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SHORT CONTRIBUTION

# A fossil crinoid with four arms, Mississippian (Lower Carboniferous) of Clitheroe, Lancashire, UK

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**Abstract**

One of the characteristic features used to define the echinoderms is five-fold symmetry. The monobathrid camerate crinoid genus *Amphoracrinus* Austin normally has five arms, but an aberrant specimen from Salthill Quarry, Clitheroe, Lancashire (Mississippian, lower Chadian), has only four. The radial plate in the B-ray supports only interbrachial and/or tegminal plates; there never has been an arm in this position. The reason why this arm failed to grow is speculative, but there is no evidence for the common drivers of aberrant growth in crinoids such as borings; rather, a genetic or developmental flaw, or infestation by an unidentified parasite, must be suspected. In the absence of the B-ray arm, the other arms of *Amphoracrinus* sp. have arrayed themselves at 90° to each other to make the most efficient feeding structure possible.

**Keywords** Salthill Quarry · Chadian · *Amphoracrinus* · Symmetry

## Introduction

The echinoderms are commonly recognized on the presence of three features: a stereom calcite microstructure to the test and associated mutable collagenous tissues; a water vascular system and associated structures, particularly tube feet; and a prevalent fivefold (pentameral) symmetry (Donovan 1999; but see Jefferies 1988). Of these criteria, it is the fivefold symmetry that is most commonly modified, as illustrated by, for example (and amongst many other examples), the bilateral symmetry of irregular echinoids that modifies the ancestral pentameral arrangement. In this example, a feature of echinoid evolution is impressed on the members of an entire clade. Much more rarely and unexpectedly, the normal five-fold symmetry of some taxa may be modified in some individuals as deformities, such as showing four- or six-fold symmetry, or asymmetries, in, for example, echinoids (Kier 1967, pp. 39–40, fig. 22, pl. 12; Donovan and Lewis 2009), blastoids (Beaver 1967, pp. S342–S344; Macurda 1980; Bohatý et al. 2010) and crinoids (Rozhnov and Mirantsev 2014).

Herein, we describe and interpret a peculiar crinoid theca, collected by A.T. from Salthill Quarry, Clitheroe. The specimen is a monobathrid camerate, *Amphoracrinus* sp., which has the normal fivefold symmetry in the radial plates of the cup, but developed only four arms. Such an abnormality is rare and poses questions that can only be explained by generalities, yet it shows features that claim illustration and comment.

## Locality and horizon

The Clitheroe area of Lancashire, NW England (Donovan and Tenny 2015, fig. 1), is one of the most important areas for Upper Palaeozoic fossil echinoderms, particularly crinoids, in the British Isles (see, amongst others, Donovan 1992; Donovan et al. 2003; Donovan and Lewis 2011). Salthill Quarry SSSI is a disused quarry now given over to industrial units and a geological trail. The specimen described herein came from locality 4 of Kabrna

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(2011; = Grayson 1981, point 3; Bowden et al. 1997, locality 6; Ausich and Kammer 2006, locality (4SH + 5 SH); NGR [SD 755 425]). This scraped area is well known to collectors. It is within the outcrop of the Salthill Cap Beds of Miller and Grayson (1972); Dinantian (Mississippian, Lower Carboniferous), Tournaisian, lower Chadian (George et al. 1976, table 2; N. J. Riley in Donovan and Sevastopulo 1985, p. 179; Ausich and Kammer 2006).

## Description

The specimen is registered in the collection of the Naturalis Biodiversity Center, Leiden (RGM.1332253). Theca small, globular, unsculptured and with a low-domed tegmen (Fig. 1c) composed of thick plates. Stem not preserved; stem facet moderately broad, rounded with a small, central lumen (Fig. 1b). Basals three, forming a low circlet; sutures between basals in CD interray, and B and E rays (Fig. 2). Radials five, hexagonal, wider than high, but much higher than basal circlet; B radial narrow, not supporting an arm. A, C, D, and E radials each support an arm. Two fixed primibrachials per arm: IBr$_1$ as broad as a radial, but lower; IBr$_2$ axillary, also broad and low; all arms incomplete at IIBr$_1$ or lower. The B radial supports a suite of polygonal interbrachial or tegminal plates.

Radial circlet interrupted by a narrower, polygonal (hexagonal?) primanal. Primanal succeeded by a row of four plates; central pair of anal plates supported by primanal and shoulders of radials; more lateral plates abut arms and are supported by IBr$_1$ (C ray) or the D radial and IBr$_1$. At least three further rows of polygonal plates occur between this level and the anal tube (Fig. 1a). The tegmen is poorly preserved, but multi-plated.

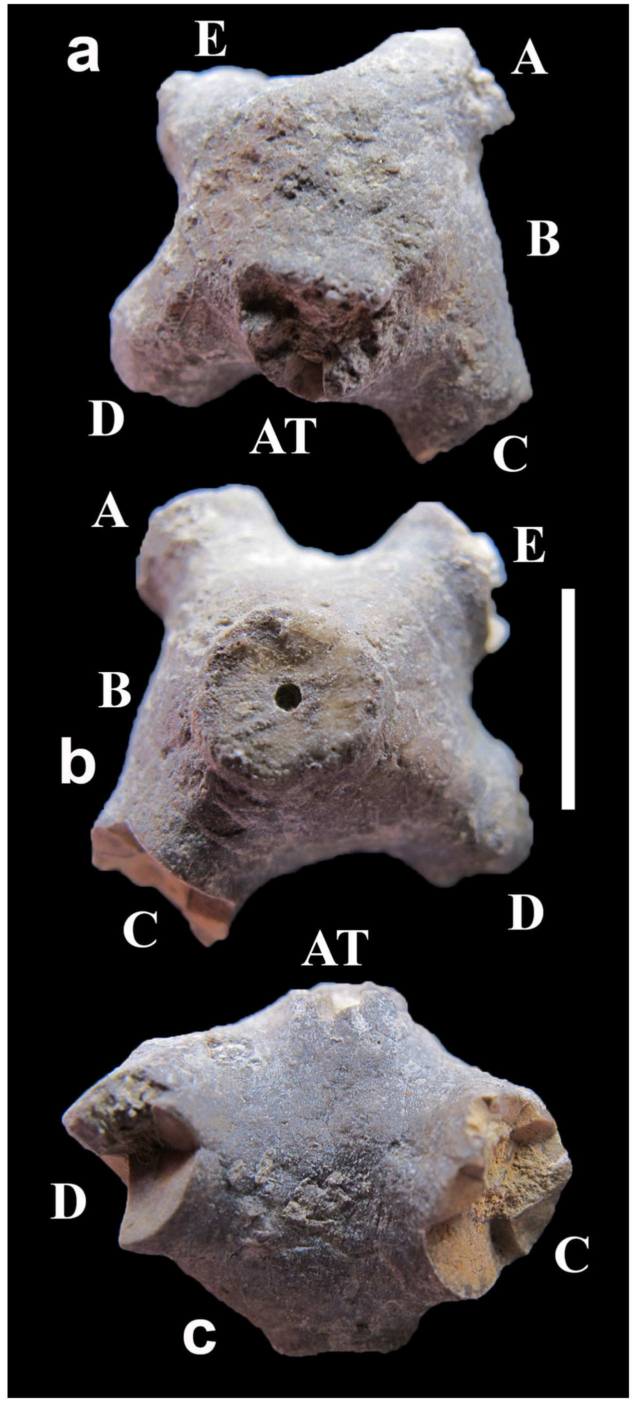


**Fig. 1** Monobathrid camerate crinoid *Amphoracrinus* sp., RGM.1332253 with only four arms. Key: A–E = Carpenter rays; AT = anal tube. **a** Apical view, anal tube (incomplete) in CD interray (= posterior); B ray to mid-right. **b** Basal view, posterior towards bottom of page; B ray to mid-left. Articular facet of column central. **c** Posterior view; CD interray centre. Specimen uncoated. Scale bar represents 10 mm

## Discussion

Two genera of monobathrid camerate crinoids from the Mississippian of the Clitheroe area broadly agree with the gross morphology of this specimen, *Actinocrinites* J.S. Miller and *Amphoracrinus* Austin. RGM.1332253 is an *Amphoracrinus*, because it "Differs from *Actinocrinites* in having the anal tube positioned sub-apically and orientated posteriorly" (Donovan and Lewis 2011, p. 59). Donovan (1992, table 2; Donovan and Lewis 2011, p. 59) listed five nominal species of *Amphoracrinus* from Salthill Quarry: *Amphoracrinus gilbertsoni* (Phillips); *Amphoracrinus atlas* (M'Coy); *Amphoracrinus bollandensis* Wright; *Amphoracrinus turgidus* Wright; and *Amphoracrinus compressus* Wright. RGM.1332253 is not close to any of these species which commonly have a more inflated tegmen (Wright 1955). This contrast may be, in part, a further growth deformity; the specimen may be an immature individual; or a combination of these factors. It is, therefore, referred to *Amphoracrinus* sp. herein. The normal

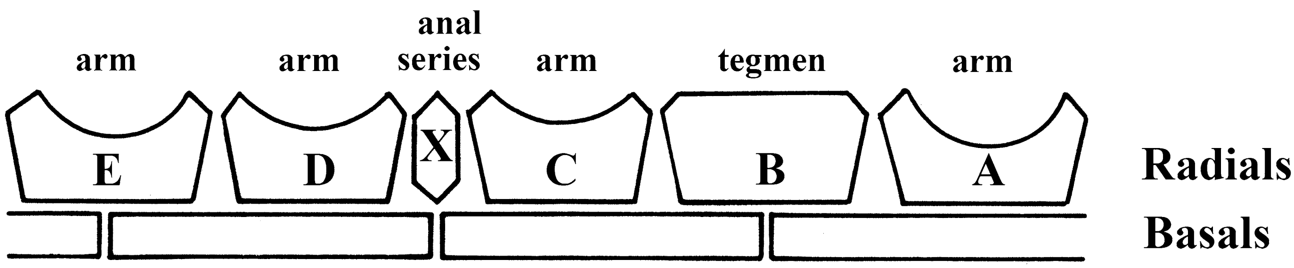


**Fig. 2** Schematic diagram of the cup plating of the monobathrid camerate crinoid *Amphoracrinus* sp., RGM.1332253. Basals three and low; radials five and with the primanal (X) in the circlet in the CD interray. There is no arm developed in the B ray. Key: A–E = Carpenter rays

geometry of this crinoid theca is, needless to say, to have five equally well-developed arms.

Why is the B-ray arm of this specimen missing? It is certainly not due to predation; there never has been an arm in this position (Figs. 1, 2). Deformed crinoids from Salthill Quarry typically have a prominent small round hole(s) produced by an invasive invertebrate(s) (for example, Donovan 1991, figs. 1, 2) and/or are swollen (such as Donovan et al. 2014, fig. 4G; for a review, see Jangoux 1987). Symmetry-altering changes without an obvious causative mechanism are rare, but not unknown. For example, Donovan (1986, fig. 1A) illustrated a crinoid columnal with a tetralobate lumen that is now suspected to be a growth deformity, in the absence of any other similar columnals having been found subsequently from this site or, indeed, the Mississippian, although that specimen is most regular. RGM.1332253 is thought to have 'lost' its B-ray arm either due to a genetic defect or to a parasitic(?) infestation that left no other evidence of invasion, similar to the gall formers of decapod crustaceans (Klompmaker et al. 2014).

Apart from the lack of one arm, the most noticeable feature of this specimen is the attitude of the remaining arms to each other. In a typical crinoid, five arms would be oriented at 72° to each other (Nichols 1967; Stephenson 1974, 1978). If one arm of a five-armed crinoid was removed by, for example, a predator, then four of the remainder would be at 72° to each other and the vacated space would be 144°. In contrast, in RGM.1332253, which has never had such a pentameral arrangement, the arms are arrayed more or less opposite each other, that is, the angles between them are about 90°. That is, never ever having had a fifth arm, the rays have adjusted to produce the most symmetrical array of feeding structures (= arms) possible. Although not preserved, the branching of the free arms and the distribution of their tube feet would have further adapted to make the most efficient feeding array possible for such a tetragonal arrangement.

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