

## Corals from the Upper Cretaceous (Maastrichtian) Ocozocoautla Formation, Chiapas, Mexico

Harry F. Filkorn<sup>1,\*</sup>, Javier Avendaño-Gil<sup>2</sup>,  
Marco A. Coutiño-José<sup>2</sup>, and Francisco J. Vega-Vera<sup>3</sup>

<sup>1</sup> Department of Invertebrate Paleontology, Natural History Museum of Los Angeles County,  
900 Exposition Boulevard, Los Angeles, California 90007 USA.

<sup>2</sup> Instituto de Historia Natural y Ecología, Calzada de los Hombres Ilustres s/n,  
29000 Tuxtla Gutiérrez, Chiapas, Mexico.

<sup>3</sup> Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria,  
04510 México, D. F., Mexico.

\* hfilkorn@nhm.org

### ABSTRACT

*The coral species from the Upper Cretaceous (Maastrichtian) strata of the Ocozocoautla Formation in Chiapas, Mexico, are identified, described and illustrated for the first time. This coral fauna is composed of 12 species, nine of which are colonial, presumably zooxanthellate, reef-building forms. This is the first time that six of these species have been reported from Mexico. The majority (11) of these species are endemic to the Caribbean region and known only from the Late Cretaceous.*

*Key words: corals, Cretaceous, Maastrichtian, Mexico, Chiapas.*

### RESUMEN

*Especies de coral recolectadas en estratos del Cretácico Superior (Maastrichtiano), correspondientes a la Formación Ocozocoautla en Chiapas, México, son identificadas, descritas e ilustradas por vez primera. Esta fauna de corales está representada por 12 especies, nueve de las cuales son formas coloniales de arrecife, presumiblemente asociadas a zooxantelas. Seis de estas especies no habían sido reportadas con anterioridad para México. La mayoría (11) de las especies son endémicas de la Provincia del Caribe, y se conocen sólo del Cretácico Tardío.*

*Palabras clave: corales, Cretácico, Maastrichtiano, México, Chiapas.*

### INTRODUCTION

Recent investigations of the Cretaceous stratigraphy in the vicinity of Tuxtla Gutiérrez, Chiapas, have resulted in the discovery of a diverse invertebrate fauna. This fauna includes many shallow marine taxa that are characteristic of the latest Cretaceous stratigraphic sequence in this region of Mexico, including the dasycladacean alga *Neogyroporella*,

the larger foraminiferan *Chubbina*, and the rudist bivalve *Titanosarcolites*, as well as many species of ostracodes, decapods, gastropods, and other bivalves. In addition, fossil corals are present in abundance at certain horizons of the Ocozocoautla Formation, particularly some of those that are exposed in road cuts along a newer highway between Ocozocoautla, Chiapas, and Cosoleacaque, Veracruz.

This is the first detailed taxonomic study of the Upper

Cretaceous coral fauna from the Ocozocoautla Formation. Although fossil corals from this region of Chiapas had been noted repeatedly by several earlier investigators (Sapper, 1894, p. 203-204; 1896a, p. 6; 1896b, p. 941-942; 1899, p. 12; Schuchert, 1935, p. 328; Sapper, 1937, p. 30; Maldonado Koerdell, 1950, p. 181; Chubb, 1959, p. 753; see Filkorn, 2003b, for additional discussion), typically the specimens were never described or illustrated and the actual identities of the species remained obscure or entirely unknown. The only possible notable exception to this is Maldonado-Koerdell's (1950, p. 196-197, figs. 3, 4) descriptions of *Trochocyathus* cf. *T. woolmani* Vaughan, 1900, and *Trochosmia* sp., two solitary coral species that were collected from upper Campanian beds in the vicinity of Ocuilapa, Chiapas. However, it is believed that many of the corals that were noted in the earlier studies cited above are represented in the more recently collected group of specimens described in this report. The objective of this study is to provide the first substantial documentation of the coral species that occur in the Ocozocoautla Formation of Chiapas.

## LOCATION AND STRATIGRAPHY

The fossil corals described in this study were collected from a series of road cuts in the Ocozocoautla Formation along a relatively new north-south trending section of highway 190 that connects the communities of Ocozocoautla, Chiapas, and Cosoleacaque, Veracruz. The latitude and longitude coordinates of each of the fossil coral localities were determined by using a modern global positioning

system (GPS) unit. The positions of the main coral localities were plotted based on their GPS coordinates (Figure 1). All of the localities are due north of Ocozocoautla. The coordinates (WGS84) of the five coral-bearing sites are: locality number 1) Lat 16°47'21.1"N, Long 93°19'58.8"W; locality number 2) Lat 16°48'19.4"N, Long 93°22'04.9"W; locality number 3) Lat 16°48'27.6"N, Long 93°21'33.4"W; locality number 4) Lat 16°48'34.3"N, Long 93°21'48.9"W; locality number 5) Lat 16°48'45.0"N, Long 93°22'06.2"W.

Locality 1 is positioned on the east side of the highway and very close to Instituto de Historia Natural y Ecología (IHN) locality 1003 (see Vega et al., 2001). Locality 2 is about 0.5 km west of the new highway, in a borrow cut related to the highway construction. The coral-bearing beds at localities 4 and 5 may be traced for several meters or more along both sides of the highway.

The stratigraphic section in the study area, lithologic characteristics of the Ocozocoautla Formation, paleoenvironmental interpretations of some of the beds, and the basis for the Late Cretaceous (Maastrichtian) age determination recently have been reviewed by Vega et al. (2001) and Filkorn (2003a). The coral-bearing strata in the road cuts are primarily composed of medium- to thick-bedded limestone and marl with intercalations of carbonaceous grey shale and argillaceous lignite. The beds are well-exposed at most of these road cuts, but lately some of the best outcrops have been covered with fencing to prevent rock falls onto the highway and one of the best exposures (at locality 3) has been blasted and bulldozed, apparently to widen the road cut. The presence of reef corals at some horizons further supports the interpretation that these beds were deposited in a shallow, near-shore,

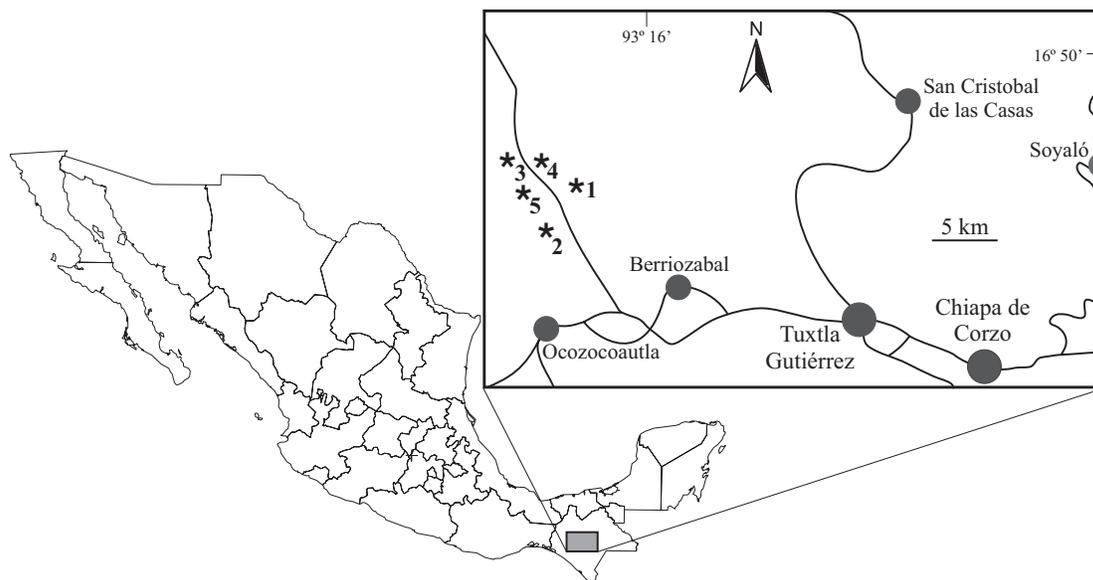


Figure 1. Map showing the location of the study area in Chiapas and the approximate positions (1-5) where the fossil corals were collected from the Ocozocoautla Formation. See text for locality coordinates.

marine environment that was affected by episodic influxes of terrigenous sediment.

## CORALS FROM THE OCOZOCAUTLA FORMATION

The coral fauna of the Ocozocoautla Formation is composed of nine colonial reef building species and three solitary species. The colonial species exhibit a broad array of corallum growth forms, including ramose, massive, encrusting and phaceloid. The identified colonial coral species, in order of decreasing abundance, are: *Multicolumnastraea cyathiformis* (Duncan, 1865); *Actinohelia elegans* (Goldfuss, 1826); *Dictuophyllia conferticostata* (Vaughan, 1899); *Barysmilia trechmanni* (Wells, 1934); *Cladocora jamaicensis* Vaughan, 1899; *Synastrea* sp. cf. *S. agaricites* (Goldfuss, 1826); *Favia? gregoryi* Wells, 1935; *Mesomorpha catadupensis* Vaughan, 1899; and *Actinastrea* sp. The solitary coral species are *Paracycloseris elizabethae* Wells, 1934, which is abundant and occurs in discoid, patellate and cylindrical growth forms, and, less commonly, *Trochoseris catadupensis* Vaughan, 1899, and *Trochosmia hilli* Vaughan, 1899, both of which are pedunculate.

Entire monospecific banks of ramose colonies of *Multicolumnastraea cyathiformis* (Duncan, 1865) in the marl beds have been vertically compressed during compaction. The compaction was complete enough to flatten individual branches of these colonies and produce flame structures in the overlying unlithified limestone bed. Massive, hemispherical colonies of *Barysmilia trechmanni* (Wells, 1934), a species which possesses a skeleton with a relatively high percentage of primary porosity, were severely flattened during compaction of the shale beds. The sizes of the ramose colonies in the marl and shale facies suggest that they were upright and relatively intact prior to a sudden influx of sediments and rapid burial of the colonies.

The majority of the coral species from the Ocozocoautla Formation described in this report are endemic to the Caribbean region and known only from Upper Cretaceous rocks, particularly in the Maastrichtian upper member of the Cárdenas Formation, San Luis Potosí, Mexico, the Upper Maastrichtian Guinea Corn Formation of Jamaica (see Steuber *et al.*, 2002, and Mitchell *et al.*, 2004, for details on the age determination of this unit), the Campanian–Maastrichtian of Cuba, and one other site in Mexico (Table 1). In addition, a small coral fauna that contains two of these species has been reported from Upper Cretaceous rocks in Puerto Rico (Kaye, 1956; Berryhill *et al.*, 1960), but there have been no subsequent investigations of that fauna. Altogether, this faunal similarity supports the correlation of the Ocozocoautla Formation with the other shallow marine Maastrichtian units within the Caribbean region, including the Barton Creek Formation in northern Belize (Vega *et al.*, 2001). All but one of the coral species listed above became extinct by the close of the Cretaceous Period: only *Favia? gregoryi* Wells, 1935, is known from the Tertiary (middle Eocene, Jamaica) and its occurrence in the Maastrichtian of Chiapas is the earliest known record of the species.

## SYSTEMATIC PALEONTOLOGY

The figured specimens are in the collections of the Museo de Paleontología of the Instituto de Geología (IGM 8432 through IGM 8443), Universidad Nacional Autónoma de México (UNAM), Mexico City. Additional studied specimens of most of these species are in the Instituto de Historia Natural y Ecología (IHN), Tuxtla Gutiérrez, Chiapas.

The abbreviations used in this section are: CD = calicular diameter; S1 = septa of first cycle, S2 = septa of second cycle, etc. The repository acronyms are noted in the preceding paragraph.

Table 1. Distribution of the Maastrichtian coral species from Chiapas, Mexico.

Species	Location				
	Chiapas	Cuba	Jamaica	Mexico	Europe
<i>Multicolumnastraea cyathiformis</i> (Duncan, 1865)	M		C-M	1, 3	
<i>Actinohelia elegans</i> (Goldfuss, 1826)	M		M	3	M
<i>Dictuophyllia conferticostata</i> (Vaughan, 1899)	M		M	3	
<i>Barysmilia trechmanni</i> (Wells, 1934)	M		M		
<i>Cladocora jamaicensis</i> Vaughan, 1899	M		M	3	?
<i>Synastrea</i> sp. cf. <i>S. agaricites</i> (Goldfuss, 1826)	M		M		?
<i>Favia? gregoryi</i> Wells, 1935	M		E		
<i>Mesomorpha catadupensis</i> Vaughan, 1899	M		M		
<i>Actinastrea</i> sp.	M		M		
<i>Paracycloseris elizabethae</i> Wells, 1934	M	C	C-M	2	
<i>Trochoseris catadupensis</i> Vaughan, 1899	M	C	C-M	3	
<i>Trochosmia hilli</i> Vaughan, 1899	M		M		

E: Eocene; M: Maastrichtian; C: Campanian. 1: Cuautla Fm., Turonian (?), Mexico (Fries, 1960); 2: Cárdenas Fm., Maastrichtian, San Luis Potosí (Wells, 1941); 3: Cárdenas Fm., Maastrichtian, San Luis Potosí (Schafhauser *et al.*, 2003). From: Vaughan (1899), Wells (1934, 1935, 1941), Fries (1960), Budd *et al.* (1992), Mitchell (2002), Schafhauser *et al.* (2003), and Mitchell *et al.* (2004).

Class Anthozoa Ehrenberg, 1834  
 Subclass Zoantharia Blainville, 1830  
 Order Scleractinia Bourne, 1900  
 Suborder Archaeocoeniina Alloiteau, 1952  
 Family Actinastreaeidae Alloiteau, 1952  
 Genus *Actinastrea* d'Orbigny, 1849

**Type species.** *Actinastrea goldfussi* d'Orbigny, 1850 (p. 277) = *Astrea geminata* Goldfuss, 1826 (p. 69-70, pl. 23, figs. 8c, 8f), by monotypy (d'Orbigny, 1849, p. 10).

*Actinastrea* sp.  
 Figure 2a

**Description.** Corallum colonial, cerioid, encrusting to ramose, noncostate, and relatively small in size. Corallites prismatic and closely packed. Colony formation by intratentacular budding. Calices distinct, monocentric, and relatively shallow. Calicular margins typically hexagonal in outline. CD ranges from about 0.8 to 1.2 mm. Centers of calices spaced about 1.0 mm apart.

Septa well-developed, slightly exsert as septocostae at calice wall, laminar, and solid. Septa typically 12 in number and hexamerally arranged in two cycles; size relationship  $S1 > S2$ .  $S1$  nearly reach corallite axis; length of  $S2$  about half that of  $S1$ . Synapticulae absent, lateral surfaces of septa mostly smooth or carinate. Upper and axial septal margins not observed. Pali absent. Columella usually present, styliiform, cylindrical, relatively narrow, and vertically continuous.

Wall well-developed, septothecate, and solid, those of adjacent corallites fused into a common mural structure. Wall relatively thin, up to about 0.2 mm in thickness. Endotheca may be present.

**Discussion.** A few species of *Actinastrea* have been reported from the Upper Cretaceous of the Caribbean region (in Wells, 1941, the species referred to the genus *Astrocoenia*). Of these species, the most similar is *Actinastrea dickersoni* (Wells, 1941) from the Upper Cretaceous of Cuba, but it primarily differs from the species described above by the larger calices (CD 2.0–3.0 mm) and more numerous septa (24, hexamerally arrayed in three cycles). Another unnamed species also has been reported from the Upper Cretaceous of Jamaica (Mitchell, 2002, p. 242), but no characteristics were given.

**Material.** Two specimens from locality 5: an encrusting colony on the underside of the hypotype specimen of *Barysmilia trechmanni* (Wells, 1934); and a small fragment or colony. The encrusting corallum exhibits evidence of skeletal dissolution whereas the other specimen has been thoroughly recrystallized. Despite the differences in preservation, both specimens appear to possess the same skeletal characteristics.

**Hypotype.** IGM-8432, from locality 5, an encrusting specimen with measurements of about 10.0 mm in diameter and 2.0 mm in height. The other specimen is about 9.0 x 13.0 mm in diameter and 5.0 mm in height.

Suborder Stylinina Alloiteau, 1952  
 Family Agatheliidae Beauvais and Beauvais, 1975  
 Genus *Multicolumnastra* Vaughan, 1899

**Type species.** *Heliastrea cyathiformis* Duncan, in Duncan and Wall, 1865, by monotypy.

*Multicolumnastra* *cyathiformis* (Duncan, 1865)  
 Figure 2b

*Heliastrea cyathiformis* Duncan, in Duncan and Wall, 1865, p. 8, pl. 1, figs. 1a-1b.

*Multicolumnastra cyathiformis* (Duncan, 1865). Vaughan, 1899, p. 236, pl. 37, figs. 5-7, pl. 38, fig. 1 (synonymy); Vaughan, 1919, p. 194; Wells, 1934, p. 90; Vaughan and Wells, 1943, p. 174, pl. 30, fig. 3; Kaye, 1956, p. 117; Wells, 1956, p. 406, fig. 302,3; Berryhill *et al.*, 1960, p. 151; Fries, 1960, p. 66, 189; ?Liao and Xia, 1994, p. 176-177, pl. 53, figs. 5 8; Baron-Szabo, 1998, p. 131, pl. 6, fig. 4 (synonymy); Baron-Szabo, 2002, p. 189, pl. 131, figs. 1-6; Mitchell, 2002, p. 242-243; Filkorn, 2003a, p. 32; Schafhauser *et al.*, 2003, p. 190; Mitchell *et al.*, 2004, p. 505.

**Description.** Corallum colonial, plocoid to subcerioid, typically ramose, and costate. Branches elongate, frequently bifurcated, tapered distally, variable in thickness, most commonly from about 5 to 10 mm, and relatively closely spaced. Corallites radially arrayed upward and outward from axis of branch. Colony formation by extratentacular budding. Calices monocentric. Calicular margins generally circular in outline and slightly protuberant above surrounding coenosteum. CD ranges from about 1.0 to 1.3 mm. Centers of adjacent calices spaced about 2.0 to 3.0 mm apart.

Septa well-developed, slightly exsert at calicular margin as septocostae, laminar, solid, 24 in number, and hexamerally arranged in three cycles; size relationship  $S1 \approx S2 > S3$ . Septa of first two cycles reach perimeter of columella. Length of  $S3$  about half that of  $S1-2$ . Axial margins of  $S1-2$  thickened. Pali-like structures (paliform lobes) on  $S1$  and pali on  $S2$ ; together the 12 form a single ring around the columella. Columella usually well-developed, composed of several interlinked pillars, spongiouse, orally papillose, vertically continuous, and wide in relation to diameter of calice, about 0.4 mm in diameter or about a third of CD.

Wall well-developed, septothecate, and structurally continuous with coenosteum. Endothecal dissepiments present. Coenosteum reticulate, surface costate near calices and more granular distally. Costae well-developed, structurally continuous with septa, and

typically much thicker and more closely spaced than septa. Costae usually not continuous with those of adjacent corallites.

**Discussion.** The specimens from the Maastrichtian of Chiapas possess all of the essential taxonomic characteristics of this species. This species was originally described from the Campanian – Maastrichtian of Jamaica. Although it was also reported from the Eocene of Jamaica (Vaughan, 1899, p. 231, Catadupa Beds; Vaughan, 1919, p. 194), the age of that occurrence was later determined to be Cretaceous (Vaughan, 1919, p. 486; Wells, 1934, p. 72-73). Occurrences of this species also have been noted in upper Turonian strata of the Cautla Formation, Morelos (Fries, 1960, p. 66), in Maastrichtian strata of the Cárdenas beds, San Luis Potosí (Fries, 1960, p. 66; Schafhauser *et al.*, 2003), and in reworked clasts of Cretaceous limestone in Puerto Rico (Kaye, 1956, p. 117; Berryhill *et al.*, 1960, p. 151). This species purportedly also occurs in the Late Cretaceous of Tibet (Liao and Xia, 1994, p. 176-177, pl. 53, figs. 5-8), but, based on the figures, the corallites are about 2.5–3.5 mm in diameter, much larger than those that are characteristic of *Multicolumnastraea cyathiformis* (Duncan, 1865), so the determination is considered to be doubtful. The geologic range of this species seems to be limited to the Late Cretaceous.

**Material.** This species was the main faunal component in some of the beds exposed at localities 3 and 5. Similar coral-rich rock samples were also collected at locality 2, but the coral-bearing horizon from which they were derived could not be located. The great abundance of this species at certain horizons suggest that many prolific colonies existed at the same time and that they probably formed a relatively well-developed coral thicket or reef structure composed almost exclusively of branching coral. Several specimens of branch fragments from each of the localities were collected for study.

**Hypotype.** IGM-8433, from locality 2. The specimen is a relatively well-preserved fragment of a corallum branch with a bifurcation, the main portion with measurements of about 25 mm in length and 10 mm in diameter. The lateral offshoot has about the same diameter and extends for at least another 25 mm. The figured piece is exposed on the surface of a rock sample that also contains several other branch fragments of the same species.

Suborder Rhipidogyrina Roniewicz, 1976

Family Rhipidogyridae Koby, 1905

Genus *Barysmilia* Milne Edwards and Haime, 1848a

**Type species.** *Dendrophyllia brevicaulis* Michelin, 1841 (p. 17, pl. 4, fig. 5), by monotypy (Milne Edwards and Haime, 1848a, p. 468).

### *Barysmilia trechmanni* (Wells, 1934)

Figure 2c

*Dichocoenia trechmanni* Wells, 1934, p. 75, pl. 2, figs. 7-8. Vaughan and Wells, 1943, p. 329, pl. 37, fig. 3; Wells, 1956, p. 415, fig. 315,1a; Coates, 1977, p. 339; Gill and Coates, 1977, p. 121; Cairns, 1991, p. 51; Mitchell *et al.*, 2004, p. 505.

*Barysmilia trechmanni* (Wells, 1934). Baron-Szabo, 2002, p. 84, pl. 59, figs. 2-3; Filkorn, 2003a, p. 32.

*Ovalastrea trechmanni* (Wells, 1934). Mitchell, 2002, p. 242.

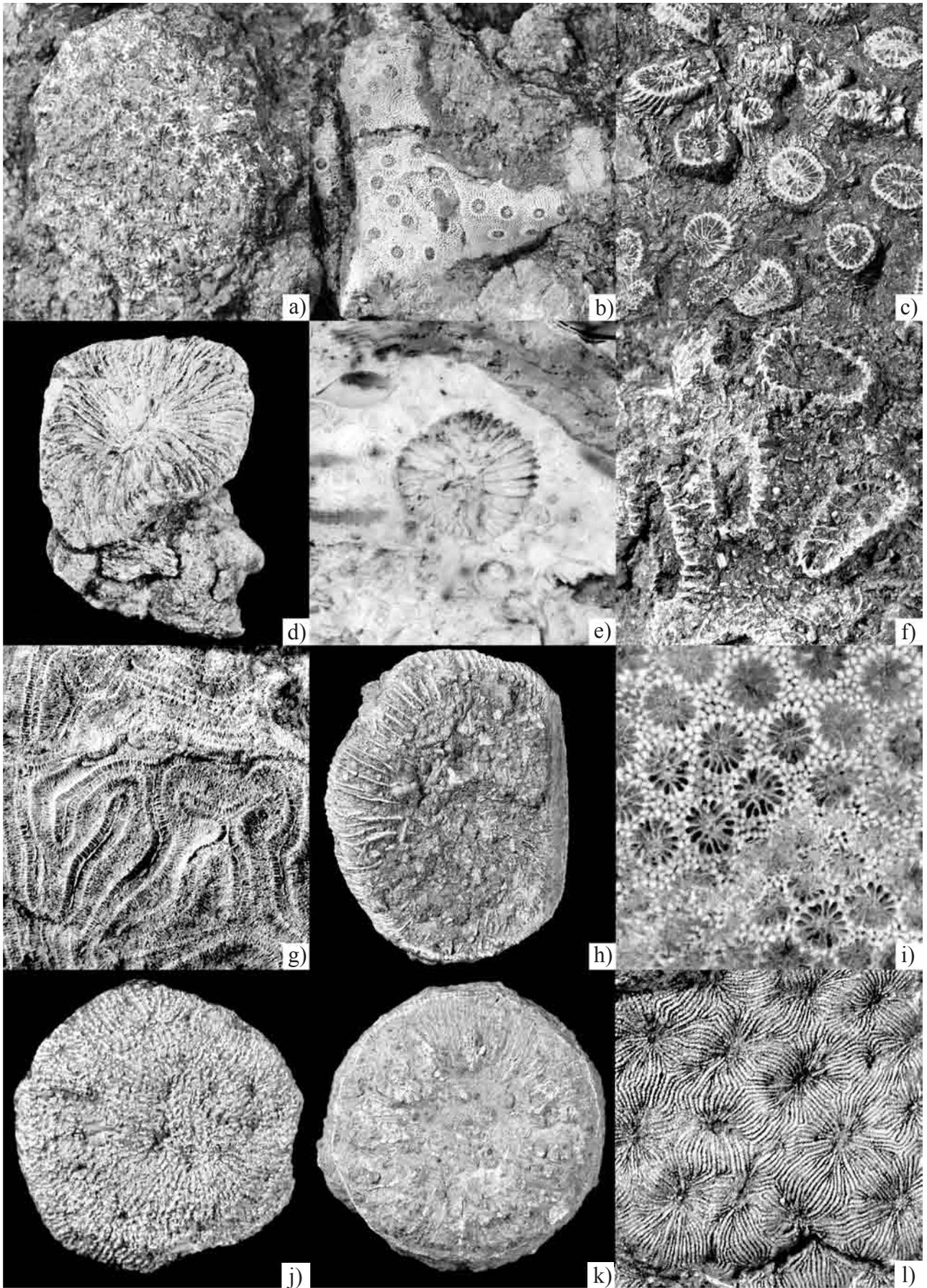
**Description.** Corallum colonial, plocoid, massive, hemispherical (in retrodeformed state), costate, and ranging from approximately 30–100 mm in diameter. Corallites cylindrical to subcylindrical in shape, with oral portions typically protuberant 1–3 mm above surrounding surface of coenosteum. Colony formation, where observed, typically by distomodaeal intratentacular budding. Calices distinct, permanent state most commonly monocentric, but some di- and tricentric forms also occur. Calicular margins circular, subcircular, elliptical, or smoothly irregularly elongate in outline, the latter case possibly representative of incipient budding. CD typically ranges from about 3 to 5 mm. Centers of mature calices fairly widely spaced, about 6–10 mm apart.

Septa well-developed, exsert, laminar, solid, continuous with costae, typically from 24 to about 36 in number, hexamerally arrayed in three to four cycles, the latter cycle usually incomplete. Size relationship of septa:  $S1 \approx S2 > S3 > S4$ . Septa of first two cycles extended to and fused with columella; S3 slightly shorter, usually to periphery of columella; length of S4 about half that of S3. Lateral surfaces of septa granulate, upper septal margins beaded or dentate. Columella usually well-developed, spongiose, often robust and deep in calice.

Wall well-developed, septothecate, solid, thickened aborally. Endothecal dissepiments present. Coenosteum porous(?), internal structural detail not preserved. Coenosteal surface costate. Costae well-developed, equal, robust, continuous with septa, with sharp, beaded crests evenly spaced about 0.5 mm apart.

**Discussion.** The morphological features of the studied specimens are well within the described characteristics that are typical of this species. The only discernable exception to this overall similarity is in the greatly reduced height of the specimens, which is due to vertical compression of the coralla during compaction of the bed. This species also occurs in the Campanian – Maastrichtian of Jamaica (the type locality). It is endemic to the Caribbean region.

**Material.** About 12 complete coralla and several fragments from locality 5. All of the studied specimens have been vertically compressed and crushed during compaction of the



enclosing sediments and their heights have been reduced to about 2 to 3 centimeters.

**Hypotype.** IGM-8434, a vertically compressed corallum from locality 5. As preserved, the specimen has measurements of about 90 x 130 mm in width and only 28 mm in height. The hypotype of *Actinastrea* sp. is preserved attached to the underside of this specimen.

Suborder Faviina Vaughan and Wells, 1943

Family Montlivaltiidae Dietrich, 1926

Genus *Trochoscilia* Milne Edwards and Haime, 1848a

**Type species.** *Turbinolia corniculum* Michelin, 1846 (p. 267, pl. 61, fig. 4), by subsequent designation (Gregory, 1900, p. 78).

***Trochoscilia hilli* Vaughan, 1899**

Figure 2d

*Trochoscilia hilli* Vaughan, 1899, p. 233, pl. 36, figs. 1-4. Vaughan, 1919, p. 194, 195; Baron-Szabo, 2002, p. 46; Filkorn, 2003a, p. 32.

**Description.** Corallum solitary, attached, pedunculate, trochoid, and finely costate. Calice monocentric; calicular margin irregularly elliptical, uneven. CD about 18 x 23 mm, height as preserved about 28 mm.

Septa well-developed, exsert, laminar, solid, continuous as costae, closely spaced, approximately 200 in number, arranged in six complete septal cycles along with some pairs from a seventh septal cycle, the latter cycle incomplete; size relationship:  $S1 \approx S2 \approx S3 \geq S4 > S5 > S6 > S7$ . Septa of first four cycles subequal, thicker than those of later cycles, mostly extended to and fused with columella. Septa of fifth through seventh cycles slightly shorter than those of preceding cycle, those of last inserted cycle shortest and thinnest. Lateral surfaces of septa uneven, upper margins of septa beaded. Columella weakly developed, deep in calice, possibly only composed of a fusion of axial edges of septa of first four cycles.

Wall septothecate, well-developed, solid. Costae dimorphic, alternate in size, crests finely beaded with those of larger size evenly spaced about 0.8 mm apart.

**Discussion.** The single specimen exhibits the basic

characteristics of this species as originally described by Vaughan (1899), but it has been severely deformed by compaction and subsequently etched by dissolution, therefore the finer details of its morphology cannot be examined. *Trochoscilia hilli* Vaughan, 1899, was originally described from its occurrence in the Catadupa beds of Jamaica. At that time it was considered to be an Eocene species, but later the age was determined to be Late Cretaceous, likely Campanian – ?Maastrichtian (Wells, 1934, p. 72). The specimen of *Trochoscilia* sp. described by Maldonado-Koerdell (1950, p. 196-197, fig. 4), which was collected from Campanian beds near Ocuilapa, Chiapas, has a different corallum shape and lacks a peduncle, therefore it probably is not the same species as described above. Additional specimens of both of these forms are needed to better determine if they are in fact closely related.

**Material.** One specimen from locality 3. The corallum has been obliquely vertically flattened by compaction, thus the given measurements probably are not entirely accurate.

**Hypotype.** IGM-8435. Measurements given in description.

Family Faviidae Gregory, 1900

Genus *Cladocora* Ehrenberg, 1834

**Type species.** *Madrepora flexuosa* Pallas, 1766 (p. 315), by subsequent designation (Milne Edwards and Haime, 1850, p. xxxviii).

***Cladocora jamaicensis* Vaughan, 1899**

Figure 2e

*Cladocora jamaicensis* Vaughan, 1899, p. 234, pl. 36, figs. 5-7. Wells, 1934, p. 72; ?Hackemesser, 1936, p. 38, pl. 5, fig. 3; Baron-Szabo, 2002, p. 34; Filkorn, 2003a, p. 32; Schafhauser *et al.*, 2003, p. 190.

?*Placophyllia* cf. *P. curvata* Turnšek, in Turnšek and Buser, 1974. Baron-Szabo, 1997, p. 70, pl. 6, figs. 3-4.

?*Procladocora jamaicensis* (Vaughan, 1899). Löser, 1999, p. 52, pl. 3, figs. 1-5.

**Description.** Corallum colonial, dendroid to phaceloid, loosely bushy, branches laterally free, costate. Each branch

Figure 2. Coral species from the Maastrichtian strata of the Ocozocoautla Formation. a: *Actinastrea* sp., hypotype, IGM-8432, oral view of corallum, x 4.5. b: *Multicolumnastra cyathiformis* (Duncan, 1865), hypotype, IGM-8433, lateral view of branch fragment, x 2.3. c: *Barysmilia trechmanni* (Wells, 1934), hypotype, IGM-8434, oral view of corallum, x 2.0. d: *Trochoscilia hilli* Vaughan, 1899, hypotype, IGM-8435, oral view, x 2.0. e: *Cladocora jamaicensis* Vaughan, 1899, hypotype, IGM-8436, polished slab with transverse section of branch, x 4.3. f: *Favia? gregoryi* Wells, 1935, hypotype, IGM-8437, oral view of corallum, x 2.2. g: *Dictuophyllia conferticostata* (Vaughan, 1899), hypotype, IGM-8438, oral view of weathered corallum, x 2.5. h: *Trochoseris catadupensis* Vaughan, 1899, hypotype, IGM-8439, oral view, specimen cut for study, x 2.1. i: *Actinhelia elegans* (Goldfuss, 1826), hypotype, IGM-8440, polished surface, oral view, transverse section just below upper surface of corallum, x 6.2. j: *Mesomorpha catadupensis* Vaughan, 1899, hypotype, IGM-8441, oral view of corallum, x 3.2. k: *Paracycloseris elizabethae* Wells, 1934, hypotype, IGM-8442, oral view of corallum, x 2.3. l: *Synastrea* sp. cf. *S. agaricites* (Goldfuss, 1826), hypotype, IGM-8443, oral view of part of corallum, x 2.3.

essentially composed of a single elongate corallite. Corallites typically cylindrical, about 5–7 mm in diameter, straight or slightly curved, vertically continuous, and terminated by a single calice. Colony formation by extratentacular budding. Calices monocentric, calicular margins circular to subcircular in outline. CD commonly 5–6 mm.

Septa well-developed, laminar, relatively thin, usually continuous as costae, typically 48 in number, and hexamerally arrayed in four complete cycles; size relationship:  $S1 = S2 \approx S3 > S4$ . Septa of first three cycles nearly equal in length and extended to and intermittently fused with columella. Length of  $S4$  about half that of  $S1-3$ . Lateral surfaces of septa appear smooth; upper margins not observed. Columella weakly developed when present, discontinuous, a loose fusion of axial edges of septa of first three cycles. Wall septothecate, solid, and possibly secondarily parathecate. Endothecal dissepiments present. Costae well-developed, usually structurally continuous with septa, equal or subequal, with sharp, ridge-like crests, evenly spaced about 0.4 mm apart, or 5 in a space of 2 mm. Intercostal furrows about equal to width of costae.

**Discussion.** The characteristics of the specimens are the same as those originally described for this species. Because the studied specimens are branch fragments from one or more coralla, the overall size and development of the colony could not be determined. This species was originally described from its occurrence in the Upper Cretaceous at Solomon Mountain, Jamaica. It also has been reported from the upper member of the Cárdenas Formation, San Luis Potosí, Mexico (Schafhauser *et al.*, 2003, p. 190), and (?) the Upper Cretaceous of Greece and Austria (see Löser, 1999, p. 52).

**Material.** Several branch fragments in a sample of limestone taken from a large displaced block of rudist – foraminiferal packstone that probably fell from higher up in the stratigraphic section exposed at locality 1. The fragments were particularly abundant along a bedding plane on the upper surface of the block. All of the specimens appeared to have been transported and abraded before deposition. The majority of the specimens have been recrystallized and much of the finer skeletal detail was not preserved.

**Hypotype.** IGM-8436, a single branch fragment from locality 1. The part of the specimen exposed to view is a cut and polished transverse cross section 6 mm in diameter. Additional specimens are visible in other cut surfaces of the same rock sample.

Genus *Favia* Oken, 1815

**Type species.** *Madrepora fragum* Esper, 1795 (p. 79, pl. 64, figs. 1-2), by subsequent designation (Verrill, 1902, p. 88-91; but also see Gregory, 1900, p. 67-68; Vaughan, 1901, p. 34-40; and Alloiteau, 1957, p. 137-138).

### *Favia? gregoryi* Wells, 1935

Figure 2f

*Favia? gregoryi* Wells, 1935, p. 185, pl. 10, figs. 1-2. Budd *et al.*, 1992, p. 571, 580, 581, 594; Filkorn, 2003a, p. 32.

**Description.** Corallum colonial, plocoid, massive, hemispherical (in retrodeformed state), costate, and about 80 x 90 mm in diameter and 20 mm in height (as preserved). Corallites subcylindrical in shape, with oral edges protuberant about 1-2 mm above surface of coenosteum. Colony formation by di- or tristomodaeal intratentacular budding. Calices distinct, mono- to tricentric. Calicular margins smoothly elliptical to elongate to irregularly elliptical in outline. CD ranges from 4 x 5 mm in elliptical calices and up to about 6 x 11 mm in larger irregularly shaped calices. Calices relatively deep, about 2 mm. Edges of adjacent mature calices usually spaced about 3–7 mm apart.

Septa well-developed, laminar, solid, structurally continuous with costae, about 32-70 in number, arranged in four to five septal cycles; size relationship among septa of larger calices:  $S1 \approx S2 \approx S3 \geq S4 > S5$ . Few septa, if any, reach corallite axis. Septa laterally spaced about 3 per 2 mm. Lateral surfaces of septa uneven, details of upper margins not preserved. Columella absent.

Wall well-developed, septothecate, possibly secondarily parathecate, solid. Endothecal dissepiments present. Coenosteum present, internal structural details not preserved. Costae well-developed, robust, structurally continuous with septa, subequal or alternate in size, about 5 or 6 costae per 5 mm. Crests of costae beaded; costal beads spaced about 4 per 2 mm. Intercostal furrows almost twice width of adjacent costae.

**Discussion.** Although the single corallum has been deformed by compaction, the preserved features of the specimen are most similar to those described for *Favia? gregoryi* Wells, 1935, including all of the essential diagnostic characteristics of the species. The calices are more widely spaced in the specimen from Chiapas, but this difference could be due to the deformed state of the corallum. This species was originally reported from its occurrence in the middle Eocene Yellow Limestone at Spring Mount, Jamaica. The studied specimen from the Maastrichtian of Chiapas constitutes the earliest known occurrence of this species and its first report from the Cretaceous.

**Material.** One corallum from locality 5. The specimen has been vertically compressed and crushed by compaction.

**Hypotype.** IGM-8437. Measurements given in description.

Genus *Dictuophyllia* Blainville, 1830

**Type species.** *Meandrina reticulata* Goldfuss, 1826 (p.

63, pl. 21, figs. 5a-5b), by subsequent designation (Wells, 1936, p. 109).

***Dictuophyllia conferticostata* (Vaughan, 1899)**

Figure 2g

*Diploria conferticostata* Vaughan, 1899, p. 239, pl. 39, figs. 1-3.

*Leptoria conferticosta* (Vaughan, 1899). Vaughan, 1919, p. 194; Mitchell *et al.*, 2004, p. 505.

*Dictuophyllia conferticostata* (Vaughan, 1899). Wells, 1934, p. 77; Kaye, 1956, p. 117; Berryhill *et al.* 1960, p. 151; Baron-Szabo, 2002, p. 27, pl. 9, fig. 2; Filkorn, 2003a, p. 32; Schafhauser *et al.*, 2003, p. 190.

*Leptoria (Dictuophyllia) conferticostata* (Vaughan, 1899). Mitchell, 2002, p. 242.

**Description.** Corallum colonial, meandroid, massive, finely costate, up to at least 22 cm in diameter and 10 cm in height. Corallites flabellate, collines separated by costate, continuous ambulacra. Calices laterally elongate, sinuous or contorted discontinuous series. Colony formation by polystomodaecal intratentacular budding. Series diameter (CD) typically ranges from about 1.0 to 1.5 mm. Collines of adjacent series separated by ambulacra about 1–3 mm in width, but most commonly nearer lower end of range. Series usually protuberant above surrounding ambulacral regions.

Septa well-developed, laminar, solid, continuous with costae, bilaterally symmetrical across width of series, subequal or slightly dimorphic and arranged in alternate fashion, and laterally spaced about 5 per mm along series wall, or about 50 per cm. Most septa extend to periphery of columella, but remain separate from it. Interseptal spaces about as wide as thickness of adjacent septa or slightly wider. Lateral surfaces of septa ornamented with spinose granulations, upper margins finely beaded or dentate. Columella well-developed, laminar, typically laterally and vertically continuous, a distinct plate-like structure along series axis.

Wall well-developed, septothecate, solid. Endothecal dissepiments present. Ambulacral regions costate and structurally similar to series and septa. Costae of adjacent series usually confluent across ambulacrum. Lateral spacing of costae similar to that of septa, about 5 per mm or 50 per cm.

**Discussion.** The characteristics of the specimens from Chiapas essentially are the same as those originally described for this species, except some of the newly collected coralla are much larger in diameter and height. This species was originally described from its occurrence in the Upper Cretaceous (Maastrichtian) of Jamaica. Although it was initially considered to also occur in the Eocene of Jamaica (Vaughan, 1899, p. 231, the Catadupa beds), the age of these strata subsequently was determined to be Late Cretaceous,

most likely Campanian – ?Maastrichtian (Wells, 1934, p. 72). This species has been reported from the Maastrichtian upper member of the Cárdenas Formation, San Luis Potosí, Mexico (Schafhauser *et al.*, 2003), and from reworked Upper Cretaceous limestone clasts in Puerto Rico (Kaye, 1956; Berryhill *et al.*, 1960). The specimens from the Maastrichtian of Chiapas represent the only other known occurrences of this species.

**Material.** Nine coralla and fragments: locality 2, one specimen with a massive to somewhat columnar or ramose growth form, also the largest corallum of this species; locality 5, eight specimens, including the hypotype, two large colonies, and five smaller colonies or fragments. The two large specimens from locality 5 have been thoroughly recrystallized.

**Hypotype.** IGM-8438, from locality 5. The measurements of the specimen, as preserved, are about 11 x 14.5 cm in diameter and 3 cm in height. The specimen may have been vertically compressed during compaction of the enclosing bed.

Suborder Fungiina Verrill, 1865

Family Agariciidae Gray, 1847

Genus *Trochoseris* Milne Edwards and Haime, 1849

**Type species.** *Anthophyllum distortum* Michelin, 1844 (p. 149, pl. 43, figs. 8a-8b), by monotypy (Milne Edwards and Haime, 1849, p. 72).

***Trochoseris catadupensis* Vaughan, 1899**

Figure 2h

*Trochoseris catadupensis* Vaughan, 1899, p. 242, pl. 39, figs. 5-6. Vaughan, 1919, p. 194, 426; Wells, 1934, p. 72, 78, pl. 2, figs. 9-10; Wells, 1941, p. 288, pl. 1, figs. 1-1c; Budd *et al.*, 1992, p. 593; Baron-Szabo, 2002, p. 122, pl. 84, figs. 3, 5; Mitchell, 2002, p. 242; Filkorn, 2003a, p. 32; Schafhauser *et al.*, 2003, p. 190; Mitchell *et al.*, 2004, p. 505.

**Description.** Corallum solitary, turbinate, cornute, pedunculate, costate. Calice monocentric, calicular margin elliptical in outline, CD 22 x 26 mm, height as preserved about 15 mm. Base of corallum truncated by flat attachment surface of peduncle oriented at about 45 degrees from plane of calice and about 9 x 11 mm in diameter.

Septa well-developed, laminar, exsert, occasionally perforate, continuous with costae, very closely spaced, about 240 in number, distinct septal cycles not apparent. Lateral surfaces of septa coarsely granulated, upper margins beaded, with about 6-8 beads per mm. Columella not observed (central part of calice not exposed).

Wall weakly developed, parathecate (?), solid. Endothecal dissepiments present. Epitheca present (?).

Costae well-developed, dimorphic, structurally continuous with septa, arranged in alternate fashion, those of larger size laterally spaced about 7 per 5 mm, crests rounded and minutely beaded, about 4–5 beads per mm.

**Discussion.** This species was originally described from its occurrence in the Catadupa beds of Jamaica. It was initially assigned an Eocene age (Vaughan, 1899, p. 231, 242), but later the age was determined to be Campanian – ?Maastrichtian (Wells, 1934, p. 72). This species also has been reported from the Maastrichtian upper member of the Cárdenas Formation, San Luis Potosí, Mexico (Schafhauser *et al.*, 2003), the Maastrichtian of Jamaica (Baron-Szabo, 2002, p. 422; Mitchell *et al.*, 2004, p. 505), and the Campanian of Cuba (Wells, 1941, p. 289).

**Material.** One specimen from locality 5. The specimen is fairly well-preserved, but the calice is mostly filled with limestone and the details of the axial region could not be examined.

**Hypotype.** IGM-8439. Measurements given in description.

Family Actinacididae Vaughan and Wells, 1943  
Genus *Actin helia* d'Orbigny, 1849

**Type species.** *Astrea elegans* Goldfuss, 1826, by monotypy.

*Actin helia elegans* (Goldfuss, 1826)  
Figure 2i

*Astrea elegans* Goldfuss, 1826, p. 69, pl. 23, figs. 6a–6d.  
*Actin helia elegans* (Goldfuss, 1826). d'Orbigny, 1849, p. 11; Baron-Szabo, 2002, p. 101, pl. 68, fig. 4, pl. 70, fig. 1; Filkorn, 2003a, p. 32; Schafhauser *et al.*, 2003, p. 190.

**Description.** Corallum colonial, cerioid or subcerioid, encrusting or massive, costate. Corallites prismatic or cylindrical, usually closely packed. Colony formation by extratentacular budding. Calices monocentric, funnel-shaped, relatively deep; calicular margins rounded-polygonal to subcircular in outline. CD ranges from 1.0 to 2.0 mm, but most commonly 1.5 mm. Centers of calices spaced about 1.5–2.0 mm apart.

Septa feebly developed, exsert at calicular margin as short costae, laminar, solid, 16 in number, symmetry obscure, possibly six S1, six S2 and two pairs of S3. Larger septa subequal in length, smaller septa or S3 about half their length and usually aborally laterally fused to adjacent parent septum. Eight to 12 septa reach and intermittently fuse with columella deep in aboral region of calice. Synapticulae possibly present near columella. Lateral surfaces of septa sparsely dentate, upper margins smooth. Columella variably

developed, spongiose, possibly false, and composed of loose fusion of axial edges of larger septa.

Wall weakly developed, synapticulothecate, perforate, relatively thin, and structurally confluent with septa and coenosteum. Coenosteum often well-developed, individual elements robust and closely spaced, structure reticulate and porous, surface granular. Costae typically not continuous beyond edge of calice, those of adjacent calices usually not confluent.

**Discussion.** This species has been reported from the Maastrichtian upper member of the Cárdenas Formation, San Luis Potosí, Mexico (Schafhauser *et al.*, 2003), the Maastrichtian of Jamaica, and the type locality in the Maastrichtian of The Netherlands (Baron-Szabo, 2002, p. 101).

**Material.** Thirteen specimens: one corallum, the largest example, from locality 3; and 12 smaller coralla from locality 5. The largest specimen is about 75 mm in width and 45 mm in height.

**Hypotype.** IGM-8440, a small encrusting corallum from locality 5. The specimen has measurements of about 21 x 26 mm in diameter and 17 mm in height.

Family Thamnasteriidae Vaughan and Wells, 1943  
Genus *Mesomorpha* Pratz, 1882

**Type species.** *Porites mammillata* Reuss, 1854 (p. 129, pl. 10, figs. 9–10), by subsequent designation (Felix, 1925, p. 133).

*Mesomorpha catadupensis* Vaughan, 1899  
Figure 2j

*Mesomorpha catadupensis* Vaughan, 1899, p. 246, pl. 41, figs. 1–3. Wells, 1934, p. 72; Baron-Szabo, 2002, p. 65; Filkorn, 2003a, p. 32; Mitchell *et al.*, 2004, p. 505.

**Description.** Corallum colonial, thamnasteroid, massive, septocostate. Corallites laterally confluent, walls absent. Colony formation by polystomodaeal circumoral budding. Calices laterally continuous, vaguely defined by shallow calicular centers and radially arrayed septa, calicular margins absent. Centers of calices spaced about 5 mm radially from center of corallum.

Septa well-developed, fenestrate, continuous between calicular centers as septocostae, subequal, closely packed, laterally spaced about 2 per mm, about 12–18 in number per calicular region, but only about six of them extend to calicular axis. Synapticulae abundant. Upper septal margins dentate, about 3 dentations per mm. Columella weakly developed, trabecular, or false and composed only of fused axial septal margins in calicular axis.

Wall absent, but aboral outer surface (base) of corallum

synapticulothecate. Base with radially arrayed costae and concentric undulations. Basal costae subequal and confluent with septocostae.

**Discussion.** The studied specimen is a small, immature corallum, but it exhibits the essential characteristics of this species. *Mesomorpha catadupensis* Vaughan, 1899, was originally described from its occurrence in the Catadupa beds of Jamaica. It was initially assigned an Eocene age (Vaughan, 1899, p. 231, 247), but later the age was determined to be Campanian–?Maastrichtian (Wells, 1934, p. 72). It is known only from the Caribbean region and thus appears to be endemic to this area.

**Material.** One small corallum from locality 3.

**Hypotype.** IGM-8441, from locality 3. The specimen has measurements of about 17 mm in diameter and 5 mm in height.

Suborder Microsolenina Morycowa and Roniewicz, 1995  
Family Cyclolitidae Milne Edwards and Haime, 1849  
(= Cunnolitidae Alloiteau, 1952)  
Genus *Paracycloseris* Wells, 1934

**Type species.** *Paracycloseris elizabethae* Wells, 1934, by original designation.

***Paracycloseris elizabethae* Wells, 1934**

Figure 2k

*Paracycloseris elizabethae* Wells, 1934, p. 86–87, pl. 3, figs. 5–10, pl. 5, figs. 1–2. Wells, 1941, p. 291, pl. 43, figs. 1–1e; Baron-Szabo, 2002, p. 145, pl. 105, figs. 1–5; Mitchell, 2002, p. 242; Filkorn, 2003a, p. 32; Mitchell *et al.*, 2004, p. 505.

**Description.** Corallum solitary, shape variable, either cupolate, discoid, patellate, or cylindrical. Base of corallum nearly flat or convex, sometimes with pointed apical attachment point, radially costate and concentrically undulate. Calice monocentric, calicular margin generally circular in outline. CD up to at least 24 mm and height 12 mm.

Septa well-developed, laminar, sparsely perforate, closely spaced, numerous, about 200 in number, hexamerally arrayed in six complete cycles with septa of incomplete seventh cycle often present peripherally. Size relationship among septa:  $S1 = S2 \geq S3 > S4 > S5 \gg S6$ . Septa of first two cycles extended to and fused with columella. S3 inserted at about 1 mm away from corallite axis, S4 at about 3 mm, S5 at about 5 mm, and S6 at around 8 mm. Synapticulae abundant between certain pairs of adjacent septa. Lateral surfaces of septa uneven, upper margins beaded; about 2 beads per mm. Columella spongiöse, orally papillose,

development variable, from feeble to robust.

Wall very weakly developed, synapticulothecate, basally intermittently epithecate, costate, and concentrically undulate. Attachment scar typically preserved at apex of base.

**Discussion.** The studied specimens exhibit various types of corallum shapes, including most notably those that Wells (1934, 1941) described previously for this species: the typical form, discoidal to patellate; a robust form, cylindrical; and a turbinate form. This species has been reported from the Campanian and Maastrichtian of Jamaica, the Upper Cretaceous of Cuba, and the Upper Cretaceous Cárdenas beds of San Luis Potosí, Mexico (Wells, 1941, p. 292). An occurrence of *Paracycloseris* cf. *elizabethae* [sic] Wells from the Upper Cretaceous of Transylvania reported by Kolosváry (1964, p. 227) is considered to be doubtful based on the brief description of the material.

**Material.** More than 200 specimens from three localities: 3 coralla from locality 3; about 195 coralla and fragments from locality 4; and 8 coralla from locality 5.

**Hypotype.** IGM-8442, from locality 4. The specimen has measurements of about 24 mm in diameter and 12 mm in height. The calicular center and interseptal spaces are filled with sediment.

Family Synastraeidae Alloiteau, 1952  
Genus *Synastrea* Milne Edwards and Haime, 1848b

**Type species.** *Astrea agaricites* Goldfuss, 1826 (p. 66, pl. 22, figs. 9a–9c), by monotypy (Milne Edwards and Haime, 1848b, p. 495).

***Synastrea* sp. cf. *S. agaricites* (Goldfuss, 1826)**

Figure 2l

*Synastrea* sp. cf. *S. agaricites* (Goldfuss, 1826). Filkorn, 2003a, p. 32.

**Description.** Corallum colonial, thamnasteroid, massive, septocostate. Corallites laterally continuous, without distinct walls. Colony formation by distomodaeal intratentacular budding. Calices typically monocentric, about 1 mm in depth; calicular margins irregularly elliptical to rounded-polygonal in outline, as vaguely delineated by inflection of confluent septocostae. CD variable, from about 3–8 mm, but most commonly near 5 mm. Centers of calices laterally spaced about 4–6 mm apart.

Septa well-developed, laminar, perforate, continuous as septocostae, closely spaced, usually from 50–60 in number, hexamerally arrayed in four complete cycles with part of fifth cycle also present; size relationship among septa:  $S1 \geq S2 > S3 > S4 > S5$ . Septa of first two cycles

extended to and fused with columella. Length of S3 and S4 progressively shorter than that of preceding cycle. S5 very short, developed peripherally. Synapticulae present. Lateral surfaces of septa uneven and granulate, upper margins beaded, about 3–4 beads per mm. Columella usually present, fairly well-developed, trabecular, spongiöse, orally papillose, deep in center of calice, contributed to by axial edges of S1 and S2.

Wall absent, calices laterally continuous. Endothecal dissepiments present. Septocostae well-developed, subequal, typically confluent with those of adjacent corallites, closely spaced, about 3 per mm. Upper margins of septocostae beaded same as septa.

**Discussion.** The characteristics of this species are most similar to those of *Synastrea agaricites* (Goldfuss, 1826), but the specimen from Chiapas has a much larger corallum and the calices are more widely spaced. Members of this species reportedly may also occur in the Maastrichtian of Jamaica (Baron-Szabo, 2002, p. 140).

**Material.** One specimen from locality 2. The external surface of the corallum is well-preserved, but the skeleton has been thoroughly recrystallized. Other coralla were observed in the solid limestone at locality 5, but the specimens could not be collected for study.

**Hypotype.** IGM-8443, from locality 2. As preserved, the specimen has measurements of about 12 x 15 cm in width and 6 cm in height.

## CONCLUSIONS

This report is the first detailed taxonomic study of the Upper Cretaceous (Maastrichtian) coral fauna from the Ocozocoautla Formation of Chiapas, Mexico. This coral fauna is composed of 12 species, including nine colonial, reef-building species, and three solitary species. This is the first time that six of these 12 species have been reported from Mexico. The majority (11) of these species are endemic to the Caribbean region and known only from the Late Cretaceous. This faunal similarity supports the correlation of the Ocozocoautla Formation with the other shallow marine Maastrichtian units within the Caribbean region.

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