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NOTE ON ONTOGENY OF THE MIDDLE DEVONIAN CRINOID *PROCTOTHYLACOCRINUS ESSERI* KESLING

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VOLUME 22

NOTE ON ONTOGENY OF THE MIDDLE DEVONIAN CRINOID *PROCTOTHYLACOCRINUS ESSERI* KESLING

ROBERT V. KESLING

ABSTRACT—Measurements of cup plates in two specimens of *Proctothylacocrinus 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 *Proctothylacocrinus 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 there 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

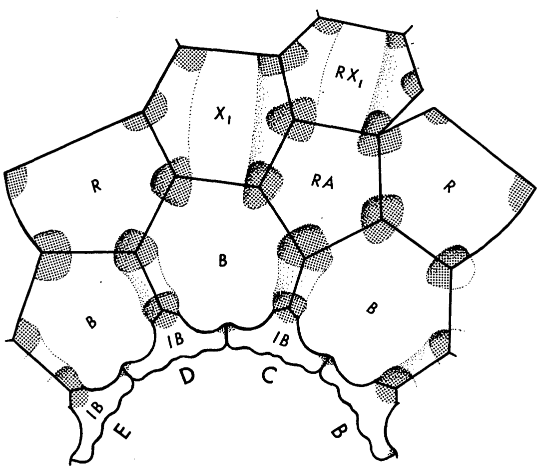
Indices computed according to the procedures described by Moore, Jeffords, & Miller (1968, p. 21–25):

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 circlet 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 circlet (B of AB interray somewhat dislocated). Each B bordered dorsally by two IBB and laterally 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_1, 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_1, 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_1 (text-fig. 1). As in holotype, each R pentagonal, dorsally acuminate between two BB or between



TEXT-FIG. *1—Proctothylacocrinus esseri* Kesling. Generalized diagram of plates in the posterior region, based on holotype.

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_1 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_1, 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_1 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_1, considering it to be the base of a vertical series including X_2, X_3, X_4, etc. The vertical series above RA is designated RX_1, RX_2, etc. Actually, the plate to the left of X_1, LX_1, is also somewhat more strongly

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EXPLANATION OF PLATE 1

All figures × 4; specimens lightly coated with sublimate of ammonium chloride

FIGS. *1–6—Proctothylacocrinus esseri* Kesling. *1, 2,* inclined view centered on D ray and anterior view, holotype UMMP 51744. *3–6,* views centered on DE interray, dorsal (basal) end, RA, and D ray, hypotype UMMP 57172. Unretouched.

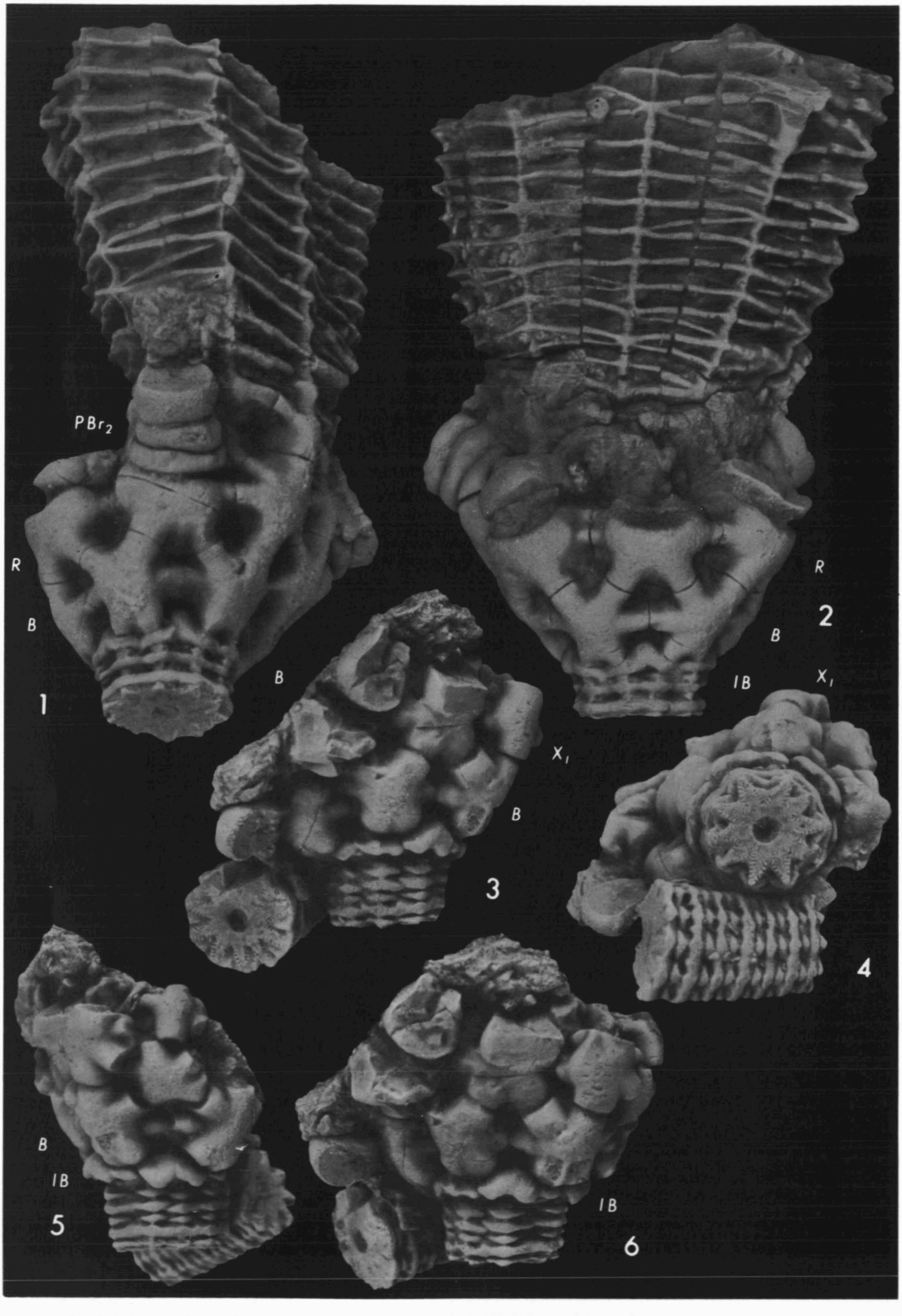


PLATE 1

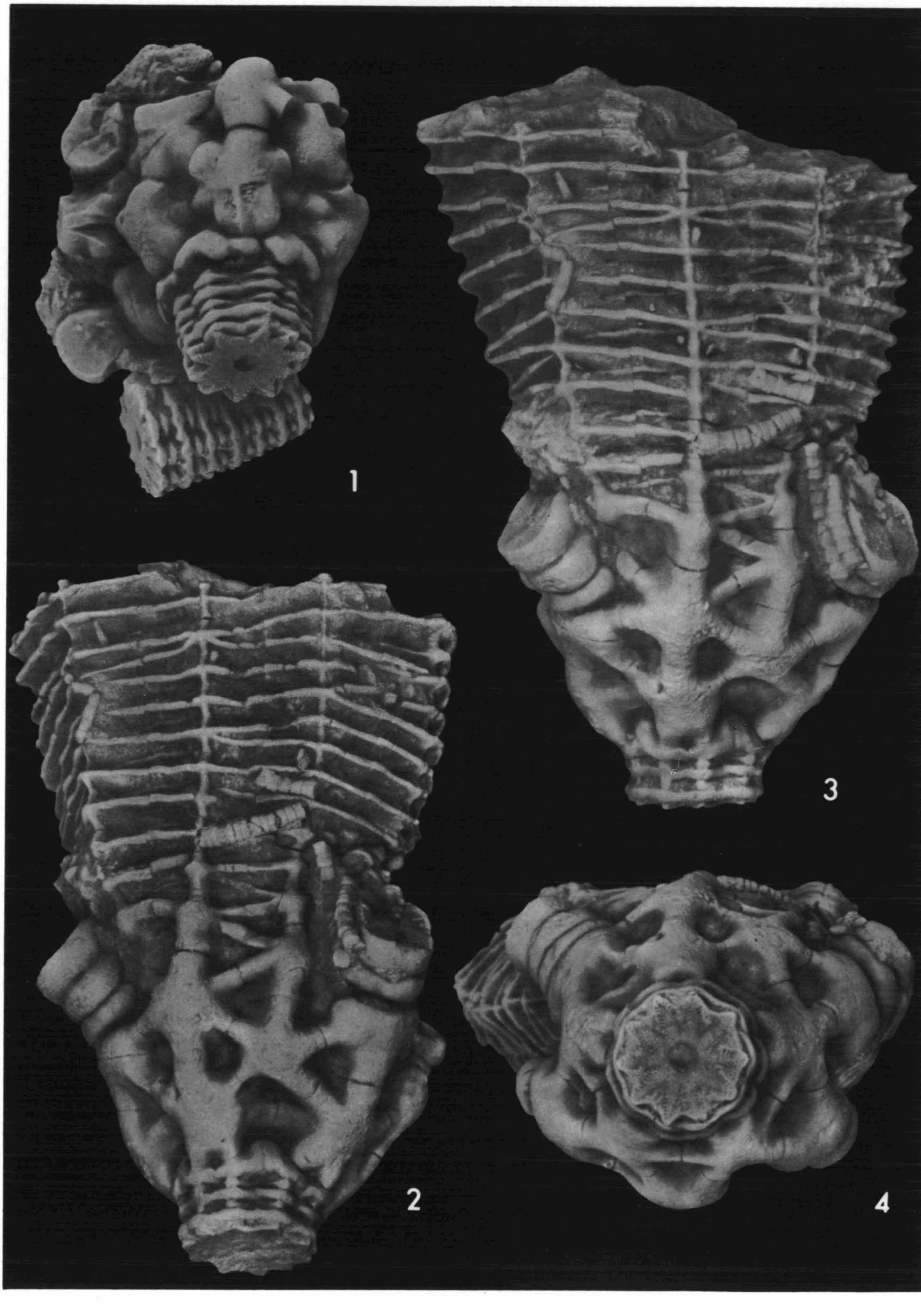


PLATE 2

TABLE *1*—MEASUREMENTS[1] OF TWO SPECIMENS OF *PROCTOTHYLACOCRINUS ESSERI* KESLING AND CONSTANT DIFFERENTIAL GROWTH RATIOS

	Hypotype			Holotype			Growth ratio (k)		
	Width (mm)	Height (mm)	Area (mm^2)	Width (mm)	Height (mm)	Area (mm^2)	Width (mm)	Height (mm)	Area (mm^2)
IB – B ray	2.9	2.1	2.8	3.6	2.1	3.6	1.44	0.00	0.82
IB – C ray	3.0	2.1	2.9	3.8	2.2	3.9	1.58	.36	.97
IB – D ray	3.5	2.0	3.2	3.6	2.0	3.4	.19	.00	.20
IB – E ray	3.0	1.9	2.6	3.4	2.0	3.2	.84	.40	.68
B – BC interray	4.0	3.8	10.6	4.5	4.3	13.5	.79	.97	.79
B – CD interray	4.2	4.1	10.6	4.9	4.3	13.1	1.03	.37	.69
B – DE interray	4.0	3.9	10.7	4.3	4.4	13.0	.48	.95	.63
R – D ray	4.6	3.2	12.8	5.3	3.6	16.6	.95	.92	.85
X_1	3.5	3.2	9.6	4.4	4.3	16.9	1.53	2.32	1.84
RA	3.2	3.1	7.2	3.9	4.2	12.0	1.32	2.38	1.66
Totals	35.9	29.4	73.0	41.7	33.4	99.2	1.00	1.00	1.00
Prox. end column	5.3	......	20.6	5.9	......	25.6	.72	......	.71
RX_1	......	2.3	......	......	3.3	......	......	2.83	......
Arm facet	3.3	3.0[2]	......	3.5	3.3[2]	......	.39	......	......

[1] Made with Gaertner Scientific Corporation measuring microscope.
[2] Radial length.

developed than the typical plates of the anal sac.

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

$$y = bx^k.$$

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_1 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.

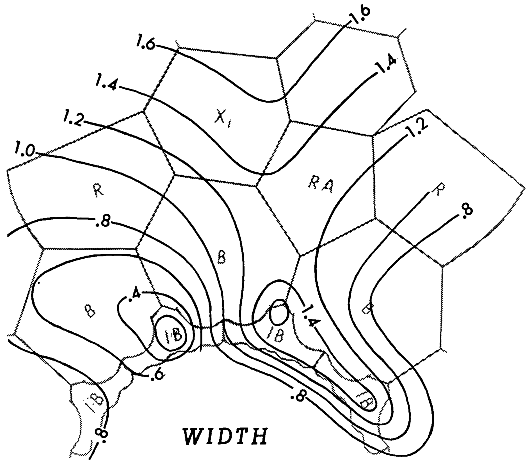
To graphically show the growth gradients in the available part of the cup in *Proctothylacocrinus esseri*, k values were plotted at plate centers on simplified plate diagrams for width, for height, and for plate area. In width (text-fig. 2), a strong growth gradient extends diagonally and ventrally from the IBB of the B and C rays, through the B of the CD interray

EXPLANATION OF PLATE 2

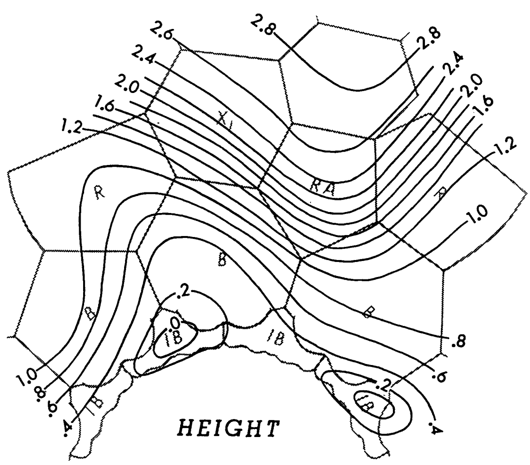
All figures × 4; specimens lightly coated with sublimate of ammonium chloride

FIGS. *1–4*—***Proctothylacocrinus esseri*** Kesling. *1*, inclined posterior view, hypotype UMMP 57172. *2–4*, inclined view centered on RA, posterior, and dorsal (basal) view, holotype UMMP 51744. Unretouched.

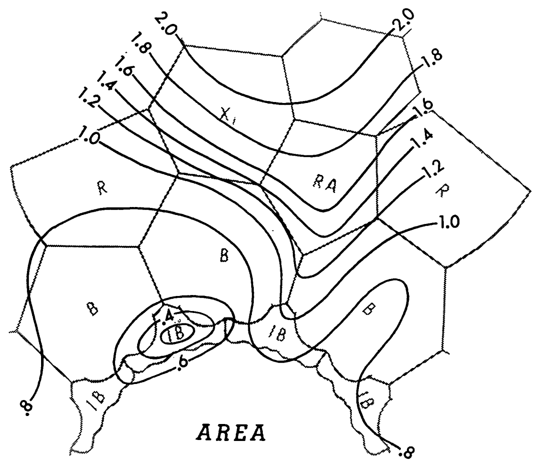
and RA, to X_1. In height (text-fig. 3), the growth gradients are directed ventrally and posteriorly toward RA and X_1. In area (text-fig. 4), maximum growth centers around RA and X_1. From the directions of growth gradients, one might presume that even greater *k* values exist in the plates of the anal sac.



TEXT-FIG. 2 — *Proctothylacocrinus esseri* Kesling. Growth in width of plates based on size differences between hypotype UMMP 57172 and holotype UMMP 51744. Contoured values of constant differential growth ratios (*k* values) show strong growth gradients centering on IBB of B and C rays and extending diagonally upward through RA and anal plates.



TEXT-FIG. 3 — *Proctothylacocrinus esseri* Kesling. Growth in height of plates based on size differences between hypotype and holotype. Contoured values of constant differential growth ratios (*k* values) show growth gradients extending ventrally and toward RA and X_1.



TEXT-FIG. 4 — *Proctothylacocrinus esseri* Kesling. Growth in area of plates based on size differences between hypotype and holotype. Contoured values of constant differential growth ratios (*k* values) form a ridge through IB of C ray, RA, and X_1, with growth gradients directed ventrally and posteriorly.

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, X_1, RA, and adjacent posterior plates grew rapidly to support the increasing weight of the plates in the anal sac.

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