Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 89 (1996)
Heft: 3

Artikel: Astrocratis acutispina, new genus and species, a new asteroid from the Late Cretaceous of Texas

Autor: Blake, Daniel B. / Sprinkle, James

DOI: https://doi.org/10.5169/seals-167941

Eclogae geol. Helv. 89/3: 1311–1320 (1996)

0012-9402/96/0301311-10 $1.50 + 0.20/0
Birkhäuser Verlag, Basel

Astrocratis acutispina, new genus and species, a new asteroid from the Late Cretaceous of Texas

DANIEL B. BLAKE[1] & JAMES SPRINKLE[2]

Key words: Asteroid, *Astrocratis acutispina* n. sp., Campanian, Texas, description, taphonomy, palaeoecology, phylogeny, morphology

ABSTRACT

Astrocratis acutispina, n. gen. and sp., is described from the Upper Cretaceous (Campanian) Pflugerville Formation of the upper Austin Group of Texas, USA. Although remarkably similar to Cenozoic *Astropecten*, *A. acutispina* differs from *Astropecten* in pairing of adambulacrals with inferomarginals and development of inferomarginal spines. *Astrocratis* provides further evidence for a Cretaceous origin of infaunal habits in post-Paleozoic asteroids. Ossicular alignment suggests a phylogenetic lineage separate from that of *Astropecten*.

ZUSAMMENFASSUNG

Aus der Oberkreide (Campanian) von Texas wird ein neuer Astropectinide, *Astrocratis acutispina*, n.gen., n.sp. beschrieben. Der Seestern hat eine bemerkenswerte Ähnlichkeit mit der kaenozoischen Gattung *Astropecten*, unterscheidet sich aber von dieser durch die Paarung von Adambulakralia und Inframarginalia und durch die Ausbildung der Inframarginalstacheln. *Astrocratis* ist ein weiterer Beleg für den kreidezeitlichen Ursprung einer grabenden Lebensweise post-palaeozoischer Seesterne. Die Anordnung der Plättchen von *Astrocratis* deutet auf eine von *Astropecten* verschiedene Abstammung.

1. Introduction

Well-preserved asteroids are among the rarest of heavily skeletonized fossil invertebrates; nevertheless, a broad history of the class is gradually emerging. *Astrocratis acutispina* provides additional information on this history.

2. Geological setting and accompanying fauna

The new specimens were collected by the junior author in late 1971 at a small gulley cutting into a large field exposure of the Pflugerville Formation of the Austin Group (Upper Cretaceous, lower Campanian), about 60 m west of Little Walnut Creek and about 150 m north of U.S. Route 290 in northeast Austin, central Texas. The holotype of *Astrocratis acutispina*, n. gen. and sp., and several other starfish arm fragments were

[1] Department of Geology, University of Illinois at Urbana-Champaign, 1301 W Green Street, Urbana IL 61801, USA

[2] Department of Geological Sciences, University of Texas, Austin, TX 78712, USA

found on a resistant marly bed with numerous brittle stars overlying a 5-cm-thick shell hash that together formed a small waterfall ledge near the middle of the Pflugerville marly slope. The paratype was found nearby in the broken-up debris from this same resistant bed, which is figured in Young (1977, Figure 29) as the "brittle star bed" about 5.5 m above the base of the Pflugerville. The 15-cm-thick marly interval just above this resistant brittle star bed contained a diverse decapod fauna that was described by Beikirch and Feldmann (1980), who figured a map of this locality (their Text-fig. 1). In the late 1970s, apartments were built just north of the field, diverting the water that periodically flowed through the gulley and over the waterfall, and the gulley with this fossiliferous bed has now become covered, heavily overgrown, and inaccessible.

In addition to the following fossils, which were closely associated with the new asteroid, the middle Pflugerville Formation fauna includes mollusks, worm tubes, and sharks teeth.

Foraminifera
Gandryina austinana (CUSHMAN)
Gandryina ellisorae (CUSHMAN)
Pseudogaudryinewlla capitosa (CUSHMAN)
Pseudoclavulina clavata (CUSHMAN)
Loxostomoides cushmani (WICKENDENI)

Echinoderms
Ophiura sp.
Astrocratis acutispina n. gen. n. sp.
Small echinoid plates and spines

Arthropods
Endoplocytia sp.
Astacodes maxwelli STENZEL
Protpcallianassa pleuralum BEIKIRCH & FELDMANN
Callinassa sp.
Notopoides? pflugervillensis BEIKIRCH & FELDMANN

3. Systematic paleontology

Class Asteroidea DE BLAINVILLE, 1830
Order Paxillosida PERRIER, 1884
Family Astropectinidae GRAY, 1840
Genus *Astrocratis* n. gen.
Type species. – *Astrocratis acutispina* n. sp.

Diagnosis. – *Astropecten*-like member of the Astropectinidae in which the adambulacrals are paired and aligned with the inferomarginals; large inferomarginal spines few, widely spaced across inferomarginal; spines slender, attenuated, tips pointed; large spine bases rounded to slightly dimpled but not dissected (horseshoe-shaped). First adambulacrals comparatively robust.

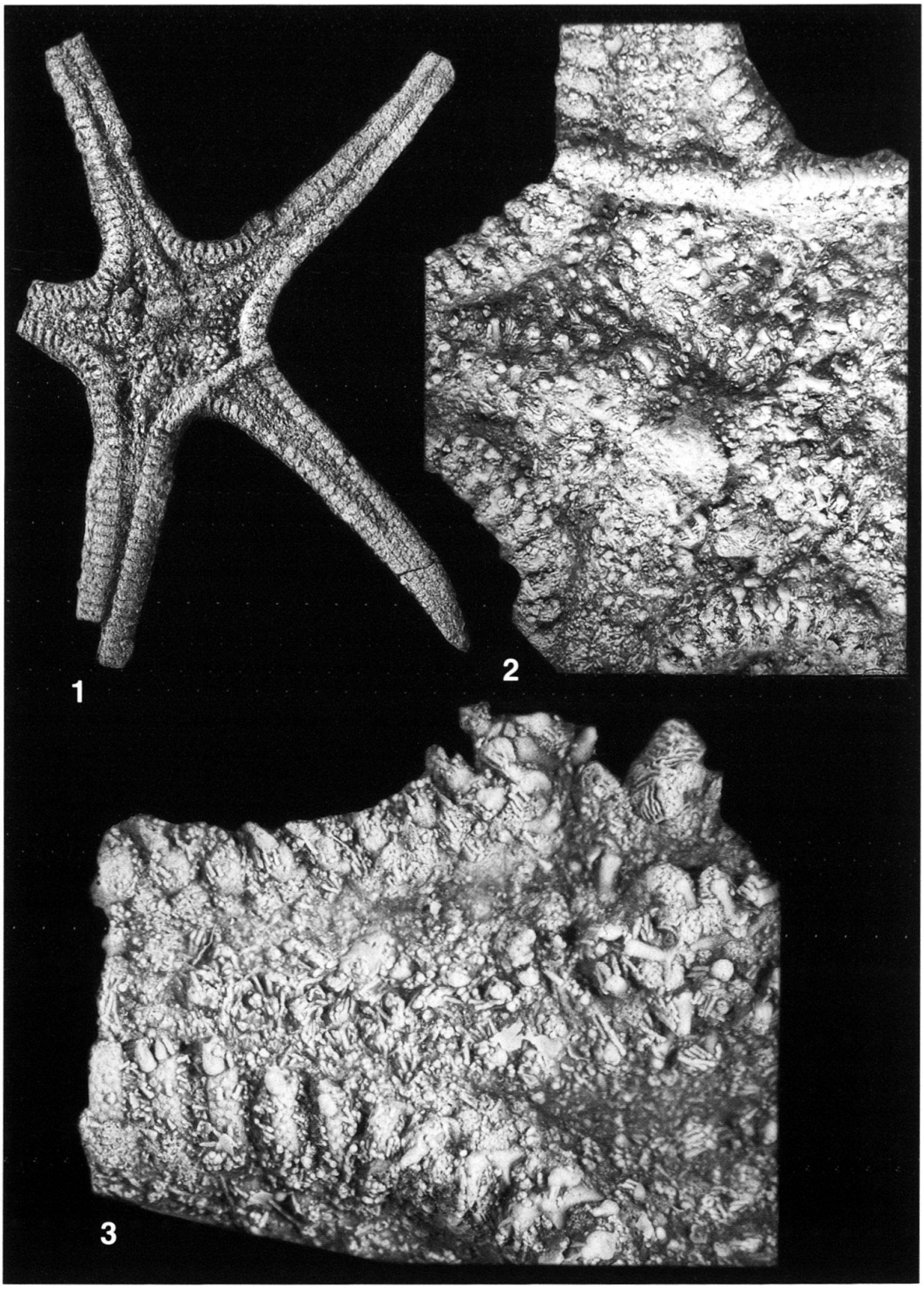

Fig. 1. *Astrocratis acutispina* n. gen. and sp., Pflugerville Formation, upper Austin Group, Upper Cretaceous (Campanian), Texas (USA), paratype, Texas Memorial Museum 1238TX37. 1, entire specimen, an ophiuroid arm is draped across the asteroid, specimen is limonitic and many details have been obscured and with some displacement of paxillae and spinelets, X1.5; 2, general form of disk showing general arrangement of dorsal surface; X5; 3, showing spines on superomarginals, form of paxillae, paxillary spines, madreporite near top of photograph, X9.

Etymology. – astro, gr., star; cratis, L., harrow. *Astropecten* is the comb star whereas *Astrocratis*, with comparatively fewer spines, is the harrow star.

Astrocratis acutispina n. sp. (Figs. 1-3)

Diagnosis. – Same as the genus, by monotypy.

Etymology. – *acutus*, L., sharp, pointed; *spina*, L., thorn. In reference to the spine development.

Material and occurrence. – Two specimens are available: Holotype, Texas Memorial Museum 1238TX36; the ventral surface is exposed, one arm is complete, a second nearly so, two are truncated medially, one proximally. Ossicular preservation is exquisite, although not all ossicular surfaces are exposed; primary radius, R = 37.0 mm, disk radius, r = 8 mm. Paratype, Texas Memorial Museum 1238TX37; the dorsal surface is exposed, one arm is complete, three are broken medially, and one proximally; primary radius, R = 41.5 mm, disk radius, r = 9 mm. Much detail is obscured by limonitic encrustation. Both specimens are in buff silty marls collected from the middle Pflugerville Formation, upper Austin Group, Upper Cretaceous (Campanian), from a resistant layer in the shale slope about 60 m west of Little Walnut Creek and about 150 m north of U.S. Route 290, in northeast Austin, Travis County, central Texas, in the southern USA.

Description. – Arms five, slender, nearly parallel-sided proximally, tapering more strongly from about mid-arm; disk small, interbrachial angles probably rather sharply rounded, R/r approximately 4.7:1; with about 47 marginals between interbrachial midline and terminal in specimens of R approximately 40 mm.

Madreporite placed near superomarginals, oval, maximum dimension approximately 1.75 mm, gyri strongly developed, radiating. Abactinals are paxillae of *Astropecten*-like form: crown slightly expanded, grading without reentrant into tapering column, abruptly expanded at base; base of larger paxillae digitate for papulae, evenly rounded in smaller examples. Crown of larger paxillae with apparently uniform cluster of about 10 columnar spinelets; spinelet surface finely spinose. Paxillae closely arranged, diminishing evenly in size both laterally and distally to approximately three rows at arm tip. Interbrachial superomarginals higher than wide, cuneate, height diminishing abruptly away from interbrachial marginals, arm marginals proportionately low. Arm superomarginals tabular, cross-section triangular; superomarginals inset from edge of inferomarginals yielding a rounded dorsal cross-section to arm; fascioles well-developed throughout. Many, perhaps all superomarginals with single stout conical spine near adradial edge; ossicular surface otherwise covered by short, acute, conical spinelets.

Interbrachial inferomarginals cuneate, those of arm rectangular, horizontal ossicular axis inclined distally, ossicles separated by deep fascioles. Arm inferomarginals with three or more long, acute, tapering, conical spines on ventral ossicular surface near distal ossicular edge, not forming robust ambital spine fringe; spine bases expanded, bulbous, spines initially tapering abruptly, then more gradually to acute tip; surface finely spinose; larger spine bases weakly dimpled, but not dissected (horseshoe-shaped). Presence of some short conical spines, only relatively small spine bases suggest elongate spines not developed interbrachially. Remainder of surface with scattered, uniform, smaller spine bases, short conical spines. In life, inferomarginal spines apparently directed distally, fairly closely appressed to arm. Actinal area small, with four to perhaps six radially elongate paxilliform ossicles.

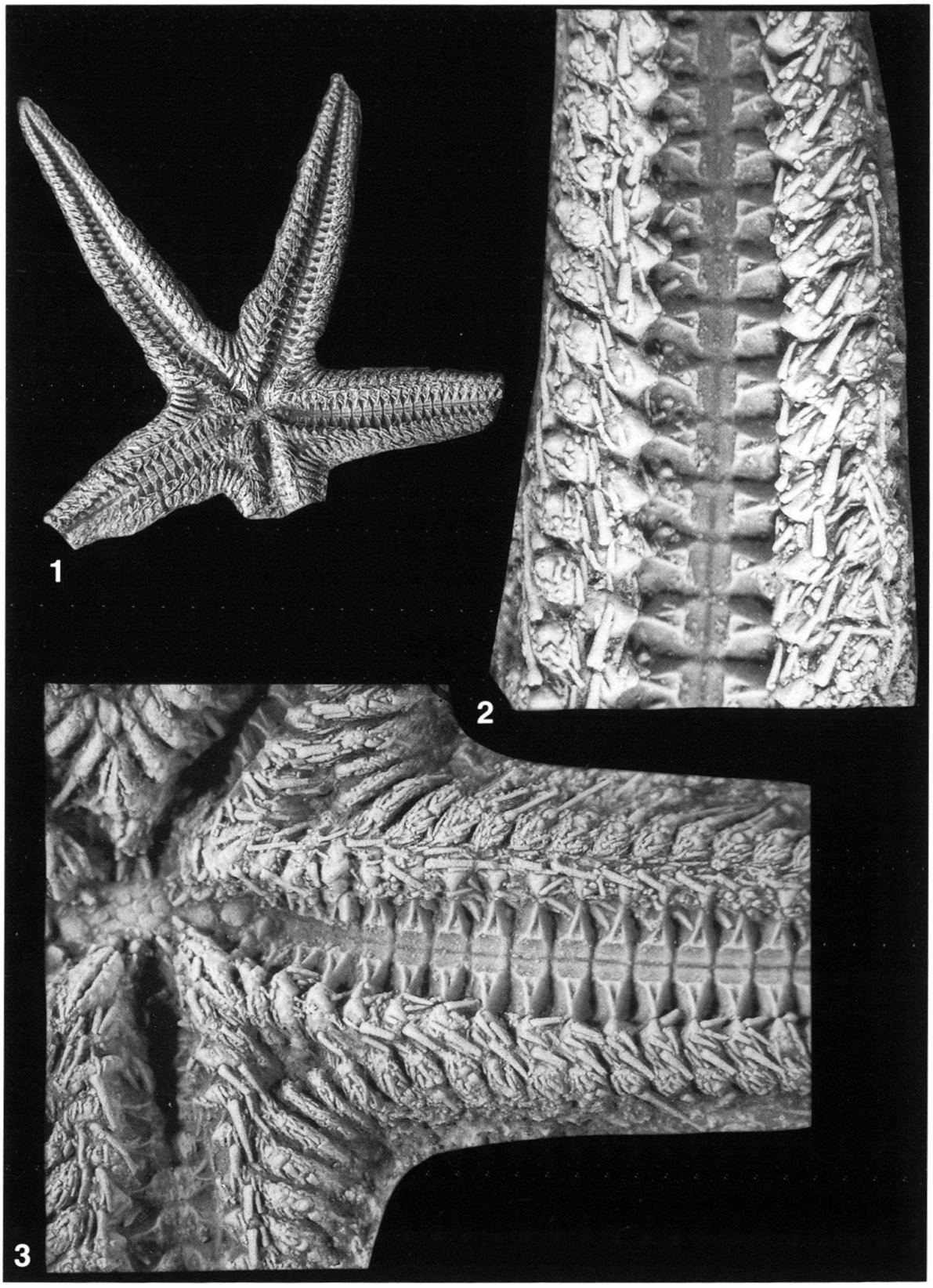

Fig. 2. *Astrocratis acutispina* n. gen. and sp., Pflugerville Formation, upper Austin Group, Upper Cretaceous (Campanian), Texas (USA), holotype, Texas Memorial Museum 1238TX36, ventral views, preservation is excellent with most spines in place. 1, entire specimen, X1.5; 2, interval of ventral surface of one arm showing of form and alignment of ambulacrals, adambulacrals, and inferomarginals; aspects of spine arrangement; X9; 3, disk and proximal arm interval, dorsal surface collapsed against ventral so that bottom of paxillae are visible at the center of mouth, X6.

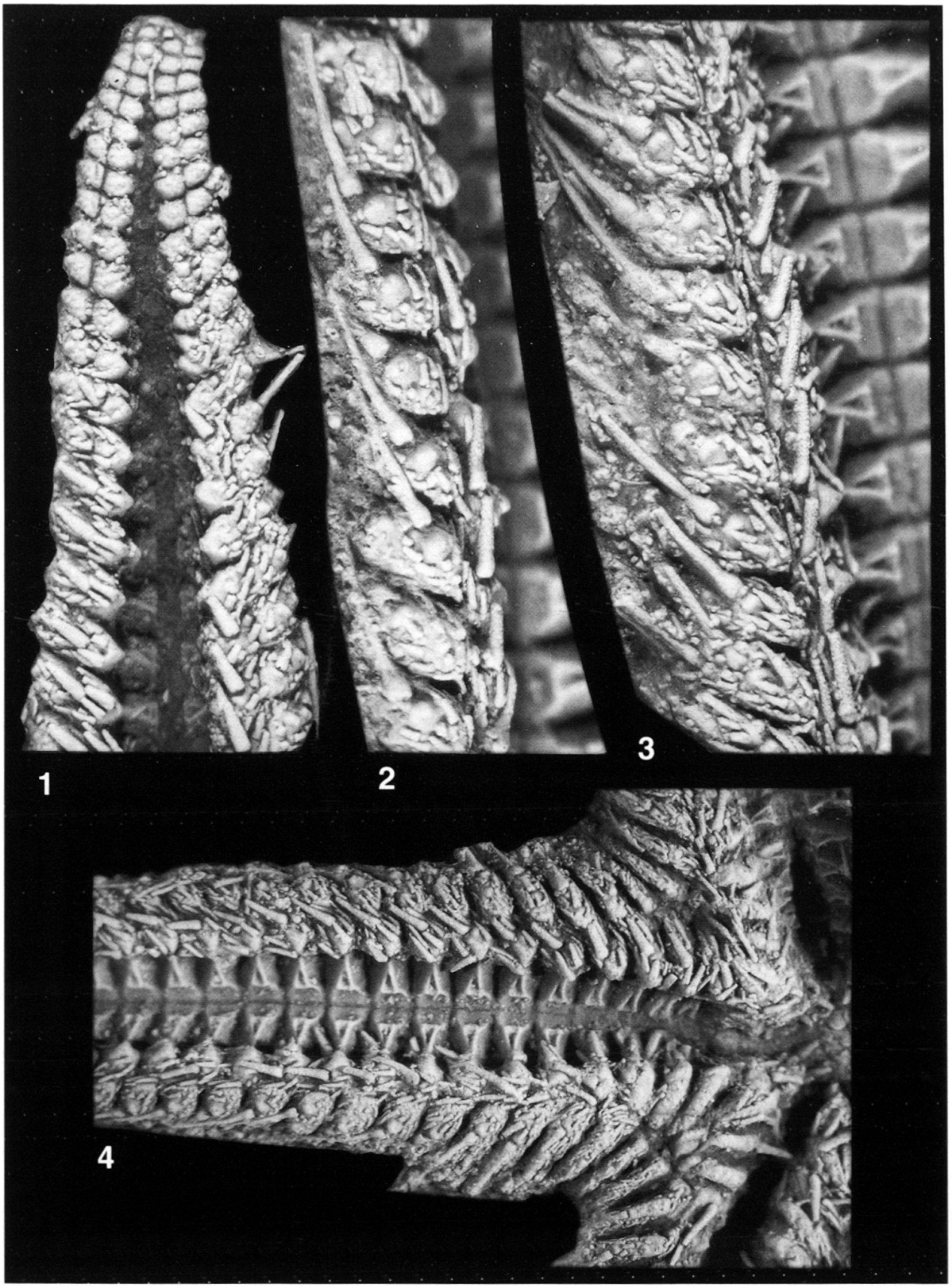

Fig. 3. *Astrocratis acutispina* n. gen. and sp., Pflugerville Formation, upper Austin Group, Upper Cretaceous (Campanian), Texas (USA), holotype, Texas Memorial Museum 1238TX36, ventral views. 1, arm tip, showing ossicular alignment, aspects of spine arrangement, X9; 2, 3, intervals of ventral surfaces of one side of arms showing inferomarginals to left with some arm spines preserved; aspects of spines on adambulacrals; X9; 4, disk and proximal arm interval showing overall arrangement of ossicles and spines, X6.

Ossicles of ambulacral column robust, adambulacrals paired with inferomarginals to arm tip. Furrow edge of adambulacrals angular, depressions for interossicular muscles broad, outer face flat. Furrow spine series probably three in number, with larger, flattened, scimitar-shaped spine at tip, flanked by conical spines. Subambulacral spine series in two? rows, first row with enlarged medial scimitar-shaped spine. First adambulacral robust, intermediate in form between mouth angle ossicle and subsequent adambulacrals. Actinal spinulation incompletely preserved but not suggesting presence of pedicellariae. Ambulacrals robust, series with deep axial groove for radial canal, deep cross-furrow tissue depressions; ambulacral head cross-section rectangular. Mouth angle ossicles robust, keel-like, with numerous spines including enlarged spine at proximal tip of each ossicle projecting into mouth area.

Comparisons. – Similarities between *Astrocratis* and *Astropecten* are strong enough to allow ready assignment of the new genus to the Astropectinidae (Paxillosida), at a position near to *Astropecten*. *Astrocratis* and *Astropecten* share presence of a small disk with long, slender, straight-sided arms; near-marginal position of the madreporite; presence of slender paxillae; enlarged, rectangular, transversely elongate marginals; overlapping, angular, transversely elongate adambulacrals, the series proximally becoming transitional in morphology with the mouth angle ossicles; robust ambulacrals; and keel-like mouth angle ossicles. Spine arrangement is a useful taxonomic guide among asteroids, and *Astrocratis* is characteristic of the Astropectinidae based on presence of short paxillary spinelets; enlarged dorsal spines on the superomarginals; a row of enlarged spines along the distal side of the inferomarginals, these surrounded by smaller spinelets; presence of a scimitar-shaped adambulacral medial furrow spine flanked by smaller spines; and presence of a double row of subambulacral spines, one significantly enlarged. Unlike most members of the family, *Astropecten* has very few actinal ossicles, these typically radially elongate and confined to the disk; arrangement in *Astrocratis* is the same.

Astrocratis can be distinguished from *Astropecten* in that the adambulacrals are exactly paired and aligned with the marginal series whereas there are more adambulacrals than marginals in *Astropecten*. Almost all larger spines are delicate, conical, and acute in *Astrocratis* (the exception is the scimitar-shaped spine on the adambulacral furrow prominence) whereas they are robust and flattened in *Astropecten*. Larger spine bases in *Astropecten* are dissected (horseshoe-shaped) for muscles connected to the spine; bases are domal and only slightly dimpled in *Astrocratis*.

Inferomarginal spines, and especially those of the ambitus, form a formidable lateral fringe in almost all species of *Astropecten* (see Döderlein, 1917); few inferomarginal spines are present on *Astrocratis*, they are much less robust, and they did not form a robust lateral fringe. First adambulacrals in *Astropecten* tend to be short and wide, and those of many species bear fasciculate pedicellariae. First adambulacrals of *Astrocratis* appear comparatively robust; the few remaining spines do not suggest presence of pedicellariae.

4. Functional and phylogenetic significance of *Astrocratis acutispina*

Most differences between *Astrocratis* and *Astropecten* are probably related to the evolution of infaunal habits. Cilia-generated superficial water currents are typical of asteroids (Gislén, 1924), and those taxa that are infaunal and semi-infaunal must have means to protect water movement from sediment blockage. Infaunal ctenodiscids and porcellanasterids (Paxillosida) have specialized structures termed „cribriform organs" between marginal ossicles and actinal ossicles on the ventral surface, whereas deep marginal fascioles provide protection in certain astropectinids (including *Astrocratis* and *Astropecten)* and *Luidia.* Hess and Blake (1995) noted that although the Astropectinidae is known from the Jurassic, it is not until the Hauterivian and Barremian (Early Cretaceous) that a taxon with deep fascioles (*Coulonia*) and presumably infaunal habits is known. Deep fascioles are also found in a Cenomanian species of *Tethyaster* from France (Breton, 1995). *Astrocratis* is another example with deep fascioles in a somewhat younger, Campanian (Late Cretaceous) genus. Like *Astropecten, Coulonia platyspina* Hess and Blake has flattened spines along the ambital fringe, but a large and therefore presumably comparatively less flexible disk, whereas *Astrocratis* has an *Astropecten*-like disk but lacks flattened spines. Apparently infaunal Maastrichtian astropectinoid occurrences have been described by Blake and Sturgeon (1995) and Breton et al. (1995). A fossil ctenodiscid is known from the Campanian (Late Cretaceous) of Mexico (Blake, 1988a); although only a single occurrence, this fossil appears structurally primitive for the family and therefore might approximately mark the evolution of infaunal habits in its lineage.

Cretaceous occurrences suggest overall timing of origin of infaunal habits in post-Paleozoic asteroids, and they are consistent with the interpretation of Blake (1988b) that such habits are derived within the order Paxillosida and the family Astropectinidae.

Differences in spine and spine base development between *Astropecten* and *Astrocratis* seem important but functionally uncertain. *Astropecten* supports itself on its tube feet while walking, and it extends it spines vertically during burial (Heddle, 1967); the robust marginal spine fringe therefore appears to be directly used neither for locomotion nor self-burial. Spines of *Astropecten* do not appear to be primarily protective because they are short and concentrated in the ambital plane rather than elongate and arranged in a radiating pattern, as are those of brisingids and benthopectinids. In *Astropecten,* the dense arrangement of laterally directed ambital spines situated in the plane of the body and sediment surface all suggest snowshoe-like support on unconsolidated substrates. Powerful articular muscles indicate that the spines actively interacted with the substrate. In contrast, the elongate and attenuated spines of *Astrocratis* suggest some protective function, and the weaker musculature suggests less active use, although presence of spine bases on the ventral surface also implies interaction with the substrate. The smaller interbrachial marginal spines in *Astrocratis* parallels development in species of *Astropecten* (see Döderlein, 1917), both suggesting erect postures in life with reduced size limiting interference among adjacent spines.

Adambulacral ossicles are aligned with the inferomarginals in *Astrocratis,* thus providing a direct passageway for surface water currents. Transverse channels are also continuous in *Astropecten,* but they are offset rather than aligned at the line of juncture between inferomarginals and ambulacrals. Alignment would seem beneficial in that it would allow more direct water flow, and the almost segmented arrangement of arm ossi-

cles could enhance arm flexibility. Comparatively small marginals, however, yield a less sturdy, perhaps less protective arm.

Phylogenetically, ossicular alignment is important because it suggests support for Fell (1963), who presented a phylogenetic hypothesis for asteroid derivation that stressed „growth gradients." In Fell's hypothesis, the dominantly transverse ossicular alignment of arms of crinoids gave way to the dominantly longitudinal alignment typical of asteroids; according to Fell, the somasteroids, *Luidia*, and then *Astropecten* represent a morphologic sequence documenting the transition. Adambulacrals and inferomarginals are aligned in *Astrocratis* as in *Luidia*, but adambulacrals are more numerous than inferomarginals in *Astropecten* and other asteroids, and hence in Fell's hypothesis, *Astrocratis* would suggest an intermediate position between *Luidia* and *Astropecten*.

The phylogenetic arguments of Fell (1963) were challenged by Madsen (1966) and Blake (1982). Ossicular alignment is known in certain Paleozoic stelleroids (e.g., Blake, 1994), but morphology of Paleozoic asteroids (Spencer, 1914–1940) does not suggest direct linkage between *Luidia*, *Astrocratis*, and Ordovician fossils. *Pentasteria* clearly is an astropectinid yet it lacks ossicular alignment (e.g., Hess, 1960; 1987) and it pre-dates the infaunal genera. Given the many *Astropecten*-like characters (see comparisons, above), alignment in *Astrocratis* appears to be homoplastic with that in Luidia, an argument also supported by stratigraphic occurrence. Based on overall similarity, *Astrocratis* appears phylogenetically close to *Astropecten*, but alignment suggests a lineage different from that leading to *Astropecten*.

Acknowledgments

JS thanks K. Young, University of Texas at Austin, for discussions about the Pflugerville Formation occurrence and its fauna, D. Boardman, Oklahoma State University, who helped collect the specimens in 1971 while a student at the University of Texas, and the Geology Foundation, University of Texas at Austin, for financial assistance with field work and publication costs. This is publication No. N.S.-74 of the Texas Memorial Museum. DBB as always is grateful to D. L. Pawson and C. Ahern for hospitality and access to collections at the U. S. National Museum. We thank H. Hess, who reviewed the manuscript, provided the German-language Zusammenfassung, and sponsored the manuscript with the Journal.

REFERENCES

Beikirch, D. W. & Feldmann, R. M. 1980: Decapod crustaceans from the Pflugerville Member, Austin Formation (Late Cretaceous: Campanian) of Texas. J. Paleont. 54, 309–324.

Blainville, H. M. de. 1830: Zoophytes. Dictionnaire des Sciences Naturelles. F. G. Levrault, Strasbourg, 60 p. (not seen)

Blake, D. B. 1982: Somasteroidea, Asteroidea, and the affinities of *Luidia (Platasterias) latiradiata*. Palaeontology 25, 167–191.

– 1988a: A first fossil member of the Ctenodiscidae (Asteriodea, Echinodermata). J. Paleont. 62, 626-631.

– 1988b: Paxillosidans are not primitive asteroids: A hypothesis based on functional considerations, p. 309–314. In Burke, R. D., et al. Echinoderm Biology. A. A. Balkema, Rotterdam.

– 1994: Reevaluation of the Palasteriscidae Gregory, 1900, and the early phylogeny of the Asteroidea (Echinodermata). J. Paleont. 68, 123–134.

– & Sturgeon, K. 1995: *Aldebarania arenitea*, a new genus and species of Astropectinidae (Asteroidea; Echinodermata) from the Maastrichtian (Upper Cretaceous) Peedee Formation of North Carolina. J. Paleont. 69, 376–380.

BRETON, G. 1995: *Tethyaster guerangeri* sp. nov. (Astropectinidae, Asteroidea, Echinodermata): deux spécimens d'astérides d'une conservation exceptionnelle du Cénomanien du Mans (Sarthe, France). Bull. trim. Soc. Géol. Normandie et Amis Muséum du Havre 82,17–29.

–, BILOTTE, M. & SIGRO, G. 1995: *Dipsacaster jadeti* sp. nov., Astropectinidae (Asteroidea, Echinodermata) du Maastrichtien des Petites Pyrénés (France). Bull. trim. Soc. Géol. Normandie et Amis Muséum du Havre 82, 35–42.

DÖDERLEIN, L. 1917: Die Asteriden der Siboga-Expedition. 1. Die Gattung *Astropecten* und ihre Stammesgeschichte. Siboga-Exped., 46b, 193–291.

FELL, H. B. 1963: The phylogeny of sea-stars. Phil. Trans. R. Soc., Lond., ser. B, 246, 381–435.

GISLÉN, T. 1924: Echinoderm studies. Zool. Bidr. Upps. 9, 1–316.

GRAY, J. E. 1840: A synopsis of the genera and species of the class Hypostoma (Asterias Linnaeus). Ann. Mag. Nat. Hist., 6,175–184. (not seen)

HEDDLE, D. 1967: Versatility of movement and the origins of asteroids. In Millott, N. Echinoderm Biology. Symp. zool. Soc. Lon. 20, 240 pp.

HESS, H. 1960: *Pentasteria (Archastropecten) procera* n. sp., (Asteroidea, Astropectinidae) aus dem Bajocien von Cheltenham (England). Eclogae geol. Helv. 53, 331–334.

– 1987: Neue Seesternfunde aus dem Dogger des Schweizer Juras. Eclogae geol. Helv. 80, 907–918.

– & Blake, D. B. 1995: *Coulonia platyspina* n. sp., a new astropectinid sea star from the Lower Cretaceous of Morocco. Eclogae geol. Helv. 88, 777–788.

MADSEN, F. J. 1966: The Recent sea-star *Platasterias* and the fossil Somasteroidea. Nature 209, 1367.

PERRIER, E. 1884: Mémoire sur les étoiles de mer recueillis dans la Mer des Antilles et la Golfe de Mexique. Nouv. Archs Mus. Hist. Nat., Paris, 6:127–276.

SPENCER, W. K. 1914–1940: British Palaeozoic Asterozoa. Palaeontogr. Soc., Lond., 540 p.

YOUNG, K. 1977: Rocks of the Austin area, p. 2.1–2.53. In Guidebook to the Geology of Travis County. Student Geology Society, University of Texas, Austin.

Manuscript received April 17, 1996
Revision accepted July 11, 1996