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A new morphological aspect of the ostracode genus *Cytherelloidea* Alexander

ABSTRACT

Three new species of *Cytherelloidea* from Tanzania are described. The various ribbing patterns in many species of the genus are shown to be based on one simple spiral pattern. Variations in this pattern allow differentiation between species but also show the affinities of different species. The use of species of *Cytherelloidea* as index fossils can be refined on the basis of the recognition of the underlying simple pattern, together with the direction and degree of departure from it.

INTRODUCTION

In 1929, Alexander erected the genus *Cytherelloidea* and described how it differed from the genus *Cytherella*, to which its species had formerly been ascribed. Howe (1934) described twelve new species and a new variety from the Gulf Coast Tertiary of the United States and noted that the patterns of ornamentation, although readily recognizable, were complex enough to show changes from formation to formation. Sexton (1951) reviewed the literature on *Cytherelloidea*, and figured and listed, with ages, the species found in North America. He described five new species from the Miocene of the Gulf Coast and commented on the use of species of *Cytherelloidea* as index fossils.

The three new species of *Cytherelloidea* here described occur in sandy marl in Mikaramu Stream at Mikaramu Village in the Kilwa district of Tanzania. The age is Late Cretaceous, probably Campanian. Dr. W. G. Aitken, formerly of the Tanganyikan Geological Survey, collected the sample.

The description of the adult of each species is followed by an analysis of the development from moult stages to the adult.

Analysis of the rib patterns in both new and previously described species shows that the rib patterns in the different species all appear to be variations of a basic simple spiral pattern.

The specimens, figured and unfigured, are deposited in the Hunterian Museum of the University of Glasgow, Scotland, with catalogue numbers A1588–A1613.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille, 1806
Suborder PLATYCOPA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea mairae Ramsay, **n. sp.**
Text-figures 1–2

Description: The ventral margin is slightly concave, especially near the middle in the left valve. The dorsal margin is straight in the left valve, slightly convex in the right valve. The anterior margin is evenly rounded. The posterior margin is smaller and slightly obliquely rounded in the left valve, more evenly rounded in the right valve. A very slight but distinct rim on the extreme edge of the valves can be seen around the anterior and posterior margins. The right and left valves are similar in ornament. A strong rib rises at the anterodorsal margin, runs round just inside the anterior, ventral and posterior margins, continues inside the

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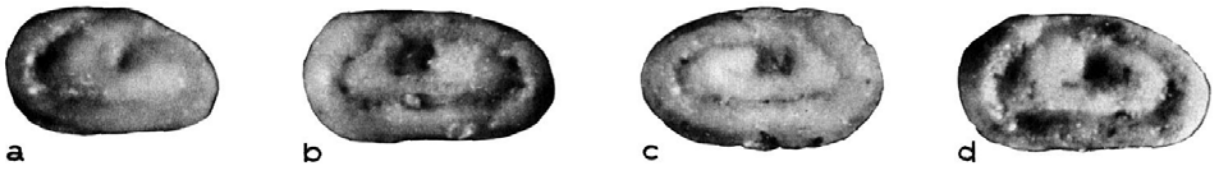


TEXT-FIGURE 1
Cytherelloidea mairae Ramsay, n. sp., ×50 : a, left valve, female, moult stage (A1591) : b, left valve of male adult, paratype (A1590) : c, right valve of female adult, holotype (A1588) : d, left valve of male adult, paratype (A1589).

dorsal margin but drops below its starting point and continues round to the posterodorsal region, paralleling its outer loop and almost surrounding the muscle depression. So regarded, the rib pattern has the form of a spiral. The rib may be less strong where it drops below its starting point. Immediately below this possibly weaker portion, and at the rib's termination in the posterodorsal region, there is a spreading of the rib into wider nodelike areas which are not, however, higher than the rest of the rib.

The females are more swollen posteriorly than the males, which are more elongate in appearance and slightly less broadly rounded posteriorly. The valves are quite smooth internally and show neither pits nor a reflection of the external ribbing. Only the muscle pit area is reflected internally.

Holotype (female) : Length 0.52 mm., height 0.28 mm.
Paratype (male) : Length 0.54 mm., height 0.28 mm.

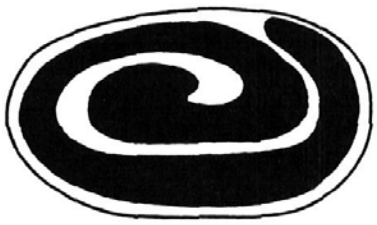
Development: All of the moult stages found resemble the adult fairly closely from the earliest onwards. All show the spreading of the rib at the two points already noted in the adult. The marginal rimming is observable in the moult stage in one or two cases where the edge is not broken.

Specimens obtained: Fifteen moults ; adults – four left valves, four right valves.

Remarks: For reasons which are given later, it is believed that the pattern on which the ribbing of the next two described species is based is that of a spiral rib similar to that of *C. mairae.* For convenience of later description, the spiral rib is considered as being composed of an inner loop, the single dorsal portion of ribbing being part of this loop, and an outer loop which has no dorsal portion (text-figure 2).

Cytherelloidea tanzaniana Ramsay, **n. sp.**
Text-figures 3–6

Description: The carapace is elongate and finely reticulate. In both valves the dorsal margin is straight and the ventral margin slightly concave. The dorsal margin is slightly inturned and the ventral margin strongly inturned, dorsolateral and ventrolateral angulations being formed in each valve. These angulations form longitudinal edges which separate the lateral surface from the dorsal and ventral surfaces respectively. These edges are henceforth referred to as the ventrolateral edge and dorsolateral edge. They are not the marginal edges of the valve. The true ventral marginal edge may be obscured in the left valve due to this inturning. The width of inturned margin is very small. The anterior and posterior margins each bear a thin rim on the marginal edge. At the posterior end two tubercles, one posterodorsal and one posteroventral, occur inside the posterior margin and in lateral view may slightly obscure a small part of the posterodorsal and posteroventral margins. The tubercles are valve swellings. The anterior margin has a thickened curved rib parallel to and just a little inside the margin. From this thickened curved rib short radiating ribs run down the slope to the anterior marginal edge. The thickened anterior marginal rib stops at the anteroventral angle, tapering off into the ventrolateral edge. Just above the anteroventral end of this thickened anterior rib, a slim slightly curved rib runs laterally towards the posterior and onto the posteroventral tubercle, where it is thickened into a slight node. This rib continues up onto the posterodorsal tubercle, where it is again thickened into a slight node. A lateral rib extends from this node, running at about the level of the top of the muscle pit. The rib curves round the top of the muscle pit, continues anteriorly for a short distance, and then curves downwards below the level of the muscle pit before running backwards laterally towards the posterior. From the anterior loop in front of the muscle pit two or three short, slim radiating ribs extend towards the anterior. The posterior half of the ventral portion of the ribbing round the muscle pit runs very close to the more ventral lateral rib below it and lies close to, or touches, the lower reaches of the posteroventral tubercle. It can, however, be seen to curve upwards towards the upper dorsal rib just in front of the posterodorsal tubercle, splitting into two portions before meeting the upper dorsal rib (text-figure 6).



TEXT-FIGURE 2
Adult stage of *Cytherelloidea mairae* (right valve). The rib pattern is a spiral. The outer loop is from the anterodorsal angle round the venter to the posterodorsal angle. The inner loop is the remainder of the rib round the muscle pit.

Internally, the valve has two deep pits, one posterodorsal and the other posteroventral, which are represented externally by the tubercles previously described. The ribbing, even on the tubercles, is not reflected internally. Both sexes possess these tubercles. The male is slightly more elongate than the female, which is more swollen from a ventrolateral region under the ribbing to a posterior region in front of the two tubercles.

Holotype (female): Length 0.56 mm., anterior height 0.30 mm., posterior height 0.32 mm. Paratype (male): Length 0.58 mm., anterior height 0.30 mm., posterior height 0.27 mm.

Development: Moult stages of *Cytherelloidea tanzaniana* are elongate, have the same general outline as the adult, and possess a single rib which starts at the anterodorsal margin and runs round the valve in a spiral manner (text-figure 4). The spiral is not so smoothly curved as that found in *Cytherelloidea mairae*, for it has some angular corners.

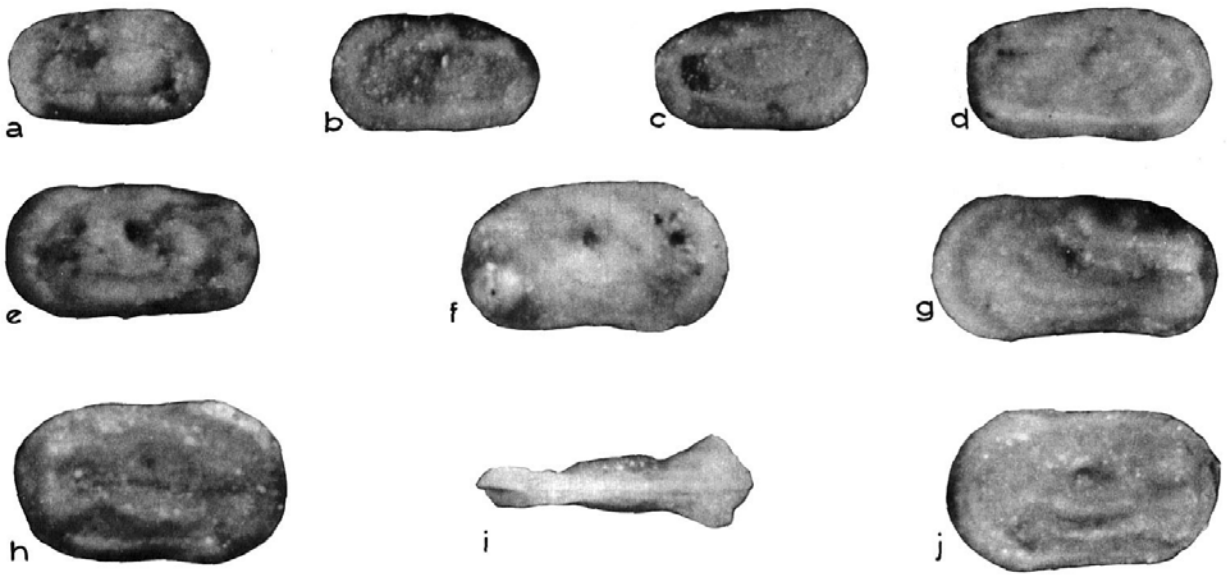
The anterior marginal rib is increasingly thickened from early moult to adult stages. In the earliest moult stages, at the anteroventral margin of the valve, the outer loop of the spiral rib swings up slightly farther away from the margin, and the ventral portion of the outer loop coincides with the ventrolateral edge formed by the inturning of the ventral margin. In what appears to be the penultimate moult stage, in the anteroventral region the ribbing is composed of some short, parallel, almost lateral ribs which are not quite separated from each other (text-figure 5, b–c). The posterior portion of a ventrolateral edge is now quite distinct, and the rib is no longer ventrolateral. In the adult, the short ribs between the anteroventral margin and the anterior end of the lateral rib have disappeared, and the two pieces of rib are completely separated. Thus the anterior and ventral portions of the outer loop are distinctly severed from each other (text-figure 6, b and c). The anterior marginal thickened rib merges at the anteroventral angle with the ventrolateral edge, which is now below the true lateral rib (text-figure 6, rib c–d), and may thus give the impression that the anterior marginal rib continues along the ventral margin in a weakened fashion.

In moult stages, the laterally lying rib (text-figure 4, c–d), the anterior end of which becomes free in the adult, continues to the posterior and round inside the posterior margin, but it is approximately right-angled posteroventrally and posterodorsally, and slightly thickened at those angles (text-figure 4, d and e). The valve is slightly swollen posterodorsally and posteroventrally. In the latest moult stages the rib is distinctly thickened, especially inside the right angles themselves, and the valve swelling is increased (dotted areas, text-figure 5). The adult valve has nodelike protuberances at the two angles, and the valve swellings are greater and more distinctly separate, so that a tubercle forms at each (text-figure 6, d and e). The spiral rib on each tubercle is still connected by a short, less thickened portion of rib.

The spiral rib in the moult extends quite distinctly from the posterodorsal angled portion of the rib, which is at a level above the top of the muscle pit, down to the top of the muscle pit. It then runs just dorsally to the pit, extends a short way to the anterior, loops round in front of and below the muscle pit, and returns to the posterior, lying ventral to the muscle pit and dorsal to the ventrolateral rib. At a position posteroventral to the muscle pit, the rib curves upwards towards the dorsal lateral rib (text-figure 4, h–i) but in front of the posterodorsal angle of the ribbing. The swelling of the valve to produce tubercles in the adult may cause the posteroventral part of the inner loop to touch and apparently join with the posteroventral tubercle and the posterior part of the ventral portion of the outer loop. This may give the impression that the tubercle gives rise to a short anteriorly directed rib, which bifurcates to send two lateral ribs to the anterior. The tubercles, which are true valve swellings, however, do not give off any ribs. The dorsal and ventral lateral ribs extend, in fact, from the thickened ribbing lying on the tubercles.

The posterior part of the inner loop is, in some adults, somewhat obscure, and two or three faint ribs may be seen in this area (text-figure 6, h–i), lying just anterior to and at a level between the two tubercles. The anterior part of the inner loop is still present in the adult but may be very weak, and there may be a suggestion of a second slight branch rib lying to the immediate anterior of the muscle pit (text-figure 6, f–g).

The moult stages of the same length and height may display different characteristics, the rib breaking at the anteroventral margin in one individual, while the other



TEXT-FIGURE 3
Cytherelloidea tanzaniana Ramsay, n. sp., ×50 : a, right valve, moult stage with continuous ribbing (A1598) : b, left valve, moult stage with continuous ribbing (A1608) : c, right valve, moult stage with continuous ribbing (A1597) : d, right valve, moult stage, male, with continuous ribbing (A1596) : e, probable final moult stage, female, left valve with beginning of break at anteroventral portion of outer loop of ribbing, also with small posterior tubercles (A1595) : f, right valve of female adult, paratype (A1594) : g, left valve of male adult, paratype (A1593) : h-j, right valve, dorsal and left valve views, respectively, of female adult, holotype (A1592).

shows no break. The former type of specimen also shows greater tuberculation, swelling and rib thickening. These moult stages are only slightly smaller than some adults which show complete rib severance and full tuberculation. The main changes in late moult and adult stages thus seem to be in valve swelling, rib change and rib thickening rather than in valve length and height.

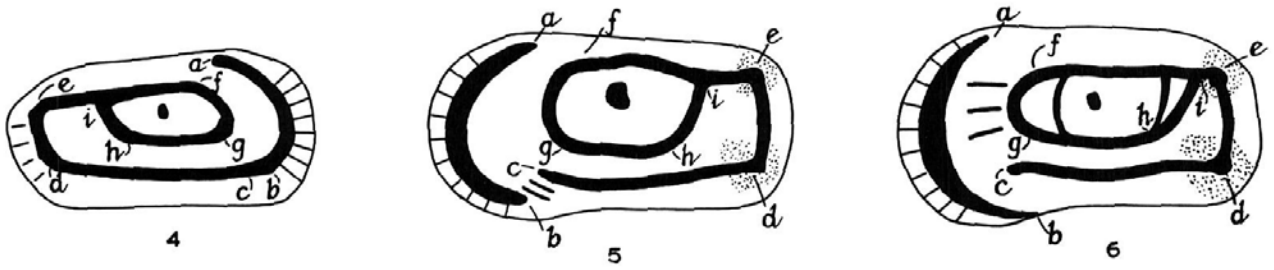
Specimens obtained: Eight moults; adults – two left valves, one right valve, one complete carapace and one broken right valve.

Cytherelloidea mikaramuana Ramsay, **n. sp.**
Text-figures 7–10

Description: The carapace is small, elongate and finely reticulate. The valves have an almost straight to very slightly concave dorsal margin and a straight to slightly concave ventral margin. The ventral and dorsal margins are inturned, thus producing angled ventrolateral and dorsolateral edges. The anterior and posterior margins are evenly rounded. Thick ribs occur just inside and parallel to the anterior and posterior margins, but are not present on the ventral or dorsal margins. The anterior thick rib extends many short ribs down a relatively steep slope to the anterior periphery. At the anteroventral margin the anterior thick rib tapers off and tends to merge into the ventrolateral angular edge. This may sometimes give the impression that the anterior marginal thickening extends in a much weakened fashion along the venter of the valve.

A very slight dorsal lateral rib runs from the posterior marginal rib towards and at the level of the top of the muscle pit, curves round the top of the pit, and extends a short distance anteriorly. The anterior part swings down ventrally, and here the ribbing becomes faint with at least three low indistinct ribs curving down below the level of the muscle pit. At least three indistinct, short low ribs radiate anteriorly from the most anterior rib of the three noted above, and this whole anterior area (text-figure 10, area g–h) is a vague plexus of faint ribbing. However, the three faint ribs curving down from the dorsal rib pass into a slight but distinct median lateral rib running backwards under the muscle pit to a slight swelling lying halfway between the mucle pit and the posteroventral angle. From this slight swelling three ill-defined ribs run to meet the posterior portion of the dorsal lateral rib at a point about halfway between the muscle pit and the posterior margin. A slight node occurs where the ribs meet.

There is a slim low lateral rib, slightly concave upwards, lying just under the lateral rib below the muscle pit. The anterior end of this ventral lateral rib lies above the anteroventral angle and only slightly in front of the anterior portion of the median lateral rib above.



TEXT-FIGURES 4–6

4. Young moult of *Cytherelloidea tanzaniana* (right valve), showing complete spiral rib pattern. 5. Latest moult stage of *Cytherelloidea tanzaniana* (left valve), showing breaking of outer loop at b–c. 6. Adult stage of *Cytherelloidea tanzaniana* (left valve). Outer loop, a–e: anterior part of outer loop, a–b: ventral part of outer loop, c–d: posterior part of outer loop, d–e. Inner loop, e–f–g–h–i: dorsal part of inner loop, e–f: anterior part of inner loop, f–g: ventral part of inner loop, g–h: posterior part of inner loop, h–i. Dotted areas indicate valve swellings.

Posteriorly, this ventral lateral rib runs very close to or touches the slight posteroventral swelling associated with the rib above and extends towards, but not completely to, the posterior margin, stopping about halfway between the swelling and the posterior marginal rib. This ventral rib is thus not connected to the anterior or posterior thickened marginal ribs.

One of the faint anteriorly radiating ribs from the anterior part of the loop in front of the muscle pit curves to meet the anterior end of the ventral lateral rib (text-figure 10, h–c).

There is a slight swelling of the valve dorsal to the muscle pit. The valve is also swollen where it underlies the ventral rib. This swelling extends back to the posteroventral area and up to the posterodorsal region. The females are more swollen in this ventrolateral and posterior region than the males, which are slightly more elongate.

Holotype (female): Length 0.54 mm., height 0.32 mm.
Paratype (male): Length 0.58 mm., height 0.30 mm.

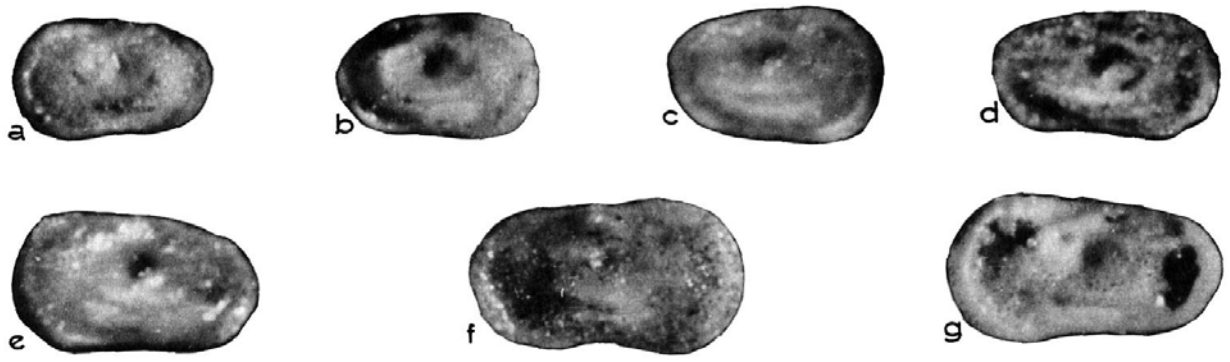
Remarks: The impression of a ventral continuation of the anterior rib is due mainly to the fact that a small portion of the ventral margin is inturned and steep, and the apparent ventral rib below the actual ventral rib is simulated by the sharply angled ventrolateral edge. This feature is more pronounced in *Cytherelloidea mikaramuana* than in *Cytherelloidea tanzaniana*. The riblike character of the ventrolateral edge is not so well displayed when the inturning is increased so that the true margin is obscured.

Female moult stages have a more ovate appearance than the more elongate males and are more distinctly swollen in the ventrolateral to posterior region.

Development: In the early moult stages the anterior and posterior margins are evenly rounded with slightly thickened ribs just inside the margins. These are the anterior and posterior parts of the outer loop. The form of the inner loop is shown in text-figure 8. From the posterodorsal angle a rib runs anteriorly to a small node about halfway between the posterior margin and the dorsal edge of the muscle pit. From this node a curved rib runs round the dorsal side of the muscle pit, swings down ventrally about a third of the way between the pit and the anterior edge of the valve, and then extends posteriorly to meet the posterodorsal node after having completely encircled the muscle pit. The anterior part of the inner loop of the spiral rib may have two or three branches and may give off two or three short anteriorly directed radiating ribs. The ventral portion of the outer loop lies below the ventral portion of the inner loop and is parallel to it. The anterior end of this lateral rib runs toward the anterior margin but does not meet it, stopping above the anteroventral margin. This rib is not connected to the anterior or posterior parts of the outer loop. The posterior of this lateral rib almost touches the inner loop rib, and indeed the two ribs may appear to meet in a slight posteroventral node.

In later moult stages it is found that the median and ventral lateral ribs are less easily distinguished as being separate. From the posteroventral swelling in which these ribs appear to meet, a slight rib may be seen extending back towards the ventral end of the most thickened part of the posterior margin, but it merges with the valve and is lost before reaching the margin. In the adult this slight short rib is only partially apparent. This rib is the posterior end of the ventral part of the outer loop and still shows no connection with the posterior part of the outer loop, the anterior and posterior parts of which are now much thickened.

The last moult stages show the most anterior part of the inner loop of the spiral rib to have become much less clearly defined, finer and less obvious. In the very



TEXT-FIGURE 7
Cytherelloidea mikaramuana Ramsay, n.sp., ×50 : a, left valve, female, moult stage (A1601) : b, right valve, female, moult stage (A1602) : c, right valve, female, moult stage (A1603) : d, right valve, male, moult stage (A1604) : e, left valve, female, moult stage (A1605) : f, right valve of female adult, holotype, with fine ribbing (A1599) : g, left valve of male adult, paratype (A1600).

latest moult stage one of the fine radiating ribs may join on to the free anterior end of the ventral part of the outer loop rib, producing a looplike junction of the median and ventral lateral ribs (text-figure 9, c–h). The adult valves show much less strong ribbing, the ribs tending to merge with the swellings of the valve and the anterior part of the inner loop of the spiral rib becoming very vague. There are two or three very low ribs in the anterior curve of the inner loop and at least two very low anteriorly radiating ribs, the most ventral of which may form a loop with the most ventral lateral rib (text-figure 10, c–h).

Late moults show the posterior part of the inner loop to be simple and distinct. The adults show this posterior part to have become two or three vague ribs running between the posterior ends of the lateral portions of the inner loop (text-figure 10, i–j). The two nodes which are distinct in the moults are very slight in the adults.

Specimens obtained: Twenty-eight moults ; adults – two left valves, one right valve, three broken right valves and one broken left valve.

COMPARISON OF RIB PATTERNS

In *Cytherelloidea mairae* there is a complete spiral rib in moults and adults. In *Cytherelloidea tanzaniana* it is complete in young moults, although the inner loop starts at a somewhat lower level than in *Cytherelloidea mairae* and the ribbing is more angular. However, in the adults of *Cytherelloidea tanzaniana* a break occurs in the outer loop between the anterior and ventral portions of the ribbing, and the development of this break can be followed in the ontogeny. None of the moult stages of *C. mikaramuana* examined showed a complete spiral. Such a pattern might possibly be displayed only by stages more juvenile than those obtained. It will be shown below that a break at the posterior end can occur just as easily as the anterior break demonstrated in *Cytherelloidea tanzaniana.*

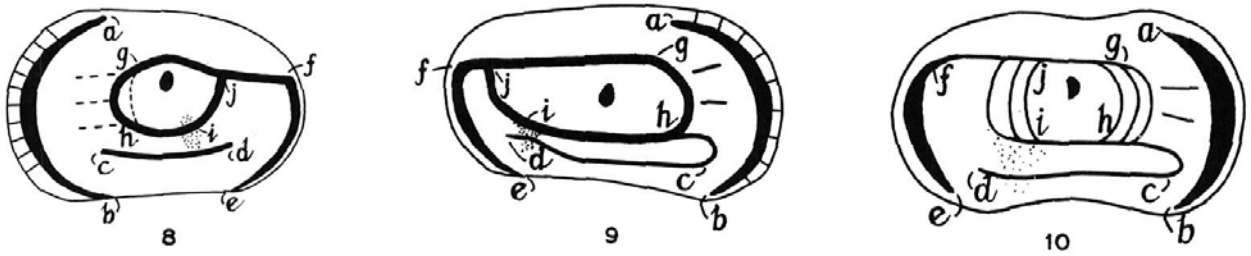
Furthermore, in *Cytherelloidea mairae* the anterior and posterior portions of the inner loop are spread out so that the spiral rib is not of the same width here as elsewhere. It is in exactly these positions that the rib may be very slim and weak, split into two or three portions, and give off radiating ribs anteriorly in *Cytherelloidea tanzaniana* and *C. mikaramuana.*

The ribbing in the adult *Cytherelloidea tanzaniana* is developed from a spiral in the young by 1) a break at the anterior end of the ventral portion of the outer loop, 2) a merging of the thickened anterior portion with the ventrolateral edge, 3) a thickening of the posterior portion of the outer loop into slight nodes, the rib here lying on two posterior valve tubercles, and 4) a splitting or spreading of the ribbing in the anterior and posterior portions of the inner loop.

By analogy with the ribbing in *Cytherelloidea tanzaniana,* the ribbing in *Cytherelloidea mikaramuana* can arise from 1) an anterior and posterior break in the ventral portion of the outer loop, 2) a merging of the thickened anterior and posterior portions of the outer loop with the ventrolateral and/or dorsolateral edges, and 3) a spreading or splitting of the rib in the anterior and posterior portions of the inner loop.

It is apparent that the three species have comparable ribbing patterns. *Cytherelloidea mikaramuana* and *C. tanzaniana* are perhaps more closely related to each other than to *C. mairae.*

It is believed that variations on the spiral rib pattern can be observed in a number of already described species.



TEXT-FIGURES 8–10
8. Young moult stage of *Cytherelloidea mikaramuana* (left valve). 9. Late moult stage of *Cytherelloidea mikaramuana* (right valve). 10. Adult stage of *Cytherelloidea mikaramuana* (right valve). Outer loop, a–b–c–d–e–f: anterior part of outer loop, a–b: ventral part of outer loop, c–d: posterior part of outer loop, e–f. Inner loop, f–g–h–i–j: dorsal part of inner loop, f–g: anterior part of inner loop, g–h: ventral part of inner loop, h–i: posterior part of inner loop, i–j. Dotted area indicates valve swelling.

In published figures of the adult specimens of these species the spiral pattern and certain of its modifications can be discerned. The following principles seem applicable.

1) The simplest rib pattern is the type of spiral rib found in *Cytherelloidea mairae*.
2) The variations are combinations of two or more of the following:
a) Splitting or spreading of the anterior portion of the inner loop. Spreading of the rib may be such as to cause the complete disappearance of the rib.
b) Splitting, spreading or disappearance of all or part of the posterior portion of the inner loop.
c) Breaking between anterior and ventral portions of the outer loop.
d) Breaking between posterior and ventral portions of outer loop.
e) Thickening of anterior portion of outer loop.
f) Merging of anterior portion of outer loop with ventrolateral and/or dorsolateral edges. Merging with the ventrolateral edge can occur only when the spiral rib is broken as in c).

As has already been described, the free ventral ends of the anterior and posterior portions of the outer loop may merge with the ventrolateral and dorsolateral edges formed by inturning and thus give the impression that the ribs are continued ventrally and/or dorsally. This development can be clearly followed in *Cytherelloidea tanzaniana*. It seems possible that secondary ribbing might be developed along such edges.

It should be noted that in all species of *Cytherelloidea* the right valve overlaps the left, and in a particular species it is probable that the right valve will have a broader ventral and dorsal margin than the left. Thus, the edges formed by inturning of the margins might show up more distinctly and appear more like ribs on the right valve than they would on the left valve. In some species the valves are described as having ornament, the right valve usually being said to possess a dorsal marginal rib while the left valve does not. This might sometimes be due to a dorsolateral edge being better developed and more conspicuous on the right valve than on the left.

g) Thickening of posterior portion of outer loop and/or formation of nodes on posterior tubercles.
h) Merging of posterior portion of outer loop with ventrolateral or dorsolateral edges. This can occur only when the spiral rib is broken as in d).
i) Ventral portion of outer loop moving away from the margin and becoming more internally situated than in the basic spiral. This condition is usually associated with a break at the anterior and/or posterior.
j) Formation of posterolateral and anterolateral edges with the posterior and anterior portions of the outer loop becoming less marginal.
k) Disappearance of the anterior and posterior portions of the outer loop.
l) Development from the anterior portion of the inner loop of an anteriorly radiating rib which joins with the free anterior end of the ventral portion of the outer loop.

Examples taken from already described species in which the ribbing can be considered as a variation of the basic type are *Cytherelloidea williamsoniana* (Jones, 1849) (type taken as that shown by Howe and Laurencich, 1958); *C. reticulata* Alexander, 1929; *C. vicksburgensis* Howe, 1934; *C. nanafaliensis* Howe, 1934; and *C. crafti* Sexton, 1951.

The type figure of *C. williamsoniana* (Jones) shows the anterior portion of the outer loop broken from the ventral portion, which continues back to the posterior portion without a break. The posterior portion appears to have a break at mid-height, its dorsal part being on a tubercle. The start of the inner loop at the posterodorsal angle does not appear to be connected to the end of the

outer loop but is complete round the muscle pit and terminates close to but not touching its start.

C. reticulata Alexander has a thickened anterior portion of the outer loop. The anterior portion is separated from the true ventral portion and runs into the ventrolateral edge, which possibly accounts for the description of a weak ventral (and dorsal) marginal rim. The true ventral portion and the posterior portion of the outer loop are complete, and valve tubercles are developed at the posteroventral and posterodorsal angles. The outer loop runs into the inner loop. The dorsal and ventral portions of the inner loop are complete. The anterior portion shows only vague anteriorly radiating ribs and the posterior portion does not exist, these two points being the main distinctions between the ribbing of *C. reticulata* and that of *C. tanzaniana*, which possesses a complete inner loop.

C. vicksburgensis Howe has the anterior portion of the outer loop separated from the ventral portion. The rest of the outer loop is complete, with thickening of the posterior portion. The inner loop is complete but the anterior portion shows splitting of the ribbing (Howe, 1934, pl. 5, fig 6), and there appear to be two vague anteriorly radiating ribs, the more ventral of which has joined with the free anterior end of the ventral portion of the outer loop (see *Cytherelloidea mikaramuana*).

The type figure of *C. nanafaliensis* Howe shows the spiral rib but displays the unusual characteristic of having lost the anterior portion of the outer loop, while retaining the rest of the outer loop and the whole of the inner loop.

C. crafti Sexton has the anterior portion of the outer loop thickened and running into the ventrolateral edge. The ventral portion of the outer loop lies above the margin but is not connected with the posterior portion, which lies on two tubercles at the posteroventral and posterodorsal angles and has lost that part of the ribbing connecting the two tubercles. The inner loop is connected to the outer loop and is complete, but displays a spreading of the rib in the anterior and posterior portions. This species shows an important point which, in the Tanzanian specimens, could not be demonstrated but only surmised. Sexton (1951) has described and figured clearly a moult stage (pl. 117, fig. 9) which shows no break between the ventral and posterior portions of the outer loop. In the adult, however, the break, according to Sexton's description and figures (pl. 117, figs. 7–8), is quite distinct. The ontogeny thus shows the breaking of the outer loop in the posteroventral region in quite the same fashion as the ontogeny of *Cytherelloidea tanzaniana* shows breaking of the outer loop in the anteroventral region. It will be remembered that in *Cytherelloidea mikaramuana* complete breaks of the outer loop, both anteriorly and posteriorly, show up even in moult stages.

Accompanying the posteroventral break in *C. crafti* is the disappearance of the connecting rib between the posterior tubercles. It is also found that the posterior portion of the inner loop does not quite meet the dorsal portion in the moult stage, but in the adult the two portions are connected. This is quite in accord with the known instability of the posterior portion of the inner loop in the later growth stages in other species.

It is apparent that where the basic pattern is recognized it is simpler and more effective to describe the ribbing by noting the variations of the outer and inner loops. Thus, in *C. crafti* the development is more apparent using this method than, for example, by describing the posterodorsal tubercle in the adult as giving off a rib which bifurcates, the portions going round the muscle pit, one on each side, and meeting in front of the muscle pit. This rib does not bifurcate in the moult, and the rib development during ontogeny is thus not clear from the description, which shows no relation between the moult and adult ribbing patterns.

OTHER SPECIES

At least ninety described species of *Cytherelloidea* can be recognized as possessing ribbing which is based on the simple spiral pattern. Since some Cretaceous species are just as complex as some Eocene or Miocene species, and indeed the same holds true for the few Jurassic species described, complexity of ornament is in itself no criterion of geological age. The Malayan and Indonesian species (see Le Roy, 1941) are distinct from all but three of those known from the Western Hemisphere (*C. subgoodlandensis* Vanderpool, *C. circumvallata* Bonnema and *C. cubana* Bold) in having a number of minor cross ribs which may connect various parts of the outer and inner loops of the spiral pattern.

Bettenstaedt (1958) indicated the phylogeny of *Cytherelloidea ovata* Weber to be a change from complex ribbing to simple ribbing. His end figure (fig. 16, text-fig. 1, p. 117) shows a thick-shelled ostracode with a small semicircular rib. The whole range of his figures (figs. 1–16, text-fig. 1, p. 117) shows a change, not only in the thickening of the middle lateral rib, which eventually forms a semicircle as described by Bettenstaedt, but also in the other variant characters of the ribbing. This ribbing is based on the spiral pattern, and probably the most important change is not the thickening of the middle rib (ventral part of inner loop) but rather the joining of the anterior and ventral portions of

the outer loop, which are shown to be separated in Bettenstaedt's figures 1–11 and joined in figures 12–16. These figures 12–16 show two nearly concentric loops with part of their dorsal ribbing common to both. This pattern is considered to represent a complete spiral.

Bettenstaedt's figures show a phylogeny opposite, in effect, to the ontogeny seen in *Cytherelloidea tanzaniana*. However, this lineage occurs within a small time range, and it is possible that changes from simple to complex may also occur in a lineage when a much greater time range is considered.

DIMORPHISM

The Tanzanian specimens were examined with regard to van Veen's contention that the females in species of *Cytherelloidea* possess two internal pits at the posterior which show up externally as nodes. Where nodes were found, for example at the junction of ribs at the posterior, no pits were found internally, the valve being quite smooth. The inside, even of *Cytherelloidea mairae*, is quite smooth and does not reflect the external strong ribbing. Even when ribs and nodes lay on true valve swellings, the swellings were quite clear as hollows internally, but there were no internal indentations corresponding to ribs or nodes. The males and females in *Cytherelloidea mikaramuana*, even in the moult stages, had identical rib patterns but generally could still be separated on valve tumidity, which is greater in the female. The two sexes in *Cytherelloidea tanzaniana* both have tubercles, but one is more swollen in the posterior part of the carapace and is thus presumed to be the female.

Cytherelloidea mikaramuana and *Cytherelloidea tanzaniana* are similar in being elongate, finely reticulate and with longitudinal ribs, but the specimens of *Cytherelloidea tanzaniana* are not considered to be the females nor the specimens of *Cytherelloidea mikaramuana* the males of a single species. The rib patterns, their developments, and the recognition of dimorphism in each species, especially *Cytherelloidea mikaramuana*, are considered to be sufficient evidence to warrant the ascription of *Cytherelloidea mikaramuana* and *Cytherelloidea tanzaniana* to separate species. The dimorphism in the species examined was therefore regarded as similar to that shown by *Cytherella*, the present author thus agreeing with van den Bold (1946).

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