First report of Silurian crinoid columnals with tetralobate and hexalobate lumen structures

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First report of Silurian crinoid columnals with tetralobate and hexalobate lumen structures

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Abstract: Two specimens of crinoid columnals with previously undocumented lumen morphologies are described from Silurian (Wenlock) strata of the Cincinnati Arch region, eastern-midcontinent North America. An attachment structure with a prominent tetralobate lumen, the first tetralobate lumen in a columnal reported from the Silurian, was recovered from a microbioherm in the Massie Formation of southeastern Indiana. An isolated columnal ossicle with a large hexalobate lumen, the first hexalobate lumen-bearing columnal documented, was recovered from a skeletal dolowackestone in the Lilley Formation of southwestern Ohio. These discoveries significantly increase the disparity of the otherwise morphologically conservative Silurian crinoid-columnal fauna.

Keywords: Crinoidea; Echinodermata; *Eucalyptocrinites*; Wenlock; holdfast.

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Introduction

Deviation from the five-part symmetry characteristic of echinoderms is rare within Crinoidea. Nevertheless, developmental abnormalities have been observed in several pelmatozoan groups (e.g., Macurda 1980) and evolutionary modifications of crown morphology, including reduction in ray number and/or fusion of calyx plates, have been occasionally documented in crinoid lineages (e.g., Foote 1994; Ciampaglio 2002; Liow 2004). Particularly rare, however, is the development of columnal symmetry that is not radial or pentaradial. Tetrameral symmetry in crinoid columnals has been documented in several Paleozoic groups, manifest in overall columnal shape (rectangular or square outline) and/or development of a tetralobate lumen (Moore & Jeffords 1968). Hexameral symmetry can potentially be expressed in the same manner, but no such morphologies have been previously documented.

Survey of the literature reveals that tetrameral symmetry in crinoid column morphology has been documented primarily in Devonian taxa, notably within the cladid genus *Ancyrocrinus* (e.g., McIntosh & Schreiber 1971) and family Cupressocrinidae (e.g., Głuchowski 1993; Ures et al. 1999; Bohaty 2009) and the flexible genus *Ammonocrinus* (Bohaty 2011), as well as a variety of Ordovician cladid and camerate taxa (e.g., Sprinkle & Kolata 1982; Donovan 1983, 1984, 1990; Cope 1988; Donovan & Veltkamp 1993; Ausich et al. 2002). The Silurian, in contrast, represents an interval of conservatism in crinoid columnal morphologies (Donovan 2012). Herein, we report the occurrence of crinoid columnal ossicles with tetralobate and hexalobate lumina from the middle Silurian of eastern Laurentia. These discoveries contribute significantly to the record of Silurian columnal morphological disparity and fill a fairly large gap in the record of unusual crinoid stem morphologies.

Localities and stratigraphy

All materials studied here were recovered from middle Silurian (Wenlock: Sheinwoodian) carbonate units from the eastern midcontinent of the USA. Lithostratigraphic nomenclature in this region has undergone a recent and long-needed revision, resulting in formation-scale terminology that is more consistently applied across state and county boundaries, but differing from historically used terms (e.g., Foerste 1897, 1906; Frest et al. 1999; Slucher et al. 2006; McLaughlin et al. 2008). Stratigraphic terminology here follows Brett et al. (2012) and the reader is directed there for detailed explanations of nomenclatorial revisions.

The tetralobate lumen-bearing attachment structure was recovered from a fistuliporoid bryozoan-dominated microbioherm (*sensu* Archer & Feldman 1986) in the Massie Formation exposed at the New Point Stone quarry near Napoleon, southeastern Indiana (N39°12′31.39″, W85°18′53.74″). The hardground horizon from which the microbioherms and associated pelmatozoan fauna emanate separates the basal carbonate lithofacies of the Massie Formation from the overlying mudstone lithofacies (see Brett et al. 2012, figure 8) and represents a major flooding surface, associated with an episode of rapid sea-level rise, that is widely traceable throughout the Cincinnati Arch region (Brett & Ray 2005; McLaughlin et al. 2008; Brett et al. 2012). Recent studies have revealed that this surface is densely encrusted by pelmatozoan
attachment structures attributable to both crinoids and blastozoans (Thomka & Brett in press); this suspension feeder-dominated biofacies is commonly found at this stratigraphic position in other Paleozoic sequences, seemingly resulting primarily from the availability of hard substrates and the decreased turbidity of bottom water (Brett 1995).

The hexalobate lumen-bearing columnal was recovered in a float block from a thick dolomitic carbonate succession in the middle portion of the Lilley Formation at a roadcut on OH-32 near Peebles, southwestern Ohio (N38°56′10.74″, W83°26′48.38″; see McLaughlin et al. 2008, pp. 142–149; Cramer et al. 2012). Although the entire Lilley Formation represents carbonate deposition in shallow upramp to midramp environments during an interval of tectonic quiescence and overall transgression, the undifferentiated middle portion is distinctly thinner-bedded, suggesting the onset of highstand sedimentation at some scale. The slab containing the columnal displays a wackestone to packstone fabric on one side and is barren on the other, which we interpret as representing a graded bed generated through storm activity.

**Tetralobate lumen-bearing columnal**

This specimen (CMC IP 70230) comprises a distal column and radicular attachment structure encrusting and cemented to a portion of a microbioherm (Fig. 1). Columnals are circular in plan view, holomeric and are approximately eight times as wide as they are high. Articulations between columnals are symplectial. The preserved portion of the column is homeomorphic, displays no tapering and terminates in a dendritic radix (*sensu* Brett 1981). Component radicles taper distally and branch dichotomously to irregularly. The lumen is centrally located, is relatively large, comprising approximately one-third the diameter of the columnal, and consists of four lobes, set at 90° from each other, each of which expands slightly before terminating in rounded lobes. The margin of the lumen is somewhat obscured by pyrite mineralization, but there is no evidence for a distinct areola. There is also no evidence for an epifacet. Crenulae radiate outward from the edge of the lumen and extend to the margin of the column, so that the crenularium comprises the zygum; culmina are sharp and straight.

**Hexalobate lumen-bearing columnal**

This specimen comprises an isolated columnal ossicle on the base of a graded skeletal dolopackstone bed (CMC IP 70231) recovered as float from the lower portion of the Lilley Formation. Dolomitization has partially obscured the fine details of sedimentary fabric and fossil texture and microstructure; however, large fossils are relatively well preserved, and a fairly diverse associated pelmatozoan fauna can be identified based on individual ossicles. Thecal and columnal plates belonging to the camerate crinoid *Eucalyptocrinoides* and the rhombiferan *Caryocrinoides* are identifiable, as are thecal plates tentatively attributed to (*gompheocystitid?*) diploporites (Fig. 2A).

As the studied material consists of a single ossicle, column homeomorphy cannot be determined, nor can the nature of articulations between adjacent columnals. The columnal (Fig. 2B) is circular in plan view and holomeric. Since it is embedded firmly in matrix sediment, the exact height cannot be determined. The lumen is relatively large, comprising over half of the diameter of the columnal; this almost certainly reflects weathering of the material, resulting in widening of the lumen and/or erosion of the margin, rather than an exceptionally large amount of viscera in the lumen (cf. e.g., Fearnhead & Donovan 2007). The lumen is centrally located and hexalobate to hexastellate, comprising six equally sized lobes spaced evenly around the center of the axial canal. Each lobe displays strong tapering toward the columnal margin, terminating in relatively sharp points. Imperfect preservation prevents description of details of the articular surface, but the columnal lacks a fulcral ridge and contains no obvious evidence for an epifacet or areola.

**Discussion**

As neither of the specimens described here is definitively associated with identifiable calyx plates, erection of new crinoid taxa is inappropriate at this time. Several authors have
developed classification schemes for columnal morphotaxa and assigned form genus and species designations (e.g., Moore & Jeffords 1968). In spite of their utility in biostratigraphy and assigned form genus and species designations (e.g., Moore & Brett 2013), the lack of secondary stereom secretion on the tetralobate lumen-bearing holdfast secretion may indicate taxonomic differentiation from Eucalyptocrinites. Further collection at these localities is necessary to provide additional material that can definitively resolve whether these columnals represent new crinoids or aberrant representatives of known taxa.

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