Zoosymposia 7: 101–110 (2012)
www.mapress.com/zoosymposia/

ISSN 1178-9905 (print edition)
ZOOSYMPOSIA
ISSN 1178-9913 (online edition)

urn:lsid:zoobank.org:pub:78F72C9B-EBE5-428E-A272-D2B9049EBAA9

An Early Permian crinoid fauna from Crete*

GARY D. WEBSTER

School of Environmental Sciences, Washington State University, Pullman, WA, U.S.A.; E-mail: webster@wsu.edu

**In*: Kroh, A. & Reich, M. (Eds.) Echinoderm Research 2010: Proceedings of the Seventh European Conference on Echinoderms, Göttingen, Germany, 2–9 October 2010. *Zoosymposia*, 7, xii+316 pp.

Abstract

Early Permian crinoids are reported from a small cape at Bali, north central Crete, Greece. The specimens have undergone low-grade metamorphism, but are moderately well preserved. At the generic level the fauna shows greatest affinity with North American faunas and secondarily with Timor faunas. This is the first Paleozoic crinoid fauna reported from Greece.

New taxa introduced are: *Synbathocrinus cretensis* n. sp., *Apographiocrinus nodosus* n. sp., *Pyndaxocrinus granulatus* n. sp., *Protencrinus baliensis* n. sp., and *Artichthyocrinus koenigi* n. sp.

Key words: Crinoidea, Echinodermata. New taxa, Greece, Palaeozoic

Introduction

For more than a century the complex structural geology of Crete has been interpreted differently by various investigators (Cayeux 1902; Hall *et al.* 1996; Papanikolaou & Vassilakis 2008, 2010; among others). All agree that the geology is complex and during the past half century fossils (including fusulinids) found in the Talea Ori Mountains of north central Crete have provided Permian ages of Asselian and Wordian for the oldest rocks recognized (Kuss 1963; Epting *et al.* 1972; König & Kuss 1980). However, the stratigraphy and stratigraphic names applied in the Talea Ori Mountains differ along with the structural interpretations in the vicinity of Bali on the north central coastal area of Crete.

A small cladid dominated crinoid fauna was discovered by Heinz König in phyllites at Bali while doing field studies in 1976–77. In 1978 the specimens were sent to Harrell Strimple for examination and he replied with tentative identifications. Nothing else was done with the specimens until Terry Frest borrowed the specimens after Strimple's death in 1983. Upon Terry's death in 2008 Webster was asked to archive his echinoderm research collections. Recognizing that the Crete fauna had not been reported and that this was the first crinoid fauna to be reported from Greece, contact was made with König via Ursula Leppig, Geologisch-Paläontologisches Institut, Freiburg im Breisgau, where the specimens had been catalogued. The purpose of this paleontological report is to describe the fauna, compare it to time equivalent faunas worldwide, and provide an approximate age for the rocks in which the fossils were found.

Accepted by A. Kroh: 22 June 2011; published 12 Dec. 2012

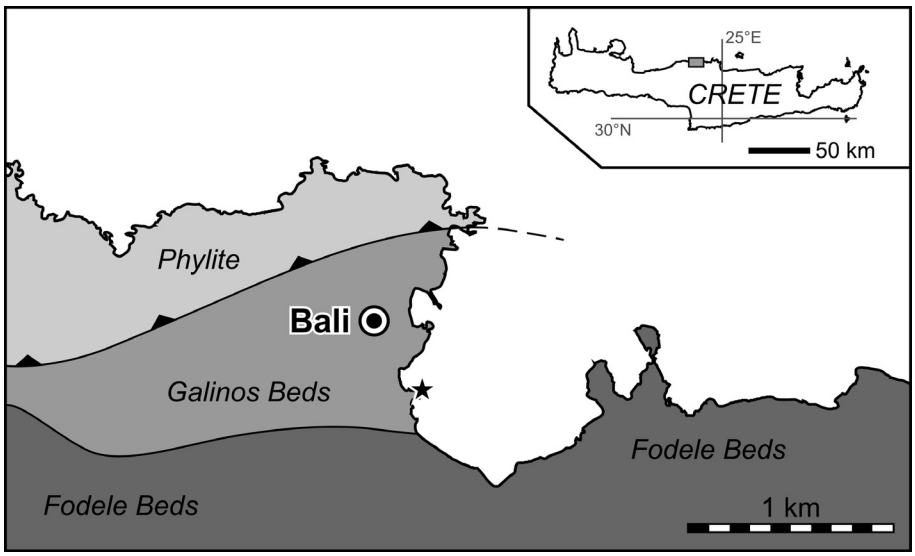

FIGURE 1. Locality and generalized geologic map. Inset map of Crete, diagonally ruled area enlarged; star indicates fossil locality. Geologic map modified after Kock *et al.* (2007).

Locality

Crinoid specimens described herein were found in phyllites on a small cape (locally referred to as "the point of rocks") south of Bali, Island of Crete, Greece, at approximately 35° 24′ 36″ N, 24° 47′ 01″ E (Fig. 1). Today the locality is part of a housing development, best accessible from the beach, but essentially no longer collectable.

The strata exposed at the cape south of Bali have been referred to as:

- Fodele-Schichten, Epting *et al.* (1972, Fig. 12)
- Phyllite-Quartzite Unit, Creutzburg *et al.* (1977, map)
- Galinos-Tonschiefer, König & Kuss (1980, Fig. 1)
- Metamorphics, Hall *et al.* (1996, Fig. 2)
- Phyllite-Quartzite Unit, Thompson *et al.* (1998, Fig. 1)
- Phyllite-Quartzite Unit, Fassoules *et al.* (2004, Fig. 1)
- Phyllites-Quartzites nappe, Kock *et al.* (2007, Fig. 1)
- "Phyllite-Quartzites s.s.", Arna Unit, Palanikolaou & Vassilakis (2008, Fig. 2; 2010, Fig. 2)

There is general agreement that the point of rocks is formed of an interbedded sequence of phyllite and quartzite metamorphic rocks. They were assigned an Early Permian age by König & Kuss (1980) based on a diverse invertebrate fauna including brachiopods, crinoids, mollusks, trilobites, gastropods and other invertebrates. The crinoids reported herein as discussed below are assigned an Early Permian age following the earlier age analysis of König & Kuss (1980).

Faunal analysis

Preservation of the Crete crinoids is moderately good. However, all specimens are metamorphosed, sutures are commonly faint, details of the radial facets are commonly lost, and ornamentation may be partly lost. The arms and stem are not preserved suggesting some post mortem disarticulation or short transport before burial.

Six genera of crinoids, one disparid, four cladids, and one flexible are present in the Crete fauna (Table 1). The cladid domination of the fauna is normal in Pennsylvanian and Permian crinoid faunas worldwide, although a non-cladid may be the most abundant taxon present as is *Artichthyocrinus* in the Crete fauna.

All genera except the flexible in the Crete fauna are recognized in North America in the Pennsylvanian. The disparid (*Synbathocrinus*) and two of the cladids (*Moapacrinus*? and *Apographiocrinus*) are also known from Early Permian (Artinskian) strata of North America as well as in Timor and Western Australia. *Protencrinus* was reported from early Middle Pennsylvanian (Atokan) of North America by Strimple (1961, as *Paradelocrinus*) and Knapp (1969) as well as late Middle Pennsylvanian (Desmoinesian) by Webster & Kues (2006). In addition, *Protencrinus* was reported from Russian Middle Pennsylvanian (Moscovian) deposits of the Moscow Basin (Jaekel 1918) and Early Permian (Artinskian) strata of Timan (Yakovlev 1948). *Apographiocrinus* was also reported from Artinskian strata of Thailand (Webster & Jell 1992) and *Moapacrinus*? was reported from Artinskian strata of Oman (Webster *et al.* 2009).

Pyndaxocrinus has not previously been reported from Permian strata; its range is extended upward into the Permian, from the Late Pennsylvanian (Virgilian) of North America where it was first reported by Knapp (1969). The flexible, *Artichthyocrinus* was described from Mississippian (Visean) strata of Scotland (Wright 1923), and its stratigraphic range is extended upward into the Early Permian. The paleogeographic range of all six genera is extended to Crete and the six species are considered endemic. They may have given rise to younger representatives of *Synbathocrinus*, *Moapacrinus*, and *Apographiocrinus* in the Basleo faunas of Timor, although the Late Permian age of the Basleo faunas has been questioned by Webster (Webster & Jell 1992; Webster 1998).

Thus, the Crete crinoid fauna is considered to have the greatest affinity with North American faunas and secondarily with Tethyan faunas. There is no single crinoid taxon in the Crete fauna that is age definitive. However, the overlapping ranges of genera within the fauna suggest a Late Pennsylvanian or Early Permian age. The range extensions of *Artichthyocrinus* and *Pyndaxocrinus* could be suggestive of the Late Pennsylvanian age, whereas the Early Permian occurrences of the other four genera along with their occurrences in the Paleotethys supports an Early Permian age, possibly somewhere within the Asselian to Artinskian.

The occurrence of all of the Crete taxa except *Artichthyocrinus* in North America suggests that they migrated from North America into the Paleotethys in the Mid to Late Pennsylvanian. *Artichthyocrinus* probably migrated from Scotland at the same time. Although the exact route of these migrations is uncertain they probably migrated from North America and Europe into the Tethys along the northern coast of Africa.

Paleogeographically Crete would have been approximately 13° S latitude in the Early Permian according to the paleogeographic maps of Golonka (2002). This is an equatorial belt fauna living in a shallow-self environment along the northern coast of Gondwana in the western part of the Paleotethys.

The Timor and Western Australia faunas lived at higher latitudes (35° S and 60° S respectively). Some of the Timor faunas lived in shallow carbonate environments that were periodically infused with volcaniclastics. The Australian faunas are commonly in cooler water, quartz sands or quartzitic carbonate environments. The quartzitic carbonate environments may represent sea-level highstands in Early Permian Gondwana interglacial periods.

Systematic Palaeontology

Specimens are reposited in the Geologisch-Paläontologisches Institut, Freiburg im Breisgau, under the numbers CrdKap 1–13.

Class Crinoidea J.S. Miller, 1821
Subclass Disparida Moore & Laudon, 1943
Superfamily Belemnocrinoidea S.A. Miller, 1883
Family Sybathocrinidae S.A. Miller, 1889
Genus *Synbathocrinus* Phillips, 1836

***Synbathocrinus cretensis* n. sp.**
Figures 2, 1–4

Etymology. For the Island of Crete

Diagnosis. Crown cylindrical, cup medium bowl, nodose ornament, 5 arms, brachials large, tapering distally; distinguished by the bulbous primanal seated on the mutual distal corners of the C and E radials followed by a larger anal at the mutual corners of the first and second brachials of the C and D rays.

Description. Partial crown, cylindrical, pentagonal in basal view, length 17 mm, width 14.2 mm. Cup medium bowl, wider (13 mm) than long (4.8 mm), base gently upflared, walls slightly out flaring, nodose ornament. Basals fused, widely out flaring. Radials 5, wider (8.2 mm) than long (6 mm), proximally out flaring, distally subvertical, moderately convex transversely, strongly convex longitudinally. Radial facet plenary. Anal notch not present on cup. Anal rectangular, length 6 mm, maximum width 3.2 mm, positioned at mutual corners of first C and D radials, extending distally to mutual corners of first and second brachials of C and D rays. Arms in juxtaposition above second anal. Arms 5. First primibrachial gently convex longitudinally, moderately convex transversely, length 6 mm, width proximally 8.1 mm tapering distally to 6.4 mm. Second brachial rectangular, moderately convex transversely, straight longitudinally. Proximal columnal round, diameter 4.3 mm; lumen roundly pentagonal. Measurements taken on holotype.

Remarks. The partial crown (holotype) and cup (paratype) of *Synbathocrinus cretensis* n. sp. are both metamorphosed. There is a slight anal notch on the mutual shoulders of the C and D radials, mostly on the C radial of the holotype. Metamorphism of the matrix has produced some recrystallization and it appears as though there are smaller plates on the base of the primanal. These small crystals are exterior and not part of the cup. The posterior cannot be determined on the paratype, which is poorly preserved. The nodose ornament is preserved in only a few places along the base of the radials on the holotype. The bulbous anal distinguishes the species from all other species of *Synbathocrinus*.

Material. Holotype CrdKap 8; paratype CrdKap 13

Type locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Subclass Cladida Moore & Laudon, 1943
Order Dendrocrinida Bather, 1889
Superfamily Cromyocrinoidea Bather, 1890

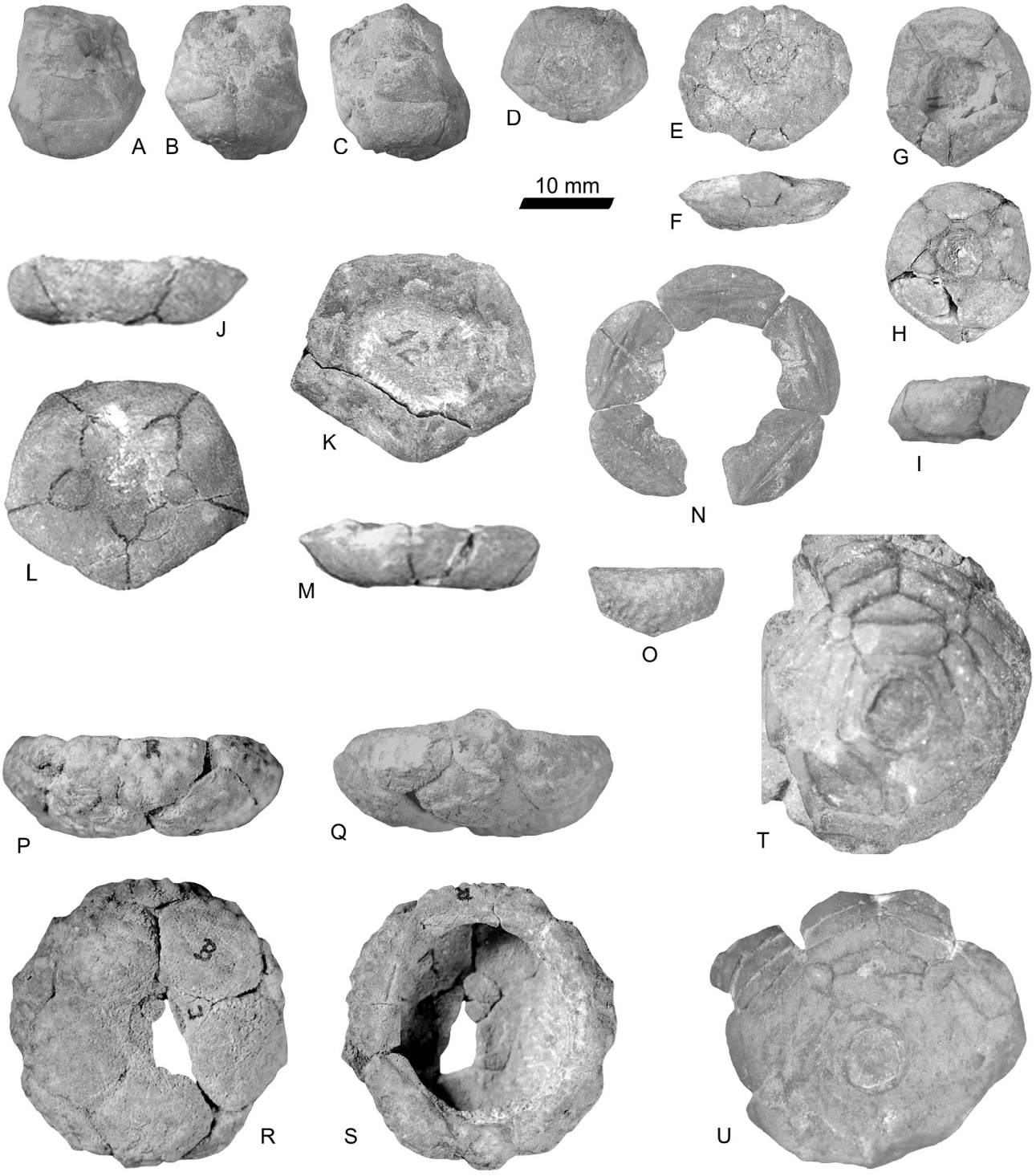

FIGURE 2. A–D, *Synbathocrinus cretensis* n. sp., holotype CrdKap 8, A-ray, CD interray, C-ray, and aboral views. E, F, *Pyndaxocrinus granulosus* n. sp., holotype CrdKap10, aboral and CD interray views. G–I, *Protencrinus baliensis* n. sp. paratype CrdKap 11, oral, aboral, and D-ray views. J–M, *Protencrinus baliensis* n. sp., holotype CrdKap12, A-ray, oral, aboral, and CD interray views. N, O, *Moapacrinus*? sp. CrdKap 9k, oral view of reconstructed radial circlet and aboral view of radial. P-S, *Apographiocrinus nodosus* n. sp., holotype CrdKap 7, a-ray, CD interray, aboral, and oral views. T, U, *Artichthyocrinus koenigi* n. sp., aboral views of holotype CrdKap 1 and paratype 1 CrdKap13. All figures times 1.5.

Family Cromyocrinidae Bather, 1890
Genus *Moapacrinus* Lane & Webster, 1966

***Moapacrinus*? sp.**
Figures 2, 14–15

Description. Radials wider (14.1 mm) than long (7 mm), thick (5.5 mm), moderately convex transversely and longitudinally, bear very coarse nodes merging to form irregular ridges that would have formed inverted Vs if extended longitudinally; sutures stitched. Radial facet plenary, deep, trifascial; morphology of prominent transverse ridge, wide deep ligament pit, narrow outer margin with angular outer margin ridge, wide shallow muscle fields, small central pit, narrow intermuscular trough, wide intermuscular furrow.

Remarks. The five radials of *Moapacrinus*? sp. were placed on clay, where they made a radial circlet with a gap for an anal plate. Although they are not a perfect fit, two of the radials do form fairly tight fits suggesting they are from the same specimen. The cup would have had a low- or medium-bowl shape with moderately declivate radial facets and a diameter of approximately 25 mm. The ornamentation is similar to that of *M. cuneatus* Webster & Jell, 1999 from the latest Artinskian or earliest Roadian Condamine Beds of Queensland, Australia. Lacking the anal(s) and rest of the cup the generic assignment is tentative and the specimens are left in open nomenclature.

Material. Figured specimens CrdKap 9k, five radials.

Locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Superfamily Apographiocrinoidea Moore & Laudon, 1943
Family Apographiocrinidae Moore & Laudon, 1943
Genus *Apographiocrinus* Moore & Plummer, 1940

***Apographiocrinus nodosus* n. sp.**
Figures 2, 16–19

Etymology. For the very coarse ornament of nodes.

Diagnosis. An ornamented species of *Apographiocrinus* with a low bowl-shaped cup, shallow basal concavity, impressed sutures, and distinguished by the very coarse nodose ornament,

Description. Cup low bowl, much wider (32.2 mm average) than long (11.4 mm); sutures impressed; very coarse nodose ornament on basals, radials, and anal; shallow basal concavity. Infrabasal circlet confined to basal concavity, slightly down flaring, diameter 11.3 mm. Infrabasals 5, dart shaped, slightly longer (5.2 mm) than wide (4.5 mm). Basals hexagonal (posterior basal heptagonal), slightly wider (12.3 mm) than long (12 mm), gently convex longitudinally, moderately convex transversely, proximally in basal concavity, medially form base of cup, widely out flaring, distal tips subvertical. Radials 5, pentagonal, much wider (16.2 mm) than long (8.3 mm), gently convex transversely, moderately convex longitudinally, inclined distally. Radial facets plenary, inclined moderately, facets trifascial, morphology poorly preserved. Primanal longer (6.5 mm) than wide (6 mm), directly above posterior basal, in radial circlet, distally projecting above radial summit adjoining two tube plates. Stem facet round, diameter 6 mm. Arms and stem not preserved.

Remarks. The cup of *Apographiocrinus nodosus* n. sp. lacks parts of the thin infrabasal circlet and has been metamorphosed and distorted. It is distinguished from all other species of *Apographiocrinus* by the very coarse nodose ornament. The cup shape is similar to that of *A. rugosus* (Wanner, 1916), a Permian species from Basleo, Timor, however, *A rugosus* has an ornament of coarse anastamosing ridges.

Material. Holotype CrdKap 7

Type locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Superfamily Erisocrinoidea Wachsmuth & Springer, 1886
Family Protencrinidae Knapp, 1969
Genus *Protencrinus* Jaekel, 1918

***Protencrinus baliensis* n. sp.**
Figures 2, 7–9

Etymolgy. For the village of Bali.

Diagnosis. A *Protencrinus* with a low bowl cup, shallow basal concavity, lacking ornament, basals not in lateral contact, anal restricted to interior notch, and distinguished by an angular pentagonal outline in oral view.

Description. Cup low bowl, shallow basal concavity, angular pentagonal in oral outline, no ornament. Infrabasal circlet confined to basal concavity, down flaring. Infrabasals 5, pentagonal, truncated distally in contact with radials. Basals 5, quadrangular, not in lateral contact, gently concave transversely, moderately convex longitudinally, proximally down flaring in basal concavity, distally up flaring with tips barely visible in lateral view. Radials 5, hexagonal, much wider than long, gently convex transversely, moderately convex longitudinally, proximal tips up flaring in basal concavity, distally gently out flaring, form base of cup. Radial facet plenary, gently declivate, trifascial; deep ligament pit; narrow outer marginal area lacking outer marginal ridge; deep central pit and intermuscular furrow; wide intermuscular notch; muscle fields shallowly concave; narrow lateral ridges. Anal notch not visible in lateral view, very shallow adorally. Stem facet round, impressed in infrabasal circlet. Lumen rounded pentagonal. Measurements given in Table 2.

Remarks. Metamorphism has destroyed the morphology of the radial facets on the larger specimen (holotype CrdKap12) of *Protencrinus baliensis* n. sp., but not on the smaller specimen (paratype CrdKap 11). There are some differences in the relative size ratios on the plates between the two specimens. For example the infrabasals and basals are both equidimensional on the paratype, whereas the lengths are considerably greater than the widths on the holotype. The notch for the primanal is not visible on the exterior of the cup, but is present as a narrow shallow V-shaped groove internally.

Protencrinus baliensis has a more angular outline in oral view than all other species of the genus. The stratigraphic range of *Protencrinus* is Pennsylvanian to Early Permian and the paleogeographic range is North America and Russia. The paleogeographic range is extended to Crete.

Material. Holotype CrdKap12; Paratype CrdKap 11

Type locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Family Catacrinidae Knapp, 1969
Genus *Pyndaxocrinus* Knapp, 1969

***Pyndaxocrinus granulosus* n. sp.**
Figures 2, 5–6

Etymology. For the granulate ornament.

Diagnosis. A *Pyndaxocrinus* distinguished by a shallow bowl-shaped cup with low granulate ornament. In addition it has a shallow basal impression with a weakly downflaring infrabasal circlet and shallow stem impression.

Description. Partial cup very shallow bowl, shallow basal concavity, granulate ornament low; length 4.3 mm, width 14.5 mm. Infrabasal circlet slightly down flaring, confined to basal concavity, not visible in lateral view; diameter 4.5 mm. Infrabasals 5, dart shaped, approximately equidimensional; length 1.5 mm, with 1.4 mm. Basals 5, hexagonal (CD basal heptagonal), wider (4.3 mm) than long (3.4 mm), very gently convex longitudinally and transversely, may be slightly concave transversely in central part of ossicle, widely out flaring. Radials 5, pentagonal, twice as wide (6.2 mm) as long (3.1 mm), gently convex transversely, moderately convex longitudinally, widely out flaring. Radial facets plenary, gently declivate, trifascial, morphology not preserved. Primanal pentagonal, directly above posterior basal, distal tip above radial summit, adjoined 2 tegmen plates distally; length 3.3 mm, width 4 mm. Stem facet round, diameter 3.3 mm. Lumen pentalobate. Arms and stem not preserved.

Remarks. The partial cup of *Pyndaxocrinus granulosus* n. sp. lacks the A and B radials and metamorphism has obliterated the finer details of the radial facet. It differs from all other species by having less vertical cup walls and coarser granulate ornament.

This is the first report of *Pyndaxocrinus* from the Permian, extending the range upward from the Late Pennsylvanian of North America and the geographic range to Crete.

Material. Holotype CrdKap10.

Type locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Infraclass Flexibilia Zittel, 1895
Order Sagenocrinida Springer, 1913
Superfamily Sagenocrinoidea Roemer, 1854
Family Euryocrinidae Moore & Strimple, 1973
Genus *Artichthyocrinus* Wright, 1923

***Artichthyocrinus koenigi* n. sp.**
Figures 2, 20–21

Etymology. For Heinz König, who discovered the specimens.

Diagnosis. An *Artichthyocrinus* with a bowl-shaped crown with a shallow basin base and incurling arms distally, one or rarely two anal plates that may or may not be in contact with the posterior basal, and distinguished by a stem facet that covers proximal two-thirds of basals, may extend over proximal tip of radials.

Description. Distorted crown globose, estimated width 35 mm. Cup discoid, length 1.4 mm, width 13.4 mm, bearing large (7.5 mm diameter) round stem impression surrounded by a flange. Infrabasal circlet confined to basal impression, upflaring, not part of cup wall, small, estimated diameter 2.3 mm. Infrabasal number uncertain, sutures may be fused. Basals 5, widely out flaring, slightly up flaring, proximally in stem impression, distally extending slightly beyond low flange surrounding stem

impression, lateral sutures may be fused in part. Radials 5, much wider (13.7 mm) than long (2.7 mm), gently convex transversely, straight longitudinally, proximal tip in or slightly beyond flange. Radial facets plenary, not exposed. Anals 1 or rarely 2, directly above extended truncated distal end of posterior basal or not in contact with distal tip of posterior basal, distally in contact with first secundibrachial. Primibrachials 2, much wider than long, both slightly wider distally; second primibrachial axillary. Secundibrachials 3, wider than long, each slightly wider distally. Single small hexagonal or heptagonal interray plate between primibrachials and first secundibrachials. All plates through the secundibrachials firmly adjoined to form base of crown. Arms free with tertibrachials. Proximal stem formed of very short columnals, completely conceals infrabasals and proximal two-thirds of basals, may extend over proximal tip of radials. Axial canal pentalobate. Distal stem and distal parts of arms unknown. Measurements taken on holotype.

Remarks. The partial crown of the holotype of *Artichthyocrinus koenigi* n. sp. is distorted and the distal parts of the arms are lost. The discoid cup and very shallow bowl-shaped basal part of the crown are developed by the adjoined, continuously widening plates of the radials, primibrachials, and secundibrachials expanding laterally. With the arms not adjoined laterally at the tertibrachials the flexibility of the arms allowed incurling of the arms when they were enclosed. Both paratypes are slightly distorted and have only the primibrachials and proximal first and or second secundibrachials in two rays. The other three specimens are only partly exposed.

Artichthyocrinus koenigi differs from *A. springeri* Wright, 1923 by having one (normal) or two (paratype 1) anal plates and lesser amounts of the basals extending beyond the round stem impression. *Artichthyocrinus* was reported from the Viséan of Scotland (Wright 1923), thus the range of the genus is extended upward into the Permian and the paleogeographic range extended to include Crete.

Material. Holotype CrdKap 1; Paratype 1 CrdKap 3, paratype 2 CrdKap 6,3 other specimens CrdKap 2, 4, 5.

Type locality. Small cape at Bali, Island of Crete, Greece, 35° 24′ 36″ N, 24° 47′ 01″ E. Early Permian.

Acknowledgments

Appreciation is extended to Ursula Leppig for recognizing the writing on the specimen labels and putting me in contact with Heinz König and to Heinz for providing historical information about the discovery and locality of the specimens. The reviews of George Sevastopulo and an anonymous reviewer are gratefully acknowledged.

References

Bather, F.A. (1889) The natural history of the Crinoidea. *Proceedings of the London Amateur Scientific Society*, 1(1–2), 32–33.

Bather, F.A. (1890) British fossil crinoids. II. The classification of the Inadunata. *Annals and Magazine of Natural History*, 6(5), 310–334.

Cayeux, L. (1902) Sur la composition et l'âge des terrains métamorphiques de la Crète. *Comptes rendus de l'Académie Sciences*, 134, 1116–1119.

Creutzburg, N. (1977) *General geological map of Greece: Crete Island 1:200,000*. Institute of Geological and Mining research, Athens.

Epting, M., Kudrass, H.-R., Leppig, U. & Schäfer, A. (1972) Geologie der Talea Ori/Kreta. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 141(3), 259–285.

Fassoules, C., Rahl, J.M., Ague, J. & Henderson, K. (2004) Patterns and conditions of deformation in the Plattenkalk Nappe, Crete, Greece: A preliminary study. *Bulletin of the Geological Society of Greece*, 36(4), 1626–1635.
Golonka, J. (2002) Plate-tectonic maps of the Phanerozoic. *SEPM Special Publication*, 72, 21–75.
Hall, R., Audley-Charles, M.G. & Carter, D.J. (1996) The significance of Crete for the evolution of the Eastern Mediterranean. *In*: Dixon, J.E. & Robertson, A.H.F. (Eds.), The geological evolution of the Eastern Mediterranean. *Geological Society of London Special Publication*, 17, 499–516.
Jaekel, O. (1918) Phylogenie und System der Pelmatozoen. *Paläontologische Zeitschrift*, 3(1), 1–128.
Knapp, W.D. (1969) Declinida, a new order of late Paleozoic inadunate crinoids. *Journal of Paleontology*, 43, 340–391.
Kock, S., Martini, R., Reischmann, T. & Stampfli, G.M. (2007) Detrital zircon and micropalaeontological ages as new constraints for the lowermost tectonic unit (Talea Ori unit) of Crete, Greece. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 243, 307–321.
König, H. & Kuss, S.E. (1980) Neue Daten zur Biostratigraphie des permotriadischen Autochthons der Insel Kreta (Griechenland). *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, [1980](9), 525–540.
Kuss, S.E. (1963) Erster Nachweis von permischen Fusulinen auf der Insel Kreta. *Praktika tēs Akadēmias Athēnōn*, 38, 431–436.
Lane, N.G. & Webster, G.D. (1966) New Permian crinoid fauna from southern Nevada. *University of California Publications in Geological Sciences*, 63, 1–60.
Miller, J.S. (1821) *A natural history of the Crinoidea, or lily-shaped animals; with observations on the genera,* Asteria, Euryale, Comatula *and* Marsupites. Bryan & Co., Bristol, 150 pp.
Miller, S.A. (1883) *The American Paleozoic fossils. a catalogue of the genera and species, with names of authors, dates, places of publication, groups of books in which found, and the etymology and signification of the words, and an introduction devoted to the stratigraphical geology of the Paleozoic rocks, 2nd Edition*. Privately published, Cincinnati, OH.
Moore, R.C. & Laudon, L.R. (1943) Evolution and classification of Paleozoic crinoids. *Geological Society of America, Special Paper*, 46, 1–151.
Moore, R.C. & Plummer, F.B. (1940) Crinoids from the Upper Carboniferous and Permian strata in Texas. *University of Texas Publication*, 3945, 1–468.
Moore, R.C., & Strimple, H.L. (1973) Lower Pennsylvanian (Morrowan) crinoids from Arkansas, Oklahoma, and Texas. *University of Kansas Paleontological Contributions, Article 60, Echinodermata*, 12, 1–84.
Phillips, J. (1836) *Illustrations of the geology of Yorkshire, or a description of the strata and organic remains. Pt. 2, The Mountain Limestone districts, 2nd Edition*. John Murray, London, 253 pp.
Papanikolaou, D. & Vassilakis, E. (2008) Middle Miocene E-W tectonic horst structure of Crete through extensional detachment faults. *Earth and Environmental Science*, 2, 1–6.
Papanikolaou, D. & Vassilakis, E. (2010) Thrust faults and extensional detachment faults in Cretan tectono-stratigraphy: Implications for Middle Miocene extension. *Tectonophysics*, 488, 233–247.
Roemer, C.F. (1852–1854) Erste Periode, Kohlen-Gebirge. *In*: Bronn, H.G. (Ed.), *Lethaea Geognostica (1851–1856), 3rd Edition, vol. 2*. E. Schweizerbart, Stuttgart, pp. 1–788.
Springer, F. (1913) Crinoidea. *In*: von Zittel, K.A. (Ed.), *Text-book of paleontology (translated and edited by C. R. Eastman), 2nd Edition, vol. 1*. Macmillan & Co., London, pp. 173–243.
Strimple, H.L. (1961) Late Desmoinesian crinoids. *Oklahoma Geological Survey, Bulletin*, 93, 1–189.
Thomson, S.N., Stöckhert, B. & Brix, M.R. (1998) Thermochronology of the high-pressure metamorphic rocks of Crete, Greece: Implications for the speed of tectonic processes. *Geology*, 26(3), 259–262.
Wanner, J. (1916) *Paläontologie von Timor, Band 6, Teil 11: Die Permischen Echinodermen von Timor, I. Teil*. Schweizerbart, Stuttgart, 329 pp.
Webster, G.D. (1998) Distortion in the stratigraphy and biostratigraphy of Timor, a historical review with an analysis of the crinoid and blastoid faunas. *Proceedings of the Royal Society of Victoria*, 110(1/2), 45–72.
Webster, G.D. & Jell, P.A. (1992) Permian echinoderms from Western Australia. *Memoirs of the Queensland Museum*, 32(1), 311–373.
Webster, G.D. & Kues, B.S. (2006) Pennsylvanian crinoids of New Mexico. *New Mexico Geology*, 28(1), 3–36.
Webster, G.D., Angiolini, L. & Tintori, A. (2009) Permian crinoids from the Saiwan and Khuff Formations, southeastern Oman. *Rivista Italiana di Paleontologia e Stratigrafia*, 115(1), 27–48.
Wright, J. (1923) *Artichthyocrinus,* n. g., a flexible crinoid from the Carboniferous limestone of Fife. *Geological Magazine*, 60, 481–490.
Yakovlev, N.N. (1948) Novye permskie morskie lilii iz Severnogo Timana [New Permian crinoids from northern Timan]. *Izvestiya Akademii Nauk USSR, Seriya Biologicheskaya*, 1, 119–122. [in Russian]
Zittel, K.A. von (1895) *Grundzüge der Palaeontologie (Palaeozoologie), 1st Edition*. R. Oldenbourg, München, 971 pp.