14327.—18 m above loc. 14326, same unit. Syringoporoid corals.

14924.—20 m above loc. 14327. Limestone, medium grained, medium gray weathers same, beds 0.5–1.0 m thick, cliff-forming. Cerioid and fasciculate rugose corals, syringoporoid corals.

14925.—12 m above loc. 14924. Limestone, medium grained, medium gray weathers same. Cerioid rugose corals.

14927.—30 m above loc. 14925. Limestone, medium grained, medium gray weathers same, some chert nodules. Tabulate coral, cerioid rugose coral.

14928.—75 m above loc. 14927. Limestone, medium grained, light gray weathers white, chalcedony-lined vugs numerous. Cerioid rugose corals.

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STRATIGRAPHIC DISTRIBUTIONS OF GENERA AND SPECIES OF NEOGENE TO RECENT CARIBBEAN REEF CORALS

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ABSTRACT—To document evolutionary patterns in late Cenozoic Caribbean reef corals, we compiled composite stratigraphic ranges of 49 genera and 175 species using Neogene occurrences in the Cibao Valley sequence of the northern Dominican Republic and faunal lists for 24 Miocene to Recent sites across the Caribbean region. This new compilation benefits in particular from increased sampling at late Miocene to early Pleistocene sites and from increased resolution and greater taxonomic consistency provided by the use of morphometric procedures in species recognition.

Preliminary examination and quantitative analysis of origination and extinction patterns suggest that a major episode of turnover took place between 4 and 1 Ma during Plio-Pleistocene time. During the episode, extinctions were approximately simultaneous in species of all reef-building families, except the Mussidae. Most strongly affected were the Pocilloporidae (*Stylophora* and *Pocillopora*), Agariciidae (*Pavona* and *Gardineroseris*), and free-living members of the Faviidae and Meandrinidae. At the genus level, mono- and paucispecific as well as more speciose genera became regionally extinct. Many of the extinct genera live today in the Indo-Pacific region, and some are important components of modern eastern Pacific reefs. Global extinctions were concentrated in free-living genera. During the turnover episode, no new genera or higher taxa arose. Instead, new species originated within the surviving Caribbean genera at approximately the same time as the extinctions, including many dominant modern Caribbean reef-building corals (e.g., *Acropora palmata* and the *Montastraea annularis* complex).

Excluding this episode, the taxonomic composition of the Caribbean reef-coral fauna remained relatively unchanged during the Neogene. Minor exceptions include: 1) high originations in the Agariciidae and free-living corals during late Miocene time; and 2) regional or global extinctions of several important Oligocene Caribbean reef builders during early to middle Miocene time.

INTRODUCTION

RECENTLY PUBLISHED and ongoing studies of the systematics of the Neogene reef-coral fauna of the northern Dominican Republic (Foster, 1986, 1987; Budd, 1991; Stemann, 1991) have resulted in significant modifications to previously reported stratigraphic distributions of many Caribbean reef corals (e.g., Vaughan, 1919; Frost, 1977), especially at the species level. The modifications stem primarily from two factors: 1) more refined methods of species recognition; and 2) new Pliocene occurrences of taxa that were previously unknown or regarded as exclusively pre-Pliocene [e.g., *Acropora saludensis, Siderastrea silicensis, Goniopora calhounensis, Montastraea canalis, M. trinitatis, Pavona* (*Pseudocolumnastrea*) spp., among others]. Of the two factors, the first is by far more important. Larger sample sizes, sampling at close intervals within a stratigraphic framework, and excellent preservation of the Dominican Republic fauna have, for the first time, permitted use of multivariate statistical procedures to discriminate morphospecies. This has improved resolution and consistency in distinguishing morphologically similar species. As a consequence, many species that were overly subdivided by early workers such as Vaughan (1919), Vaughan and Hoffmeister (1925, 1926), and Weisbord (1971, 1973, 1974) have been synonymized; many other species that were lumped by more recent workers such as Frost (1977) have been teased apart (see discussion in Foster, 1986, and Budd, 1991).

Since data on these newly revised stratigraphic ranges are scattered throughout a number of published and unpublished accounts, our purpose in the present paper is to synthesize all existing information on the entire Caribbean reef-coral fauna so that it can be readily available, especially to paleontologists and evolutionary ecologists analyzing evolutionary patterns. Such information is essential for evaluating extinction and origination patterns in tropical reef biotas over the past 20 m.y. and for assessing reef community reorganization associated with Neogene to Recent climatic perturbations. In the present paper, we present a preliminary comparison of species-level extinction and origination rates within and among families as part of our documentation of stratigraphic ranges. In this comparison, we show that evolutionary rates were accelerated during Plio-Pleistocene time, and that times of acceleration differ little among families. We also briefly explore evolutionary patterns in genera and show that many of the genera that became extinct in the Caribbean still survive today in the Indo-Pacific. Some even dominate modern eastern Pacific reefs, suggesting that the dispersal hypothesis for the origin of the eastern Pacific fauna may be oversimplified. In later papers, we plan to use the data presented

TABLE 1—Occurrences of species of reef corals in the Neogene of the northern Dominican Republic. Numbers ≤15 within each river section refer to Neogene nannoplankton zones indicated on stratigraphic sections by Saunders et al. (1986); 25 refers to Paleogene Zone NP25. Numbers for each species correspond with those given in Appendix I.

	Río Cana					Río Gurabo					Río Mao	Río Yaque del Norte				Río Amina	
Species	11	12	13	14	15	11	12	13	14	15		11	12	4–6	25	11	12
Family Astrocoeniidae																	
3) *Stephanocoenia* *duncani*	•	X	•	X	•	X	•	•	•	•	X	•	•	•	X	•	•
4) *Stephanocoenia* *spongiformis*	•	X	X	X	•	X	•	•	X	X	•	•	•	•	•	•	•
Family Pocilloporidae																	
5) *Stylophora* *affinis*	•	X	•	X	•	X	•	•	X	•	•	•	•	•	•	•	•
7) *Stylophora* *granulata*	X	X	•	X	•	X	X	•	X	X	•	X	X	X	•	•	•
9) *Stylophora* *minor*	X	X	X	X	X	X	X	•	X	X	X	X	•	X	X	•	•
10) *Stylophora* *monticulosa*	X	X	X	•	•	X	•	•	X	X	•	•	X	•	X	•	•
11) *Stylophora* *canalis*	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
14) *Pocillopora* *baracoaensis*	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
15) *Pocillopora* *crassoramosa*	X	X	•	•	X	X	•	•	•	•	•	•	•	X	X	•	•
17) *Madracis* *decactis*	•	X	•	X	•	X	X	•	X	X	X	•	•	•	•	•	•
18) *Madracis* *decaseptata*	•	X	X	•	X	X	X	•	•	X	•	•	•	•	•	•	•
20) *Madracis* *mirabilis*	•	•	•	X	•	X	X	•	•	•	•	•	•	•	•	•	•
Family Acroporidae																	
26) *Acropora* *saludensis*	•	X	X	•	X	•	•	•	•	X	X	•	•	X	•	•	•
Family Agariciidae																	
30) *Agaricia* *lamarcki*	•	X	•	X	•	X	•	•	•	X	X	•	•	•	•	X	•
31) *Agaricia* sp. A	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•
32) *Agaricia* *undata*	•	•	•	•	•	X	•	•	X	X	•	•	•	•	•	•	•
33) *Undaria* *agaricites*	X	X	•	X	•	X	X	•	•	X	X	•	•	•	•	•	•
34) *Undaria* *crassa*	•	X	•	X	•	X	•	•	•	•	X	•	•	•	•	•	•
36) *Undaria* sp. A	•	X	•	•	•	X	X	•	X	X	X	•	•	•	•	•	•
37) *Gardineroseris* *planulata*	•	X	•	X	•	X	•	•	•	•	•	X	•	•	•	•	•
38) *Pavona* (*Pseudo.*) sp. A	•	X	•	X	•	X	•	•	X	X	•	•	•	•	•	•	•
39) *Pavona* (*Pseudo.*) sp. B	•	X	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•
43) *Helioseris* *cucullata*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•
46) *Leptoseris* *cailleti*	•	•	•	•	•	X	X	•	•	X	•	•	•	•	•	•	•
47) *Leptoseris* *gardineri*	•	X	•	•	•	X	X	•	•	X	•	•	•	•	•	•	•
48) *Leptoseris* *glabra*	•	X	•	•	•	X	•	•	X	X	X	•	•	•	•	•	•
49) *Leptoseris* sp. A	•	X	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•
50) *Leptoseris* sp. B	•	X	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•
Family Siderastreidae																	
52) *Psammocora* *trinitatis*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•
54) *Siderastrea* *mendenhalli*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
57) *Siderastrea* *silecensis*	•	X	•	•	•	X	•	•	•	X	•	X	•	•	X	•	•
58) *Siderastrea* *siderea*	•	X	•	X	•	X	•	•	•	•	•	X	•	•	X	•	•
Family Poritidae																	
64) *Porites*—I *macdonaldi*	•	X	•	•	•	X	•	•	X	•	X	•	•	•	•	•	•
65) *Porites*—I *portoricensis*	X	X	•	X	X	X	•	•	X	X	X	X	•	X	•	•	•
68) *Porites*—I *waylandi*	X	•	•	•	X	X	•	•	X	•	•	X	•	•	X	•	•
69) *Porites*—II *baracoaensis*	X	X	X	X	X	X	•	•	X	X	X	•	•	•	•	•	•
70) *Porites*—II *convivatoris*	X	X	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•
78) *Goniopora* *calhounensis*	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
79) *Goniopora* *hilli*	•	X	•	•	•	X	•	•	•	•	•	•	•	•	X	•	•
80) *Goniopora* *imperatoris*	X	X	•	•	•	•	•	•	•	•	X	•	•	•	X	•	•
82) *Alveopora* *tampae*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•
Family Faviidae																	
83) *Cladocora* sp. A	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•
87) *Favia* *dominicensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
91) *Favia* sp. A	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
98) *Diploria* sp. A	•	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
99) *Diploria* sp. B	•	X	•	X	•	X	•	•	•	X	•	•	•	•	•	•	•
102) *Manicina* (*Man.*) *puntagordensis*	X	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•
103) *Manicina* (*Teleio.*) *grandis*	X	X	X	X	•	X	X	•	•	•	X	•	•	•	•	X	•
104) *Manicina* (*Teleio.*) *navicula*	X	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
105) *Manicina* (*Teleio.*) sp. A	X	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
106) *Manicina* (*Teleio.*) sp. B	X	X	X	•	•	X	X	•	•	•	•	•	X	•	•	•	•
107) *Manicina* (*Teleio.*) sp. C	•	X	X	•	•	X	•	•	•	•	X	•	•	•	•	•	•
108) *Manicina* (*Teleio.*) sp. D	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
110) *Thysanus* *excentricus*	•	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
111) *Thysanus* *floridanus*	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•
112) *Colpophyllia* *amaranthus*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•
114) *Colpophyllia* *natans*	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
119) *Montastraea*—I *brevis*	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
121) *Montastraea*—I *limbata*	X	X	•	•	•	X	•	•	X	X	X	X	•	•	•	•	•
123) *Montastraea*—I *trinitatis*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•

TABLE 1—Continued.

		Río Cana					Río Gurabo					Río Mao	Río Yaque del Norte				Río Amina	
Species		11	12	13	14	15	11	12	13	14	15		11	12	4–6	25	11	12
124) *Montastraea*—II	*canalis*	•	X	•	X	•	•	•	•	•	X	•	•	•	X	X	•	•
126) *Montastraea*—II	*cavernosa*—2	•	•	•	X	•	X	•	•	•	•	X	•	•	X	X	•	•
128) *Montastraea*—II	*cylindrica*	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
129) *Montastraea*—II	*endothecata*	•	X	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•
131) *Solenastrea*	*bournoni*	X	X	•	X	•	X	•	•	X	•	X	•	X	X	X	•	•
133) *Solenastrea*	*hyades*	X	•	•	•	•	X	•	•	•	•	•	•	•	•	X	•	•
Family Trachyphylliidae																		
135) *Trachyphyllia*	*bilobata*	X	X	X	•	•	X	•	•	X	X	X	X	X	•	•	•	X
136) *Trachyphyllia*	sp. A	•	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
137) *Antillophyllia*	*sawkinsi*	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
Family Meandrinidae																		
138) *Meandrina* (*Mea.*)	*braziliensis*	X	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
139) *Meandrina* (*Mea.*)	*meandrites*	•	X	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•
140) *Meandrina* (*Placo.*)	*alveolus*	X	•	X	•	•	X	•	•	X	X	•	•	•	•	•	•	•
142) *Meandrina* (*Placo.*)	*costatus*	X	X	X	X	•	X	•	•	X	X	•	•	•	•	•	•	•
143) *Meandrina* (*Placo.*)	*trinitatis*	X	X	•	X	•	X	X	•	•	•	•	•	•	•	•	•	•
144) *Meandrina* (*Placo.*)	*variabilis*	X	X	X	X	•	X	X	•	X	X	X	•	X	•	•	X	X
145) *Dichocoenia*	*caloosahatcheensis*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•
150) *Dichocoenia*	*tuberosa*	•	X	•	X	•	X	•	•	X	X	•	•	•	•	•	•	•
Family Oculinidae																		
152) *Galaxea*	*excelsa*	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
Family Mussidae																		
153) *Antillia*	*dentata*	•	•	X	•	•	X	X	•	X	X	X	X	X	•	•	•	X
155) *Scolymia*	*cubensis*	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
158) *Mussa*	*angulosa*	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
172) *Eusmilia*	*carrizensis*	•	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•
175) *Eusmilia*	sp. A	X	•	•	•	•	X	•	•	X	•	•	•	•	•	•	•	•

here: 1) quantitatively to analyze a major turnover episode in the fauna during Plio-Pleistocene time (Budd et al., 1994); and 2) to examine the role of ecological factors in determining susceptibility to extinction. Eventually, we hope the data can be used to develop a biostratigraphic framework useful to marine geologists and sedimentologists in age dating Neogene reef sequences.

One important aim in our present summary is to document explicitly the criteria used to discriminate taxa, to assign ages to occurrences, and to estimate composite stratigraphic ranges. Outlining these criteria should facilitate future modifications and additions to the present compilation as more faunas are studied, higher resolution age dates become available, and methods of species recognition are further refined. Outlining these criteria will also permit a rigorous evaluation of sample bias, essential to subsequent quantitative analysis of evolutionary patterns (Koch and Morgan, 1988). Because of numerous sampling irregularities, we do not provide confidence intervals on our stratigraphic ranges (e.g., as suggested by Marshall, 1990). We believe that, as in other macrofossil occurrence data derived from samples not taken in bulk, our data violate many assumptions of such methods.

MATERIAL

The compilation consists of occurrences of 175 species of Caribbean reef corals from early Miocene to Recent time, and contains all recorded hermatypic taxa except the families Oculinidae and Rhizangiidae. The latter two families were excluded because their species only questionably or variably contain zooxanthellae and therefore are not important reef builders. The one exception is the inclusion of the large massive reef builder *Galaxea* in the family Oculinidae.

The data were derived from: 1) material in Neogene sections along five rivers in the northern Dominican Republic (Table 1), which was collected by J. Geister, P. Jung, and J. B. Saunders (Saunders et al., 1986); and 2) 22 faunal lists from early Miocene to Pleistocene sites scattered across the Caribbean (Tables 2, 3). These data include all published Miocene to Pleistocene Caribbean material. Occurrences in the Recent Caribbean were obtained from a faunal list for the north coast of Jamaica (Wells and Lang, 1973). The Jamaican list was selected because of the location in a high-diversity area, generally regarded as representative of the modern species composition of the entire Caribbean. Because of similarities between some of the Neogene Dominican Republic fauna and modern Brazilian taxa, occurrences in Brazil (Laborel, 1969) have also been noted in the compilation. With the possible exception of Brazil, endemic species currently are believed to be rare in the Caribbean today (Liddell and Ohlhorst, 1988). Together the localities include both carbonate and siliciclastic sequences deposited in a range of nearshore to deeper forereef environments (Table 2).

Absolute age dates for the northern Dominican Republic occurrences were estimated by comparing nannofossil zones indicated on the stratigraphic sections and text in Saunders et al. (1986) with the Neogene Time Scale of Berggren et al. (1985). Age dates for the 22 published faunal lists were taken from the most up-to-date available published information (Table 2). Because of uncertainties in these dates, especially in many of the 22 faunal lists, overly long time intervals (mean locality duration = 2.8 m.y.) have been assigned to many localities, even though the deposits most likely accumulated over short periods of time. The compilation is based on an uneven distribution of localities in geologic time, with large numbers of localities at 8–6 Ma and at 3–1 Ma. Furthermore, corals in some localities were much more intensively sampled than in others. Except in the northern Dominican Republic, first and last occurrences of species lie

TABLE 2—List of localities (excluding the northern Dominican Republic) used in the present compilation. S = siliciclastic; C = carbonate; SB = soft bottom; SR = shallow reef; DF = deep forereef; MIX = transported mixture of shallow and deep reef habitats; NMB = Naturhistorisches Museum Basel; PPP = Panama Paleontological Project; USNM = U.S. National Museum of Natural History.

Locality	Absolute age	Environment	Age reference	Faunal list
Early to middle Miocene				
1. Tampa Formation, Florida	22–23.7 Ma	S/SB, SR	Carter and Rossbach, 1989	Weisbord, 1973*
2. Emperador Limestone, Panama	17.6–22 Ma	S/SR	Blacut and Kleinpell, 1969	Vaughan, 1919
3. Anguilla Formamtion, Anguilla	16.2–22 Ma	C/SB, SR	Bold, 1970	Budd et al., 1989
4. Chipola Formation, Florida	15–18 Ma	S/SB, SR	Bryant et al., 1992	Weisbord, 1971*
†5. Providencia	15–22 Ma	C/SB, SR	Geister, 1992	Geister, 1992
6. Brasso and Tamana Formations, Trinidad	11.2–15 Ma	S/SB, SR	Maurrasse, 1990	Vaughan and Hoffmeister, 1926
Late Miocene to early Pliocene				
7. Manzanilla Formation, Trinidad	5.3–11.2 Ma	S/SB, SR	Maurrasse, 1990	Vaughan and Hoffmeister, 1926
†8. Lirio Limestone, Mona	5.3–11.2 Ma	C/SB, SR, DF	Gonzalez et al., 1992	Gonzalez et al., 1992
9. Buff Bay Formation, Jamaica	5.3–11.2 Ma	S/MIX	Aubry, 1993	Jung collections at NMB
†10. Imperial Formation, California	4.5–8 Ma	S/SB, SR	Kerr and Kidwell, 1991	Vaughan, 1917
Middle to late Pliocene				
11. Bowden Formation, Jamaica	2–3.8 Ma	S/MIX	Aubry, 1993	Jung collections at NMB
12. Pinecreast Sandstone, Florida	3–3.5 Ma	C/SB, SR	Jones et al., 1991	Meeder, 1987*
13. La Cruz Marl, Cuba	1.6–3.5 Ma	?C/SB, SR	Bold, 1975	Vaughan, 1919
14. Matanzas, Cuba	1–3.5 Ma	?C/SB, SR	Bold, 1975	Vaughan, 1919
15. Moín Formation, Costa Rica	1.7–3 Ma	S/DF	Coates et al., 1992	PPP collections at USNM
16. Old Pera Beds, Jamaica	1.6–2.5 Ma	C/SB, SR	Bold, 1971	Jung collections at NMB
17. Caloosahatchee Formation, Florida	1.6–1.8 Ma	C/SB	Carter and Rossbach, 1989	Weisbord, 1974*
Early Pleistocene				
18. Manchioneal Formation, Jamaica	1–1.6 Ma	C/SB, SR	Bolli, 1970	Jung collections at NMB
19. Glades Formation, Florida	1–1.6 Ma	C/SB	Carter and Rossbach, 1989	Weisbord, 1974*
Late Pleistocene				
20. Santo Domingo, Dominican Republic	100–500 Ka	C/SB, SR	Geister, 1982	Geister, 1982
21. San Andrés	100–500 Ka	C/SB, SR	Geister, 1975	Geister, 1975*
22. Key Largo Limestone, Florida	100–500 Ka	C/SB, SR	Weisbord, 1974	Weisbord, 1974*

* Not all material examined.

† Localities excluded from stratigraphic range charts (Figure 4) and from calculations of origination and extinction rates (Figure 6).

between and not within sequences. These sampling biases need to be considered in subsequent analyses of evolutionary patterns.

METHODS

Species recognition.—The diagnostic morphologic characters used in routine specimen identification (Table 4) were derived primarily through morphometric study of the reef corals collected in the Dominican Republic (Foster, 1986, 1987; Budd, 1991; Stemann, 1991). The procedures in the morphometric analyses involved first sorting all collected Neogene material into families and genera, regardless of stratigraphic position, using diagnostic criteria (Appendix) derived from Vaughan and Wells (1943) and Wells (1956), and modified following Veron et al. (1977) and Veron and Pichon (1979). Representatives of each of the important genera in the Dominican Republic collection are illustrated in Figures 1–3. Preliminary phylogenetic study of the genera suggests that some previously described genera are similar enough morphologically to warrant treatment only as subgenera of one genus and not as separate genera (i.e., *Manicina* and *Teleiophyllia*; *Meandrina* and *Placocyathus*). Others contain evolutionary subunits, distinct enough to form subgenera [i.e., species of *Porites* with widely spaced corallites (I) vs. those with closely spaced corallites (II), and species of *Montastraea* with approximately 24 septa per corallite (I) vs. those with 30 or more septa per corallite (II)]. The details of these taxonomic problems will be outlined separately in later systematic publications. In the present compilation, genera and subgenera have been modified to correct for inconsistencies.

After the collections were sorted, a unique set of five to twelve quantitative characters, including both linear measures and counts made on calicular surfaces or in thin section, were assembled for each genus. These characters were selected to include all features traditionally used to distinguish species within each genus, as outlined in Vaughan (1919). Where possible, the characters were measured on five to ten corallites per colony. Colony means were analyzed using principal component analysis, average linkage cluster analysis, and canonical discriminant analysis to recognize discrete groups of colonies separated from one another by morphologic gaps. Type specimens from many of the 22 faunal lists in the compilation were subsequently measured and analyzed using similar multivariate statistical techniques to determine the degree of similarity with the Dominican Republic morphospecies. On the basis of the results, names were designated for the Dominican Republic morphospecies following established rules of taxonomic nomenclature. The details of these procedures, as well as resampling methods applied in the implementation of multivariate statistical procedures, are described in Budd (1991) and Budd and Coates (1992). At least for *Porites* (Potts et al., 1993) and *Montastraea* (Knowlton et al., 1992; Budd, 1993), living species recognized using similar morphometric methods generally correspond with those recognized using molecular data.

The results of these morphometric procedures include the synonymy of many species separated by early workers such as Vaughan (1919), Vaughan and Hoffmeister (1925, 1926), and Weisbord (1971, 1973, 1974), and the teasing apart of species previously synonymized by Frost (1977). For example, in the Poritidae (Foster, 1986), 13 species (eight in *Porites* and five in *Goniopora*) described by the first three sets of authors were synonymized, yielding a total of six species (four in *Porites* and two in *Goniopora*); conversely, in contrast to four species listed by Frost (1977), a total of eight species (five *Porites* and three *Goniopora*) were recognized in the upper Miocene and lower Pliocene of the Dominican Republic. Similarly, in *Montastraea* and *Solenastrea*, three previously described species of *Montastraea* and two species of *Solenastrea* were synonymized, yielding a total of seven species of *Montastraea* and two species of *Solenastrea* in the upper Miocene and lower Pliocene of the Dominican Republic (Budd, 1991). In contrast, Frost (1977) listed only three species of *Montastraea,* but two species of *Solenastrea.* In addition to these taxonomic modifications, the morphometric analyses also detected new species, many of which remain undescribed to date. These new species will be described as part of more extensive systematic monographs that form part of the "Neogene Paleontology of the Northern Dominican Republic" series. We refer here to these new species with letters.

Based on the results of morphometric analyses, three or more diagnostic characters were selected for use in routine species identification within each genus (Table 4). These characters were used to identify species in unidentified collections in the present compilation [e.g., the Jung collections at the Naturhistorisches Museum Basel (NMB) and the Panama Paleontological Project (PPP) collections at the U.S. National Museum (USNM)]. Together with the morphometric data, they were also used to evaluate the validity of species in the faunal lists (Table 3) and to modify these lists (Appendix). Original specimens were actually examined in most cases; in the few instances where this was not possible (Table 2), published photographs and systematic descriptions were used.

Composite stratigraphic ranges.—Stratigraphic ranges (Figure 4) were estimated at the species level using first and last occurrences for each of the 175 species included in the compilation (Tables 1, 3). The estimates were derived using maxima for the absolute age dates for each locality, as shown in Table 2. Occurrences at three localities (Table 2) for which age determinations are highly speculative or which lie in geographically remote areas were not included in the data set. Taxa occurring in only one locality (species 6, 71, 86, 93, 96, 122, 132, 147, 164 listed in the Appendix) were also not included. This information, together with data presented in Budd et al. (1992), was used to estimate total stratigraphic ranges for Neogene to Recent genera in the Caribbean region (Figure 5).

Comparisons of extinction and origination rates among families.—Differences in evolution among families were studied by quantitatively examining patterns of origination and extinction (Figure 6). To calculate these rates, the past 22 million years were subdivided into 2 m.y. time intervals, and numbers of first and last occurrences and species richness were estimated for each interval (Table 5). Estimates of species richness were made using the range-through method, in which species are counted within a given time interval based on earlier and later occurrences, even if they were not actually encountered during that particular interval. Because of uncertainties in age determinations for some localities, estimates of numbers of originations and extinctions were made by weighting first and last occurrences relative to the time duration assigned to the site in which they took place (methods modified after Barry et al., 1990). Estimated numbers of originations and extinctions were then divided by species richness to calculate evolutionary rates and compare temporal trends among families (Figure 6). Originations in localities on a boundary between time intervals were assigned to the lower interval. Calculations were made for only the seven families containing more than 10 species over the entire time period (as listed in Table 5 and Figure 6).

RESULTS

Qualitative examination of species-level patterns.—Stratigraphic range charts (Figures 4, 5) and plots of extinction and origination rates (Figure 6) reveal accelerated rates of extinction between 4 and 1 Ma in all seven of the major families except the Mussidae. Origination rates were equally high at the same

TABLE 3—Occurrences of species of reef corals at 22 Neogene localities outside of the northern Dominican Republic (numbered 1–22), and in the Recent of the Caribbean (CA) and Brazil (BR). Occurrences of these taxa in the middle Eocene (mE), late Eocene (lE), and late Oligocene (lO) of the Caribbean and in the Recent of the Indo-Pacific (IP) are also noted. Numbers for the 22 faunal lists correspond with locality numbers given in Table 2. Eocene occurrences are based on data in Budd et al. (1992). Oligocene occurrences are based on fauna described in Antigua (Vaughan, 1919; Frost and Weiss, 1979), Puerto Rico (Frost et al., 1983), and Chiapas, Mexico (Frost and Langenheim, 1974).

Species		mE	lE	lO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	CA	BR	IP
Family Astrocoeniidae																													
1) *Astrocoenia*	*incrustans*	X	X	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2) *Stephanocoenia*	*intersepta*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	X	X	•	X	X	•
3) *Stephanocoenia*	*duncani*	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•
4) *Stephanocoenia*	*spongiformis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Pocilloporidae																													
5) *Stylophora*	*affinis*	•	•	•	•	X	•	•	X	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•
6) *Stylophora*	*"affinis"*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•
7) *Stylophora*	*granulata*	•	•	•	•	X	•	•	•	•	•	X	•	•	X	X	•	X	•	X	•	•	•	•	•	•	•	•	•
8) *Stylophora*	*imperatoris*	•	•	•	•	X	X	X	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9) *Stylophora*	*minor*	•	•	•	X	X	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10) *Stylophora*	*monticulosa*	•	•	•	•	•	•	•	X	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
11) *Stylophora*	*canalis*	•	•	•	X	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12) *Stylophora*	*undata*	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
13) *Pocillopora*	*arnoldi*	•	•	•	•	X	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
14) *Pocillopora*	*baracoaensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•
15) *Pocillopora*	*crassoramosa*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
16) *Pocillopora*	*palmata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•
17) *Madracis*	*decactis*	•	•	•	•	•	•	•	•	•	•	•	X	X	•	X	•	•	X	•	•	•	•	•	X	•	X	X	•
18) *Madracis*	*decaseptata*	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
19) *Madracis*	*formosa*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
20) *Madracis*	*mirabilis*	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	X	•	•	X	•	•	X	•	X	•	•
21) *Madracis*	*pharensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
Family Acroporidae																													
22) *Acropora*	*cervicornis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	X	•	X	X	X	X	•	•
23) *Acropora*	*palmata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	X	X	•	•
24) *Acropora*	*panamensis*	•	•	X	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
25) *Acropora*	*prolifera*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
26) *Acropora*	*saludensis*	•	•	X	X	X	X	•	•	•	•	X	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•
27) *Astreopora*	*goethalsi*	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Agariciidae																													
28) *Agaricia*	*fragilis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	X	•
29) *Agaricia*	*grahamae*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
30) *Agaricia*	*lamarcki*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	•	X	•	•	•	•	X	•	•
31) *Agaricia*	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
32) *Agaricia*	*undata*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
33) *Undaria*	*agaricites*	•	•	•	•	•	•	•	•	•	•	X	X	•	•	X	•	•	X	•	•	X	•	X	X	X	X	•	•
34) *Undaria*	*crassa*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	X	•	•	X	•	•	•	•	X	X	•
35) *Undaria*	*pusilla*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•
36) *Undaria*	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
37) *Gardineroseris*	*planulata*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	X
38) *Pavona* (*Pseudo.*)	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
39) *Pavona* (*Pseudo.*)	sp. B	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
40) *Pavona* (*Pavona*)	*panamensis*	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
41) *Pavona* (*Pavona*)	*pennyi*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
42) *Pavona* (*Pavona*)	*trinitatis*	•	•	•	•	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
43) *Helioseris*	*cucullata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	X	X	X	•
44) *Helioseris*	sp. A	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
45) *Leptoseris*	*anguillensis*	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
46) *Leptoseris*	*cailleti*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
47) *Leptoseris*	*gardineri*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X
48) *Leptoseris*	*glabra*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X
49) *Leptoseris*	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
50) *Leptoseris*	sp. B	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
51) *Leptoseris*	*walli*	•	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

TABLE 3—Continued.

Species		mE	lE	lO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	CA	BR	IP
Family Siderastreidae																													
52) *Psammocora*	*trinitatis*	•	•	•	•	•	•	•	X	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
53) *Siderastrea*	*conferta*	•	•	X	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
54) *Siderastrea*	*mendenhalli*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
55) *Siderastrea*	*pliocenica*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	•	X	•	•	•	•	•	•
56) *Siderastrea*	*radians*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	X	X	•	X	X	X	•	•
57) *Siderastrea*	*silecensis*	•	•	•	X	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•
58) *Siderastrea*	*siderea*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	X	•	X	X	•	X	X	X	X	X	X	•	•
59) *Siderastrea*	*stellata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
60) *Pironastrea*	*anguillensis*	•	•	X	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
61) *Pironastrea*	*antiguensis*	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Poritidae																													
62) *Porites*—I	*anguillensis*	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
63) *Porites*—I	*astreoides*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	X	•	•	X	•	•	X	X	X	X	•
64) *Porites*—I	*macdonaldi*	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
65) *Porites*—I	*portoricensis*	•	•	X	X	X	X	•	•	X	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
66) *Porites*—I	*trinitatis*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
67) *Porites*—I	*verrilli*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
68) *Porites*—I	*waylandi*	•	•	•	X	X	X	•	X	X	X	X	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
69) *Porites*—II	*baracoaensis*	•	•	•	•	X	X	•	X	•	X	X	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•
70) *Porites*—II	*branneri*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	•	•	•	X	X	•
71) *Porites*—II	*carrizensis*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
72) *Porites*—II	*chipolanum*	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
73) *Porites*—II	*colonensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
74) *Porites*—II	*convivatoris*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
75) *Porites*—II	*divaricata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	X	•	•	X	X	X	•	•
76) *Porites*—II	*furcata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	X	X	•	•	X	X	X	•	•
77) *Porites*—II	*porites*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	X	X	•	•	X	X	X	X	•	•
78) *Goniopora*	*calhounensis*	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
79) *Goniopora*	*hilli*	•	•	X	X	X	X	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•
80) *Goniopora*	*imperatoris*	•	•	X	X	X	X	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•
81) *Goniopora*	*panamensis*	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
82) *Alveopora*	*tampae*	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Faviidae																													
83) *Caulastrea*	*portoricensis*	•	•	X	•	•	•	•	•	•	•	X	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
84) *Cladocora*	*arbuscula*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	X	•	•
85) *Cladocora*	*johnsoni*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•
86) *Cladocora*	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
87) *Favia*	*dominicensis*	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
88) *Favia*	*fragum*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	X	X	X	•	•
89) *Favia*	*gravida*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
90) *Favia*	*leptophylla*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
91) *Favia*	sp. A	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
92) *Goniastrea*	*canalis*	X	X	X	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
93) *Diploria*	*bowersi*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
94) *Diploria*	*clivosa*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	X	•	X	X	X	X	•	•
95) *Diploria*	*labyrinthiformis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	X	•	•
96) *Diploria*	*sarasotana*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•
97) *Diploria*	*strigosa*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	X	•	X	X	X	X	•	•
98) *Diploria*	sp. A	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
99) *Diploria*	sp. B	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
100) *Manicina* (*Man.*)	*areolata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	X	X	X	•	X	X	X	•	•
101) *Manicina* (*Man.*)	*mayori*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
102) *Manicina* (*Man.*)	*puntagordensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	X	•	•	•	•	•	•	•	•
103) *Manicina* (*Teleio.*)	*grandis*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Table 3—Continued.

Species		mE	lE	lO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	CA	BR	IP
104) *Manicina* (*Teleio.*)	*navicula*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•
105) *Manicina* (*Teleio.*)	sp. A	•	•	•	•	•	•	•	•	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•
106) *Manicina* (*Teleio.*)	sp. B	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
107) *Manicina* (*Teleio.*)	sp. C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
108) *Manicina* (*Teleio.*)	sp. D	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
109) *Thysanus*	*crassicostatus*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•
110) *Thysanus*	*excentricus*	•	•	•	•	•	•	X	•	•	•	•	•	•	X	X	X	X	•	X	•	•	•	•	•	•	•	•	•
111) *Thysanus*	*floridanus*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•
112) *Colpophyllia*	*amaranthus*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	X	•	•
113) *Colpophyllia*	*breviserialis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
114) *Colpophyllia*	*natans*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	X	X	X	•	•
115) *Antiguastrea*	*cellulosa*	•	X	X	X	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
116) *Montastraea*—I	*annularis*—1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
117) *Montastraea*—I	*annularis*—2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	X	X	X	•	•
118) *Montastraea*—I	*annularis*—3	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	•	•
119) *Montastraea*—I	*brevis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
120) *Montastraea*—I	*imperatoris*	•	•	•	X	X	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
121) *Montastraea*—I	*limbata*	•	•	•	•	•	•	•	X	X	•	X	X	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•
122) *Montastraea*—I	sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
123) *Montastraea*—I	*trinitatis*	•	•	•	•	•	•	•	•	X	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
124) *Montastraea*—II	*canalis*	•	•	X	X	X	X	X	•	•	•	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
125) *Montastraea*—II	*cavernosa*—1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
126) *Montastraea*—II	*cavernosa*—2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	X	X	X	X	X	•
127) *Montastraea*—II	*cavernosa*—3	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	X	•	•
128) *Montastraea*—II	*cylindrica*	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
129) *Montastraea*—II	*endothecata*	•	•	X	•	•	X	X	X	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•
130) *Montastraea*—II	*tampaensis*	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
131) *Solenastrea*	*bournoni*	•	•	•	X	•	•	•	•	•	•	•	•	•	•	X	X	•	X	•	X	•	X	•	•	•	X	•	•
132) *Solenastrea*	*fairbanksi*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
133) *Solenastrea*	*hyades*	•	•	•	X	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	X	•	X	•	•	X	X	•	•
134) *Agathiphyllia*	*hilli*	•	•	X	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Trachyphylliidae																													
135) *Trachyphyllia*	*bilobata*	•	•	•	X	•	•	X	X	X	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•
136) *Trachyphyllia*	sp. A	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
137) *Antillophyllia*	*sawkinsi*	•	•	•	•	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Meandrinidae																													
138) *Meandrina* (*Mea.*)	*braziliensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
139) *Meandrina* (*Mea.*)	*meandrites*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	X	•	•	X	X	X	•	•
140) *Meandrina* (*Placo.*)	*alveolus*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•

TABLE 3—Continued.

Species	mE	lE	lO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	CA	BR	IP
141) *Meandrina (Placo.)* *barretti*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•
142) *Meandrina (Placo.)* *costatus*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•
143) *Meandrina (Placo.)* *trinitatis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
144) *Meandrina (Placo.)* *variabilis*	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•
145) *Dichocoenia* *caloosahatcheensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•
146) *Dichocoenia* *eminens*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•
147) *Dichocoenia* *merriami*	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
148) *Dichocoenia* *stokesi*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	X	X	X	X	•	•
149) *Dichocoenia* *stellaris*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	X	•	•
150) *Dichocoenia* *tuberosa*	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
151) *Dendrogyra* *cylindricus*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	X	X	•	•
Family Oculinidae																												
152) *Galaxea* *excelsa*	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Family Mussidae																												
153) *Antillia* *dentata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
154) *Antillia* *gregorii*	•	•	•	X	•	•	•	•	•	•	•	•	•	X	•	•	•	X	•	•	•	•	•	•	•	•	•	•
155) *Scolymia* *cubensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
156) *Scolymia* *wellsi*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
157) *Scolymia* *lacera*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
158) *Mussa* *angulosa*	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	X	X	X	X	•	•
159) *Mussismilia* *braziliensis*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
160) *Mussismilia* *harttii*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•
161) *Mussismilia* *hispida*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	X	•
162) *Isophyllia* sp. A	•	•	•	•	•	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
163) *Isophyllia* *sinuosa*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	X	X	X	X	•	•
164) *Isophyllastrea* sp. A	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
165) *Isophyllastrea* *rigida*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	X	•	•
166) *Mycetophyllia* *aliciae*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
167) *Mycetophyllia* *bullbrooki*	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
168) *Mycetophyllia* *danaana*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
169) *Mycetophyllia* *ferox*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
170) *Mycetophyllia* *lamarckiana*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	X	X	•	•
171) *Mycetophyllia* *reesi*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	•	•	•	•	•	X	•	•
Family Caryophyllidae																												
172) *Eusmilia* *carrizensis*	•	•	•	•	•	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
173) *Eusmilia* *fastigiata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•	X	•	•	X	•	X	X	X	X	•	•
174) *Eusmilia* *flabellata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	X	•	•
175) *Eusmilia* sp. A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

time in all families except the Agariciidae. Nevertheless, on close examination of range charts, subtle differences in both timing and magnitude can be detected among families, especially with respect to origination. In the families Astrocoeniidae, Pocilloporidae, and Acroporidae (Figure 4), high numbers of extinctions occurred between approximately 4 and 1 Ma during the Plio-Pleistocene and between 18 and 15 Ma during the early to middle Miocene. In the later episode, the genera *Stylophora* (four species) and *Pocillopora* (three species) were affected most heavily, resulting in the extinction of both genera in the Caribbean. However, as indicated in Figure 5, *Pocillopora* remains common today in the eastern Pacific; both genera are abundant elsewhere in the Indo-Pacific (Glynn and Wellington, 1983; Budd, 1989; Veron, 1986). In the earlier Miocene episode, two genera with only one Caribbean species, *Astrocoenia* and *Astreopora,* both became extinct in the Caribbean region. Although *Astrocoenia* became globally extinct, *Astreopora* remains common today in the Indo-Pacific (Veron, 1986). Post-Miocene Caribbean originations in the three families occurred largely in two genera, *Acropora* (three species) and *Madracis* (three species).

In the Agariciidae (Figure 4), large numbers of species originated between 11 and 6 Ma during the late Miocene, while extinctions were concentrated during the early Pliocene (5–3 Ma). Nevertheless, five species survived the period of Plio-Pleistocene turnover. The genera *Pavona, Gardineroseris,* and *Leptoseris* experienced the highest numbers of extinctions of species, resulting in the extinction of *Pavona* (four species) and *Gardineroseris* (one species) from the Caribbean region. However, as in *Pocillopora* (Figure 5), these two genera remain common today in the eastern Pacific (Glynn and Wellington, 1983; Budd, 1989) and elsewhere in the Indo-Pacific (Veron, 1986). By contrast, late Miocene originations were rare in the Siderastreidae (Figure 4). Notable in the siderastreids is the extinction of the single Neogene Caribbean species of *Psammocora* from the Caribbean region at the end of the Miocene. The genus lives today in the eastern Pacific and elsewhere in the Indo-Pacific (Glynn and Wellington, 1983; Budd, 1989; Veron, 1986). Like *Astrocoenia,* the siderastreid genus *Pironastrea* (two species) became globally extinct during the early to middle Miocene.

In the Poritidae (Figure 4), extinctions and originations were concentrated between 4 and 1 Ma during Plio-Pleistocene time, with species originating only in *Porites* (seven species). The genus *Goniopora* (three species) became extinct in the Caribbean during this time. The single remaining Caribbean species of *Alveopora* went extinct during the earliest Miocene. Both *Goniopora* and *Alveopora* survive today in the Indo-Pacific.

In the Faviidae (Figure 4), relatively large numbers of free-living species (*Manicina, Teleiophyllia, Thysanus*) and more massive meandroid species (*Diploria*) originated between 11 and 6 Ma during the late Miocene. However, as in the agariciids, which also radiated at that time, extinctions in many of these taxa were concentrated between 4 and 1 Ma, resulting in the complete extinction of the subgenus *Teleiophyllia* (five species) and the genus *Thysanus* (three species). As in *Porites,* extinctions and possible originations were common in *Montastraea* between 4 and 1 Ma. Three faviid genera with only one Neogene Caribbean species (*Goniastrea, Antiguastrea,* and *Agathiphyllia*) suffered early to middle Miocene extinctions. In contrast to other faviids, members of the genus *Solenastrea* (two species) were strikingly long lived. In the closely related free-living trachyphylliids (Figure 4), extinctions were staggered over the late Miocene to late Pliocene, and originations were rare.

Seven species originated in the meandrinids between 11 and 6 Ma during the late Miocene (Figure 4), and most involved free-living species of the subgenus *Placocyathus.* Four species also originated in the attached massive genus *Dichocoenia* between 5 and 3 Ma during the early to middle Pliocene. Extinctions of genera and subgenera were concentrated between 4 and 1 Ma during the Plio-Pleistocene. Between the early to middle Pliocene and today, *Meandrina braziliensis* became geographically restricted to Brazil. The genus *Galaxea* (Oculinidae) followed an evolutionary pattern more similar to that of *Psammocora* (Figure 4), characterized by only one Miocene Caribbean species, Caribbean extinction during the late Miocene, and occurrences today in the Indo-Pacific (Veron, 1986).

The Mussidae and *Eusmilia* (Caryophyllidae) differ considerably from the other groups by exhibiting a large radiation between 4 and 1 Ma, accompanied by few extinctions, and resulting in a relatively high number of extant species (Figure 4). As in the agariciids and free-living faviids and meandrinids, other originations in these two groups were concentrated between 11 and 6 Ma during the late Miocene. Like *Meandrina braziliensis,* the genus *Mussismilia* became geographically restricted to Brazil.

Quantitative analysis of species-level patterns.—Comparison of plots of extinction and origination rates for each family (Figure 6) shows that the mussids had the highest rates of origination (>20 percent per 2 m.y.) over the past 6 m.y., resulting in a steady increase in richness in the family since the late Miocene. Similarly high rates of origination were achieved in the siderastreids between 6 and 4 Ma, and in the pocilloporids over the past 2 m.y. In general, however, species richness declined slightly among the siderastreids since the middle Miocene, and among the pocilloporids since the early Pliocene (Table 5). New species of *Madracis* were responsible for the accelerated post-Pliocene origination rates in the pocilloporids. Moderately high origination rates (10–20 percent per 2 m.y.) prevailed in the agariciids throughout the Miocene (i.e., 22–6 Ma), in the faviids between 8 and 4 Ma, and in the meandrinids between 10 and 4 Ma. Increases in numbers of free-living corals most likely played a major role in the faviid and meandrinid originations. The pocilloporids had the lowest overall rates of origination (<10 percent per 2 m.y.) over the last 22 m.y.

Chi-square statistical tests confirm that rates of extinction differed little among families (Figure 6) (e.g., at 6–4 Ma, chi-square for origination = 6.78, d.f. = 6, $P > 0.25$, chi-square for

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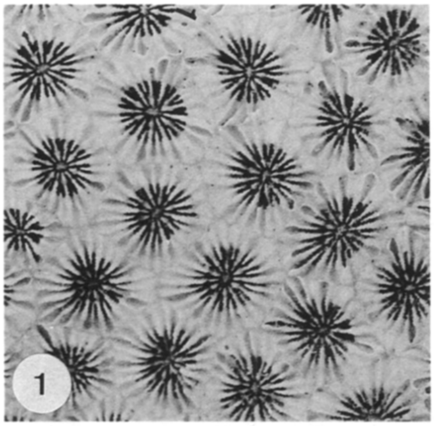
FIGURE *1*—Common genera of reef corals collected in the Neogene sequence of the northern Dominican Republic. Calical surfaces. *1, Stephanocoenia spongiformis,* NMB D5763, upper Miocene, NMB loc. 15847, ×5. *2, Stylophora monticulosa,* NMB D6007, upper Miocene, NMB loc. 16883, ×10. *3, Pocillopora crassoramosa,* NMB D6008, upper Miocene, NMB loc. 16934, ×10. *4, Madracis decaseptata,* NMB D6009, upper Miocene, NMB loc. 15846, ×10. *5, Acropora saludensis,* NMB D6015, upper Miocene, NMB loc. 16855, ×5. *6, Agaricia* sp. A, NMB D5932, lower Pliocene, NMB loc. 15822, ×5. *7, Undaria crassa,* NMB D5997, upper Miocene, NMB loc. 15858, ×5. *8, Gardineroseris planulata,* NMB D5943, lower Pliocene, NMB loc. 16818, ×5. *9, Pavona* (*Pseudocolumnastrea*) sp. A, NMB D5943, upper Miocene, Arroyo Bellaco, ×5. *10, Leptoseris gardineri,* NMB D5945, upper Miocene, NMB loc. 15855, ×5. *11, Psammocora trinitatis,* NMB D6016, lower Miocene, NMB loc. 16943, ×5. *12, Siderastrea silecensis,* USNM 88302, lower Pliocene, Tulane loc. 1363, ×5.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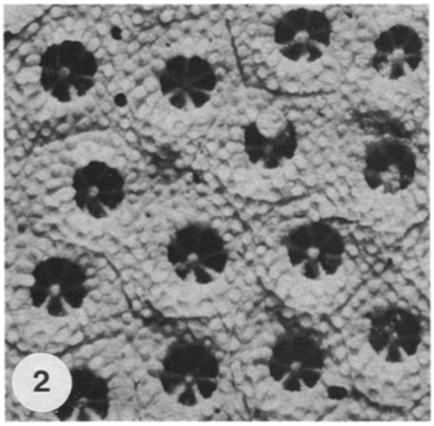
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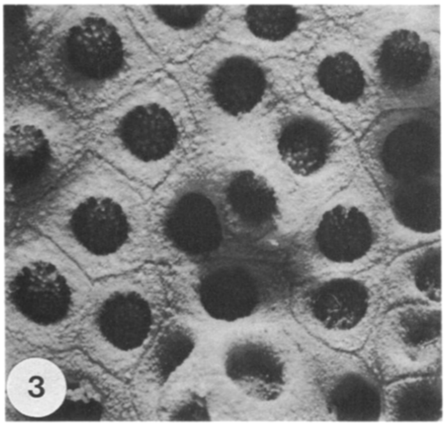
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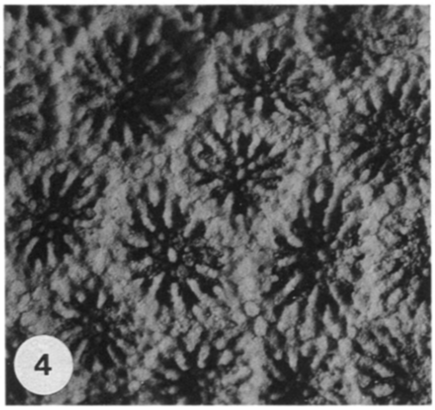
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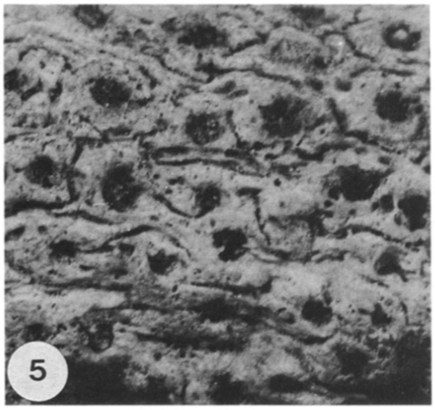
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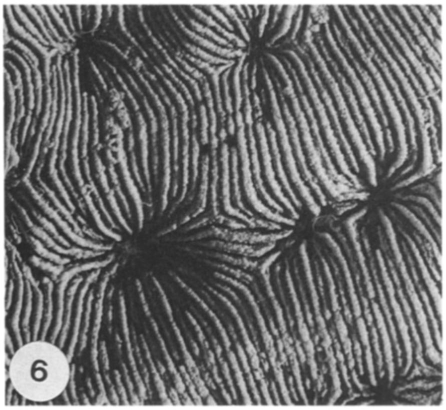
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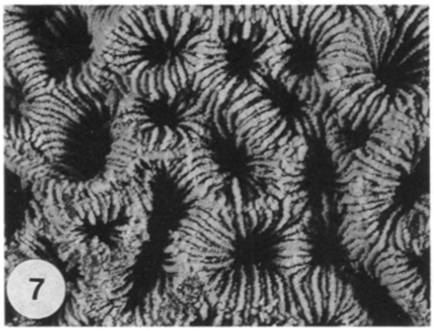
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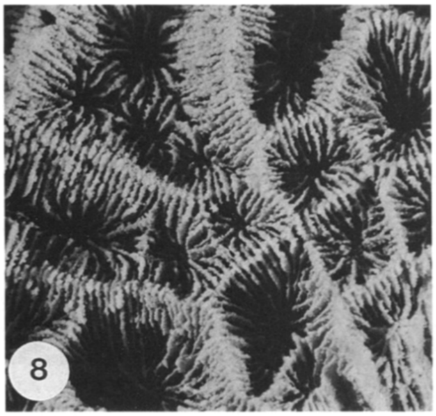
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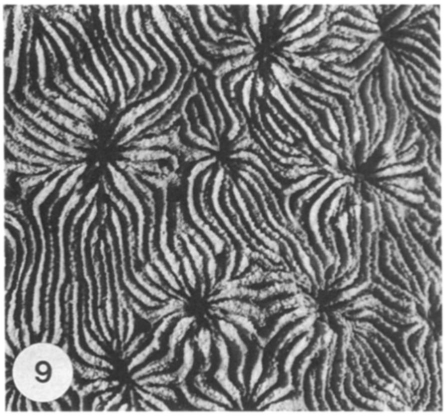
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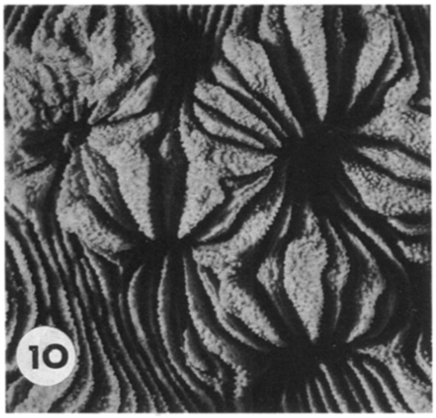
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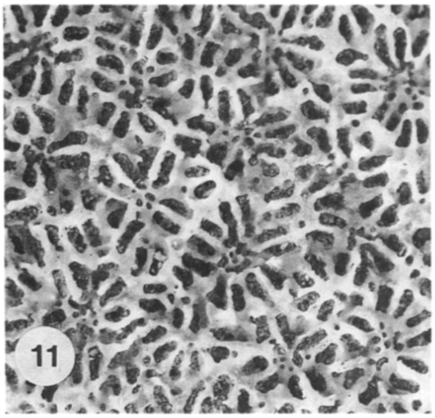
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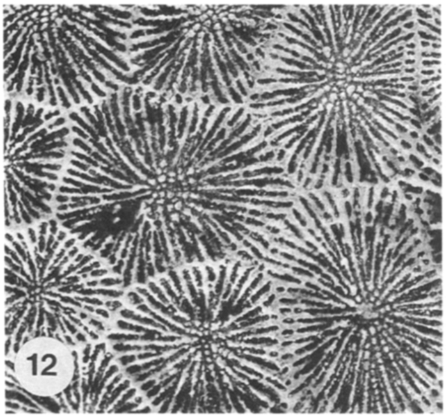
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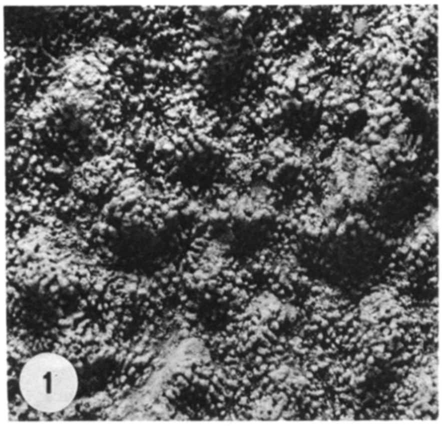
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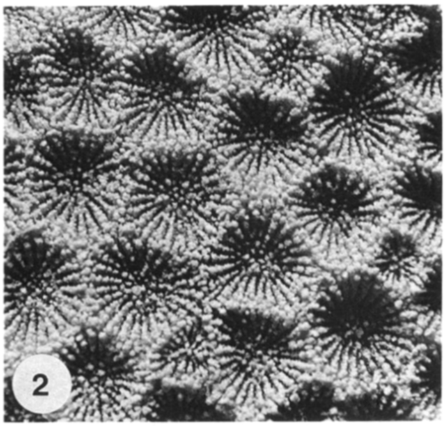
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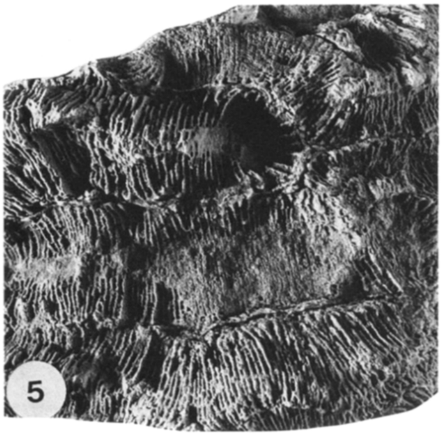
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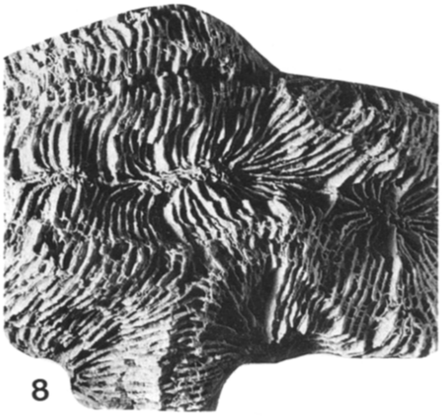
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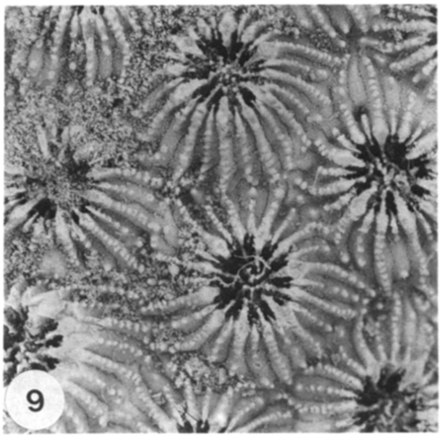
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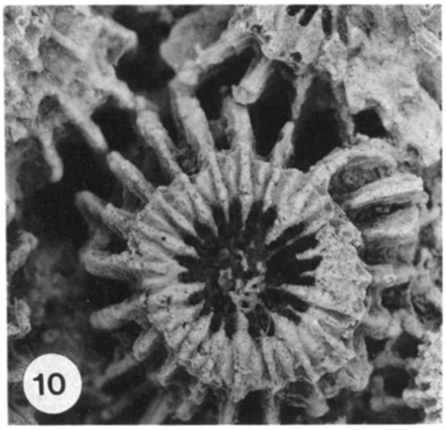
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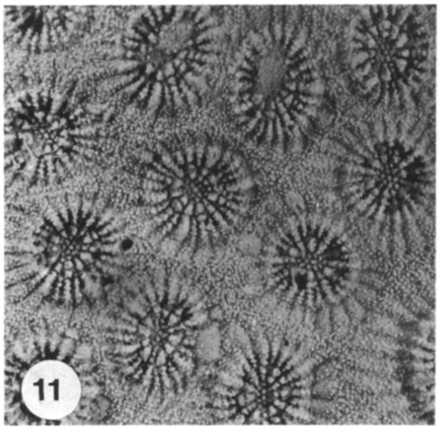
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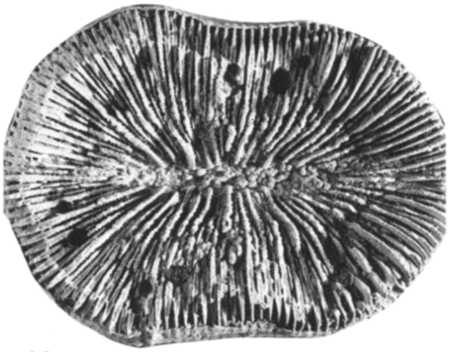
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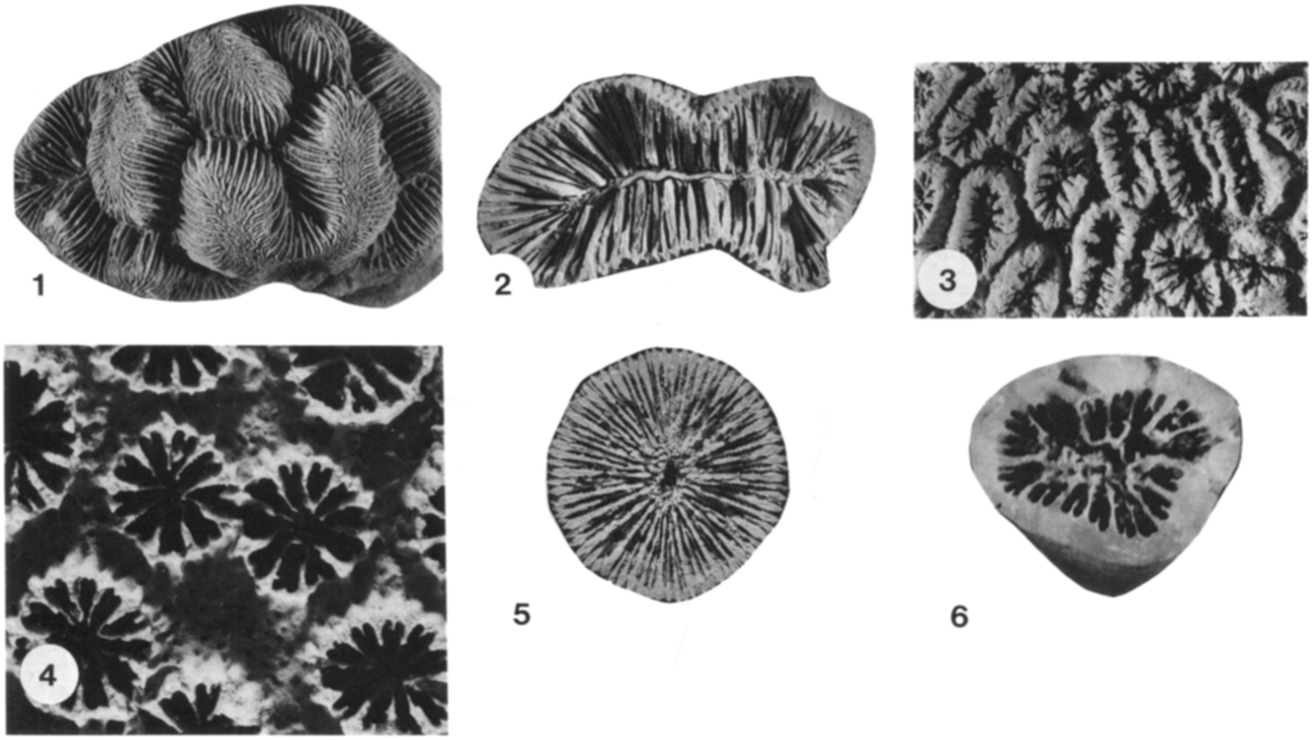

FIGURE 3—Common genera of reef corals collected in the Neogene sequence of the northern Dominican Republic. Calical surfaces. *1, Meandrina* (*Meandrina*) *braziliensis,* NMB D6013, upper Miocene, NMB loc. 16821, ×1. *2, Meandrina* (*Placocyathus*) *costatus,* NMB D6012, lower Pliocene, NMB loc. 15822, ×1. *3, Dichocoenia tuberosa,* NMB D6014, lower Pliocene, NMB loc. 15826, ×2. *4, Galaxea excelsa,* NMB D6010, upper Miocene, NMB loc. 15855, ×5. *5, Antillia dentata,* NMB D6011, upper Miocene, NMB loc. 15807, ×1. *6, Eusmilia* sp. A, NMB D6024, upper Miocene, NMB loc. 15806, ×5.

extinction = 6.80, d.f. = 6, $P > 0.25$; at 4–2 Ma, chi-square for origination = 6.54, d.f. = 6, $P > 0.25$, chi-square for extinction = 4.62, d.f. = 6, $P > 0.25$). Unusually high rates (>20 percent per 2 m.y.) occurred between 4 and 2 Ma, especially in the pocilloporids, agariciids, and meandrinids. Moderately high rates (10–20 percent per 2 m.y.) were present in the faviids and poritids during this time. High rates in the siderastreids appear delayed until 2–0 Ma. In contrast, rates of extinction in the mussids remained low throughout the Miocene to Recent.

Genus-level patterns.—The composite range chart for genera (Figure 5) reveals some of the same general patterns described above for species, with periods of Caribbean extinction mainly in the late Oligocene through early Miocene (seven genera, three of which live today in the Indo-Pacific) and in the latest Miocene through early Pleistocene (15 genera and subgenera, nine of which live today in the Indo-Pacific and one in Brazil). Neogene originations were concentrated during the late Miocene in the agariciids (three genera) and mussids (three genera), and in the free-living corals (three genera and subgenera). In contrast to species-level patterns, however, *Dendrogyra* and *Mussismilia* are the only genera that appeared in the Caribbean after the Miocene, and both genera occurred earlier in the Mediterranean. Thus, much of the post-Miocene evolutionary history of the reef corals in the Caribbean region has involved a sharp decline in total number of genera with little or no change in overall species richness (see Budd et al., 1994). Many of the genera that became extinct in the Caribbean still live today in the Indo-Pacific. Some extinct Caribbean genera that survived in the Indo-Pacific (i.e., *Pocillopora, Gardineroseris, Pavona,* and *Psammocora*) are important components of modern eastern Pacific reefs.

SUMMARY AND CONCLUSIONS

Preliminary examination of the stratigraphic distributions of Neogene to Recent Caribbean reef corals suggests the following.

1. Turnover in the fauna was especially pronounced during the Plio-Pleistocene (4–1 Ma) with high extinction rates in all families except the Mussidae. The higher taxa that became ex-

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FIGURE 2—Common genera of reef corals collected in the Neogene sequence of the northern Dominican Republic. Calical surfaces. *1, Porites macdonaldi,* NMB D5846, upper Miocene, NMB loc. 16883, ×10. *2, Goniopora hilli,* NMB D5853, upper Miocene, NMB loc. 15861, ×5. *3, Favia* sp. A, NMB D6017, upper Miocene, NMB loc. 16855, ×2. *4, Diploria* sp. B, NMB D6018, lower Pliocene, NMB loc. 16817, ×2. *5, Manicina* (*Manicina*) *puntagordensis,* NMB D6019, lower Pliocene, NMB loc. 16859, ×1. *6, Manicina* (*Teleiophyllia*) sp. B, NMB D6020, lower Pliocene, NMB loc. 16862, ×1. *7, Thysanus excentricus,* NMB D6021, upper Miocene, NMB loc. 16910, ×1. *8, Colpophyllia natans,* NMB D6022, lower Pliocene, NMB loc. 16818, ×1. *9, Montastraea limbata,* USNM 66827 (NF439), Neogene, USGS loc. 7775, ×5. *10, Montastraea cylindrica,* USNM 155277, Neogene, Nivaje Shale, ×5. *11, Solenastrea bournoni,* NMB D5603, upper Miocene, NMB loc. 16811, ×5. *12, Trachyphyllia bilobata,* NMB D6023, upper Miocene, NMB loc. 16910, ×1.

TABLE 4—Diagnostic morphologic characters used in routine identification of species. Abbreviations: M = massive, B = branching, P = plate, E = encrusting, S = solitary, (F) = often freeliving, (C) = columnar, (T) = >2 cm thick, (I) = 1–2 cm thick, (N) = <1 cm thick, (P) = phaceloid, (H) = horizontal, (U) = upright, cd = corallite diameter, vw = valley width, nnd = distance between walls of nearest neighboring corallites, cs = distance between centers of nearest neighboring corallites, cll = columella length, clw = columella width, tt = wall thickness, cht = corallum height. All measurements are in millimeters unless noted otherwise.

Species		Colony shape	Corallite size	Corallite spacing	Number of septa	Columella, wall, etc.
Family Astrocoeniidae						
1) *Astrocoenia*	*incrustans*	M	cd = 1.3–1.8	nnd = 0.1–0.2	16	—
2) *Stephanocoenia*	*intersepta*	M	cd = >2.0	nnd = 0.8	24	thick columella and wall
3) *Stephanocoenia*	*duncani*	M	cd = <2.0	nnd = 0.5	24	prominent thin, dense wall
4) *Stephanocoenia*	*spongiformis*	M	cd = <2.0	nnd = 1.0	24	porous intercorallite area; thin columella
Family Pocilloporidae						
5) *Stylophora*	*affinis*	B(T)	cd < 1.0	nnd < 1.0	—	smooth colony surface
6) *Stylophora*	*"affinis"*	B(T)	cd > 1.0	nnd > 1.0	—	smooth colony surface
7) *Stylophora*	*granulata*	B(N)	cd = 0.8–1.0	nnd = 0.5–0.8	—	smooth colony surface
8) *Stylophora*	*imperatoris*	B(I)	cd > 1.0	nnd > 1.0	—	raised colony surface
9) *Stylophora*	*minor*	B(N)	cd = 0.6–0.8	nnd = 1.0–1.5	—	—
10) *Stylophora*	*monticulosa*	B(I)	cd = <1.0	nnd < 1.0	—	protuberances
11) *Stylophora*	*canalis*	B(I)	cd > 1.0	nnd = 0.8–1.0	—	smooth colony surface
12) *Stylophora*	*undata*	M, E	cd > 1.0	nnd < 1.0	—	—
13) *Pocillopora*	*arnoldi*	B(N)	cd = 1.0–1.2	nnd = 0.3–1.0	12	deep calices
14) *Pocillopora*	*baracoaensis*	B(N)	cd = <0.8	nnd = 0.7	12	shallow calices
15) *Pocillopora*	*crassoramosa*	B(T)	cd ~ 1.0	nnd = 0.3	—	deep calices, protuberances
16) *Pocillopora*	*palmata*	B(T)	cd = 0.6–1.0	nnd = 0.5–1.0	—	protuberances
17) *Madracis*	*decactis*	B(I), E	cd = 1.3–1.9	nnd = <1.0	10+	—
18) *Madracis*	*decaseptata*	B(I)	cd = 1.3–1.7	—	15–20	paliform lobes
19) *Madracis*	*formosa*	B(I)	cd = 1.0–1.3	—	8	paliform lobes
20) *Madracis*	*mirabilis*	B(N)	cd = 1.1–1.6	nnd = 1.0	10+	—
21) *Madracis*	*pharensis*	E	cd < 1.6	—	20	paliform lobes
Family Acroporidae						
22) *Acropora*	*cervicornis*	B(I)	cd = 0.8–1.4	—	—	dense coenosteum
23) *Acropora*	*palmata*	B(T)	cd = 0.8–1.0	nnd = 1.0	—	—
24) *Acropora*	*panamensis*	B(T), E	cd = 1.2–1.5	nnd < 1.0	—	granular coenosteum
25) *Acropora*	*prolifera*	B(N)	cd = 1.4–1.8	—	—	exsert corallites
26) *Acropora*	*saludensis*	B(I)	cd = 1.8–2.2	—	—	porous coenosteum
27) *Astreopora*	*goethalsi*	B(T)	cd = 1.5–2.0	nnd = 0.5–1.5	24	—
Family Agariciidae						
28) *Agaricia*	*fragilis*	P(H)	cd = 1.9–2.5	—	17–36	weak columella, low collines
29) *Agaricia*	*grahamae*	P(H)	cd = 2.0–2.9	—	18–28	strong columella, low collines
30) *Agaricia*	*lamarcki*	P(H)	cd = 3.1–4.5	—	20–32	broad collines
31) *Agaricia*	sp. A	P(H)	cd = 2.7–4.0	—	20–32	low collines, closed calices
32) *Agaricia*	*undata*	P(H)	cd = 2.0–2.9	—	13–24	round collines, widely spaced series
33) *Undaria*	*agaricites*	P(H, U), M, E	cd = 2.2–3.1	—	17–29	reticulate series
34) *Undaria*	*crassa*	P(H), M, E	cd = 1.9–3.0	—	20–33	short reticulate series
35) *Undaria*	*pusilla*	P(H), M	cd = 1.4–1.9	—	15–21	low collines, closed calices
36) *Undaria*	sp. A	P(H)	cd = 2.8–4.3	—	19–35	moderately long series
37) *Gardineroseris*	*planulata*	M	cd = 2.9–4.9	—	27–50	deep calices
38) *Pavona* (*Pseudo.*)	sp. A	B(T)	cd = 2.2–3.4	—	13–24	occasional series
39) *Pavona* (*Pseudo.*)	sp. B	B(N)	cd = 1.3–1.9	—	13–19	—
40) *Pavona* (*Pavona*)	*panamensis*	M, E	cd = 2.0–4.0	—	20–26	discontinuous series
41) *Pavona* (*Pavona*)	*pennyi*	M	cd = 2.7–3.8	cs = 2.0–5.0	—	weak series
42) *Pavona* (*Pavona*)	*trinitatis*	P(U)	cd = 1.5–3.0	cs < 1.2	—	no series
43) *Helioseris*	*cucullata*	P(H)	cd = 3.0–4.6	—	15–25	—
44) *Helioseris*	sp. A	P(H)	cd = 2.5–4.6	—	20–30	plate thickness >15 mm
45) *Leptoseris*	*anguillensis*	B(N)	cd = 1.5–4.5	—	15–38	short or absent series, low collines
46) *Leptoseris*	*cailleti*	B(N)	cd = 1.6–2.3	—	15–22	short series
47) *Leptoseris*	*gardineri*	B(T)	cd = 2.5–4.7	—	14–26	short or absent series
48) *Leptoseris*	*glabra*	P(H)	cd = 3.3–5.2	—	17–27	long or absent series
49) *Leptoseris*	sp. A	P(H)	cd = 1.6–2.5	—	13–20	long or absent series
50) *Leptoseris*	sp. B	B(T)	cd = 3.8–5.6	—	21–33	short or absent series
51) *Leptoseris*	*walli*	P(H)	cd = 2.0–3.0	—	25–36	long series, low collines

TABLE 4—Continued.

Species		Colony shape	Corallite size	Corallite spacing	Number of septa	Columella, wall, etc.
Family Siderastreidae						
52) *Psammocora*	*trinitatis*	M	cd = 2.0–3.0	nnd = 0.5–1.5	11–16	—
53) *Siderastrea*	*conferta*	M	cd = 6.0–8.0	—	≫60	weak columella and wall
54) *Siderastrea*	*hillsboroensis*	M	cd = 4.0–4.5	—	48–50	strong wall
55) *Siderastrea*	*pliocenica*	M	cd = 4.5–5.0	—	40–46	prominent columella and wall
56) *Siderastrea*	*radians*	M(F)	cd = 2.5–3.5	—	36	prominent columella and wall
57) *Siderastrea*	*silecensis*	M	cd = 5.0–6.5	—	50–60	—
58) *Siderastrea*	*siderea*	M	cd = 3.5–5.0	—	46–48	weak wall
59) *Siderastrea*	*stellata*	M	cd ~ 3.0–4.0	—	≪48	weak columella
60) *Pironastrea*	*anguillensis*	M	vw = 2.5–5.5	—	38–45	high collines
61) *Pironastrea*	*antiguensis*	M	vw = 5.5–7.5	—	>48	low collines
Family Poritidae						
62) *Porites*—I	*anguillensis*	P(H)	cd = 1.8–2.0	—	—	strong columella, 5–6 pali
63) *Porites*—I	*astreoides*	M	cd < 1.2	—	—	strong columella, <2 pali
64) *Porites*—I	*macdonaldi*	M	cd = 1.4–1.6	—	—	strong columella, 2–4 pali
65) *Porites*—I	*portoricensis*	B(T)	cd = 1.6–1.8	—	—	strong columella, 2–4 pali
66) *Porites*—I	*trinitatis*	P(H)	cd = 1.6–1.8	—	—	intermediate columella, 6–8 pali
67) *Porites*—I	*verrilli*	M	cd < 1.2	—	—	strong columella, <2 pali, extensive wall reticulum
68) *Porites*—I	*waylandi*	M	cd = 1.4–1.6	—	—	strong columella, 2–4 pali
69) *Porites*—II	*baracoaensis*	B(N)	cd < 1.2	—	—	weak columella, 5–6 pali
70) *Porites*—II	*branneri*	E	cd = 1.6–1.8	—	—	no columella, 5–6 pali
71) *Porites*—II	*carrizensis*	E	cd = 1.6–1.8	—	—	strong columella, 5–6 pali
72) *Porites*—II	*chipolanum*	E	cd = 1.6–1.8	—	—	intermediate columella, 5–6 pali
73) *Porites*—II	*colonensis*	E	cd = 1.2–1.4	—	—	no columella, 5–6 pali
74) *Porites*—II	*convivatoris*	E	cd = 1.2–1.4	—	—	strong columella, 2–4 pali
75) *Porites*—II	*divaricata*	B(N)	cd = 1.2–1.6	—	—	weak columella, 4–6 pali
76) *Porites*—II	*furcata*	B(I)	cd = 1.6–1.8	—	—	strong columella, 5–6 pali
77) *Porites*—II	*porites*	B(T)	cd = 1.8–2.0	—	—	strong columella, 5–6 pali
78) *Goniopora*	*calhounensis*	M	cd = 3.5–5.0	nnd ~ 1.0	~26	clw = 1.2–1.5
79) *Goniopora*	*hilli*	M	cd = 2.5–3.5	nnd = 0.5–0.8	~24	clw = 0.8–1.0
80) *Goniopora*	*imperatoris*	M	cd = 1.5–2.5	nnd = 0.5–0.8	~24	clw = 0.8–1.0
81) *Goniopora*	*panamensis*	M	cd = 2.5–3.5	nnd ~ 2.5	~24	clw < 1.0
82) *Alveopora*	*tampae*	M	cd = 2.0–3.0	—	—	thecal pore diameter ~ 0.5
Family Faviidae						
83) *Caulastrea*	*portoricensis*	B(P)	cd = 5.0–9.0	nnd = 2.0–5.0	48–60	—
84) *Cladocora*	*arbuscula*	B(P)	cd ~ 3.0	—	36	clw = 1.0
85) *Cladocora*	*johnsoni*	B(P)	cd < 3.0	—	24–30	—
86) *Cladocora*	sp. A	B(P)	cd ~ 4.0	—	38–40	clw = 2.1
87) *Favia*	*dominicensis*	M	cd = 4.0–5.0	—	—	strong columella, short series with 1–2 centers
88) *Favia*	*fragum*	M	cd = 2.5–3.5	—	—	short series with 1–2 centers
89) *Favia*	*gravida*	M	cd = 2.5–4.0	—	—	long series with up to 4–6 centers
90) *Favia*	*leptophylla*	M	cd = 5.0–7.0	—	—	short series with 1–2 centers
91) *Favia*	sp. A	M	cd = 3.0–4.0	—	—	short series with 1–2 centers
92) *Goniastrea*	*canalis*	M	cd = 1.5–2.0	—	>30	short series with 1–2 centers
93) *Diploria*	*bowersi*	M	vw = 3.5–5.0	nnd = 2.0	8/cm	no minor septa, grooved colline
94) *Diploria*	*clivosa*	M	vw = 2.8–3.5	nnd < 1.5	~32/cm	#major = #minor septa, long valleys
95) *Diploria*	*labyrinthiformis*	M	vw = 3.5–5.0	nnd = 2.0	12–16/cm	no minor septa, grooved colline
96) *Diploria*	*sarasotana*	M	vw = 7.0–13	—	~22/cm	#major = #minor septa, valleys juxtaposed
97) *Diploria*	*strigosa*	M	vw = 4.5–6.0	nnd < 1.5	14–20/cm	#major ≫ #minor septa
98) *Diploria*	sp. A	M	vw = 3.0–4.0	nnd > 1.5	~28/cm	#major = #minor septa
99) *Diploria*	sp. B	M	vw = 5.5–7.0	nnd > 2.0	~15/cm	no minor septa, grooved colline
100) *Manicina* (*Man.*)	*areolata*	M(F)	vw = 10–11	—	17–18/cm	spongy columella, #major ≫ #minor septa, tt = 0.8–1.0, single continuous valley
101) *Manicina* (*Man.*)	*mayori*	M	vw = 11–13	—	16–17/cm	spongy columella, #major ≫ #minor septa, discontinuous valleys

TABLE 4—Continued.

	Species		Colony shape	Corallite size	Corallite spacing	Number of septa	Columella, wall, etc.
102)	*Manicina* (*Man.*)	*puntagordensis*	M(F)	vw = 15–16	—	13–14/cm	lamellar columella, #major ≫ #minor septa, tt ~ 0.5, single continuous valley
103)	*Manicina* (*Teleio.*)	*grandis*	M(F)	vw = 13–15	—	16–17/cm	#major ≫ #minor septa
104)	*Manicina* (*Teleio.*)	*navicula*	M(F)	vw = 10–12	—	14–15/cm	#major ≫ #minor septa
105)	*Manicina* (*Teleio.*)	sp. A	M(F)	vw = 18–20	—	14–15/cm	#major ≫ #minor septa
106)	*Manicina* (*Teleio.*)	sp. B	M(F)	vw = 10–12	—	26–30/cm	#major = #minor septa
107)	*Manicina* (*Teleio.*)	sp. C	M(F)	vw = 16–18	—	22–25/cm	#major = #minor septa
108)	*Manicina* (*Teleio.*)	sp. D	M(F)	vw > 20	—	10–11/cm	no minor septa
109)	*Thysanus*	*crassicostatus*	M(F)	vw = 5.0–10	—	10/cm	no minor septa, branched series
110)	*Thysanus*	*excentricus*	M(F)	vw = 10–12	—	12/cm	no minor septa, unbranched series
111)	*Thysanus*	*floridanus*	M(F)	vw = 10–12	—	26/cm	#major = #minor septa, thin outer wall
112)	*Colpophyllia*	*amaranthus*	M	—	—	8/cm	short, deep valleys; small (<10 cm diameter) colonies
113)	*Colpophyllia*	*breviserialis*	M	—	—	6/cm	short, shallow valleys; intermediate (10–20 cm diameter) colonies
114)	*Colpophyllia*	*natans*	M	—	—	10/cm	long valleys; large (>20 cm diameter) colonies
115)	*Antiguastrea*	*cellulosa*	M	cd = 4.5–6.0	—	48	clw ~ 1
116)	*Montastraea*—I	*annularis*—1	M(C)	cd = 2.1–2.7	nnd = 1.0–1.2	24	—
117)	*Montastraea*—I	*annularis*—2	M	cd = 2.1–2.7	nnd = 0.6–0.9	24	—
118)	*Montastraea*—I	*annularis*—3	M	cd = 3.0–3.5	nnd = 1.0–1.2	24–26	—
119)	*Montastraea*—I	*brevis*	M	cd = 3.3–3.8	—	24–28	small colonies
120)	*Montastraea*—I	*imperatoris*	M	cd = 2.5–3.5	—	18–24	prominent primary septa
121)	*Montastraea*—I	*limbata*	M(C)	cd = 2.0–2.5	nnd = 1.2–1.8	24	—
122)	*Montastraea*—I	sp. A	M	cd ≪ 2.3	—	20–22	narrow columella
123)	*Montastraea*—I	*trinitatis*	M	cd = 2.5–3.5	—	28–32	irregular corallite shape
124)	*Montastraea*—II	*canalis*	M	cd = 4.5–5.5	—	36–42	—
125)	*Montastraea*—II	*cavernosa*—1	M	cd = 5.5–6.5	—	24–32	—
126)	*Montastraea*—II	*cavernosa*—2	M	cd = 5.5–6.5	—	38–48	—
127)	*Montastraea*—II	*cavernosa*—3	M	cd = 6.3–7.2	—	38–48	—
128)	*Montastraea*—II	*cylindrica*	M	cd = 4.0–5.0	—	24–36	—
129)	*Montastraea*—II	*endothecata*	M	cd = 7.2–9.0	—	36–50	—
130)	*Montastraea*—II	*tampaensis*	M	cd = 4.5–5.5	—	42–48	highly exsert calices
131)	*Solenastrea*	*bournoni*	M	cd = 2.0–2.5	—	—	tertiary septa free
132)	*Solenastrea*	*fairbanksi*	M	cd = 2.0–3.0	—	—	reduced, dense coenosteum
133)	*Solenastrea*	*hyades*	M	cd = 2.5–3.0	—	—	tertiary septa fused
134)	*Agathiphyllia*	*hilli*	M	cd = 7.0–12	—	≫60	—
	Family Trachyphylliidae						
135)	*Trachyphyllia*	*bilobata*	M(F)	cd ~ 40–60	—	8/cm	bilobate shape
136)	*Trachyphyllia*	sp. A	M(F)	cd = 90–130	—	—	cll = 50–65, 5–6 septa/cm near columella
137)	*Antillophyllia*	*sawkinsi*	S(F)	cd ~ 45	—	10/cm	septa of equal thickness
	Family Meandrinidae						
138)	*Meandrina* (*Mea.*)	*braziliensis*	M(F)	vw = 10–20	—	14/cm	grooved colline (2 mm thick), single continuous valley

TABLE 4—Continued.

Species		Colony shape	Corallite size	Corallite spacing	Number of septa	Columella, wall, etc.
139) *Meandrina* (*Mea.*)	*meandrites*	M	vw = 6.0–8.0	—	16–20/cm	grooved colline (4 mm thick), numerous valleys
140) *Meandrina* (*Placo.*)	*alveolus*	M(F)	vw = 25–32	—	18–22/cm	cht = 35–50
141) *Meandrina* (*Placo.*)	*barretti*	M(F)	vw < 20	—	12/cm	sinuous valley
142) *Meandrina* (*Placo.*)	*costatus*	M(F)	vw = 20–35	—	12–20/cm	strong costae, cht = 20–35
143) *Meandrina* (*Placo.*)	*trinitatis*	M(F)	vw = 10–18	—	22–32/cm	cht = 15–35
144) *Meandrina* (*Placo.*)	*variabilis*	M(F)	vw = 15–30	—	16–24/cm	thick epitheca, cht = 25–50
145) *Dichocoenia*	*caloosahatcheensis*	M	cd = 4.5–5.0	—	—	short series with 1–2 centers, pedicel
146) *Dichocoenia*	*eminens*	M	cd > 6.0	—	—	highly exsert corallites, pedicel
147) *Dichocoenia*	*merriami*	M	cd ~ 4.5	—	—	strong columella, many series with 3 centers, no pedicel
148) *Dichocoenia*	*stokesi*	M	cd = 3.5–4.5	—	—	weak columella, thin walls, many series with 3 centers, no pedicel
149) *Dichocoenia*	*stellaris*	M	cd ~ 3.0	—	—	short series with 1–2 centers, no pedicel
150) *Dichocoenia*	*tuberosa*	M	cd = 2.5–3.0	—	—	thick walls, many series with 3 centers, pedicel
151) *Dendrogyra*	*cylindricus*	M(C)	vw = 3.0–4.0	—	—	clw = 1.0, grooved colline (3–5 mm thick)
Family Oculinidae						
152) *Galaxea*	*excelsa*	M	cd = 2.9–5.4	—	<24	—
Family Mussidae						
153) *Antillia*	*dentata*	S(F)	cd ~ 30–41	—	~96	cll = 9–13, clw = 4.6–6.3, cht = <60
154) *Antillia*	*gregorii*	S(F)	cd ~ 50–65	—	—	cll = 22–24, clw = 7.0–8.6, cht < 45
155) *Scolymia*	*cubensis*	S	cd = <100	—	<80	5–9 teeth/cm
156) *Scolymia*	*wellsi*	S	cd = <70	—	~60	numerous teeth
157) *Scolymia*	*lacera*	S	cd = <150	—	<80	<5 teeth/cm
158) *Mussa*	*angulosa*	B(P)	cd = <70	—	~60	mono- to polycentric with trabecular linkage
159) *Mussismilia*	*braziliensis*	M	cd = 8.0–10	—	<48	weak columella, plocoid to subcerioid
160) *Mussismilia*	*harttii*	B(P)	cd = 12–30	—	—	phaceloid or subplocoid
161) *Mussismilia*	*hispida*	M	cd = 14–15	—	~48	strong columella, plocoid to subcerioid
162) *Isophyllia*	sp. A	M	vw = 10–20	—	13–15/cm	—
163) *Isophyllia*	*sinuosa*	M	vw = 20–25	—	7–10/cm	lamellar linkage
164) *Isophyllastrea*	sp. A	M	cd = 6.0–8.0	—	18–24	—
165) *Isophyllastrea*	*rigida*	M	cd = 10–14	—	25–35	weak columella
166) *Mycetophyllia*	*aliciae*	P(H)	vw = 20–80	—	10–12/cm	no columella, thick septa, low collines
167) *Mycetophyllia*	*bullbrooki*	M	—	cs = 15–25	6–9/cm	no series
168) *Mycetophyllia*	*danaana*	M	vw = 10–20	cs = 10–15	12–16/cm	series
169) *Mycetophyllia*	*ferox*	P(H)	vw = 10–20	cs = 10–15	18–20/cm	discontinuous series
170) *Mycetophyllia*	*lamarckiana*	P(H)	vw = 10–20	cs = 8–11	10–15/cm	continuous, radiating series
171) *Mycetophyllia*	*reesi*	P(H)	—	cs = 7–15	10–15/cm	no collines, exsert calices, continuous series
Family Caryophylliidae						
172) *Eusmilia*	*carrizensis*	B(P)	vw = 9–33	—	8–10/cm	mono- to dicentric
173) *Eusmilia*	*fastigiata*	B(P)	vw = 8–13	—	15–18/cm	monocentric, triangular
174) *Eusmilia*	*flabellata*	B(P)	vw ~ 8–12	—	—	polycentric, flabellate
175) *Eusmilia*	sp. A	B(P)	vw = 2.0–2.5	—	—	monocentric, triangular

TABLE 5—Estimates of species richness (R) and numbers of originations (O) and extinctions (E) for seven families over twelve 2-myr time intervals. Richness was estimated using the range-through method. Numbers of originations and extinctions were estimated by weighting first and last occurrences relative to locality durations. ns = number of species. Numbers given for time intervals correspond with beginnings for originations and ends for extinctions.

	Pocilloporidae ns = 17			Agariciidae ns = 25			Siderastreidae ns = 10			Poritidae ns = 21			Faviidae ns = 51			Meandrinidae ns = 14			Mussidae ns = 19		
Ma	R	O	E	R	O	E	R	O	E	R	O	E	R	O	E	R	O	E	R	O	E
24–22	6	—	0.25	3	—	0.5	4	—	0.75	9	—	1.5	9	—	1	0	—	0	2	—	0.25
22–20	6	0.75	0.25	3	0.75	0.5	3	0.75	0.75	8	1	0.5	7	0.5	1	0	0	0	1	0.25	0.25
20–18	10	1.75	0.917	3	0.75	0.5	7	1.75	1.083	10	1.667	0.833	13	1.5	1.667	0	0	0	1	0.25	0.25
18–16	7	1	0.667	1	0.25	0.25	7	1.75	1.083	9	0.667	0.583	12	1.5	1.417	0	0	0	1	0.25	0.25
16–14	4	0.667	0	0	0	0	4	1	0.333	4	0	0	8	1.333	0.333	0	0	0	0	0	0
14–12	6	0.583	0.25	9	2	1	1	0	0.25	4	0.25	0.25	6	1.167	0.25	2	0.5	0	2	0.5	0.25
12–10	6	0.25	0.25	9	2	1	1	0	0.25	3	0.25	0.25	6	0.5	0.25	2	0.5	0	2	0.5	0.25
10–8	10	0.583	0.25	17	4.667	1	3	0	0.25	9	0.583	0.25	21	3.833	0.917	7	2.167	0	3	0.833	0.25
8–6	10	0.583	1.25	17	4.667	4	3	0	0.25	9	0.583	1.25	22	4.833	1.917	7	2.167	0	4	1.833	0.25
6–4	9	0	5.5	15	1.5	9	4	2	0	12	4	4	24	7	6.5	10	3	4.5	5	3	1
4–2	5	0	1.5	7	1	0	4	0	2	9	0.5	2	26	6	7	6	1	2.5	8	3	0.5
2–0	5	3	—	9	1	—	3	1	—	7	2	—	20	7	—	4	0	—	14	5	—

tinct in the Caribbean include *Stylophora, Pocillopora, Gardineroseris, Pavona, Goniopora, Caulastrea, Trachyphyllia, Teleiophyllia, Thysanus, Placocyathus, Antillia,* and *Mussismilia.* Of these 12 taxa, the first seven occur today in the Indo-Pacific, and three of the seven (*Pocillopora, Gardineroseris,* and *Pavona*) are common in the impoverished fauna of the modern eastern Pacific, which consists of seven genera total, only two of which occur in the modern Caribbean. One extinct genus (*Mussismilia*) lives today in Brazil. The remaining four taxa became globally extinct and consist entirely of free-living corals. Thus, the Caribbean reef coral fauna did not achieve a distinctively modern aspect (>60 percent generic similarity) until the early to middle Pleistocene.

2. The fact that extinct Caribbean genera are among the most important constituents of the modern eastern Pacific fauna suggests that the dispersal hypothesis for the origin of the eastern Pacific fauna may be over-simplified and needs to be re-evaluated in light of fossil occurrences (see discussion in Budd, 1989). Both the eastern Pacific and Brazilian faunas may partially represent relicts of the more generically diverse Neogene Caribbean reef-coral fauna.

3. In contrast to the apparent synchrony of Plio-Pleistocene extinctions, extinctions of taxa that were common during the late Oligocene were scattered throughout the early to middle Miocene. Included among these taxa were the then mono- or paucispecific Caribbean genera such as *Astrocoenia, Astreopora, Pironastrea, Goniastrea, Antiguastrea,* and *Agathiphyllia.* Of these, only *Astreopora* and *Goniastrea* live today in the Indo-Pacific. The others are globally extinct.

4. The fact that extinction patterns differed little among families during Plio-Pleistocene time indicates that the accelerated extinction was not taxonomically selective and therefore may have been part of a larger scale biotic crisis, ultimately caused by external abiotic factors. High extinction rates have also been reported at this time in Caribbean molluscs (Stanley and Campbell, 1981; Stanley, 1986) and bryozoans (A. H. Cheetham, personal commun.), but not in Indo-Pacific corals (Potts, 1984; Veron and Kelley, 1988). The temporal correspondence of accelerated evolutionary rates in several unrelated Caribbean groups suggests that the abiotic factors may have been regional in extent. Although the roles of specific factors are still debated, all appear directly or indirectly related to long-term, unidirectional changes in climate and/or ocean circulation in association with closure of the Isthmus of Panama at approximately 3.5 Ma (Coates et al., 1992).

5. Originations during Plio-Pleistocene turnover were highest in the families Acroporidae, Poritidae, Faviidae, and Mussidae, but occurred only at the species level. Many dominant shallow-water components of modern Caribbean reefs arose during this period of time, including the common modern species *Acropora palmata, Diploria strigosa,* and *Porites astreoides* and the *Montastraea annularis* complex.

6. Relatively high origination rates also prevailed during the late Miocene, when large numbers of species arose in the agariciids and in the free-living faviids and meandrinids. With the exception of *Psammocora* and *Galaxea* (both common today in the Indo-Pacific, with *Psammocora* extending to the eastern

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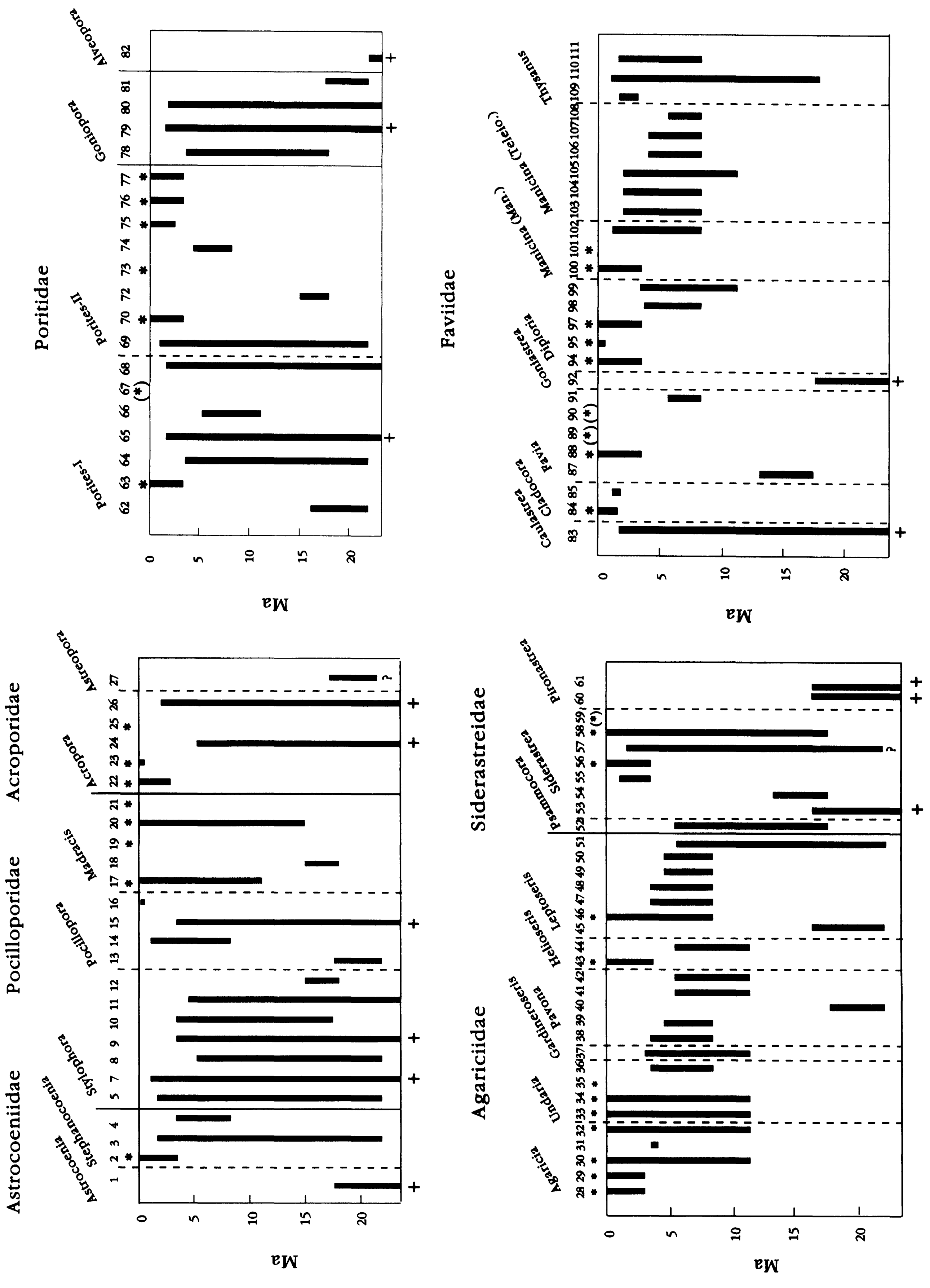
FIGURE 4—Composite stratigraphic range charts for all Neogene Caribbean reef coral species. Taxa are arranged by families. Numbers for each species correspond with those in Appendix. Asterisks indicate Recent Caribbean occurrences; parentheses indicate Recent occurrences in Brazil; pluses indicate pre-Miocene occurrences; dashes delineate genera or subgenera within families.


Astrocoeniidae
Pocilloporidae
Acroporidae
Astrocoenia
Stephanocoenia
Stylophora
Pocillopora
Madracis
Acropora
Astreopora
Agariciidae
Siderastreidae
Agaricia
Undaria
Gardineroseris
Pavona
Helioseris
Leptoseris
Psammocora
Siderastrea
Pironastrea
Poritidae
Porites-I
Porites-II
Goniopora
Alveopora
Faviidae
Caulastrea
Cladocora
Favia
Goniastrea
Diploria
Manicina (Man.)
Manicina (Teleio.)
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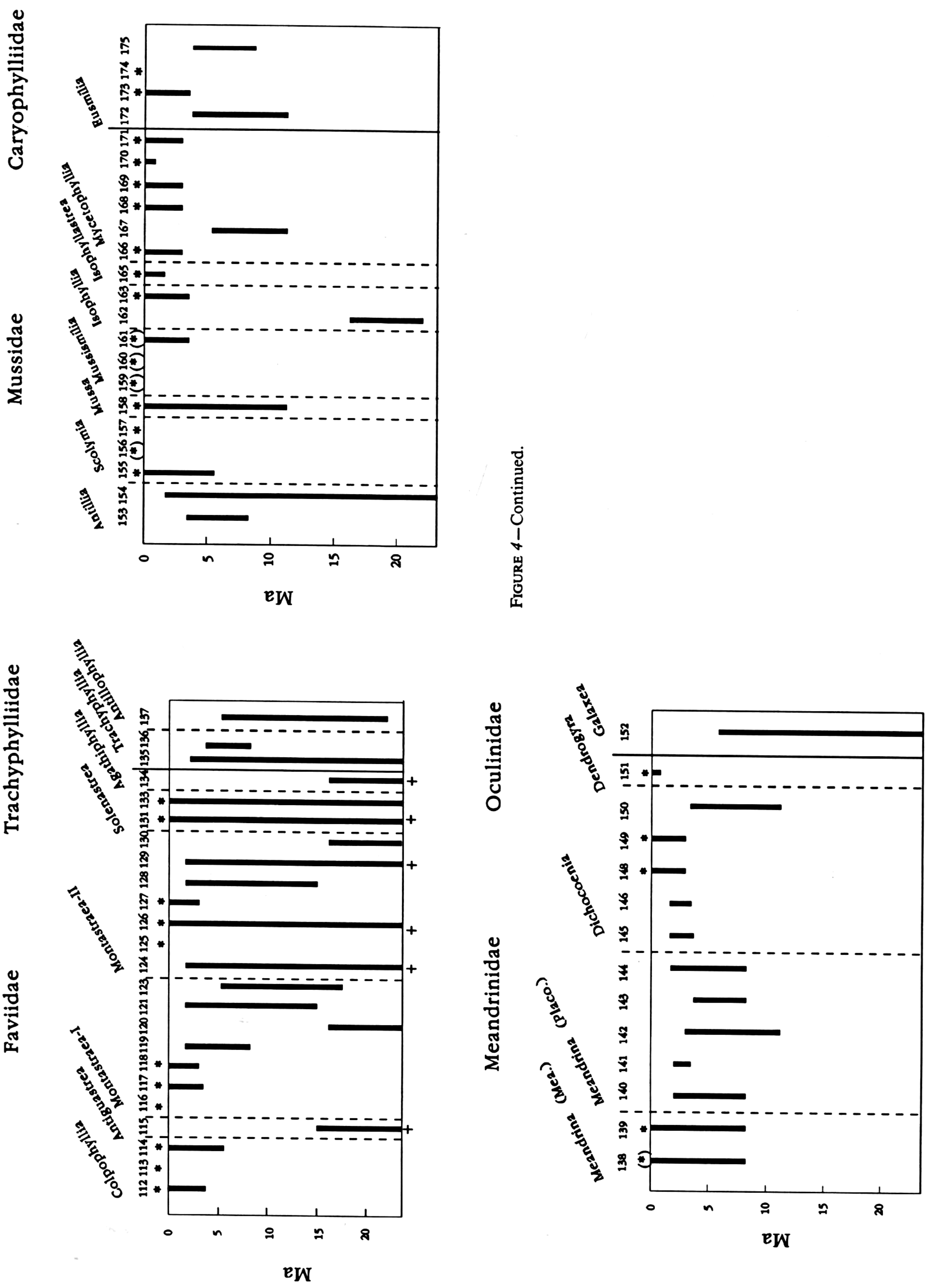

FIGURE 4—Continued.

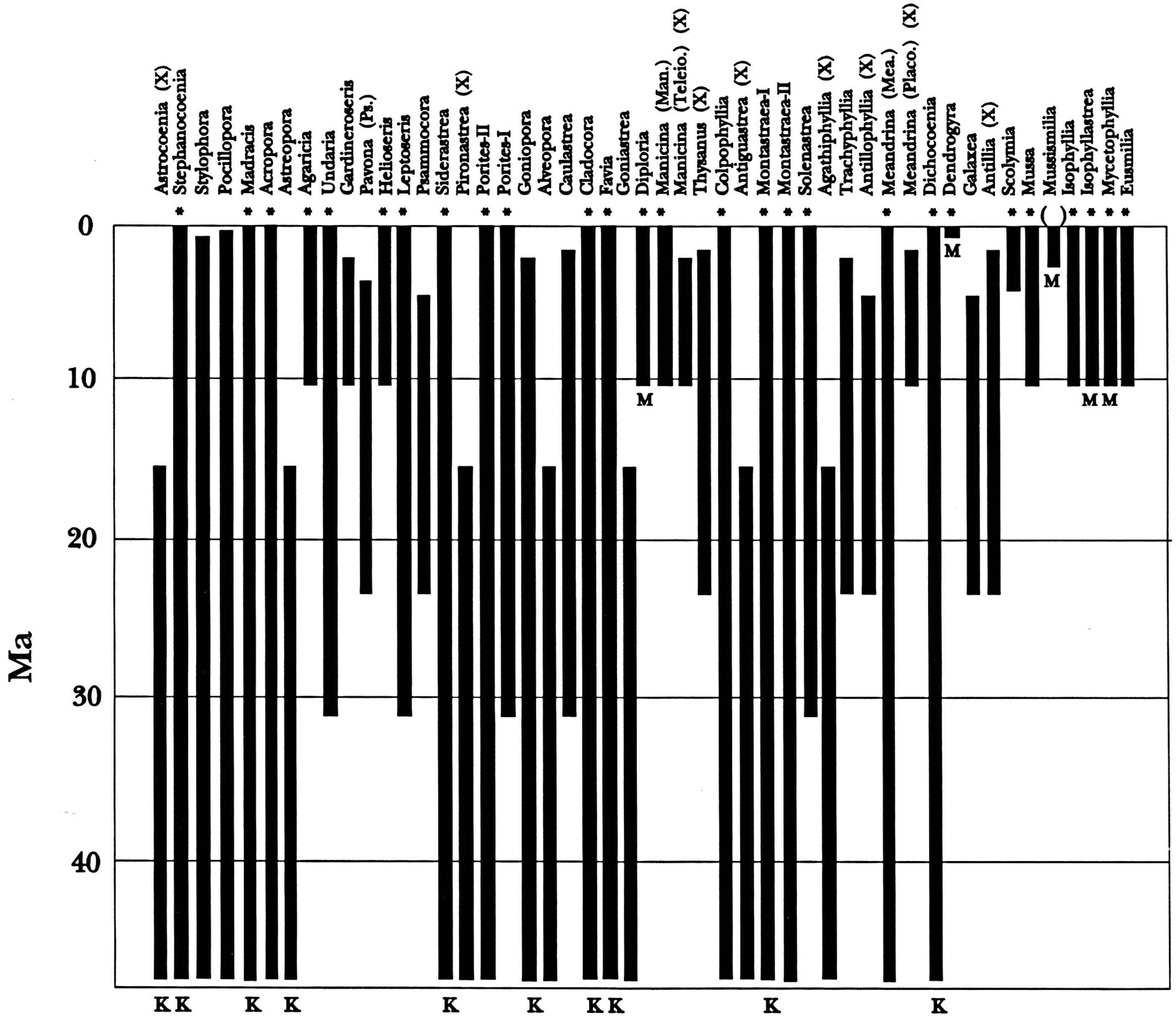

FIGURE 5—Composite stratigraphic range chart for Caribbean reef coral genera. Only genera with Neogene occurrences are shown. Asterisks indicate Recent Caribbean occurrences; parentheses indicate Recent occurrences in Brazil; "K"s indicate possible Cretaceous occurrences; "M"s indicate possible post-middle Miocene Mediterranean emigrants (after Wells, 1956). Genera marked "(X)" are now extinct.

Pacific), as well as *Antillophyllia,* relatively few Caribbean extinctions took place during this time interval.

7. Because of the high numbers of generic extinctions during Plio-Pleistocene and early to middle Miocene time, and because of the lack of new genera in the Caribbean since the late Miocene, generic richness in the Caribbean dropped sharply from Neogene to Recent time. Of the 41 genera occurring in the late Miocene and Pliocene of the Caribbean, only 68 percent live there today. In part, this drop in richness may be related to increasing isolation of the Caribbean region and complete breakdown in dispersal from the Mediterranean during the late Miocene, and from the Indo-Pacific during the Pliocene. Despite the drop in generic richness, species richness remained relatively constant over the same time interval. Thus, different patterns prevail at the species and genus levels, and genus-level patterns cannot be used to approximate species-level patterns.

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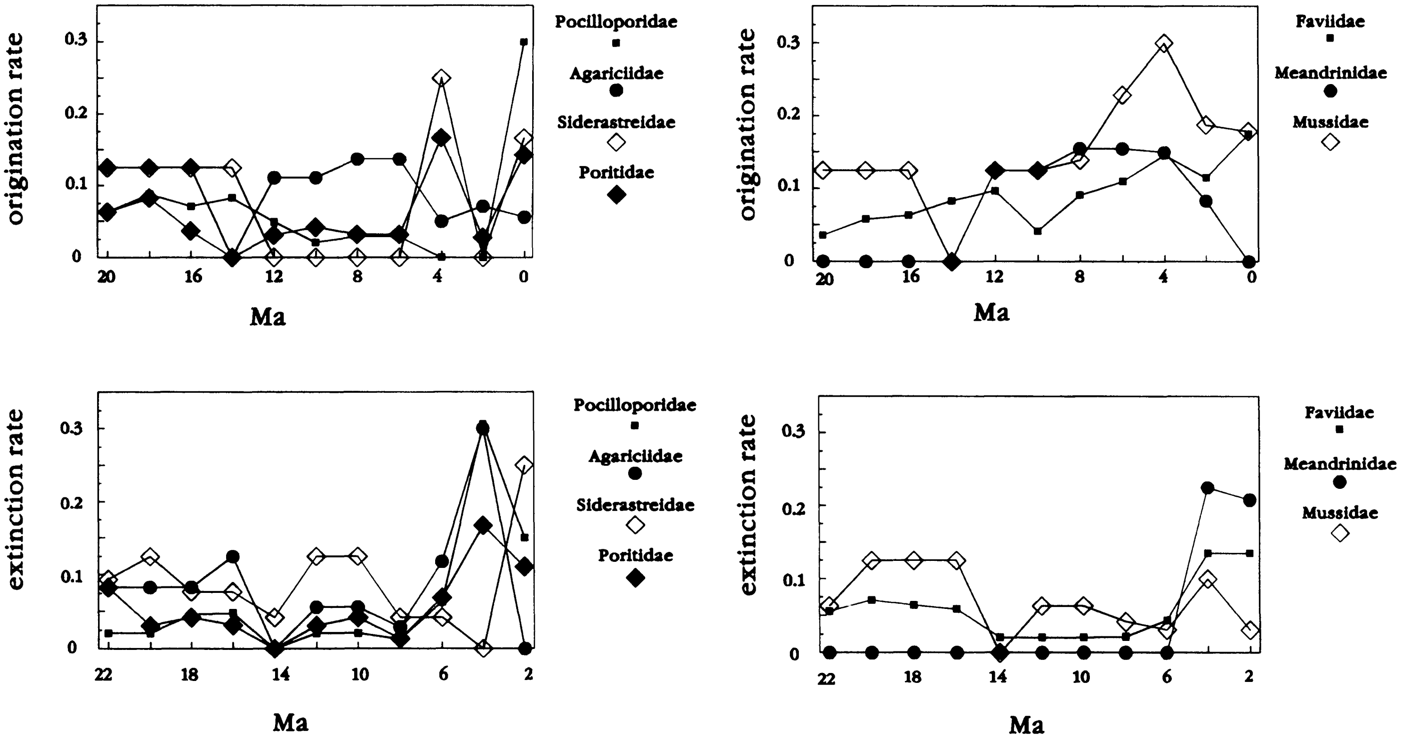

FIGURE 6—Extinction and origination rates per 2-m.y. time intervals for species within seven families. Rates were calculated by dividing the number of originations and extinctions in each interval in Table 5 by species richness. Numbers on the horizontal axis correspond with beginnings of time intervals for origination rates, and with ends of time intervals for extinction rates.

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APPENDIX

List of taxa in the compilation including diagnostic morphologic characters used in the recognition of families and genera, and synonyms applied to published faunal lists.

A. Family Astrocoeniidae Koby, 1890: small corallites, simple trabeculae, reduced coenosteum, beaded septal margins.

Astrocoenia Milne Edwards and Haime, 1848: cerioid; two septal cycles; styliform columella; no pali.

1) *A. incrustans* (Duncan, 1873). Synonyms = *Astrocoenia portoricensis* Vaughan, 1919.

Stephanocoenia Milne Edwards and Haime, 1848: plocoid or subcerioid; 3 septal cycles; styliform columella; prominent pali.

2) *S. intersepta* (Lamarck, 1816). Synonyms = *Stephanocoenia michelini* Milne Edwards and Haime of Geister, 1975, and of Wells and Lang (1973).

3) *S. duncani* (Foster, 1987). Synonyms = *Stephanocoenia intersepta* (Esper) of Vaughan, 1919.

4) *S. spongiformis* (Duncan, 1864); Figure 1.1.

B. Family Pocilloporidae Gray, 1842: small corallites, simple trabeculae; nonporous coenosteum.

Stylophora Schweigger, 1819: plocoid; septa in two cycles of six; first cycle uniting with styliform columella.

5) *S. affinis* Duncan, 1863. Synonyms = *Stylophora panamensis* Vaughan, 1919.

6) *S. "affinis"* of Meeder, 1987.

7) *S. granulata* Duncan, 1864. Synonyms = *Stylophora macdonaldi* Vaughan, 1919.

8) *S. imperatoris* Vaughan, 1919.

9) *S. minor* Duncan, 1863. Synonyms = *Stylophora goethalsi* Vaughan, 1919; *Stylophora minutissima* Vaughan of Weisbord, 1973.

10) *S. monticulosa* Vaughan in Vaughan and Hoffmeister, 1925; Figure 1.2.

11) *S. canalis* Vaughan, 1919. Synonyms= *Stylocoenia* cf. *C. pumpellyi* (Vaughan) of Weisbord, 1971; *Stylophora silicensis* Weisbord, 1973.

12) *S. undata* Weisbord, 1971.

Pocillopora (Lamarck, 1816): plocoid; reduced septa; strong tabular endothecal dissepiments.

13) *P. arnoldi* Vaughan, 1919.

14) *P. baracoaensis* Vaughan, 1919.

15) *P. crassoramosa* Duncan, 1864; Figure 1.3.
16) *P. palmata* Palmer, 1928.

Madracis Milne Edwards and Haime, 1849a: plocoid to subcerioid; strong septa in cycles of 8 or 10; prominent styliform columella.

17) *M. decactis* (Lyman, 1859).
18) *M. decaseptata* (Weisbord, 1971); Figure 1.4.
19) *M. formosa* Wells, 1973.
20) *M. mirabilis* (Duchassaing and Michelotti, 1860).
21) *M. pharensis* (Heller, 1868).

C. Family Acroporidae Verrill, 1902: small corallites, simple trabeculae; extensive porous, reticulate coenosteum.

Acropora Oken, 1815: ramose with axial corallites; septa in two cycles of six; no columella.

22) *A. cervicornis* (Lamarck, 1816).
23) *A. palmata* (Lamarck, 1816).
24) *A. panamensis* Vaughan, 1919.
25) *A. prolifera* (Lamarck, 1816).
26) *A. saludensis* Vaughan, 1919; Figure 1.5. Synonyms = *Acropora tampaensis* Weisbord, 1973; *Acropora* sp. 1 of Meeder, 1987.

Astreopora Blainville, 1830: plocoid; extensive porous coenosteum; massive with solid corallite walls; sometimes with columella.

27) *A. goethalsi* Vaughan, 1919.

D. Family Agariciidae Gray, 1847: corals with confluent septa comprised of closely packed simple trabeculae and united by synapticulae.

Agaricia Lamarck, 1801: unifacial explanate colonies; thickened outer wall; long series; horizontal bars on septocostae.

28) *A. fragilis* Dana, 1846.
29) *A. grahamae* Wells, 1973.
30) *A. lamarcki* Milne Edwards and Haime, 1851.
31) *A.* sp. A; Figure 1.6.
32) *A. undata* (Ellis and Solander, 1786).

Undaria Oken, 1815: bifacial or unifacial colonies; thin outer wall; short to long series; randomly oriented septocostal ornamentation.

33) *U. agaricites* (Linnaeus, 1758).
34) *U. crassa* (Verrill, 1901); Figure 1.7.
35) *U. pusilla* (Verrill, 1901).
36) *U.* sp. A.

Gardineroseris Scheer and Pillai, 1974: mounding or explanate colonies; thin outer wall; short series surrounded by acute collines.

37) *G. planulata* (Dana, 1846); Figure 1.8.

Pavona Lamarck, 1801: massive or bifacial folia; subcerioid to plocoid; thin outer wall; irregular short series; septal ornament fine or absent.

I. *P.* (*Pseudocolumnastrea*) Yabe and Sugiyama, 1933: bifacial folia or rounded branches; plocoid, exsert calices; rare discontinuous collines.

38) *P.* (*P.*) sp. A; Figure 1.9.
39) *P.* (*P.*) sp. B.

II. *P.* (*Pavona*) s.s.: massive or foliaceous; calical walls often indistinct; collines irregular, radiating or absent.

40) *P.* (*Pavona*) *panamensis* Vaughan, 1919.
41) *P.* (*Pavona*) *pennyi* Vaughan in Vaughan and Hoffmeister, 1926. Synonyms = *Pavona machapooriensis* Vaughan in Vaughan and Hoffmeister, 1926.
42) *P.* (*Pavona*) *trinitatis* Vaughan in Vaughan and Hoffmeister, 1926.

Helioseris Milne Edwards and Haime, 1849a: unifacial explanate colonies; thickened outer wall; short to long series; open calices; horizontal bars on septocostae; smooth thin septa; weak or absent columella.

43) *H. cucullata* (Ellis and Solander, 1786).
44) *H.* sp. A.

Leptoseris Milne Edwards and Haime, 1849a: unifacial explanate or branched colonies; thickened outer wall; proximally exsert calices; horizontal bars on septocostae.

45) *L. anguillensis* (Vaughan, 1919).
46) *L. cailleti* (Duchassaing and Michelotti, 1866).
47) *L. gardineri* (van der Horst, 1921); Figure 1.10.
48) *L. glabra* Dinesen, 1980.
49) *L.* sp. A.
50) *L.* sp. B.
51) *L. walli* Vaughan in Vaughan and Hoffmeister, 1926.

E. Family Siderastreidae Vaughan and Wells, 1943: fenestrate septa, synapticulothecal.

Psammocora Dana, 1846: collines present; intratentacular budding; petaloid septal arrangement.

52) *P. trinitatis* Vaughan in Vaughan and Hoffmeister, 1926; Figure 1.11. Synonyms = *Psammocora wyckoffi* Hoffmeister in Vaughan and Hoffmeister, 1926.

Siderastrea Blainville, 1830: cerioid; extratentacular budding.

53) *S. conferta* (Duncan, 1863).
54) *S. mendenhalli* Vaughan, 1917. Synonyms = *S. californica* Vaughan, 1917; *S. hillsboroensis* Vaughan, 1919.
55) *S. pliocenica* Vaughan, 1919.
56) *S. radians* (Pallas, 1766).
57) *S. silecensis* Vaughan, 1919; Figure 1.12. Synonyms = *Siderastrea banksi* Weisbord, 1973; *Siderastrea dalli* Vaughan of Meeder, 1987, and of Weisbord, 1974.
58) *S. siderea* (Ellis and Solander, 1786).
59) *S. stellata* Verrill, 1868.

Pironastrea d'Achiardi, 1875: explanate colonies with centers in concentric series formed by circumoral budding.

60) *P. anguillensis* Vaughan, 1919.
61) *P. antiguensis* Vaughan, 1919.

F. Family Poritidae Gray, 1842: porous septa, well-defined calices, reduced coenosteum.

Porites Link, 1807: cerioid to subplocoid; two septal cycles; bilateral symmetry.

I. *Porites* with widely spaced calices and a well-developed wall reticulum.

62) *P. anguillensis* Vaughan, 1919.
63) *P. astreoides* Lamarck, 1816 [may be >1 sp.].
64) *P. macdonaldi* Vaughan, 1919; Figure 2.1.
65) *P. portoricensis* (Vaughan, 1919). Synonyms = *Goniopora clevei* Vaughan, 1919; *Porites* (*Synaraea*) *howei* Vaughan, 1919; *Psammocora gasparillensis* Vaughan in Vaughan and Hoffmeister, 1926; *Goniopora ballistensis* Weisbord, 1973; *Goniopora matsoni* Weisbord, 1973.
66) *P. trinitatis* Vaughan in Vaughan and Hoffmeister, 1926.
67) *P. verrilli* Rehberg, 1893.
68) *P. waylandi* Foster, 1986. Synonyms = *Porites panamensis* Vaughan, 1919; *Porites* aff. *P. astreoides* Lamarck of Vaughan and Hoffmeister, 1926; *Porites floridaeprima* Bernard of Weisbord, 1973.

II. *Porites* with narrowly spaced calices and a poorly developed wall reticulum.

69) *P. baracoaensis* Vaughan, 1919. Synonyms = *Porites douvillei* Vaughan, 1919; *Porites toulai* Vaughan, 1919; *Porites* aff. *P. porites* (Pallas) of Vaughan and Hoffmeister, 1926.
70) *P. branneri* Rathbun, 1887.
71) *P. carrizensis* Vaughan, 1917.
72) *P. chipolanum* Weisbord, 1971.
73) *P. colonensis* Zlatarski, 1990.
74) *P. convivatoris* Foster, 1986.
75) *P. divaricata* Lesueur, 1821 [may be >1 sp.]. Synonyms = *Porites porites* var. *divaricata* of Geister, 1975.
76) *P. furcata* Lamarck, 1816. Synonyms = *Porites porites* var. *furcata* of Geister, 1975.
77) *P. porites* (Pallas, 1766). Synonyms= *Porites clavaria* Lamarck of Geister, 1975.

Goniopora Blainville, 1830: cerioid to subplocoid; 3 septal cycles; bilateral symmetry.

78) *G. calhounensis* Weisbord, 1971.
79) *G. hilli* Vaughan, 1919; Figure 2.2. Synonyms = *Goniopora jacobiana* Vaughan, 1919; *Goniopora tampaensis* Weisbord, 1973.
80) *G. imperatoris* Vaughan, 1919. Synonyms = *Goniopora decatu-*

rensis Vaughan of Weisbord, 1973; *Goniopora jacobiana* Vaughan of Meeder, 1987.

81) *G. panamensis* Vaughan, 1919.

Alveopora Blainville, 1830: cerioid to subplocoid; rudimentary septa; distinctive thecal pores.

82) *A. tampae* Weisbord, 1973.

G. Family Faviidae Gregory, 1900: strongly dentate margins and rare synapticulae.

Caulastrea Dana, 1846: phaceloid; mono- to tristomodaeal budding; spongy columella; equal, well-developed costae.

83) *C. portoricensis* (Coryell in Coryell and Ohlsen, 1929).

Cladocora Ehrenberg, 1834: phaceloid; trabecular columella; septothecal.

84) *C. arbuscula* (Lesueur, 1821).
85) *C. johnsoni* Gane, 1895.
86) *C.* sp. A.

Favia Oken, 1815: massive; plocoid, intratentacular budding; strong costae, not thickened near the wall; trabecular columella; septothecal.

87) *F. dominicensis* Vaughan in Vaughan and Hoffmeister, 1925.
88) *F. fragum* (Esper, 1797).
89) *F. gravida* Verrill, 1868.
90) *F. leptophylla* Verrill, 1868.
91) *F.* sp. A; Figure 2.3.

Goniastrea Milne Edwards and Haime, 1848: massive; meandroid or cerioid; mono- to polycentric corallites arranged in a series; dentate septa; discontinuous columella with paliform lobes.

92) *G. canalis* Vaughan, 1919. Synonyms = *Favites yborensis* Weisbord, 1973.

Diploria Milne Edwards and Haime, 1848: massive; meandroid; continuous columella, trabecular; single walled, septothecal; no internal lobes; valley width usually <12 mm.

93) *D. bowersi* Vaughan, 1917.
94) *D. clivosa* (Ellis and Solander, 1786).
95) *D. labyrinthiformis* (Linnaeus, 1758).
96) *D. sarasotana* Weisbord, 1974.
97) *D. strigosa* (Dana, 1848).
98) *D.* sp. A.
99) *D.* sp. B; Figure 2.4.

Manicina Ehrenberg, 1834: meandroid; continuous, trabecular columella; single walled (sometimes double walled), septothecal; internal lobes; valley width usually >12 mm.

I. *Mancina* s.s.: branched series.

100) *M. areolata* (Linnaeus, 1758).
101) *M. mayori* Wells, 1936.
102) *M. puntagordensis* Weisbord, 1968; Figure 2.5. Synonyms = *Manicina* cf. *M. gyrosa* (Ellis and Solander) of Weisbord, 1974; *Manicina areolata* forma *mayori* of Meeder, 1987.

II. *Teleiophyllia* Duncan, 1864: unbranched series; freeliving.

103) *M.* (*T.*) *grandis* (Duncan, 1864).
104) *M.* (*T.*) *navicula* (Duncan, 1864).
105) *M.* (*T.*) sp. A.
106) *M.* (*T.*) sp. B; Figure 2.6.
107) *M.* (*T.*) sp. C.
108) *M.* (*T.*) sp. D.

Thysanus Duncan, 1863: unidirectional branched and unbranched series; continuous, trabecular columella; septothecal; freeliving.

109) *T. crassicostatus* Vaughan in Vaughan and Hoffmeister, 1925.
110) *T. excentricus* Duncan, 1863; Figure 2.7. Synonyms = *Thysanus hayesi* Vaughan, 1919; *Thysanus vaughani* Weisbord, 1971.
111) *T. floridanus* Weisbord, 1974.

Colpophyllia Milne Edwards and Haime, 1848: massive; meandroid; discontinuous columella with lamellar linkage; commonly double walled, parathecal: valley width usually >15–20 mm.

112) *C. amaranthus* (Müller, 1775).
113) *C. breviserialis* Milne Edwards and Haime, 1849a.
114) *C. natans* (Müller, 1775); Figure 2.8.

Antiguastrea Vaughan, 1919: massive, plocoid; extratentacular budding; weak costae; lamellar columella; septothecal.

115) *A. cellulosa* (Duncan, 1863). Synonyms = *Antiguastrea* cf. *A. cellulosa silicensis* Vaughan of Weisbord, 1971.

Montastraea Blainville, 1830: plocoid, extratentacular budding; strong costae, not thickened near the wall; trabecular columella; septothecal; massive.

I. *Montastraea* with approx. 24 septa.

116) *M. annularis* (Ellis and Solander, 1786) morph 1 of Knowlton et al., 1992.
117) *M. annularis* (Ellis and Solander, 1786) morph 2 of Knowlton et al., 1992. Synonyms = *Montastrea annularis* (Ellis and Solander) of Meeder, 1987, of Geister, 1982, of Weisbord, 1974, and of Geister, 1975.
118) *M. annularis* (Ellis and Solander, 1786) morph 3 of Knowlton et al., 1992.
119) *M. brevis* (Duncan, 1864).
120) *M. imperatoris* (Vaughan, 1919). Synonyms = *Montastrea annularis* (Ellis and Solander) of Weisbord, 1973.
121) *M. limbata* (Duncan, 1863); Figure 2.9.
122) *M.* sp. A.
123) *M. trinitatis* (Vaughan in Vaughan and Hoffmeister, 1926). Synonyms = *Orbicella cumutensis* Hoffmeister in Vaughan and Hoffmeister, 1926; *Orbicella altissima* (Duncan) of Vaughan and Hoffmeister, 1926.

II. *Montastraea* with ≫24 septa.

124) *M. canalis* (Vaughan, 1919). Synonyms = *Montastrea* cf. *M. costata* (Duncan) of Weisbord, 1971; *Montastrea tampaensis silecensis* (Vaughan) of Weisbord, 1973.
125) *M. cavernosa* (Linnaeus, 1767) morph 1 of Budd, 1993.
126) *M. cavernosa* (Linnaeus, 1767) morph 2 of Budd, 1993.
127) *M. cavernosa* (Linnaeus, 1767) morph 3 of Budd, 1993.
128) *M. cylindrica* (Duncan, 1863); Figure 2.10.
129) *M. endothecata* (Duncan, 1863). Synonyms = *Montastrea cavernosa* (Linnaeus) of Weisbord, 1971.
130) *M. tampaensis* (Vaughan, 1919).

Solenastrea Milne Edwards and Haime, 1848: massive; plocoid; extratentacular budding; extremely weak costae; trabecular columella with reduced paliform lobes; septothecal.

131) *S. bournoni* Milne Edwards and Haime, 1849a; Figure 2.11. Synonyms = *Cyphastrea tampae* Weisbord, 1973.
132) *S. fairbanksi* (Vaughan, 1900).
133) *S. hyades* (Dana, 1846). Synonyms = *Montastrea davisina* Weisbord, 1973; *Montastrea peninsularis* Weisbord, 1973.

Agathiphyllia Reuss, 1864: massive; plocoid; extratentacular budding; strong costae; trabecular collumella with strong paliform lobes; synapticulothecal.

134) *A. hilli* (Vaughan, 1919).

H. Family Trachyphylliidae Verrill, 1901: dentate septa, inner fan of trabeculae forming prominent lobes.

Trachyphyllia Milne Edwards and Haime, 1848: flabello-meandroid, polycentric.

135) *T. bilobata* (Duncan, 1863); Figure 2.12. Synonyms = *Antillia bullbrooki* Hoffmeister in Vaughan and Hoffmeister, 1926; *Antillophyllia chipolana* Weisbord, 1971; *Antillia willcoxi* (Dana) Vaughan of Weisbord, 1973; *Trachyphyllia* sp. 2 of Meeder, 1987; *Antillia* sp. 3 of Meeder, 1987; *Scolymia* sp. 4 of Meeder, 1987.
136) *T.* sp. A.

Antillophyllia Vaughan, 1932: solitary, monocentric.

137) *A. sawkinsi* (Vaughan in Vaughan and Hoffmeister, 1926).

I. Family Meandrinidae Gray, 1847: fine septal dentations, lamellar columella, solid coenosteum, invariably intratentacular budding.

Meandrina Lamarck, 1801: meandroid, intratentacular budding; lamellar septa; discontinuous columella.

I. *Meandrina* s.s.: species with more than one valley.

138) *M. braziliensis* (Milne Edwards and Haime, 1849a); Figure 3.1.
139) *M. meandrites* (Linnaeus, 1767).

II. *Placocyathus* Milne Edwards and Haime, 1848: species with only one valley; freeliving.

140) *M.* (*P.*) *alveolus* Duncan, 1863.
141) *M.* (*P.*) *barretti* Duncan, 1863.
142) *M.* (*P.*) *costatus* Duncan, 1864; Figure 3.2.
143) *M.* (*P.*) *trinitatis* Vaughan in Vaughan and Hoffmeister, 1926.
144) *M.* (*P.*) *variabilis* Duncan, 1864.

Dichocoenia Milne Edwards and Haime, 1848: polystomodaeal to meandroid; intratentacular budding; heavy, granular coenosteum; well-developed, trabecular columella.

145) *D. caloosahatcheensis* Weisbord, 1974.
146) *D. eminens* Weisbord, 1974.
147) *D. merriami* (Vaughan, 1900).
148) *D. stokesi* Milne Edwards and Haime, 1848.
149) *D. stellaris* Milne Edwards and Haime, 1849a.
150) *D. tuberosa* Duncan, 1863; Figure 3.3.

Dendrogyra Ehrenberg, 1834: meandroid with long corallite series; intratentacullar budding; columella composed of discontinuous lamella.

151) *D. cylindricus* Ehrenberg, 1834.

J. Family Oculinidae Gray, 1847: fine septal dentations, vesicular or solid coenosteum, extratentacular budding (only massive, exclusively hermatypic taxa included).

Galaxea Oken, 1815: massive, plocoid, no columella.

152) *G. excelsa* Weisbord, 1973; Figure 3.4.

K. Family Mussidae Ortmann, 1890: solitary or colonial with large coarse septal dentition.

Antillia Duncan, 1863: solitary, free living; septothecate with epitheca; regular large rounded septal dentition.

153) *A. dentata* Duncan, 1864; Figure 3.5.
154) *A. gregorii* Vaughan, 1901. Synonyms = *Syzygophyllia tampae* Weisbord, 1973.

Scolymia Haime, 1852: solitary, attached; parathecate, no epitheca; irregular attenuate or triangular septal dentition.

155) *S. cubensis* (Milne Edwards and Haime, 1849b).
156) *S. wellsi* (Laborel, 1967).
157) *S. lacera* (Pallas, 1766).

Mussa Oken, 1815: branched phaceloid; septothecate; no epitheca; irregular thin teeth.

158) *M. angulosa* (Pallas, 1766).

Mussismilia Ortmann, 1890: branched phaceloid or plocoid, parathecate, small regular septal dentition.

159) *M. braziliensis* (Verrill, 1868).
160) *M. harttii* (Verrill, 1868).
161) *M. hispida* (Verrill, 1901).

Isophyllia Milne Edwards and Haime, 1851: massive; parathecate; discontinuous series; trabecular linkage between centers; irregular thin teeth.

162) *I.* sp. A.
163) *I. sinuosa* (Ellis and Solander, 1786).

Isophyllastrea Matthai, 1928: massive; parathecate; mono- to tricentric calices; coarse or thin septal dentition; weak or absent columella.

164) *I.* sp. A.
165) *I. rigida* (Dana, 1848).

Mycetophyllia Milne Edwards and Haime, 1848: massive or plate shaped; calices in series with lamellar linkage between centers; irregular thin to coarse septal dentition.

166) *M. aliciae* Wells, 1973.
167) *M. bullbrooki* Vaughan in Vaughan and Hoffmeister, 1926.
168) *M. danaana* Milne Edwards and Haime, 1849a.
169) *M. ferox* Wells, 1973.
170) *M. lamarckiana* Milne Edwards and Haime, 1848.
171) *M. reesi* Wells, 1973.

L. Family Caryophylliidae Gray, 1847: costae covered by epitheca; exsert, subequal septa.

Eusmilia Milne Edwards and Haime, 1848: phaceloid; mono- to tristomodaeal budding; reduced columella.

172) *E. carrizensis* Vaughan, 1917.
173) *E. fastigiata* (Pallas, 1766).
174) *E. flabellata* Wells, 1973.
175) *E.* sp. A; Figure 3.6.

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