Cretaceous Roveacrinids from Mexico revisited: Overcoming the taxonomic misidentifications and subsequent biostratigraphic abuse

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ABSTRACT

The Mesozoic carbonate deposits of Mexico yield a number of overlooked, ill-known, and even enigmatic microfossils, among which are roveacrinoids (Echinodermata, Crinoidea, Roveacrinida). Most of these pelagic organisms probably came from the central Tethysian seaways, and later on from the early central Atlantic Ocean through the northwestern Tethysian neck, thus reaching the Central American platforms (Comanchean shelf, Central Texas platform, and Coahuila platform) and the Western Interior seaway. The present work intends to enlist as comprehensively as possible the Mexican records of roveacrinid crinoids, to propose a revised interpretation of the sections illustrated (most of them being originally erroneously assigned) and to provide a sound data base for further systematic and biostratigraphic research.

Keywords: Echinodermata, Crinoidea, Roveacrinida, Cretaceous, Microfacies, Mexico.

RESUMEN

Los depósitos carbonatados mesozoicos de México ofrecen una gran cantidad de microfósiles que no han sido objeto de la atención merecida, por ello están mal conocidos y algunos de ellos son aún enigmáticos, entre estos microfósiles se encuentran los roveacrínidos (Echinodermata, Crinoidea, Roveacrinida). La mayoría de estos organismos pelágicos probablemente provenían de los corredores del tetis central y después de la parte media de un primitivo océano Atlántico y a través del corredor noroeste del tetis, llegaron a las plataformas de América Central (Plataforma de Comanche, Plataforma de Texas Central, Plataforma de Coahuila) y el Mar Interior Occidental. Esta publicación pretende enlistar con el mayor detalle posible los registros mexicanos de crinoideos roveacrínidos, proponer una nueva interpretación de las secciones ilustradas (generalmente erróneamente asignadas) y proporcionar una base de datos sólida para poder realizar investigaciones más detalladas de su sistemática y bioestratigrafía.

Palabras clave: Echinodermata, Crinoidea, Roveacrinida, Cretácico, Microfacies, México.

1. Introduction

During the last three decades, the Mid-Cretaceous ocean of northern Mexico has been the focus of intense and diversified geological interpretations that were initiated with the UNESCO International Geological Correlation Program - IGCP 381 "South Atlantic Mesozoic Correlations". This area has been subdivided into a number of wide depressions, basins, swells and platforms, all inherited from large tectonic units in the Triassic that partially continued to exist during the Jurassic as continental blocks. Meanwhile, evaporites were being deposited during the Late Triassic and Jurassic in the Gulf of Mexico that served as a great evaporating basin in which brines derived from the Atlantic Ocean seawater were concentrating. After intense halokinesis of Triassic salts and general subsidence initiated in the Jurassic, this whole area was the scene of a homogeneous ocean in Early Cretaceous times. During this period, northern Mexico was located at the marine crossroad between the eastern central Tethys and the Pacific Ocean, the Western Interior Sea and the Paleo-Andean corridor, with widespread rudistid-bioconstructions rimming the shelf margins (Scott *et al.*, 2016). Such a paleogeographic location favoured pelagic biodiversity by means of productivity enhancement and overdrive of ecological niches. Along with an abundance of nannofossil and dinoflagellate microfossils, a few prominent microfacies taxa of echinodermal affinity diversified and have been used to subdivide the stratigraphy of the Upper Tamaulipas Formation (Fm.; Bonet, 1956; Trejo, 1975, 1981, 1983). Recently, some other related crinoidal microfacies have been found in abundance; however their use as stratigraphic markers requires a systematic revision of formerly reported sections.

The present work intends to enlist as comprehensively as possible the Mexican records of roveacrinid crinoids, propose a revised interpretation of the sections illustrated (most of them being originally erroneously assigned), and provide a sound data base for further systematic and biostratigraphic research (*e.g.*, geological mapping efforts, oil industry exploration).

2. Morphology, Petrogenetics, Palaeoecology and Systematics

2.1. ANATOMY

Since discarded or accumulated roveacrinid remains are not easily spotted in the field and are therefore studied under a petrographic microscope and/or SEM (Scanning Electron Microscopy), they are usually mentioned as microcrinoids or misinterpreted as planktonic crinoids (instead of pelagic). The thecal size does not exceed a few millimetres; a complete specimen is about 5 cm wide. Roveacrinids are small articulate crinoids with five dichotomous arms, each displaying many brachial plates (up to three dozen in complete specimens). Their minute theca is devoid of any stem or anchoring device, and is built of two sets of plates, basal and dorsal, sometimes showing a prominent centrodorsal bulge. When exceptionally preserved, it displays an inner plate ring defining a double body cavity (Schneider, 1987, 1989). Each roveacrinid species displays a distinctive architecture and widely different ornamental elements, such as a spine-like aboral element, simple bowls with or without processes, flanged or winged brachials, lateral processes, and flanges or spines (*e.g.*, Schneider, 1987, 1989; Jagt, 1999; Hess, 2015; Gale, 2016). Figure 1 depicts a synthetic diagram of a complete roveacrinid individual.

These small, mostly pelagic, crinoids are first reported after the Permian-Triassic Boundary event of the Tethys realm (Salamon *et al.*, 2015). Since then, the pelagic roveacrinids experienced several periods of extensive radiation (Gorzelak *et al.*, 2016) that might coincide with some diversification and abundance phases of calcareous phytoplankton. Their early planktonic larval stage as many open-marine organisms and their massive occurrence, partly explain their opportunistic standing and paleogeographic dissemination through the Tethysian seaways and corridors. They are also valuable to indicate high-productivity event beds (and also subsequently hypoxic-anoxic events, *sensu* Schlanger and Jenkyns, 1976).

2.2. PETROGENETIC CONTRIBUTION

Goldfuss (1826-1844) reported complete articulated roveacrinids ("*Saccocoma*" *auct.*) from the Tithonian platy limestones of southern Germany, which have become famous worldwide. Because their disarticulated remains are inconspicuous but they are very abundant in Jurassic marls, specific recognition of isolated plates was only achieved through the pioneering studies of Verniory (1954, 1955, 1956, 1960, 1961, 1962). Meanwhile the stratigraphic value of roveacrinidal microfacies was made noteworthy by Brönnimann (1955).

The genuine roveacrinoidal contribution to the Mesozoic (Jurassic) limestones was first mentioned in Verniory's seminal works (*ibidem*), and later only evoked in various articles (*i.e.*, Lombard, 1937, 1945; Brönnimann, 1955; Bengtson and Berthou, 1983; Berthou and Bengtson, 1988; Dias-Brito, 1994, 1995; Dias-Brito and Ferré, 1997, 2001; Benzaggagh *et al.*, 2015).

Roveacrinids within worldwide Mid-Cretaceous carbonate research were only rarely mentioned in the literature ("*Saccocoma*" limestones *auct.*) and ignored by overspecialized palaeontologists, or simply turned down by oil industry engineers.

As for microfacies analysis, the roveacrinidal affinity of some Cretaceous sections was originally reported by Ferré and Berthou (1993, 1994). At the same time, they provided a morphological 3D-reconstruction of a whole individual from

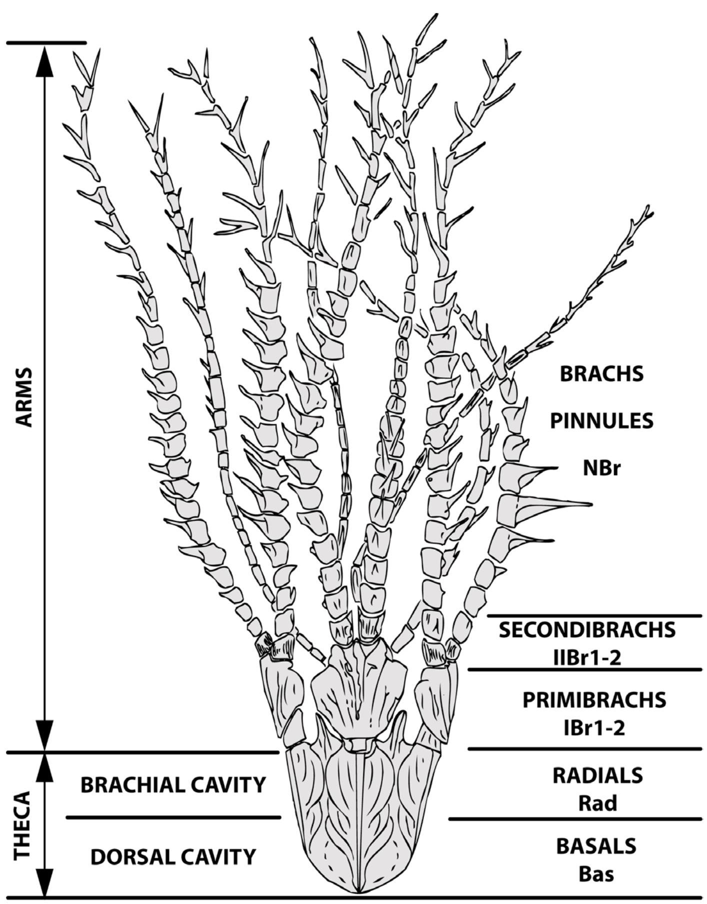

Figure 1 Tentative reconstitution of a complete roveacrinid individual (namely *Roveacrinus geinitzi* SCHNEIDER, from Ferré and Berthou, 1994).

various sections and diverse section planes, and coined the formal terminology for section orientation. Limited at first to roveacrinids, the section orientation scheme was then extended to saccocomids (Ferré and Dias-Brito, 1999). Meanwhile, Ferré and Granier (1997, 2001) defined at length the orientation and taxonomic use of roveacrinid sections. Following that, the systematic assignment of Cretaceous roveacrinid sections was fully debated for both the roveacrinids and the saccocomids (Ferré, 1997; Ferré *et al.*, 1999; see Figure 2).

2.3. SUSPECTED ECOLOGY

As with any echinoderm and many other oceanic groups, the first stage of roveacrinid life is planktonic, allowing wide passive dispersal by marine currents. Though the planktonic character of the adult and gerontic forms has not been fully substantiated, they are pelagic organisms. As adult life forms, they are found in pelagic and hemipelagic sediments, in outer carbonate shelves (outer-shelf and upper-slope environments) and outer neritic environments. As far as their arm structure is concerned, they were likely capable of temporary active swimming to escape predators (*e.g.* most likely slow moving benthic predators; Baumiller *et al.*, 2010; Gorzelak *et al.*, 2012). However, they were not that swift since some of their brachial plates can be found in bromalites (*i.e.*, *Lumbricaria*). Every element of their delicate skeleton facilitates floating or support on softground, upgrades

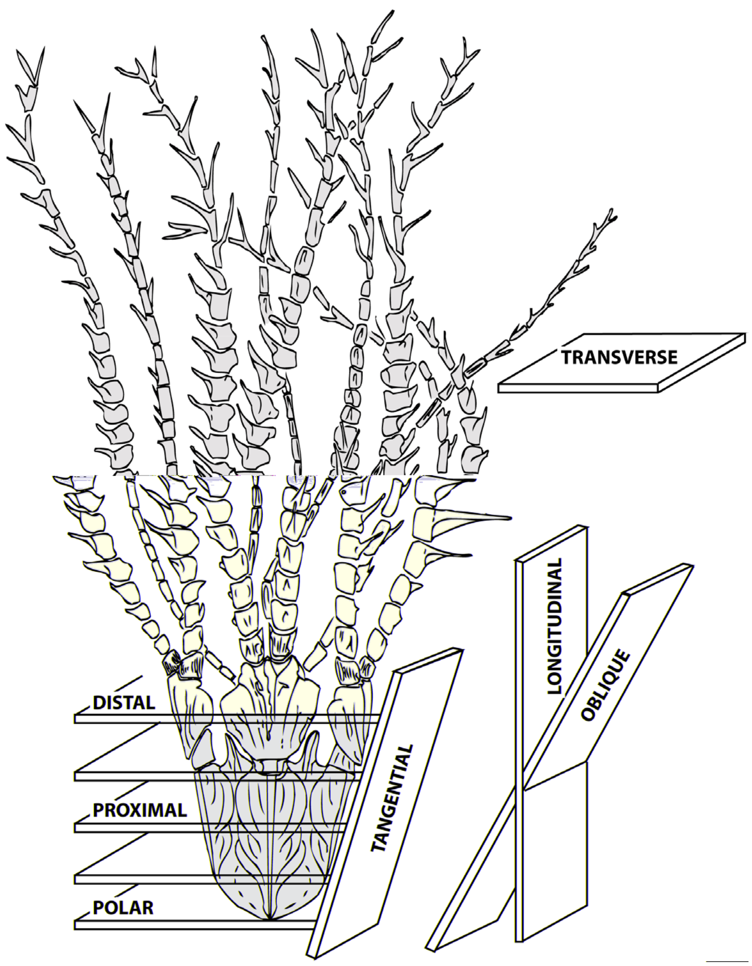

Figure 2 Terminology and orientation of the main thin-section planes in a roveacrinid individual as could be observed in microfacies (from Ferré and Berthou, 1994).

basket-net feeding and enhances defence against or the repelling of predators.

Usually conspicuous in washing residues of fine-grained pelagic facies, along with common opportunistic microfossils (calciodinoflagellate cysts = calcispheres, foraminifers, ostracodes, etc.) but without classical index markers, roveacrinids are generally overlooked by experienced but incurious palaeontologists, but are always puzzling open-minded keen microbiostratigraphers.

From the rather limited number of papers mentioning their existence, that particular crinoidal component appears to be mostly composed of opportunistic roveacrinids responsible for these very special microfacies scattering.

For saccocomids, Milsom (1989) advocated for a benthic "snow-shoe" way of life. As for other relatives, they are suspected of being active swimmers filtering the sedimentary planktonic pelagic snow in some schools of feeding crinoids. However, they look merely much like active filter-feeders hidden in the bottom current flows (planktonic larvae, organic cysts, pellets, etc.), like any comatulid, passively resting most of their time on the sea bottom with their arm basket wide open (Ferré and Bengtson, 1997; rehearsed in Souza-Lima and de Castro Manso, 2000) and capable of fleeing predator attacks by swift active swimming and escape contractions. As opportunistic filter-feeders, they thrive during high sea-level stands and high-productivity times; their abundance horizons underline flooding surfaces and transgressive system tracts (Ferré *et al.*, 2005), making them first-grade litho-, bio-, event- and sequence-stratigraphic markers.

2.4. SYSTEMATICS

The suprageneric systematics follows the classification of the Treatise (Hess and Messing, 2011). As recorded in this updated version, the order Roveacrinida consists of 4 families:

a) **Axicrinidae** (monogeneric), from the Triassic deposits of central Tethys;
b) **Somphocrinidae**, from early Triassic (Dienerian-Griesbachian: Salamon *et al.*, 2015) to Late Triassic (Kozur and Mostler, 1971; Donofrio and Mostler, 1975; Kristan-Tollman, 1975, 1977, 1991; Hess *et al.*, 2016), ranging mostly over the whole Tethysian Ocean and further north to the Svalbard archipelago, with a special emphasis on the first described member, *Somphocrinus mexicanus* PECK, 1948, from Mexico (Peck, 1948);
c) **Saccocomidae**, from Jurassic (for review see Hess, 2002) to early Maastrichtian (Jagt, 1999) with a special emphasis on the Santonian-Campanian boundary (Gale, 2016);
d) **Roveacrinidae**, from early Hauterivian of Spain (Ferré and Granier, 2000) to Late Cretaceous of Boreal Europe (Jagt, 1999; Hess, 2015; Ferré *et al.*, 2016a; Gale, 2016, 2017), with "inconsistent" records beyond (Paleogene-Neogene of Poland; Salamon *et al.*, 2010; Gorzelak *et al.*, 2011).

3. Microfacial studies

3.1. GENERAL IN-FIELD PRACTICE

Since they are not easily detected by field collectors (except for their rock-building abundance of brachial plates), and they are studied under a petrographic microscope and/or through SEM, roveacrinoids are sometimes mentioned as microcrinoids (maximum thecal size of a few millimetres).

Complete articulated roveacrinids ("*Saccocoma*" *auct.*) have been known from the Tithonian platy limestones of southern Germany since Goldfuss (1826-1844). Thus far complete individuals of Cretaceous roveacrinoids can be counted on the fingers of one paleontologist's hand (Scott *et al.*, 1977; Ferré and Bengtson, 1997; Ferré, personal data).

Their minute disarticulated remains are inconspicuous and are hardly noticed during field research. Fortunately, their abundance provides an obvious petrogenetic contribution to Jurassic deposits (Verniory, *ibidem*). Brönnimann (1955) considered them as potential stratigraphical indicators based on microfacies analysis. Likewise, Ferré and Berthou (1993, 1994), and Ferré and Granier (1997) applied such a methodology to the Cretaceous microfacies of Brazil and its Angolese counterpart.

Obviously frequent in washing residues of pelagic facies (outer neritic and outer-shelf environments), they are highlighted by default since the standard classical microfossil groups (foraminifers, ostracodes, etc.) are simply missing.

3.2. BRIEF HISTORICAL REVIEW OF ROVEACRINOIDAL STUDIES

The first illustration recorded to date ever confidently assignable to roveacrinoids comes from Hanns Bruno Geinitz (1871), who illustrated a genuine roveacrinid theca as an Aristotle's lantern. More than a hundred years later, this original material became the holotype of *Roveacrinus geinitzi* Schneider (Schneider, 1989; Niebuhr and Ferré, 2016). At the turn of the 20th century, while tackling the English Chalk stratigraphy by means of *Micraster* lineages, Arthur Rowe retrieved eccentric ossicles from washed Sussex "flint meal" (*i.e.*, soft chalk cores of hollow flints): this original material was then first formally described (and subsequently dedicated to their discoverer) as *Roveacrinus* by Douglas (1908). Peck (1943, 1948) extensively traced their stratigraphic range through the Cretaceous (Albian-Cenomanian) of the U.S. Gulf States and in the Triassic of Mexico, and enhanced their potential stratigraphic value. Rasmussen (1961) compiled an updated knowledge of roveacrinid systematics. While investigating the Lower Cretaceous deposits of Cuba, Bonet (1956) described quite a number of original microfossils among which are calcispheres, and the genus *Microcalamoides* (as *incertae sedis*). This later unrelated genus was then extensively used in Mexican stratigraphy to define a biozone straddling the Aptian-Albian boundary. This microfacies genus was later assigned to saccocomids (Ferré and Dias-Brito, 1997). By defining a new Tethysian carbonate microfacies ("Osteocrinusfazies"), Kristan-Tollmann extended the knowledge of these crinoids back to the Triassic of Austria (1975, 1977) and farther east to Iran (1991). Likewise, though often occurring in masses in Cretaceous deposits and rock-building carbonate microfacies, this wealth of microfacies data is turned down by collecting palaeontologists who prefer complete third-dimensional specimens to tackling their mental agility with the relative complexity of their microfacial-morphological features.

3.3. "CONTROVERSIES"

Whether isolated from the rock (and sometimes badly preserved or frequently harmed during the extraction process from the indurated rock) or evidenced in thin sections, any ossicle tentatively assigned to the order Roveacrinida is subject to careful consideration. Even currently their study by means of microfacies remains confidential to some authors, and all Chinese, who favour nearly complete specimens. Unfortunately, such an analytical restriction hampers the opportunity of filling some of the numerous stratigraphic gaps in their fossil record.

Regardless of their ontogeny, relatives of the order Roveacrinida are termed "microcrinoids" since their study requires the use of binoculars. Their origin is still questionable but is believed to have occurred with the Permian crinoids.

Recently roveacrinidal remains (within related somphocrinid- and *Osteocrinus*-microfacies) have been found in the Induan Vardebukta Fm. of Svalbard (Salamon *et al.*, 2015), indicating that they first "appeared" after the Permian-Triassic Boundary event of the Tethys realm.

After the Permian-Triassic boundary, the pelagic roveacrinoids experienced several periods of extensive radiations that might coincide with some diversification and abundance phases of calcareous phytoplankton. However, we must keep in mind that this "positive" correlation is more a guess than a ground truth; their stratigraphic record is far from complete: they are best-known in the Middle Triassic, in the middle and Late Tithonian (before the J/K boundary), and in the Albian-Cenomanian, Santonian-Campanian and Maastrichtian for Cretaceous times. As for their extinction, which is in need of further investigation, there are isolated records in the Neogene of Poland (Salamon *et al.*, 2010; Gorzelak *et al.*, 2011), which have reopened the debate of their survival past the K/T boundary.

Each roveacrinoid relative displays a distinctive architecture and widely different ornamental elements, such as a spine-like aboral element, simple bowls with or without processes, flanged or winged brachial plates, lateral processes, flanges or spines (*e.g.*, Schneider, 1987, 1989; Gale, 2016). Every element of their delicate skeleton facilitates floating or helps support them on a soft-ground substrate. Consideration of such ornamental elements can help reconstruct the paleoenvironment and sea bottom hydrodynamics. With this in mind, the position of roveacrinoids in the water column is still debatable: the most parsimonious interpretation envisions the adult stage of these organisms as pelagic benthonics, passively filter-feeding in the current flow, and with reduced lift-off capability to escape predatory pressure.

4. Plate recognition and identification of thin sections

Following the revision of the Mid-Cretaceous carbonate microfacies of the Sergipe basin (Bengtson and Berthou, 1983; Berthou and Bengtson, 1988), Ferré and Berthou (1993, 1994) first introduced formal recognition of roveacrinid microfacies and coined the general identification frame in thin section. Later on, this was further refined and upgraded into a detailed plate-focused panel (Ferré and Granier, 1997). The general orientation and taxonomic value of such roveacrinidal sections were then given in Ferré and Granier (2001) as a definitive issue. Moreover, some particular microfacies sections, widely used for local biozonation (*i.e.*, *Microcalamoides* Bonet, 1956), were synonymized and revised (Ferré, 1997). Noteworthy is the common occurrence of *Microcalamoides* Bonet, 1956 roughly defining the Microcalamoides Zone (around the Aptian-Albian boundary) of the Upper Tamaulipas Fm. in Mexico (see comments below). Figure 2 illustrates the main terminology of thin-section plane orientation within a roveacrinidal skeleton, from the basal plates of the calyx (Bas/Rad) to the last tertibrachial plates (NBrn) of the five dichotomous arms.

5. Revised description of the Mexican roveacrinoids and subsequent implications

Historically, the first report of roveacrinoids from the Gulf of Mexico (Mexico and southern USA) is due to the thorough stratigraphic range records made during the mapping efforts of Peck (1943).

Shortly after, Peck (1948) erected *Somphocrinus mexicanus* on original material from the Carnian deposits of Mexico, which remains the only Triassic occurrence of roveacrinoids in the far western Tethys, unlike the relative abundance of somphocrinids in central Tethys as described by Kristan-Tollman (1975) under the term “Osteocrinusfazies”, and further extended (Austria: Mostler, 1972; Donofrio and Mostler, 1975; Kristan-Tollmann, in Kristan-Tollmann and Krystyn, 1975; Kristan-Tollmann, 1977; Kristan-Tollmann and Tollmann, 1981) to the eastern part of Tethys (the early Carnian of Turkey and latest Ladinian of Iran; Kristan-Tollmann, 1991).

During the Jurassic, though worldwide famous, the only available Mexican references of roveacrinoids are the stratigraphic and paleoenvironmental reports of Aguilera-Franco and Franco-Navarrete (1995) concerning the Mid-Tithonian occurrence of some “*Saccocoma Arachnoidea* (Brönnimann,

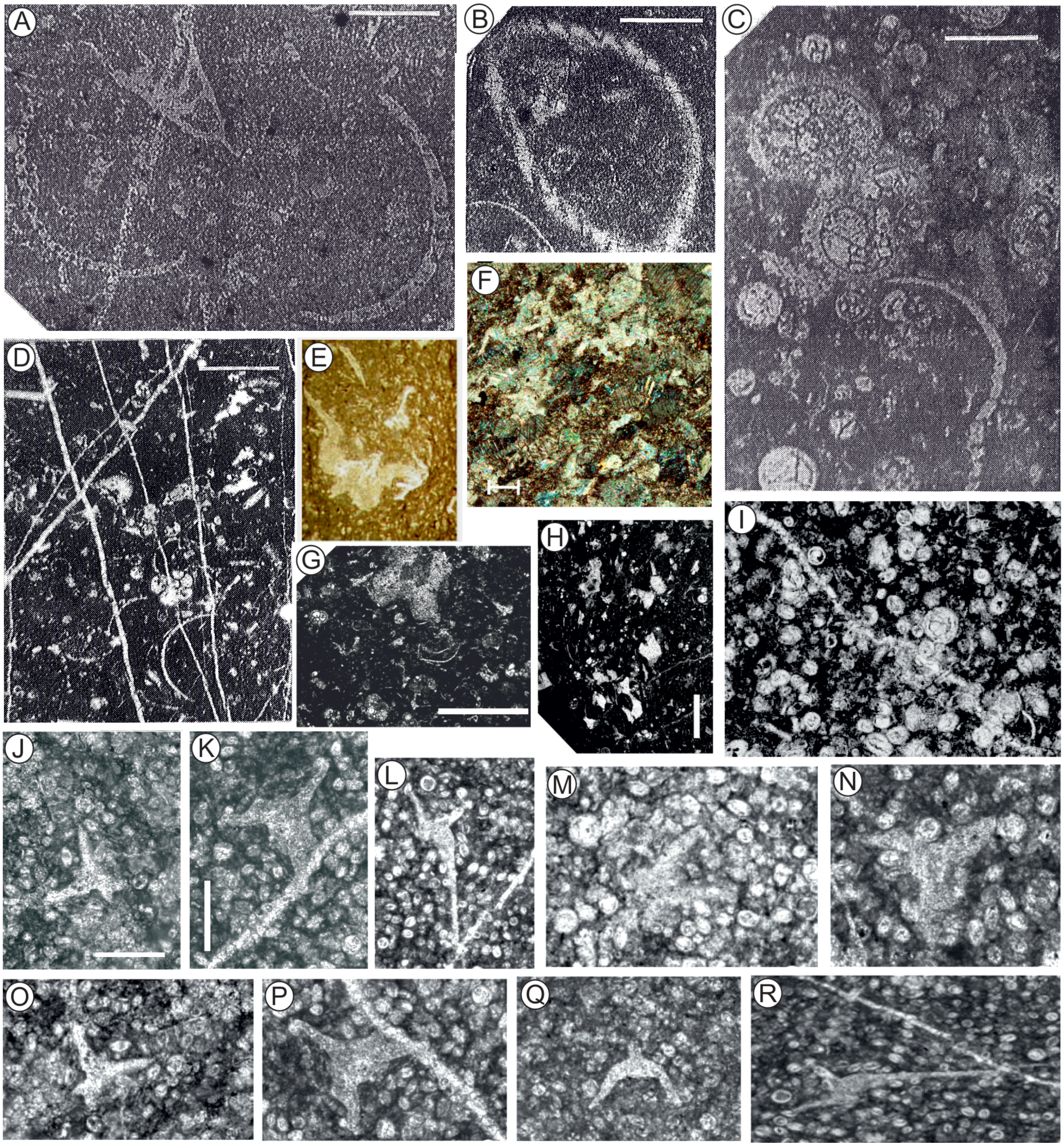

Figure 3 Re-interpretation of previously illustrated roveacrinids. Abbreviations used: Ax, axial; Lg, longitudinal; Obl, oblique; S, section; T, transverse; Tg, tangential. Rad, radial plate (or theca), IBr, primibrachial plate; IIBr, secundibrachial plate, NBrn, distal/indeterminate brachial plate. For revised taxonomic assignment and detailed stratigraphical assignment, see Appendix C.

1955)" [actually oblique-transverse sections of primi- and secundi-brachial plates (Obl/Ts-I-IIBrn) of *Saccocoma tenella* (Goldfuss)].

In their taphonomic survey of the Jurassic/Cretaceous boundary carbonates from nearby western Cuba, López-Martínez *et al.* (2014) illustrated a "highly disarticulated and densely packed Soccocomids" [*sic!*] (figure 3E: 436). They interpreted the abundance levels associated with calpionellid blooms as the sudden development of deep environmental, pelagic conditions, and suggested their auto-allochthonous origin (moderate transportation from the original drowning platform) by the "high disarticulation degree, orientation of many *Saccocoma* arms fragments, high fragmentation index, and the accumulation of coarse debris" (*ibidem*: 437). Furthermore they lament that the taphonomical conditions of *Saccocoma* event beds hamper any interpretation of paleo-community indices due to the high replication and redundancy of saccocomids. However they consider that saccocomids are a key constituent of the paleo-community, since saccocomids are pioneering organisms, colonizing new ecological niches after the carbonate bank drowning.

On the whole, the extensive record of saccocomids in the Jurassic carbonate rocks of Mexico have never been successfully exploited for stratigraphic purposes, unlike in the European Alpine areas. Nevertheless, saccocomids is often used incorrectly both in academic and internal reports of the oil industry concerning the Mexican stratigraphy.

The present paper aims to restore the straightforward use of saccocomids (in a broader sense, as pelagic crinoids) in the micropaleontology and stratigraphy of Mexico.

5.1. ALBIAN MICROFACIES GUIDELINE: THE *MICROCALAMOIDES* CONTROVERSY

In the late 1950s, F. Bonet analyzed the Cretaceous successions of Cuba and described a large number of new microfossils of undefined affinity. Among them, the genus *Microcalamoides* BONET, with three species (Bonet, 1956; O'Neill and Waite, 1969; Trejo, 1975, 1981, 1983, in Trejo and Bautista, 1977; Enos and Stephens, 1993; Rosales-Domínguez *et al*., 1995), which were also extensively recovered in the (Aptian?-) Albian deposits of Mexico (and the U.S.A., see McNulty, 1985; Enos and Stephens, 1993) and used to describe a microfacial biozone, the Microcalamoides Zone. While reviewing the multiple look-alike roveacrinidal sections, Ferré (1997) came to the conclusion that *Microcalamoides* was a microfacial equivalent of some *Applinocrinus* thecal sections and subsequently a junior synonym of genus *Applinocrinus*. Therefore, we are facing a paradoxical situation: from a Systematics point of view, we must now use the generic appellation *Applinocrinus* for such sections; from a stratigraphic point of view, the historical "Microcalamoides Zone" has priority for vernacular usage (though it is incorrect).

In the last decade, some saccocomid sections, said to contain the classical *Microcalamoides* microfacies, were mentioned from the Albian-Cenomanian of the Coahuila block (NE-Mexico) during public conferences. These sections were discussed informally afterwards, but these presentations and discussions were never published (Gréselle *et al.*, 2009, 2010).

While investigating the microfacial stratigraphic potentials of the Barremian-Albian interval of the state of Durango, Núñez-Useche and Barragán (2012) coined a term Microfacies Association MA-17, said to contain "abundant saccocomids and plates of crinoids" [*sic!*]. The presence of microcalamoids in the La Peña and the Upper Tamaulipas Fms is also mentioned (figures 7b - 7c in Núñez-Useche and Barragán, 2012: 210-211). In their following discussion, these alleged saccocomids turned into *Saccocoma* spp. in MA-17 (*ibidem*: 215). Unfortunately, the blunt and massive crinoid plates indeed belong to stemmed crinoids (most probably bourgueticrinids). In their figure 7a (*ibidem*: 212) "the largest bioclast" does not "correspond to a brachial element of *Saccocoma* sp."; but instead belongs to a stemmed crinoid (sample PFZ533). However, there is a genuine rather "smooth" thecal section of saccocomid above this largest one: *Applinocrinus* sp. (ex *Microcalamoides* sp.). The alignment of crinoidal plates in their figure 7b (*ibidem*: 212) is effective and corresponds to the dismantling of an arm fragment (stemmed crinoid), with some minute sections of saccocomid brachial plates (sample PFZ613). Their figure 7c (*ibidem*: 212) only illustrates the honeycomb structure of a tangential transverse section of an inoceramid shell while their figure 7d (*ibidem*: 212) illustrating a "Wackestone with calcispheres and ostracods" (*ibidem*: 212) also yields a couple of minute saccocomid brachial sections (sample PFZ582). As far as dating is concerned, their figure 2 (*ibidem*: 207) indicates "Saccocomids" in the last 20 m of the La Peña Fm., but does not show any in the above Upper Tamaulipas Fm. Furthermore the presence of *Favusella* sp. in their MA-17 indicates a Late Albian age.

A series of new microfacies sections and localities discussing these "microproblematics" will be described in detail soon from the Albian deposits of Sierra Azul, Coahuila (Monier-Castillo *et al.*, 2017a, 2017b).

Currently the only known single complete specimen of a roveacrinoid is *Roveacrinus spinosus* PECK from the Sergipe basin, Brazil (Ferré and Bengtson, 1997), and the only few Cretaceous roveacrinid ossicles still in connection were described by Scott *et al.* (1977) from the Albian deposits (Weno Fm.) of Texas. In addition, some complete connected specimens of Roveacrinidae from the Lower Cretaceous deposits were recently found in museum collections and in a field search (Ferré, personal data).

5.2. THE CENOMANIAN-TURONIAN INDEX LEVELS: TOWARDS THE C/T BOUNDARY POSITIONING

While studying the Mesozoic deposits of Sierra La Nieve (Coahuila, NE Mexico), Longoria and Monreal (1991) illustrated two sections of *Microcalamoides diversus* BONET and, following Bonet's first suggestions, interpreted such sections as ostracod shell or brachiopod valve sections.

At the 1997 Heidelberg meeting (18th Symposium of the International Association of Sedimentologists, Regional Meeting of IGCP Project 381 "South Atlantic Mesozoic Correlations" and Second European Meeting on the Paleontology and Stratigraphy of South America, Heidelberg, Germany, Sept. 2-4, 1997), Noemi Aguilera-Franco's poster presented some echinodermal sections that were on that occasion identified as roveacrinoids and identified down to the specific level (Aguilera-Franco *et al.*, 1997, 2001; Aguilera-Franco, in Hernández-Romano *et al.*, 1997). This became the first formal report of indigenous Mexican roveacrinids around the C/T boundary ever published (Aguilera-Franco, 1995, 2003; Aguilera-Franco *et al.*, 1997, 2001).

In their stratigraphic and sedimentological analysis of CSDP drill-core Yaxcopoil-1, Stinnesbeck *et al.* (2004) reported the occurrence of rare pelagic crinoids in the Cenomanian core deposits. They illustrated a section of a "planktic crinoid" [*sic!*, figure 3.1: 1046] from the Uppermost Cenomanian (Unit B, sample 1851). The associated foraminiferal assemblage (*Whiteinella archaeocretacea*, *W. baltica*, *Rotalipora cushmani*, *R. greenhornensis*, and *Hedbergella* spp.) precisely marks the top of the *Rotalipora cushmani* TRZ. Noteworthy is the joint occurrence of "rare pelagic crinoids, filaments, and calcispheres" as a faint sign of hypoxic environment typical of OAE2 (but not sufficient to tell which side of the C/TB). However their figure 3.1 (Stinnesbeck *et al.*, 2004: 1046) actually illustrates an oblique/tangential section of a complete theca (Obl/TgS-Theca) of *Roveacrinus alatus* DOUGLAS.

Omaña *et al.* (2014) observed roveacrinid remains from calcisphere-rich, packstone-wackestone carbonates (Microfacies 3: 32) of the Archaeocretacea Partial Range Zone (that is, Latest Cenomanian) and illustrated these indeterminate plates and sections (roveacrinids: figures 5h, i: 34).

More recently, Buitrón-Sánchez and Omaña-Pulido (2014, 2015) tentatively assigned roveacrinid remains to the Cenomanian-Turonian deposits of Cerritos (west of the Valles-San Luis Potosí Platform). Unfortunately, despite the standard microfossil events correlatable to OAE2, the foraminiferal assemblage [*Muricohedbergella delrioensis* (CARSEY), *M. planispira* (TAPPAN), *Heterohelix moremani* (CUSHMAN), *H. reussi* (CUSHMAN), *Whiteinella archaeocretacea* PESSAGNO, *W. aprica* (LOEBLICH and TAPPAN), *W. brittonensis* (LOEBLICH and TAPPAN), *W. baltica* DOUGLAS and RANKIN, and *W. paradubia* (SIGAL)] only permits assignation of their occurrences to the Latest Cenomanian. Besides, the absence of *Helvetoglobotruncana praehelvetica* (TRUJILLO), and most importantly of *H. helvetica* (BOLLI), supports the Latest Cenomanian determination. With respect to the plate and the specific identification, the taxonomical assignments are flawed due to superficial comparison to European taxa (see Appendix A herein) and must be revised for further taxonomical and stratigraphic purposes (see Appendices A and B herein). In addition, most of the roveacrinidal information gathered from the published literature is not well supported due to flaws of confusion.

More recently Hess (2015) and Gale (2016) provided additional insights on loose roveacrinoid materials from the Albian-Cenomanian deposits of Texas and the Santonian-Campanian U.S. Gulf Coast respectively.

5.3. THE LATE CRETACEOUS EXPECTATIONS

Thus far, no roveacrinoidal microfacies, or anything similar, have ever been found or reported from the Upper Cretaceous of Mexico. It is most unlikely that they are absent since Peck (1973) reported that the distribution of *Applinocrinus* in North America; and uintacrinids, marsupitids, and similar chalk associated macrofossils, are well known from deposits in southern Texas.

Such an absence may be due to the lack of knowledge of such remains, both in microfacies and in loose washing residues, and to the field paleontology format of the academe teaching that primarily focuses on "first-order" microfossil groups and general fossil index.

6. Paleoenvironmental proxies and hypoxic events (OAEs)

Due to built-in magnesium calcite, the roveacrinoidal plates are rather resistant to weathering, leaching and erosion but are prone to bio-erosion (microbial and microborers) and fading with general recrystallization through diagenesis. Therefore, in microfacies, their sections are easily preserved and readily observable. However the disarticulation pattern of the isolated roveacrinoid ossicles, the relative state of preservation, and the shape of ossicles (preservation of ornamental elements) can help to reconstruct their relative transport after death: from autochthonous deposition (complete specimens or large individual fragments) to parautochthonous (cluster of ossicles still connected) to allochthonous (isolated ossicles scattered within the microfacies). Actually, the roveacrinoidal plates are not interlocked. Consequently, soon after death, the skeleton is swept away by bottom currents and the whole skeleton decays and crumbles into fragments that may either be transported or locally dismantled before final burial.

Besides transportation, their abundant concentration in a certain level or their regular presence in a carbonate bed set document a relative productivity level, given their alleged feeding on "pelagic snow" or bottom current filtering/screening, and their association with nannofossil blooms (nannofossils, calcispheres and organic dinoflagellate cysts, heterohelicidids, pellets, etc.). Besides revealing key flooding surfaces and/or relative high sea-levels, such abundance levels of roveacrinoid clasts represent a faint sign of hypoxic environments in which those pelagic organisms which were bottom dwellers of mud/fine-grain supported bottoms (lagoonal conditions) and pseudo-reefal hideaways (from upper dynamic tidal bar to open-shelf marine sediments) had been thriving.

As for any echinoderm brood or juvenile (and many marine organisms), their revealed widespread paleogeographic distribution and global (at least central Tethysian-wide) dispersal merely reflect their early planktonic stage. Whether they once had a stem (and therefore fixed benthic bugs) and later lost it, or were devoid of any anchoring device from their very early bloom, is another story (not documented so far). However, the crossroad between the central Tethysian seaway, the Western Interior Sea, and the Paleo-Andean corridor easily explains their presence in such high numbers, especially during OAEs. These anoxic-hypoxic events have been focusing much of the attention of stratigraphers: Therefore most of the roveacrinoidal literature records we found address the Aptian-Albian boundary (OAE1b), referred to as the Microcalamoides Zone, and around the Cenomanian-Turonian boundary (OAE2). In such a context the lack of Coniacian-Santonian roveacrinoid record (OAE3) is most intriguing. These roveacrinoid debris levels can be interpreted as among the first stirrings of surface productivity and a hypoxic bottom environment.

7. Bio-stratigraphic potentials

Roveacrinoidal remains were on the whole ignored or clumsily evoked during working sessions of international congresses and symposia. Classically, in Mexico, thanks to the seminal works of Bonet (1956) and Trejo (1975, 1981, 1983, in Trejo and Bautista, 1977), the abundance of saccocomids around the Aptian-Albian was used by field geologists and stratigraphers to build the Microcalamoides Zone. Unfortunately, these remains are also occurring to a lesser extent below and above this abundance zone. This situation is rather confusing since this zone is generally understood and considered as a Total Range Zone (instead of an Abundance Range Zone) and its taxonomical assignment/reference is not outdated (Ferré *et al.*, 1999). However, the mere reporting of such 'bioclastic' component is most valuable and contributes towards its further use in a synthetic comprehension of their geographic extension and stratigraphic range.

Consequently, if not compiled outside any other event time frame, their abundance levels must be considered with extreme caution since the fossil blooms they represent occur as sometimes conspicuous, sometimes faint, flooding levels in transgressive tracts and can be easily confused with another from the next transgressive trend. Within this respect, qualitative range has not been effective, though the reported levels are susceptible to exploitation on a biostratigraphic level [likewise the southern England biozonation of Gale (2016, 2017)] since macrofossil zonation is rather loose and positioning any boundary remains rather difficult (the rule of hypoxia over these periods made the coeval respective environment adverse for datation-supporting macro- and micro-fossils). Meanwhile the semi-quantitative analysis of their microfacies occurrence is sometimes flawed by taxonomical laxness or inexactitude (see above with concerns on the assignment of *Microcalamoides*). However, when macrofossil data are lacking and standard microfossil datation is loose, they may give interesting hints for positive correlations, both locally and regionally, and could be in the near future framed into a tentative biozonation similar to that of the Sergipe Basin (Ferré *et al.*, 1996) or to the seminal tentative record of Peck (1943, 1955). The main problem is the uncomfortable silence of field geologists when they find such echinoderm abundance levels (numerous elusive citations in grey in-house publications), and the confidentiality required by the economic significance for Oil Companies themselves complaining about the lack of stratigraphic precisions (the debate has come in full circle).

These "event" and accumulation beds have potential as field marker beds, for at least regional, and even Tethysian-wider long distance correlation. Meanwhile this underrated fossil group provides potential fossil guides (both in the field and in the lab) to the detection of even minor ecological disturbances and the constraint of some key crises.

8. Conclusions

In the Cretaceous Tethysian deposits around the world, roveacrinoidal microfacies have proven to be an excellent field guide for stratigraphic exploration, useful to the determination of special index horizons and provide first-hand material to document crinoid biodiversity.

We have to recognize the pioneering stratigraphic masterpiece of Bonet (1956) who first highlighted the potential stratigraphic use of *Microcalamoides* in Cuba and brilliantly introduced the Microcalamoides Zone into the Mexican stratigraphical Lexicon (Bonet, 1956; Trejo, 1975; Trejo-Bautista, 1977).

The field stratigraphic value of *Microcalamoides* is indisputable. Nevertheless we must take a fresh look at its taxonomic assignment and reconsider its possible biozonal range. Since Ferré (1997) synonymized this microfacies taxon to a saccocomid section, we shall go further into the specific microfacies details for a better stratigraphic refinement and a true saccocomid biozonation to better serve the Mexican stratigraphy.

After a Stinnesbeck *et al.* (2004) illustration, we are glad to acknowledge the genuine occurrence of true roveacrinids in well-dated Cenomanian-Turonian Mexican deposits. Nevertheless, such C/T sediments are not that well constrained (calcisphere microfacies, Archaeocretacea Partial Range Zone, lack of index ammonite), and roveacrinoid sections can be hard to analyze accurately. On the whole, Buitrón-Sánchez Omaña-Pulido (2015) were at least right when mentioning roveacrinidal occurrences in the Cenomanian-Turonian carbonate microfacies of the Valles-San Luis Potosi platform. However, the cited species are not consistent with their known stratigraphic ranges and do not fit with the illustrated sections. We can possibly assign oblique sections of indeterminate brachial plates to the family Roveacrinidae - most likely but with some extreme caution to genus *Roveacrinus* DOUGLAS. The presence of roveacrinidal plates (of genuine Roveacrinidae) recalls and strongly supports Aguilera-Franco's original findings (1995, 2003) further south in the adjacent Guerrero-Morelos Basin. This "abundance zone" of roveacrinid plates is consistent with the characteristic *Roveacrinus* levels mentioned around the C/T boundary in the Boreal realm and around the southern Tethysian margin (Jefferies, 1962, 1963; Gale *et al.*, 1993; Ferré *et al.*, 2016a, 2016b, 2017). When they are properly identified, these roveacrinoid abundance levels are potentially good indicators of the vicinity of the C/T boundary. Moreover, when clear microfossil evidence are lacking, they can help to identify which side of the boundary (Cenomanian or Turonian) these levels belong to.

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Appendix A

Revised taxonomical list of roveacrinid taxa (found in the literature) occurring in Mexico and adjacent areas (Cuba, U.S. Gulf Coast).

Axicrinidae [unreported]

Somphocrinidae
Somphocrinus [OD: Peck, 1948]
Somphocrinus mexicanus Peck, 1948 [OD: Peck, 1948; synonymy lists]

Saccocomidae
Applinocrinus [= *Microcalamoides* Bonet, 1956]
Applinocrinus cretaceus (Bather, 1924) [Peck, 1973: Campanian from the US Gulf Coast and Jamaica, and the Mendez Shale of? Tamaulipas or? Nuevo Leon, Mexico]
Applinocrinus texanus Peck, 1973 [OD, Peck, 1973; Uppermost Campanian-lower Maastrichtian of Texas, Florida and Mississippi: Gale, 2016]
Applinocrinus sp. [= *Microcalamoides diversus* Bonet, 1956; *M. confusus* Trejo, 1983; *M. ornatus* Trejo, 1983: for review, see Ferré *et al.*, 1999]
"*Microcalamoides*" spp. [junior synonyms of *Applinocrinus* spp., non-conservative specific assignment]
"*Saccocoma*" [= *Lombardia* Brönnimann, 1955; to date, any Cretaceous *Saccocoma* reference should be regarded as a saccocomid better to as potential genuine *Applinocrinus*; along with some slanted references of *Globochaete alpina* Lombard (support) and *Eothrix alpina* Lombard]
Saccocomidae indet. [López-Martínez *et al.*, 2014)]

Roveacrinidae
Discocrinus [OD: Peck, 1943]
Discocrinus catastomus Peck, 1943 [Duck Creek and lower Fort Worth Fms, Texas]
Orthogonocrinus apertus Peck, 1943 [Duck Creek and Grayson Fms, Texas]
Poecilocrinus [OD: Peck, 1943]
Poecilocrinus dispandus Peck, 1943 [Fort Worth to Main Street Fms, Texas and Oklahoma; Peck, 1943; Scott *et al.*, 1977; *non* Buitrón-Sánchez and Omaña-Pulido, 2015]
P. dispandus elongatus Peck, 1943 [Peck, 1943: Weno Fm., Texas; *non* Buitrón-Sánchez and Omaña-Pulido, 2014, 2015]
P. dispandus explicatus Peck, 1943 [Main Street Fm., Texas]
P. dispandus molestus Peck, 1943 [Main Street Fm., Texas]
P. latealatus (Peck, 1943) [= *Roveacrinus latealatus* PECK from the Fort Worth Fm. of Texas; Hess, 2015]
P. pendulus Peck, 1943 [Duck Creek and lower Fort Worth Fms., Texas]
P. porcatus Peck, 1943 [Duck Creek and lower Fort Worth Fms., Texas]
P. spiculatus Peck, 1943 [Duck Creek and lower Fort Worth Fms., Texas]
Plotocrinus [OD: Peck, 1943]
Plotocrinus distinctus Peck, 1943 [Goodland and Kiamichi Fms., Texas]
P. hemisphericus Peck, 1943 [Duck Creek and lower Fort Worth Fms., Texas; *non* Pl. 71 fig. 4 in Peck, 1943: 456 - *Roveacrinus latealatus* (Peck); Hess, 2015: 80]
P. inornatus Peck, 1943 [Duck Creek and lower Fort Worth Fms., Texas]
P. modulatus Peck, 1943 [Duck Creek Fm., Texas]
P. primitivus Peck, 1943 [= *Roveacrinus pyramidalis* PECK ? from the Goodland and Kiamichi Fms., Texas: Hess, 2015]
Roveacrinus alatus Douglas, 1908 [= *Roveacrinus pentagonus* PECK from the Grayson Fm. of Texas: HESS, 2015; "Planktic crinoid": Aguilera-Franco and Hernández-Romano, 2004; Stinnesbeck *et al.*, 2004]
R. euglypheus Peck, 1943 [Grayson Fm., Texas]
R. geinitzi Schneider, 1989 [Aguilera-Franco *et al.*, 2001; Aguilera-Franco, 2003; *non* Buitrón-Sánchez and Omaña-Pulido, 2014, 2015]

R. cf. *geinitzi* Schneider, 1989 [Aguilera-Franco and Hernández-Romano, 2004]
R. multisinuatus Peck, 1943 [Main Street and Grayson Fms., Texas]
R. peracutus (Peck, 1943) [Goodland to Grayson Fms., Texas; ex *Drepanocrinus*: Hess, 2015]
R. pyramidalis Peck, 1943 [Duck Creek to Grayson Fms., Texas; = *Plotocrinus primitivus* Peck, 1943? from the Goodland and Kiamichi Fms., Texas: Hess, 2015]
Roveacrinus aff. *rugosus* Douglas, 1908 [Aguilera-Franco, 2003]
R. signatus PECK, 1943 [Main Street and Grayson Fms., Texas]
R. spinalatus Peck, 1943 [Grayson Fm., Texas]
R. spinosus Peck, 1943 [Main Street and Grayson Fms., Texas]
Roveacrinus sp. cf. *alatus* Douglas, 1908 [Aguilera-Franco *et al*., 2001]
Roveacrinus sp. [Aguilera Franco *et al*., 2001; Aguilera-Franco and Hernández-Romano, 2004; "*R. geinitzi* Schneider", *non Roveacrinus* sp.: Buitrón-Sánchez and Omaña-Pulido, 2014; Omaña *et al.*, 2014]
Roveacrinidae indet. [Núñez-Useche and Barragán, 2012; "*R. geinitzi* Schneider", *non Roveacrinus* sp.: Omaña *et al*., 2014; López-Martínez *et al*., 2014; Buitron-Sánchez and Omaña-Pulido, 2015.

Appendix B

Table 1. Correspondance between published roveacrinid taxa and their revised assignment.

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Peck (1943)	p. 461	Family Roveacrinidae n. fam. [OD]	Cretaceous North America		
	p. 462	Subfamily Drepanocrininae n. subfam. [OD]	Lower Cretaceous of Texas		
	p. 463 Pl. 76 Figs. 9-22, 26, 28	*Drepanocrinus peracutus* Peck, n. sp.	Lower Cretaceous of Texas Goodland to Grayson Fms.	*Roveacrinus peracutus* (Peck, 1943) [Hess, 2015]	
	p. 464	*Orthogonocrinus* Peck, n. sp.	Lower Cretaceous of Texas		
	p. 464 Pl. 76 figs. 2-8	*Orthogonocrinus apertus* Peck, n. sp.	Duck Creek to Grayson Fms.		
	p. 465	Subfamily Roveacrininae n. subfam.	Lower Cretaceous of Texas		
	p. 466 Pl. 74 figs. 1-5, 11-14	*Roveacrinus signatus* Peck, n. sp.	Main Street and Grayson Fms.		
	p. 466 Pl. 72 figs. 8, 14-17	*Roveacrinus multisinuatus* Peck, n. sp.	Grayson Fm.		
	p. 467 Pl. 72 figs. 12; Pl. 73 figs 1-7, 7	*Roveacrinus pentagonus* Peck, n. sp.	Grayson Fm.	*Roveacrinus alatus* Douglas [Hess, 2015]	
	p. 467 Pl. 74 figs. 6-7, 9; Pl. 76 figs. 37, 39	*Roveacrinus spinosus* Peck, n. sp.	Grayson and Main Street Fms.		
	p. 467 Pl. 74 figs. 8, 10	*Roveacrinus spinalatus* Peck, n. sp.	Grayson Fm.		
	p. 468 Pl. 73 figs. 9-12, 14; Pl. 76 fig. 1	*Roveacrinus latealatus* Peck, n. sp.	Fort Worth Fm.	*Poecilocrinus latealatus* (Peck) [Hess, 2015]	
	p. 468 Pl. 72 figs. 24-29	*Roveacrinus pyramidalis* Peck, n. sp.	Duck Creek to Grayson Fms.		
	p. 469 Pl. 72 figs. 18-23	*Roveacrinus euglypheus* Peck, n. sp.	Grayson Fm.		
	P. 469	*Plotocrinus* Peck, n. gen.	Lower Cretaceous of Texas		
	p. 469 Pl. 71 figs. 4-5, 7-15, 24	*Plotocrinus hemisphericus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.	Pl. 71 fig. 4: *Roveacrinus latealatus* (Peck) [Hess, 2015]	
	p. 470 Pl. 71 figs. 16-18, 23	*Plotocrinus modulatus* Peck, n. sp.	Duck Creek Fm.		
	p. 470 Pl. 71 figs. 6, 19-22	*Plotocrinus inornatus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.		
	p. 470 Pl. 71 figs. 1-3	*Plotocrinus primitivus* Peck, n. sp.	Goodland and Kiamichi Fms.	*Roveacrinus pyramidalis* Peck ? [Hess, 2015]	
	p. 471 Pl. 72 figs. 1, 7, 13	*Plotocrinus distinctus* Peck, n. sp.	Goodland and Kiamichi Fms.		
	p. 471	*Poecilocrinus* Peck, n. gen.	Lower Cretaceous of Texas		
	p. 471 Pl. 75, figs. 1-2, 6, 8, 12	*Poecilocrinus dispandus* Peck, n. sp.	Fort Worth to Main Street Fms.		
	p. 471 Pl. 75 fig. 7	*Poecilocrinus dispandus elongatus* Peck, n. var.	Weno Fm.		
	p. 472 Pl. 75 figs. 11, 14	*Poecilocrinus dispandus explicatus* Peck, n. var.	Main Street Fm.		
	p. 472 Pl. 75 fig. 4	*Poecilocrinus dispandus molestus* Peck, n. var.	Main Street Fm.		
	p. 472 Pl. 73 figs. 6, 8, 13	*Poecilocrinus spiculatus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.		
	p. 474 Pl. 75 figs. 3, 5, 9-10, 13	*Poecilocrinus pendulus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.		
	p. 474 Pl. 72 figs. 2-6	*Poecilocrinus porcatus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.		
	p. 474	*Discocrinus* Peck, n. gen.	Lower Cretaceous of Texas		
	p. 474 Pl. 72 figs. 9-11	*Discocrinus catastomus* Peck, n. sp.	Duck Creek and lower Fort Worth Fms.		

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Peck (1948)	p. 82	*Somphocrinus* n. gen.			
	p. 82 Pl. 20 Figs. 1-38	*Somphocrinus mexicanus* n. sp. [OD]	Lower part (Carnian) of Upper Triassic Cerro Colorado (or Cerro de la Cruz), Sonora, Mx		
Brönnimann (1955)	p. 42 Text-figs. 6a-k, o-s	*Globochaete alpina* Lombard	Middle Portlandian Las Villas Province, Cuba	Text-fig. 6o: (?) Transverse section of a radial plate (TS-rad) "*Saccocoma*" sp.	
	Text-fig. t	Group of aptychi	Middle Portlandian Las Villas Province, Cuba	[lower section]: (?) Transverse section of a radial plate (TS-rad) "*Saccocoma*" sp.	
	p. 43 Text-figs. 6n-l	*Eothrix alpina* Lombard ?	Middle Portlandian Las Villas Province, Cuba	(?) Transverse section of a radial plate (TS-rad) "*Saccocoma*" sp.	
	p. 43-44	*Lombardia* n. gen.			
	p. 44 Pl. 1 figs. 18-20, 24(?), Text-figs. 7-8	*Lombardia arachnoidea* n. sp.	Middle Portlandian Las Villas Province, Cuba	Transverse sections of brachial plates (TS-NBrn) "*Saccocoma*" sp.	
	p. 44 Pl. 1 fig. 22, Text-fig. 9	*Lombardia perplexa* n. sp.	Middle Portlandian Las Villas Province, Cuba	Oblique sections of brachial plates (OblS-NBrn) "*Saccocoma*" sp.	
	p. 44 Pl. 1 fig. 23, Text-fig. 10	*Lombardia angulata* n. sp.	Middle Portlandian Las Villas Province, Cuba	Longitudinal (Transverse) sections of brachial plates (LgS-Nbrn) "*Saccocoma*" sp.	
Bonet (1956)	p. 47	*Microcalamoides* gen. nov. [OD]	Barremian-lower Albian	*Applinocrinus* Peck, 1973	Barremian(?)-Aptian-Albian
	p. 47 Pls. XXVII [sic], [XXVIII] XXIX-XXX	*Microcalamoides diversus* nov. sp.	Cañon de Lajitas Sierra de Tamaulipas La Peña, Cupido, Lower Tamaulipas and Ahuacatlán Fms. basal Barremian-basal Albian	[forma A]: basal horizontal transverse section of a complete theca [TS-Theca] [forma B]: transverse-oblique section of a nearly complete theca [Obl/TS-Theca] [forma C]: deeply crenulated oblique-transverse section of a nearly complete theca [T/OblS-Theca] *Applinocrinus* sp.	Barremian (?)-Aptian
	Pl. XXXI Fig. 1 [no fig.]	*Globochaete alpina* Lombard… junto con *Nannoconus* sp. y *Microcalamoides diversus* no visibles…	Cañón del Guaje Sierra de Tamaulipas Aptian	*Applinocrinus* sp.	Aptian
	Pl. XXXI Fig. 3	Varias "esporas" de *Globochaete alpina* adheridas a un soporte	Cañon del Chilpitin, Sierra de la Gloria, Coahuila Lower Cretaceous	Transverse section of a radial plate [TS-Rad] *Applinocrinus* sp.	lower Cretaceous
Peck (1973)	p. 95	*Applinocrinus* n. gen.			
	p. 97-98 Pl. 1, figs. 1-3, 6-12; Text-figs. 1c-d	*Applinocrinus cretaceus* (Bather, 1924)	Campanian uppermost Taylor-lower Navarro Fms US Gulf Coast and Jamaica Mendez Shale ?Tamaulipas or ?Nuevo Leon, Mx		
	p. 98, Text-figs. 1a, b, Pl. 1 figs. 4-5	*Applinocrinus texanus* n. sp.[OD]	Upper Taylor and Navarro Fms Texas and Jamaica		Uppermost Campanian-Lower Maastrichtian Texas, Florida and Mississippi

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Trejo (1975)	p. 14-15 Fig. 5	*Microcalamoides diversus*	upper part of the *Colomiella coahuilensis* Subzone to - *Calcisphaerula* Zone	Oblique-Transverse sections of isolated radials- thecal plates (Obl/TS-Rad) ? *Applinocrinus* sp.	Lower Albian, *Calpionellopsella* - *C. recta* Subzones
	p. 17 Fig. 5	*Saccocoma* sp.	*Calpionellopsella* - *C. recta* Subzones - lower part of the *S. similis* Zone	Diverse oblique and transverse sections of brachial plates (OblS/TgS -NBrn) Saccocomidae indet.	
	Pl. V figs. 1-7	*Saccocoma* sp.	Cañón de la Alameda, Coahuila. Lower Albian, *Calpionellopsella* - *C. recta* Subzones	Various tangential-longitudinal and transverse sections of brachial plates (Tg/LgS+OblS-NBrn) [pars 1, 2, 4-5]: Tg/LgS-NBrn; [pars 1, 3]: OblS-NBrn; [6-7]: TS-NBrn Saccocomidae indet.	
Trejo and Bautista (1977)	Internal report [grey literature, unavailable for 'public' use]				
Scott *et al*. (1977)	Pls 1-2	*Poecilocrinus dispandus* Peck, 1943	Fort Worth Limestone to Main Street Limestone Fms (upper Albian to basal Cenomanian)		
Trejo (1981)	p. 6-8	"Zona de *Microcalamoides* nov. sp./*Nannoconus steinmanni*"	Upper Valanginian - Lower Aptian	Diverse sections of isolated radials - thecal plates (Obl/TS-Rad) ? *Applinocrinus* sp.	Upper Valanginian - Lower Aptian
	p. 7	*Microcalamoides* "*confusus* es nom. nud."		? *Applinocrinus* sp.	
Trejo (1983)	p. 14 and following	*Phylum arthropoda* Class Crustacea Order Ostracoda *Incertae Sedis* *Microcalamoides* Bonet, 1956	Late Valanginian-Middle Albian	Echinodermata Crinoidea Roveacrinida Saccocomidae *Applinocrinus* Peck, 1973 Miscellaneous sections of thecae (OblS+TS/Theca)	[Late Valanginian?-Late Albian]
	p. 15 Pl. XVII Figs. 3-6; Pl. XVIII Figs. 1-5	*Microcalamoides diversus* Bonet, 1956	Barremian-Lower Albian (Trejo, 1956). Aptian-Middle Albian (Trejo, 1960). Lower-Middle Albian, Colomiella Zone, Calpionellopsella Subzone-Calcisphaerula Zone, *Stomiosphaera sphaerica* Subzone (Trejo and Bautista, 1977). Cañón de Huizachal and Cañón de Peregrina	Oblique-Transverse sections of isolated radials- thecal plates (Obl/TS-Rad) [Pl. XVII Figs. 3-6; Pl. XVIII Figs. 1-2]; Tangential sections of isolated radials-thecal plates [Pl. XVIII Figs. 3-5] *Applinocrinus* sp.	Various saccocomid events ranging from the Upper Barremian to middle Albian, with an acme zone at the Aptian-Albian boundary
	Pl. XIV; Pl. XV Figs. 3-4	*Microcalamoides confusus* sp. nov.	Middle Valanginian lower part of Late Aptian (*M. confusus* /*N. steinmanni* ·Zone - *N. wassalli* Zone, Leupoldina Subzone)	Oblique-Transverse sections of isolated radials- thecal plates (Obl/TS-Rad) [Pl. XIV; Pl. XV Figs. 3-4] *Applinocrinus* sp	.
	Pl. XV Figs. 1-2; Pl. XVI; Pl. XVII Figs. 1-2	*Microcalamoides ornatus* sp. nov.	same as *M. confusus* Cañón de Huizachal, Tamaulipas; Cañón"de Peregrina.	Transverse- Oblique sections of isolated radials- thecal plates (T/OblS-Rad) [Pl. XV Figs. 1-2]; Oblique sections of isolated radials- thecal plates (OblS-Rad) [Pl. XVI]; sub-Tangential Oblique sections of isolated radials- thecal plates (subTg/OblS-Rad) [Pl. XVII Figs. 1-2] *Applinocrinus* sp.	

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
McNulty (1985)	No figure	"Microcalamoides" mentioned in the text	'Lower Cretaceous'	Most probably Transverse-Oblique sections of isolated plates or complete thecas (T/OblS-Rad) *Applinocrinus* sp.	Most probably "Lower Albian?"
Longoria and Monreal (1990)	p. 21: Fig. 7.2	Sample AR77-25. Biomicrite. Unit III-33-IV-33. Planktonic echinoderm Saccocoma, ostracod fragments (*Microcalamoides diversus*).	uppermost Aptian Biozone K-13 La Peña ?-Tamaulipas ? Fms.	Transverse-Longitudinal section of an isolated radial plate (T/LgS-Rad) *Applinocrinus* sp.	Aptian-Albian boundary (?)
	p. 21: Fig. 7.5	Sample AR75-35. Biomicrite. Unit III-33-IV-33. Ostracod.	uppermost Aptian Biozone K-13 / upper Albian Biozone K-14 / K-15 La Peña ?-Tamaulipas ? Fms.	Transverse-Oblique section of a complete theca (T/OblS-Rad) *Applinocrinus* sp.	Aptian-Albian boundary
	p. 21: Fig. 7.7	Sample AR84-50. Biomicrite. Unit IV-35-V-35. Planktonic foraminifer (*Hedbergella washitensis*), calcisphaerulids (*Calcisphaerula innominata*), ostracod fragment (Microcalamoides?).	Upper Albian Biozone K-15/Cenomanian Biozone K-17 Tamaulipas ?-Cuesta del Cura ? Fms.	Axial/sub-Oblique section of an isolated radial plate (Ax/sub-OblS-Rad) *Applinocrinus* sp.	upper Albian-lower Cenomanian (?)
	p. 21: Fig. 7.10	Sample AR68-25. Biomicrite. Unit III-33-IV-33. Ostracod shell fragment (*Microcalamoides diversus*), calcisphaerulids (*Calcisphaerula innominata*).	La Peña ?-Tamaulipas ? Fms.	Transverse Longitudinal section of a isolated radial plate (T/LgS-Rad) *Applinocrinus* sp.	Aptian-Albian boundary (?)
	p. 23: Fig. 8.21	Sample AR139-4. Biomicrite. Unit IV. Planktonic foraminífera, ostracods, echinoderm fragments	upper Albian Biozone K-15 Tamaulipas ? Fm.	Transverse Oblique section of an isolated radial plate (T/OblS-Rad) *Applinocrinus* sp.	Upper Albian (?)
	p. 27 No photograph	5.3. … Ostracods (Microcalamoides) 5.5. …Pelagic echinoids (saccocomids)	Lower Cretaceous	[5.3.]: roveacrinoids (*Applinocrinus* sp.) [5.5.]: pelagic crinoids (saccocomids)	Lower Cretaceous (Aptian-Albian)
		"Microcalamoides" mentioned in the text		Most likely Transverse-Oblique sections of thecal plates (T/OblS-Rad) *Applinocrinus* sp.	
Enos and Stephens (1993)	p. 51 Fig. 6 No photograph	*Microcalamoides ornatus*	middle of the Morita Fm. (upper) Aptian	(?) Transverse- Oblique sections of isolated radials-thecal plates (T/OblS-Rad) *Applinocrinus* sp.	Upper Aptian (?)
Rosales-Dominguez *et al*. (1995)	Fig. 6 No photograph	*Microcalamoides ornatus*	Mural Limestone Cullantrillo sequence Lower Albian	(?) Transverse- Oblique sections of isolated radials-thecal plates (T/OblS-Rad) *Applinocrinus* sp.	Lower Albian
	p. 56	*Saccocoma* sp.	Cenomanian-Turonian transition	Roveacrinidae indet.	C/T B
Aguilera-Franco (1995)	p. 70 Fig. 39	Litofacies 11 packstone de equidermos y calciferúlidos, UH 94.38	Zotoltitlán section Mexcala Fm. Turonian	Tangential section of a second primibrachial plate (TgS-IBr2) Roveacrinidae indet.	C/T B Tithonian
	p. 24 Pl. I figs. 3, 5, Pls. II-IV	*Saccocoma arachnoidea* (Brönnimann, 1955)	Middle-late Tithonian SE-Mexico	Transverse and Oblique sections of brachial plates (Obl/TS-NBrn) "*Saccocoma*" sp.	
Aguilera-Franco and Franco-Navarrete (1995)	p. 681 no fig.	*Saccocoma* sp.	Cenomanian/Turonian B. Guerrero-Morelos Platform, Guerrero, S. Mexico	Roveacrinidae indet. [see subsequent publication: 2001]	C/T B

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Aguilera-Franco *et al*. (1997)	p. 245 p. 250 (fig. 13a)	roveacrinids (*Roveacrinus geinitzi*)	*Whiteinella archaeocretacea* PRZ	Roveacrinidae indet. [*Roveacrinus "geinitzi"*]	C/T B
Hernandez-Romano *et al*. (1997)	Fig. 4	*Roveacrinus* sp.	Mexcala Fm. Amacuzac section. *Whiteinella archaeocretacea* PRZ	*Roveacrinus* sp.	C/T B Lower Turonian (?)
Aguilera-Franco *et al*. (2001)	Fig. 5	*Roveacrinus* sp.	Morelos Fm. Las Tunas section. Cenomanian *Whiteinella archaeocretacea* PRZ	*Roveacrinus* sp.	C/T B Lower Turonian (?) Turonian *H. helvetica* TRZ (?)
	Fig. 5 Fig. 6	*Roveacrinus geinitzi* *Roveacrinus* cf. *alatus*	Mexcala Fm. Las Tunas section Turonian *Whiteinella archaeocretacea* PRZ	*Roveacrinus "geinitzi"* *Roveacrinus* cf. *alatus*	
	Fig. 5 Fig. 6 Fig 7	*Roveacrinus geinitzi*	Mexcala Fm. Barranca del Tigre section lower Turonian and lower-middle Turonian *Whiteinella archaeocretacea* PRZ-*H. helvetica* TRZ *pars*	*Roveacrinus "geinitzi"*	
		Roveacrinus geinitzi	Mexcala Fm. Zototitlán section Turonian	*Roveacrinus "geinitzi"*	
	Fig. 11	B3. Increase in abundance of calcisphaerulids, echinoids, roveacrinoids and globigerinids (hedbergellids and heterohelicids)	Guerrero-Morelos Basin C/T	Roveacrinida indet. [Roveacrinidae]	Uppermost Cenomanian
	Fig. 12(d)	Crinoids	Las Tunas section between B3 and B4 sample 28	Tangential oblique sections of radial plates (Tg/OblS-Rad) Roveacrinidae indet.	Uppermost Cenomanian
	Fig. 13(a)	Roveacrinids	Las Tunas section above B6 (upper part of the *Whiteinella archaeocretacea* PRZ) sample 36	Oblique sections of brachial plates (OblS-NBrn) Roveacrinidae indet.	Uppermost Cenomanian
	p. 205	*Microcalamoides* sp.	Morelos Fm. Upper Albian-Cenomanian/Turonian	*Most likely* Transverse-Oblique sections of thecal plates (T/OblS-Rad) *Applinocrinus* sp.	Morelos Fm. [=Upper Tamaulipas Fm] Upper Albian-Cenomanian
	Pl. 1 Fig. 10	*Roveacrinus* sp.RMCH aff. *rugosus*, Las Tunas, NA96-28	Morelos Fm. Upper Cenomanian Whiteinella archaeocretacea PRZ	*Roveacrinus* aff. *R. rugosus* Douglas, 1908	Morelos Fm. Upper Cenomanian Archaeocretacea PRZ

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Aguilera-Franco (2003)	Figs. 4, 6-7, p. 215 Fig. 10	*Roveacrinus* sp.	Base of Cuautla Fm [Figs. 6-7] Upper Cenomanian / Lower Turonian Whiteinella archaeocretacea PRZ Base of the Mexcala Fm. [Fig. 10]	Oblique and transverse sections of proximal brachial plates (T/Obl-NBrn) *Roveacrinus* sp.	Upper Cenomanian- Lower Turonian
	Figs. 4, 6-7 p. 215	*Roveacrinus geinitzi*	Base of Cuautla Fm Upper Cenomanian Whiteinella archaeocretacea PRZ	Transverse sections of radial plates and thecas (TS-Rad) *Roveacrinus geinitzi*	Uppermost Cenomanian Top of the Archaeocretacea Zone Lower Turonian
	Fig. 4 p. 215	*R.* cf. *alatus*	Upper part of the Whiteinella archaeocretacea PRZ	Oblique and Transverse sections of radial and thecal plates (T/OblS-Rad) *R.* cf. *alatus*	Uppermost Cenomanian (?) Top of the Archaeocretacea Zone [p. 215] Cuautla Fm. Lower Turonian [Fig. 4]
	p. 144 (and following) Tables 2-3	roveacrinids	Cuautla Fm, Zototitlán Mb Guerrero-Morelos Basin late Cenomanian-Coniacian extending beyond the *Whiteinella archaeocretacea* PRZ	Roveacrinidae indet.	C/T B
	Fig. 8	*Roveacrinus* sp. cf. *alatus* *Roveacrinus geinitzi*	Cuautla Fm, Zototitlán Mb Guerrero-Morelos Basin late Cenomanian-Coniacian extending beyond the *Whiteinella archaeocretacea* PRZ "Uppermost Cenomanian age , top of *R. cushmani* zone" [in the text] Late Cenomanian, Rotalipora cushmani zone (Unit B, sample 1851) [as legend] CSDP-drill core Yaxcopoil-1	*Roveacrinus* sp. cf. *alatus* , *Roveacrinus* cf. *geinitzi*	C/T B Latest Cenomanian Top of Cushmani TRZ CSDP-drill core Yaxcopoil-1
Aguilera-Franco and Hernández-Romano (2004)	Fig. 13(D)	Calcisphaerulid-roveacrinid-thin-bivalve shell packstone (facies F1). Las Tunas section, sample NA96-30.	Cuautla Fm, Zototitlán Mb Guerrero-Morelos Basin late Cenomanian-Coniacian extending beyond the *Whiteinella archaeocretacea* PRZ "Uppermost Cenomanian age, top of *R. cushmani* zone" [in the text] Late Cenomanian, Rotalipora cushmani zone (Unit B, sample 1851) [as legend] CSDP-drill core Yaxcopoil-1 Around the Aptian-Albian boundary (*in coll*.)	Tangential oblique sections of brachial plates (Tg/OblS-NBrn) Roveacrinidae indet.	C/T B Latest Cenomanian Top of Cushmani TRZ CSDP-drill core Yaxcopoil-1 Base of early Albian
	p. 157	*Roveacrinus* sp., *Roveacrinus* cf. *geinitzi*		*Roveacrinus* sp., *Roveacrinus* cf. *geinitzi*	
	Figure 31	« Rare pelagic crinoids » (in the text) « Planktic crinoid » (as legend)		Slightly tilted oblique, transverse section of a sub-complete theca (sub-Obl/TS-Theca) of *Roveacrinus alatus* Douglas, 1901	
	No figure	"Microcalamoides" mentioned in the text		Most likely Transverse-Oblique sections of thecal plates (T/OblS-Rad) *Applinocrinus* sp.	

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
Stinnesbeck *et al*. (2004)	p. 1044	"rare pelagic crinoids"		Roveacrinidae	Miscellaneous "early" C/TBE Most likely the Roveacrinus beds of the Plenus Marls
	Fig. 3.1.	"Planktic crinoid"	Late Cenomanian Rotalipora cushmani zone (Unit B, sample 1851)	Oblique/Tangential section of a sub-complete theca (Obl/TgS-Theca) *Roveacrinus alatus* Douglas	
Gréselle *et al*. (2009, 2010)	in coll. No photograph	Roveacrinids	Latest Cenomanian Archaeocretacea PRZ Soyatal Formation (Sample C13)	Roveacrinidae indet. (Tg/LS-NBrn)	Archaeocretacea PRZ Latest Cenomanian
Núñez-Useche and Barragán (2012)	Fig. 2 (legend)	Saccocomids	MA-15 La Peña Formation	Oblique section of a distal brachial plate (OblS-NBrn) Roveacrinidae indet.	Uppermost Cenomanian (?) Base of the *Whiteinella archaeocretacea* Zone
	p. 209, 210	(?) Crinoids	MA-14 [Crinoids] "MA-15" [no mention]	Roveacrinida	Top of La Peña Fm - Base of Upper Tamaulipas Fm
	Figs. 7a, 7b p. 210	"MA-17: …microcalamoids (Figure 7a-7b)" "MA-18: …microcalamoids" (p. 211) Probably some 'crinoids' reported in the text, some other confused with ophuroid plates	Upper Tamaulipas Formation Lower Albian	Rather proximal brachial plates of stem crinoids [Figures 7a-7b], and with some caution most probably Transverse-Oblique sections of thecal plates (T/OblS-Rad) Saccocomidae indet.	Early Albian
Omaña *et al*. (2014)	p. 32 p. 34 Fig. 5h, i	Roveacrinids	Latest Cenomanian Archaeocretacea PRZ Soyatal Formation (Sample C13)	Roveacrinidae indet. (Ax/LgS-IBr2) [Possible ophiuroid plate]	Archaeocretacea PRZ Latest Cenomanian
Buitron and Omaña (2014)	p. 20 Fig. 3a, d	*Poecilocrinus dispandus elongatus* Peck, 1943	Lower Turonian Platform, Valles-San Luis Potosí, Mexico:	a: oblique section of a distal brachial plate [TgS-NBrn] Roveacrinidae indet. d: tangential section of a distal brachial plate [TgS-NBrn] Roveacrinidae indet.	Uppermost Cenomanian (?) Base of the *Whiteinella archaeocretacea* Zone
	p. 20 Fig. 3b, c, e	*Roveacrinus geinitzi* Schneider, 1989	Lower Turonian Platform, Valles-San Luis Potosí, Mexico: Guassa Fm. San Vicente Mb. Upper Jurassic Tithonian	b: possible tangential section of a radial plate [TgS-Rad] ?*Roveacrinus* sp.; c: tangential section of a distal brachial plate [TgS-NBrn] Roveacrinidae indet. [e: possibly an ophiuroid plate section].	Uppermost Cenomanian (?) Base of the *Whiteinella archaeocretacea* Zone San Vicente Mb. (Guassa Fm.) uppermost Jurassic (Tithonian) Below the J/K boundary
	p. 20 Fig. 3f	*Roveacrinus* sp.	Lower Turonian Platform, Valles-San Luis Potosí, Mexico: Guassa Fm. San Vicente Mb. Upper Jurassic Tithonian Guassa Fm. San Vicente Mb. Upper Jurassic Tithonian Cenomaniano superior-Turoniano inferior (in text, p.18) Cenomaniano-Touriano [sic, in Fig. 2] Zona Whiteinella archeocretacea Formación Soyatal	Possible oblique tangential section of a second primibrachial or an isolated radial plate (Tg/OblS-IBr2/Rad) Roveacrinidae indet.	Uppermost Cenomanian (?) Base of the *Whiteinella archaeocretacea* Zone San Vicente Mb. (Guassa Fm.) uppermost Jurassic (Tithonian) Below the J/K boundary San Vicente Mb. (Guassa Fm.) uppermost Jurassic (Tithonian) Below the J/K boundary Archaeocretacea PRZ Latest Cenomanian
	p. 434	"saccocomids" and "filaments"		Various sections ['saccocomids'] (T/Obl-NBrn) and longitudinal sections (LgS-NBrn) of brachial plates ['filaments'] of Saccocomidae indet.	
	Figure 2 (second microfacies picture from the top)	"roveacrinidos" [comment in text, p. 18]		Oblique section of a brachial plate (OblS-NBrn) Roveacrinidae indet.	

Table 1. Correspondance between published roveacrinid taxa and their revised assignment (continuation).

Authors (Date)	Illustrations	Original identification	Age	Revised Identification	Revisited Age
López-Martínez *et al.* (2014)	Fig. 3E	"Highly disarticulated and densely packed Soccocomids"	Guassa Fm. San Vicente Mb. Upper Jurassic Tithonian Cenomaniano superior-Turoniano inferior (in text, p.18) Cenomaniano-Touriano [sic, in Fig. 2] Zona Whiteinella archeocretacea Formación Soyatal lower Turonian Platform Valles-San Luis Potosí	Transverse sections of second primibrachial plates	San Vicente Mb. (Guassa Fm.) uppermost Jurassic (Tithonian) Below the J/K boundary Archaeocretacea PRZ Latest Cenomanian Archaeocretacea PRZ Latest Cenomanian *Cerratescens cerratescens* Zone [from Scott *et al.* 2016] (upper Albian)
	p. 434-436, 439	*Saccocoma*		Rather "*Saccocoma*" auct.	
	Fig. 3A	Tangential section of the theca of *Poecilocrinus dispandus elongatus* Peck, 1943		Tangential longitudinal section of a median brachial (Tg/LS-NBrn) of Roveacrinidae indet. (comparable to *R. alatus* Douglas or *R. spinosus* Peck)	
Buitron and Omaña (2015)	Fig. 3B	Longitudinal section of the theca of *Roveacrinus geinitzi* Schneider, 1989	lower Turonian Platform Valles-San Luis Potosí	Longitudinal section of a brachial (LS-NBrn) of Roveacrinidae indet.	Archaeocretacea PRZ Latest Cenomanian *Cerratescens cerratescens* Zone [from Scott *et al.*, 2016] (upper Albian)
	Fig. 3C [=Fig. 5h, Omaña *et al.* 2014]	Longitudinal section of the theca of *Roveacrinus geinitzi* Schneider, 1989		Tangential longitudinal section of a proximal brachial (Tg/LS-NBrn) of Roveacrinidae indet. (comparable to *R. alatus* Douglas or *R. spinosus* Peck)	
	Fig. 3D	Longitudinal section of the theca of *Poecilocrinus dispandus elongatus* Peck, 1943		Tangential longitudinal section of a first primibrachial (Tg/LS-IBr1) of Roveacrinidae indet.	
	Fig. 3E [=Fig. 5i, Omaña *et al.* 2014]	Longitudinal sections of the theca of *Roveacrinus geinitzi* Schneider, 1989		Possible axial longitudinal section of a second primibrachial of Roveacrinidae indet. or Axial longitudinal section of an ophiuroid plate	
	Fig. 3F	Longitudinal section of the theca of *Roveacrinus* sp.		Possible sub-Tangential section of a radial plate –around the articular facet- (TgS-Rad) of *Roveacrinus* sp.	
	Figs. 4-8	*Poecilocrinus latealatus* (Peck, 1943)			
Hess (2015)	Figs. 9-11	*Roveacrinus pyramidalis* Peck, 1943	Top of the upper Duck Creek Fm., Del Rio Clay Fm., *Mortoniceras rostratum* Zone [*Heterohelix reussi* Zone] (upper Albian)		
	Figs. 12-13	*Orthogonocrinus apertus* Peck, 1943	Top of the upper Duck Creek Fm., Del Rio Clay Fm., *Mortoniceras rostratum* Zone [*Heterohelix reussi* Zone] (upper Albian) Del Rio Fm. (lower Cenomanian)		*Cerratescens cerratescens* Zone [from Scott *et al.*, 2016] (upper Albian) Del Rio Clay Fm. (lower Cenomanian)
	Figs. 12h, ?13a, d	*Roveacrinus peracutus* (Peck, 1943)	Top of the upper Duck Creek Fm., Del Rio Clay Fm., Mortoniceras rostratum Zone [Heterohelix reussi Zone] (upper Albian) Del Rio Fm. (lower Cenomanian) Del Rio Fm. (lower Cenomanian) Taylor-Navarro Fms. Uppermost Campanian - Lower Maastrichtian		*Cerratescens cerratescens* Zone [from Scott *et al.*, 2016] (upper Albian) Del Rio Clay Fm. (lower Cenomanian) Del Rio Clay Fm. (lower Cenomanian)
	Figs. 14d, p, t, ?15a, b	*Roveacrinus alatus* Douglas, 1908			
	Figs. 14a-c, e-o, q-s, 15c-w	*Roveacrinus spinosus* Peck, 1943			
	Fig. 17	*Roveacrinus peracutus* (Peck, 1943)			
	Figs. 6D-E, 7D-E, H-K	*Applinocrinus texanus* Peck, 1973	Del Rio Fm.(lower Cenomanian) Taylor-Navarro Fms. Uppermost Campanian - Lower Maastrichtian Prairie Bluff Chalk Fm. Upper Maastrichtian Mississippi		Del Rio Clay Fm. (lower Cenomanian)
	Figs. 6C, G, 7B-C, F-G	*Applinocrinus russelli* n. sp. [OD]			
	Figs. 5E, G-I, 6A, 7L-Q, T	*Sagittacrinus torpedo* n. gen. n. sp. [OD]			
Gale (2016)	Figs. 9L, P	*Jakeocrinus ellisensis* n. gen. n. sp. [OD]	Taylor Fm. Lower Campanian Texas		
	Figs. 12M-O	*Platelicrinus* sp.	Taylor Fm. Lower Campanian Texas		
Monier *et al.* (2017a, b)	Figs. 4A-L	Diverse sections of brachial and thecal plates of Roveacrinida, Saccocomidae	Albian Sierra Azul, Cuenca de Sabinas [Coahuila, Mx]	Full description in prog. (to be published elsewhere)	

Appendix C

Re-interpretation of previously illustrated roveacrinids.

A. *Applinocrinus* sp. - isolated radial - (T/LgS-Rad), Aptian-Albian boundary (?) (La Peña ?-Tamaulipas ? Fms.) [sub *Microcalamoides diversus*, figure 7.2 in Longoria and Monreal, 1991: 21].

B. *Applinocrinus* sp. - complete theca - (T/OblS-Rad), Aptian-Albian boundary (?) (La Peña ?-Tamaulipas ? Fms.) [*sub* Ostracod, figure 7.5 in Longoria and Monreal, 1991: 21].

C. *Applinocrinus* sp. - isolated radial - (Ax/sub-OblS-Rad), Upper Albian-lower Cenomanian (?) (Tamaulipas ?-Cuesta del Cura ? Fms.) [*sub Microcalamoides*?, figure 7.7 in Longoria and Monreal, 1991 21].

D. *Applinocrinus* sp. - isolated radial - (T/OblS-Rad), Upper Albian (?) (Tamaulipas ? Fm.) [*sub* echinoderm fragments, figure 8.21 in Longoria and Monreal, 1991: 23].

E. *Roveacrinus alatus* Douglas - sub-complete theca - (Obl/TgS-Theca), Uppermost Cenomanian, top of the Cushmani Zone (ZoneYaxcopoil-1 drill site, southwest Merida) [*sub* 'Planktic crinoid' *ex* Stinnesbeck *et al.*, 2004 (figure 3.1 in Stinnesbeck *et al.*, 2004)].

F. Saccocomidae indet. - thecal plates - (T/OblS-Rad) with some caution, Lower Albian (La Peña and Upper Tamaulipas Fms.) [Roveacrinids *ex* Núñez-Useche and Barragán, 2012 (figure 7a, b in Núñez-Useche and Barragán, 2012)].

G. Roveacrinidae indet. - distal brachial plate - (OblS-NBrn), Uppermost Cenomanian (?), Base of the *Whiteinella archaeocretacea* Zone [without legend *ex* Omaña *et al.*, 2014 (figure 2 in Omaña *et al.*, 2014; second microfacies picture from top)].

I. Roveacrinidae indet. (Ax/LgS-IBr2) [Possible ophiuroid plate], Uppermost Cenomanian (?), Base of the *Whiteinella archaeocretacea* Zone (Soyatal Fm.) [Roveacrinids ex Omaña *et al.*, 2014 (figure 5h, i in Omaña *et al.*, 2014)].

J. Roveacrinidae indet. (TgS-NBrn), Base of the Whiteinella archaeocretacea Zone (Uppermost Cenomanian ?), Valles-San Luis Potosí [*non Poecilocrinus dispandus elongatus* Peck, 1943; *ex* Buitrón-Sánchez and Omaña-Pulido, 2015 (figure 3a in Buitrón-Sánchez and Omaña-Pulido, 2015: 20)].

K. Roveacrinidae indet. (TgS-NBrn), Base of the *Whiteinella archaeocretacea* Zone (Uppermost Cenomanian ?), Valles-San Luis Potosí [*non Poecilocrinus dispanduselongatus* Peck, 1943; *ex* Buitrón-Sánchez and Omaña-Pulido, 2015 (figure 3d in Buitrón-Sánchez and Omaña-Pulido, 2015: 20)].

L.? *Roveacrinus* sp. (TgS-Rad), Base of the *Whiteinella archaeocretacea* Zone (Uppermost Cenomanian ?), San Vicente Mb. (Guassa Fm.), Valles-San Luis Potosí [*non Roveacrinus geinitzi* Schneider, 1989; *ex* Buitrón-Sánchez and Omaña-Pulido, 2014 (figure 3b in Buitrón-Sánchez and Omaña-Pulido, 2014: 20)].

M. Roveacrinidae indet. (TgS-NBrn), Base of the *Whiteinella archaeocretacea* Zone (Uppermost Cenomanian ?), San Vicente Mb. (Guassa Fm.), Valles-San Luis Potosí [*non Roveacrinus geinitzi* Schneider, 1989; *ex* Buitrón-Sánchez and Omaña-Pulido, 2014 (figure 3c in Buitrón-Sánchez and Omaña-Pulido, 2014: 20)].

N. Roveacrinidae indet. (Tg/OblS-IBr2/Rad), Base of the *Whiteinella archaeocretacea* Zone (Uppermost Cenomanian ?), San Vicente Mb. (Guassa Fm.), Valles-San Luis Potosí [*non Roveacrinus* sp.; *ex* Buitrón-Sánchez and Omaña-Pulido, 2014 (figure 3f in Buitrón-Sánchez and Omaña-Pulido, 2014: 20)].

O. Roveacrinidae indet. (OblS-NBrn), Tithonian below the J/K boundary - Archaeocretacea PRZ (Latest Cenomanian), Soyatal Fm. [*non* roveacrin-idos (comment in text, p. 18); *ex* Buitrón-Sánchez and Omaña-Pulido, 2014 (figure 2 in Buitrón-Sánchez and Omaña-Pulido, 2014 (second micro-facies picture from the top)].

P. Roveacrinida indet. (TS-IBr2), Tithonian below the J/K boundary - Archaeocretacea PRZ (Latest Cenomanian), Soyatal Fm. [*non* Highly disarticulated and densely packed Soccocomids; *ex*

López-Martínez *et al.*, 2014 (figure 3E in López-Martínez *et al.*, 2014)].

Q. Roveacrinidae indet. (Tg/LS-NBrn), Archaeocretacea PRZ (Latest Cenomanian), Valles-San Luis Potosí Platform [*non* Tangential section of the theca of *Poecilocrinus dispandus elongatus* Peck, 1943; *ex* Buitrón-Sánchez and Omaña-Pulido, 2015 (figure 3A in Buitrón-Sánchez and Omaña-Pulido, 2015)].

R. Roveacrinidae indet. (LS-NBrn), Archaeocretacea PRZ (Latest Cenomanian), Valles-San Luis Potosí Platform [*non* Longitudinal section of the theca of *Roveacrinus geinitzi* Schneider, 1989; *ex* Buitrón-Sánchez and Omaña-Pulido, 2015 (figure 3B in Buitrón-Sánchez and Omaña-Pulido, 2015)].