribs.

Ektyphocythere aff. *champeauae* Bizon, 1960

Plate 90, fig. 16

aff. 1954	Ostracod 1099a, Buck.
aff. 1956	*Cytheropteron* sp. 1099 (Buck 1954), Apostolescu and Bourdon, table 2.
aff. 1960 (March)	*Procytheridea champeauae*—Bizon, pp. 205, 208, and 210, pl. 1, fig. 1*a–d*. Pl. 2, fig. 1*a–g*.
aff. 1960 (June)	*Procytheridea arcuatocostata*—Martin, pp. 142–144, pl. 11, figs. 38–39.
1962	Ostracod Nr. 85 Klingler, p. 107, pl. 14, fig. 48, table 7.

Material. 4 carapaces, 7 valves, and fragments.

Distribution. D80 and D82—Down Cliff Clay—Thorncombe Beacon. W1 and W6—Down Cliff Clay—Watton Cliff.

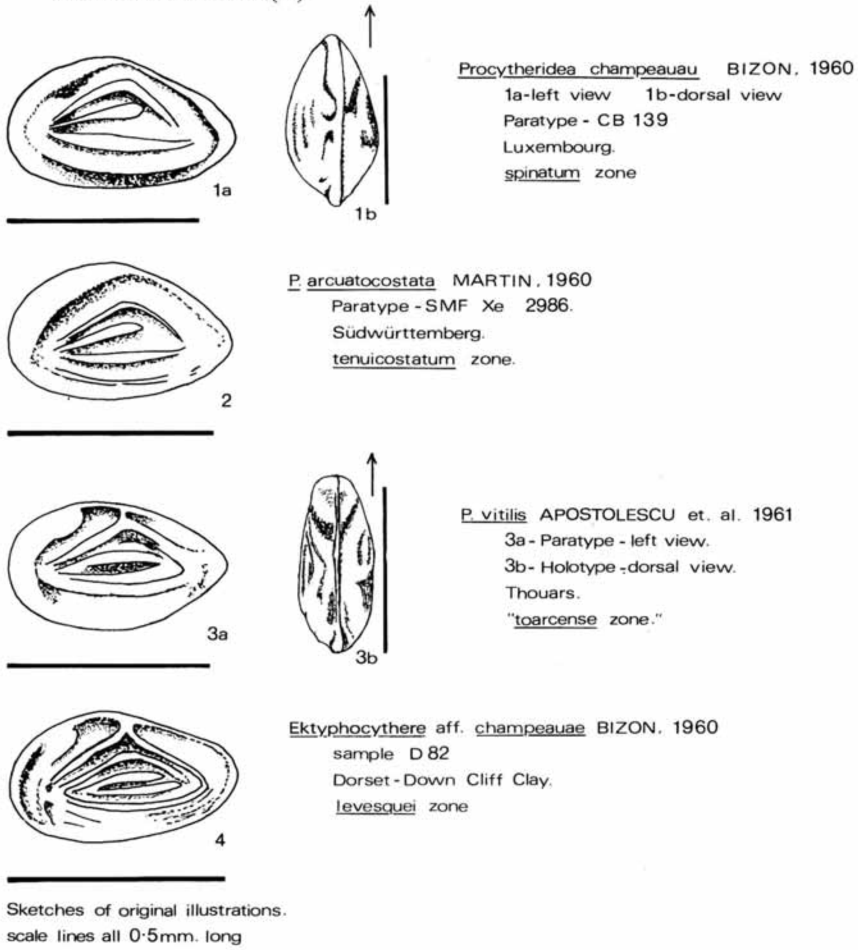
Dimensions.

	Length (mm)	Height (mm)	Width (mm)
Left valve (W1) HU.57.J.3	0·58	0·34	0·17
Left valve (D52) HU.57.J.4	0·52	0·34	0·16
Right valve (W6) HU.57.J.5	0·56	0·27	0·14
Carapace (D82) HU.57.J.6	0·54	0·30	0·25

Remarks. The specimens are identical with figures of Ostracod Nr. 85 Klingler (Klingler 1962) from the Upper Toarcian of south Germany. This species is very close to Ostracod 1099a Buck which that worker recorded from the top and bottom of the German Toarcian. In shape (laterally) and in ornament this species is close to *Procytheridea champeauae* Bizon, 1960 (synonymous with *P. arcuatocostata* Martin, 1960) and *P. vitilis* Apostolescu, Magné and Malmoustier, 1961 but has more primary ribs and is here considered to show affinities with the former species, although the difference may prove to be of sub-specific rank. The comparison of the rib patterns is of interest (text-fig. 5). The following three taxa would appear to be closely related:

(i) the present species, which may be a sub-species of (ii).

(ii) *Procytheridea champeauae* Bizon, 1960. Fewer primary ribs than (i) but ornament almost same as (iii).



TEXT-FIG. 5. Morphology of *Procytheridea champeauae* Bizon, 1960, *P. arcuatocostata* Martin, 1960, *P. vitilis* Apostolescu *et al.*, 1961, and *Ektyphocythere* aff. *champeauae* Bizon, 1960.

(iii) *Procytheridea vitilis* Apostolescu, Magné and Malmoustier, 1961 which differs from (i) and (ii) in shape when viewed dorsally—other comparative features poorly known.

The use of the generic name *Procytheridea* is discussed above.

Genus Indeterminate
Gen. indet. sp. A

Plate 90, figs. 13–15

Material. 20 valves, 1 carapace.

Distribution. Samples K6–9—Margaritatus Zone. Kirton-in-Lindsey.

Dimensions.

	Length (mm)	Height (mm)	Width (mm)
Left valve ?female (K8) HU.56.J.26	0·50	0·26	0·15
Right valve ?female (K8) HU.56.J.27	0·46	0·25	0·14
Carapace ?male (K6) HU.56.J.28	0·56	0·25	0·26

Remarks. This species is probably Ostracod 999 of Buck (1954) and possibly *Procytheridea* ? sp. 22 of Oertli and Grosdidier (1961, p. 460) or the species called *Procytheridea*? sp. E (Apostolescu 1959) by Oertli (1963, pl. 15). The species may be related to *Procytheridea vermiculata* Apostolescu, 1959.

Gen. indet. ?*bucki* Bizon, 1960

Plate 90, figs. 17–21

?1960 *Procytheridea bucki* Bizon, p. 205, pl. 1, fig. 2*a–e*.
1963 *Procytheridea bucki* Bizon, 1960, Oertli, pl. 20.

Material. 4 carapaces, 255 valves.

Distribution. Samples B1–4—Lower Toarcian. Byfield.

Dimensions.

	Length (mm)	Height (mm)	Width (mm)
All specimens from Sample B4			
Left valve, male HU.57.J.7	0·79	0·43	0·23
Left valve, male HU.57.J.8	0·77	0·41	0·21
Right valve, male HU.57.J.9	0·76	0·37	0·22
Right valve, male HU.57.J.10	0·78	0·39	0·24
Left valve, female HU.57.J.11	0·66	0·44	0·22
Left valve, female HU.57.J.12	0·63	0·40	0·22

	Length (mm)	Height (mm)	Width (mm)
Right valve, female HU.57.J.13	0·66	0·38	0·23
Right valve, female HU.57.J.14	0·68	0·38	0·23
Carapace, female HU.57.J.15	0·70	0·43	0·40

Remarks. As figured by Bizon *Procytheridea bucki* differs from the specimens described here which are higher and more truncated posteriorly, especially in the females; slight differences in ornament may also exist but it is difficult to be certain from Bizon's figures. Comparison of internal structures is also unsatisfactory, the hinge of *P. bucki* for example having been described simply as the same as in *Procytheridea*. A very distinctive early Toarcian species.

DISCUSSION AND CONCLUSIONS

Mesozoic ostracods are almost all considered to have been of benthonic habit existing as scavengers around vegetation, on the sea-floor, or between sediment particles in the uppermost layers of the substrate. Modern planktonic forms are well known, as are analogous Palaeozoic types which are interpreted as having had a similar life style, but Mesozoic planktonic ostracods are almost unknown, with the exception of a very few Cretaceous forms (Pokorny 1964; Kaye 1965). The forms described in this account thus belong to marine benthic communities, are typical elements of the ostracod fauna inhabiting the north-west European shelf sea of the time and as such are indicative of relatively shallow-water conditions. They are also influenced in their distribution by facies variation. It will be clear that only certain sediments are susceptible to micropalaeontological preparation techniques for Ostracoda, i.e. clays, marls, sands, and that others such as limestones and well-cemented sandstones and ironstones cannot be disaggregated without destroying the calcareous microfossils. Thin-section analysis is not an appropriate method for identifying ostracods. There is thus an initial facies control over the assemblages examined in that only particular facies can be studied and it is very difficult to investigate the full range of facies control.

In Margaritatus Zone times the assemblages in south-west England not unnaturally bear close comparison with those of the Paris Basin. In a similar way the species found in Lincolnshire closely resemble forms recorded from Germany and there is no reason to suppose that there was any hindrance to the movement of these benthonic organisms to the north or south of the Anglo-Belgian landmass. Faunal elements common to both France and Germany occur, but with greater affinity to the former in south-west England and to the latter in north-east England. The situation does not hold between the Cotswolds and Lincolnshire, that is immediately to the west of the landmass, where not only are exposures poor but ostracods rare, e.g. Napton-on-the-Hill. This phenomenon might be considered a feature associated with shallow-water conditions just off-shore (the so-called 'Oxfordshire Shallows'), but the sediments at Napton are not particularly shallow water and ammonites occur. Evidence from further east and west would be enlightening.

The progressive shallowing of the sea during Domerian times is generally thought to have reached its maximum during the Spinatum Zone. Here, shallow-water sediments including oolitic limestones were deposited, local erosion took place, and the sea was shallow enough to form partially isolated water bodies thus permitting the development of provincialism in ammonites and brachiopods. Present data suggest that ostracod diversity decreased through the Margaritatus Zone, although the pattern may be disturbed at the end by pre- or early Spinatum Zone erosion. For reasons referred to earlier, ostracods from the Spinatum Zone are rare and do not permit any useful comment, but it is noteworthy that a number of species described from this zone in north-east Germany by Herrig (1969*a*, *b*) occur in the Margaritatus Zone in England, viz. *Pseudohealdia bispinosa*, *Ogmoconcha contractula*, *Trachycythere tubulosa seratina*, *Nanacythere* (*N.*) *simplex*, and probably *Ogmoconcha adenticulata* (if this is synonymous with *Ogmoconcha* sp. E). The deepening of the sea after Spinatum Zone time was part of an early Toarcian transgressive phase which affected most of the north-west European shelf sea and with this deepening came a different ostracod fauna distinguished by a Middle Jurassic aspect. Lower Jurassic ostracod faunas in the strict sense disappear at the end of the Domerian. Hallam (1967) has described how bottom stagnation during Falciferum Zone times resulted in extinction for much of the benthonic fauna which was then in part replaced by forms with Middle Jurassic affinities; the ostracod evidence is too fragmentary at the moment to show whether the same is true for this particular group. The Whitbian (Tenuicostatum Zone) ostracods from Kirton are species described from Germany, whereas the Whitbian assemblages from Byfield contain species described from both France and Germany but with the former the first to be established in the area. For the Toarcian of south-west England from the south Cotswolds to Dorset, Davies (1969) postulated a sedimentological model in which the diachronous Middle and Upper Toarcian sands are looked on as a large sand bar which gradually migrated southwards. Thus these youngest Lias sediments are well represented but generally in a non-calcareous condition in which ostracods are not preserved. The only Yeovillian assemblages examined, those from the Down Cliff Clay below the sand-bar facies in Dorset, contain many species from the Paris Basin but are noteworthy for the absence of *Aphelocythere*, an important genus in the Upper Toarcian and Aalenian of Germany and France (Plumhoff 1967). Much of the early Toarcian occurs in the form of a condensed deposit in Dorset, and around Yeovil where a clay facies is developed exposure is poor. A similar situation is found in the north Cotswolds where most of the Toarcian is clay but exposure again is poor. In the Midlands two Whitbian sections were examined (see above) but Yeovillian is absent. Thus both sediment type and exposure hamper full examination of Toarcian ostracods.

Comparatively little is known about Tethyan ostracods of this period, although Barbieri (1964) has described microfossils from a Sinemurian to Aalenian sequence in Sicily wherein the ostracods are generally comparable to species from north-west Europe.

The Pliensbachian–Toarcian boundary. The marked change which occurred both in fauna and sediments at the end of the Upper Pliensbachian (i.e. Domerian) is generally recognized and has been well documented, particularly by Hallam (e.g. 1967 and

1972). Distinct changes occurred in the composition of both planktonic and benthonic faunas. The very shallow-water conditions at the end of the Pliensbachian were followed by transgressive marine conditions during which argillaceous sediments were deposited over much of north-west Europe. The change in ostracod fauna has been described by Plumhoff (1967) who emphasized the faunal turnover by referring to the Middle Jurassic aspect of Toarcian faunas. When examined in detail, as Plumhoff has done, it is clear that the change begins to take place during the early phase of the transgression, in the Tenuicostatum Zone, where a mixed assemblage can be found. The most important change is the disappearance of metacopid ostracods, in particular the important genus *Ogmoconcha*. This genus occurs in the Tenuicostatum Zone (Kirton-in-Lindsey) but soon disappears and, since it is a ubiquitous and frequently dominant element in Lower and Middle Lias assemblages, its absence coupled with the appearance of new ostracods such as the cytheracean genus *Kinkelinella* completely alters the structure of the assemblages. The Toarcian transgression thus coincides and is intimately associated with the distribution of quite a different set of species which can be readily distinguished throughout the area of the north-west European epicontinental sea.

Ostracod Zonation. No attempt has been made to provide an ostracod based zonal scheme for the Domerian and Toarcian in view of the incompleteness of the sections studied and the absence or poor representation of ostracods at certain levels, for example in the Toarcian of the Dorset coast. The best complete sequence of ostracods was found in the Dorset coast Domerian, the species distribution of which is given in text-fig. 2 and is discussed in the text. Individual species seem to be of value as stratigraphic indices but this may be a purely local or ecologically controlled phenomenon. With the data available it is not possible to postulate assemblage zones.

The record provided in this paper is only relatively complete for the Margaritatus Zone, almost non-existent for the Spinatum Zone because of unfavourable sediment type, and fragmentary for the Toarcian for a number of reasons. To complete the investigation borehole material is essential, particularly for the Midlands. The sequence in the Llanbedr (Mochras) Borehole is of great importance since it is not only thick (Domerian 483 feet (147 m), Toarcian 858 feet (261 m)) but contains rich assemblages of foraminifera and ostracods (B. Johnson and P. F. Sherrington, personal communication) which will provide most valuable information about the history of the Lower Jurassic on the western edge of Europe.

Acknowledgements. I am greatly indebted to Dr. J. W. Neale (University of Hull) and Professor D. T. Donovan (University College London) for critically reading the original manuscript. Dr. M. K. Howarth (British Museum (Natural History)) kindly provided information about his work in the Midlands and Yorkshire. Mrs. J. Irvine (University of East Anglia) prepared the scanning electron micrographs and Mrs. G. Watkin and Mr. H. Williams (University College of Wales, Aberystwyth) drafted and photographed most of the diagrams. Financial aid from the University of Hull is gratefully acknowledged.

REFERENCES

ADAMS, C. G. 1957. A study of the morphology and variation of some Upper Lias foraminifera. *Micropaleontology*, **3**, 205-226.

ANDERSON, F. W. 1964. Rhaetic Ostracoda. *Bull. geol. Surv. Gt Br.* **21**, 133-174.

APOSTOLESCU, V. 1959. Ostracodes du Lias du bassin de Paris. *Revue Inst. fr. Pétrole*, **14**, 795-826.

—— and BOURDON, M. *In* DE CHARPEL, O., VATAN, A., FONDEUR, C., ROUGE, P. E., APOSTOLESCU, V. and BOURDON, M. 1956. Corrélation dans le Lias marneux des Causses majeurs. Ibid. **11**, 439-450.

—— MAGNÉ, J. and MALMOUSTIER, G. 1961. Quelques espéces nouvelles d'Ostracodes du Toarcien de Thouars (Deux Sévres). *Colloque sur le Lias Français. Mém. Bur. Recherches geol. min.* **4**, 399-405.

ARKELL, W. J. 1947. *The Geology of Oxford.* 267 pp. Oxford.

—— 1956. *Jurassic Geology of the World.* xvi+806 pp. Edinburgh.

BARBIERI, F. 1964. Micropaleontologia del Lias e Dogger del Pozzo Raguso 1 (Sicilia). *Riv. ital. Paleont.* **70**, 709-831.

BARNARD, T. 1950. Foraminifera from the Upper Lias of Byfield, Northamptonshire. *Q. Jl geol. Soc. Lond.* **106**, 1-34.

BATE, R. H. 1972. Upper Cretaceous Ostracoda from the Carnarvon Basin, Western Australia. *Special Papers in Palaeontology*, **10**, 85 pp., 27 pls.

BIZON, G. 1961. Lorraine, région de Nancy et Thionville. *Colloque sur le Lias Français. Mém. Bur. Recherches geol. min.* **4**, 433-436.

BIZON, J. J. 1960. Sur quelques Ostracodes du Lias du bassin parisien. *Revue Micropaléont.* **2**, 203-211.

BLAKE, J. F. 1876. Subclass Entomostraca. *In* TATE, R. and BLAKE, J. F. *The Yorkshire Lias*, pp. 429-435.

BUCK, E. 1954. *Stratigraphisch wichtige Ostracoden aus dem Lias und Dogger von SW-Deutschland.* Unpublished table.

CHAMPEAU, H. 1961. Étude de la microfaune des niveaux marneux du Lias dans le sud-est du bassin de Paris. *Colloque sur le Lias Français. Mém. Bur. Recherches geol. min.* **4**, 437-443.

COUSIN, N. and APOSTOLESCU, V. *In* COUSIN, N., ESPITALIER, J., SIGAL, J. and APOSTOLESCU, V. 1961. Ardennes, région de Méziéres (Département des Ardennes). Ibid. 423-431.

CURRY, D., HAMILTON, D. and SMITH, A. J. 1970. *Geological and shallow subsurface geophysical investigations in the Western Approaches to the English Channel.* Report 70/3 I.G.S. H.M.S.O.

DAVIES, D. K. 1969. Shelf Sedimentation: an example from the Jurassic of Britain. *J. sedim. Petrol.* **39**, 1344-1370.

DEAN, W. T. 1954. Notes on part of the Upper Lias succession at Blea Wyke, Yorkshire. *Proc. Yorks. geol. Soc.* **29**, 161-179.

—— DONOVAN, D. T. and HOWARTH, M. K. 1961. The Liassic ammonite zones and subzones of the North-west European Province. *Bull. Br. Mus. nat. Hist.* (*Geol.*), **4**, 435-505.

DINGLE, R. V. 1967. *The Geology of the North Sea off the North-East coast of England.* University of Hull, unpublished Ph.D. thesis.

—— 1971. A marine geological survey off the north-east coast of England (western North Sea). *Jl geol. Soc.* **127**, 303-338.

FIELD, R. A. 1966. Species of the family Cytherellidae (Ostracoda) from the Lower Lias of South Dorset, England. *Senckenberg. leth.* **47**, 87-105.

FISCHER, W. 1962. Ostracoden der Gattungen *Monoceratina* Roth, 1928, *Cytheropteron* G. O. Sars 1865 und andere im Lias Zeta Schwabens. *Neues Jb. Geol. Paläont. Abh.* **114**, 333-345.

FOX-STRANGWAYS, C. 1892. The Jurassic Rocks of Britain, vol. I. Yorkshire. *Mem. geol. Surv. U.K.* ix+551 pp.

GAD, M. A., CATT, J. A. and LE RICHE, H. H. 1969. Geochemistry of the Whitbian (Upper Lias) Sediments of the Yorkshire Coast. *Proc. Yorks. geol. Soc.* **37**, 105-139.

GRAMANN, F. 1962*a*. Extremitätenfunde an liassischen Bairdien (Ostracoda). *Paläont. Z.* **36**, 28-32.

—— 1962*b*. Skulptierte Ostracoden aus dem niederrheinischen Lias. *Fortschr. Geol. Rheinld Westf.* **6**, 185-198.

—— 1963. *Liasina* n. gen. (Ostracoda) aus dem deutschen Lias. *Geol. Jb.* **82**, 65-74.

GRÜNDEL, J. 1964. Zur Gattung *Healdia* (Ostracoda) und zu einigen verwandten Formen aus dem unteren Jura. *Geologie*, **13**, 456-477.

HALLAM, A. 1955. The Palaeontology and Stratigraphy of the Marlstone Rock-bed in Leicestershire. *Trans. Leicester lit. phil. Soc.* **49,** 17–35.
—— 1963. Observations on the palaeoecology and ammonite sequence of the Frodingham Ironstone (Lower Jurassic). *Palaeontology*, **6,** 554–574.
—— 1967. An environmental study of the Upper Domerian and Lower Toarcian in Great Britain. *Phil. Trans. Roy. Soc. Lond. B*, **252,** 393–445.
—— 1972. Diversity and density characteristics of Pliensbachian–Toarcian molluscan and brachiopod faunas of the North Atlantic margins. *Lethaia*, **5,** 389–412.
HERRIG, E. 1969*a*, *b*. Ostracoden aus dem Ober-Domérien von Grimmen westlich Greifswald. *Geologie*, **18,** 446–471 and 1072–1101.
HOFFMANN, K. 1962. Lias und Dogger im Untergrund der Niederrheinischer Bucht. *Fortschr. Geol. Rheinld Westf.* **6,** 105–184.
HOWARTH, M. K. 1955. Domerian of the Yorkshire coast. *Proc. Yorks. geol. Soc.* **30,** 147–175.
—— 1957. The Middle Lias of the Dorset coast. *Q. Jl geol. Soc. Lond.* **113,** 185–203.
—— 1958. The Ammonites of the Liassic Family Amaltheidae in Britain. *Palaeontogr. Soc.* (*Monogr.*), xxxvii + 53 pp. London.
—— 1962. The Jet Rock Series and the Alum Shale Series of the Yorkshire coast. *Proc. Yorks. geol. Soc.* **33,** 381–422.
—— 1964. Whitbian and Yeovilian Substages. *Colloque du Jurassique* (*1962*), pp. 189–192. Luxembourg.
—— and RAWSON, P. F. 1965. The Liassic Succession in a Clay Pit at Kirton-in-Lindsey, North Lincolnshire. *Geol. Mag.* **102,** 261–266.
JACKSON, J. F. 1926. The Junction-Bed of the Middle and Upper Lias on the Dorset coast. *Q. Jl geol. Soc. Lond.* **82,** 490–525.
JONES, T. R. 1872. On some Bivalve Entomostraca from the Lias ('Infralias') of Yorkshire. Ibid. **28,** 146–147.
—— 1894. On the Rhaetic and some Liassic Ostracoda of Britain. Ibid. **50,** 156–169.
KAYE, P. 1965. Some new British Albian Ostracoda. *Bull. Br. Mus. nat. Hist.* (*Geol.*), **11,** 215–253.
KENT, P. E. 1949. A structure contour map of the surface of the buried pre-Permian rocks of England and Wales. *Proc. Geol. Ass.* **60,** 87–104.
KLINGLER, W. *In* SIMON, W. and BARTENSTEIN, H. (eds.). 1962. *Leitfossilien der Mikropaläontologie*. Vol. 1, viii + 432 pp.; vol. 2, 59 plates and 22 tables. Berlin.
LORD, A. R. 1968. *English Domerian and Toarcian Ostracoda*. Unpublished thesis, University of Hull.
—— 1971*a*. Revision of some Lower Jurassic Ostracoda from Yorkshire. *Palaeontology*, **14,** 642–665.
—— 1971*b*. *In* CATT, J. A., GAD, M. A., LE RICHE, H. H. and LORD, A. R. Geochemistry, Micropalaeontology and Origin of the Middle Lias Ironstones in north east Yorkshire (Great Britain). *Chem. Geol.* **8,** 61–76.
—— 1972*a*. *Wicherella* and *Gramannella*, two new genera of Lower Jurassic Ostracoda (Crustacea). *Palaeontology*, **15,** 185–194.
—— 1972*b*. The ostracod genera *Ogmoconcha* and *Procytheridea* in the Lower Jurassic. *Bull. geol. Soc. Denmark*, **21,** 319–336.
MCKERROW, W. S. and BADEN-POWELL, D. F. W. 1953. Easter Field Meeting 1952: The Jurassic rocks of Oxfordshire and their superficial deposits. *Proc. Geol. Ass.* **64,** 88–98.
MALZ, H. 1971. Zur Taxonomie 'glattschaliger' Lias-Ostracoden. *Senckenberg. leth.* **52,** 433–455.
MARTIN, G. P. R. *In* HOFFMANN, K. and MARTIN, G. P. R. 1960. Die Zone des *Dactylioceras tenuicostatum* (Toarcien, Lias) in NW- und SW-Deutschland. *Paläont. Z.* **34,** 103–149.
MOUTERDE, R. 1953. Études sur le Lias et le Bajocien des Bordures Nord et Nord-est du Massif Central Français. *Bull. Servs. Carte geol. Fr.* **50,** 63–521.
NEALE, J. W. *In* DE BOER, G., NEALE, J. W. and PENNY, L. F. 1958. A guide to the geology of the area between Market Weighton and the Humber. *Proc. Yorks. geol. Soc.* **31,** 157–209.
OERTLI, H. J. 1963. *Faunes d'Ostracodes du Mésozoique de France/Mesozoic ostracod faunas of France*. 57 pp., 90 plates. Leiden.
—— and GROSDIDIER, E. 1961. Ostracodes de quelques sondages du Lias du bassin de Paris. *Colloque sur le Lias Français. Mém. Bur. Recherches geol. min.* **4,** 459–461.
PALMER, C. P. 1971. The Stratigraphy of the Stonehouse and Tuffley claypits in Gloucestershire. *Proc. Bristol nat. Soc.* **32,** 58–68.
PLUMHOFF, F. 1967. Die Gattung *Aphelocythere* (Ostracoda) in NW-europäischen Jura und zur Entwicklung der Mikrofauna am Ubergang Domerium/Toarcium. *Senckenberg. leth.* **48,** 549–577.

POKORNY, V. 1964. *Conchoecia? cretacea* n. sp., first fossil species of the family Halocyprididae (Ostracoda, Crustacea). *Acta Univ. Carolinae Geol.* **2,** 175–180.

SOHN, I. G. 1968. Triassic ostracodes from Makhtesh Ramon, Israel. *Bull. geol. Surv. Israel*, **44,** 1–71.

TERQUEM, O. 1885. Les Entomostracés Ostracodes du systéme oolithique de la zone á *Ammonites parkinsoni* de Fontoy (Moselle). *Mém. Soc. geol. Fr.* (*ser. 3*), **4,** 1–46.

TRIEBEL, E. 1941. Zur Morphologie und Oekologie der fossilen Ostracoden. Mit Beschreibung einiger neuer Gattungen und Arten. *Senckenbergiana*, **23,** 294–400.

—— and KLINGLER, W. 1959. Neue Ostracoden-Gattungen aus dem deutschen Lias. *Geol. Jb.* **76,** 335–372.

TRUEMAN, A. E. 1918. The Lias of South Lincolnshire. *Geol. Mag.* **5,** 64–73, 101–111.

WALFORD, E. A. 1879. On some Upper and Middle Lias beds, in the neighbourhood of Banbury. *Proc. Warwick. Nat. Archaeol. Fld Club* [for 1878], appendix pp. 1–23.

WICHER, C. A. 1938. Mikrofaunen aus Jura und Kreide insbesondere Nordwestdeutschlands. I. Teil: Lias alpha bis epsilon. *Abh. preuss. geol. Landesanst.* (*n.F.*) **193,** 1–16.

WILSON, V., WELCH, F. B. A., ROBBIE, J. A. and GREEN, G. W. 1958. Geology of the Country around Bridport and Yeovil (explanation of sheets 327 and 312). *Mem. geol. Surv. U.K.* xii+239 pp.

WOOD, A. and WOODLAND, A. W. 1968. Borehole at Mochras, West of Llanbedr, Merionethshire. *Nature*, **219,** 1352–1354.

WOODWARD, H. B. 1893. The Jurassic rocks of Britain, vol. III. The Lias of England and Wales (Yorkshire excepted). *Mem. geol. Surv. U.K.* xii+399 pp.

A. R. LORD

Department of Geology
University College London
London, WC1E 6BT

Revised manuscript received 21 November 1973