NOTE ON ONTOGENY OF THE MIDDLE DEVONIAN CRINOID

PROCTOTHYLACOCRINUS ESSERI KESLING

BY

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ABSTRACT—Measurements of cup plates in two specimens of Proctothyacocrinus esseri indicate that in general its growth in height and width increased ventrally and posteriorly from the IBB and that its growth in area (at least in the plates measured) centered on RA and the anal series. Basal anal plates probably expanded in order to support the very large, chimney-like anal sac in the adult.

INTRODUCTION

Discovery of an immature Proctothyacocrinus esseri Kesling permits comparison of its measurements with those of the holotype. The new specimen was found by Mrs. Ruth Berner Chilman in September 1967. Like the holotype, it was weathered from shale in a large dump pile in the northeast corner of the North Quarry of the Medusa Portland Cement Company (now abandoned), near Sylvania, Lucas County, Ohio. Without doubt it came from the Middle Devonian Silica Formation unit 12 of Ehlers, Stumm, & Kesling (1951).

I express my thanks to Mrs. Chilman for donating this crinoid to our Museum of Paleontology, where it is catalogued. My appreciation goes to Mr. Karoly Kutasi for his photographic assistance and to Mrs. Gladys Newton for typing the manuscript.

PROCTOTHYLACOCRINUS ESSERI Kesling

Text-figs. 1-4; pls. 1, 2

Immature specimen. — Hypotype UMMP 57172. Specimen incomplete, lacking tegmen and anal sac. Anterior part of cup crushed and partly obscured by adhering brachiopod and bryozoa fragments. Two sections of column, one still united with cup and the other broken off. After photographs (pl. 1, figs. 3-6; pl. 2, fig. 1), broken section worked free from rest of specimen and found to fit perfectly on exposed facet of other section, the two together forming nearly 10 mm of the column.

Proximal section of column slightly flared, the difference in diameters of nodals and internodals less pronounced than lower in column. Nodals in typical section of column distinctly wider than internodals, their latera forming a decagon with rounded corners and only slightly indented (pl. 1, fig. 3); slight development of epifacet, wider at indentations of latera than at apices. Articular facet of nodal rather sharply decastellate, its indentations set at half the radius of its apices. Lumen large, circular. Crenularium narrow, forming a border around smooth decastellate areola, its crenellae shallow but distinctly incised, about ten oriented normal to each of the 20 sides of areola. Internodals narrower than nodals, their latera strongly indented to produce decastellate shape (pl. 1, fig. 4); crenularium of same size and shape as that of adjoining nodal, its culmina articulating with the crenellae of the nodal in symplexy. Epifacet of internodal wider than that of nodal. Smaller size and lateral indentations in internodals producing reticulate pattern in column. Measurements of typical internodal (mm):

| Diameter of facet: | FC = 1.7 + 2.5 = 4.2 |
| Diameter of lumen: | LD = 1.0 |
| Total width of areola: | AD = 0.5 + 1.5 = 2.0 |
| Total width of crenularium: | CD = 0.7 + 0.5 = 1.2 |

Indices computed according to the procedures described by Moore, Jeffords, & Miller (1968, p. 21-25):

- Luminal index: \( Li = 24 \)
- Areolar index: \( Ai = 48 \)
- Crenularial index: \( Ci = 29 \)
- Articular shape index: \( FSi = 68 \)

Cup subconical, all sutures faintly crenulate. IBB all exposed, subequal, their circle nearly round in dorsal (basal) view (pl. 1, fig. 4). Each IB much wider than high, with three prominent dorsal lobes (that of C ray may have only two) projecting over the columnal facet and producing a strongly sinuous border in lateral view (pl. 1, figs. 3, 5, 6). Each IB ventrally acuminate, inserted between two BB, its apex at B-IB-B junction in a pit; IB nearly triangular, its ventral sides almost straight but appearing sinuous because of overhanging lobes of BB.

BB large, probably forming a complete circle (B of AB interray somewhat dislocated). Each B bordered dorsally by two IBB and
lateral by two BB. BB of BC and CD interrays septagonal, the former bordered ventrally by RA and (presumably) by two RR (pl. 1, fig. 5) and the latter by RA, X,, and R of D ray (pl. 2, fig. 1). Other BB hexagonal. Each B with a faint tapering groove from its dorsal apex at IB-B-IB junction (pl. 1, fig. 3), broad rounded ridges from the large central elevated area toward RR and/or RA and X,, lower and narrower ridges toward adjacent BB, and pits at all corners (pl. 1, figs. 3, 5, 6).

RR circlet interrupted by RA and X, (text-fig. 1). As in holotype, each R pentagonal, dorsally acuminate between two BB or between B and RA. Rotund ridges to the four laterally and dorsally adjacent plates (pl. 1, fig. 6). RR facets very large, subpyriform, with a narrow, deeply incised slot for the ambulacral channel (pl. 1, figs. 3, 6).

X, hexagonal, about same height as RR but narrower, with conspicuous broad, rounded ridges to B of CD interray below and to overlying plate of anal series, lower and narrower ridges to RA and R of D ray, and still lower and narrower ridges to lateroventral plates of anal sac (pl. 1, fig. 6).

RA pentagonal, with prominent ridges to bordering two BB, X,, R of C ray, and overlying anal plates (pl. 1, fig. 5). No PBrBr in place; one dislocated, large, nearly as wide as R and about half as high (pl. 1, fig. 3).

Remarks.—The holotype was recently described (Kesling, 1965, p. 77–78). Compared with the holotype (pl. 1, figs. 1, 2; pl. 2, figs. 2–4), the immature specimen has broader and more rotund ridges on the cup plates. There is also a conspicuous difference in the dorsal border of the IBB circlet: whereas the smaller specimen has about three prominent lobes on each IB, the larger has about four small lobes and even an additional small central lobe on one plate. Thus, the “scalloped edge” overhanging the columnal facet seems to have grown toward more numerous and less prominent lobes.

Moore & Jeffords (1968, p. 34–35) recently described columnals in Proctothylacocrinus longus Kier and P. esseri Kesling. Their indices computed for P. longus contain some misprints, but their descriptions are correct. What they say about columnals of the holotype of P. esseri applies also to the hypotype, except for the slightly flared proximal section. In the holotype (pl. 1, figs. 1–2), the nodals and internodals in the proximal section are distinctly of different diameters, resembling those in the lower part of the column in the hypotype.

As previously mentioned for the holotype (Kesling, 1965, p. 77), both X, and RA are succeeded ventrally by series of strongly developed anal plates which gradually merge into the short, wide, ribbed plates typical of the anal sac. Inasmuch as the sac is composed of eight series of plates, some difficulty arises in naming particular plates. Here, I have called the anal-x plate X,, considering it to be the base of a vertical series including X,, X,, X,, etc. The vertical series above RA is designated RX,, RX,, etc. Actually, the plate to the left of X,, LX,, is also somewhat more strongly...
### Table 1—Measurements\(^1\) of Two Specimens of *Proctothylacocrinus esseri* Kesling and Constant Differential Growth Ratios

<table>
<thead>
<tr>
<th></th>
<th>Hypotype</th>
<th>Holotype</th>
<th>Growth ratio (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Width (mm)</td>
<td>Height (mm)</td>
<td>Area (mm(^2))</td>
</tr>
<tr>
<td>IB – B ray</td>
<td>2.9</td>
<td>2.1</td>
<td>2.8</td>
</tr>
<tr>
<td>IB – C ray</td>
<td>3.0</td>
<td>2.1</td>
<td>2.9</td>
</tr>
<tr>
<td>IB – D ray</td>
<td>3.5</td>
<td>2.0</td>
<td>3.2</td>
</tr>
<tr>
<td>IB – E ray</td>
<td>3.0</td>
<td>1.9</td>
<td>2.6</td>
</tr>
<tr>
<td>B – BC interray</td>
<td>4.0</td>
<td>3.8</td>
<td>10.6</td>
</tr>
<tr>
<td>B – CD interray</td>
<td>4.2</td>
<td>4.1</td>
<td>10.6</td>
</tr>
<tr>
<td>B – DE interray</td>
<td>4.0</td>
<td>3.9</td>
<td>10.7</td>
</tr>
<tr>
<td>R – D ray</td>
<td>4.6</td>
<td>3.2</td>
<td>12.8</td>
</tr>
<tr>
<td>X(_1)</td>
<td>3.5</td>
<td>3.2</td>
<td>9.6</td>
</tr>
<tr>
<td>RA</td>
<td>3.2</td>
<td>3.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Totals</td>
<td>35.9</td>
<td>29.4</td>
<td>73.0</td>
</tr>
</tbody>
</table>

\(1\) Made with Gaertner Scientific Corporation measuring microscope.

\(2\) Radial length.

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**Ontogeny**

In addition to the differences in ridges and lobes just mentioned, the smaller crinoid also appeared to differ from the holotype in the relative sizes and proportions of its plates. To determine the magnitude of these differences, measurements were made of comparable plates in both specimens by using a Gaertner Scientific Corporation measuring microscope. Camera lucida sketches were made of individual plates, and their areas measured with a polar planimeter; these areas were then converted to square millimeters of actual plate area (table 1).

Assuming that the two specimens represent different growth stages of the species, I determined constant differential growth ratios (\(k\)) by my simplified mechanical solution (Kesling, 1951, p. 231–235) for Huxley's growth-rate formula

\[ y = b x^k \]

For \(k\) values of width, the standard \(x\) for comparison was selected as the combined widths of all plates measured; similarly, for \(k\) values of height and area, \(x\) was selected as the combined heights and the total area respectively.

Results of these determinations (table 1) show strong allometry in dimensions and areas of most plates. In general, the IBB grow less than BB, the BB less than R (only R of D ray present in hypotype), and RA and X, grow most of all. If more specimens were available, regression lines could have been plotted on log-log paper to determine the average constant differential growth ratios of width, height, and area of each plate of the cup. Additional specimens would change the \(k\) values slightly. Nevertheless, even though only two specimens were involved, the growth ratios are probably close to those of the population and the directions of growth gradients seem clearly indicated.

To graphically show the growth gradients in the available part of the cup in *Proctothylacocrinus esseri*, \(k\) values were plotted at plate centers on simplified plate diagrams for width, for height, and for plate area. In width (text-fig. 2), a strong growth gradient extends diagonally and ventrally from the IBB of the B and C rays, through the B of the CD interray...
and RA, to X₁. In height (text-fig. 3), the growth gradients are directed ventrally and posteriorly toward RA and X₁. In area (text-fig. 4), maximum growth centers around RA and X₁. From the directions of growth gradients, one might presume that even greater k values exist in the plates of the anal sac.

The exceptional growth of plates in the posterior region of the cup may be related to development of the very large anal sac, which characterizes the genus. The chimney-like stack of plates in the anal sac is supported primarily on the posterior plates of the cup, which are reinforced by radial ridges. Presumably, X₁, RA, and adjacent posterior plates grew rapidly to support the increasing weight of the plates in the anal sac.

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