III

AMBOCŒLIA HALL AND CERTAIN SIMILAR BRITISH SPIRIFERIDÆ

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I. INTRODUCTION

Several small Spirifers of the Upper Palæozoic rocks of this country have been referred to *Ambocœlia* Hall. This genus was proposed to include certain American Devonian and Carboniferous forms with a peculiar internal structure; the genotype, designated by Hall, is *Orthis umbonata* Conrad, a species from the Hamilton Group (Lower Devonian) of North America. In the paper in which he established the genus, Hall (1860, p. 71) suggested that *Spirifer unguiculus* Sowerby sp. (a British Devonian form) might also be included in the genus. The opinion generally held, for example by King (1850, p. 135) and Davidson (1858, vol. ii, pt. 4, p. 59), that *Spirifer unguiculus* is closely allied to, if not identical with, *Spirifer urei* Fleming and *Martinia clannyana* King, led observers to place these species also in the genus *Ambocœlia*. It naturally followed that, so far as the British species were concerned, the genus was described in terms of the external form of these species. In particular, emphasis was laid upon the presence of a dorsal valve considerably flatter than the ventral, and upon the development of a more or less narrowly defined median sulcus in the former. Such a procedure resulted in a neglect of the internal features that Hall so clearly distinguished. Further, the discovery of spines in *Martinia clannyana*, and later in *Spirifer urei*, led to a belief that a

spinose surface is also characteristic of the genus. In no instance, so far as I am aware, has any reference been made to the internal structure of the British Carboniferous species, which are the most abundant, and although both Phillips (1841, p. 69, & pl. xxviii, fig. 119) and King (1850, p. 135) figured and described internal moulds of Devonian and Permian forms respectively, neither of them interpreted correctly the features they observed. Yet the essence of Hall's diagnosis is concerned with a special internal structure combined with certain external peculiarities. It therefore becomes necessary to determine the true relationships of the British species with Hall's genus.

During the prosecution of this work, I have received much help from several geologists. For the loan of specimens, for permission to examine material, and for assistance while working in the various institutions, I acknowledge my indebtedness to Dr. F. A. Bather, F.R.S., Dr. W. D. Lang, F.R.S., and Miss H. M. Muir-Wood (British Museum, Natural History), Dr. F. L. Kitchin, F.R.S., and Mr. J. Pringle (Museum of Practical Geology), the late Mr. P. MacNair (Kelvingrove Museum, Glasgow), Dr. E. D. Currie and Prof. J. W. Gregory, F.R.S. (Hunterian Museum, University of Glasgow), Prof. G. Hickling (Hancock Museum, and Armstrong College, Newcastle-upon-Tyne), Prof. J. Mitchell (University College, Galway), and Mr. Henry Woods, F.R.S. (Sedgwick Museum, Cambridge).

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II. *Ambocœlia* Hall, 1860

(*a*) Summary of Characters

It is unnecessary to recapitulate in full Hall's diagnoses of *Ambocœlia* (J. Hall, 1860, p. 71; J. Hall & J. M. Clarke, 1894, p. 55), but as there appears to be considerable confusion concerning the characteristics of the genus, it is advisable in the first place to give a brief summary of its features as described by Hall. These are as follows:—

i. The shell-shape is generally plano- or concavo-convex; the cardinal line is fairly long (megathyrid).
ii. The shell-substance is fibrous, impunctate.
iii. In external ornament, the shell-surface is ' very finely cancellated by obscure radiating striæ '.

iv. The deep equilateral ventral cardinal area is divided by a large delthyrium; a smaller, though relatively well-developed area is present in the dorsal valve, which is likewise divided. The deltidium consists of two more or less discrete deltidial plates running along the borders of the delthyrium, and united apically. Analogous plates bound the dorsal delthyrium.

v. The development of the brachidium is similar to that of *Spirifer*: there is an absence of either jugum or jugal processes.

vi. The prominent teeth are not supported by umbonal plates, though frequently they may be thickened ventrally, and there may be a secondary deposit of callus in the umbo. (In his original diagnosis, Hall recorded the presence of strong dental lamellæ in the ventral umbo, but later (1894, p. 55) remarked that the teeth are 'not supported by dental plates'. I have seen no signs of ventral umbonal plates in members of the genus.)

vii. Crural plates (Hall's 'foveal plates') are more or less developed in the dorsal valve.

viii. The cardinal process is elevated, bifurcate.

ix. The musculature of the dorsal valve is peculiar, in that four large quadrangular adductor-impressions are situated towards the anterior border.

(*b*) The American Species

The various American species that have been referred to the genus are remarkably similar to the genotype in outward form, but, while some agree also in the internal features of musculature, cardinal process, and crural plates—as, for example, the form identified with *Ambocœlia umbonata* by Clarke and Swartz (1913, p. 602), and that called *Ambocœlia umbonata*? by Schuchert & Maynard (1913, p. 427)—others are markedly different in those features. Thus, Clarke (1908, p. 182) remarked that his species *Spirifer modestus* 'expresses in its outward form and characters the usual features of the middle Devonic genus *Ambocœlia*, save for the greater convexity of the dorsal valve. *Ambocœlia* unquestionably belongs in this category [with *Spirifer modestus*] but has certain differentials in the arrangement of the dorsal adductor scars and cardinal structure'. Girty (1911, p. 73) was likewise hesitant concerning the species he doubtfully referred to *Ambocœlia levicula* Rowley: 'As regards its generic position, this can hardly be called a normal *Ambocœlia*. The ventral valve is not so elevated as usual, and the dorsal valve is not as planate as in the most characteristic species, but the internal

features are perhaps more noteworthy than the configuration. I mean the absence or imperfect development of crural plates and the character of the muscle scars, not close together and anterior as in typical *Ambocœlia*.' I have seen a very similar development of the internal features of certain Upper Carboniferous American forms probably referable to *Spirifer planoconvexus* Shumard.

Reference has already been made to the different types of external ornament included within the genus. Some forms are certainly spinous, such as *Ambocœlia nana* Grabau (1899, p. 276) and *Ambocœlia plano-convexa* Shumard Girty (1915, p. 96), the spines being identical in structure with those of the British species. On the other hand, other forms are not spinous—the genotype, for example, has a surface marked with clathrate ornament developed from the intersection of growth lamellæ and obscure radiating striæ. As yet, information is inadequate to determine whether the clathrate ornament is limited exclusively to the species with internal features agreeing with those of the genotype, and the spinous ornament exclusively to species with internal features of the type of *Ambocœlia levicula* Rowley? Girty. But if this limitation does not occur, then it is evident that the American species hitherto assigned to *Ambocœlia* display the most intricate phenomena of homœomorphy.

(*c*) The British Species

Of the British species that have, at one time or another, been considered members of the genus *Ambocœlia*, none appears to be congeneric with *Ambocœlia umbonata*. *Spirifer infimus* Whidborne is perhaps the most similar, but its internal characters, other than crural plates, have not been determined, and as its ornament is quite unlike that of *Ambocœlia* (*sensu stricto*), it is here referred to the new genus *Ambothyris*, of which it is the solitary species and genotype. The rest of the British so-called *Ambocœliæ* differ markedly from *Ambocœlia*, particularly in the characters of the ornament, of the dorsal musculature, and of the cardinal process. For these, all of which appear to be congeneric, the new genus *Crurithyris* is proposed, with *Spirifer urei* Fleming as the genotype.

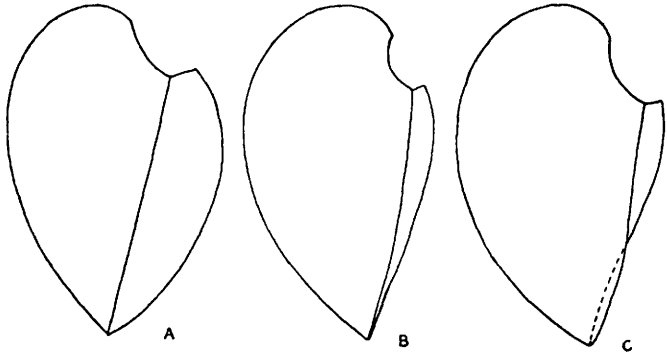
III. Morphology of *Ambothyris* and *Crurithyris*

Shell-shape.—While many of the British forms are plano- or concavo-convex in the adult state, they all show an ontogenetic development from a nepionic biconvex stage in which

there is a similar degree of inflation in the dorsal and ventral valves.[1] During growth, however, the dorsal valve becomes more or less flattened, forming a lid-like covering to a stoutly-rolled ventral valve; the degree to which this planate development proceeds is apparently quite unconnected with the stratigraphical horizon of the species: for example, *Crurithyris fissa sp. nov.* (Avonian, D_2 Zone) is approximately biconvex, while *Crurithyris unguiculus* (Upper Devonian) and *Crurithyris urei* (Avonian, D_2–D_3 Zone) approach a plano-convex condition (fig. 1).

In all the forms examined, a more or less well-marked,

FIG. 1.



A = Lateral view of *Crurithyris clannyana* from Pössneck.
B = ,, ,, *Crurithyris urei* from Scotland.
C = ,, ,, *?Ambocœlia sp.* from Ontario.

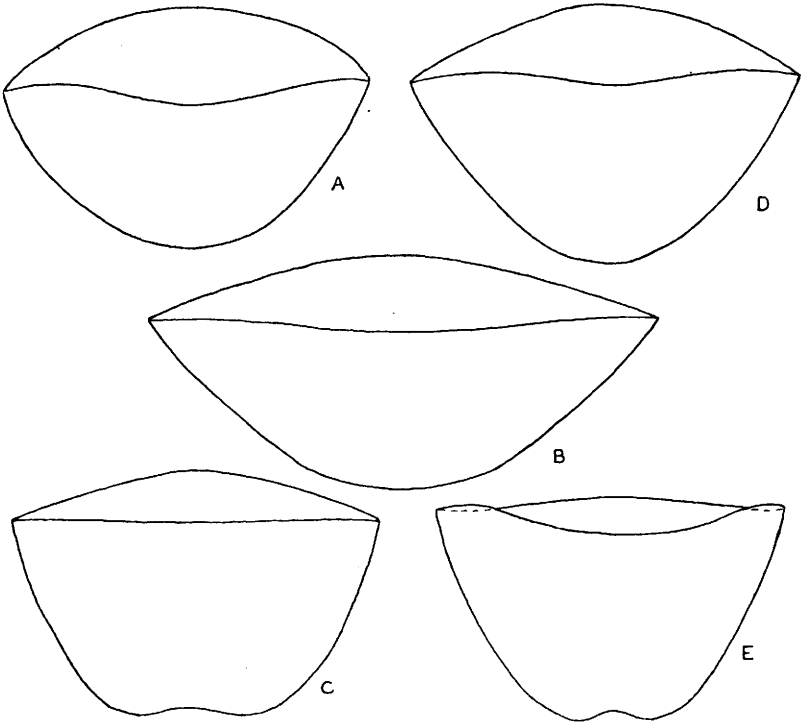
To show the development of a planate dorsal valve.

though shallow, ventral median sulcus usually appears early in life, and generally extends along the whole length of the valve. This unmodified everse stage, in which the anterior margin is very slightly uniplicate, is typical of the neanic stages of most species. There is, however, no corresponding median fold in the dorsal valve. On the contrary, there is usually present a more or less well-developed median furrow of varying definition—broad and shallow in *Crurithyris urei*, narrowly defined on an otherwise convex valve in *Crurithyris fissa*. The elements of the two valves are thus essentially opposed, and most of the species are in the ligate stage.

[1] In several species the dorsal umbo is very prominent, while the umbonal slopes fall away rapidly and may even be slightly concave, returning, towards the lateral and anterior borders, to a slightly convex condition. Thus, in the adult state the dorsal umbo frequently possesses a peculiar peaked appearance, for which it is suggested the term 'cacuminate' (Latin, *cacumen* = peak, summit) may be employed.

According as the dorsal furrow is approximately as deep as, or is deeper than, the ventral, so is the anterior border rectimarginate or unisulcate, respectively. When the latter condition is attained (as in typical members of *Crurithyris urei*), the shell is essentially in the inverse stage. There is

FIG. 2.



A = Anterior view of *Crurithyris clannyana* from Pössneck.
B = ,, ,, *Crurithyris urei* from Scotland.
C = ,, ,, *Crurithyris unguiculus* from Devon.
D = ,, ,, *Ambothyris infima* from Devon.
E = ,, ,, *? Ambocœlia sp.* from Canada.

To show the development of dorsal and ventral sulci, and the relation of the latter with the development of a planate dorsal valve and with the anterior margin.

apparently no degree of correlation between the development of a planate anterior portion and of a dorsal median furrow; similarly, in the genotype of *Ambocœlia*, for example, while the valve is markedly concave anteriorly, there is no development of a sulcus.

Hinge and Cardinal Area.—The hinge-line is rectilinear,

moderately long (for such small shells), megathyrid [1] in *Ambothyris*, brachythyrid in *Crurithyris*; it terminates in angular extremities, in consequence of which the dorsal and ventral cardinal areas are clearly defined from the umbonal slopes by well-marked beak-ridges. (It is evident that these beak-ridges commence at the terminations of the hinge-line, and are the relics of previous terminations; they are therefore correlated with the degree of abruptness with which the hinge-line terminates—that is, with the development and acuteness of the cardinal angles.) The delthyrium is large and extends into both valves; its ventral area is more or less covered with ankylosed deltidial plates (see Pl. IV, figs. 3 & 4; and T. Davidson, 1863, vol. ii, pl. liv, fig. 14), discrete along the greater portion of their inner margins, but coalescing near the apex of the valve; they are very similar to those figured by Hall as occurring in *Ambocœlia umbonata*. The dorsal valve of *Crurithyris* also appears to possess a covering-plate or plates analogous to those of the ventral valve; such plates are likewise recorded in *Ambocœlia*.

In *Crurithyris* the ventral umbo is large and moderately inrolled, while that of the dorsal valve is relatively markedly prominent and not infrequently cacuminate. In *Ambothyris*, on the other hand, the ventral umbo is only slightly incurved, and the cardinal area is almost plane.

Ornament.—Both King and Davidson recorded the presence of spines on certain members of the British species, the former especially creating, in part, a new species for the reception of the Permian spinose forms. I have seen spines on specimens of three species of *Crurithyris*; their absence in at least some of the other species of the genus is in all probability due to conditions of preservation. It has been shown by various authors (for example, J. Hall & J. M. Clarke, 1892, p. 608; C. Leidhold, 1922, pl. xiii; C. Beecher, 1898) that in numerous groups of Brachiopoda spines are characteristically developed by a process of imbrication at the points of coincidence of transcrescent and concrescent ornamental features. In *Crurithyris*, however, there is little evidence of such development. In most species growth-lines are exceed-

[1] S. S. Buckman (1917, p. 230) has suggested a series of terms for the various stages attained in the development of the hinge-margin in the Terebratuloids, of which, as nearly all those shells possess a curved hinge-line, only one ('megathyrid') is applicable to the Spirifers. The following supplementary terms are therefore suggested:

Megistothyrid: Hinge-line straight and very long, cardinal angles acute. As in *Spirifer alatus* and *Spirifer convolutus*.

Megathyrid: Hinge-line straight and long, cardinal angles approximately right angles. As in *Spirifer bisulcatus*.

Brachythyrid: Hinge-line straight and considerably shorter than the width of the shell, cardinal angles obtuse. As in *Spirifer ovalis* and *Spirifer decorus*.

ingly delicate, and in none of the forms is there any development of costation. Although spines are developed, rather irregularly, along growth lines, they are not arranged correspondingly on contiguous rows in radial linear series, and there is no longitudinal ridge connecting any two spines along their length, such as frequently occurs, for example, amongst the Productids. The spines are simple, of circular or slightly oval cross-section, and do not traverse the substance of the shell to the interior; nevertheless, the spines pass through some thickness of the shell, as may be clearly seen in some translucent specimens. Although at present they are apparently solid throughout, it is evident that during the extension with growth of the particular lamella upon which they occur they must have been hollow, and were connected with the interior of the shell by cæcal prolongations of the mantle. These, however, occurred only along the shell-secreting border of the mantle, and must have retracted with further addition of shell material, causing the spines to be cut off from the interior. The spines are more or less evenly distributed over the surface of both valves (except, of course, on the cardinal areas, for such ornament, like the remainder of the shell substance, is introduced peripherally during growth, and while the peripheral portion of the areas is in operation as a hinge). There is no increase in size of the spines with growth, but in all the spine-bearing species there appear to be two series of spines, which are of different sizes, and between which there is no gradation. The larger spines are sporadically distributed, and in one species at least (*Crurithyris urei*) are not evenly scattered either over both valves or over one individual valve: the magnispinous development is apparently in catagenesis. In *Crurithyris magnispina sp. nov.*, on the other hand, there seems to be an anagenetic development of the series in the dorsal valve.

The spines are rarely preserved entire; in the great majority of specimens they are broken off near the surface of the shell and are represented only by the spine-bases. From each base there usually extends towards the anterior border a narrow, elongate, triangular depression on the surface of the shell—presumably the groove in which the spine originally reposed.

The ornament of *Ambothyris* is very different. Spines are absent, and the surface is marked with a series of fine transcrescent striæ. These extend from the umbo to the anterior border, and remain of approximately the same size throughout growth, increasing in number by dichotomy.

Shell-structure.—In all the specimens of *Crurithyris* I have examined in which the shell-structure is sufficiently well preserved, the thick inner prismatic layer can usually be well seen, and shows the minute structure in considerable detail.

It consists of a more or less parallel arrangement of closely-set polygonal prisms, such as characterize the majority of the Articulata. These extend in a direction normal to the lines of growth, and are inclined at a fairly low angle, sloping anteriorly when traced from the external surface. The imbricated mosaic designed by the terminations of the prisms may be observed on the inner shell-surface, when this is carefully removed, the borders of the prisms being slightly depressed into the shell-substance. Consequently, well-preserved internal moulds display exquisitely this imbrication, which extends not only over the surface, but also on to the internal structures, such as the cardinal process and the crural plates (see J. Young, 1886, p. 151). In none of the forms are punctæ developed.

Cardinal process.—This structure has been seen in *Crurithyris amœna sp. nov.*, in *Crurithyris magnispina*, and in *Crurithyris urei*. In all these species it shows little variation, and consists of a low elevation above, rather than a projection from, the hinge-plate, such as occurs in most members of the Spiriferidæ. It deserves special mention, however, as its appearance differs considerably from that of the other members of the family. In most genera of the latter it is a 'low, transverse, sessile apophysis, having its surface vertically striated' (J. Hall & J. M. Clarke, 1894, p. 6). The process in *Crurithyris*, while possessing the transverse sessile habit, differs markedly in being ornamented with bluntly rounded elongate tubercles, symmetrically arranged, which appear as deep pittings on the internal mould.

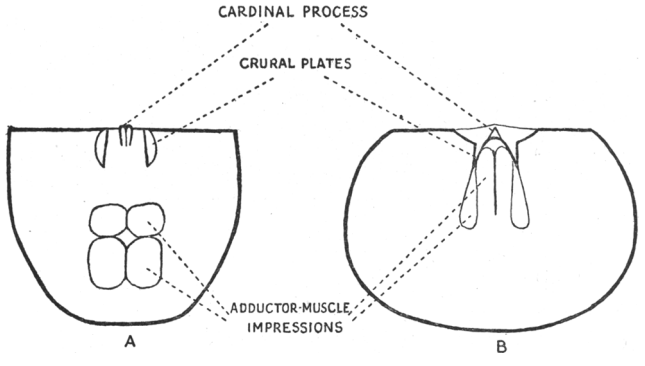
In contrast to this, Hall's figures of *Ambocœlia umbonata* (J. Hall, 1860, p. 72, figs. 4 & 5) indicate that the process in that species projects posteriorly to a considerable extent above the surface of the dorsal valve, is bifid and not unlike that of certain of the Productids in appearance, and is devoid of either striations or tubercles (and, apparently, of all other surface markings). (For a comparison of the internal features of *Crurithyris* and *Ambocœlia*, see fig. 3.)

Internal Septa.—In all the species of *Crurithyris*, the ventral valve is devoid of apical or other plates, though occasionally there may be a low bluntly-rounded median elevation dividing the muscle-area, such as that relatively well marked in the type of *Crurithyris unguiculus*.

Hall emphasized, as a characteristic of *Ambocœlia*, the presence on each side of the cardinal process in the dorsal valve of two more or less well-developed, sub-parallel, lamellar extensions connecting the bases of the crura with the floor of the valve; these have generally been considered to have served as supports for the crura, and have received the name of

'crural plates'. It is doubtful, however, whether the plates functioned as such supports; for example, I have shown (1927, May, p. 199) that in *Camarophoria* the crura are quite distinct and removed from these plates (which in that genus are modified to a spondylium). In *Ambocœlia* and *Crurithyris* the crural plates not infrequently appear absurdly massive and long, and in some species (as in the type of *Ambocœlia*) apparently do not support the crura for any considerable distance. In yet other species—for instance, *Ambocœlia levicula* Rowley? Girty (1911, p. 73)—the plates are absent or imperfectly developed: that is, are incipient or obsolescent. In view of the invariable contiguity of the postero-lateral borders of the muscle-area with these plates, it may be suggested that

FIG. 3.



Diagrammatic reconstructions of the internal structures of the dorsal valve of A, *Ambocœlia* (after Hall), and B, *Crurithyris*, showing the differences in the length of hinge-line, in the cardinal process, and in the shape and location of the muscles.

they more probably increased the area of attachment of the adductor-muscles, which would thus become more efficient. The variable development of these plates in different species implies that the character is not absolutely diagnostic for the genera—probably there is a cyclical series of changes during evolution. As with the development of a planate dorsal valve, the stage attained by the crural plates is apparently unconnected with the stratigraphical horizon of the respective forms: that is, the several forms at present known are, for the most part, not closely connected genetically.

On internal moulds, the plates appear as more or less well-marked notches running anteriorly from the borders of the teeth-sockets.

Musculature.—No indications of pedicle-muscles have

been observed on any of the forms described. On the other hand, the impressions of the adductor- and divaricator-muscles are frequently well displayed on internal moulds.

In the ventral valve, the situation of these muscle-impressions agrees with that of *Ambocœlia umbonata* as described by Hall. They invariably consist of a pair of narrow, elongate, almost linear, adductors, sometimes divided by a residual median septum, flanked by a pair of relatively wider, but still elongate, divaricators, the whole being located in the posterior umbonal region.

Hall laid much emphasis upon the shape and position of the muscle-impressions of the dorsal valve as a distinguishing feature of *Ambocœlia*: he remarked them to be situated towards the anterior border, and his figures show four subquadrate scars of approximately equal size, one pair lying completely posterior to the other. This arrangement is very different from that which occurs in any hitherto described genus of the Spiriferidæ. In this particular, none of the British specimens agrees with Hall's description; the muscle area in *Crurithyris* is essentially contained within and continued anteriorly from the crural plates: that is, it occupies the mid-posterior and umbonal region of the valve. The muscle-scars consist, as in most Spirifers, of two pairs of adductors. One pair lies almost in contiguity with the hinge-line between the crural plates; the two elements are usually in contact, or may be separated by a residual septum. The second pair is situated outside and anterior to the first, which, posteriorly, it partially encloses; posteriorly also, this pair is in lateral contiguity with the crural plates. Not infrequently, the outer adductors may commence as simple undivided units, but become bifid or trifid towards the anterior.

Vasculature.—Very occasionally, the vascular system can be determined. Little else than radiating depressions on the anterior and lateral portions of the inner shell surface can usually be seen; the customary system of branching canals has not been recognized.

Genitalia.—While these are well marked on the ventral valve of certain American species—for example, *Ambocœlia spinosa* Clarke Grabau (1899, p. 279) and *Ambocœlia umbonata* Hall Prosser & Kindle (1913, p. 201)—they have not been seen on any British forms.

Brachidium.—This structure has been seen in specimens of *Crurithyris clannyana* (T. Davidson, 1857, vol. ii, pt. 4, pl. i, fig. 49); it has also been determined in *Crurithyris urei* by means of serial sections. In both species it consists of two spiralia directed laterally, as in *Ambocœlia umbonata* and in other members of the Spiriferidæ; each spiral is composed of

from three to six whorls. In no instance has a jugum or jugal processes been observed.

IV. Classification

Ambocœlia has been considered to be closely related to the lævigate Spirifers, and has usually been classed with the Martiniinæ, Waagen, as by Schuchert (1913, p. 142) on the basis of its 'usually smooth surface', and by Frederiks (1926, p. 399) because of an absence of internal plates in the ventral valve. Waagen (1883, p. 498), on the other hand, referred it to the Reticulariinæ, Waagen, the members of which subfamily he supposed to possess a surface-ornament consisting of hair-like processes, and to be devoid of internal plates in either valve.

The previous discussion on morphology shows clearly the differences between the *Ambocœlia* group and *Martinia*. The latter genus, together with its close ally *Brachythyris*,[1] is characterized in its most primitive species by a smooth shell-surface, but this lævigate condition is modified in the more advanced species by the development of radially disposed costæ, which differ from the striations of *Ambocœlia* and *Ambothyris*, and more obviously from the spines of *Crurithyris*. In shell-sculpture the Martiniinæ are characterized by the development of a sulcus in the ventral valve and of a corresponding median fold in the dorsal—that is, the development is from an unmodified biconvex to an everse alternate uniplicate stage, which may become further complicated. In the three genera here considered, the shape-development is the reverse of this in the dorsal valve: the neanic convex condition becomes planate or even concave (as opposed to inflated) with growth, and there is frequently present a more-or-less prominent median sulcus; this, together with a sulcate ventral valve, leads to shell-sculpture in the opposed stage, and in those species in which the dorsal sulcus is more prominent than the ventral, the shape becomes inverse. Internally, differences between the groups are equally distinct. *Martinia* possesses a cardinal process striated as in *Spirifer*, is completely devoid of internal plates in both valves, and in the disposition of the muscle-scars, particularly in the dorsal valve, is very dissimilar from both *Ambocœlia* and *Crurithyris*.

The various species which have hitherto been referred to *Reticularia*, while being analogous to *Crurithyris* in the possession of a spinous ornament, differ from that genus and from *Ambocœlia* in a manner similar to that of the Martiniinæ. The development of the shell-shape is from biconvex rectimarginate to everse alternate uniplicate, while, internally, comparable differences exist in the cardinal process, in the

[1] For an outline-study of these forms, see T. N. George, 1927, March.

musculature, and in the absence of crural plates in the dorsal valve.

It is evident, therefore, that *Ambocœlia*, *Crurithyris*, and *Ambothyris* are radically different from either the Martiniinæ or the Reticulariinæ, in which two subfamilies the species now referred to those genera have previously been placed. It is equally evident that they are as distantly removed from the other subfamilies of the Spiriferidæ. Consequently, I have little hesitation in creating for their reception a new subfamily —the Ambocœliinæ. The proposed classification may be summarized as follows:

SPIRIFERIDÆ King, 1846, emend. Schuchert, 1913

'Derived Spiriferacea with the crura directly continuous with the bases of the primary lamellæ, which are situated between the laterally-directed spiralia. Jugum simple, complete or incomplete.'

AMBOCŒLIINÆ subfam. nov.

Specialized Spiriferidæ with a jugum very much reduced or completely absent; spiralia with few and widely-spaced coils. Shell-shape everse becoming inverse; shell-sculpture, when present, opposed. No internal plates in ventral valve; crural plates more or less developed in dorsal valve.

AMBOCŒLIA Hall, 1860

Hinge-line advanced, forming the greatest, or nearly the greatest, width of shell. Ventral umbo markedly incurved. Surface-ornament filistriate-clathrate. Cardinal process projecting, bifid, smooth. Dorsal musculature specialized, consisting of four equi-sized quadrate adductors situated anteriorly.

Genotype—*Orthis umbonata* Conrad.

AMBOTHYRIS gen. nov.

Hinge-line advanced, forming the greatest, or nearly the greatest, width of shell. Ventral umbo primitive, feebly incurved. Surface-ornament (? smooth to) planistriate. Internal features, other than crural plates, unknown.

Genotype—*Spirifer infimus* Whidborne.

CRURITHYRIS gen. nov.

Hinge-line relatively primitive, considerably less than the width of shell. Ventral umbo markedly incurved. Surface-ornament (? smooth to) spinose. Cardinal process sessile, elevated, triangular, tuberculate. Dorsal musculature normally situated, muscle-scars elongate.

Genotype—*Spirifer urei* Fleming.

It is with some doubt that all three genera are united within the one subfamily. They are evidently very similar in shell-shape, in opposed shell-sculpture, in internal septation, and in their small size and cardinal development. But they are markedly different in ornament, and in the features of the cardinal process and dorsal musculature. It is possible that further research, particularly on the species of *Ambocœlia* (*sensu stricto*), may demonstrate the complete independence of the genera.

It is evident that several American species that have in the past been referred to *Ambocœlia*—for example, *Ambocœlia levicula* Rowley? Girty, *Spirifer modestus* Clarke, and probably *Spirifer plano-convexus* Shumard—are not members of that genus, and probably would be more correctly included in *Crurithyris*. The remarkable similarity in the structure of the spines of certain other American species (*Ambocœlia nana* Grabau, *Ambocœlia spinosa* Clarke) with those of the British species suggests a transference here also.

V. Systematic Description of the British Species

(*a*) AMBOTHYRIS

Ambothyris infima (Whidborne). Pl. III, figs. 1 & 2.

Spirifera infima G. F. Whidborne, 1893, vol. ii, pt. 3, pl. xiii, figs. 1–3.

Of the three specimens figured by Whidborne, and considered by him doubtfully conspecific, I select the largest specimen (illustrated in Whidborne's fig. 1) as lectotype.

Description of the Lectotype

External features.—The shell is of moderate size for members of the subfamily, tumid, slightly wider than long, with a hinge-line a little less than the width of the shell. The cardinal areas are well developed, that of the ventral valve being very deep and only gently incurved. The obtuse cardinal extremities approach right angles, but no angular beak-ridges are present (probably a result of exfoliation); the ridges are clearly defined on the dorsal valve. The delthyrium is wide and large; no delthyrial plates can be observed.

The ventral valve is considerably stouter than the dorsal (though not to the extent represented in Whidborne's figure), but the latter remains moderately convex throughout growth, and there is little or no flattening apparent. While the median portion of the ventral valve shows no ontogenetic modification, the dorsal valve, at about two-thirds of its length, develops a

median furrow, ill-defined from the flanks, increasing in prominence anteriorly. The anterior border is thus slightly sulcate. The lateral margins are practically straight.

No ornament can be observed, possibly as a result of exfoliation.

Internal features.—These cannot be determined in the lectotype.

Lectotype.—A specimen in the Whidborne Collection in the Sedgwick Museum, Cambridge, from the Middle Devonian of Lummaton, Devonshire.

Description of the Syntypes

The specimen represented in Whidborne's fig. 2 differs considerably from the lectotype in possessing a feeble, though clearly defined, ventral median sulcus. The dorsal valve is decidedly planate, with a relatively cacuminate umbo; its median sulcus is broad and poorly defined. The anterior margin is slightly sulcate, but more broadly so than in the lectotype. Ornament is preserved on the ventral valve: this consists of very fine regular transcrescent striæ, separated by relatively flat elevations, which remain of about the same size throughout growth, and increase in number by dichotomy; the striæ are clearly defined from the umbo, and there are about 18 to 20 in a width of 1 millimetre.

The specimen represented in Whidborne's fig. 3 is similar to the lectotype in general shape, but differs in its relatively shorter hinge-line, narrower cardinal areas, and incurved ventral umbo. It may represent a young stage.

In both the syntypes, the translucent dorsal valve shows more or less clear indications of the crural plates; these appear to converge when traced anteriorly, thus differing from those of *Crurithyris*, which diverge.

Dimensions.—

Specimen illustrated in Whidborne's	fig. 1.	fig. 2.	fig. 3.
Length	7·2 mm.	4·0 mm.	4·4 mm.
Length of dorsal valve	6·0 mm.	3·2 mm.	3·5 mm.
Width	7·9 mm.	5·0 mm.	4·3 mm.
Depth	5·3 mm.	3·8 mm.	3·0 mm.
Length of hinge-line	about 7·4 mm.	about 4·6 mm.	about 3·0 mm.
Length of crural plates	—	about 0·8 mm.	about 0·7 mm.

Remarks.—I much doubt whether the three specimens are conspecific. The differences in shape may be due merely to variation, but the small size, megathyrid hinge, planate dorsal valve, and ventral sulcus of the striate syntype indicate that it is a form morphologically more advanced than the others.

(*b*) CRURITHYRIS

CRURITHYRIS AMŒNA sp. nov. Pl. V, figs. 5 & 6.

Ambocœlia urei (Fleming), T. N. George, 1927, March, p. 119.

Description of the Holotype

External features.—The shell is of moderate size, tumid, almost as long as broad, subtrigonal in outline. The transversely ovate dorsal valve is considerably shorter than the ventral. The hinge-line is rather greater than half the width of the shell. The obtuse cardinal angles are well marked; beak-ridges are distinct in both valves. The dorsal cardinal area is unusually wide. The ventral umbo is moderately large and projects considerably behind the hinge-line; the apex is broken and the degree of incurvature cannot be determined. The dorsal umbo is moderately prominent, not cacuminate. There is little change in shell-outline with growth. The ventral valve is considerably stouter than the dorsal, though the latter is regularly curved from the umbo to the anterior border.

For the greater portion of its length the ventral valve remains entire, though the median portion is slightly flattened, but towards the anterior border there is developed a broad, shallow, ill-defined furrow. A relatively deep and more distinct furrow is present near the anterior border of the dorsal valve. The anterior margin is feebly sulcate. The lateral commissures are practically straight.

No indications of ornament can be seen.

Internal features.—The crural plates may be observed within the delthyrium of the dorsal valve, but they are better seen in moulds of other specimens.

Holotype.—A specimen in the British Museum (Natural History), No. B56428, out of my collection, from the Upper Limestone Shales (Avonian D_2–D_3 Zone) of Port Eynon Bay, Gower, Glamorganshire.

Dimensions.—

Length	6·2 mm.
Length of dorsal valve	4·6 mm.
Width (calculated)	about 6·5 mm.
Depth	4·0 mm.
Length of hinge-line	about 3·6 mm.

Remarks.—In no specimens have spines been seen.

A series of topotypes and chorotypes, together with some specimens from the Upper Limestone Shales of the Cribarth neighbourhood (Tawe Valley, Glamorganshire) display the

internal features in minute detail. The cardinal process is characteristic, very similar to that of *Crurithyris magnispina* (Pl. V, fig. 4) but apparently with fewer and relatively larger tubercles. The location of the ventral muscle-scars is normal. In the dorsal valve, however, there is considerable variation, both in the shape of the scars and in their degree of depression into the shell; those of the outer pair vary between the simple lachrymate shape (Pl. V, fig. 6) and the subdivided tripartite condition such as is seen frequently in *Crurithyris urei* and *Crurithyris magnispina*.

The species is more-or-less readily distinguished from the other Avonian forms by its external characters, though it presents many similar features to *Crurithyris magnispina*. Internally it presents differences, particularly in the features of the cardinal process, and in the narrow lachrymate outer pair of dorsal adductor-muscle impressions; when the latter become tripartite, however, there is danger of confusion.

CRURITHYRIS CARBONARIA (Hind)

Ambocœlia carbonaria Wheelton Hind, 1905, p. 531, pl. xxxv, figs. 7 & 7*a*.

Of the two syntypes figured by Hind, that represented in his fig. 7*a* (a dorsal valve) is preserved as the holotype. The specimen of fig. 7 has not been definitely recognized.

Description of the Holotype

External features.—The shell (dorsal valve only) is of moderate size, slightly broader than long, with a hinge-line equal to rather more than half the width of the shell. The narrow cardinal area is distinctly defined from the flanks by angular beak-ridges. The shell is subcircular in outline, the antero-lateral margins being slightly expanded. There is a considerable change in outline during ontogeny, the early stages being much more elongate and the hinge-line relatively much longer, the cardinal angles approaching right angles, while the outline is more subquadrate. The shell, with a well-marked cacuminate umbo, becomes flattened anteriorly. The median sulcus is comparatively prominent, commencing near the umbo; it is delimited from the flanks by two radial undulations, which, while being by no means prominent, give the shell a characteristic tripartite appearance.

No ornament can be seen, though the shell is well preserved.

Internal features.—These are not displayed.

Holotype.—A specimen in the Wheelton Hind Collection in the British Museum (Natural History), No. B47308, from the Coal Measures below the Gin Mine Coal (*pulchra* Zone), of Nettlebank Colliery, Staffordshire.

Dimensions.—

Length (of dorsal valve) 5·0 mm.; Width 5·6 mm.

Remarks.—In other specimens the ventral valve is moderately stout, considerably longer than broad. The umbo is considerably inrolled. The ventral sulcus is relatively very prominent, but is more marked towards the umbo than anteriorly (Hind's fig. 7 is a fairly good representation, but the sulcus is generally much deeper and more excavated in the umbonal region than is shown in the figure). The ventral valve is spinose, both series of spines being present over the entire surface; they are of about the same size and density as in *Crurithyris urei*.

In the dorsal valve the crural plates are fairly prominent, but are not so well-developed as are those of the Lower Carboniferous species. Between them the posterior adductors are clearly defined, while each of the anterior pair is more or less crescent-shaped, the concave side being turned inwards; the impressions are shorter and narrower than in most species. The features of the cardinal process have not been determined. In the ventral valve the relatively narrow adductors are partly enclosed by slightly wider divaricators.

As Hind pointed out, the species differs widely from *Crurithyris urei* (and from the other species of *Crurithyris*), not only in its shell-outline, but also in the presence of the elevations bordering the dorsal median sulcus, and in the deeply excavated ventral sulcus which becomes catagenetic towards the anterior margin. The ventral valve, however, is not unlike that of *Crurithyris unguiculus* in its internal as well as its external features; the latter species is distinguished by its more prominent ventral sulcus and by the characters of the musculature of the dorsal valve.

CRURITHYRIS CLANNYANA (King). Pl. V, figs. 7–10.

Martinia clannyana W. King, 1848, p. 9.
Martinia clannyana W. King, 1850, p. 134, pl. x, figs. 11–13.
Martinia clannyana W. King, 1856, p. 337.
Spirifera ? *clannyana* (King), T. Davidson, 1857, vol. ii, pt. 4, p. 15, pl. i, figs. 48 & 49.
Martinia clannyana King, K. von Schauroth, 1853, p. 186, figs. 16 & 27.
Spirifer clannyanus (King), K. von Schauroth, 1856, p. 215.
? *Martinia winchiana* W. King, 1848, p. 9.
? *Martinia winchiana* W. King, 1850, p. 135, pl. x, figs. 14–17.
? *Martinia winchiana* W. King, 1856, p. 338.

The two species *Crurithyris clannyana* and *Crurithyris winchiana* are here considered synonymous, but with some hesitation. According to King's original descriptions, the only real distinguishing feature between them is the presence of spines on *Crurithyris winchiana*, but spines were later recorded on *Crurithyris clannyana* by both von Schauroth and Davidson.

Apart from this ornament, the great similarity between the species is evidenced by King's figures, which, however, are synthesized. Unfortunately, direct comparison is not possible, as the original syntypes of *Crurithyris clannyana* (which has priority over *Crurithyris winchiana*) cannot be discovered. Further confusion is entailed by the fact that none of the specimens of *Crurithyris winchiana* figured by King in 1850 (from which, presumably, the type of that species must be taken) is spinose; they were, also, obtained from a locality different from that of the types of *Crurithyris clannyana*. In these circumstances, and in view of the possibility that further work, especially on the external characters of the species, may show them to be distinct, it appears inadvisable to select a lectotype of *Crurithyris clannyana* from amongst the syntypes of *Crurithyris winchiana*; the neotype here described is a topotype preserved in the Davidson Collection at the British Museum (Natural History).

Description of the Neotype

External features.—The specimen is an internal mould. The shell is small, rounded in outline, slightly broader than long. The hinge-line is rather more than half the width of the shell. The cardinal extremities are obtusely angular. The dorsal valve is considerably shorter than the ventral, and there is, apparently, some development of a planate anterior portion, which is, however, obscured by the median furrow; the dorsal umbo appears to be cacuminate.

The ventral median sulcus is shallow and poorly defined, but extends along practically the whole length of the shell. The broad clear-cut dorsal sulcus is more prominent than the ventral, particularly so anteriorly. The anterior margin is slightly sulcate. The lateral commissures are practically straight.

Internal features.—The crural plates are well-displayed as prominent notches; they are set widely apart, and are shorter than in most other British species. No details of the musculature or cardinal process can be observed.

Neotype.—A specimen in the Davidson Collection in the British Museum (Natural History), No. B50301, from the Permian (Magnesian Limestone), of Field House, Ryhope, Northumberland.

Dimensions.—

Length	2·8 mm.
Length of dorsal valve	2·3 mm.
Width	3·0 mm.
Depth	1·7 mm.
Length of hinge-line	about 2·0 mm.
Length of crural plates	about 0·4 mm.

Remarks.—Some specimens from the Muschelkalk of Pössneck, Thuringia, studied for comparison, show the cardinal areas of both valves to be very well developed, that of the dorsal valve being very broad; beak-ridges are prominent and angular.

Davidson has figured a British specimen of the species which shows the delthyrial plates well developed, and meeting and coalescing along the middle line to cover the greater portion of the ventral delthyrium.

It has already been remarked that the characteristic spines of the genus have been recorded on several individuals, but I have not observed them personally, and can offer no details concerning their form and distribution.

On few of the smaller specimens is there any indication of the internal features, other than crural plates, but on some of King's types of *Crurithyris winchiana* the muscle-scars are well-displayed; their situation is normal for *Crurithyris*. In the ventral valve the inner adductors are relatively long—about one-third the length of the shell—and wider than in other species; not infrequently, they are divided by a feeble septum. Anteriorly, they may be continued to the border as a more or less rounded ridge (on the internal mould), which is, presumably, a relic of the vascular system. They are surrounded by the shorter and stouter divaricator muscles. The dorsal musculature has not been clearly determined, but it is evident that the scars are situated between and anterior to the crural plates, and are sometimes divided by a median septum.

The more minute details of the cardinal process have not been observed, but in general form it is the typical triangular sessile elevation characteristic of the genus.

Crurithyris clannyana is readily distinguished from the other British species by the shorter and more widely set crural plates, and by the more transverse anterior border of the hinge-plate. Externally, the tumid form, the wide dorsal cardinal area, the feebly incurved ventral umbo, and the development of sulci are contributory distinguishing characters.

CRURITHYRIS FISSA sp. nov. Pl. IV, fig. 5.

Description of the Holotype

External features.—The shell is larger than in most species of this genus, transversely ovate, slightly broader than long, with a hinge-line rather more than half the width of the shell. The cardinal angles and beak-ridges are obscure, probably as a result of exfoliation. Both valves are moderately tumid; there is no development of anterior dorsal planation. There is very little change of shape with growth.

A sharply incised furrow, very narrow and distinctly delimited from the flanks, extends along the whole length of both valves. The anterior border, consequently, bears a slight median notch in dorsal view. The lateral commissures are practically straight, as also is the anterior margin in anterior view.

The ventral umbo is moderately large and incurved; the cardinal area is wide and bears a prominent delthyrium. The dorsal umbo is inconspicuous and the cardinal area very narrow.

No ornament can be observed.

Internal features.—The crural plates, seen through the translucent shell, are set rather closely together, are moderately long, and diverge at a low angle.

Holotype.—A specimen in the Wheelton Hind Collection in the British Museum (Natural History), No. B50290, from the Avonian, D_2 Zone, of Park Hill, Derbyshire.

Dimensions.—

Length	10·6 mm.
Length of dorsal valve	8·3 mm.
Width	12·5 mm.
Depth	7·2 mm.
Length of crural plates	about 1·8 mm.

Remarks.—Metatypes show slight variation. The dorsal valve may become slightly planate anteriorly, and the anterior margin may be faintly sulcate, while the dorsal umbo is sometimes cacuminate.

The species is readily distinguished from all other British forms by its large size, relatively great width, the deep narrow median incision in both valves, and the more or less corresponding convexity of the valves. In its convexity it approaches the form described as *Spirifer carlukensis* by Davidson (1858, vol. ii, pt. 4, p. 59, & pl. xiii, fig. 14), from which, however, it differs in most other characters.[1]

CRURITHYRIS MAGNISPINA sp. nov. Pl. V, figs. 1–4.

? *Spirifera urii* Fleming, T. Davidson, 1858, vol. ii, pt. 4, p. 58 (pars.), pl. xii, figs. 13 & 14, and 1862, vol. ii, pt. 5, pl. liv, fig. 14.

[1] It is probable that *Spirifer carlukensis* is a member of a new genus —a Martiniid—though it is clear that Davidson considered it allied to *Crurithyris urei*. It agrees with the Martiniids in the development of a uniplicate anterior border, and in its dorsal valve being neither planate nor medially sulcate. The ventral umbo, also, is very much less prominent and inrolled than in all species of *Crurithyris* (though in this character it is similar to *Ambothyris*), while the dorsal umbo is not cacuminate. Ornament appears to be absent. The species is peculiar in its perbrachythyrid hinge-line, and in its diminutive ventral umbo.

Description of the Holotype

External features.—The shell is large, rather longer than broad, with a hinge-line equal to about two-thirds the width of the shell. The cardinal areas are well developed, though that of the ventral valve is relatively narrow. The cardinal extremities are obtusely angular, and beak-ridges are well marked. The ventral umbo is considerably inrolled; the dorsal umbo appears to be cacuminate.

The dorsal valve appears to be slightly flattened anteriorly, and to be very shallowly sulcate. The ventral sulcus is somewhat more prominent, but only leads to slight median depression; it commences near the umbo, and becomes, if anything, rather less distinct anteriorly. The lateral and anterior margins are practically rectimarginate.

The ornament is well displayed. The first order of (smaller) spines, as in *Crurithyris urei*, covers the surface of both valves, and has approximately the same density of surface distribution as in that species. The second order of (larger) spines is also present, but occurs on the dorsal as well as on the ventral valve; these have a density of about 5 to 10 per square millimetre—that is, they are larger than the corresponding series in *Crurithyris urei*. During ontogeny there is very little change in the development or distribution of the spines.

Internal features.—None of these is displayed.

Holotype.—A specimen in the Young Collection in the Hunterian Museum, University of Glasgow, No. L1794, from (? the D_2–D_3 Zone of) the Avonian of Thornton, Busby, Lanarkshire.

Dimensions.—

Length	9·2 mm.	
Length of dorsal valve	7·2 mm.	
Width	8·9 mm.	
Depth	4·2 mm.	(but the specimen is slightly crushed)
Length of hinge-line	about 6·2 mm.	

Remarks.—Chorotypes show little variation in shape. The dorsal valve may be sometimes more inflated than in the type; the anterior margin is occasionally feebly sulcate. The dorsal umbo is cacuminate. During ontogeny there is little change in shape, but the neanic trapezoidal outline recalls young specimens of *Crurithyris urei*.

The two orders of spines are present on both valves of all specimens when these are sufficiently well preserved. They are more or less evenly distributed for the most part, but in certain forms the larger spines occur only on the anterior and lateral portions of the dorsal valve, the umbonal region being

only microspinous: that is, the ontogenetic development of the larger spines in the dorsal valve shows anagenesis. In the ventral valve there is practically no change.

Specimens from Kittoch Water, Lanarkshire, display the internal features. The imbricate shell-structure is usually very clearly visible; the polygons are more or less rhomboidal and slightly elongated longitudinally; there are approximately 900 to 1000 per square millimetre. On other specimens, the larger spines appear to give rise to corresponding depressions on the inner surface of the shell; nevertheless, it is evident that the mantle was not continued into any cavity in the spine.

The cardinal process (Pl. V, fig. 4) is characteristically tuberculate, triangular.

The adductor-muscles are similar to those of *Crurithyris urei* and of *Crurithyris amœna* in the frequent and sometimes extreme tripartite development of the outer pair.

The crural plates are very prominent, are set at a moderate distance apart, diverge slightly towards the anterior, and have a comparatively wide basis of attachment to the floor of the dorsal valve. The portion of the muscle-scar between them has a well-rounded posterior termination, in contrast to the relatively bifid character of that usual in *Crurithyris amœna* and to the acutely angular termination in *Crurithyris urei*.

In the ventral valve the inner adductors are very narrow, approaching linear, and extend anteriorly for about a third of the length of the shell; the divaricators are approximately parallel-sided and are almost as narrow as the adductors, which they bound for their whole length. Anteriorly, the middle line of the muscle-area, which may be marked by a blunt septum, is continued to the margin as a narrow, rounded depression, presumably of vascular origin.

The species is well marked, and readily distinguished from most others by its large size, spinous development, and internal characters. It is, perhaps, most closely allied to *Crurithyris amœna*, but the differences in the cardinal process and dorsal musculature are distinctive.

CRURITHYRIS UNGUICULUS (J. de C. Sowerby). Pl. III, figs. 3–6.

Atrypa unguiculus J. de C. Sowerby, 1840, pl. liv, fig. 8.
Spirifera unguiculus (Sowerby), J. Phillips, 1841, p. 69, pl. xxviii, fig. 119.
Spirifera urii Fleming, T. Davidson, 1864, vol. iii, pt. 6, p. 41, pl. iv, figs. 25–28.
Spirifera (*Martinia*?) *urii* Fleming, G. F. Whidborne, 1897, vol. iii, p. 157, pl. xix, figs. 5–7.

Sowerby figured, very badly, two poorly-preserved specimens which show the interior of the ventral valve only. Of these the larger is here selected as lectotype of the species.

Description of the Lectotype

The specimen, a ventral valve, is an internal mould, and none of the characters of the shell structure or ornament can be seen.

The shell, slightly crushed, is of moderate size, rather broader than long, with a hinge-line considerably less than the width of the shell. The cardinal extremities are subangular, and the beak-ridges are apparently well marked. A shallow, rather narrow, sulcus is present in the anterior region of the valve.

A relatively well-developed median septum, extending anteriorly from the umbo for about a third of the length of the shell, separates two very narrow elongate muscle-areas. Faint radiating ridges on both this specimen and the paratype presumably represent relics of the vascular system.

Lectotype.—A specimen in the Sedgwick Museum, from the Upper Devonian of South Petherwin, Cornwall.

Dimensions.—

Length	about 7·0 mm. (? +)
Width	about 8·0 mm.

Remarks.—The original syntypes being so poor, I append a supplementary description of some well-preserved chorotypes, in the collections at the British Museum (Natural History) and the Museum of Practical Geology.

External features.—The shell is usually rather longer than wide, with a hinge-line slightly longer than half the width of the shell. The cardinal areas are narrow; the ventral umbo is considerably inrolled. The hinge-extremities are obtusely angular; beak-ridges are clearly defined. The features of the delthyrium have not been determined.

During growth the dorsal valve becomes decidedly planate in many specimens, though in others (for example, in Phillips's types) it may remain convex. The umbo appears to be cacuminate.

The rather narrow ventral sulcus, relatively clearly defined from the flanks, is well marked throughout, becoming increasingly prominent anteriorly. The dorsal sulcus is feeble, appearing at about half-size. In dorsal view the anterior border shows a marked notch, but in anterior view is practically straight, as are also the lateral commissures.

No ornament has been observed on any specimens, although the shell structure is frequently well preserved.

Internal features.—The internal features are well-displayed on certain of Phillips's types.

The ventral adductors are almost linear, extending from the umbo for about half the length of the shell. The divaricators

are shorter, and are situated outside and slightly posterior to the adductors. A median septum, prominent at the umbo, terminates anteriorly with the adductors.

The crural plates are well developed but short and closely set, extending anteriorly at a markedly obtuse angle. The posterior adductors are narrow and elongate, though rather short, set between the crural plates for about half their length. The anterior pair is not clearly defined, but each is apparently rather broad, subtriangular to pyriform in outline, and removed from the posterior pair by a slight elevation.

Faint radial markings, presumably of vascular origin, can frequently be observed.

Dimensions (of a typical specimen, illustrated in Pl. III, fig. 3).—

Length	6·3 mm.
Length of dorsal valve	4·7 mm.
Width	6·2 mm.
Depth	3·8 mm.
Length of hinge-line	about 3·4 mm.

The species is easily recognized by the stout ventral valve and turgid ventral umbo, the marked ventral sulcus, the short, closely-set crural plates, and the disposition and size of the dorsal muscle-impressions.

Davidson (1864, vol. iii, pt. 6, p. 41), in his description of these Devonian forms under the title of *Spirifera urii*, remarked that ' This little species has been fully described in the second volume of this work [that is, in the volume on the Carboniferous Brachiopoda]; therefore all we need now repeat is, that the Permian, Carboniferous, and Upper Devonian specimens are identical in shape and character. . . .' He even reproduced in practically identical phraseology his description of the Carboniferous species, recorded the presence of spines in the Devonian forms (which I have seen in no specimens, and which almost certainly were not seen by Davidson), and quoted identical dimensions for the Carboniferous and Devonian specimens. His figure of the type (*op. cit.*, pl. iv, fig. 26) is very poor and inaccurate, introducing a dorsal valve which is not present on the specimen.

Whidborne (1897, vol. iii, p. 157) agreed with Davidson in referring the Devonian forms to *Spirifer urei*.

Phillips (1841, p. 69, pl. xxviii, fig. 119), on the other hand, was aware of the difference between the two species, and was forestalled by Sowerby in naming the Devonian forms. His division of the species into two varieties, however, does not appear to be well founded, and he probably confused the appearance of moulds and externals: his figures of internal moulds indicate that he failed to appreciate the structures he observed.

EXPLANATION OF PLATES III–V.

PLATE III.

Figs. 1*a*–1*e*. *Ambothyris infima* (Whidborne). Lectotype (= specimen figured by Whidborne, 1893, pl. xiii, fig. 1). Middle Devonian, Lummaton, Devonshire. Sedgwick Museum Collection. × 3. 1*a*, Ventral view; 1*b*, Dorsal view, showing the slight anterior sulcate development; 1*c*, Anterior view; 1*d*, Lateral view; 1*e*, Cardinal area.

2*a*–2*e*. *Ambothyris infima*. Syntype (= specimen figured by Whidborne, *loc. cit.*, fig. 2). Horizon, locality, and collection as for lectotype. × 3·1. 2*a*, Ventral view, showing the median sulcus; 2*b*, Dorsal view; 2*c*, Anterior view; 2*d*, Lateral view; 2*e*, Cardinal area.

Fig. 3. *Crurithyris unguiculus* (J. de C. Sowerby). The original syntypes, of which the larger specimen is the lectotype. Internal mould of the ventral valves. Upper Devonian, South Petherwin, Cornwall. Sedgwick Museum Collection. × 3·6.

Figs. 4*a*–4*d*. *Crurithyris unguiculus*. Chorotype. Upper Devonian, South Petherwin Quarry, Cornwall. British Museum (Natural History) Collection, No. B43947. × 4·1. 4*a*, Ventral view, showing the well-developed median sulcus; 4*b*, Dorsal view; 4*c*, Anterior view; 4*d*, Lateral view.

Fig. 5. *Crurithyris unguiculus* (= *Spirifera divisa* J. Phillips, 1841, pl. xxviii, fig. 119). Chorotype. Internal mould, showing the development of the crural plates and musculature in the dorsal valve. The radial ridges presumably represent relics of the vascular system. Upper Devonian, Petherwin, Cornwall. Museum of Practical Geology Collection, No. 7003. × 3.

6. *Crurithyris unguiculus*. Another of Phillips's specimens of *Spirifera divisa*. Internal mould of the ventral valve showing the musculature and the narrow septum in the posterior region. × 3.

PLATE IV.

Figs. 1*a*–1*d*. *Crurithyris urei* (Fleming). Lectotype. Upper Avonian (? D_2–D_3 Zone), near Strathaven, Lanarkshire. Ure Collection, Hunterian Museum, Glasgow, No. L1790. × 9. 1*a*, Ventral view, showing the bases of the series of smaller spines; 1*b*, Dorsal view, showing the ontogenetic change in the shape, and also the spine-bases; 1*c*, Anterior view; 1*d*, Lateral view.

Figs. 2*a* & 2*b*. *Crurithyris urei*. Topotype. Ure Collection, Hunterian Museum, No. L1793. Internal mould. × 9. 2*a*, Ventral view, showing the narrow elongate posterior muscle-impressions; 2*b*, Dorsal view, showing the cavities of the crural plates, the two pairs of adductor-muscle impressions (of which each of the anterior pair is feebly tripartite), and the obliquely-sloping antero-lateral margins of the hinge-plate.

Fig. 3. *Crurithyris urei*. Cardinal area of a small specimen showing the development of the delthyrial covering-plates. Hosie Limestone, Upper Avonian (D_2–D_3 Zone), Hillhead, Carluke, Lanarkshire. Rankin Collection, Hunterian Museum. × 16.

4. *Crurithyris urei*. Cardinal area of an adult specimen, showing the development of the delthyrial covering-plates. Horizon, locality, and collection as for the last specimen. × 8.

Figs. 5*a*–5*e*. *Crurithyris fissa sp. nov.* Holotype. Upper Avonian (D_2 Zone), Park Hill, Derbyshire. Wheelton Hind Collection, British Museum (Natural History), No. B50290. × 3. 5*a*, Ventral view, showing the narrow median incision; 5*b*, Dorsal view, showing a similar incision in the dorsal valve.

Traces of the crural plates may be distinguished in the umbonal region of this valve; 5*c*, Anterior view; 5*d*, Lateral view; 5*e*, Cardinal area (restored).

Plate V.

Figs. 1*a*–1*e*. *Crurithyris magnispina sp. nov.* Holotype. Upper Avonian (? D_2–D_3 Zone), Thornton, near Busby, Lanarkshire. Young Collection, Hunterian Museum, No. L1794. × 3. 1*a*, Ventral view, showing the development of the series of larger spines over the whole of the valve, with very little, if any, change in the distribution-density with growth; 1*b*, Dorsal view. The dorsal valve is crushed and exfoliated; 1*c*, Anterior view; 1*d*, Lateral view; 1*e*, Cardinal area.

Fig. 2. *Crurithyris magnispina.* Topotype. Dorsal view, showing the cacuminate dorsal umbo and the shape-ontogeny in the dorsal valve. Horizon, locality, and collection (No. L1795) as for the holotype. × 3.

Figs. 3*a* & 3*b*. *Crurithyris* aff. *magnispina.* Internal mould preserved in iron pyrites. Upper Avonian (? D_2–D_3 Zone), Kittoch Water, Lanarkshire. British Museum (Natural History) Collection, No. B47308. × 3. 3*a*, Ventral view, showing the feebly-impressed long narrow muscle-impressions; 3*b*, Dorsal view. The cavities of the crural plates are clearly displayed, together with the two pairs of adductor-muscle impressions. Each of the anterior pair is tripartite. The specimen is not typical in the development of a pronounced median furrow in this valve.

Fig. 4. *Crurithyris magnispina.* Topotype. An enlarged reproduction of the umbonal region of the dorsal valve to show the development of the crural plates and the sessile tuberculate cardinal process situated on a slightly elevated platform (actually depressed on the mould). Horizon, locality, and collection (No. L1796) as for the holotype. × 25.

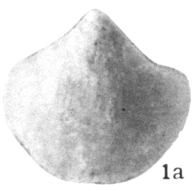
Figs. 5*a*–5*e*. *Crurithyris amœna sp. nov.* Holotype. Upper Limestone Shales, Upper Avonian (D_2–D_3 Zone), Port Eynon Bay, Gower, Glamorganshire. British Museum (Natural History) Collection, No. B56428. × 3. 5*a*, Ventral view; 5*b*, Dorsal view; 5*c*, Anterior view; 5*d*, Lateral view; 5*e*, Cardinal area.

Fig. 6. *Crurithyris amœna.* Chorotype. Internal mould of the dorsal valve, showing the development of the crural plates and of the musculature, of which the elongate lachrymate anterior pair are well marked. Rottenstones, Upper Avonian (D_2–D_3 Zone), Bishopston Road Cutting, Gower, Glamorganshire. British Museum (Natural History) Collection, No. B56427. × 4.

Figs. 7*a*–7*c*. *Crurithyris clannyana* (King). Neotype. Permian, Field House, Ryhope, Northumberland. Davidson Collection, British Museum (Natural History), No. B50301. × 4·3. 7*a*, Dorsal view, showing the short, widely-spaced, crural plates; 7*b*, Anterior view; 7*c*, Lateral view.

Figs. 8*a*–8*d*. *Crurithyris clannyana.* Permian, Pössneck, Thuringia. King Collection, University College, Galway. For comparison with the last specimen. × 4·3. 8*a*, Ventral view; 8*b*, Dorsal view; 8*c*, Anterior view; 8*d*, Lateral view.

Fig. 9. *Crurithyris clannyana* (= *Martinia winchiana* King). One of the syntypes of the latter species. Internal mould of the ventral valve, showing the very prominent adductor surrounded by the rather less-well marked divaricator muscles, and the very short umbo due to a deposit of callus in the original shell. Permian, Whitley, Northumberland. King Collection, University College, Galway, No. FC,D.368. × 2·3.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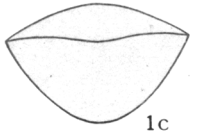
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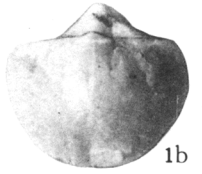
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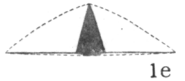
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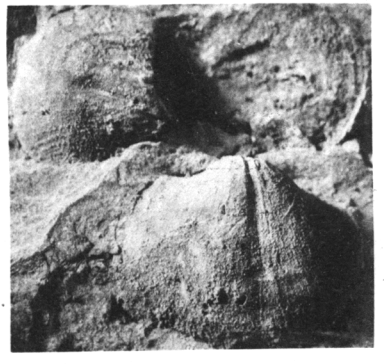
2e


2c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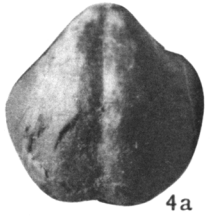
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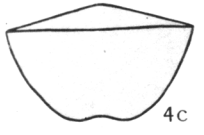
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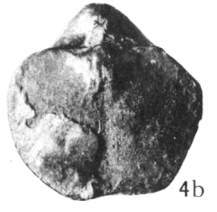
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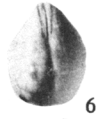
4d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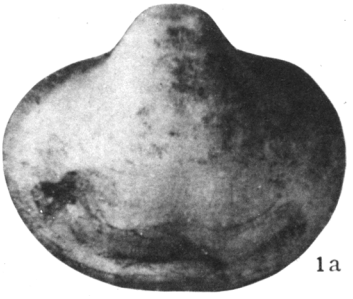
T.N.G., photo.

Zinco-Collotype Co., Edinburgh.

AMBOTHYRIS and CRURITHYRIS.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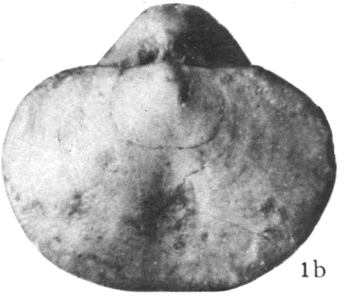
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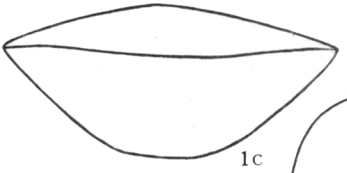
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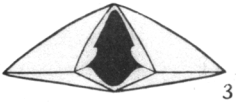
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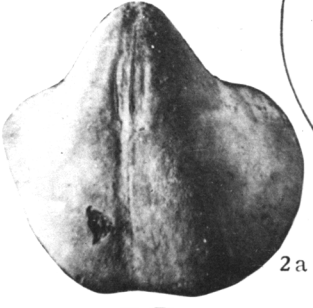
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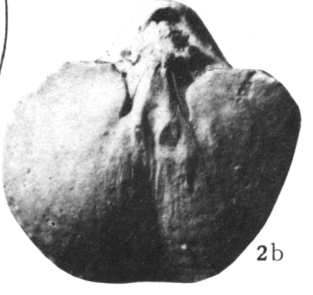
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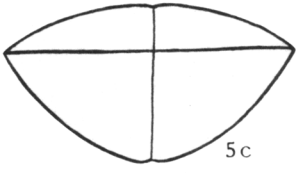
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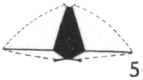
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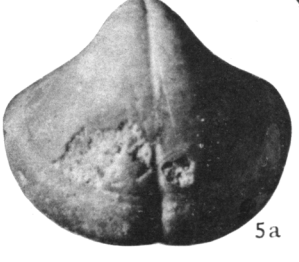
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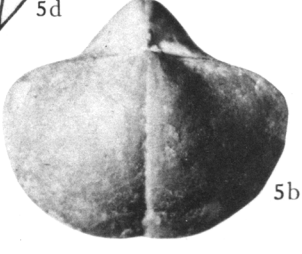
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T.N.G., photo.

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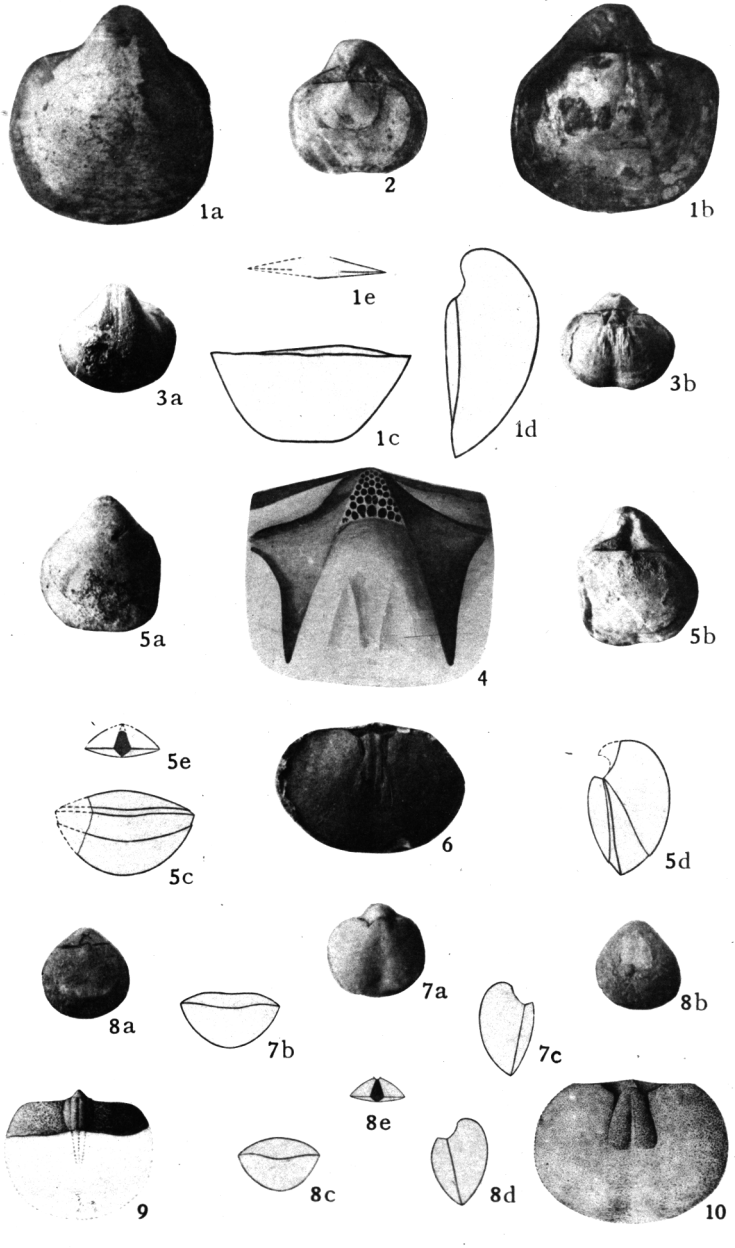
CRURITHYRIS.



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CRURITHYRIS.

Fig. 10. *Crurithyris clannyana* (= *Martinia winchiana*). Another of King's syntypes. Internal mould of the dorsal valve, showing the development of the crural plates and the broad outline of the muscle-area, which is divided by a feeble septum. Horizon, locality, and collection as for the last specimen. × 3·8.

Discussion

Prof. G. Hickling desired to express his appreciation of the valuable work done by the Author in clearing up our knowledge of one of the less-known sections of the Spiriferidæ. He had provided one more striking illustration of the small value of external form as a guide to relationships among the Brachiopoda. The speaker felt that the Author had amply established the generic distinctness of the British species hitherto referred to the genus *Ambocœlia*, and agreed that the correctness of including them in the same family with the American species of that genus would seem open to doubt.

The Author agreed with the previous speaker concerning the possibility of the genera described not being members of one subfamily; but, in view of the small number of specimens which he had examined, especially of the American species, he thought it inadvisable for the present to subdivide the group any further.