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A new crinoid genus from the Middle Devonian of Iowa, USA (Camerata, Melocrinitidae)

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Abstract. **This study describes a new genus of melocrinitid crinoid from the Middle Devonian, Givetian Stage, of Iowa (subclass Camerata, family Melocrinitidae). The specimen described is assigned to *Ronsocrinus* gen. nov. within the family Melocrinitidae. *Ronsocrinus rabia* gen. et sp. nov. possesses a long heteromorphic column, small calyx plates with raised stellate patterns and a well-developed, long anal tube. Species within the family Melocrinitidae do not commonly possess a long anal tube or a spherical cup shape and the family diagnosis is expanded to include species with these characteristics.**

Key words: anal tube, camerate, Givetian, Iowa, Melocrinitidae

Introduction

Crinoids are sessile, stemmed echinoderms that were once a critical component of Devonian reef communities as upper-tier filter feeders and bioclastic sources (Schindler and Wehrmann, 2011; Bohatý *et al*., 2012). Evolutionary processes, such as richness increases and changes in disparity, can be studied by investigating crinoid morphology (Deline and Ausich, 2011). However, before any of these data synthesis studies can be done, a detailed description of Paleozoic crinoids, as well as publication of new species, is needed.

Research on the taxonomy of Paleozoic crinoids—subclasses Flexibilia, Disparida, Cladida and Camerata—has been occurring for at least a hundred years (Ausich, 1998; Ausich and Kammer, 2001). Subclass Camerata Wachsmuth and Springer, 1885 includes the family Melocrinitidae d'Orbigny, 1852, which defines the type genus as *Melocrinites*. The diagnostic criteria of family Melocrinitidae have since come under some scrutiny. Kesling (1964) provided three different diagnostic criteria from different authors for the family such as Moore and Laudon (1943) describing the family as having an anal area with few extra plates or not being differentiated at all. However, it is believed that this definition is potentially not inclusive of the full range of morphologies in the family. The midcontinent of North America, Iowa in particular, contains a large number of crinoids within this family, some of which have not been described.

The goal of this study is to describe a new genus of melocrinitid crinoid from the Devonian of Iowa and emend the diagnosis of the family.

Geologic setting

The uppermost stage of the Middle Devonian is the Givetian, which lies directly below the Frasnian Stage of the Upper Devonian (Figure 1). Spanning across the Middle Devonian are rock units belonging to the Cedar Valley Group. This group is separated from the underlying Wapsipinicon Group by a disconformity and is dominated by fossiliferous limestones and dolostones. The lowest formation of the Cedar Valley Group is the Little Cedar Formation, which is bounded by the Wapsipinicon Group below and the Coralville Formation above (Witzke *et al*., 1989). Thicknesses of the Little Cedar Formation can range from 15 to 37 meters, with higher thicknesses in the northern or central region of Iowa. More specifically, the east and central Iowa portions of the formation are dominated by fossiliferous limestone. In addition, an evaporate-dominated unit, composed of gypsum and anhydrite, is present in the upper section of central Iowa. This component of the Little Cedar Formation is interpreted as a sequence of transgressive-regressive sea level

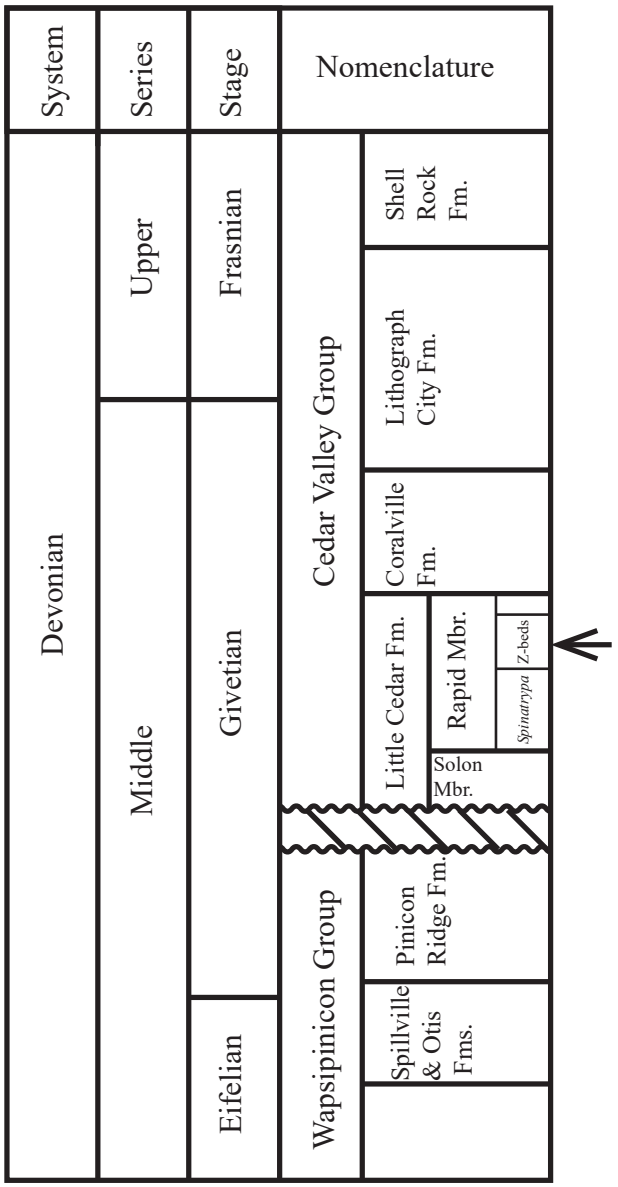

Figure 1. Chronostratigraphy of Devonian of eastern Iowa. Arrow indicates approximate horizon of specimen collection. Modified from Witzke *et al*. (1999).

changes (Witzke *et al*., 1989).

Within the Little Cedar Formation is the Rapid Member, which conformably overlies the Solon Member. The Rapid Member ranges from two to five meters thick and is composed mainly of argillaceous mudstone with minor lenses of packstone. This member can further be divided based on biostratigraphy, with the lowest bed, called the *Spinatrypa* bed, overlain by the Key Beds of Zawistowski or "Z-beds" as described in Witzke and Bunker (1994). The specimen described for this study is from these Z-beds at a location known as Devonian Fossil Gorge.

The fauna of the lower *Spinatrypa* Zone is sparse compared to the overlying beds, but still contains bryozoans, brachiopods (*Schizophoria, Pseudoatrypa, Orthospirifer, Cyrtina*, and *Tylothyris*), as well as sparse echinoderms, conularids, and arthropods (Witzke *et al*., 1989). The upper component of the *Spinatrypa* Zone has an increase in biostromes containing corals (*Hexagonaria*, rugose and favositids) and stromatoporoids. In addition, less common bryozoans, brachiopods, echinoderms, and fish debris occur (Witzke *et al*., 1989). Transitioning into the Z-beds of the Rapid Member, an ecosystem rich in crinoid-dominated reefs emerged, particularly camerate crinoids such as *Melocrinites*, *Megistocrinus* and undescribed species. Additional faunal elements such as brachiopods, ostracodes, corals, trilobites, and fish are also present (Witzke *et al*., 1989). This fauna is primarily concentrated within laterally discontinuous skeletal stringers of wackestones-packstones (<3 cm) and surrounded by rippled bedforms and argillaceous mudstones. Overlaying the Z-beds are beds dominated by more biostromes.

The lower Rapid Member has been interpreted as a deepening of the midcontinent seaway, followed by a period of shoaling in which storm events could have created lenses of packstone within the *Spinatrypa* and Z-beds (Witzke *et al*., 1989). Gradually, sea level would have dropped, but a short transgression occurred to allow for a thriving reef ecosystem. This was followed by more sea level fall, evidenced by concentrated deposits of the skeletal stringer and tidal burrowing organisms in the upper portions of the Rapid Member before being covered by deposition from the Coralville Formation.

The Devonian Fossil Gorge is an ancient fossiliferous seafloor preserve, free and open to the public. The gorge is known for containing a large variety of rugose and tabulate corals, brachiopods, stromatoporoids, and crinoids (Witzke *et al*., 1999). Preserves such as this offer a view into the seafloor communities of Paleozoic ecosystems, and repeated modern flooding in the region has exposed more fossils for description and study. The crinoids for this study were removed in a large limestone slab, with permission, to be held by the Paleontological Repository of the University of Iowa (SUI) after flooding naturally exhumed it.

Systematic palaeontology

Subclass Camerata Wachsmuth and Springer, 1885
Order Monobathrida Moore and Laudon, 1943
Family Melocrinitidae d'Orbigny, 1852
Genus ***Ronsocrinus*** gen. nov.

Type species.—*Ronsocrinus rabia* Cordie and Witzke, gen. et sp. nov.; by original designation.

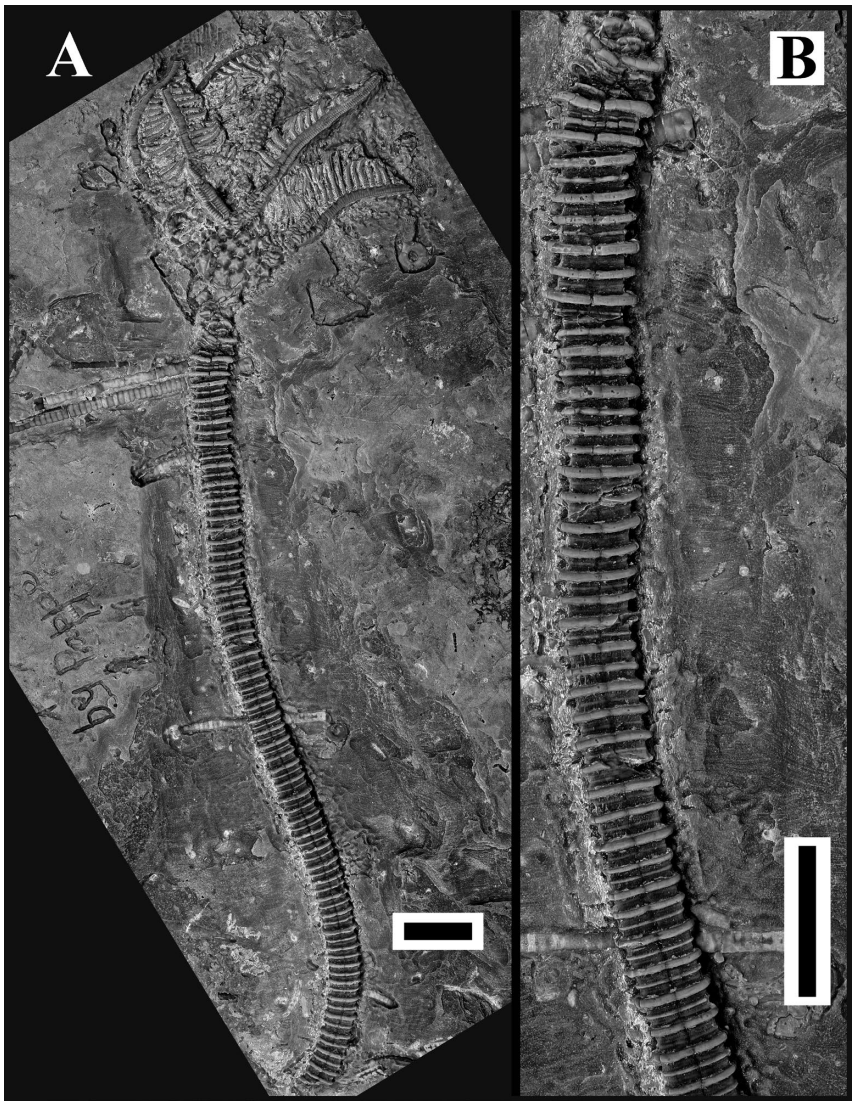

Figure 2. Lateral view of *Ronsocrinus rabia* gen. et sp. nov., SUI 102745. Holotype from Devonian Fossil Gorge near Coralville, Iowa. Scale bars equal 20 mm. **A,** Specimen coated with ammonium chloride showing long stem and overall calyx size; **B,** Close-up of heteromorphic stem.

Diagnosis.—Spherical calyx, high anal tube.

Etymology.—*Ronsocrinus* comes from the word *Ronso*, a reference to a large humanoid race of creatures from an electronic game series, and *crinus*, New Latin form of the Greek word *krinon* meaning lily. The specimen is tall and possesses an upward pointing anal tube, much like the tall, cutaneous horn of the *Ronso*. Genus name is masculine.

Ronsocrinus rabia sp. nov.

Figures 2, 3

Type specimen.—SUI 102745, articulated stem, calyx and arms. The holotype is housed at the Paleontological Repository of the University of Iowa (SUI), Department of Earth and Environmental Sciences, Iowa City, Iowa, U.S.A.

Diagnosis.—Melocrinitid with small spherical calyx; stellate patterned plates; pinnulated biserial arms and high anal tube.

Etymology.—The specific epithet *rabia* comes from the Latin noun for rage, which is commonly associated with the *Ronso*.

Description.—Calyx shape spherical, approximately as wide as high but with a slight horizontal elliptical shape. Connection between stem and calyx obscured due to poor

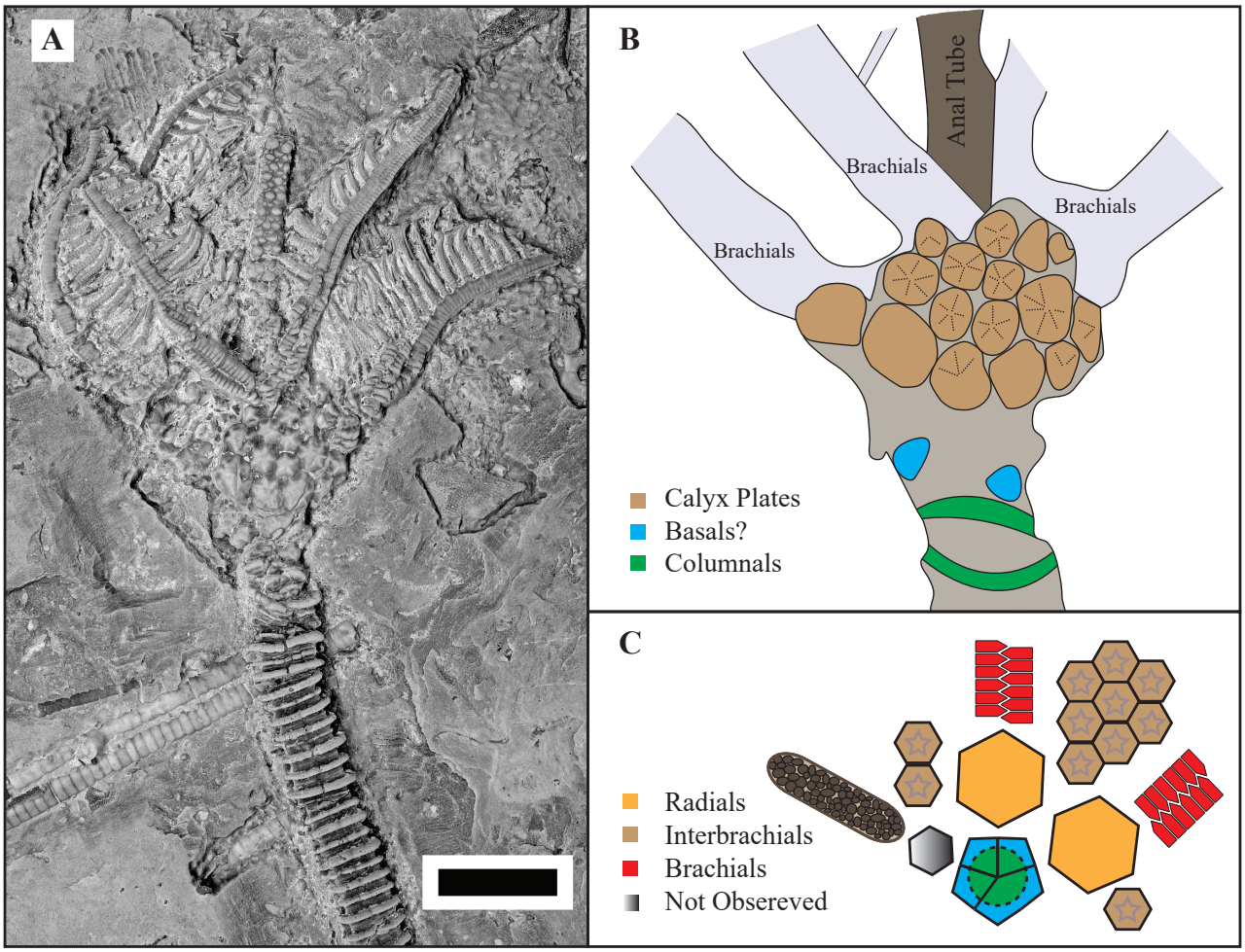

Figure 3. Calyx morphology of *Ronsocrinus rabia* gen. et sp. nov., SUI 102745. Scale bars equal 20 mm. **A,** Close-up of calyx showing numerous interbrachial plates with stellate patterns and slightly raised centers, long anal tube with elliptical ossicles emerging from center of calyx; **B,** Lateral plate structure diagram with stellate pattern added for emphasis; **C,** Reconstructed exploded plate diagram based on material visible in holotype, number of basals estimated based on other members of family Melocrinitidae, not all features to scale.

preservation and preparation. Poor preservation prevents a precise description of calyx shape, but appears more spherical than conical. Basal plates too poorly preserved to describe (Figure 2A). All radial plates tightly packed with slightly raised stellate ridges of five or six points and comprise the majority of the cup. Plates are approximately four millimeters in diameter. Stellate patterns slightly raised in middle; connect to ridges of neighboring plates. Individual plates have equal heights and rounded corners, but gradually decrease in size toward the upper portion of the calyx. No ridges or grooves on plate boundaries. Anterior interray visible (Figure 3A).

Arms biserial; gradually narrow toward distal ends. Central groove visible on only three arms, obscured on other arms. Portions of two primibrachs visible (potentially arms A and E), one branching to two secundibrachs (arm A), the other arm (E) to one complete and one partial secundibrachs. Branching brachial location poorly preserved. Distal end of two additional arms also present, unattached to calyx. Remaining arms unknown. Brachials generally rectangular with slightly pointed medial edges. Pinnules emerging from just one side of arms—orientated medially—and gradually shorten in length near distal end of arm. Pinnules same shape as brachials, but uniserial starting at the primibrachs and running entirely down the arms. Pinnules laterally sutured medially. Anal tube long and thick; emerging from center of tegmen; covered by multiple overlapping, roughly spherical, irregular ossicles. Anal tube ossicles approximately 1–2 mm in diameter. Anal tube does not taper toward distal end; but is slightly rounded. Anal tube is projecting upwards, no bends or curves, and approximately twice as tall as calyx height (see Haude, 2007 for alternative anal tube positions).

Table 1. Measurements (mm) for *Ronsocrinus rabia* gen. et sp. nov. holotype. Maximum values given. H, height; W, width.

Cup		Basal		Radials		Arm		Pinnule		Columnar		Anal Tube	
H	W	H	W	H	W	H	W	H	W	H	W	H	W
19.2	21.9	2.8	3.5	5.9	4.9	56.7	3.8	11.5	1.1	1.5	13.2	39.4	5.3

Table 2. Specimen repository information. All specimens from University of Iowa Paleontological Repository (SUI), Iowa City, Iowa, U.S.A.

Species	Material	Type Status	Cat. Num.
Ronsocrinus rabio	articulated stem and calyx	holotype	102745
Melocrinites nodosus	articulated stem and calyx	non-type	42324
Melocrinites nodosus var. *irregularis*	calyx	holotype	3600
Melocrinites belanskii	partial calyx, isolated plates	holotype	3602
Melocrinites solonensis	isolated calyx	holotype	3601
Melocrinites tiffanyi	isolated calyx	non-type	11508
Stereocrinus littletonensis	partial calyx	holotype	3627
Stereocrinus triangulatus	partial calyx	non-type	3629
Megistocrinus fitzpatricki	partial calyx	holotype	3534
Megistocrinus merrilli	partial calyx	holotype	3762
Megistocrinus robustus	partial calyx	holotype	3604
Megistocrinus clarki	partial crown	holotype	3668
Hexacrinus occidentalis	stem, partial calyx, crown	non-type	39744

Images of specimens freely available at University of Iowa Digital Library

Stem heteromorphic, becoming more apparent in the proxistele. Proxistele has alternating wide and narrow columnals with difference of roughly 1–2 mm. Columnals smooth and circular; separated from next by less than twice its height. Mesistele columnals approximately even width, but alternating columnals appear to be thinner. No holdfast or cirri preserved.

Measurements.—See Table 1.

Type locality.—Devonian Fossil Gorge in eastern Iowa, U.S.A. outside of Coralville, Iowa. 41°43′18″N, 91°31′57″W.

Occurrence.—The middle Rapid Member of the Little Cedar Formation. Stratigraphic range is Givetian, potentially Middle to Upper Devonian.

Remarks.—Other unprepared specimens are known from this region, specifically from the Klein Quarry also near Coralville, Iowa. However, they are not in public collections and include articulated stems and fragments of the calyx with little additional morphological information. Field measurements of other specimens were measured at >90 cm tall from the truncated bottom of the column to the calyx.

Comparison.—Numerous Camerata crinoids are known from the Devonian of Iowa. In particular, species belonging to the genera *Melocrinites* and *Megistocrinus* are common in the Cedar Valley Group. Comparisons of many crinoids within the family Melocrinitidae and species commonly in association with the Devonian of Iowa are summarized below (Table 2; Thomas, 1924).

Family Melocrinitidae.—*Melocrinites nodosus* var. *irregularis* (Thomas, 1924) has a conical calyx and large nodes on calyx plates. No trace of the stellate pattern of *Ronsocrinus rabia* exists. Additional specimens have the same type of column as *R. rabia. Melocrinites belanskii* (Thomas, 1924) has a bowl-shaped calyx that rapidly expands distally. Plates are smooth and have grooves along the suture lines, unlike *R. rabia*. *Melocrinites solonensis* (Calvin, 1883) also has a conical calyx shape and

nodes on plates, it is smaller than *M. nodosus*, but it lacks stellate patterns. Sutures are also heavily grooved. *Melocrinites tiffanyi* (Wachsmuth and Springer, 1897) also has a conical calyx and laterally projecting basals, unlike *R. rabia*. Although *M. tiffanyi* does possess faint stellate surficial ridges, they are not as raised as in *R. rabia*. *Stereocrinus littleonensis* (Thomas, 1924) and *Stereocrinus triangulatus* (Barris, 1878) both have a relatively large calyx with smooth plates except for bulbous basals that indent into a basal concavity. *S. littleonensis* has several radials possessing nodes and *S. triangulatus* has striated plates not resembling *R. rabia*.

Family Periechocrinidae.—Many of the species within Periechocrinidae Bronn, 1849 are commonly found in the same assemblages as *R. rabia*. *Megistocrinus fitzpatricki* Thomas, 1924 has smooth, large plates with no obvious tegmen and *Megistocrinus merrilli* Thomas, 1924 has smooth plates and sutures and a wide bowl-shaped calyx. *Megistocrinus clarki* Thomas, 1924 has indented plates and branching brachials. *Megistocrinus robustus* Thomas, 1924 has thick plates, slightly raised in center and a smoothly rising tegmun, but no anal tube. In general, the flat-bottomed bowl shape of the calyx for these species is absent in *R. rabia.*

Family Hexacrinitidae.—Hexacrinitidae Wachsmuth and Springer, 1885 are also commonly associated with Iowa Devonian crinoids. *Hexacrinus occidentalis* (Wachsmuth and Springer, 1897) has clearly longer than wide radials and is fairly small overall.

Discussion

Ronsocrinus rabia gen. et sp. nov. is difficult to be classified. In particular, the raised stellate pattern on the calyx plates and long anal tube make it unique. Previous studies have shown that anal tubes are uncommon in Devonian Monobathrida crinoids (Foote, 1994). Out of 25 species, three (12%) possessed an anal tube to cup height ratio greater than two while five (20%) had a ratio less than two. The remaining 17 (68%) did not possess noticeable anal tubes. Specifically, *Melocrinites* did not possess an anal tube and *Megistocrinus* possesses a short anal tube. Furthermore, the lack of a conical calyx, raised plate edges and grooves, and alternating pinnules precludes its assignment to a known genus within the family Melocrinitidae. *Ronsocrinus rabia* possesses a more spherical, as opposed to conical, calyx, centrally raised stellate plate ornamentation, and high column compared to other similar genera, in addition to its long anal tube. *Ronsocrinus* most closely resembles species within the genus *Melocrinites*. However, Goldfuss (1831) diagnosed this genus as having an obconical calyx, pinnules emerging from alternating sides of the arms and only a small anal area—none of which are present in this new specimen (Wachsmuth and Springer, 1897). Based on the currently available material and diagnosis of related genera, this specimen represents a new genus within the family Melocrinitidae. Future phylogenetic analysis and comparisons, in particular to *Melocrinites*, should be performed to further confirm this.

This species is grouped within the family Melocrinitidae as it contains diagnostic features such as alternating columnal sizes and sturdy biserial arms that taper at the distal ends (Moore *et al*., 1978). This particular diagnosis says that "anal tube may be present", but other diagnoses state that no anal tube and poor anal ridges are present (Bassler, 1938; Moore *et al*., 1978, p. T492). This specimen demonstrates that species within the family Melocrinitidae may possess an anal tube and the family diagnosis is hereby emended to include such features.

The purpose for possessing an exaggerated anal tube may be to reduce the negative effects of platyceratid gastropod parasitism of the crinoids. Drilling into a host with a long anal tube is more energy intensive and crinoids possessing this feature are associated with lower infestation rates (Gahn and Baumiller, 2006). Anal tubes have developed numerous times in the crinoid fossil record and incorporating the full range of morphological variability within a taxon is important for understanding their adaptability to changing environments and functional morphology (Baumiller, 1990).

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