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A NEW OTARIONINE TRILOBITE FROM THE HENRYHOUSE FORMATION (SILURIAN, LUDLOW) OF OKLAHOMA
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ABSTRACT—Cyphaspis wessmani new species is a morphologically aberrant taxon from the Ludlow Henryhouse Formation of south-central Oklahoma. Its long, scoop-shaped cephalic border is without close comparison in the family Aulacopleuridae, but its possession of eleven thoracic segments with an axial spine on the sixth, an inflated gibsella with tiny L1 and dorsal tuberculate sculpture, a prominently expressed bilobate eye socket, and a micropygous pygidium all support assignment to Cyphaspis. The genus is common in Silurian rocks from most parts of the world, but C. wessmani is the first published record from southern Laurentia.

INTRODUCTION
Ludlow trilobites from the Henryhouse Formation of south-central Oklahoma have been described by Campbell (1967), who identified 11 species assigned to 10 genera. That record is here supplemented by an additional genus and species. Cyphaspis wessmani new species is of interest in that it represents the first Silurian record of the genus from the southern Laurentian region (i.e., that portion of Laurentia lying to the south of the Transcontinental Arch). It is a highly autapomorphic taxon with no obvious close relatives.

Southern Laurentian Silurian aulacopleurids are not especially well known, and only a few species have received modern taxonomic treatment. Aulacopleurids (sensu Adrain and Chatterton, 1995b) are unknown from the region, and otarionines, where they are found, are typically represented by the genus Maurotarion Alberti, 1969 (see Adrain and Chatterton, 1995a, for a revision). Occurrences include M. instita Whittington and Campbell, 1967, and M. plautum Whittington and Campbell, 1967, from the Ludlow Hardwood Mountain Formation of Maine, an undescribed Maurotarion from the Wenlock Rochester Shale of New York State (D.K. Tetreault, personal communication, and M. christyi (Hall, 1864), from the Wenlock Waldron Shale of Indiana. The only other aulacopleurid genera reported are Harpidella McCoy, 1849, (H. sentosa [Whittington and Campbell, 1967]; H. spinulocervix [Foerste, 1923]), and Malimanaspis Baldis and Longobucco, 1977, (M. butora [Holloway, 1980]; see Adrain and Edgecombe [in press]). Otarion Zenker, 1833 (as revised by Adrain and Chatterton, 1994), is common in Silurian rocks from most other parts of the world, but has not been reported from southern Laurentia. Cyphaspis wessmani is the first Silurian representative of the tribe Otarionin (see Adrain and Chatterton, 1994) yet described from the region.

LOCALITY AND STRATIGRAPHY
The Henryhouse Formation (Amsden, 1960, p. 66-84) is typically developed as a thin bedded, yellowish-gray weathering, argillaceous calcilutite. The formation is lithologically nearly indistinguishable from the overlying unit in the Hunton Group, the Haragan Formation, which contains diverse Lochkovian trilobite faunas (Campbell, 1977). The formations, however, are separated by a significant erosional unconformity. The type section of the Henryhouse Formation is near Woodford (T2S, R1W, Marshall County), but the unit attains its maximum measured thickness and is most fossiliferous in the region of the Lawrence Uplift (T2N, R6E, Pontotoc County; Amsden, 1960). It is from the latter area that the specimen described herein was collected.

Campbell’s (1967) description of the Henryhouse trilobite fauna was based mainly on museum, university, and state survey collections, most of which were in general poorly localized (Campbell, 1967, p. 6). The present specimen was collected in situ by F. H. Wessman, who has leased an area containing a section of the Henryhouse on the east side of the Lawrence
Uplift. The locality is in the bed of Bois d’Arc Creek, near the very center of section 10, T2N, R6E, Pontotoc County, Oklahoma. The total thickness of the Henryhouse has not been measured at this section, but to the north and west in the Lawrence Uplift, the formation attains its maximum thickness of some 75 m (Amsden, 1960, p. 8). Wessman (personal commun.) estimates that the specimen occurs in the lower quarter of the formation. He further reports that articulated trilobites are generally rare in the section, with 95 percent of those recovered belonging to the species Calymene clavicula Campbell, 1967. Also definitely occurring at the locality are Anasobella aspera Campbell, 1967, Dalmanites rutelium Campbell, 1967, Fragiscutum globalis Campbell, 1967, Kainops guttulus (Campbell, 1967), and Proetus foculus Campbell, 1967.

SYSTEMATIC PALEONTOLOGY

Repository. — The specimen is housed in the collections of the National Museum of Natural History (Smithsonian Institution), Washington, with prefix USNM.

Superfamily AULACOPLEUROIDEA Angelin, 1854
Family AULACOPLEURIDAE Angelin, 1854
Subfamily Otarioninae Richter and Richter, 1926
Tribe Otarionini Richter and Richter, 1926
Genus CYPHASPIS Burmeister, 1843

Type species. — Phacops ceratophthalmus Goldfuss, 1843, Eifelian, Gees, near Gerolstein, Germany.

Discussion. — See Adrain and Chatterton (1996) for a list of additional species, diagnosis, and discussion. See that work and Adrain and Chatterton (1994) for discussion of Otarionini and the relationship of Cyphaspis and Otarion.

CYPHASPIS WESSMANI new species

Figure 1

Diagnosis. — Cephalic border extremely broad for genus, inner part dorsally concave; librigenal field narrow; eye elongate (exagittally) and low; genal spine with broad base; thoracic axial spine relatively short; pygidium evidently lacking tuberculate sculpture.

Description. — Cranidium with sagittal length about 69 percent maximum width across posterior fixigenae; anterior border very long (sag.); exsag.); dorsally concave except convex rim near anterior margin; anterior border of similar length medially and laterally, lacking dorsal sculpture; anterior border furrow poorly differentiated from slope of posterior aspect of anterior border medially; prelabellar field similar in length (sag.) to L0, with considerable dorsal convexity, and with sculpture of muted caecal pits and fine, scattered tubercles; glabella inflated, maximum width across rear of L1 subequal to length (sag.) between prelabellar furrow and S0; prelabellar furrow strongly arcuate, deeply incised; axial furrows slightly anteriorly convergent in front of L1, running uninterrupted into prelabellar furrow; L0 with uneven dorsal convexity, describing smooth scarp from elongate, shallow S0 to strong transverse swelling along posterior aspect; L0 with very subdued median node and fine tubercles scattered along posterior margin; L1 small, slightly deviating from glabellar outline to produce subtle bell shape in plan view; S0 as deep as axial furrow anteriorly, shallowly slightly to contact with S0; S2 represented by a very faint depression dorsally (Figure 1.1, 1.7); S3 obscure dorsally; median glabellar lobe with dorsal sculpture of fine, scattered tubercles similar to that on prelabellar and librigenal fields; interocular fixigena narrow, dorsally inflated, with sculpture of small caecal pits;
anterior sections of facial sutures strongly anteriorly divergent, reaching maximum divergence opposite anterior \( \frac{1}{4} \) of elongate anterior border; pleural lobes very large for genus, with relatively deep, central pit; cranial width across maximum divergence of anterior branches of facial sutures about 80 percent width across midlength (exsag.) of pleural lobes; posterior border furrow very deep; posterior border similar in length (exsag.) to thoracic posterior pleural bands.

Libriena with very broad, spatulate, lateral border anteriorly, grading posteriorly into more typical subcylindrical form with distinct, deep lateral border furrow; lateral border lacking obvious dorsal sculpture; libral facial field with width (tr.) at midlength of eye about half maximum length (exsag.), with sculpture of caecal pits and fine, scattered tubercles; eye very large, low, and exsagittally elongate for genus; eye so placed as to evaluate on available specimen, anterior lobe certainly inflated; genal spine relatively short and subtriangular for subspecies, with very broad base and rapid distal taper; posterior and lateral border furrows uniting in front of genal angle, and running distally on genal spine, strongly impressed in oblique vector until reaching the abaxial aspect of the spine at about \( \frac{1}{4} \) of its length, then continued posteriorly as very faint furrow running subparallel to spine margins; doublet with sculpture of fine, closely-set, subparallel terrace lines.

Rostral plate incompletely known; broad anteriorly (tr.; Figure 1.6), about 70 percent maximum width of pygidium; connective sutures strongly posteriorly convergent; entire plate likely subtriangular.

Hypostome unknown.

Thorax of 11 segments, with axial spine on the sixth; axial ring and posterior pleural band of similar, relatively short, length (sag.; exsag.), pleural lobe about 75 percent width (tr.) of axial lobe; articulating half-ring transversely elliptical; anterior pleural band very short (exsag.), about \( \frac{1}{5} \) length of relative posterior band; relatively weak anterior articulatory boss developed from anterior pleural band at fulcrum; axial furrow shallow; intrapleural furrow shallow adaxially, deepening considerably near fulcra; furcal angle relatively shallow, about 120 degrees; fulcrum set about half distance distally on pleural lobe; axial ring and anterior spines with band lacking dorsal sculpture; posterior pleural band with two or three subdorsal tubercles proximal to fulcra; pleural tips subquadrate, lacking obvious sculpture; axial spine relatively short, stout, with significant dorsal curvature, evidently not extending posteriorly past pygidium in outstretched posture.

Pygidium with sagittal length (excluding articulating half-ring) about \( \frac{1}{5} \) maximum width; only first axial ring well defined, second and third indistinct; first intrapleural and interpleural furrows distinct, posterior furrows nearly effaced; moderately strong border furrow and narrow border developed posteriorly (i.e., behind first segment, on which the pleural tip is well expressed); axial furrow shallow, but meeting posteriorly to fully defined short axis; pygidium entirely lacking dorsal tuberculate sculpture.

Discussion.—The morphology of Cyphaspis wessmani is sufficiently unusual that its generic assignment is somewhat equivocal. The very broad, scoop-like cephalic border has no obvious close comparisons among otarions, and the short, subtriangular glabellar lobes with broad bases are seen elsewhere in otarionines only in the Devonian Maurotarion dereaui species group (see Adrain and Edgecombe, in press). Disregarding these autapomorphies, however, the species does appear to possess what Adrain and Chatterton (1994, in press) interpreted as synapomorphies of Cyphaspis. In particular, the glabella is distinctly inflated (Figure 1.3) and only 11 thoracic segments are present, with an axial spine on the sixth. Virtually all species of Cyphaspis have the glabella overhanging the preglabellar field when L0 is oriented vertically. Cyphaspis wessmani obviously does not, but this is easily accounted for as compensation for the hypertrophied and forwardly extended anterior border. The pygidium of C. wessmani is also strongly microgyous, another Cyphaspis apomorphy, and the dorsal cephalic tuberculate sculpture, small size of L1, and presence of a well-expressed bilobate eye soles all support assignment to that genus.

Nevertheless, in addition to the structure of the cephalic border and genal spine, the species differs from its congenerics in the following ways: the pleural lobe has a greater area than is normal, with significantly greater lateral extent; the eye is lower than normal, and much more elongate (exsag.); the librigenal field is narrower than normal; the thoracic axial spine is shorter than normal; and both the posterior few thoracic posterior pleural bands and the anterior pygidial pleurae lack the prominent transverse tubercle rows seen in most species of Cyphaspis.

One weakly supported alternative hypothesis that must at least be considered is that the species is related to Maurotarion Alberti, 1969 (sensu Adrain and Chatterton, 1995). Features shared with that genus (and considered synapomorphy for Maurotarion) include large pleural lobes that are extended laterally a good distance past the maximum divergence of the anterior branches of the facial sutures, and a librigenal field that is significantly narrow relative to its exsagittal length. Absence of dorsal pygidial tuberculation is also seen in many species of Maurotarion. It would seem, however, that the occurrence of these features in Cyphaspis wessmani is very likely homoplasic, and unlikely to indicate phylogenetic relationship. Cyphaspis wessmani has a dorsal cephalic sculpture of fairly densely scattered tubercles, a prominently inflated and subconical glabella, eleven thoracic segments, and a thoracic axial spine, all of which are either rare or unknown in Maurotarion.

In sum, the balance of evidence, though by no means conclusive, favors relationship with Cyphaspis, to which the species is assigned. The taxon appears to occupy an isolated position, phylogenetically, geographically, and stratigraphically. Stronger hypotheses of its affinity must await discoveries of relevant new diversity.

Etymology.—After Mr. Fred. H. Wessman, who discovered the unique specimen and made it available for study.

Material and occurrence.—Unique holotype USNM 476728 (Figure 1), enrolled exoskeleton, from the lower \( \frac{1}{4} \) of the Henryhouse Formation, Ludlow, bed of Bois d'Arc Creek, almost exactly at the center of section 10, T 2 N, R 6 E, Pontotoc County, south-central Oklahoma. Collected by F.H. Wessman.

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CARABOCRINID CRINOIDS FROM THE ORDOVICIAN OF NORTHERN IOWA AND SOUTHERN MINNESOTA

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ABSTRACT—Four species of carabocrinid crinoids from the Ordovician of northern Iowa and southern Minnesota are described, namely Carabocrinus radiatus E. Billings, C. vancoortlandti E. Billings, C. magnificus Sardeson from the Middle Ordovician Dunkle Formation and C. slocomi Forste from the Upper Ordovician Maquoketa Formation. Carabocrinus radiatus and C. vancoortlandti are also known from the Middle Ordovician of Ontario and Quebec. In addition, C. magnificus and C. vancoortlandti are from the Decorah of the Twin Cities area and the Curdsville Limestone of Kentucky, respectively. Biogeographically, the Middle Ordovician carabocrinids from Iowa and Minnesota are most similar to those from rocks of similar age in the northern Appalachians.

Development of the cup and its component plates in C. slocomi is almost entirely isometric so that the its shape is largely constant regardless of size. This species exhibits ridge canals on the shoulders of the radial plates in the cup. The ridge canals probably served for respiration. As expected, the number of ridge canals and their length increase with positive allometry compared to the size and volume of the cup. Growth of the ridge canals restricts the width of the radial facets.

INTRODUCTION

This paper on carabocrinid crinoids is one of a sequence describing the diverse and well-preserved Ordovician echinoderms of northern Iowa and southern Minnesota. Calceocrinids, cupulocrinids, hyocrinids and disparids, camarates, eoparasisocrinids, and dendroocrinids were analyzed by Brower and Sprinkle (1983) and Brower (1992a, 1992b, 1994, 1995a, 1995b). Although, all of the carabocrinids were proposed by previous workers, modern descriptions and discussions of growth and functional morphology are appropriate. Paleoecology will be considered in a later paper.

Templeton and Willman (1963) and Levorson and Gerk (1972a, 1972b, 1975, 1983), and Levorson, Gerk, Sloan and Bisagno (1987) outlined the stratigraphic framework adopted here. Some localities are still being examined; consequently most occurrences are given in terms of Levorson and Gerk or Gossman numbers. Qualified workers can secure a locality list from the Repository of the Geology Department at the University of Iowa.

Most terms are in Ubahgs (1978). The AB, BC, DE and AE interrays are designated lateral interrays. Many carabocrinids have hollow tube-like canals located inside of the plates in the vicinity of the junctions between the radials and proximal plates of the tegmen. In unweathered specimens, these canals are covered with thin stenere or covering plates which form external ridges on the plates. These canals are termed ridge canals in this paper. Hudson (1911), Brower and Veinus (1974, p. 38-59), and Sprinkle (1982) provide detailed discussions of these structures and their functional morphology in palaecocrinids and carabocrinids. The procedures adopted for measurements follow. Calipers were used for the overall calyx dimensions of large specimens. All other measurements were made with a binocular microscope at magnifications ranging from 10 to 50 times, depending on size and preservation.