ON THE
PALÆOZOIC BIVALVED ENTOMOSTRACA.

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THE ENTOMOSTRACA, or lower order of CRUSTACEA, are divided into the *Gnathostomata*, *Cormostomata*, and *Merostomata*, according to the characters of their mouth apparatus. The first comprises (1) the Lophyropods, such as *Cyclops*, *Daphnia*, *Cypris*, *Cythere*, *Cypridina*, *Halocypris*, *Conchæcia*, *Polycope*, and *Cytherella*, all of them, except *Cyclops*, having a bivalved carapace; and (2) the Phyllopods, such as *Artemia*, *Nebalia*, *Apus*, *Limnadia*, etc., many of which are also bivalved.

The genera above mentioned are found living in either seas, lakes, or rivers at the present day; and some of them occur fossil also, together with many others that are known either in both the recent and the fossil state, or only living, or only extinct. Much has been done of late in extending our knowledge of the Bivalved Entomostraca, both of fresh and salt water, and of the open seas and the coast lines, by Baird, Grube, Sars, Norman, and G. S. Brady; and the fossil forms have also received attention from G. S. Brady, Dr. Holl, J. Kirkby, myself, and others. It is to the older fossil species that we are to give attention at present, namely—those that are found in any strata as old as, or older than, the Permian formation—that is, the Palæozoic Rocks.

The genera of Bivalved Entomostraca, known to occur in these very ancient deposits are :—

[P., Permian; C., Carboniferous; D., Devonian; S., Silurian.]

C.....	1	<i>Candona</i> (?) ¹	} belong to the CYPRIDÆ.
P. C.....S.	2	<i>Bairdia</i> ¹	
P. C.....S.	3	<i>Cythere</i> ¹	} and possibly others of the CYTHERIDÆ.
S.	4	<i>Thlipsura</i>	
P. C.....S.	5	<i>Cypridina</i>	} referable to the CYPRIDINIDÆ.
C.....	6	<i>Cypridella</i> ¹	
C.....	7	<i>Cyprella</i>	
C. D. S.	8	<i>Entomis</i>	
C.....	9	<i>Entomoconchus</i> , possibly a member of the HALOCYPRIDÆ.	} the last two are grouped provisionally with the CYTHERELLIDÆ.
C.....S.	10	<i>Cytherella</i> ¹	
S.	11	<i>Cytherellina</i>	
S.	12	<i>Echmina</i>	} related also to the foregoing, but forming the separate tribe of LEPERDITIADÆ.
P. C. D. ...	13	<i>Estheria</i> , of the LIMNADIADÆ.	
P. C.	14	<i>Leaia</i> , of unknown alliance, but not far distant from the last.	
C. D. S.	15	<i>Leperditia</i>	
S.	16	<i>Primitia</i>	}
C. D. S.	17	<i>Beyrichia</i>	
C.....S.	18	<i>Kirkbya</i>	
C.....S.	19	<i>Moorea</i>	

There are also some Palæozoic Entomostraca that are almost bivalved; that is, have the carapace folded down on each side, but not hinged. These are *Hymenocaris* and *Ceratiocaris*, related to *Nebalia*, but they do not occupy us at present; nor does the *Dithyrocaris*, with its allies, *Dictyocaris*, *Peltocaris*, etc., although their flat carapaces occur often split in half, thus simulating single valves of the bivalved forms.

1. *Candona*² is a genus very closely allied to the *Cypris*, but addicted to crawling, and to a life on the mud and among water weeds, instead of swimming free in its water-world. With hooks only, instead of pencils of long filaments, on its anterior limbs (*antennæ*), it cannot be otherwise than a crawler and a grubber on the silty floors of ponds and lakes, and has been buried in the laminated clays deposited in old lagoons, of many different ages. Throughout the Tertiary and Secondary periods we find layers on layers of such oblong valves of small Entomostraca as correspond

¹ These are still living genera.

² For the latest and most comprehensive, as well as detailed account of many of the Bivalved Entomostraca, the reader must consult Mr. G. S. Brady's "Monograph of the Recent British Ostracoda," published by the Linnean Society in their Transactions; vol. xxvi., 1868.

very closely with those of the existing *Candonæ*; and such also are not wanting in some of the shales of the Coal-measures and Mountain-limestone. We may quote *Candona* (?) *Salteriana*, and *C.* (?) *Tateana* (from Lancashire and Berwickshire respectively), as examples. On account of the fact that similar carapace-valves exist among closely allied species, and dissimilar carapace-valves characterise members of one genus, it is necessarily difficult, if not impossible, to speak positively of the exact generic relationship of any old Cypridiform shell; hence the above-mentioned Palæozoic species are referred to the genus under notice with some doubt.

2. *Bairdia*. The peculiar subrhomboidal valves of numerous species closely related one to another, if we may judge by the slight differences in the shape of the valves, are seen in many sea-sands of the present day, and especially in the warmer climates, and are as profusely distributed in Tertiary strata of marine origin, in the Chalk and Gault, in the Magnesian Limestone of Germany and England, and in the Carboniferous Limestone of Ireland, Scotland, Bavaria, and Australia. They are not wanting even in the Silurian rocks, for one species is recorded by D'Eichwald as belonging to the Upper Silurian Limestone of Russia, and we have found one species in the Wenlock Limestone of Malvern and of Scandinavia, and three species in the Lower Silurian Limestone of Kildare, Ireland. (See *Annals Nat. Hist.* ser. 4, vol. iii. p. 213).

The wide distribution and the incalculably long persistence of this genus, though not extraordinary among the Entomostraca, deserves much attention. At the same time it must be remembered that we have nothing but the carapace-valves to guide us in our determination of the alliances of the fossil *Bairdiæ*; and, indeed, there is very little known of the limbs and other soft parts of the living *Bairdia*, though some of its living congeners, such as *Paracypris*, *Pontocypris*, and *Macrocypris* are well understood. These are all marine members of the Cyprid family, whilst very many others are inhabitants of fresh water. (See G. S. Brady, *Transactions Linn. Soc.*, vol. xxvi., pp. 360, 388, etc.)

3. *Cythere*. Under this name it is still convenient to catalogue numerous forms of the bivalved carapaces which we find in the

fossil state (Tertiary, Secondary, Primary), but which may belong to some other genus of the Cytherid family, if we could study the soft parts of the animal. Indeed, in some instances, it is possible to indicate a closer resemblance of the valves to those of *Cytheridea*, *Cytherura*, *Cytheropteron*, *Cytherideis*, *Bythocythere*, *Pseudocythere*, etc., than to those of *Cythere* itself, and yet it is not always advisable to attempt an exact generic determination for isolated, and perhaps imperfect, specimens. Hence, especially among the Palæozoic faunæ, several somewhat dissimilar Cytherids are possibly grouped together as *Cythere* by palæontologists; and of the twelve published Permian species, of the twenty or more Carboniferous species known to Mr. Kirkby and myself, and partly published, and of the six or seven known Silurian species, several might be sorted, according to approximation of outlines, under other genera than *Cythere*; for the present, however, it seems best not to venture so far.

4. *Thlipsura*. A Cytheroid carapace, pinched in at the hinder part, and otherwise peculiar, is abundant in the Upper Silurian beds near Malvern, and has lately been described and figured by Dr. Holl and myself as an interesting addition to the known Crustacean fauna of Palæozoic age.

5, 6, 7. *Cypridina*. This is the type of a special group of Ostracods, living in the open seas, some crawling on the sea-bed, and some swimming free and coming to the surface at night (crepuscular). Their bivalve test is usually larger than those of the Cyprids and Cytherids, often fully globular, or at least oval and tumid. Fossil forms are known in the Chalk (Bosquet); but in some of the Palæozoic rocks *Cypridina* and its relations abound, making up the mass of the Carboniferous Limestone at some spots (Isle of Man, Tenby, Scotland, Bolland, Kildare, Cork, etc.), just as much smaller Entomostraca constitute the mass of some Silurian (Sweden, Malvern, Russia, etc.), and other limestones (Mount-field in Sussex, Swanage, etc.).

Cypridina first appears, in unmistakeable form, in the Carboniferous Limestone of Ireland, Scotland, Isle of Man, etc., and recurs in the Permian. One specimen, which, however, is merely a cast, has been found by Mr. Salter in a pebble of the New Red

Conglomerate, at Budleigh-Salterton; and, as these pebbles are rounded fragments mostly of Silurian rock, with some of Devonian rock intermingled, this specimen in question must be older than those from the Carboniferous Limestone. With *Cypridina* occur, in this last-named limestone, both in the British Isles and in Belgium, multitudes of carapaces essentially Cypridiniform, but modified by furrows, elevations, and differences of outline, to a most puzzling extent. Among these are *Cyprella* and *Cypridella*¹

8. Probably allied to the last-named is their associate, the *Entomis* (De Koninck's so-called *Cypridina concentrica* is an *Entomis*), which is represented in the Devonian strata, where also it has been misnamed *Cypridina*, and is the characteristic fossil of some of the so-called "Cypridinen-Schiefer." *Entomis* is not rare, moreover, in the Upper Silurian rocks of Scotland, Shropshire, and Australia.

9. In the Silurian strata of Australia occur also some casts of valves not unlike those of *Halocypris*, a marine Ostracod; and allied to this probably is *Entomoconchus*, found in great numbers, and constituting some portions of the Carboniferous Limestone at Bolland, in Yorkshire, Kildare, etc. A recent globular bivalved carapace of a Halocyprid, described, figured, and named *Heterodesmus* by Mr. G. S. Brady, is very nearly, if not quite, the modern representative of *Entomoconchus*.

10. *Cytherella* is a frequent companion of *Cytheræ* and *Bairdia* in existing seas, and in Tertiary and Secondary deposits. It is present also in Palæozoic strata. It has not yet been recognized as a Permian fossil; but in the Carboniferous formations below Mr. Stottard has found it at Clifton, in a very interesting bed of ferruginous Polyzoa, Entomostraca, and other small organisms, more or less rounded, and there constituting part of the Lower Carboniferous series. We also know of one Carboniferous species common to Bavaria and Scotland, and of two Scotch species of the same age.

11. *Cytherellina* is a Silurian form, of uncertain alliance, but showing some characters seen also in *Cytherella*. Its individuals

¹ Little Island, Cork, has yielded a host of these interesting specimens to Mr. Joseph Wright, F.G.S., and the Mountain-limestone of Settle, Westmoreland, has been a rich ground for Mr. Burrow. Derbyshire, Isle of Man, and Belgium are rich also with these Entomostraca.

are very abundant in some Upper Silurian beds of Sweden and Malvern.

12. *Æchmina* is also Silurian (Malvern), and is difficult to be understood as yet, for want of a larger supply of material than has been yielded, even to the energetic researches of Dr. Holl. We place it provisionally near *Cytherella*. There are two species (and perhaps another in North America) of this curious Entomostrakon, which has the convexity of its valves produced into relatively large, hollow, conical spines, even more so than in *Cythere* (*Limnocythere*?) *umbonata* of the Chalk.

13. *Estheria* (called also *Cyzicus* and *Isaura*) is a well known Limnadiad genus, of which 24 recent species are known. (See E. Grube, Ueber die Gattungen Estheria und Limnadia, etc., in the Archiv für Naturges., 1865). Its bivalved carapace is often extremely like the shell of some Molluscs, and in the fossil state it is readily mistaken for them. Dr. Baird has described and figured in the Zool. Soc. Proceedings many recent specimens of *Estheria*, with the shapes and ornaments of the valves; others are illustrated by Grube, Joly, Durckheim, etc.; and the fossil forms, as far as known at the time, were represented and described in the Monograph of Fossil Estheriæ (Pal. Soc.), 1862. Characteristic of marsh and lagoon, *Estheriæ* are found in nearly all warm countries; and their fossil analogues rarely, if ever, occur in those deposits which are certainly of marine origin, but frequently in those that have been decidedly the result of brackish water inundations, and of more permanent lagoons. The evidences for this are collected in the Monograph above mentioned, and in the Quart. Jour. Geol. Soc., vol. xix., pp. 140–157. The oldest *Estheria* is *E. membranacea*, occurring in the Old Red of Scotland and Russia. *E. striata* belongs to the Lower Carboniferous of Bavaria and Belgium, and is found in Scotland; so also is *E. punctatella*. *E. Tateana* belongs to this zone in North Britain; *E. Beinertiana* is found in the Coal-measures of Silesia and of Britain; *E. Binneyana* occurs in those of Derbyshire; a new *Estheria* has just now been found in the South-Welsh coal-fields by Mr. W. Adams, and another by Mr. Peach in the Carboniferous beds at Edinburgh; *E. tenella* is found extensively in the

Upper Carboniferous and the Permian of Britain and Europe; *E. exigua* (possibly the same as *E. tenella*) is in the Permian beds of Russia, *E. rugosa* in those of Thuringia; and *E. Portlockii* in the Permian of Tyrone, Ireland.

14. *Leaia* comprises several varieties or species of minute bivalved Entomostraca, of which the valves only are known, and of which no modern representative has yet been recognised. The peculiar dark, horny, subquadrate valves, obliquely ridged from umbo to angles, and ornamented with distinct lines of growth, parallel with the border, carry very distinctive features separating *Leaia* from the Molluscs, and leaving the low Crustaceans only as the probable allies of this lost animal. This fossil has turned up in the Carboniferous strata of widely separate parts of the world. *Leaia Leidyi* is Pennsylvanian, *L. Williamsoniana* is from Manchester, and *L. Salteriana* is from Fifeshire; *L. Baentschiana* is Permian from Saarbrück; and Carboniferous *Leaia* have been found in Nova Scotia by Dr. Dawson, in Illinois by the American geologists, and in South Wales lately by Mr. Wm. Adams, F.G.S. We may mention that *Leaia* is probably allied to the still older Crustaceans *Myocaris* (Salter) and *Ribeiria*¹ (Sharpe).

15. *Leperditia*. This form had its largest development in Silurian times, when numerous species flourished in the sea of the period, especially towards its end, when the Wenlock and Ludlow strata were formed. Being extinct now, it is known only by the carapace-valves; these are relatively large, thick, and well characterised by their brownish and somewhat horny appearance, their peculiar bean-like appearance, their straight back (the two dorsal angles cut off, as it were), and their curved ventral margins, their ocular tubercles corresponding with the position of the eyes within, and their muscle-spot, or subcentral area on the valve, marked by delicate furrows and other modified conditions where the great closing muscle was attached on either side of the animal. *Leperditia Balthica*, abounding in Sweden, is the full-grown type of the genus; and local modifications and degeneracy affect the other forms of the period. The genus lived on during Devonian times in the

¹ Referred to Crustaceans by Mr. Salter, in the Geol. Mag., vol. i. p. 12, 1864.

European area ; and in Carboniferous waters *Leperditia Okeni* attained almost a full size, but was far more generally represented by dwarf forms that now supply the manifold but unsatisfactory basis for a dozen or so of nominal species and varieties that, often in great numbers, inhabited the brackish and muddy waters of the great Coal Period ; *Leperditia subrecta*, *L. Scotoburdigalensis*, and such like, lying as thick as *Candonæ* in a mud bank, wherever fish-remains and other garbage supplied food and occupation for these little Crustacean scavengers.

16. *Primitia* presents a very simple form of solidly made bivalved carapace, rather oblong and Leperditia-like, but somewhat indented with a vertical dorsal furrow, and otherwise characterised ; and thus standing typical of a group of Entomostraca. These are of early date. *Primitia Solvensis* comes in the Lingula-flags ; and others follow in abundance. The Upper Silurian Limestones near Malvern, however, have yielded the best specimens, and Dr. Holl has been their discoverer ; in most other instances dubious casts and moulds alone have been our guides in interpreting their characters and nature. This genus is essentially Silurian. (See Appendix.)

17. *Beyrichia*. With a much more indented and lobulated carapace, *Beyrichia* leaves its associate *Primitia*, and holds its characters as a genus through the Silurian and Devonian formations into the Carboniferous, where its last representatives seem to occur. There are very numerous species of *Beyrichia* already recorded, and others wait opportunity to appear in public. Mr. Bean's "*Cypris arcuata*" is a *Beyrichia* of the Coal-measures of Yorkshire, occurring also in Staffordshire and many other places, and is probably the last of its kind. (See Appendix.)

18. *Kirkbya* is a well-marked, but variable form, characterised by a Leperditoid valve, more or less ridged concentrically, and impressed with a subcentral pit. It began, as far as we know, in the later Silurian era, as *K. fibula* (Malvern) ; it flourished in the Carboniferous period ; and still survived abundantly in the Permian (and from one of the elucidators of these beds it got its name) ; but with the Palæozoic period it ceased to exist, as far as evidence goes at present.

19. *Moorea* stands near *Kirkbya*, but it presents feeble characters in its valve-structure, and has no central pit. Like *Kirkbya*, it begins with the Upper Silurian beds (Malvern) ; and we see it again in the Carboniferous beds (where it was found originally by Mr. C. Moore). *Moorea* is related to *Primitia* and *Leperditia* through *Kirkbya*, and thus forms an important member of the *Leperditiadæ*, an extinct family of Bivalved Entomostraca, combining characters now found in other different families, and eminently characteristic of the Palæozoic Period. (See *Annals Nat. Hist.*, ser. 2, 1856, vol. xvii. p. 98 ; and *Quart. Journ. Microsc. Sc.*, 1868, p. 46.)