Gilbert Dennison Harris
(1864 - 1952)

Founder of the *Bulletins of American Paleontology* (1895)

ISBN 0-87710-41-

Bulletins of American Paleontology

VOLUME 102, NUMBER 340 JUNE 26, 1992

Neogene Paleontology in the northern Dominican Republic

14. Otoliths of teleostean fishes

by

Dirk Nolf and Gary L. Stringer

Paleontological Research Institution
1259 Trumansburg Road
Ithaca, New York, 14850 U.S.A.

A list of titles in both series, and available numbers and volumes may be had on request. Volumes 1–23 of *Bulletins of American Paleontology* have been reprinted by Kraus Reprint Corporation, Route 100, Millwood, New York 10546 USA. Volume 1 of *Palaeontographica Americana* has been reprinted by Johnson Reprint Corporation, 111 Fifth Ave., New York, NY 10003 USA.

Subscriptions to *Bulletins of American Paleontology* may be started at any time, by volume or year. Current price is US $45.00 per volume. Numbers of *Palaeontographica Americana* are priced individually, and are invoiced separately on request.

for additional information, write or call:

Paleontological Research Institution
1259 Trumansburg Road
Ithaca, NY 14850 USA
(607) 273-6623

The Paleontological Research Institution
acknowledges with special thanks
the contributions of the following individuals and institutions

PATRONS

($1000 or more at the discretion of the contributor)

James E. Allen (1967)
American Oil Company (1976)
Atlantic Richfield Company (1978)
Christina L. Balk (1970, 1982, 1983)
Hans M. Bolli (1984)
Ruth G. Browne (1986)
Mr. & Mrs. Kenneth E. Caster (1967)
Chevron Oil Company (1978, 1982)
Exxon Company (1977 to date)
Lois S. Fogelsanger (1966)
Gulf Oil Corporation (1978)
Merrill W. Haas (1975)
Robert C. Hoerle (1974–1977)
Richard I. Johnson (1967, 1986)
J. M. McDonald Foundation (1972, 1978)
Mobil Oil Corporation (1977 to date)
Samuel T. Pees (1981)
Richard E. Petit (1983)
Robert A. Pohowsky (1982)
Texaco, Inc. (1987 to date)
Union Oil of California (1982 to date)
United States Steel Foundation (1976)
Charles G. Ventress (1983 to date)
Christine C. Wakeley (1976–1984)

(continued overleaf)

LIFE MEMBERS

($400)

R. Tucker Abbott
James E. Allen
Elizabeth A. Balcells-Baldwin
Christina L. Balk
Bruce M. Bell
Robert A. Black
Richard S. Boardman
Hans Bolli
David John Bottjer
Ruth G. Browne
J. David Bukry
Sybil B. Burger
Lyle D. Campbell
John L. Carter
Anneliese S. Caster
Kenneth E. Caster
John E. DuPont
J. Thomas Dutro, Jr.
J. Mark Erickson
Richard J. Erickson
Lois S. Fogelsanger
A. Eugene Fritsche
Christopher L. Garvie
Ernest H. Gilmour
Merrill W. Haas
Anita G. Harris
Steven M. Herrick
Carole S. Hickman
Robert C. Hoerle
F. D. Holland, Jr.
Frederick H. C. Hotchkiss
David Jablonski
Richard I. Johnson
David B. Jones
Peter Jung
Tomoki Kase
Patricia H. Kelley
David Garrett Kerr
Cecil H. Kindle
William F. Klose, II
Jiří Kříž
Ralph L. Langenheim, Jr.
Harry A. Leffingwell
Egbert G. Leigh, Jr.
Gerard A. Lenhard
Louie N. Marincovich, Jr.
Donald R. Moore
Shuji Niko
Hiroshi Noda
Sakae O'Hara
William A. Oliver, Jr.
Samuel T. Pees
Richard E. Petit
Edward B. Picou, Jr.
Robert A. Pohowsky
John Pojeta, Jr.
John K. Pope
Anthony Reso
Arthur W. Rocker
Arnold Ross
Walter E. Sage, III
John B. Saunders
Judith Schiebout
Edward S. Slagle
Robert E. Sloan
Richard L. Squires
David H. Stansbery
Jorge P. Valdes
Raymond Van Houtte
Charles G. Ventress
William P. S. Ventress
Emily H. Vokes
Harold E. Vokes
Christine C. Wakeley
Thomas R. Waller
Albert D. Warren, Jr.
Gary D. Webster
Ralph H. Willoughby
Armour C. Winslow
Thomas E. Yancey
Victor A. Zullo

PALEONTOLOGICAL RESEARCH INSTITUTION
FOUNDED 1932

Bulletins of American Paleontology

VOLUME 102, NUMBER 340 JUNE 26, 1992

Neogene Paleontology in the northern Dominican Republic

14. Otoliths of teleostean fishes

by

Dirk Nolf and Gary L. Stringer

Paleontological Research Institution
1259 Trumansburg Road
Ithaca, New York, 14850 U.S.A.

Library of Congress Card Number: 85-63715

Printed in the United States of America
Allen Press, Inc.
Lawrence, KS 66044 U.S.A.

CONTENTS

Page

Abstract ... 45
Resumen ... 45
Introduction ... 46
Acknowledgments ... 48
Abbreviations of Repository Institutions ... 48
Some anatomical and morphological remarks on otoliths ... 48
Systematic Paleontology
  Introduction ... 49
  Description of new species and remarks on taxa requiring comments
    Genus *Plotosus* Lacepède, 1803 ... 51
    Genus *Diaphus* Eigenmann and Eigenmann ... 51
    Genus *Brotula* Cuvier, 1829 ... 51
    Genus *Lepophidium* Gill, 1895 ... 52
    Genus *Otophidium* Gill *in* Jordan, 1885 ... 52
    Genus *Neobythites* Goode and Bean, 1885 ... 53
  Tribe Dinematichthyini
    "genus Dinematichthyinorum" ... 53
    Genus *Apogon* Lacepède, 1801 ... 54
    Genus *Lactarius* Valenciennes *in* Cuvier and Valenciennes, 1833 ... 54
    Genus *Conodon* Cuvier *in* Cuvier and Valenciennes, 1830 ... 54
    Genus *Haemulon* Cuvier, 1829 ... 55
    Genus *Ctenosciaena* Fowler and Bean, 1923 ... 55
    Genus *Larimus* Cuvier *in* Cuvier and Valenciennes, 1830 ... 56
    Genus *Menticirrhus* Gill, 1861b ... 56
    Genus *Ophioscion* Gill, 1863 ... 56
    Genus *Pareques* Gill *in* Goode, 1876 ... 56
  Family Gobiidae Bonaparte, 1832 ... 56
  Family Pleuronectidae Rafinesque, 1815 ... 57
Conclusions
  Critical considerations of the available data ... 57
Paleoenvironmental evaluation ... 57
Paleobiogeographic affinities and relationships of the Paleogene and Recent Caribbean fauna ... 60
Comparison with other Neogene otolith associations in the Eastern North American and Caribbean realm ... 61
Appendix. Alphabetical list of otolith-based fish taxa in the localities from the Neogene of the Dominican Republic ... 61
References Cited ... 63
Plates ... 66
Index ... 76

LIST OF ILLUSTRATIONS

Text-figure | Page

1. Geological sketch map of the Cibao Valley, northern Dominican Republic 46
2. Position of otoliths in the braincase of *Oncorhynchus mykiss* (Walbaum, 1792), and in the labyrinth of *Salvelinus fontinalis* (Mitchill, 1814) 48
3. Morphology of the inner face of a saccular otolith 49

LIST OF TABLES

Table | Page

1. Stratigraphic sections from six of the river valleys studied for this project, showing approximate correlations 47
2. List of teleost species represented by otoliths in the Neogene of the Dominican Republic 50
3. Present-day bathymetric range of taxa represented in the Neogene of the Dominican Republic 58

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC
14. Otoliths of teleostean fishes

by

DIRK NOLF[1]
and
GARY L. STRINGER[2]

ABSTRACT

The study of fossil otoliths has allowed us to reconstruct a teleost fauna of 84 species for the Neogene of the Cibao Valley area, northern Dominican Republic. Thirty-one of those could be attributed to nominal species and 53 are described in open nomenclature. Among the nominal species, 22 belong to Recent Central American species or very closely related species, and eight represent extinct species that are new: *Lepophidium latesulcatum*, *Otophidium robinsi*, *Otophidium robustum*, "genus Dinematichthyinorum" *smithvanizi*, "genus Dinematichthyinorum" *sauli*, *Conodon moreauxi*, *Ctenosciaena latecaudata*, and *Menticirrhus chaoi*. Many taxa could not be identified at the species level because the knowledge of otoliths of related Recent Central American species is too restricted. Although the bulk of the material comes from the late Miocene NN11 Zone, restricted associations from other levels allow us to draw some paleoenvironmental conclusions for most of the levels. The association from the Baitoa Formation consists of very shallow-water taxa that all occur in depths of less than 50 meters. The associations from the Cercado Formation and from the the basal part of the Gurabo Formation consist essentially of neritic taxa that lived in depths of less than 50 meters. At least 11 of the taxa are also regular inhabitants of euryhaline environments such as lagoons or estuaries. Beside these forms, some deeper-ranging taxa also occur, but none of these are confined to soft-bottom neritic environments. The information available for the NN12–NN13 interval of the Gurabo Formation is very scattered. The otolith associations are restricted in the Mao Formation (NN14–NN15 interval), but it is possible to conclude that the environment was deep neritic or, more likely, upper slope. The studied fauna can be considered very close to that of the present-day Caribbean, except for *Plotosus* Lacepède, 1803 and *Lactarius* Valenciennes *in* Cuvier and Valenciennes, 1833, which we interpret as relicts of the Paleogene Western Tethys fauna. In terms of both abundance in number of specimens and taxonomic diversity, the best-represented groups are ophidiids, haemulids, and sciaenids. These groups are also well-represented in Paleogene otolith associations of the U. S. Gulf Coast and in the Recent Caribbean fauna. Analysis of the available data provides evidence that near the Oligocene–Miocene boundary, important evolutionary events affected some of the groups of Caribbean teleosts, and that in the concerned groups, affinities of the Neogene forms are much closer to the Recent fauna than to the Paleogene one. A weak point in such a statement however, is our complete ignorance of Paleogene faunas for the southern Caribbean and eastern Pacific realm, because the possibility exists that in these areas relatives of "modern" Central American taxa already existed in the Paleogene.

RESUMEN

El estudio de otolitos fósiles nos ha permitido reconstruir una fauna teleostea de 84 especies en el Neógeno del Valle Cibao, localizado en el norte de la República Dominicana. De estos taxones, treinta y uno han sido atribuidos a especies nominales y 53 descriptos con nomenclatura abierta. Dentro de las especies nominales, vientidos pertenecen a especies centroamericanas recientes, o especies consanguineas, mientras que ocho representan nuevas especies extintas: *Lepophidium latesulcatum*, *Otophidium robinsi*, *Otophidium robustum*, "genus Dinematichthyinorum" *smithvanizi*, "genus Dinematichthyinorum" *sauli*, *Conodon moreauxi*, *Ctenosciaena latecaudata*, y *Menticirrhus chaoi*. Muchos taxones no han podido identificados a nivel específico porque el conocimiento de otolitos de especies centroamericanas consanguineas recientes es demasiado restringido. Aún cuando la mayor parte de las muestras provienen de la zona N11 (Mioceno tardío), asociaciones restringidas de otros niveles nos permiten llegar a conclusiones paleoambientales para la mayor parte de los niveles. Las asociaciones de la Formación Baitoa consisten en taxones de aguas muy someras localizadas a menos de 50 m de profundidad. Las asociaciones de la Formación Cercado y de la parte basal de la Formación Gurabo consisten esencialmente de taxones neríticos que vivieron en profundidades menores que 50 m. Por lo menos 11 de los taxones son también habitantes regulares de ambientes salobres como albúferas o estuarios. Además de estas formas, también se encuentran algunos taxones que habitan aguas profundas, pero ninguno de éstos se halla confinado a ambientes neríticos de sedimentación fina. La información disponible de las zonas NN12–NN13 de la Formación Gurabo se encuentra muy dispersada. Las asociaciones otolíticas están restringidas a la Formación Mao (zonas NN14–NN15), pero es posible concluir que el paleoambiente fue nerítico de aguas profundas, o, probablemente, de la parte alta del talud continental. Se puede considerar a la fauna estudiada muy cercana a la actual del Mar Caribe, con excepción de *Plotosus* Lacepède, 1803 y *Lactarius* Valenciennes *en* Cuvier y Valenciennes, 1833, que interpretamos como relictos de la fauna paleógena del Tethys occidental. En términos de abundancia de especímenes y de diversidad taxonómica, los grupos mejores representados son ophidiidos, haemulidos, y sciaenidos. También estos grupos se hallan bien representados en las asociaciones otolíticas paleógenas

[1] Royal Belgian Institute of Natural Sciences, 29, Vautierstraat, 1040 Brussels, BELGIUM.
[2] 110 Patton Drive, West Monroe, LA 71291, U. S. A.

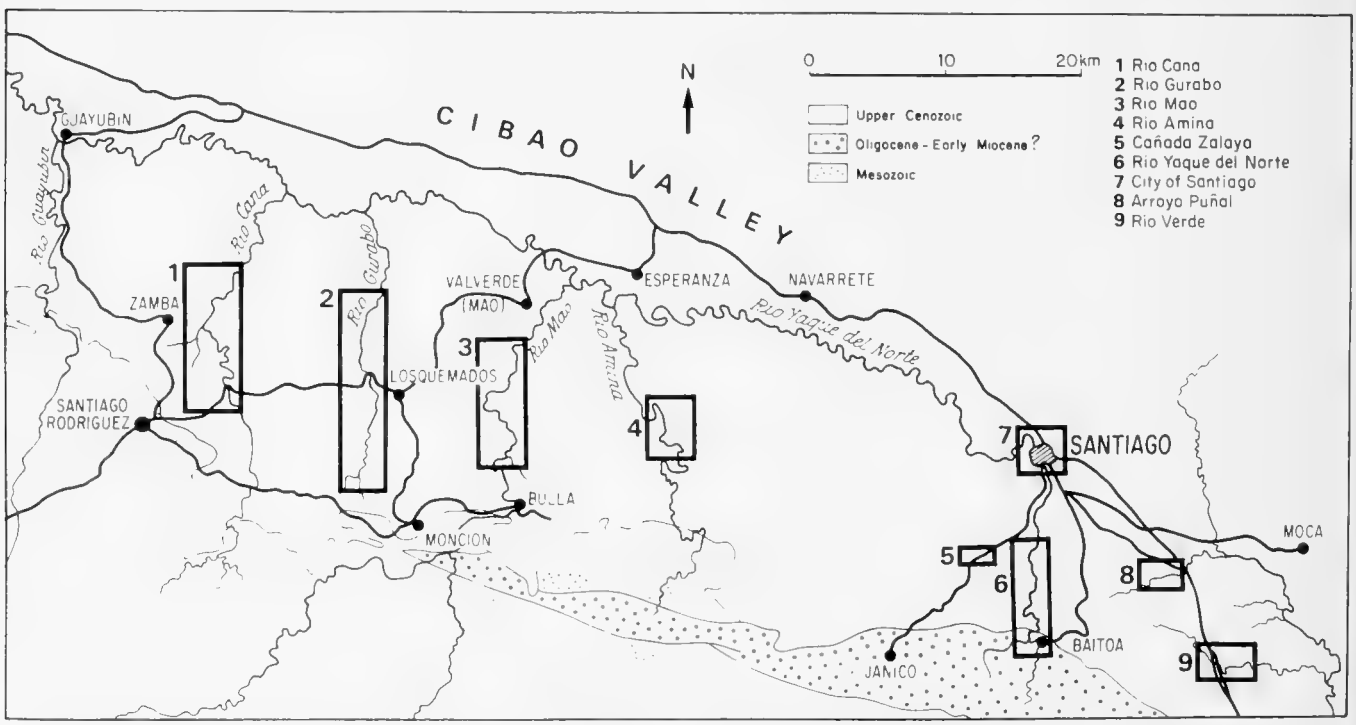
de la costa del golfo de Mexico de los Estados Unidos, como así también en la fauna reciente del Mar Caribe. Análisis de los datos disponibles muestran evidencias de que cerca del límite Oligoceno–Mioceno, importantes eventos evolutivos afectaron a unos de los grupos de teleósteos del Caribe, y dentro de estos grupos, las formas Neógenas se parecen más a las faunas modernas que a las del Paleógeno. Un punto débil en esta declaracion es, sin embargo, nuestra falta de conocimiento acerca de las faunas paleógenas de las regiones del sur de Caribe y este del Océano Pacifico, porque existe la posibilidad de que en estas áreas, parientes de estos taxones centroamericanos "modernos" hubieran existido en el Paleógeno.

INTRODUCTION

Otoliths, or ear stones, are very common fossils of teleostean fishes, and are present in a broad spectrum of sedimentary environments. They are unique among vertebrate fossils in the sense that they are not parts of the skeletons but specialized hard parts of the acousticolateralis system. The mineral composition of otoliths is calcium carbonate, not calcium phosphate like in bone. In most genera, otoliths are species-diagnostic and represent a valuable tool in the reconstruction of the teleostean fauna of a specific geologic period.

In contrast to the situation in Europe, little is known about the otoliths in the North American Tertiary. The first report on North American otoliths is by Koken (1888), who described 23 species from Paleogene deposits of the U. S. Gulf Coast. Except for some casual remarks (Eastman, 1904), no otolith-based faunal reconstruction was published before the work of Frizzell and Dante (1965), who described 24 species resulting from an eclectic sampling of the U. S. Gulf Coast Paleogene. Previously, Frizzell and Lamber (1961, 1962) published two short articles, one on "myripristids" and one on congrid otoliths from the same area and age. Several species described in the above cited papers appeared in faunal lists of two localities in the late Eocene of Louisiana (Stringer, 1979, 1986), but no formal descriptions of additional species were included. The above cited publications, except for Eastman (1904), deal with Paleogene material and although they are not directly related to the present study, provide information on the Paleogene history of teleosts in the Caribbean and Gulf Coast areas.

For the Neogene of the U. S. Gulf and Atlantic coasts, only two relevant papers treat fossil fish otoliths: Fitch and Lavenberg (1983) provided a list of 45 otolith-based taxa, including 16 Recent species, from the Pliocene of the Lee Creek Mine, North Carolina; Clarke and Fitch (1979), in a paper on cephalopods, referred to the presence of otoliths of ten fish families in the early Miocene Chipola Formation, about 80 km east of Tallahassee, Florida. In the Plio-Pleistocene of California, the presence of many Recent eastern Pacific species has been reported in various publications by Fitch and collaborators, but those data do not pertain to the present topic.



Text-figure 1.—Geological sketch map of the Cibao Valley, northern Dominican Republic, showing areas from which samples were collected (Saunders, Jung and Biju-Duval, 1986, text-fig. 3, p. 7).

For the Central American and Caribbean, a few otoliths were described by Schubert (1909), Casier (1958, 1966) and Weiler (1959), but the only more substantial description of an otolith-based fauna in this area is by Nolf (1976) on the Neogene otoliths of Trinidad, describing 66 teleost taxa among which 11 are Recent species. The only other sources of information for this region are a locality description of the Bowden Formation of Jamaica in which some fish taxa based on otoliths are reported (Clarke and Fitch, 1979), and an annotated list of names (genus or family level), published by Gillette (1984) after provisional identifications of otoliths by the late John Fitch (Gillette, 1984, p. 182 writes: "I have accepted the identifications uncritically . . . and prepared the annotations"). The entire knowledge of South American fossil otoliths consists of a single sciaenid species described by Leriche (1938).

This brief survey of the status of North and South American fossil otolith studies emphasizes the importance of a fauna of 84 teleosts based on otoliths from the Dominican Republic. Identifiable otoliths have been recorded from 109 localities from the Neogene of the Dominican Republic. The stratigraphic interval that furnished the richest assemblages was the late Miocene Cercado Formation and, more generally, the late Miocene sediments that can be attributed to the NN11 Zone.

Detailed descriptions of the localities and their geographic and stratigraphic position are provided by Saunders, Jung, and Biju-Duval (1986). However, to make the present study more relevant, the survey of the sampled areas in the Cibao Valley and the stratigraphic framework of the area as given by Saunders, Jung and Biju-Duval (1986) are presented in Textfigure 1 and Table 1 respectively. A complete and de-

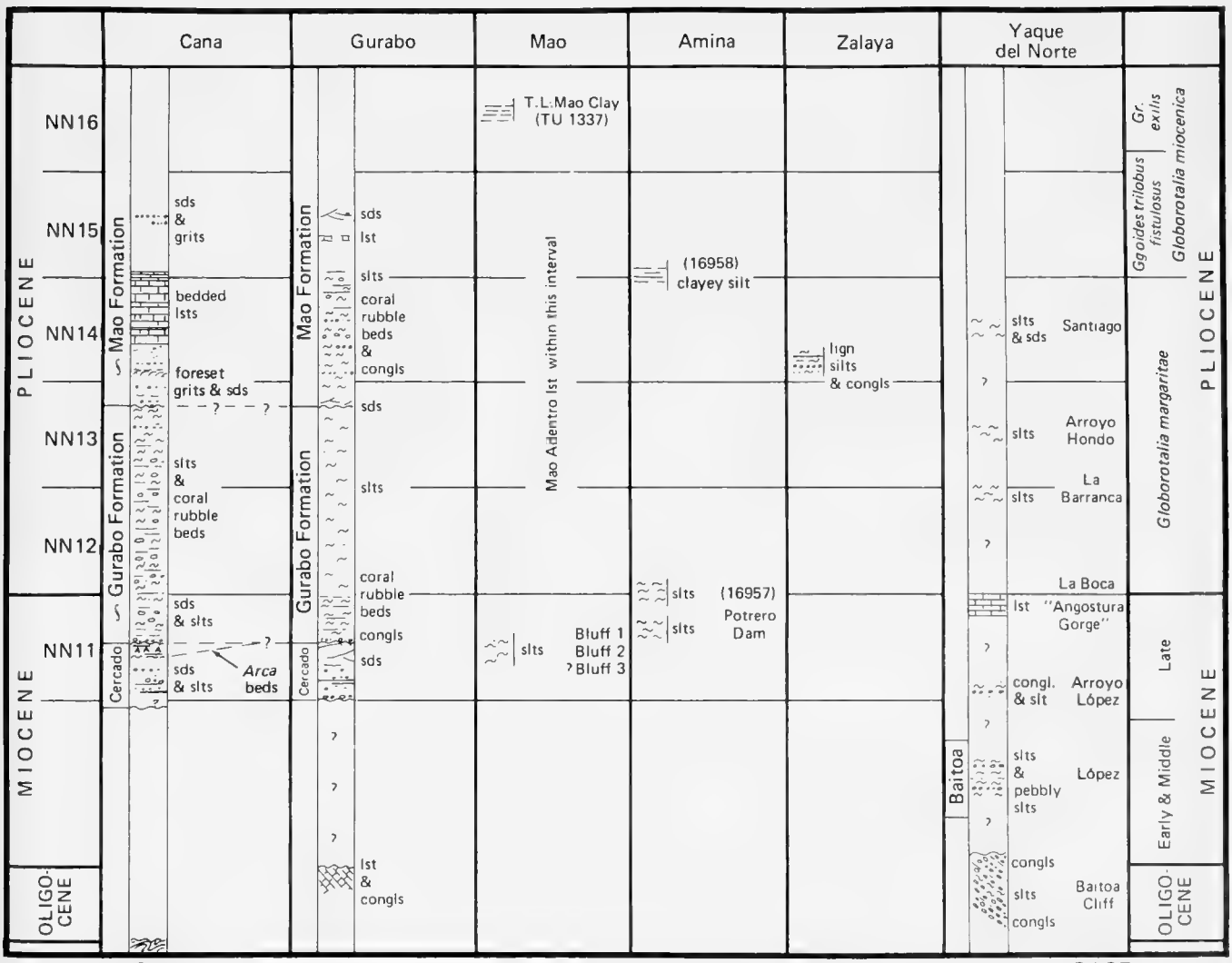


Table 1.—Stratigraphic sections from six of the river valleys studied for this project, showing approximate correlations. The sections are arranged in geographic order, *i.e.*, left to right = west to east (from Saunders, Jung and Biju-Duval, 1986, table 3, p. 35).

tailed summary of the otolith-bearing localities is presented in the Appendix.

ACKNOWLEDGMENTS

We especially thank Peter Jung (Naturhistorisches Museum, Basel, Switzerland) and Emily and Harold Vokes (Tulane University, New Orleans, LA, U. S. A.) for the confidence that they accorded us by proposing the study of the otolith material from their Dominican Republic expeditions. This study would not have been possible without their assistance.

Precise identifications and evaluations of the relationships of the fossil taxa to their Recent relatives would not have been possible without the assistance of all the people who authorized the dissection of the necessary comparative Recent fish species in the collections under their care. Eugenia Böhlke, William F. Smith-Vaniz, and William Saul (ANSP), C. Richard Robins (UMML), Stanley H. Weitzman, Robert H. Gibbs, G. David Johnson, and Bruce B. Collette (USNM), Daniel M. Cohen and Robert Lavenberg (LACM), Karl Liem and Karsten Hartel (MCZ), P. Humphrey Greenwood, Colin Patterson, and Peter J. P. Whitehead (BMNH) generously provided us with the Caribbean species required for this study.

Finally, we are very obliged to Jiri Zidek (New Mexico Bureau of Mines and Mineral Resources, Socorro, NM, U. S. A.) for his critical reading of the text, to Rostislav Brzobohaty (University of Brno, Czechoslovakia) and to C. Richard Robins for reviewing our manuscript, and to Daniel Bavay (State University of Ghent, Belgium) for the plate drawings.

ABBREVIATIONS OF REPOSITORY INSTITUTIONS

ANSP: Academy of Natural Sciences, Philadelphia, PA, U. S. A.

BMNH: British Museum (Natural History), London, England, U. K.

IRSNB: Institut royal des Sciences naturelles de Belgique [Royal Belgian Institute of Natural Sciences], Brussels, Belgium.

LACM: Los Angeles County Museum of Natural History, Los Angeles, CA, U. S. A.

MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, MA, U. S. A.

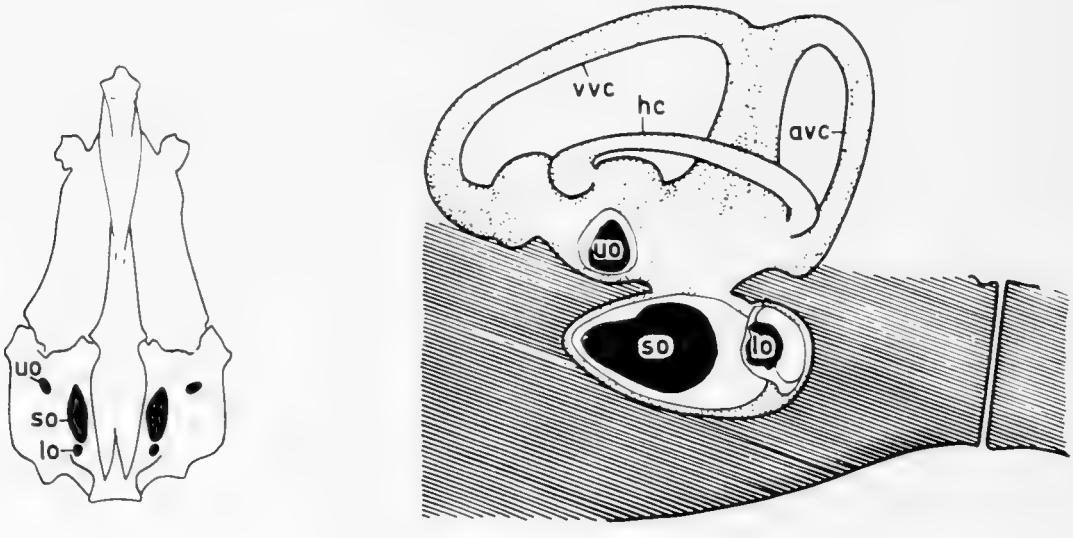
NMB: Naturhistorisches Museum Basel, Basel, Switzerland.

UMML: University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, U. S. A.

USNM: United States National Museum of Natural History, Smithsonian Institution, Washington, DC, U. S. A.

SOME ANATOMICAL AND MORPHOLOGICAL REMARKS ON OTOLITHS

The otoliths, statico-acoustic organs of actinopterygian and sarcopterygian fishes, are situated in the membraneous labyrinth located in the otic capsules of the neurocranium. The otoliths consist of calcium carbonate, mainly in the aragonite form, and organic matter known as otoline. On each side of the brain, inside the brain, there are three otoliths: one in the utriculus,



Text-figure 2.—**a**, Position of otoliths in the braincase (ventral view) of *Oncorhynchus mykiss* (Walbaum, 1792); **b**, position of the otoliths in the labyrinth of *Salvelinus fontinalis* (Mitchill, 1814), after Rosen and Greenwood (1970). **avc** = anterior vertical semicircular canal; **hc** = horizontal semicircular canal; **lo** = lagenar otolith; **so** = saccular otolith; **uo** = utricular otolith; **vvc** = posterior vertical semicircular canal.

one in the sacculus and one in the lagena of the labyrinth. The position of the otoliths in the neurocranium and their position in the labyrinth are shown in Text-figure 2.

In nearly all teleosts (with the exception of non-gonorhynchiform ostariophysians), the saccular otolith grows much larger than the utricular or lagenar otolith. Except in ostariophysian fishes, the saccular otolith is usually the only one collected in paleontological samples and is the usual tool for taxonomic investigations.

All identifications in this study are based on saccular otoliths with the exception of the ariids, which are represented by utricular otoliths, and the genus *Bairdiella* Gill, 1861a, which is represented by saccular and utricular otoliths. When the term otolith is used in this study, it refers to the saccular otolith. The major morphological features of actinopterygian and paracanthopterygian fish otoliths are shown in Text-figure 3. The major diagnostic features of an otolith are its outline, the pattern and degree of incision of the sulcus (contact area with the sensorial epithelium), the convexity of the inner face, the convexity or concavity of the outer face, and the thickness. Problems concerning variability, ontogenetic changes, and preservation of otoliths are discussed extensively by Nolf (1985).

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

A list of all otolith-based species from the Neogene of the Dominican Republic with their stratigraphic position and occurrence in the various sampled sections is given in Table 2. An alphabetical list of otolith-based species and the localities at which they occur, as well as their abundance at each locality in the Neogene of the Dominican Republic is given in the Appendix.

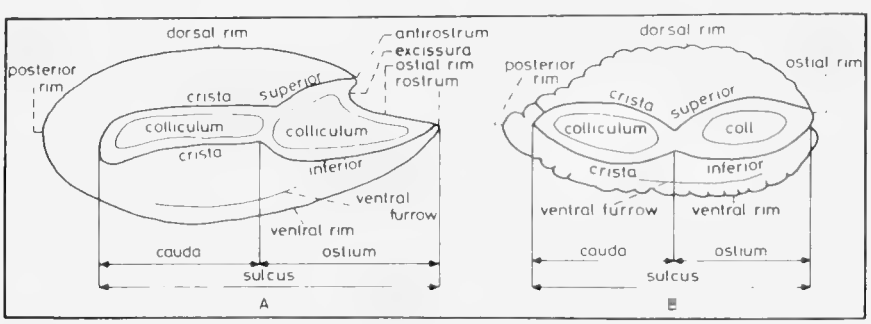
The classification adopted here is the one utilized by Nolf (1985) in the *Handbook of Paleoichthyology*. The classification is basically the same as that of Greenwood *et al.* (1966) with some modifications as noted by Nolf (1985, p. 34).

Drawings of all cited species are presented in the plates. In some cases, the Recent comparative material on which the generic identification was based is also figured. Additional comments are given only for new species or those subject to discussion.

Studies by Nolf (1976) on the Neogene otoliths of Trinidad indicated clearly that various Recent species, especially some of those inhabiting low relief sandy and muddy environments or living on the continental slope, were already present in the Neogene of the Caribbean area. Recent species have also been identified in various Neogene strata of Europe. This makes it difficult to decide whether a Neogene otolith, identified at the generic level, belongs to an extinct or an extant species, if the otoliths of all the Recent species of the genus from the concerned biogeographic area are not known. Therefore, the precaution has been taken not to introduce any new species unless otoliths of all known Recent Caribbean species of the genus are known.

In several cases, specific identity could not be unequivocally decided. In those cases, the abbreviation *aff.* (*affinis*) was inserted between the name of the genus and the name of the group species. The abbreviation *cf.* (*confer*) was used in cases where the condition of preservation of the otolith did not allow conclusive specific identification. Many taxa appear in open nomenclature for identification at the species level due to insufficient knowledge of related Recent species or because the fossil material is too limited or too poorly preserved to decide.

Although nearly all the otoliths could easily be allocated to Recent genera, a few did not match any Recent genus known to us. Such otoliths may belong either to an extinct genus or to a Recent genus whose otoliths have not yet been described, and placing them in a fossil genus would thus be a purely arbitrary decision. Even in those rare cases where knowledge of Recent otoliths of a group is very extensive and might justify a fossil genus, we think that it is wise not to use exclusively otolith-based genera. For such species of uncertain generic position, the word "genus" is used, followed by the name of the identifiable taxonomic level in the plural genitive, followed by the species name (*e.g.*, "genus Dinematichthyinorum" *smithvan-*



Text-figure 3.—Morphology of the inner face of a saccular otolith. A, actinopterygian type; B, paracanthopterygian type.

izi). This is currently practiced in papers on otolith taxonomy (for further explanation, see Nolf, 1985, p. 30).

All numbered collecting localities are those published in Appendices 3 and 4 of Saunders, Jung, and Biju-Duval (1986).

A = Río Amina
C = Río Cana
G = Río Gurabo
M = Río Mao
R = Recent
V = Río Verde (only sample TU1250)
Y = Río Yaque del Norte
Z = Arroyo Zalaya (only sample TU1227A)

		OLIGOCENE	MIOCENE			PLIOCENE							RECENT	ICONOGRAPHY
			Early & Middle	Late		*Globorotalia margaritae*			*Globorotalia miocenica*					
					NN11	NN12	NN13	NN14	NN15		NN16			
			Bartoa	arcado		← Gurabo Formation			← Mao Formation					
Albulidae	*Albula* sp.				GM									Pl. 9, figs. 1, 2
Congridae	*Ariosoma balearica* (Delaroche, 1809)		Y		CGM	C	A			Z			R	Pl. 9, fig. 3
	Ariosoma aff. *A. selenops* Reid, 1934				G					Y			R	Pl. 9, fig. 5
	Hildebrandia flava (Goode and Bean, 1896)						G		G	YZ	G		R	Pl. 9, figs. 11–13
	Rhechias tysanochila (Reid, 1934)				G					Z			R	Pl. 9, fig. 7
Heterenchelyidae	*Pythonichthys* sp.						V			Z	G			Pl. 9, figs. 8–10
Engraulidae	Engraulidae indet.				CGM									Pl. 9, fig. 16
Clupeidae	*Opisthonema* sp.					M								Pl. 9, fig. 17
	Clupeidae indet.				C									Pl. 9, fig. 18
Ariidae	*Arius* sp.		Y		CGM	G								Pl. 10, fig. 1
Plotosidae	*Plotosus* sp.				CM					Z				Pl. 10, fig. 3
Sternoptychidae	*Polyipnus* sp.				C		V							Pl. 10, fig. 10
Synodontidae	*Saurida caribbaea* Breder, 1927				GM		V						R	Pl. 10, figs. 26, 27
Myctophidae	*Diaphus* aff. *D. brachycephalus* Táning, 1928						AV			GZ	G		R	PL. 10, figs. 11–13
	Diaphus sp. 1		Y		CGM	GM	AV			GYZ	G			Pl. 10, figs. 18–23
	Diaphus sp. 2					M								Pl. 10, fig. 28
	Hygophum aff. *H. benoiti* (Cocco, 1838)				GM								R	Pl. 10, fig. 32
	Myctophum sp.				CM									Pl. 10, figs. 14, 15
Batrachoididae	*Porichthys* sp.				CGM	M								Pl. 11, fig. 3
Chaunacidae	*Chaunax* sp.						V							Pl. 11, fig. 4
Bregmacerotidae	*Bregmaceros* sp.				C	G	GV							Pl. 11, figs. 7, 8
Macrouridae	*Coelorinchus caribbaeus* (Goode and Bean, 1885)									Y			R	Pl. 11, fig. 6
	Nezumia aequalis (Günther, 1878)									G			R	Pl. 11, fig. 10
Carapidae	*Carapus* aff. *C. bermudensis* (Jones, 1874)				M					Z			R	Pl. 11, fig. 12
Ophidiidae	*Brotula* aff. *B. clarkae* Hubbs, 1944						V						R	Pl. 11, fig. 13
	Brotula sp.									Z				Pl. 11, fig. 14
	Lepophidium latesulcatum, n. sp.		Y		CGM	GM	A GVY	‹	G	Z				Pl. 11, fig. 11
	Otophidium robinsi, n. sp.				CGM	G								Pl. 11, figs. 16–19
	Otophidium robustum, n. sp.				CG	‹	V							Pl. 12, figs. 4, 5
	Parophidion aff. *P. schmidti* (Woods and Kanazawa, 1951)						G						R	Pl. 12, fig. 6
	Neobythites gillii Goode and Bean, 1885									‹	G		R	Pl. 12, fig. 10
	Neobythites marginatus Goode and Bean, 1886									Z	G		R	Pl. 12, fig. 3
Bythitidae	"genus Dinematichthyinorum" *smithvanizi*, n. sp.				?	C				Z				Pl. 12, figs. 11, 12
	"genus Dinematichthyinorum" *sauli*, n. sp.									Z				Pl. 12, figs. 7, 8
Atherinidae	*Atherinomorus stipes* (Müller and Trotschel, 1847)						Y			‹				Pl. 12, fig. 13
Hemiramphidae	*Euleptorhamphus* sp.				‹								R	Pl. 12, fig. 20
	Hemiramphus aff. *H. brasiliensis* (Linnaeus, 1758)				GM									Pl. 12, fig. 23
	Hyporhamphus aff. *H. unifasciatus* (Ranzani, 1842)				GM								R	Pl. 12, fig. 19
Polymixiidae	*Polymixia* sp.				GM	‹							R	Pl. 12, fig. 24
Holocentridae	*Holocentrus* sp.									G				Pl. 12, fig. 25
Scorpaenidae	Scorpaenidae indet.				M		G							Pl. 12, fig. 26
Triglidae	*Prionotus* sp.				C									Pl. 12, fig. 28
Centropomidae	*Centropomus* sp.						V							Pl. 12, fig. 29
Serranidae	*Centropristis* sp.				GM									Pl. 13, figs. 3–5
	Epinephelus sp.				‹G					Z				Pl. 13, fig. 9
	Diplectrum sp.									Z				Pl. 13, fig. 7
Priacanthidae	*Pristigenys* sp.				‹					Z				Pl. 13, fig. 2
Apogonidae	*Apogon* sp. 1				C		VY							Pl. 13, fig. 10
	Apogon sp. 2				CG	M	V			Z				Pl. 13, fig. 13
	Apogon sp. 3				CGM	GM	V			Z				Pl. 13, figs. 15, 16
	Apogon sp. 4				CGM	G	VY			Z				Pl. 13, fig. 12
	Epigonus sp.				G									Pl. 13, fig. 11
Lactariidae	*Lactarius* sp.				GM	G								Pl. 13, fig. 14
Lutjanidae	*Lutjanus* aff. *L. campechanus* Poey, 1861				M								R	Pl. 13, fig. 21
	Ocyurus aff. *O. chrysurus* (Bloch, 1791)				‹ GM								R	Pl. 13, figs. 19, 20
	Pristipomoides sp.		Y		‹	GM	V			Z				Pl. 14, figs. 2–4
Gerreidae	*Eucinostomus* sp. 1				GM					‹				Pl. 14, fig. 7
	Eucinostomus sp. 2				G									Pl. 14, fig. 10
	Hoharra rhombea (Cuvier, 1829)		Y		CGM	M							R	Pl. 14, figs. 12, 13
Pomadasyidae	*Anisotremus* sp.				‹									Pl. 14, fig. 14
	Conodon moreauxi, n. sp.				GM									Pl. 15, figs. 4–6
	Haemulon sp.		Y		CGM	CG				Z				Pl. 14, figs. 16–19
	Pomadasys sp.		Y			M	V							Pl. 14, figs. 8, 9
Sciaenidae	*Bairdiella ronchus* (Cuvier, 1830)				M								R	Pl. 15, fig. 2
	Ctenosciaena latecaudata, n. sp.		Y		CGM	C							R	Pl. 16, figs. 6, 7
	Larimus breviceps Cuvier, 1830				CGM					‹			R	Pl. 16, fig. 12
	Menticirrhus chaoi, n. sp.				‹									Pl. 16, fig. 9
	Ophioscion sp. 1				CGM	C	CG			Z				Pl. 16, figs. 3, 5
	Ophioscion sp. 2		Y											Pl. 16, fig. 4
	Pareques sp.						C							Pl. 16, figs. 13, 14
	Umbrina sp.				CM									Pl. 16, fig. 18
Mugilidae	*Mugil* sp.					G								Pl. 15, fig 11
Sphyraenidae	*Sphyraena* sp.				C									Pl. 17, fig. 1
	Polydactylus sp.				‹		V							Pl. 15, fig. 13
Opisthognathidae	*Lonchopisthus micrognathus* (Poey, 1861)		Y		GM	G	V			Z			R	Pl. 15, figs. 7, 9
Dactyloscopidae	Dactyoscopidae indet.													Pl. 17, fig. 5
Clinidae	*Labrisomus* sp.				C									Pl. 17, fig. 4
Gobiidae	Gobiidae sp. 1		Y		CGM	M								Pl. 17, fig. 12
	Gobiidae sp. 2		Y		GM	CG								Pl. 17, fig. 13
	Gobiidae sp. 3													Pl. 17, fig. 14
Bothidae	Bothidae indet.									G				Pl. 17, figs. 15, 16
Pleuronectidae	? Pleuronectidae indet.		Y		CGM		V			Z				Pl. 17, fig. 20
Soleidae	Soleidae indet.				CM					Z				Pl. 17, figs. 18, 19
Cynoglossidae	Cynoglossidae indet.				G									Pl. 17, fig. 17
					M									

Table 2.—List of teleost species represented by otoliths in the Neogene of the Dominican Republic.

DESCRIPTION OF NEW SPECIES AND REMARKS ON TAXA REQUIRING COMMENTS

Genus **PLOTOSUS** Lacepède, 1803

Plotosus species
Plate 10, figure 3

The presence of the Indo-Pacific genus *Plotosus* Lacepède, 1803 in the Caribbean Neogene seems odd in terms of biogeographic affinity. However, the morphological resemblance between fossil utricular otoliths from the Dominican Republic (Pl. 10, fig. 3) and those of the Recent species *Plotosus anguillaris* (Bloch, 1794) [Pl. 10, fig. 2] are so strong that the affinity of the fossils can hardly be denied. The catfish genus *Plotosus* occurs in nearly all neritic, estuarine, and even fresh waters of the Indo-Pacific area, the Australian realm, and the Pacific plate (see Berra, 1981). The presence of *Plotosus* is interpreted as a relict element of the ancient Western Tethys fauna.

Genus **DIAPHUS** Eigenmann and Eigenmann, 1890

Although not common in the Neogene of the Dominican Republic, myctophid otoliths, especially those of the genus *Diaphus*, have been found at several localities. *Diaphus*, the most speciose myctophid, is mesopelagic, occurring mainly between 200 and 1000 meters in depth. At night, most of the species migrate vertically and are commonly found near the surface. While on the surface, myctophid species may be carried by currents to the continental platform or may be eaten by epipelagic predators that may excrete the otoliths of their prey in neritic environments. Therefore, the otoliths of *Diaphus* are often found in neritic areas that are broadly exposed to the oceanic realm.

Problems concerning the identification of *Diaphus* otoliths have been discussed at length by Nolf and Steurbaut (1988) and Nolf and Cappetta (1989). The major problems are that extensive series of large otoliths are required to find good species-diagnostic criteria, and that some species have otoliths with such generalized morphology that not even large specimens seem to be diagnostic.

In the Neogene Dominican Republic material, there are at least three species of *Diaphus*. One of them (Pl. 10, figs. 11–13) seems to be closely related to the Recent species *Diaphus brachycephalus* Tåning, 1928 (Pl. 10, figs. 4–9). The two other species are identified as *Diaphus* sp. 1 and *Diaphus* sp. 2. A series of *Diaphus* sp. 1 specimens is shown in Plate 10, figures 18–23. These specimens may constitute a new species, but more extensive samples of large otoliths are required to assure the homogeneity of the series. The best preserved specimens of the series are in figures 22 and 23 of Plate 10. These specimens are characterized by a well-developed anterior and central portion of the dorsal area and by a marked notch at the transition of the dorsal and posterior rim. The narrow anteroventral area seems to be a constant feature also. *Diaphus* sp. 2 (Pl. 10, fig. 28) is a small specimen that cannot be considered a juvenile of *Diaphus* aff. *Diaphus brachycephalus* or *Diaphus* sp. 1 because of its shape and strong posterodorsal angle. However, it lacks further diagnostic features to allow more specific identification.

Genus **PORICHTHYS** Girard, 1854

Porichthys species
Plate 11, figure 3

In otoliths of the genus *Porichthys* Girard, 1854, there is a marked ontogenetic change in the outline of the dorsal rim. Those of juveniles have a non-excavated dorsal rim and show only a marked posterodorsal angle, whereas those of adults have a strongly developed posterodorsal expansion and a concave central portion of the dorsal rim. Adult characteristics are evident in the specimen of *Porichthys myriaster* Hubbs and Schultz, 1939, figured by Nolf and Steurbaut (1989). The fossil figured in the present study is a good example of the juvenile morphology. Although *Porichthys* otoliths are not very diagnostic at this juvenile stage, the late Miocene otoliths from the Dominican Republic belong to a different species than the small *Porichthys* otoliths from the early Miocene Brasso and Nariva formations of Trinidad figured by Nolf (1976). The Trinidad specimens have a much more salient posterior end. However, reexamination of the Trinidad material revealed that an unfigured specimen from the Springvale Formation cited by Nolf (1976) from Sample KR 11862 probably belongs to the same species as the late Miocene material from the Dominican Republic.

Genus **BROTULA** Cuvier, 1829

The genus *Brotula* is represented by two species in the Dominican Republic Pliocene deposits. One (Pl. 11, fig. 13) seems closely related, if not identical, to the Recent species *Brotula clarkae* Hubbs, 1944 (see Nolf, 1980, pl. 2, fig. 3 for comparative Recent material). *Brotula clarkae* is presently restricted to the Pacific Central American coasts. Otoliths of *Brotula clarkae* are very diagnostic because they are the only *Brotula* species with a salient rostrum.

A second species of *Brotula* (Pl. 11, fig. 14) is represented by a relatively short, thick otolith that does not match either those of the Recent Atlantic species *Brotula barbata* (Bloch and Schneider, 1801) (see Nolf, 1980, pl. 2, figs. 1, 2) or *Brotula clarkae*. This otolith agrees much better with the morphology of the Recent Indo-Pacific species *Brotula multibarbata* (Temminck

and Schlegel, 1846) (see Nolf, 1980, pl. 2, figs. 4, 5). However, since the otoliths of the Recent Peruvian species *Brotula ordwayi* Hildebrand and Barton, 1949 and of the western Pacific species *Brotula townsendi* Fowler, 1900 are not known, it can only be stated that this otolith belongs to a species that is more closely related to present-day Indo-Pacific species than to Atlantic and Central American ones.

Although otoliths of *Brotula barbata*, the only Recent Atlantic species of the genus, do not occur in the Dominican Republic Neogene, it should be noted that the species is known from the lower Miocene of Trinidad (Nolf, 1976) and from the Pliocene of North Carolina (Fitch and Lavenberg, 1983).

Genus **LEPOPHIDIUM** Gill, 1895

Lepophidium latesulcatum, new species
Plate 11, figure 11

Type material.—Holotype, NMB P62, a left otolith (Pl. 11, fig. 11) from loc. NMB 15878. Paratypes are from the following localities (each locality number is followed by the number of specimens in parentheses): NMB 15805 (1), 15896 (1), 15873 (1), 15900 (7), 15903 (8), 15904 (5), 15906 (2), 15907 (3), 15914 (1), 15915 (2), 16854 (2), 16856 (1), 16857 (4), 16912 (1), 16914 (2), 16915 (2), 16917 (13), 16918 (9), 16922 (2), 16923 (21), 16924 (5), 16926 (1), 16927 (4), 16928 (1), 16930 (8), 16932 (4), 16935 (2), 17003 (2), 17009 (1), 17268 (1), 17269 (1); TU 1206 (2), 1219 (1), 1225 (1), 1227A (129), 1230 (4), 1250 (3), 1293 (2), 1294 (25), 1343 (2), 1358 (1), 1373 (1), 1378 (1), 1379 (3), 1405 (1), 1419 (3).

Dimensions of the holotype.—Length: 4.9 mm; height: 3.2 mm; thickness: 1.7 mm.

Type locality.—Locality NMB 15878 in the Río Gurabo section; Gurabo Formation, late Miocene NN11 Zone. This species also occurs in the Baitoa Formation and at many localities throughout the NN11–NN14 interval.

Etymology of name.—L. *latesulcatus, a, um* = with a wide sulcus.

Diagnosis.—This species is characterized by robust, thick otoliths, which are readily distinguished from those of related Recent species of the genus by the very wide posterior end of their sulcus. They have a marked spiniform posterior process that in ventral view lies below the main plane of the otolith. The outer face is convex and smooth; the inner face consists of a regular, bulging main plane with an oval outline, an anterodorsal process and a posterior spine that lies slightly deeper than the main plane. The incision of the sulcus is very superficial, and the sulcus is filled with regular colliculum, making the ostial and caudal division barely discernable. The ostium is much longer than the cauda and shows a gradual enlargement towards the posterior end.

Relationships.—There are 13 described Caribbean and tropical eastern Pacific Recent *Lepophidium* species and eight undescribed tropical Atlantic species (*fide* C. Robins, written commun., 1991), and otoliths are available for all of them. Those of *Lepophidium staurophor* Robins, 1959a (see Nolf, 1980, pl. 4, figs. 10, 11) and *Lepophidium kallion* Robins, 1959b (see Nolf, 1980, pl. 3, fig. 12) seem to be most closely related to *Lepophidium latesulcatum*, but these are easily distinguished from the latter by the more narrow posterior end of the ostium.

Genus **OTOPHIDIUM** Gill *in* Jordan, 1885

Otophidium robinsi, new species
Plate 11, figures 16–19

Type material.—Holotype, NMB P68, a right otolith (Pl. 11, fig. 19) from loc. TU 1359; three figured paratypes, NMB P66, NMB P67, and NMB 69 (Pl. 11, figs. 16–18) from locs. TU 1359, TU 1359, and NMB 15905, respectively. Paratypes have been recorded from the following localities (each locality number is followed by the number of specimens in parentheses): NMB 15876 (1), 15896 (1), 15897 (1), 15904 (4), 15905 (7), 15906 (1), 15907 (2), 15910 (2), 15911 (1), 15915 (2), 16837 (3), 16915 (1), 16917 (1), 16923 (4), 16926 (1), 17005 (2); TU 1230 (1), 1294 (5), 1358 (17), 1359 (13), 1373 (12), 1377 (1), 1405 (1), 1419 (1).

Dimensions of the holotype.—Length: 2.8 mm; height: 2.3 mm; thickness: 0.9 mm.

Type locality.—Locality TU 1359 in the Río Gurabo section; Cercado Formation, late Miocene NN11 Zone. This species also occurs in the late Miocene NN11 interval in the Río Cana and Río Amina sections.

Etymology of name.—This species is named after C. R. Robins (Miami, FL) to honor his numerous contributions to Caribbean ichthyology.

Diagnosis.—Otoliths of this species are characteristically massive and robust, with a nearly circular outline, except for their pointed posterior end and, in several specimens, a slight posterodorsal angle. The ventral profile of the otolith is very characteristic, showing clearly that the greatest thickness is located at the posterior end. The outer face is slightly convex and shows an entirely smooth surface. The inner face shows a regularly bulging plane, and the sulcus is rather long and narrow. The sulcus consists of a long ostium that is equally wide over the whole length and a short cauda that is only differentiated from the ostium by a notch in the crista inferior. Incision of the sulcus is very superficial and undifferentiated colliculum fills nearly the whole sulcus . In a few specimens, there is a vague furrow in the colliculum that extends from near the

ostial–caudal junction of the crista inferior in an anterodorsal direction.

Relationships.—There are five Recent species in the genus *Otophidium*: *O. chickcharney* Böhlke and Robins, 1959 (see Nolf, 1980, pl. 5, fig. 18); *O. dormitator* Böhlke and Robins, 1959 (Pl. 11, fig. 15); *O. indefatigable* Jordan and Bollman, 1890 ; *O. omostigmum* (Jordan and Gilbert, 1883); and an undescribed species (UMML 29310). Otoliths of *O. robinsi* differ from those of the first three species by a more circular outline; the last two species have otoliths with a more circular outline, but they differ from those of *O. robinsi* by a more strongly developed anterodorsal portion.

Otophidium robustum, new species
Plate 12, figures 4, 5

Type material.—Holotype, NMB P71, a right otolith (Pl. 12, fig. 4) from loc. NMB 16837; one figured paratype, NMB P72 (Pl. 12, fig. 5) from loc. NMB 16832. Paratypes have been recorded from the following localities (each number is followed by the number of specimens in parentheses): NMB 15910 (1), 16832 (3), 16835 (1), 16837 (1), 16844 (1); TU 1250 (1).

Dimensions of the holotype.—Length: 2.4 mm; height: 1.8 mm; thickness: 0.9 mm.

Type locality.—Locality NMB 16837 in the Cercado Formation of the Río Cana section. This species is also known from several localities in the upper Miocene of Río Cana and Río Gurabo and from locality TU 1250 (Gurabo Formation, without an exact stratigraphic placement, in the Río Verde).

Etymology of name.—L. *robustus, a, um* = robust; refers to the very massive, thick otolith.

Diagnosis.—This species is characterized by very thick otoliths with an ovoid outline, the largest side of the ovoid being the anterior. The posterior end is regularly rounded, without any formation of a spiniform process. The greatest thickening is located in the posterior portion of the otolith. The profile of the ventral rim is sharp, and the profile of the dorsal rim is very blunt. The outer face is regularly smooth and convex while the inner face is regularly bulging. The sulcus on the inner face is rather wide with a long ostial and a short caudal portion. The caudal portion of the sulcus is slightly bent in a ventral direction. The ostial–caudal division is only clear in the crista inferior. The incision of the sulcus is very superficial. The sulcus is filled with one single colliculum without clear division into ostial and caudal portions.

Relationships.—Otoliths of *Otophidium robustum* can be distinguished immediately from those of *Otophidium robinsi*, n. sp. and those of all Recent *Otophidium* species by their greater thickness. Although none of the available specimens has a posterior spiniform process, the structure can be expected in larger otoliths because it is related to the ontogenetic development in the genera *Otophidium* and *Lepophidium* Gill, 1895 (see Nolf, 1985, text-fig. 8a). At a size below 3 mm in length, otoliths of *Otophidium robustum* can be distinguished from those of *Otophidium robinsi*, which occurs in the same strata, by the lack of a posterior spine.

Genus **NEOBYTHITES** Goode and Bean, 1885

Neobythites gillii Goode and Bean, 1885
Plate 12, figure 10

Neobythites gillii Goode and Bean, 1885, p. 601; Nolf, 1985, p. 66.
Neobythites marginatus Goode and Bean, 1886. Nolf, 1980, p. 142 (not of Goode and Bean, 1886).
Neobythites sp. Nolf, 1976, pl. 5, fig. 12.

A *Neobythites* otolith from the early Miocene Brasso Formation in Trinidad was referred to as *Neobythites marginatus* based on a single Recent otolith of that species figured by Nolf (1980, pl. 10, fig. 9). More extensive series of both the Recent species *Neobythites marginatus* and *Neobythites gillii* are now available. These series show clearly that the Recent otolith available in 1980 can be considered as marginal in the variability of *Neobythites marginatus*. Recent otoliths of these two species are shown in Plate 12, figures 1, 2 and Plate 12, figure 9, respectively. A comparison of the morphology of these two species with the figure of Nolf (1976, pl. 5, fig. 12) shows clearly that this fossil otolith belongs to *Neobythites gillii*. In the Dominican Republic, otoliths of *Neobythites gillii* are known only from the Mao Formation, probably due to the deeper facies represented by this deposit.

Tribe **DINEMATICHTHYINI**[3]

"genus Dinematichthyinorum" **sauli**, new species
Plate 12, figures 7, 8

Type material.—Holotype, NMB P74, a left otolith (Pl. 12, fig. 7) from loc. TU 1227A; one figured paratype, NMB P75 (Pl. 12, fig. 8) from loc. NMB 17268; and one paratype from loc. TU 1405.

Dimensions of the holotype.—Length: 3.0 mm; height: 1.5 mm; thickness: 0.6 mm.

Type locality.—Locality TU 1227A from the Arroyo Zalaya section; turbidity lens in sediments of the Pliocene, NN14 Zone. One paratype is from the Río Yaque del Norte section, loc. NMB 17268, Gurabo Formation, Pliocene, NN12 Zone. The exact stratigraphic position of the paratype from loc. TU 1405 is not known.

Etymology of name.—This species is named after W. G. Saul of Philadelphia, Pennsylvania.

[3] See discussion on p. 49.

Diagnosis.—Otoliths of this species have a generally elliptical outline with two slight concavities in the dorsal rim. One concavity is situated anteriorly, just above the rostrum, and the other is located in the posterior part of the dorsal rim. The outer face is smooth and slightly convex. The inner face is slightly more convex with an elliptical sulcus without any division into ostial and caudal portions. The sulcus does not reach the anterior rim. However, a rudimentary track of an ostial channel can be observed in some specimens such as the holotype. The whole sulcus is filled with regular colliculum. There is a small depression in the dorsal area just above the sulcus.

Relationships.—Otoliths of this species seem to be most closely related to those of the Recent *Brotulina* sp. from Queensland, Australia figured by Nolf (1980). However, no diagnostic features to distinguish the otoliths of the genera *Brotulina* Fowler, 1946 and *Dermatopsis* Ogilby, 1896 (see Nolf, 1980) could be found. Therefore, no relationship to any Recent genera is proposed here. Furthermore, neither one of the above named genera has yet been identified in the Caribbean area. Also, the whole tribe of Recent Dinematichthyini is in need of revision. Otoliths of "genus Dinematichthyinorum" *sauli* can easily be distinguished from those of the other species of Dinematichthyini from the Dominican Republic Neogene, "genus Dinematichthyinorum" *smithvanizi*, by their less elongated otoliths and relatively larger sulcus.

"genus Dinematichthyinorum" **smithvanizi**, new species
Plate 12, figures 11, 12

Type material.—Holotype, NMB P78, a right otolith (Pl. 12, fig. 12) from loc. TU 1227A; one figured paratype, NMB P77 (Pl. 12, fig. 11) from loc. NMB 15864; and three paratypes from loc. TU 1227A.

Dimensions of the holotype.—Length: 3.3 mm; height: 1.4 mm; thickness: 0.6 mm.

Type locality.—Locality TU 1227A from the Arroyo Zalaya section; turbidity flow lens in the Pliocene, NN14 Zone. One paratype is from loc. NMB 15864 in the Río Gurabo section; Gurabo Formation, late Miocene, NN11 Zone.

Etymology of name.—This species is named after Dr. W. F. Smith-Vaniz of Philadelphia, Pennsylvania.

Diagnosis.—This species is characterized by very elongate otoliths with slightly aculeate anterior and posterior ends. The outer face is smooth and convex. The inner face is also convex with a very short sulcus (about one-third of the total otolith length). The sulcus has an oval outline and is connected to the anterior rim by a rudimentary ostial channel. The crista superior is slightly salient. The entire sulcus is filled with regular, undivided colliculum.

Relationships.—See discussion under "genus Dinematichthyinorum" *sauli*, n. sp.

Genus **APOGON** Lacepède, 1801

Apogonid otoliths have been recorded at many localities in the Dominican Republic Neogene. Various Recent *Apogon* otoliths figured by Nolf (1985, text-fig. 12) illustrate that specific features are not very diagnostic in this genus and that species are differentiated by minor differences in outline. Therefore, fossil apogonid species can be evaluated only on the basis of well-preserved and abundant material. Due to this reason and to the incomplete knowledge of Recent Caribbean apogonid otoliths, all *Apogon* otoliths are placed in open nomenclature. In the localities sampled in this study, four species [*Apogon* sp. 1 (Pl. 13, fig. 10); *Apogon* sp. 2 (Pl. 13, fig. 13); *Apogon* sp. 3 (Pl. 13, figs. 15, 16); and *Apogon* sp. 4 (Pl. 13, fig. 12)] were recognized, with *Apogon* sp. 3 being the most common. Apogonid otoliths have also been identified from the Miocene of Trinidad (Nolf, 1976) and from the Miocene of Jamaica (Stringer, unpublished data).

Genus **LACTARIUS** Valenciennes *in* Cuvier and Valenciennes, 1833

Lactarius species
Plate 13, figure 14

As in the case of *Plotosus* Lacepède, 1803, the presence of the Indo-Pacific genus *Lactarius* seems odd in the context of biogeographic affinity. It is believed, as in the case of *Plotosus*, that *Lactarius* is an example of a relict element from the ancient Tethys fauna. Fossil *Lactarius* otoliths are known from the middle Eocene of Barbados, from the United States Gulf Coast Paleogene, from the European Paleogene (see Nolf, 1985) and from the Miocene of Portugal and Aquitaine, southwest France (see Steurbaut, 1984). They also have been recorded from many Paleogene localities of the U. S. Gulf Coast (Nolf, unpublished data).

Genus **CONODON** Cuvier *in* Cuvier and Valenciennes, 1830

Conodon moreauxi, new species
Plate 15, figures 4–6

Type material.—Holotype, NMB P116, a left otolith (Pl. 15, fig. 4) from loc. NMB 15910; two figured paratypes, NMB P117 and P118 (Pl. 15, figs, 5, 6) from locs. NMB 16918 and TU 1359, respectively. Paratypes have been recorded from the following localities (each locality is followed by the number of specimens in parentheses): NMB 15903 (1), 15904 (1), 15915 (2), 16917 (1), 16918 (2 [including the figured paratype]), 16923 (1); TU 1294 (1), 1359 (1).

Dimensions of the holotype.—Length: 10.1 mm; height: 6.1 mm; thickness: 2.2 mm.

Type locality.—Locality NMB 15910 in the Río Gurabo section, Cercado Formation, late Miocene NN11 Zone. This species is known only from the late Miocene NN11 Zone of the Río Gurabo and Río Mao sections.

Etymology of name.—This species is named after F. Moreaux, who contributed numerous Recent otoliths from Haiti for this study. His contributions significantly increased the taxonomic accuracy of this paper.

Diagnosis.—Otoliths of this species are thick and have a very marked convex inner face. The outer face is nearly flat dorsoventrally but concave anteroposteriorly. The outer surface is characterized by some slightly salient crestlike tubercles. The sulcus consists of a rather long and narrow ostium that is filled with flat, regular colliculum and a much more narrow, deeply incised cauda. The posterior half of the cauda is bent downward towards the ventral margin. The central part of the dorsal margin is markedly angular, and both the rostral and the posterior portions of the otolith are aculeate.

Relationships.—There are only two Recent *Conodon* species: *Conodon serrifer* Jordan and Gilbert, 1883 (Pl. 15, fig. 3) from the Pacific side of Central America and the Gulf of California, and *Conodon nobilis* (Linnaeus, 1758) (Pl. 15, figs. 1, 2) from the Caribbean area. Otoliths of *Conodon moreauxi* are distinguished from those of *Conodon serrifer*, which are more elongate, have a shorter ostium, and have a truncated posterior end. Otoliths of *Conodon moreauxi* are more closely related to those of *Conodon nobilis*, but differ from them by their more slender outline, more aculeate anterior and posterior ends, and a more narrow sulcus.

Genus **HAEMULON** Cuvier, 1829

Haemulon species
Plate 14, figures 16–19

Otoliths of *Haemulon* Cuvier, 1829 are common fossils at most localities in the Cercado Formation and in the Miocene part of the Gurabo Formation. A few specimens have also been recorded from the Miocene Baitoa Formation and from a turbidity lens (loc. TU 1227A) in the Pliocene NN14 Zone of Arroyo Zalaya. *Haemulon* otoliths are also known from the Miocene Brasso and Manzanilla formations of Trinidad (Nolf, 1976) as well as the Miocene Chipola Formation of Florida (Stringer, unpublished data).

At least 17 Recent *Haemulon* species inhabit the neritic environments of tropical Central America. Therefore, more than one species is probably present in the Neogene Dominican Republic material. Unfortunately, the fossil specimens are too small to be of diagnostic value. This problem is discussed by Nolf and Lapierre (1979) and Nolf (1985).

Genus **CTENOSCIAENA** Fowler and Bean, 1923

Ctenosciaena latecaudata, new species
Plate 16, figures 6, 7

Type material.—Holotype, NMB P127 (Pl. 16, fig. 6) from loc. NMB 15903; one figured paratype, NMB P128 (Pl. 16, fig. 7) from loc. NMB 15907. Paratypes have been recorded from the following localities (each locality is followed by the number of specimens in parentheses): NMB 15900 (2), 15903 (1), 15904 (1), 15907 (1), 15912 (1), 16832 (1), 16837 (1), 16855 (1), 16914 (1), 16923 (2); TU 1292 (1), 1294 (1), 1363 (1).

Dimensions of the holotype.—Length: 9.4 mm; height: 7.1 mm; thickness: 3.9 mm.

Type locality.—Locality NMB 15903 from the Cercado Formation, late Miocene NN11 Zone of the Río Gurabo section. This species has also been recorded from the Baitoa Formation and from the Miocene NN11 Zone in the Río Cana and Río Mao sections.

Etymology of name.—L. *latecaudatus, a, um* = with a large cauda.

Diagnosis.—This species is characterized by short, massive otoliths with a rounded to subtriangular shape. The greatest thickness is located in the dorsal half. The outer face is markedly convex, especially dorsoventrally. The ventral margin forms a sharp angle in a dorsoventral view. The dorsal margin almost forms a right angle at the junction of the inner face and the upper part of the outer face. The inner face is slightly convex. The sulcus is formed by a wide subcircular ostium with very flat colliculum and a large, deep cauda with a ventrally bent posterior end. The horizontal portion of the cauda is always longer than the vertical portion. The angle between the horizontal and vertical portions of the cauda is always greater than 90°. The posterior portion of the cauda is slightly enlarged. There is a small depression in the area just above the cauda.

Relationships.—Otoliths of *Ctenosciaena latecaudata* are easily distinguished from those of *Ctenosciaena gracilicirrhus* (Metzelaar, 1919), which is the only Recent Caribbean species of that genus (see Nolf, 1976, pl. 8, fig. 1). *Ctenosciaena gracilicirrhus* has a more narrow cauda and the vertical portion of the cauda joins the horizontal portion at an angle of less than 90°. Although only Formalin-eroded specimens of the eastern Pacific Recent species *Ctenosciaena peruviana* Chirichigno, 1969 have been studied, this species seems to have a more elongated ostium than *Ctenosciaena latecaudata*.

Genus **LARIMUS** Cuvier
in Cuvier and Valenciennes, 1830

Larimus breviceps Cuvier
in Cuvier and Valenciennes, 1830
Plate 16, figure 12

Larimus breviceps Cuvier, 1830. Nolf, 1976, p. 730, pl. 7, figs. 8–10.

This Recent Caribbean species is one of the most common otoliths in the Cercado Formation (Río Cana, Gurabo and Mao sections) and is also recorded from locality TU 1227A (NN14 of the Pliocene), a turbidity flow lens in the Arroyo Zalaya section. In Trinidad, it is known from the Miocene Tamana and Manzanilla formations.

Genus **MENTICIRRHUS** Gill, 1861b

Menticirrhus chaoi, new species
Plate 16, figure 9

Type material.—Holotype, NMB P129 (Pl. 16, fig. 9) from loc. NMB 15904. Paratypes have been recorded from the following localities (each locality is followed by the number of specimens in parentheses): NMB 15896 (1), 15900 (1), 15907 (1); TU 1358 (1).

Dimensions of the holotype.—Length: 5.8 mm; height: 2.9 mm; thickness: 1.4 mm.

Type locality.—Locality NMB 15904 in the Cercado Formation of the Río Gurabo section, late Miocene NN11 Zone.

Etymology of name.—This species is named after L. N. Chao of Brazil in honor of his work on the systematics of western Atlantic sciaenids.

Diagnosis.—Otoliths of this species are robust and have a trapezoidal shape. The greatest thickness of the otolith is situated in the posterior half. The outer face shows some rudiments of large tubercles. The inner face is slightly concave with a sulcus that is formed by an elongate ostium and a cauda with an anterior horizontal portion and posterior vertical portion. In the crista inferior, the angle between these horizontal and vertical portions is well-developed and is less than 90°. The caudal crista superior is uniformly bent. The central portion of the dorsal margin forms an obtuse angle.

Relationships.—There are three Recent Caribbean species of *Menticirrhus*: *Menticirrhus americanus* (Linnaeus, 1758) (Pl. 16, fig. 8), *Menticirrhus saxatilis* (Bloch and Schneider, 1801) (Pl. 16, fig. 10) and *Menticirrhus littoralis* (Holbrook, 1860) (Pl. 16, fig. 11). The otoliths of *Menticirrhus chaoi* are relatively higher than those of the Recent species, and they are also readily distinguished from them by the combination of features of the outline.

Genus **OPHIOSCION** Gill, 1863

There are two different *Ophioscion* species in the Dominican Republic Neogene. They are readily distinguished by differences in the shape of their ostium and by their outline (Pl. 16, figs. 3, 4), but too little is known about the otoliths of Recent Central American species of *Ophioscion* to allow specific identifications. *Ophioscion* sp. 2 is the only element in the Baitoa fauna whose stratigraphic range is restricted to that formation.

The utricular otoliths of the sciaenid genera *Ophioscion* Gill, 1863, *Bairdiella* Gill, 1861a, *Odontoscion* Gill, 1862a, and *Stellifer* Oken (*ex* Cuvier), 1817 attain fairly large size. These utricular otoliths are figured and discussed by Chao (1978). Utricular otoliths of the *Ophioscion* type are present in the Dominican Republic Neogene material. Specimens from the Cercado Formation (Pl. 16, fig. 5) probably belong to *Ophioscion* sp. 1 since this is the only *Ophioscion* species represented there. A single incomplete specimen from the Baitoa Formation is markedly shorter. This specimen probably belongs to *Ophioscion* sp. 2 for the same reason. (Association with the saccular otoliths means that they should have been found together in a skull.)

Genus **PAREQUES** Gill *in* Goode, 1876

Pareques species
Plate 16, figures 13, 14

In his revision of the Recent western Atlantic sciaenids, Chao (1978) regarded the genus *Pareques* Gill *in* Goode, 1876 as distinct from *Equetus* Rafinesque, 1815, but his view is not shared by others such as Robins *et al.* (1980) and Robins, Ray, and Douglass (1986). Examination of saccular otoliths of all the Recent species of *Pareques*, such as *Pareques acuminatus* (Bloch and Schneider, 1801) (Pl. 16, fig. 16), indicates that these species have a very elongate ostium, while *Equetus* species have a subquadrangular ostium (Pl. 16, figs. 15, 17). As these features correlate with the ones used by Chao (1978) to decide on the species content of both genera, the distinction of the two genera is maintained here. Although our fossil material (Pl. 16, figs. 13, 14) is too eroded to allow any specific identification, the elongate ostium undoubtedly refers the otoliths to *Pareques*.

Family **GOBIIDAE** Bonaparte, 1832

Problems related to the identification of gobiid otoliths have been treated at length by Nolf (1985, pp. 98, 99). In order to demonstrate even more clearly the inanity of rigorous otolith-based identification attempts in this family, six otoliths of the Recent species *Nes longus* (Nichols, 1914) are figured (Pl. 17, figs. 6–

11). These specimens do not result from an astute choice of the extremes of variability in a large sample: they originated from six fishes removed at random from a jar containing material captured at a single station near the Bermudas.

It could be assumed that a mixture of different species is present, but the dissected material comes from a thoroughly identified sample in the collections of the Academy of Natural Sciences at Philadelphia. Morever, the distinctiveness of this species (see Robins, Ray, and Douglass, 1986, pl. 47) makes any confusion impossible.

The otoliths of *Nes longus* evidently illustrate a case of extreme variability that has not been observed in all gobiid species. Nevertheless, it should be taken into consideration, because such species may be represented in a fossil association, and in that case, their presence makes identification of all gobiids in the sample equivocal. Apart from this problem, our knowledge of Recent Caribbean gobiid otoliths is far too limited for any pertinent identification of our fossil material at generic or species level. Therefore, form groups were designated as Gobiidae sp. 1, sp. 2 and sp. 3 (Pl. 17, figs. 12–14, respectively). Among them, Gobiidae sp. 1 is by far the most common form.

Family **PLEURONECTIDAE** Rafinesque, 1815

? Pleuronectidae indeterminate
Plate 17, figure 20

Representatives of the cold-water family Pleuronectidae are uncommon in the Caribbean realm and otoliths of the concerned species are unknown. Although otoliths of many genera of the related family Bothidae are also still unknown, the general shape and elongation of the fossil otoliths from the Dominican Republic Neogene conform to pleuronectid morphology rather than bothid morphology. Therefore based on morphology, rather than ecological or biogeographical considerations, the fossil specimens are tentatively identified as pleuronectids.

CONCLUSIONS

Critical Considerations of the Available Data

A major problem in the interpretation of the otolith data is that the sampling technique utilized in the Dominican Republic project was designed essentially for mollusca. Most of the otoliths described in this study were either surface-collected as individual specimens or screenwashed from small samples (usually less than 20 kg). In order to gain a good idea of the fauna at a given locality, the average size of a sample intended for otolith study should be at least 500 kg, but no such samples were available for the Dominican Republic Neogene. The most prolific recorded otolith association in the Basel localities is found in the largest size sample (60 liters or about 120 kg) according to the index of NMB macrofossil collecting localities (Saunders, Jung, and Biju-Duval, 1986). Analysis of the index of collecting localities shows a positive correlation between sample sizes and the number of species represented.

Based on experience in similar deposits, a sample of 500 kg, *e.g.*, from the Cercado Formation, would have yielded an otolith association of about 40 species. Although samples from 109 localities were studied, only 14 of them provided associations of more than 10 species, and in 25 cases, only a single species was represented in the sample. Therefore, none of the isolated samples gives sufficient information about the ichthyological fauna for the sampled locality, and direct comparison of single samples makes no sense.

To gain a better idea abut the fauna of a given level, one must turn to composite samples. Such composite information is presented in Table 2, where the presence of species has been arranged according to nannoplankton zones and formation limits. This provides a more comprehensive picture of the available data and it illustrates that only for the late Miocene NN11 Zone in the Cercado Formation is a fauna of considerable size known (62 species). From the Baitoa Formation, only a restricted association of 13 species is available. For the Gurabo Formation, the information is very scattered. In the lower part, belonging to the NN11 Zone, a restricted fauna of 26 species is known that essentially reflects an impoverished association such as the one known from the Cercado Formation. However, this may be due to the sampling, which was not intended primarily for otoliths. If locality TU 1250 from the Río Verde, which is of uncertain stratigraphic position, is disregarded, there are virtually no data available for the NN12–NN13 interval. A fairly large fauna of 33 species is known for the NN14 interval of the Mao Formation. However, 27 of the species are from locality TU 1227A, which is a local turbidity flow lens with an exceptionally rich otolith association that cannot be regarded as standard for the Lower Mao Formation. Only six species are known for the NN15 interval of the Mao Formation.

PALEOENVIRONMENTAL EVALUATION

All studied otolith associations exhibit close relationships with the Recent Caribbean fauna and seem to belong to the same climatic realm as their present-day relatives.

Even with the restricted size of the associations at most of the studied levels, interesting conclusions on the evolution of the bathymetry in the Neogene Cibao Valley in the Dominican Republic can be developed.

In Table 3, the present-day bathymetric distribution of related Recent taxa is shown for forms from the NN11 Zone of the Cercado Formation (Table 3a), those from the NN14 Zone of the Mao Formation, excluding locality TU 1227A (Table 3b), and those from locality TU 1227A, a turbidity flow lens in the NN14 Zone (Table 3c).

For extinct taxa or taxa indeterminate as to species, the bathymetric distribution indicated is the global one for all Recent species of the concerned genus. In the case of extant species or those considered quasi-identical to living ones (*e.g.*, *Ariosoma* aff. *A. selenops* Reid, 1934), the bathymetry indicated is that of the species. Taxa identified only at the family level are not included in the analysis because at that taxonomic level, ecological data are too vague to be useful for bathymetric analysis.

Baitoa Formation.—The association from the Baitoa Formation consists of very shallow-water taxa which, except for *Pristipomoides* Bleeker, 1852, occur in depths of less than 50 m. Taxa such as *Arius* Valenciennes *in* Cuvier and Valenciennes, 1840, *Moharra* Poey, 1875, *Ophioscion* Gill, 1863 and *Lonchopisthus* Gill, 1862b do not occur at greater depths. The only oceanic element is the mesopelagic genus *Diaphus* Eigenmann and Eigenmann, 1890. However, as these fishes migrate to the surface waters at night, their presence in a neritic zone open to oceanic waters is not unexpected or unusual.

Cercado Formation (NN11 Zone).—The otolith association of this unit is the most prolific of all known units from the Dominican Republic. Table 3 indicates that the association consists mainly of neritic taxa that do not live at depths exceeding 50 m. At least 11 of the taxa are regular inhabitants of euryhaline environments such as lagoons or estuaries. Among the deeper-ranging taxa, none are exclusively bathyal, and all of them may also occur in neritic areas. Some taxa, such as the Dinematichthyini, *Holocentrus* Scopoli (*ex* Gronow), 1777 and *Labrisomus* Swainson, 1839, may suggest the proximity of reef environments, but most of the represented taxa are confined to shallow neritic environments with rather soft bottoms.

Gurabo Formation (NN11 Zone).—The association of this interval is very similar to that of the Cercado interval, but it is less diversified. This may be due to less intensive sampling.

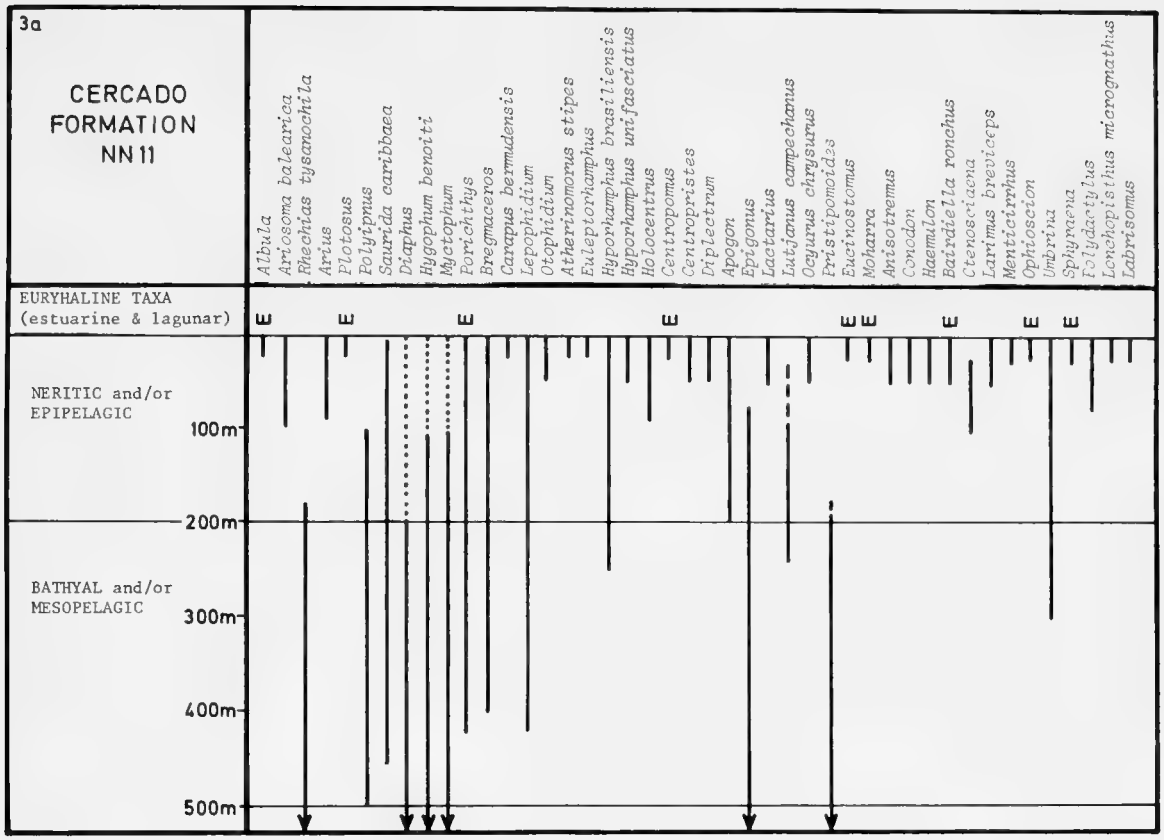
Gurabo Formation (NN12–NN13 zones).—For this interval, the data are too scattered to permit an unequivocal interpretation. It can be stated that most of the represented taxa are neritic with the exception of some pelagic elements such as *Diaphus* and *Bregmaceros* Thompson, 1840. However, the presence of these pelagic species in neritic environments is not unusual. No true bathyal genera have been recorded. The presence of the genera *Holocentrus* and *Pareques* Gill *in* Goode, 1876, which are frequently found in reefal areas, is in agreement with the frequent levels of coral rubble found in these sediments and suggests transport from nearby reef areas. For the NN13 interval, available information is almost nonexistent.

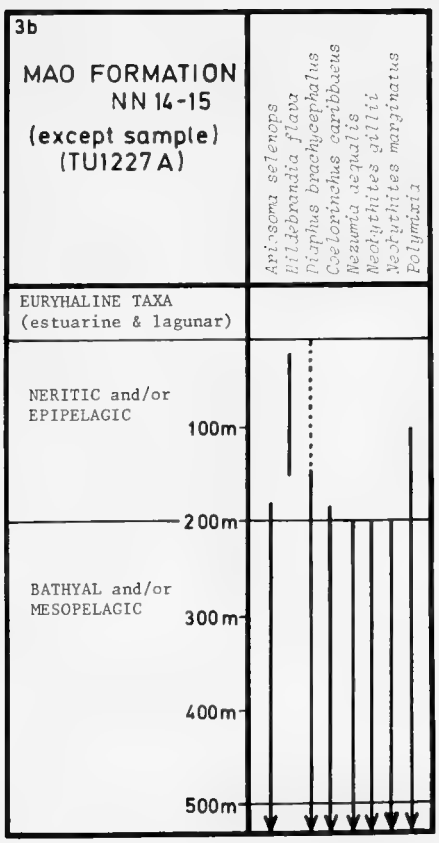
Mao Formation (NN14–NN15 zones).—For this interval, the turbidity flow lens association of locality TU 1227A in the Arroyo Zalaya section is treated separately due to its unusual occurence. Analysis of the bathymetry in the non-turbiditic samples (Table 3b) reveals an increasing water depth, and the absence of any typical shallow-water taxa suggests a deep-neritic or upper-slope environment. The presence of demersal deep-water fishes such as macrourids and *Neobythites* Goode and Bean, 1885 is suggestive of a slope environment. In the restricted association of the NN15 Zone, five of the six represented taxa have a deep-neritic or upper-slope habitat. One of the taxa, *Pythonichthys* Poey, 1867, occurs in deep sulfurous muds, often with poor oxygen, but it has a wide depth range from upper shelf to 400 m.

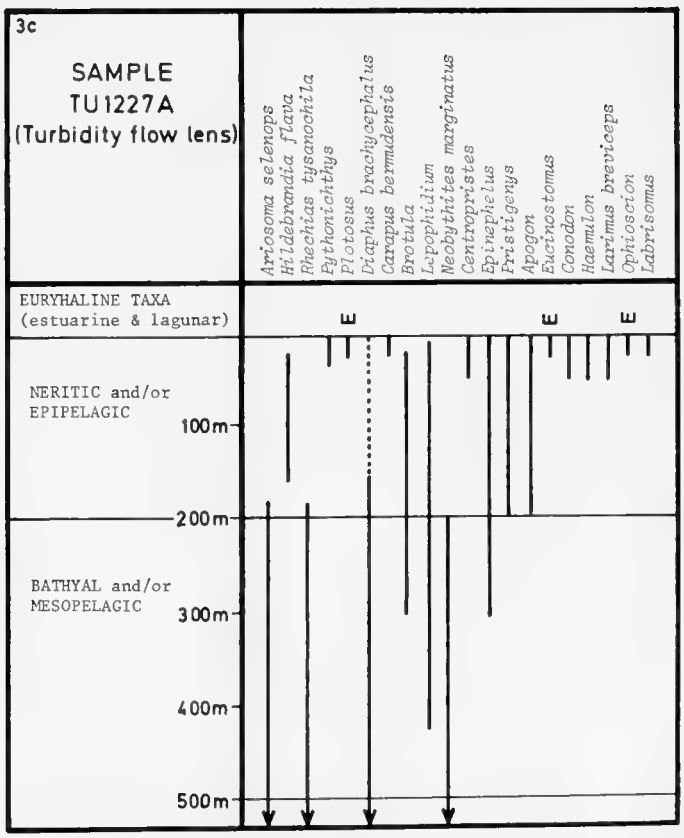
Bathymetric data for the association of the turbidity flow lens sample from locality TU 1227A in the Arroyo Zalaya are given in Table 3c. This association is a mixture of shallow-water, deep-neritic and mesopelagic taxa. The nature of the deposit, the data on otolith associations from other sites in the NN14–NN15 zones and the data on foraminifers (Saunders, Jung, and Biju-Duval, 1986) suggest "open marine conditions with moderate water depths" for the Arroyo Zalaya and support the hypothesis of transport and hydraulic selection of the otoliths in this association.

No data on otoliths are available above the NN15 Zone. Although the otoliths from the Mao Formation are by no means abundant, they clearly indicate deep-water conditions of sedimentation. This is in agreement with the general deepening of the Cibao Valley Basin in the late early and middle Pliocene, as concluded from the general geologic study of the section (Saunders, Jung and Biju-Duval, 1986) and from ostracodes (Bold, 1988). Bold also notes a short period of deepening in the middle part of the Gurabo For-

Table 3.—Present-day bathymetric range of taxa (see Table 2 for family assignments) represented in the Cercado Formation (3a), the lower part of the Mao Formation (3b) and locality TU 1227A of the Arroyo Zalaya section (3c). Dotted lines indicate the nightly occurence near the surface of mesopelagic species and interrupted lines indicate occasional presence of the species at the concerned depth interval. Data after Goode and Bean (1896), Lee *et al.* (1980), Mayer (1974), Poll (1953, 1954, 1959), Reid (1934), Robins, Ray, and Douglass (1986), Rosenblatt and Rubinoff (1972), Smith and Kanazawa (1977), and Whitehead *et al.* (1984–1986).


3a
CERCADO FORMATION NN 11
Albula
Ariosoma balearica
Rhechias tysanochila
Arius
Plotosus
Polyipnus
Saurida caribbaea
Diaphus
Hygophum benoiti
Myctophum
Porichthys
Bregmaceros
Carapus bermudensis
Lepophidium
Otophidium
Atherinomorus stipes
Euleptorhamphus
Hyporhamphus brasiliensis
Hyporhamphus unifasciatus
Holocentrus
Centropomus
Centropristes
Diplectrum
Apogon
Epigonus
Lactarius
Lutjanus campechanus
Ocyurus chrysurus
Pristipomoides
Eucinostomus
Moharra
Anisotremus
Conodon
Haemulon
Bairdiella ronchus
Ctenosciaena
Larimus breviceps
Mentticirrhus
Ophioscion
Umbrina
Sphyraena
Polydactylus
Lonchopisthus micrognathus
Labrisomus
EURYHALINE TAXA (estuarine & lagunar)
NERITIC and/or EPIPELAGIC
BATHYAL and/or MESOPELAGIC
100m
200m
300m
400m
500m


3b
MAO FORMATION NN 14-15 (except sample) (TU1227A)
Ariosoma selenops
Hildebrandia flava
Diaphus brachycephalus
Coelorinchus caribbaeus
Neamia sejalis
Neobythites gilli
Neobythites marginatus
Polymixia
EURYHALINE TAXA (estuarine & lagunar)
NERITIC and/or EPIPELAGIC
BATHYAL and/or MESOPELAGIC
100m
200m
300m
400m
500m


3c
SAMPLE TU1227A (Turbidity flow lens)
Ariosoma selenops
Hildebrandia flava
Rhechias tysanochila
Pythonichthys
Plotosus
Diaphus brachycephalus
Carapus bermudensis
Brotula
Lepophidium
Neobythites marginatus
Centropristes
Epinephelus
Fristigenys
Apogon
Eucinostomus
Conodon
Haemulon
Larimus breviceps
Ophioscion
Labrisomus
EURYHALINE TAXA (estuarine & lagunar)
NERITIC and/or EPIPELAGIC
BATHYAL and/or MESOPELAGIC
100m
200m
300m
400m
500m

mation in the Río Cana and Río Gurabo sections, but this interval is not adequately covered by otolith samples.

PALEOBIOGEOGRAPHIC AFFINITIES AND RELATIONSHIPS OF THE PALEOGENE AND RECENT CARIBBEAN FAUNA

Because so much in the composition of the successive faunas recorded from the Dominican Republic Neogene is related to differences in environment, bathymetry, and sampling method, it is impossible to ascertain to which of those differences any stratigraphic significance should be attributed. Therefore, all the Neogene teleosts of the Cibao Valley are treated as one fauna. Such an approach is supported by the fact that the bulk of this fauna (66 of the 84 recorded species) is represented in a single nannoplankton zone (NN11) of the late Miocene. The studied fauna can be regarded as similar to the present-day fauna of the Caribbean. Most of the recorded taxa are represented in the Recent Caribbean fauna. Exceptions are *Brotula* species with western Central America affinities and *Plotosus* Lacepède, 1803 and *Lactarius* Valenciennes *in* Cuvier and Valenciennes, 1833, which are interpreted as relicts of the Paleogene western Tethys fauna. The two Dinematichthyini should not be considered of great importance because their status is due mainly to the precarious systematic knowledge of Recent fishes of this tribe.

In a general discussion of otolith taphonomy, Nolf (1985) noted that nearly all known fossil otolith associations consist either of fishes inhabiting sandy and muddy environments or of mesopelagic fishes, or both, accompanied by a few epipelagic forms. Fossil otolith associations rarely contain inhabitants of rocky shores or reefs. This general trend seems to be true for the Dominican Republic Neogene as well.

In terms of both abundance in number of individuals and taxonomic diversity, the best represented groups are the ophidiids, the pomadasyids, and the sciaenids. These groups contain the most important taxa in the studied fossil association. These groups also represent the most characteristic groups of the Central American shallow-marine fauna, not only in the Recent fauna, but also in the Paleogene United States Gulf Coast (no significant Paleogene data are available for other Central American areas). Samples from 25 localities in the Paleogene of Mississippi and Alabama covering a stratigraphic range from late Paleocene to late Oligocene indicate the above-named groups as predominant together with congrid otoliths (Nolf, unpublished data). Although the same families are present, some differences from their Dominican Republic counterparts are striking. For example in the ophidiids, all Paleogene Gulf Coast associations (among them a well-sampled late Oligocene site) consist nearly exclusively of species belonging to extinct genera of neritic Neobythitini and Sirembini; in the Neogene of the Dominican Republic and Trinidad, such taxa are not recorded and seem to be replaced by an abundant association of neritic Lepophidiini and Ophidiini, which are closely related to Recent forms. A similar picture can be drawn for the pomadasyids. In the Paleogene of the Gulf Coast, they are represented by abundant otoliths of various elongate types, with no evident relationships to otoliths of Recent taxa. In the Neogene of the Dominican Republic and Trinidad, taxa such as *Haemulon* Cuvier, 1829 and *Pomadasys* Lacepède, 1803 are abundant and speciose. This trend is repeated for the sciaenids, which are well represented in the Gulf Coast Paleogene. However, except for groups with plesiomorph otolith morphology such as *Umbrina* Cuvier, 1816 and *Sciaena* Linnaeus, 1758, most of the characteristic modern Central American genera are absent. In the Neogene of the Dominican Republic, modern taxa such as *Bairdiella* Gill, 1861a, *Ctenosciaena* Fowler and Bean, 1923, *Larimus* Cuvier *in* Cuvier and Valenciennes, 1830, *Menticirrhus* Gill, 1861b, and *Pareques* Gill *in* Goode, 1876 appear suddenly. If the Trinidad Neogene is also included, the genera *Cynoscion* Gill, 1861b, *Isopisthus* Gill, 1862a, *Macrodon* Schinz, 1822, *Nebris* Cuvier *in* Cuvier and Valenciennes, 1830, *Pachypops* Gill, 1861b, *Plagioscion* Gill, 1861b and *Polyclemus* Berg, 1895 can be added to the list, which results in a highly diversified group of modern Central American genera already present in the Neogene.

These data seem to indicate that profound evolutionary changes affected at least some groups of the Caribbean teleost fauna near the Oligocene–Miocene boundary. However, the lack of data on Paleogene faunas for the entire southern Caribbean and southeastern Pacific realm make it difficult to substantiate this statement. It cannot be *a priori* excluded that in this area relatives of modern Central American taxa existed by Paleogene times. The Mississippi embayment is a very specific depostional environment, and it is by no means certain that the conditions that prevailed there may be extended as standard for the whole Caribbean area. Although the presently available fossils are suggestive of an important evolutionary change in the Caribbean fish fauna near the Oligocene–Miocene boundary, investigations of more southern Paleogene Caribbean otolith associations are required to corroborate this hypothesis.

COMPARISON WITH OTHER NEOGENE OTOLITH ASSOCIATIONS IN THE EASTERN NORTH AMERICAN AND CARIBBEAN REALM

Trinidad.—Sixty-six otolith-based taxa have been published by Nolf (1976). Most of them come from various Miocene formations and a few also occur in the Pliocene. No further attention is given to the stratigraphic range within the Trinidad Neogene deposits because the true picture of their stratigraphic range is probably strongly distorted by uneven sampling and facies differences within the succession.

The Trinidad fauna is essentially of the same type as the one from the Dominican Republic. It also resembles the present-day Caribbean Fauna and consists primarily of neritic fishes, together with a few mesopelagic elements and demersal fishes from the upper slope. Among the quantitatively well-represented taxa, ophidiids, pomadasyids and especially sciaenids comprise an important portion, just as in the Dominican Republic.

Jamaica.—Clarke and Fitch (1979) briefly commented on the presence of some otolith-based fish taxa from the early Pliocene Bowden Formation of Jamaica. Among the taxa, shallow-water forms such as *Albula* Scopoli (*ex* Gronow), 1777, clupeids, engraulids, ariids, ophidiids, triglids, *Larimus* Cuvier *in* Cuvier and Valenciennes, 1830, *Holocentrus* Scopoli (*ex* Gronow), 1777, *Apogon* Lacepède, 1801, opisthognathids and gobiids are cited. The families Congridae, Apogonidae, Gobiidae, and Ophidiidae are abundant in the Bowden material (Stringer, unpublished data). Although many of the taxa are similar between the Bowden Formation and the Dominican Republic Neogene, the Bowden Formation seems to be markedly richer in deep-water taxa. Except for this last aspect, the two faunas are quite comparable.

Northwestern Florida.—Clarke and Fitch (1979) mentioned that otoliths of *Albula*, clupeids, *Apogon*, gerreids, pomadasyids, sparids, sciaenids, dactyloscopids, gobiids, and bothids are common in the early Miocene Chipola Formation. Except for the sparids, otoliths of all the above-mentioned taxa are present in the Dominican Republic Neogene.

North Carolina.—Fitch and Lavenberg (1983) cited and figured 44 otolith-based taxa from the Pliocene of the Lee Creek Mine exposure. Although 10 of the 17 represented families are also known from the Dominican Republic Neogene, most of the taxa from Lee Creek belong to different genera. The presence of five gadoid and three merlucciid species gives this association a markedly more boreal aspect in comparison with the Dominican Republic Neogene.

Other localities.—Although a few otoliths have been mentioned from Colombia (Leriche, 1938), Barbados (Casier, 1966), Panama (Schubert, 1909), and Mexico (Veracrúz) (Weiler, 1959), these records are too isolated and scattered to make any comparisons.

APPENDIX

Alphabetical list of otolith-based fish taxa in the samples from the Neogene localities of the Dominican Republic. Each locality number is followed in parentheses by the number of specimens represented (complete descriptions of each locality may be found in Saunders, Jung and Biju-Duval, 1986)

Albula sp.: NMB 15904 (2), 15907 (1), 15910 (1), 15920 (1), 16923 (2), 16930 (1); TU 1294 (1), 1358 (1).
Anisotremus sp.: NMB 17005 (1).
Apogon sp. 1: NMB 16854 (1); TU 1250 (1), 1405 (1).
Apogon sp. 2: NMB 17003 (3); TU 1227A (1), 1250 (2).
Apogon sp. 3: NMB 15901 (1), 15910 (1), 16837 (2), 16844 (1), 16865 (1), 16923 (1), 16924 (1), 17003 (1); TU 1206 (2), 1227A (73), 1230 (1), 1246 (1), 1250 (3), 1293 (3), 1338 (1), 1358 (1), 1359 (1), 1450 (8).
Apogon sp. 4: NMB 17268 (1); TU 1206 (4), 1227A (9), 1230 (1), 1250 (11), 1338 (1), 1410 (1).
Ariosoma balearica: NMB 15903 (2), 16832 (1), 16857 (2), 16932 (1), 17286 (1); TU 1219 (1), 1227A (5), 1230 (1), 1358 (1), 1359 (1).
Ariosoma aff. *A. selenops*: TU 1357 (1), 1358 (1).
Arius sp.: NMB 15878 (1), 15900 (1), 15903 (3), 16836 (1), 17003 (1), 17286 (1), 17287 (1), 17288 (1); TU 1294 (1), 1358 (1), 1363 (1).
Atherinomorus stipes: NMB 16856 (2).
Bairdiella ronchus: TU 1294 (1).
Bothidae indet.: NMB 15896 (1), 15904 (1), 15912 (1), 16857 (1), 16915 (1), 16918 (1), 16922 (1), 16923 (1), 16924 (1), 16932 (1), 17003 (1), 17287 (2); TU 1227A (16), 1250 (6), 1294 (5), 1358 (2), 1364 (1), 1405 (3).
Bregmaceros sp.: TU 1206 (6), 1210 (8), 1230 (3), 1246 (3), 1250 (14).
Brotula aff. *B. clarkae*: TU 1250 (1).
Brotula sp.: TU 1227A (1).
Carapus aff. *C. bermudensis*: TU 1227A (1), 1294 (1).
Centropomus sp.: NMB 15896 (1), 16916 (1); TU 1373 (1), 1419 (1).
Centropristis sp.: NMB 15911 (1), 16837 (1); TU 1227A (1), 1301 (1).
Chaunax sp.: TU 1250 (1).
Clupeidae indet.: TU 1225 (1), 1301 (1).
Coelorinchus caribbaeus: TU 1357 (2).
Conodon moreauxi: NMB 15903 (1), 15904 (1), 15910 (1), 15915 (2), 16917 (1), 16918 (2), 16923 (1); TU 1294 (1), 1359 (1).
Ctenosciaena latecaudata: NMB 15900 (2), 15903 (2), 15904 (1), 15907 (1), 15912 (1), 16832 (1), 16837 (1), 16855 (1), 16914 (1), 16923 (2); TU 1292 (1), 1294 (1), 1363 (1).
Cynoglossidae indet.: NMB 15912 (1); TU 1230 (1), 1294 (1).
Dactyloscopidae indet.: TU 1206 (2).

Diaphus aff. *D. brachycephalus*: NMB 15823 (1); TU 1205 (1), 1206 (3), 1219 (1), 1220 (1), 1227A (2), 1250 (2), 1352 (1), 1359 (1), 1373 (1), 1405 (1), 1412 (1).
Diaphus sp. 1: NMB 15823 (7), 15827 (1), 15829 (2), 15864 (1), 15869 (1), 15905 (1), 15910 (1), 16854 (6), 16855 (1), 16856 (8), 16913 (1), 16915 (2), 16916 (1), 16918 (2), 16922 (2), 16923 (1), 16926 (1), 16932 (2), 17003 (1), 17269 (1); TU 1206 (6), 1219 (1), 1227A (210), 1230 (6), 1250 (46), 1251 (1), 1277 (1), 1293 (1), 1294 (14), 1298 (1), 1301 (1), 1352 (1), 1357 (1), 1358 (15), 1359 (1), 1363 (1), 1364 (2), 1365 (1), 1366 (13), 1373 (3), 1379 (1), 1405 (1), 1410 (1).
Diaphus sp. 2: TU 1293 (1).
"genus Dinematichthyinorum" *sauli*: NMB 17268 (1); TU 1227A (1), 1405 (1).
"genus Dinematichthyinorum" *smithvanizi*: NMB 15864 (1); TU 1227A (4).
Diplectrum sp.: TU 1230 (1), 1412 (1).
Engraulidae indet.: NMB 15910 (2), 15912 (1), 15913 (1), 15916 (6), 16837 (1), 16838 (2), 16854 (4), 16855 (1), 16913 (1), 16915 (1), 16916 (3), 16922 (1), 16923 (1), 17003 (9), 17005 (1), 17269 (1); TU 1230 (5), 1294 (1), 1301 (5), 1358 (1), 1359 (1).
Epigonus sp.: NMB 15907 (1); TU 1358 (2).
Epinephelus sp.: TU 1227A (2).
Eucinostomus sp. 1: NMB 15907 (1), 15910 (1), 16918 (1), 16923 (1); TU 1227A (1), 1250 (1), 1294 (2), 1358 (5), 1373 (1), 1405 (1).
Eucinostomus sp. 2: TU 1359 (1), 1405 (1).
Euleptorhamphus sp.: NMB 15903 (2), 15912 (2), 15914 (1), 15916 (1).
Gobiidae sp. 1: NMB 15901 (2), 15903 (2), 15904 (1), 15907 (1), 15912 (1), 15914 (1), 15916 (1), 16857 (3), 16913 (1), 16915 (2), 16916 (1), 16917 (1), 16918 (2), 16922 (2), 16923 (3), 16926 (3), 16930 (1), 16932 (1), 16935 (1), 17003 (10), 17290 (1); TU 1225 (4), 1226 (2), 1230 (1), 1293 (1), 1294 (28), 1298 (1), 1358 (4), 1359 (3), 1363 (6), 1366 (1), 1373 (1), 1379 (3), 1405 (8), 1419 (1).
Gobiidae sp. 2: NMB 15862 (2), 15864 (1), 15912 (1), 16837 (1), 16932 (1), 17287 (11).
Gobiidae sp. 3: NMB 15823 (1).
Haemulon sp.: NMB 15873 (1), 15882 (1), 15896 (6), 15900 (11), 15903 (112), 15904 (17), 15906 (13), 15907 (29), 15911 (6), 15912 (8), 15913 (1), 15914 (3), 15915 (4), 16828 (1), 16832 (1), 16835 (1), 16837 (6), 16838 (4), 16844 (1), 16855 (1), 16857 (1), 16912 (1), 16913 (1), 16914 (2), 16915 (6), 16916 (3), 16917 (4), 16918 (5), 16923 (5), 16924 (6), 16926 (5), 16927 (2), 16930 (2), 16935 (1), 16986 (1), 16988 (1), 17280 (4), 17290 (1); TU 1225 (1), 1227A (5), 1230 (5), 1294 (5), 1354 (1), 1358 (40), 1359 (9), 1373 (11), 1378 (2), 1379 (14), 1403 (1), 1405 (9), 1419 (2).
Hemiramphus aff. *H. brasiliensis*: NMB 15903 (1); TU 1294 (2), 1358 (1).
Hildebrandia flava: TU 1206 (4), 1210 (2), 1211 (1), 1227A (23), 1343 (1), 1352 (2), 1366 (1), 1405 (1).
Holocentrus sp.: NMB 16817–16818 (1); TU 1294 (2), 1379 (1).
Hygophum aff. *H. benoiti*: TU 1294 (1), 1359 (1).
Hyporhamphus aff. *H. unifasciatus*: NMB 15903 (1), 16977 (1); TU 1294 (1).
Labrisomus sp.: NMB 17005 (1).
Lactarius sp.: NMB 15901 (1), 15903 (4), 15904 (1); TU 1359 (1), 1379 (1).
Larimus breviceps: NMB 15900 (8), 15903 (31), 15904 (23), 15906 (5), 15907 (2), 15911 (1), 15912 (7), 15915 (1), 15916 (1), 16854 (6), 16855 (2), 16856 (2), 16915 (6), 16916 (1), 16917 (10), 16918 (4), 16923 (20), 16924 (4), 16926 (3), 16927 (1), 16930 (1), 17003 (5), 17287 (1); TU 1227A (2), 1230 (2), 1294 (25), 1358 (11), 1359 (3), 1373 (2), 1379 (5).
Lepophidium latesulcatum: NMB 15805 (1), 15869 (1), 15873 (1), 15878 (1), 15896 (1), 15900 (7), 15903 (8), 15904 (5), 15906 (2), 15907 (3), 15914 (1), 15915 (2), 16854 (2), 16856 (1), 16857 (4), 16912 (1), 16914 (2), 16915 (5), 16916 (3), 16917 (13), 16918 (9), 16922 (2), 16923 (21), 16924 (5), 16926 (1), 16927 (4), 16928 (1), 16930 (8), 16932 (4), 16935 (2), 17003 (2), 17009 (1), 17268 (1), 17269 (1); TU 1206 (2), 1219 (1), 1225 (1), 1227A (129), 1230 (4), 1250 (3), 1293 (2), 1294 (25), 1343 (2), 1358 (1), 1373 (1), 1378 (1), 1379 (3), 1405 (1), 1419 (3).
Lonchopisthus micrognathus: NMB 15864 (1); TU 1226 (1), 1227A (1), 1250 (2), 1358 (1), 1405 (1), 1410 (1).
Lutjanus aff. *L. campechanus*: NMB 16923 (1).
Menticirrhus chaoi: NMB 15896 (1), 15900 (1), 15904 (1), 15907 (1); TU 1358 (1).
Moharra rhombea: NMB 15903 (2), 15904 (1), 16935 (3), 17283 (1), 17286 (4), 17288 (3); TU 1226 (1), 1230 (2), 1293 (2), 1294 (1), 1358 (4), 1359 (1), 1364 (1), 1419 (1).
Mugil sp.: TU 1246 (1), 1278 (1).
Myctophum sp.: NMB 17003 (1); TU 1294 (1).
Neobythites gillii: NMB 15823 (2), 15828 (3).
Neobythites marginatus: NMB 15829 (1), 16865 (1); TU 1227A (1), 1292 (1).
Nezumia aequalis: TU 1365 (1).
Ocyurus aff. *O. chrysurus*: NMB 15904 (1), 16837 (1); TU 1294 (1).
Ophioscion sp. 1: NMB 15896 (1), 15900 (2), 15903 (62), 15904 (12), 15907 (14), 15911 (1), 15912 (8), 15913 (2), 15914 (3), 15915 (2), 15916 (3), 16817–16818 (1), 16845 (1), 16854 (1), 16855 (1), 16856 (3), 16912 (2), 16913 (1), 16914 (1), 16915 (1), 16916 (3), 16917 (5), 16918 (4), 16922 (2), 16923 (8), 16924 (1), 16926 (1), 16927 (1), 16985 (1), 17003 (1); TU 1227A (1), 1230 (4), 1294 (20), 1358 (15), 1359 (11), 1373 (12), 1377 (2).
Ophioscion sp. 2: NMB 17286 (3), 17287 (2); TU 1364 (1).
Opisthonema sp.: TU 1225 (1).
Otophidium robinsi: NMB 15876 (1), 15896 (1), 15897 (1), 15904 (4), 15905 (7), 15906 (1), 15907 (2), 15910 (2), 15911 (1), 15915 (2), 16837 (3), 16857 (3), 16915 (1), 16917 (1), 16923 (4), 16926 (1), 17005 (2); TU 1230 (1), 1294 (5), 1358 (17), 1359 (14), 1373 (12), 1377 (1), 1405 (1), 1419 (1).
Otophidium robustum: NMB 15910 (1), 16832 (3), 16835 (1), 16837 (2), 16844 (1); TU 1250 (1).
Pareques sp.: TU 1206 (1), 1354 (2).
Parophidion aff. *P. schmidti*: NMB 16817–16818 (1).
? Pleuronectidae indet.: TU 1227A (2), 1230 (1), 1294 (1).
Plotosus sp.: NMB 16844 (1), 16923 (1); TU 1227A (4), 1250 (1).
Polydactylus sp.: TU 1250 (1), 1282 (1).
Polyipnus sp.: TU 1250 (3), 1282 (1).
Polymixia sp.: NMB 15827 (1).
Pomadasys sp.: NMB 16935 (1), 17287 (2), 17288 (2); TU 1250 (1), 1293 (1).
Porichthys sp.: NMB 15896 (1), 15903 (3), 15910 (2), 17005 (1); TU 1230 (1), 1293 (1), 1294 (1), 1358 (3), 1359 (1), 1373 (1).
Prionotus sp.: TU 1250 (1).
Pristigenys sp.: TU 1227A (1).
Pristipomoides sp.: NMB 15869 (1), 16910 (1); TU 1225 (2), 1227A (4), 1230 (2), 1363 (1), 1379 (1), 1405 (1).
Pythonichthys sp.: TU 1227A (4), 1250 (1), 1352 (1).
Rhechias tysanochila: TU 1227A (1), 1298 (1).
Saurida caribbaea: NMB 16926 (1); TU 1250 (1), 1358 (1), 1359 (2).
Scorpaenidae indet.: NMB 16837 (1).
Soleidae indet.: TU 1294 (1), 1373 (1).
Sphyraena sp.: NMB 16817–16818 (1); TU 1230 (1).
Umbrina sp.: NMB 16932 (2), 17003 (2).

REFERENCES CITED[4]

Berg, C.
1895. *Enumeración sistemática y sinonomica de los Peces de las costas Argentina y Uruguaya.* Buenos Aires, 120 pp., 1 pl.

Berra, T. M.
1981. *An atlas of distribution of the freshwater fish families of the world.* University of Nebraska Press, Lincoln and London, 197 pp.

Bleeker, P.
1852. *Diagnostische beschrijvingen van nieuwe of weinig bekende vischsoorten van Sumatra.* Tiental I–IV. Natuurkundig Tijdschrift voor Nederlandsch Indië, vol. 3, pp. 569–608.

Bloch, M. E.
1785–1795. *D. M. E. Bloch's . . . Naturgeschichte der ausländischen Fische.* 324 pls. in 3 vols.

Bloch, M. E., and Schneider, J. G.
1801. *M. E. Blochii . . . Systema Ichthyologiae iconibus CX illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit J. G. Schneider.* 2 vols., lx + 584 pp., 110 pls.

Böhlke, J. E., and Robins, C. R.
1959. *Studies on fishes of the family Ophidiidae. II. Three new species from the Bahamas.* Philadelphia Academy of Natural Sciences, Proceedings, vol. 111, pp. 37–52, 1 pl., 3 figs.

Bold, W. A. van den
1988. *Neogene paleontology in the northern Dominican Republic. 7. The subclass Ostracoda (Arthropoda: Crustacea).* Bulletins of American Paleontology, vol. 94, No. 329, pp. 1–105.

Bonaparte, C. L. J. L.
1832. *Saggio d'una distribuzione metodica degli Animali Vertebrati a sangue freddo.* Rome, 86 pp.

Breder, C. M., Jr.
1927. *Scientific results of the first oceanographic expedition of the "Pawnee", 1925. Fishes.* Bulletin of the Bingham Oceanographic Collection, New York, vol. 1, art. 1 , 90 pp., 36 figs.

Casier, E.
1958. *Contribution a l'étude des poissons fossiles des Antilles.* Memoires suisses de Paléontologie, vol. 73, pp. 1–95.
1966. *Sur la faune ichthyologique de la formation de Bissex Hill et de la série océanique de l'Ile de la Barbade, et sur l'âge de ces formations.* Eclogae geologiae Helvetiae, vol. 53, pp. 493–515.

Chao, L. N.
1978. *A basis for classifying Western Atlantic Sciaenidae (Teleostei: Perciformes).* National Oceanic and Atmospheric Administration Technical Report, National Marine Fisheries Circular 415, pp. 1–64.

Chirichigno F., N.
1969. *Lista sistematica de los peces marinos comunes para Ecuador–Peru–Chile.* Comision permanente del Pacifico Sur, pp. 1–108.

Clarke, M. R., and Fitch, J. E.
1979. *Statoliths of Cenozoic teuthoid cephalopods from North America.* Palaeontology, vol. 22, part 2, pp. 479–511.

Cocco, A.
1838. *Osservazioni intorno taluni Pesci del Mare di Messina lettera, etc.* Messina, 16 pp.

Cuvier, G.
1816. *Le Régne Animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des Animaux et d'introduction à l'Anatomie Comparée. Les reptiles, les poissons, les mollusques et les annélides.* Paris, edition 1, vol. 2, xviii + 532 pp.
1829. *Le Régne Animal distribué d'après son organisation, pour servir de base à l'Anatomie Comparée.* Nouvelle édition. Paris, vol. 2.

Cuvier, G., and Valenciennes, A.
1828–1849. *Histoire naturelle des Poissons.* Paris, 22 vols.

Dawson, C. E.
1969. *A new Eastern Pacific sand stargazer,* Dactyloscopus byersi *(Pisces: Dactyloscopidae).* Copeia, pp. 510–514, 2 figs., 1 table.

Delaroche, F.
1809. *Observations sur les Poissons recueillis dans un voyage aus Iles Baléares et Pythiuses.* Museum National d'Histoire Naturelle, Paris, Annales, vol. 13, 75 pp., 6 pls.

Eastman, C. R.
1904. *Systematic paleontology of the Miocene deposits of Maryland, Class Pisces* in Maryland Geological Survey, *Miocene.* Baltimore, The Johns Hopkins University Press, pp. 71–93.

Eigenmann, C. H., and Eigenmann, R. S.
1890. *Additions to the fauna of San Diego.* Proceedings of the California Academy of Sciences, ser. 2, vol. 3, pp. 1–24.

Fitch, J. E., and Lavenberg, R. J.
1983. *Teleost fish otoliths from Lee Creek Mine, Aurora, North Carolina (Yorktown Formation: Pliocene).* Smithsonian Contributions to Paleobiology, No. 53, pp. 509–529.

Fowler, H. W.
1900. *Contributions to the ichthyology of the tropical Pacific.* Philadelphia Academy of Natural Sciences, Proceedings, vol. 52, pp. 493–528.
1946. *A collection of fishes obtained in the Riu Kiu Islands by Captain Ernest R. Tinkham, A. U. S.* Philadelphia Academy of Natural Sciences, Proceedings, vol. 98, pp. 123–218, 76 text-figs.

Fowler, H. W., and Bean, B. A.
1923. *Descriptions of eighteen new species of fishes from the Wilkes Exploring Expedition, preserved in the United States National Museum.* Proceedings of the United States National Museum, vol. 63, art. 19, 27 pp.

Frizzell, D. L., and Dante, J. H.
1965. *Otoliths of some Early Cenozoic fishes of the Gulf Coast.* Journal of Paleontology, vol. 39, No. 4, pp. 687–718.

Frizzell, D. L., and Lamber, C. K.
1961. *New genera and species of myripristid fishes, in the Gulf Coast Cenozoic, known from otoliths (Pisces, Beryciformes).* Bulletin of the University of Missouri School of Mines and Metallurgy, Technical Series, No. 100, pp. 1–25.
1962. *Distinctive "congrid type" fish otoliths from the Lower Tertiary of the Gulf Coast (Pisces: Anguilliformes).* Proceedings of the California Academy of Sciences, fourth series, vol. 32, No. 5, pp. 87–101.

Garman, S.
1899. *Fishes of the coasts of Mexico, Central and South America, and the Galapagos Islands.* Harvard University, Museum of Comparative Zoology, Memoirs, vol. 24.

Gill, T. N.
1861a. *Catalogue of the Fishes of the Eastern Coast of North America, from Greenland to Georgia.* Philadelphia Acad-

[4] The Editor gratefully acknowledges the assistance of C. Lavett Smith (American Museum of Natural History, New York, NY), U. S. A., and C. Richard Robins (Miami, FL, U. S. A.), in locating and verifying many of these references.

emy of Natural Sciences, Proceedings for 1860, 63 pp.

1861b. *Revision of the Genera of North American Sciaeninae.* Academy of Natural Sciences of Philadelphia, Proceedings for 1861, pp. 79–89.

1862a. *Note on the Sciaenoids of California.* Philadelphia Academy of Natural Sciences, Proceedings for 1862, pp. 16–18.

1862b. *Remarks on the relations of the Genera and other groups of Cuban Fishes.* Philadelphia Academy of Natural Sciences, Proceedings for 1862, pp. 235–242.

1863. *Descriptive Enumeration of a collection of Fishes from the Western Coast of Central America, Presented to the Smithsonian Institution, by Capt. John M. Dow.* Philadelphia Academy of Natural Sciences, Proceedings for 1863, pp. 162–174.

1895. *The genus* Leptophidium. American Naturalist, vol. 29, No. 338, pp. 167–168.

Gillette, D. D.

1984. *A marine ichthyofauna from the Miocene of Panama, the Tertiary faunal province.* Journal of Vertebrate Paleontology, vol. 4, No. 2, pp. 172–186.

Girard, C. F.

1854. *Enumeration of the Species of marine fishes, collected at San Francisco, California, by Dr. C. B. R. Kennerly, naturalist attached to the survey of the Pacific railroad route, under Lieut. A. W. Whipple.* Philadelphia Academy of Natural Sciences, Proceedings for 1854, pp. 141–142.

Goode, G. B.

1874. *Descriptions of two new species of fishes from the Bermuda Islands.* American Journal of Science, vol. 8, pp. 123–125.

1876. *Catalogue of the fishes of the Bermudas, based chiefly upon the collection of the United States National Museum.* U. S. National Museum, Bulletin, vol. 5, pp. 1–82.

Goode, G. B., and Bean, T. H.

1885. *Descriptions of new fishes obtained by the United States Fish Commission mainly from deep water off the Atlantic and Gulf coasts.* United States National Museum, Proceedings, vol. 8, pp. 589–605.

1886. *Report on the results of dredging, under the supervision of Alexander Agassiz in the Gulf of Mexico (1877–78) and in the Caribbean Sea (1879–80), by the U. S. Coast Survey Steamer "Blake," Lieut. Commander C. D. Sigsbee, U. S. N., and Commander J. R. Bartlett, U. S. N., commanding.* Harvard University, Museum of Comparative Zoology, Bulletin, vol. 12, No. 5, pp. 153–170.

1896. *Oceanic ichthyology, a treatise on the deep-sea and pelagic fishes of the world, based chiefly upon the collections made by the steamers* Blake, Albatross *and* Fish Hawk *in the Northwestern Atlantic.* United States National Museum Special Bulletin, pp. 1–553.

Greenwood, P. H., Rosen, D. H., Weitzman, S. H., and Myers, G. S.

1966. *Phyletic studies of teleostean fishes, with a provisional classification of living forms.* Bulletin of the American Museum of Natural History, vol. 131, art. 4, pp. 339–456.

Günther, A.

1878. *Preliminary notices of deep-sea fishes collected during the voyage of H. M. S.* Challenger. Annals and Magazine of Natural History, ser. 5, vol. 2, pp. 17–28.

Hildebrand, S. F., and Barton, O.

1949. *A collection of fishes from Talara, Peru.* Smithsonian Miscellaneous Collections, vol. 111, No. 10, pp. 1–36, 9 text-figs.

Holbrook, J. E.

1860. *Ichthyology of South Carolina.* Charleston, second edition, vol. 1, 205 pp.

Hubbs, C. L.

1944. *Species of the circumtropical fish genus* Brotula. Copeia, 1944, pp. 162–178, 2 text-figs.

Hubbs, C. L., and Schultz, L. P.

1939. *A revision of the toadfishes referred to* Porichthys *and related genera.* Proceedings of the U. S. National Museum, vol. 86, No. 3060, pp. 473–496.

Jones, J. M.

1874. *A new fish.* The Zoologist, Second Series, vol. 9, pp. 3837–3838.

Jordan, D. S.

1885. *A catalogue of the fishes known to inhabit the waters of North America, north of the Tropic of Cancer, with notes on species discovered in 1882 and 1883.* Report of the U. S. Fisheries Commission, vol. 13, pp. 789–973.

Jordan, D. S., and Bollman, C. H.

1890. *Scientific results of explorations by the U. S. Fish Comission Steamer "Albatross." No. 4, Descriptions of new species of fishes collected at the Galapagos Islands and along the coast of the United States of Colombia, 1887–'88.* Proceedings of the U. S. National Museum, vol. 12, No. 770, pp. 149–183.

Jordan, D. S., and Gilbert, C. H.

1883. *Synopsis of the Fishes of North America.* United States National Museum, Bulletin No. 16, lv + 1018 pp.

Koken, E.

1888. *Neue Untersuchungen an tertiaren Fisch-Otolithen.* Zeitschrift der Deutschen geologischen Gesellschaft, Bd. 40, pp. 274–305.

Lacepède, B. G. E. V.

1798–1803. *Histoire naturelle des Poissons.* Paris, 5 vols.

Lee, D. S., Gilbert, C. R., Hocutt, C. H., Jenkins, R. E., McAllister, D. E., and Staufer, J. R.

1980. *Atlas of North American freshwater fishes.* Publication of the North Carolina Biological Survey, 867 pp.

Leriche, M.

1938. *Contribution a l'étude des poissons fossiles des pays riverains de la Méditerranée Américaine (Vénézuéla, Trinité, Antilles, Mexique).* Mémoires de la Sociéte Paléontologique Suisse, vol. 61, pp. 1–42.

Linnaeus, C.

1758. *Systema naturae, vol. 1. Regnum Animale.* 10th ed., Stockholm, 824 pp.

1771. *Mantissa plantarum altera generum editionis VI et specierum editionis II,* in *Regni Animalis animalis appendix,* Holmiae, pp. i–iv, 143–510.

Lütken, C. F.

1892. *Spolia Atlantica. Scopelini Musei Zoologici Universitatis Hauniensis. Bidrag til Kundskab om det aabne Havs Laxesild eller Scopeliner. Med en Tillaeg om en anden pelagisk Fiskeslaegt . . . Avec Résumé en Français.* Kongeligt Dansk Videnskabernes Selskab, Raek. 6, Bd. 7, No. 6, pp. 221–297, 3 pls.

Mayer, G. F.

1974. *A revision of the cardinalfish genus* Epigonus *(Perciformes, Apogonidae), with description of two new species.* Bulletin of the Museum of Comparative Zoology, vol. 146, No. 3, pp. 147–203.

Metzelaar, J.

1919. *Over tropisch Atlantische visschen.* Amsterdam, A. H. Kruyt, 314 pp.

Mitchill, S. L.
1814. *Report, in part, of Samuel L. Mitchill, M. D., Professor of Natural History, etc., on the fishes of New York.* J. Carlisle, New York, 30 pp.

Müller, J., and Trotschel, F. H.
1845–1849. *Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische.* Berlin, 3 hefte in 1 vol.

Nichols, J. T.
1912. *Notes on Cuban fishes.* Bulletin of the American Museum of Natural History, vol. 31, art. 18, pp. 179–194.
1914. Gobiosoma longum *and* Rivulus heyei, *new fishes from the West Indian fauna.* Bulletin of the American Museum of Natural History, vol. 33, art. 10, pp. 143–144.

Nolf, D.
1976. *Les otolithes de téléostéens néogènes de Trinidad.* Eclogae geologicae Helvetiae, vol. 69, pt. 3, pp. 703–742.
1980. *Etude monographique des otolithes des Ophidiiformes actuels et révision des espèces fossiles (Pisces, Teleostei).* Mededelingen van de Werkgroep voor Tertiaire en Kwartaire Geologie, vol. 17, pt. 2, pp. 71–195.
1985. *Otolithi Piscium.* In Schultze, H. P. [ed.], *Handbook of Paleoichthyology*, vol. 10, pp. 1–145. Gustav Fischer Verlag, Stuttgart and New York.

Nolf, D., and Cappetta, H.
1989. *Otolithes de poissons du Pliocène du Sud-Est de la France.* Bulletin de l'Institut royal des Sciences Naturelles de Belgique, Sciences de la Terre, vol. 58 (1988), pp. 209–271.

Nolf, D., and Lapierre, H.
1979. *Otolithes de poissons nouveaux ou peu connus du Calcaire Grossier et de la Formation d'Auvers (Eocene du Bassin parisien).* Bulletin du Muséum national d'Histoire naturelle, Paris, fourth ser., No. 1, section C, No. 2, pp. 79–125.

Nolf, D., and Steurbaut, E.
1988. *Description de la première faune ichthyologique exclusivement bathyale du Tertiaire d'Europe: otolithes de l'Oligocène Inférieur du gisement de Pizzocorno, Italie septentrionale.* Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre, vol. 57, pp. 217–230.
1989. *Evidence from otoliths for establishing relationships between gadiforms and other groups.* In Cohen, D. M. [ed.], *Papers on the systematics of gadiform fishes.* Natural History Museum of Los Angeles County, Science Series, No. 32, pp. 37–45.

Ogilby, J. D.
1896. *Descriptions of two new genera and species of Australian fishes.* Proceedings of the Linnaean Society of New South Wales, vol. 21, pp. 136–142.

Oken, L.
1817. *V. Kl. Fische.* Isis oder Encyclopädische Zeitung, vol. 8, No. 148, pp. 1179–1182, 1182a.

Poey, F.
1858–1861. *Memorias sobra la historia natural de la Isla de Cuba, acompañadas de sumarios Latinos y extractos en Francés.* La Habana, vol. 2, pp. 337–442, pls. 1–19.
1866–1868. *Repetorio fisico-natural de la Isla de Cuba.* La Habana. vol. 2, pp. 1–468.
1868. *Synopsis piscium cubensium.* La Habana, vol. 2, pp. 279–484.
1875–1877. *Enumeratio Piscium Cubensium.* Sociedad Real Española de Historia Natural, Anales, vols. 4–6, 224 pp., 9 pls.

Poll, M.
1953. *Poissons III—Téléostéens malacoptérygiens.* Résultats scientifiques de l'expédition océanographique belge dans les eaux cotières africaines de l'Atlantique sud, vol. 4, fasc. 2, pp. 1–250.
1954. *Poissons IV—Téléostéens acanthoptérygiens (première partie).* Résultats scientifiques de l'expédition océanographieque belge dans les eaux cotières africaines de l'Atlantique sud, vol. 4, fasc. 3A, pp. 1–300.
1959. *Poissons V—Téléostéens acanthoptérygiens (deuxième partie).* Résultats scientifiques de l'expédition océanographique belge dans les eaux cotières africaines de l'Atlantique sud, vol. 4, Fasc. 3B, pp. 1–417.

Rafinesque, C. S.
1815. *Analyse de la nature, ou tableau de l'univers et des corps organisés.* Palermo, 224 pp.

Ranzani, C.
1842. *De novis speciebus piscium. Dissertationes Secunda.* Novi Commen. Acad. Sci. Hist. Bonon., vol. 5, pp. 1–21, pls. 1– 6.

Regan, C. T.
1912. *Description of two new Eels from West Africa, belonging to a new genus and family.* Annals and Magazine of Natural History, ser. 8, vol. 10, pp. 323, 324.

Reid, E.
1934. *Two new congrid eels and a new flatfish.* Smithsonian Miscellaneous Collections, vol. 91, No. 15, pp. 1–11.

Robins, C. R.
1959a. *Studies on fishes of the family Ophidiidae. I. A new species of* Lepophidium *from the Caribbean Sea.* Bulletin of Marine Science, Gulf and Caribbean, vol. 8, No. 4, pp. 360–368.
1959b. *Studies on fishes of the family Ophidiidae. III. A new species of* Lepophidium *from Barbados.* Harvard University, Museum of Comparative Zoology, Breviora, No. 104, pp. 1–7.

Robins, C. R., Bailey, R. M., Bond, C. E., Brooker, J. R., Lachner, E. A., Lea, R. N. and Scott, W. B.
1980. *A list of common and scientific names of fishes from the United States and Canada (fourth edition).* American Fisheries Society Special Publication, No. 12, pp. 1–174.

Robins, C. R., Ray, G. C. and Douglass, J.
1986. *A field guide to the Atlantic coast fishes of North America.* Houghton Mifflin Company, Boston, 354 pp.

Rosen, D. E., and Greenwood, P. H.
1970. *Origin of the Weberian apparatus and the relationships of the ostariophysian and gonorhynchiform fishes.* American Museum Novitates, No. 2428, 25 pp., 16 figs.

Rosenblatt, R. H., and Rubinoff, I.
1972. Pythonichthys ascodes, *a new heterenchelyid eel, from the Gulf of Panama.* Bulletin of Marine Science, vol. 22, No. 2, pp. 355–364.

Saunders, J. B., Jung, P., and Biju-Duval, B.
1986. *Neogene paleontology in the northern Dominican Republic. 1. Field surveys, lithology, envionment, and age.* Bulletins of American Paleontology, vol. 89, No. 323, pp. 1–79.

Schinz, H. R.
1822. *Das Thierreich . . . aus dem Französischen frey übersetzt und mit vielen Zusätzen versehen von H. R. Schinz.* vol. 2, *Fische.* Stuttgart and Tübingen, 4 vols.

Schubert, R.
1909. *Fischreste,* in Toula, F., *Eine jungtertiäre Fauna von Gatun am Panama-Kanal.* Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt, Bd. 58, pp. 687–691.

Scopoli, G. A.
1777. *Introductio ad historiam naturalem, sistens genera lapi-*

dum, plantarum et animalium hactenus detecta carateribus essentialibus donata, in tribus divisa, subinde ad leges naturae. Prague, x + 506 pp.

Smith, D. G., and Kanazawa, R.
1977. *Eight new species and a new genus of congrid eels from the Western North Atlantic with redescriptions of* Ariosoma analis, Hildebrandia guppyi *and* Rhechias vicinalis. Bulletin of Marine Science, vol. 27, No. 3, pp. 530–543.

Steindachner, F.
1875. *Die Süsswasserfische des südöstlichen Brasilien*. Sitzungsberichte der mathematisch-naturwissenschaftlichen Classe der königlichen Akademie der Wissenschaften (Wien), vol. 71, pp. 61–136.

Steurbaut, E.
1984. *Les Otolithes de téléostéens de l'Oligo-Miocène d'Aquitaine (Sud-Ouest de la France)*. Palaeontographica, Abt. A, Bd. 186, pp. 1–162.

Stringer, G. L.
1979. *A study of the Upper Eocene otoliths of the Yazoo Clay in Caldwell Parish, Louisiana*. Tulane Studies in Geology and Paleontology, vol. 15, No. 3, pp. 95–104.
1986. *Teleostean otoliths and their paleoecological implications at the Montgomery Landing locality*, in Schiebout, J. A., and Bold, W. A. van den, *Montgomery Landing Site, Marine Eocene (Jackson) of Central Louisiana*, pp. 209–222. Proceedings of the Gulf Coast Association of Geological Societies Symposium, Baton Rouge, Louisiana.

Swainson, W.
1838–1839. *The natural history and classification of Fishes, Amphibians, and Reptiles, or monocardian Animals*. London, vol. 2, vi + 448 pp.

Tåning, A. V.
1928. *Synopsis of the scopelids in the North Atlantic*. Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i København, vol. 86, pp. 49–69.

Temminck, C. J., and Schlegel, H.
1842–1850. *Fauna Japonica . . . notis, observationibus et adumbrationibus illustravit P. F. de Siebold. Conjunctis studiis . . . C. J. Temminck . . . pro Vertebratis . . . elaborata. Pisces*. 323 pp., 160 pls.

Thompson, W.
1840. *On a new genus of fishes from India*. Magazine of Natural History, new series, vol. 4, pp. 184–187.

Valenciennes, A.
1828. *in* Cuvier, G., and Valenciennes, A., *Histoire Naturelle des Poissons*, vol. 2, xvi + 490 pp., pls. 9– 40.
1836. *in* Cuvier, G., and Valenciennes, A., *Histoire Naturelle des Poissons*, vol. 11, Paris, F. G. Levrault, 506 pp., pls. 307–343.

Walbaum, J. J.
1792. *Petri artedi sueci genera piscium in quibus systema totum ichthyologiae proponitus cum classibus, ordinibus, generum characteribus, specierum differentiis, observationibus plurimus*. Ichthyologiae, pars. 3, Grypeswaldii, 723 pp.

Weiler, W.
1959. *Miozane Fisch-Otolithen aus der Bohrung* S. Pablo 2 *im Becken von Veracruz in Mexiko*. Neues Jahrbuch fur Geologie und Palaontologie, Abhandlungen, Bd. 109, Heft 1, pp. 147–172.

Whitehead, P. J., Bauchot, M. L., Hureau, J. C., Nielsen, J., and Tortonese, E.
1984–1986. *Fishes of the Northeastern Atlantic and the Mediterranean*. Unesco, vol. I (1984), pp. 1–510, vol. II (1986), pp. 511–1007, vol. III (1986), pp. 1008–1473.

Woods, L. P., and Kanazawa, R. H.
1951. *New species and new records of fishes from Bermuda*. Fieldiana, Zoology, vol. 31, No. 53, pp. 629–644.

EXPLANATION OF THE PLATES

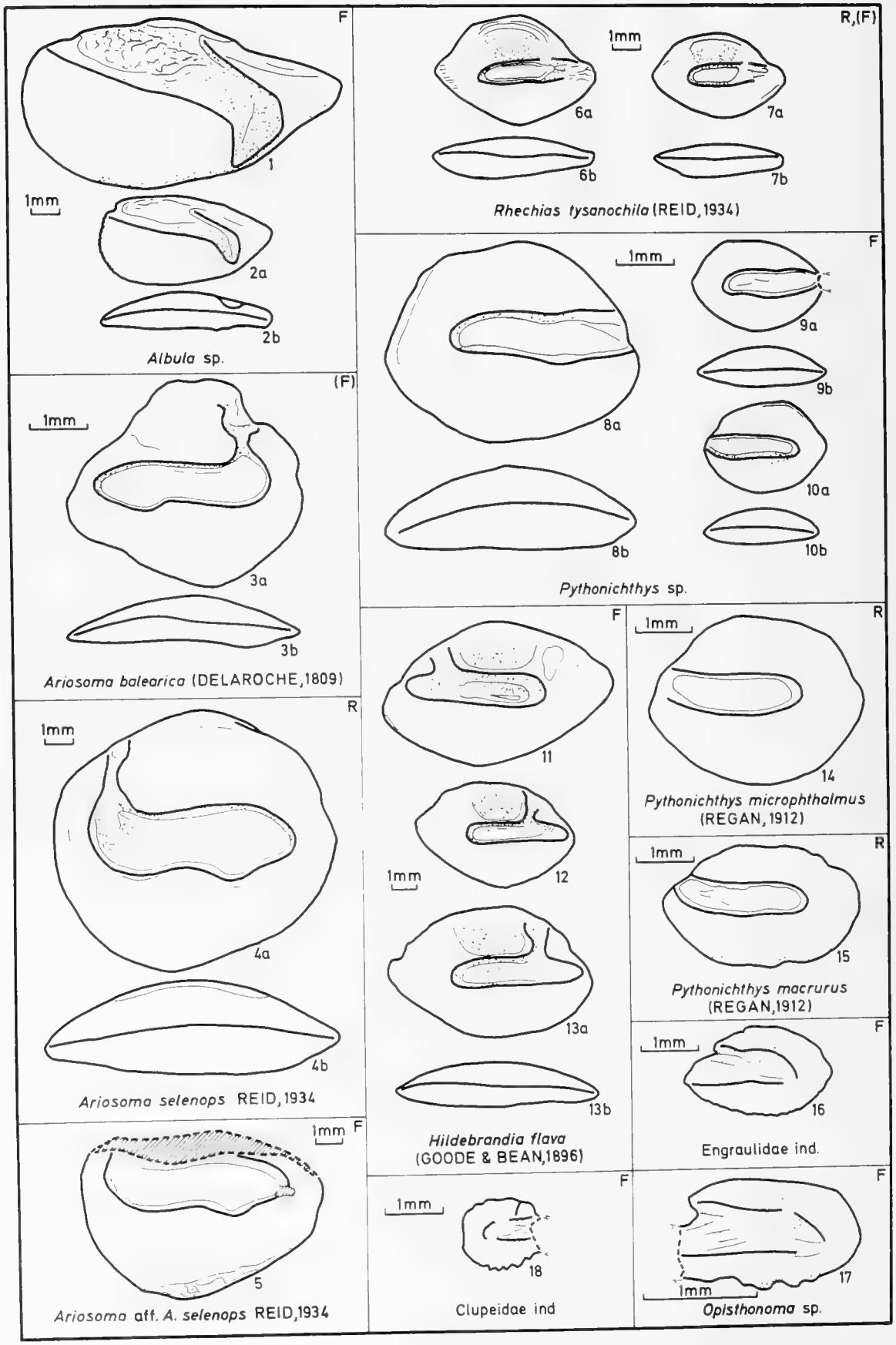
Abbreviations utilized on the plates

F = fossil species

(F) = Recent species found as fossil

R = Recent species

All fossil specimens from this study are deposited in the collections of the Naturhistorisches Museum, Basel, Switzerland (NMB). Unless noted otherwise, all Recent material included for comparative purposes is from the reference collection of the Royal Institute of Natural Science of Belgium (IRSNB). Since the latter collection is arranged in a systematic order, the specimens do not have collection numbers and are designated by the acronym IRSNB.


F
1
1mm
2a
2b
Albula sp.
R,(F)
1mm
6a
7a
6b
7b
Rhechias tysanochila (REID, 1934)
F
1mm
8a
8b
9a
9b
10a
10b
Pythonichthys sp.
(F)
1mm
3a
3b
Ariosoma balearica (DELAROCHE, 1809)
R
1mm
4a
4b
Ariosoma selenops REID, 1934
1mm F
5
Ariosoma aff. A. selenops REID, 1934
F
11
1mm
12
13a
13b
Hildebrandia flava
(GOODE & BEAN, 1896)
R
1mm
14
Pythonichthys microphthalmus
(REGAN, 1912)
R
1mm
15
Pythonichthys macrurus
(REGAN, 1912)
F
1mm
16
Engraulidae ind.
F
1mm
18
Clupeidae ind
F
17
1mm
Opisthonoma sp.

EXPLANATION OF PLATE 9

Figure — Page

1, 2. ***Albula*** species 61
1. NMB P26, right otolith, inner view, loc. NMB 15907, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
2. NMB P27, right otolith (a, inner view; b, ventral view), loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.

3. ***Ariosoma balearica*** (Delaroche, 1809) 61
NMB P28, left otolith (a, inner view; b, ventral view), loc. NMB 16932, Río Mao, Maury's Bluff 2, late Miocene NN11 Zone.

4. ***Ariosoma selenops*** Reid, 1934
IRSNB, right otolith (a, inner view; b, ventral view), off Cuba, Recent [included for comparative purposes].

5. ***Ariosoma*** aff. ***A. selenops*** Reid, 1934 61
NMB P29, right otolith, inner view, loc. TU 1357, Río Yaque del Norte, Gurabo Formation, Pliocene NN14 Zone.

6, 7. ***Rhechias tysanochila*** (Reid, 1934) 62
6. IRSNB, left otolith (a, inner view; b, ventral view), off Florida, Recent.
7. NMB P30, left otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

8–10. ***Pythonichthys*** species 62
NMB P31, loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.
8, 9. left otoliths (a, inner view; b, ventral view).
10. right otolith (a, inner view; b, ventral view).

11–13. ***Hildebrandia flava*** (Goode and Bean, 1896) 62
11, NMB P32, right otolith, inner view; 12, NMB P33, left otolith, inner view; 13, NMB P34, left otolith (a, inner view; b, ventral view); all from loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

14. ***Pythonichthys microphthalmus*** (Regan, 1912)
IRSNB, right otolith, inner view, Gulf of Guinea, Recent [included for comparative purposes].

15. ***Pythonichthys macrurus*** (Regan, 1912)
IRSNB, right otolith, inner view, Gulf of Guinea, Recent [included for comparative purposes].

16. Engraulidae indeterminate 62
NMB P35, right otolith, inner view, loc. NMB 16922, Río Mao, Cercado Formation, late Miocene NN11 Zone.

17. ***Opisthonema*** species 62
NMB P36, right otolith, inner view, loc. TU 1225, Río Mao, Gurabo Formation, near Mio-Pliocene boundary.

18. Clupeidae indeterminate 61
NMB P37, left otolith, inner view, loc. TU 1301, Río Cana, Cercado Formation, late Miocene NN11 Zone.

EXPLANATION OF PLATE 10

Figure — Page

1. ***Arius*** species 61
NMB P38, left utricular otolith (a, inner face; c, outer face), loc. NMB 15900, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

2. ***Plotosus anguillaris*** (Bloch, 1794) 51
IRSNB, right utricular otolith, outer face, Gulf of Thailand, Recent.

3. ***Plotosus*** species 51
NMB P39, right utricular otolith (a, inner face; b, ventral face), loc. NMB 16923, Río Mao, Cercado Formation, late Miocene NN11 Zone.

4–9. ***Diaphus brachycephalus*** Tåning, 1928 51
IRSNB, left otoliths, inner views, off Mauritania, Recent.

10. ***Polyipnus*** species 62
NMB P40, left otolith (a, inner view; c, posterior view), loc. TU 1250, Río Verde, Gurabo Formation.

11–13. ***Diaphus*** aff. ***D. brachycephalus*** Tåning, 1928 51
11. NMB P41, left otolith, inner view; 12, NMB P42, right otolith, inner view; both from loc. TU 1250, Río Verde, Gurabo Formation.
13. NMB P43, right otolith, inner view, loc. NMB 15823, Río Gurabo, Mao Formation, Pliocene NN14–15 Zone.

14, 15. ***Myctophum*** species 62
14. NMB P44, right otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.
15. NMB P45, left otolith, inner view, loc. NMB 17003, Río Cana, Cercado Formation, late Miocene.

16, 17. ***Myctophum affine*** (Lütken, 1892)
IRSNB, left otoliths, inner views, off Venezuela, Recent [included for comparative purposes].

18–23. ***Diaphus*** species 1 51
18–21, 23. loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone. 18, NMB P46, right otolith, inner view, 19, NMB P47, left otolith, inner view; 20, NMB P48, left otolith, inner view; 21, NMB P49, left otolith, inner view; 23, NMB P50, left otolith (a, inner view; b, ventral view).
22. NMB P51, left otolith, inner view, loc. TU 1357, Río Yaque del Norte, Pliocene NN14 Zone.

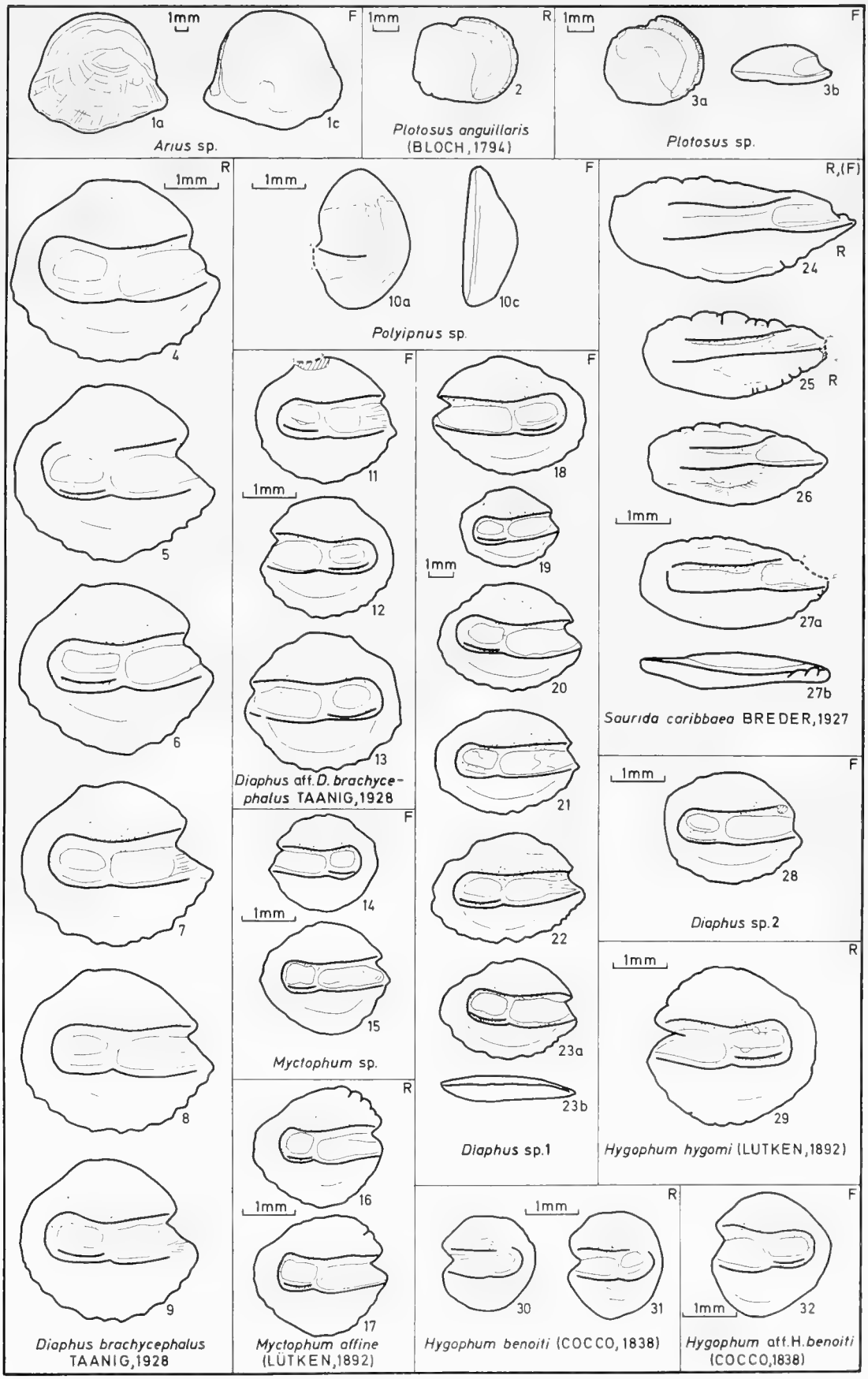
24–27. ***Saurida caribbaea*** Breder, 1927 62
24, 25. IRSNB, left otoliths, inner views, off Cuba, Recent.
26. NMB P52, left otolith, inner view, loc. TU 1359, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
27. NMB P53, left otolith (a, inner view; b, ventral view), loc. NMB 16926, Río Mao, Cercado Formation, late Miocene NN11 Zone.

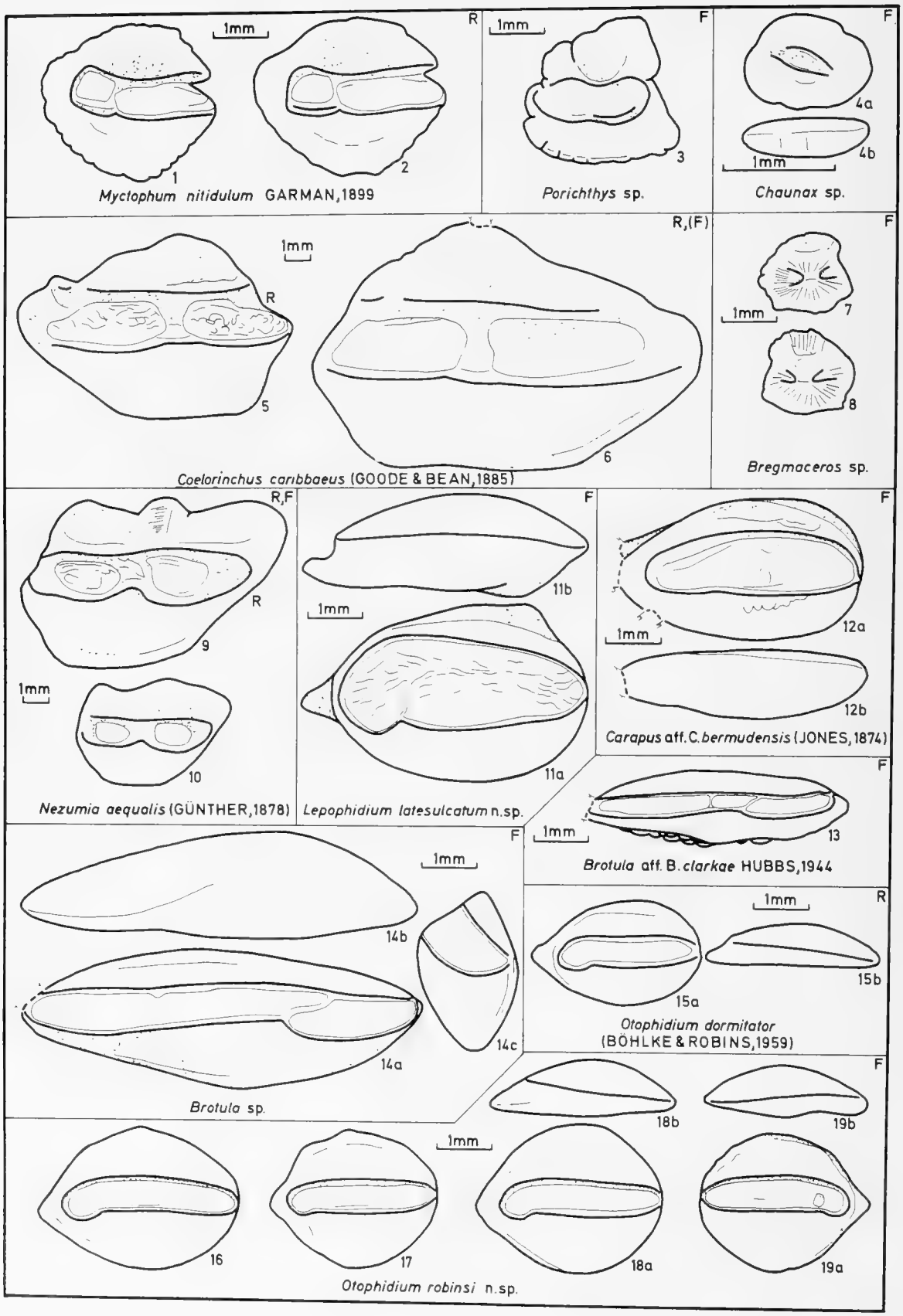
28. ***Diaphus*** species 2 51
NMB P54, left otolith, inner view, loc. TU 1293, Río Mao, Maury's Bluff 1, Gurabo Formation, late Miocene NN11 Zone.

29. ***Hygophum hygomi*** (Lütken, 1892)
IRSNB, right otolith, inner view, off Canaries, Recent [included for comparative purposes].

30, 31. ***Hygophum benoiti*** (Cocco, 1838)
IRSNB, right otoliths, inner views, off Marrakech, Morocco, Recent [included for comparative purposes].

32. ***Hygophum*** aff. ***H. benoiti*** (Cocco, 1838) 62
NMB P55, right otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.


1mm
F
1a
1c
Arius sp.
1mm
R
2
Plotosus anguillaris (BLOCH, 1794)
1mm
F
3a
3b
Plotosus sp.
R
1mm
4
5
6
7
8
9
Diaphus brachycephalus TAANIG, 1928
1mm
F
10a
10c
Polyipnus sp.
F
11
1mm
12
13
Diaphus aff. D. brachycephalus TAANIG, 1928
F
14
1mm
15
Myctophum sp.
R
16
1mm
17
Myctophum affine (LÜTKEN, 1892)
F
18
1mm
19
20
21
22
23a
23b
Diaphus sp.1
R,(F)
24
R
25
R
26
1mm
27a
27b
Saurida caribbaea BREDER, 1927
1mm
F
28
Diaphus sp.2
1mm
R
29
Hygophum hygomi (LUTKEN, 1892)
R
1mm
30
31
Hygophum benoiti (COCCO, 1838)
F
1mm
32
Hygophum aff. H. benoiti (COCCO, 1838)


1mm
R
1
2
Myctophum nitidulum GARMAN, 1899
F
3
Porichthys sp.
4a
4b
Chaunax sp.
R,(F)
5
6
Coelorinchus caribbaeus (GOODE & BEAN, 1885)
7
8
Bregmaceros sp.
R,F
9
10
Nezumia aequalis (GÜNTHER, 1878)
11a
11b
Lepophidium latesulcatum n.sp.
12a
12b
Carapus aff. C. bermudensis (JONES, 1874)
13
Brotula aff. B. clarkae HUBBS, 1944
14a
14b
14c
Brotula sp.
15a
15b
Otophidium dormitator (BÖHLKE & ROBINS, 1959)
16
17
18a
18b
19a
19b
Otophidium robinsi n.sp.

EXPLANATION OF PLATE 11

Figure — Page

1, 2. ***Myctophum nitidulum*** Garman, 1899
IRSNB, left otoliths, inner views, west of Cape Verde Islands, Recent [included for comparative purposes].

3. ***Porichthys*** species 51
NMB P56, right otolith, inner view, loc. NMB 15896, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

4. ***Chaunax*** species 61
NMB P57, right otolith (a, inner view; b, ventral view), loc. TU 1250, Río Verde, Gurabo Formation.

5, 6. ***Coelorinchus caribbaeus*** (Goode and Bean, 1885) 61
5. IRSNB, right otolith, inner view, off French Guyana, Recent.
6. NMB P58, right otolith, inner view, loc. TU 1357, Río Yaque del Norte, Pliocene NN14 Zone.

7, 8. ***Bregmaceros*** species 61
Loc. TU 1230, Río Cana, Cercado Formation, late Miocene NN11 Zone.
7. NMB P59, left otolith, inner view.
8, NMB P60, right otolith, inner view.

9–10. ***Nezumia aequalis*** (Günther, 1878) 62
9. IRSNB, right otolith, inner view, west of Ireland, Recent.
10. NMB P61, right otolith, inner view, loc. TU 1365, Río Gurabo, Mao Formation, Pliocene NN15 Zone.

11. ***Lepophidium latesulcatum***, new species 52
NMB P62, holotype, left otolith (a, inner view; b, ventral view), loc. NMB 15878, Río Gurabo, Gurabo Formation, late Miocene NN11 Zone.

12. ***Carapus*** aff. ***C. bermudensis*** (Jones, 1874) 61
NMB P64, left otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

13. ***Brotula*** aff. ***B. clarkae*** Hubbs, 1944 51
NMB P64, left otolith, inner view, loc. TU 1250, Río Verde, Gurabo Formation.

14. ***Brotula*** species 51
NMB P64, left otolith (a, inner view; b, ventral view, c, anterior view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

15. ***Otophidium dormitator*** Böhlke and Robins, 1959 53
IRSNB, left otolith (a, inner view; b, ventral view), off Jamaica coast, Recent.

16–19. ***Otophidium robinsi***, new species 52
16. NMB P66, paratype, left otolith, inner view; 17, NMB P67, paratype, left otolith, inner view; loc. TU 1359, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
18. NMB P69, paratype, left otolith (a, inner view; b, ventral view), loc. NMB 15905, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
19. NMB P68, holotype, right otolith (a, inner view; b, ventral view), loc. TU 1359, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

EXPLANATION OF PLATE 12

Figure — Page

1–3. ***Neobythites marginatus*** Goode and Bean, 1886 53
1, 2. IRSNB, left otoliths, inner views, Florida Strait, Recent.
3. NMB P70, left otolith (a, inner view; b, ventral view), loc. NMB 15829, Río Gurabo, Mao Formation, Pliocene NN15 Zone.

4, 5. ***Otophidium robustum***, new species 53
4. NMB P71, holotype, right otolith (a, inner view; b, ventral view), loc. NMB 16837, Río Cana, Cercado Formation, late Miocene.
5. NMB P72, paratype, right otolith (a, inner view; b, ventral view), loc. NMB 16832, Río Cana, Gurabo Formation, late Miocene.

6. ***Parophidion*** aff. ***P. schmidti*** (Woods and Kanazawa, 1951) 62
NMB P73, right otolith (a, inner view; b, ventral view), loc. NMB 16817, Río Cana, Gurabo Formation, Pliocene.

7, 8. "genus Dinematichthyinorum" ***sauli***, new species 53
7. NMB P74, holotype, left otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.
8. NMB P75, paratype, right otolith (a, inner view; b, ventral view), loc. NMB 17268, Río Yaque del Norte, Gurabo Formation, Pliocene NN12 Zone.

9, 10. ***Neobythites gillii*** Goode and Bean, 1885 53
9, IRSNB, right otolith, inner view, Antilles Sea, Recent.
10, NMB P76, right otolith (a, inner view; b, ventral view), loc. NMB 15828, Río Gurabo, Mao Formation, Pliocene *Globorotalia miocenica* Zone (?NN14–15 Zone).

11, 12. "genus Dinematichthyinorum" ***smithvanizi***, new species 54
11, NMB P77, paratype, left otolith, inner view, loc. NMB 15864, Río Gurabo, Gurabo Formation, late Miocene NN11 Zone.
12, NMB P78, holotype, right otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

13–16. ***Atherinomorus stipes*** (Müller and Trotschel, 1847) 61
13, NMB P79, left otolith, inner view, loc. NMB 16856, Río Cana, Cercado Formation, late Miocene.
14–16, IRSNB, left otoliths, inner views, Bahamas, Recent.

17, 18. ***Hyporhamphus unifasciatus*** (Ranzani, 1842)
17, IRSNB, left otolith, inner view, off Acapulco, Mexico, Recent [included for comparative purposes].
18, IRSNB, left otolith, inner view, off Margarita Island, Venezuela, Recent [included for comparative purposes].

19. ***Hyporhampus*** aff. ***H. unifasciatus*** (Ranzani, 1842) 62
NMB P80, left otolith, inner view, loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

20. ***Euleptorhamphus*** species 62
NMB P81, left otolith, inner view, loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

21. ***Euleptorhamphus velox*** Poey, 1868
IRSNB, right otolith, inner view, off Trinidad, Recent [included for comparative purposes].

22. ***Hemiramphus brasiliensis*** (Linnaeus, 1758)
IRSNB, left otolith, inner view, off Cuba, Recent [included for comparative purposes].

23. ***Hemiramphus*** aff. ***H. brasiliensis*** (Linnaeus, 1758) 62
NMB P82, left otolith, inner view, loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

24. ***Polymixia*** species 62
NMB P83, right otolith, inner view, loc. NMB 15827, Río Gurabo, Mao Formation, Pliocene NN14–15 Zone.

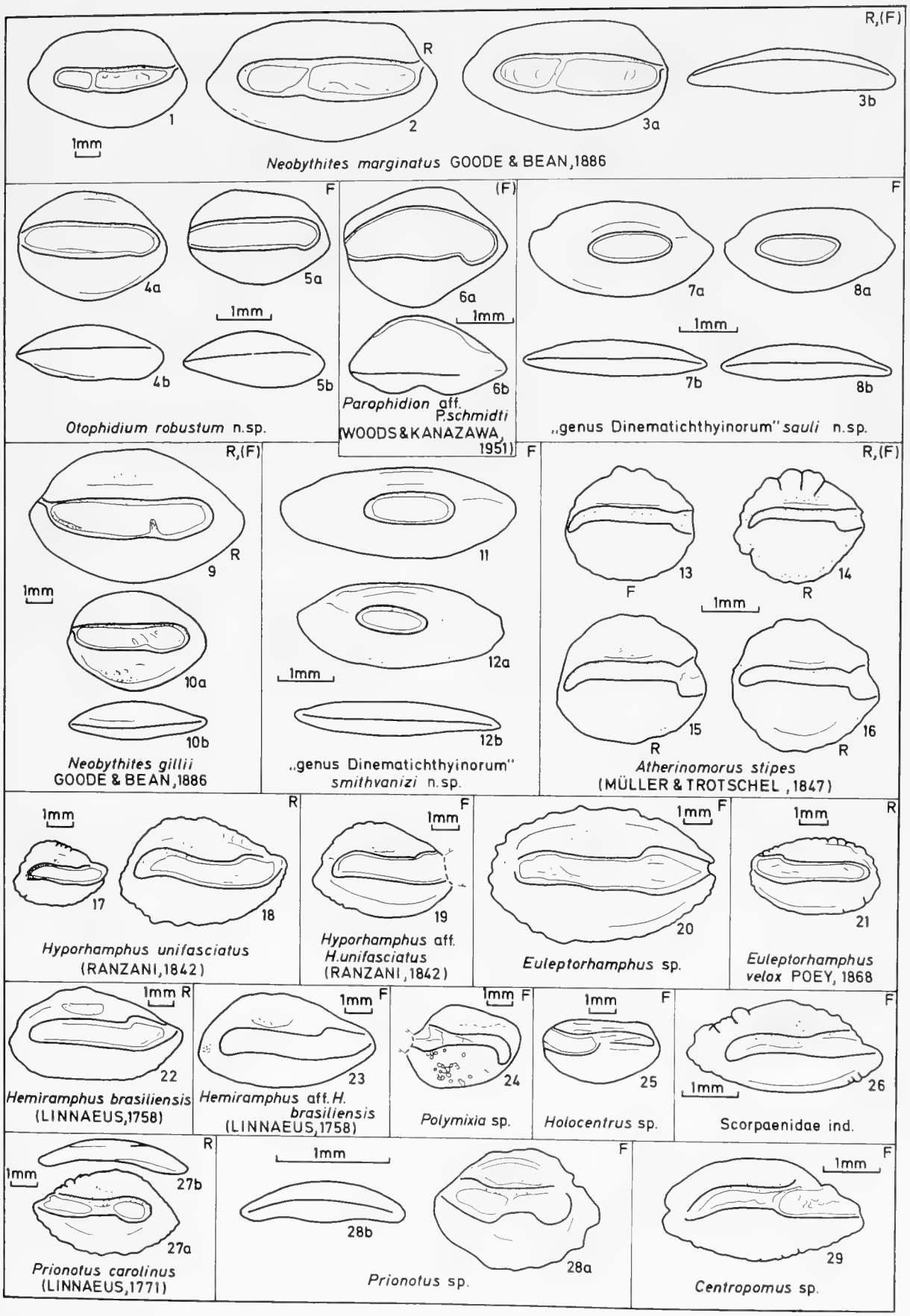
25. ***Holocentrus*** species 62
NMB P84, right otolith, inner view, loc. NMB 16818, Río Cana, Gurabo Formation, Pliocene ?NN12 Zone.

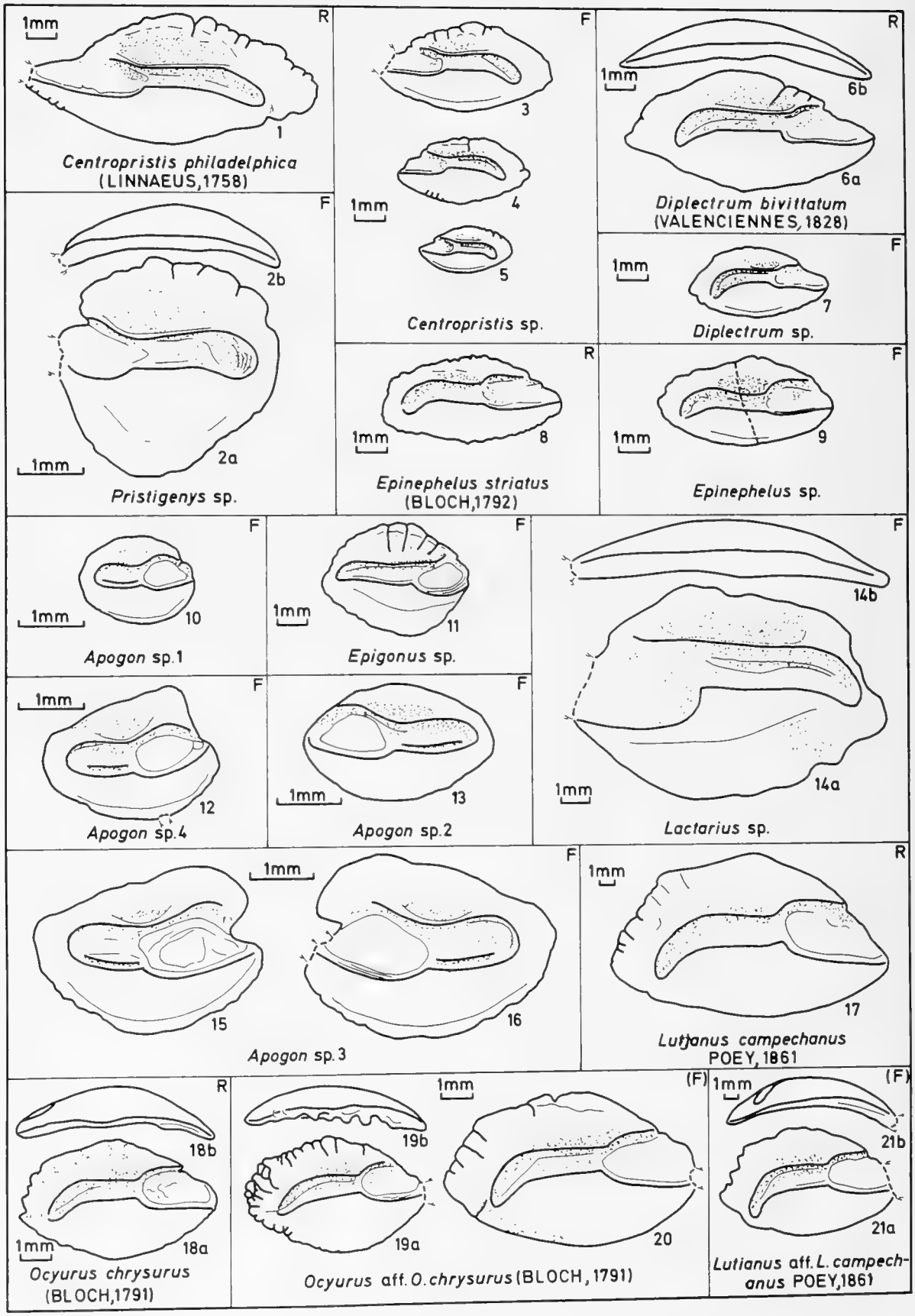
26. Scorpaenidae indeterminate 62
NMB P85, left otolith, inner view, loc. NMB 16837, Río Cana, Cercado Formation, late Miocene.

27. ***Prionotus carolinus*** (Linnaeus, 1771)
IRSNB, right otolith (a, inner view, b, ventral view), off Georgia, U. S. A., Recent [included for comparative purposes].

28. ***Prionotus*** species 62
NMB P86, right otolith (a, inner view; b, ventral view), loc. TU 1250, Río Verde, Gurabo Formation.

29. ***Centropomus*** species 61
NMB P87, left otolith, inner view, loc. NMB 16916, Río Mao, Cercado Formation, late Miocene NN11 Zone.


R,(F)
1
2
R
3a
3b
1mm
Neobythites marginatus GOODE & BEAN,1886
F
4a
5a
1mm
4b
5b
Otophidium robustum n.sp.
(F)
6a
1mm
6b
Parophidion aff. P.schmidti (WOODS&KANAZAWA, 1951)
F
7a
8a
1mm
7b
8b
„genus Dinematichthyinorum" sauli n.sp.
R,(F)
9
R
1mm
10a
10b
Neobythites gillii GOODE & BEAN,1886
F
11
12a
1mm
12b
„genus Dinematichthyinorum" smithvanizi n.sp.
R,(F)
13
F
14
R
1mm
15
R
16
R
Atherinomorus stipes (MÜLLER & TROTSCHEL, 1847)
1mm
R
17
18
Hyporhamphus unifasciatus (RANZANI,1842)
1mm
F
19
Hyporhamphus aff. H.unifasciatus (RANZANI,1842)
1mm F
20
Euleptorhamphus sp.
1mm
R
21
Euleptorhamphus velox POEY, 1868
1mm R
22
Hemiramphus brasiliensis (LINNAEUS,1758)
1mm F
23
Hemiramphus aff. H. brasiliensis (LINNAEUS,1758)
1mm F
24
Polymixia sp.
1mm F
25
Holocentrus sp.
F
1mm
26
Scorpaenidae ind.
R
1mm
27b
27a
Prionotus carolinus (LINNAEUS,1771)
1mm
28b
F
28a
Prionotus sp.
1mm
F
29
Centropomus sp.


1mm
R
1
Centropristis philadelphica
(LINNAEUS,1758)
F
3
4
5
Centropristis sp.
R
6b
6a
Diplectrum bivittatum
(VALENCIENNES,1828)
F
7
Diplectrum sp.
F
2b
2a
Pristigenys sp.
R
8
Epinephelus striatus
(BLOCH,1792)
F
9
Epinephelus sp.
F
10
Apogon sp.1
F
11
Epigonus sp.
F
14b
14a
Lactarius sp.
F
12
Apogon sp.4
F
13
Apogon sp.2
F
15
16
Apogon sp.3
R
17
Lutjanus campechanus
POEY,1861
R
18b
18a
Ocyurus chrysurus
(BLOCH,1791)
(F)
19b
19a
20
Ocyurus aff. O. chrysurus (BLOCH, 1791)
(F)
21b
21a
Lutianus aff. L. campechanus POEY,1861

EXPLANATION OF PLATE 13

Figure — Page

1. ***Centropristis philadelphica*** (Linnaeus, 1758)
IRSNB, right otolith, inner view, off Georgia coast, U. S. A., Recent [included for comparative purposes].

2. ***Pristigenys*** species 62
NMB P87 *bis*, right otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene, NN14 Zone.

3–5. ***Centropristis*** species 61
3, NMB P88, right otolith; inner view; 5, NMB P89, right otolith, inner view, loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.
4, NMB P90, right otolith, inner view, loc. NMB 15911, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

6. ***Diplectrum bivittatum*** (Valenciennes, 1828)
IRSNB, left otolith (a, inner view; b, ventral view), Gulf of Mexico off Texas coast, Recent [included for comparative purposes].

7. ***Diplectrum*** species 62
NMB P91, left otolith, inner view, loc. TU 1230, Río Cana, Cercado Formation, late Miocene.

8. ***Epinephelus striatus*** (Bloch, 1792)
IRSNB, left otolith, inner view, off Haiti, Recent.

9. ***Epinephelus*** species 62
NMB P92, left otolith, inner view, loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.

10. ***Apogon*** species 1 54
NMB P93, left otolith, inner view, loc. NMB 16854, Río Cana, Cercado Formation, late Miocene.

11. ***Epigonus*** species 62
NMB P94, left otolith, inner view, loc. NMB 15907, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

12. ***Apogon*** species 4 54
NMB P95, left otolith, inner view, loc. NMB 17268, Río Yaque del Norte, Gurabo Formation, Pliocene NN12 Zone.

13. ***Apogon*** species 2 54
NMB P96, right otolith, inner view, loc. NMB 17003, Río Cana, Cercado Formation, late Miocene.

14. ***Lactarius*** species 54
NMB P97, right otolith (a, inner view; b, ventral view), loc. NMB 15904, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

15, 16. ***Apogon*** species 3 54
15, NMB P98, left otolith, inner view; 16, NMB P99, right otolith, inner view, loc. NMB 16837, Río Cana, Cercado Formation, late Miocene.

17. ***Lutjanus campechanus*** Poey, 1861
IRSNB, left otolith, inner view, Gulf of Mexico, off Texas, U. S. A., Recent [included for comparative purposes].

18. ***Ocyurus chrysurus*** (Bloch, 1791)
IRSNB, left otolith (a, inner view; b, ventral view), off Haiti, Recent [included for comparative purposes].

19, 20. ***Ocyurus*** aff. ***O. chrysurus*** (Bloch, 1791) 62
19, NMB P100, left otolith (a, inner view; b, ventral view), loc. NMB 16837, Río Cana, Cercado Formation, late Miocene.
20, NMB P101, left otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.

21. ***Lutjanus*** aff. ***L. campechanus*** Poey, 1861 62
NMB P102, left otolith (a, inner view; b, ventral view), loc. NMB 16923, Río Mao, Cercado Formation, late Miocene NN11 Zone.

EXPLANATION OF PLATE 14

Figure — Page

1. ***Pristipomoides aquilonaris*** (Goode and Bean, 1896)
IRSNB, left otolith, inner view, off Mobile, Alabama, U. S. A., Recent [included for comparative purposes].

2–4. ***Pristipomoides*** species 62
2, NMB P103, left otolith, inner view; 3, NMB P104, left otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.
4, NMB P105, right otolith (a, inner view; b, ventral view), loc. NMB 16910, Río Mao, Maury's Bluff 1, Gurabo Formation, late Miocene NN11 Zone.

5. ***Eucinostomus lefroyi*** (Goode, 1874)
IRSNB, left otolith, inner view, near Fortaleza, Brazil, Recent [included for comparative purposes].

6. ***Eucinostomus havana*** (Nichols, 1912)
IRSNB, left otolith, inner view, Bermuda, Recent [included for comparative purposes].

7. ***Eucinostomus*** species 1 62
NMB P106, right otolith (a, inner view; b, ventral view), loc. NMB 15910, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

8, 9. ***Pomadasys*** species 62
8, NMB P107, right otolith, inner view, loc. NMB 17288, Río Yaque del Norte, Baitoa Formation, early or middle Miocene.
9, NMB P108, left otolith, inner view, loc. NMB 16935, Río Yaque del Norte, Baitoa Formation, early or middle Miocene.

10. ***Eucinostomus*** species 2 62
NMB P109, right otolith (a, inner view; b, ventral view), loc. TU 1359, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

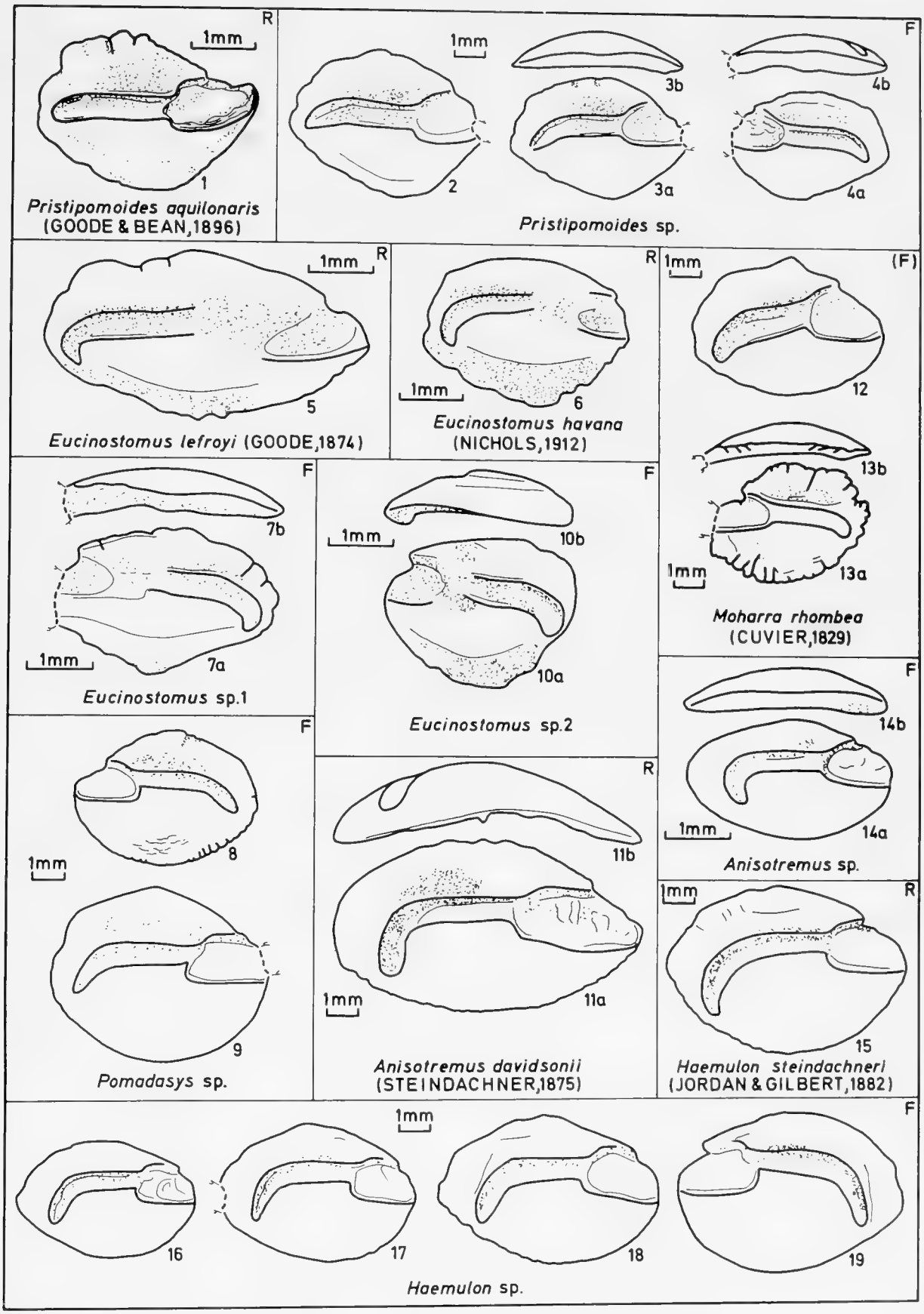
11. ***Anisotremus davidsonii*** (Steindachner, 1875)
IRSNB, left otolith (a, inner view; b, ventral view), off California, U. S. A., Recent [included for comparative purposes].

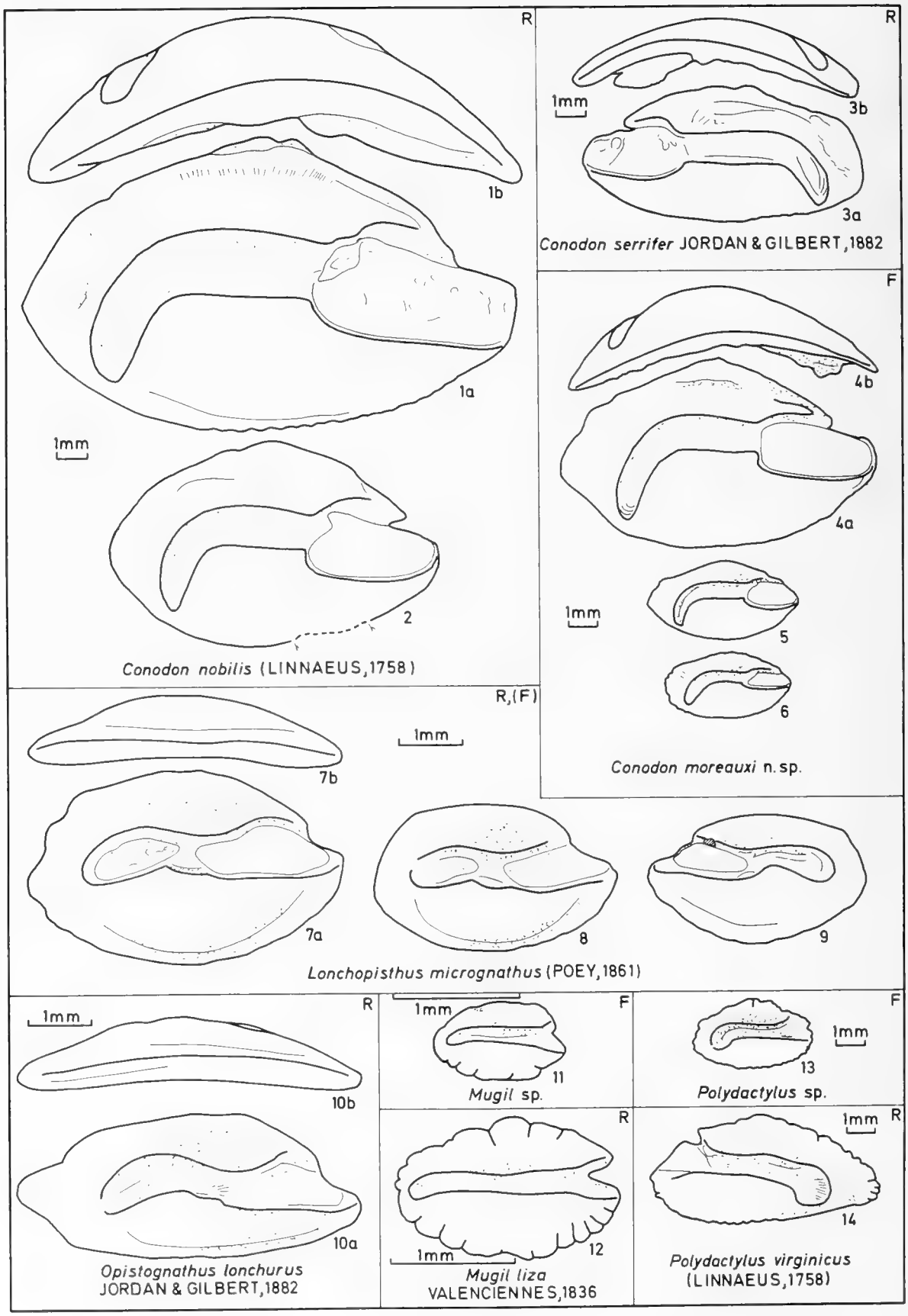
12, 13. ***Moharra rhombea*** (Cuvier, 1829) 62
12, NMB P110, left otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.
13, NMB P111, right otolith (a, inner view; b, ventral view), loc. NMB 15904, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

14. ***Anisotremus*** species 61
NMB P112, left otolith (a, inner view; b, ventral view), loc. NMB 17005, Río Cana, Cercado Formation, late Miocene.

15. ***Haemulon steindachneri*** (Jordan and Gilbert, 1883)
IRSNB, left otolith, inner view, off Guyana, Recent [included for comparative purposes].

16–19. ***Haemulon*** species 55
16, NMB P113, left otolith, inner view; 17, NMB P114, left otolith, inner view; 19, NMB P115, right otolith, inner view; loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
18, NMB P146, left otolith, inner view, loc. NMB 16923, Río Mao, Cercado Formation, late Miocene NN11 Zone.


R
1mm
1
Pristipomoides aquilonaris
(GOODE & BEAN, 1896)
F
1mm
2
3b
3a
4b
4a
Pristipomoides sp.
R
1mm
5
Eucinostomus lefroyi (GOODE, 1874)
R
1mm
6
Eucinostomus havana
(NICHOLS, 1912)
(F)
1mm
12
13b
13a
Moharra rhombea
(CUVIER, 1829)
F
7b
1mm
7a
Eucinostomus sp.1
F
1mm
10b
10a
Eucinostomus sp.2
F
14b
1mm
14a
Anisotremus sp.
F
1mm
8
9
Pomadasys sp.
R
11b
1mm
11a
Anisotremus davidsonii
(STEINDACHNER, 1875)
1mm
R
15
Haemulon steindachneri
(JORDAN & GILBERT, 1882)
1mm
F
16
17
18
19
Haemulon sp.


R
1b
1a
1mm
2
Conodon nobilis (LINNAEUS,1758)
R
1mm
3b
3a
Conodon serrifer JORDAN & GILBERT,1882
F
4b
4a
1mm
5
6
Conodon moreauxi n.sp.
R,(F)
1mm
7b
7a
8
9
Lonchopisthus micrognathus (POEY,1861)
1mm
R
10b
10a
Opistognathus lonchurus JORDAN & GILBERT,1882
1mm
F
11
Mugil sp.
R
12
1mm
Mugil liza VALENCIENNES,1836
F
13
1mm
Polydactylus sp.
1mm
R
14
Polydactylus virginicus (LINNAEUS,1758)

EXPLANATION OF PLATE 15

Figure — Page

1, 2. ***Conodon nobilis*** (Linnaeus, 1758) 55
1, IRSNB, left otolith (a, inner view; b, ventral, view); 2, IRSNB, left otolith, inner view, Caribbean, Recent.

3. ***Conodon serrifer*** Jordan and Gilbert, 1883 55
IRSNB, right otolith (a, inner view; b, ventral view), Gulf of California, Recent.

4–6. ***Conodon moreauxi***, new species 54
4, NMB P116, holotype, left otolith (a, inner view; b, ventral view), loc. NMB 15910, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
5, NMB P117, paratype, left otolith, inner view, loc. NMB 16918, Río Mao, Cercado Formation, late Miocene NN11 Zone.
6, NMB P118, paratype, left otolith, inner view, loc. TU 1359, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

7–9. ***Lonchopisthus micrognathus*** (Poey, 1861) 62
7, NMB P119, left otolith (a, inner view; b, ventral view), loc. TU 1227A, Arroyo Zalaya, turbidity flow lens, Pliocene NN14 Zone.
8, IRSNB, left otolith, inner view, off coast of Puerto Rico, Recent.
9, NMB P120, right otolith, inner view, loc. NMB 15864, Río Gurabo, Gurabo Formation, late Miocene NN11 Zone.

10. ***Opistognathus lonchurus*** Jordan and Gilbert, 1883
IRSNB, left otolith (a, inner view; b, ventral view), off Puerto Rico, Recent [included for comparative purposes].

11. ***Mugil*** species 62
NMB P121, left otolith, inner view, loc. TU 1278, Arroyo east of Río Gurabo, Gurabo Formation, near Mio-Pliocene boundary.

12. ***Mugil liza*** Valenciennes, 1836
IRSNB, left otolith of juvenile specimen, inner view, Haiti, Recent [included for comparative purposes].

13. ***Polydactylus*** species 62
NMB P122, left otolith, inner view, loc. TU 1282, Río Cana, Cercado Formation, late Miocene.

14. ***Polydactylus virginicus*** (Linnaeus, 1758)
IRSNB, right otolith, inner view, Margarita Island, Venezuela, Recent [included for comparative purposes].

EXPLANATION OF PLATE 16

Figure — Page

1, 2. ***Bairdiella ronchus*** (Cuvier *in* Cuvier and Valenciennes, 1830) 61
1, IRSNB, left otolith, inner view, off Rio de Janeiro, Brazil, Recent.
2, NMB P123, left otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.

3, 5. ***Ophioscion*** species 1 56
3, NMB P124, right otolith, inner view, loc. NMB 16913, Río Mao, Maury's Bluff 3, Cercado Formation, late Miocene NN11 Zone.
5, NMB P126, utricular otolith, inner view, loc. NMB 15907, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

4. ***Ophioscion*** species 2 56
NMB P125, left otolith, inner view, loc. NMB 17287, Río Yaque del Norte, Baitoa Formation, early or middle Miocene.

6, 7. ***Ctenosciaena latecaudata***, new species 55
6, NMB P127, holotype, left otolith, inner view, loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.
7, NMB P128, paratype, left otolith, inner view, loc. NMB 15907, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

8. ***Menticirrhus americanus*** (Linnaeus, 1758) 56
IRSNB, left otolith, inner view, off Margarita Island, Venezuela, Recent.

9. ***Menticirrhus chaoi***, new species 56
NMB P129, holotype, left otolith, inner view, loc. NMB 15904, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

10. ***Menticirrhus saxatilis*** (Bloch and Schneider, 1801) 56
IRSNB, left otolith, inner view, Caribbean, Recent.

11. ***Menticirrhus littoralis*** (Holbrook, 1860) 56
IRSNB, left otolith, inner view, off Rio de Janeiro, Brazil, Recent.

12. ***Larimus breviceps*** Cuvier *in* Cuvier and Valenciennes, 1830 56
NMB P130, left otolith, inner view, loc. NMB 15903, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

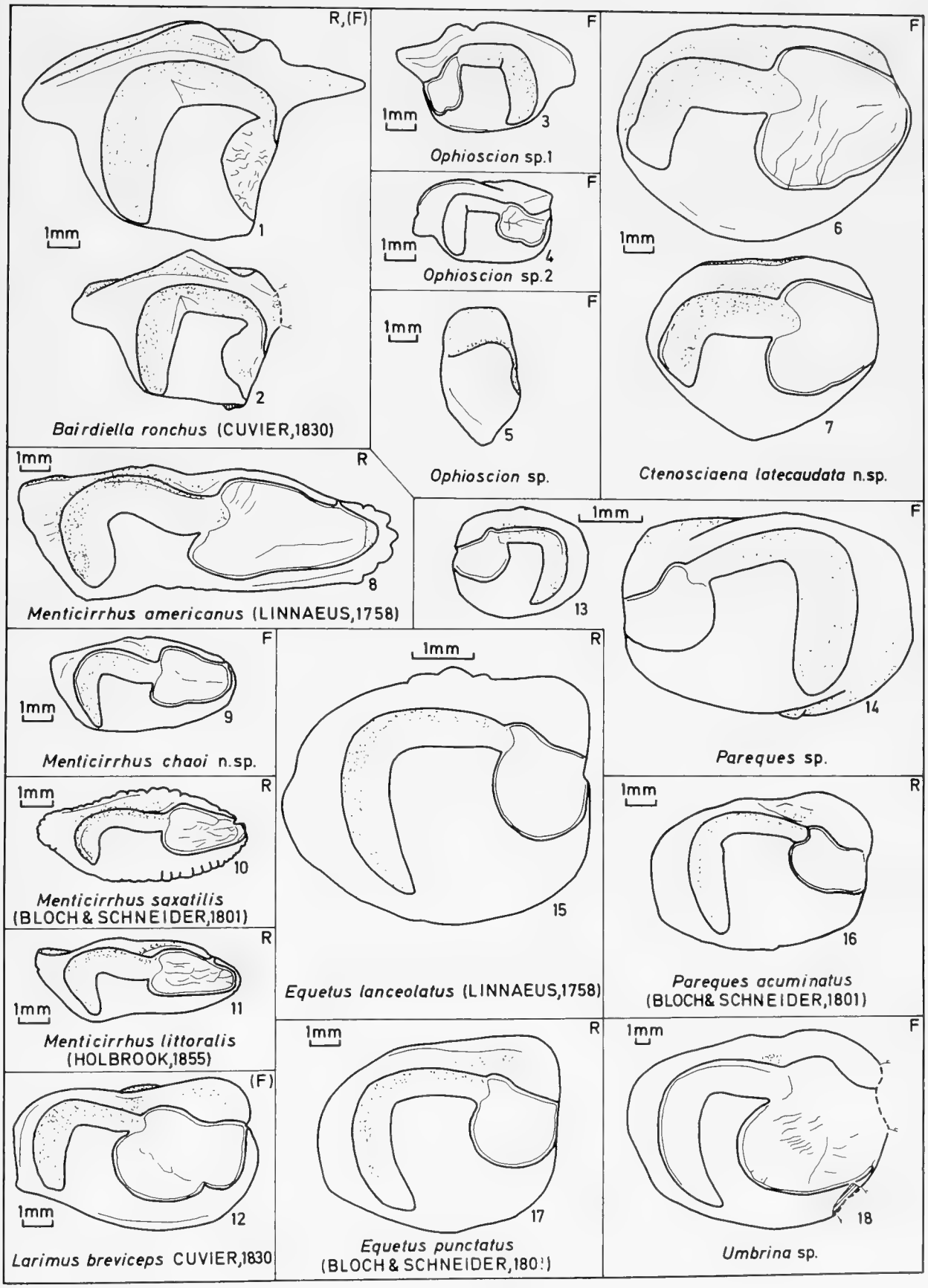
13, 14. ***Pareques*** species 56
13, NMB P131, right otolith, inner view, loc. TU 1206, roadcut at K17, Gurabo Formation, Pliocene.
14, NMB P132, right otolith, inner view, loc. TU 1354, Río Cana, Cañada de Zamba, Gurabo Formation, Pliocene.

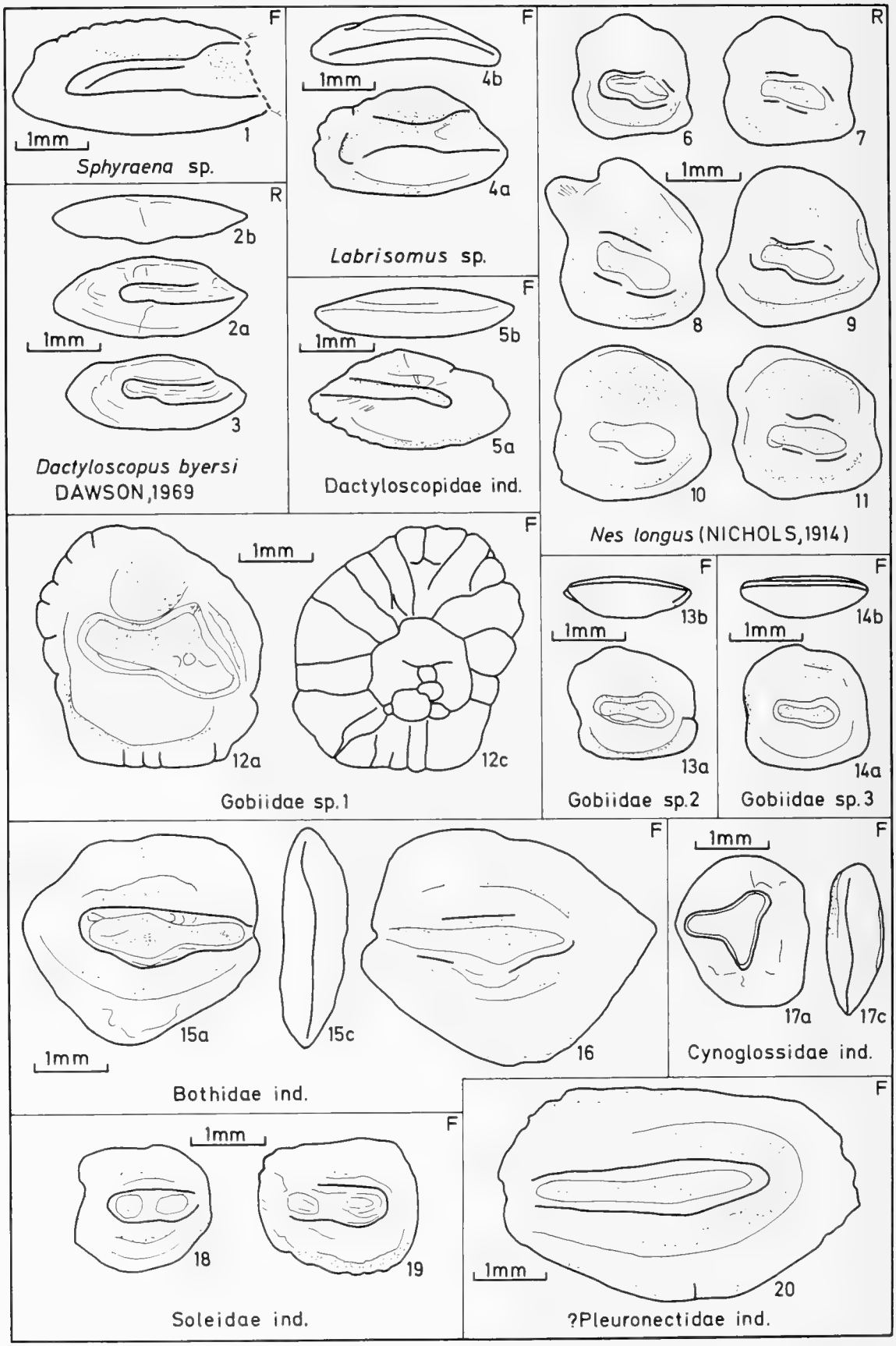
15. ***Equetus lanceolatus*** (Linnaeus, 1758) 56
BMNH, Stinton coll., left otolith, inner view, off Curaçao, Recent.

16. ***Pareques acuminatus*** (Bloch and Schneider, 1801) 56
LACM, Fitch coll., left otolith, inner view, off Puerto Rico, Recent.

17. ***Equetus punctatus*** (Bloch and Schneider, 1801) 56
IRSNB, left otolith, inner view, off Haiti, Recent.

18. ***Umbrina*** species 62
NMB P133, left otolith, inner view, loc. NMB 16932, Río Mao, Maury's Bluff 2, Cercado Formation, late Miocene NN11 Zone.


R,(F)
1mm
1
2
Bairdiella ronchus (CUVIER,1830)
F
1mm
3
Ophioscion sp.1
F
1mm
4
Ophioscion sp.2
F
1mm
5
Ophioscion sp.
F
1mm
6
7
Ctenosciaena latecaudata n.sp.
1mm
R
8
Menticirrhus americanus (LINNAEUS,1758)
1mm
13
F
14
Pareques sp.
F
1mm
9
Menticirrhus chaoi n.sp.
1mm
R
15
Equetus lanceolatus (LINNAEUS,1758)
1mm
R
10
Menticirrhus saxatilis
(BLOCH & SCHNEIDER,1801)
1mm
R
16
Pareques acuminatus
(BLOCH& SCHNEIDER,1801)
R
1mm
11
Menticirrhus littoralis
(HOLBROOK,1855)
1mm
R
17
Equetus punctatus
(BLOCH & SCHNEIDER,1801)
(F)
1mm
12
Larimus breviceps CUVIER,1830
1mm
F
18
Umbrina sp.


F
1mm
1
Sphyraena sp.
F
1mm
4b
4a
Labrisomus sp.
R
6
7
1mm
8
9
10
11
Nes longus (NICHOLS, 1914)
R
2b
2a
1mm
3
Dactyloscopus byersi
DAWSON, 1969
F
1mm
5b
5a
Dactyloscopidae ind.
F
1mm
12a
12c
Gobiidae sp. 1
F
1mm
13b
13a
Gobiidae sp. 2
F
1mm
14b
14a
Gobiidae sp. 3
F
15a
15c
16
1mm
Bothidae ind.
F
1mm
17a
17c
Cynoglossidae ind.
F
1mm
18
19
Soleidae ind.
F
1mm
20
?Pleuronectidae ind.

EXPLANATION OF PLATE 17

Figure — Page

1. ***Sphyraena*** species 62
NMB P134, left otolith, inner view, loc. NMB 16818, Río Cana, Gurabo Formation, Pliocene.

2, 3. ***Dactyloscopus byersi*** Dawson, 1969
LACM, Fitch coll. 2, left otolith (a, inner view; b, ventral view); 3, left otolith, inner view, Gulf of California, Recent [included for comparative purposes].

4. ***Labrisomus*** species 62
NMB P135, left otolith (a, inner view; b, ventral view), loc. NMB 17005, Río Cana, Cercado Formation, late Miocene.

5. Dactyloscopidae indeterminate 61
NMB P136, right otolith (a, inner view; b, ventral view), loc. TU 1206, roadcut at K17, Gurabo Formation, late Miocene.

6–11. ***Nes longus*** (Nichols, 1914) 56
IRSNB, left otoliths, inner views, off Bermuda, Recent.

12. Gobiidae species 1 57
NMB P137, left otolith (a, inner view; c, outer view), loc. NMB 16915, Río Mao, Cercado Formation, late Miocene NN11 Zone.

13. Gobiidae species 2 57
NMB P138, left otolith (a, inner view; b, ventral view), loc. NMB 15864, Río Gurabo, Gurabo Formation, late Miocene NN11 Zone.

14. Gobiidae species 3 57
NMB P139, left otolith (a, inner view; b, ventral view), loc. NMB 15823, Río Gurabo, Mao Formation, Pliocene NN15 Zone.

15, 16. Bothidae indeterminate 61
15, NMB P140, left otolith (a, inner view; c, posterior view), loc. NMB 16924, Río Mao, Cercado Formation, late Miocene NN11 Zone.
16, NMB P141, right otolith, inner view, loc. NMB 16923, Río Mao, Cercado Formation, late Miocene NN11 Zone.

17. Cynoglossidae indeterminate 61
NMB P142, left otolith (a, inner view; c, posterior view), loc. NMB 15912, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

18, 19. Soleidae indeterminate 62
18, NMB P143, left otolith, inner view, loc. TU 1294, Río Mao, Cercado Formation, late Miocene NN11 Zone.
19, NMB P144, right otolith, inner view, loc. TU 1373, Río Gurabo, Cercado Formation, late Miocene NN11 Zone.

20. ? Pleuronectidae indeterminate 57
NMB P145, right otolith, inner view, loc. TU 1227A, Arroyo Zalaya, turbidite, Pliocene NN14 Zone.

INDEX

Note: Page numbers are in light face; plate numbers are in **bold face** type; the page numbers on which principal discussions occur are in *italics*.

actinopterygian saccular otolith, morphology of 49
acuminatus, Pareques ..... **16** *56*,74
aequalis, Nezumia ..... **11** 50,59,*62*,69
aff. [defined] 49
affine, Myctophum ..... **10** *68*
Albula Scopoli (*ex* Gronow), 1777 59,61
  sp. ..... **9** 50,*61*,67
Albulidae 50
American Museum of Natural History, New York, New York, U.S.A. 63
americanus, Menticirrhus ..... **16** *56*,74
anguillaris, Plotosus ..... **10** *51*,68
Anisotremus 59
  davidsonii (Steindachner, 1875) ..... **14** *72*
  sp. ..... **14** 50,*61*,72
ANSP [Academy of Natural Sciences, Philadelphia, Pennsylvania, U.S.A.] 48,57
Antilles Sea 70
Apogon Lacepède, 1801 ..... *54*,59,61
  sp. 1 ..... **13** 50,*54*,61,71
  sp. 2 ..... **13** 50,*54*,61,71
  sp. 3 ..... **13** 50,*54*,61,71
  sp. 4 ..... **13** 50,*54*,61,71
Apogonidae 50,54,61
aquilonaris, Pristipomoides ..... **14** *72*
Arca beds 47
Ariidae 49,50,61
Ariosoma
  balearica (Delaroche, 1809) ..... **9** 50,59,*61*,67
  selenops Reid, 1934 ..... **9** 59,*67*
  aff. *A. selenops* Reid, 1934 ..... **9** 50,58,*61*,67
Arius Valenciennes *in* Cuvier and Valenciennes, 1840 58,59
  sp. ..... **10** 50,*61*,68
Atherinomorus stipes (Müller and Trotschel, 1847) ..... **12** 50,59,*61*,70
Atlantic Ocean 46,52
  western 56
Australia, Queensland 54
Australian realm 51

Bairdiella Gill, 1861a 49,56,60
  ronchus (Cuvier *in* Cuvier and Valenciennes, 1830) ..... **16** 50,59,*61*,74
Baitoa Formation 45,50,52,55–58,72,74
balearica, Ariosoma ..... **9** 50,59,*61*,67
barbata, Brotula 51,52
bathyal taxa 59
Batrachoididae 50
Bavay, Daniel 48
benoiti, Hygophum ..... **10** 59,*68*
benoiti (aff.), *Hygophum* ..... **10** 50,*62*,68
Berg (1895) 60
bermudensis, Carapus 59
bermudensis (aff.), *Carapus* ..... **11** 50,*61*,69
Berra (1981) 51
bivittatum, Diplectrum ..... **13** *71*
Bleeker (1852) 58
Bloch (1785–1795) 50,51,68,71
Bloch and Schneider (1801) 51,56,74
BMNH [British Museum (Natural History), London, England, U.K.] 48,74
  Stinton Collection 74
Böhlke and Robins (1959) 53,69
Böhlke, Eugenia 48
Bold (1988) 58
Bonaparte (1832) 56
Bothidae 50,57,61
  indet. ..... **17** 50,*61*,75
Bowden Formation 47,61
brachycephalus, Diaphus ..... **10** *51*,59,68
brachycephalus (aff.), *Diaphus* ..... **10** 50,*51*,62,68
brasiliensis,
  Hemiramphus ..... **12** *70*
  Hyporhamphus [= *Hemiramphus brasiliensis*] 59
brasiliensis (aff.), *Hemiramphus* ..... **12** 50,*62*,70
Brasso Formation 51,53,55
Breder (1927) 50,68
Bregmaceros Thompson, 1840 58,59
  sp. ..... **11** 50,*61*,69
Bregmacerotidae 50
breviceps, Larimus ..... **16** 50,*56*,59,62,74
Brotula Cuvier, 1829 ..... *51*,59,60
  barbata (Bloch and Schneider, 1801) 51,52
  clarkae Hubbs, 1944 51
  aff. *B. clarkae* Hubbs, 1944 ..... **11** 50,*51*,61,69
  multibarbata (Temminck and Schlegel, 1846) 51
  ordwayi Hildebrand and Barton, 1949 52
  sp. ..... **11** 50,*51*,61,69
  townsendi Fowler, 1900 52
Brotulina Fowler, 1946 54
  sp. of Nolf (1980) 54
Brzobhatý, Rostislav 48
byersi, Dactyloscopus ..... **17** *75*
Bythitidae 50

campechanus, Lutjanus ..... **13** 59,*71*
campechanus (aff.), *Lutjanus* ..... **13** 50,*62*,71
Canary Islands 68
Cape Verde Islands 69
Carapidae 50
Carapus
  bermudensis (Jones, 1874) 59
  aff. *C. bermudensis* (Jones, 1874) ..... **11** 50,*61*,69
caribbaea, Saurida ..... **10** 50,59,*62*,68
caribbaeus, Coelorinchus ..... **11** 50,59,*61*,69
Caribbean region 45–47,49,51,52,54,55,57,60,61
  Bahamas 70
  Barbados 54,61
  Bermuda Islands 57,72,75
  Cuba 67,68,70
  Dominican Republic,
    Cibao Valley 45–47,57,58,60
      Arroyo Puñal 46
      Arroyo Zalaya [= Cañada Zalaya] 46,47,50,53–56,58,67–73,75
      Baitoa 46
      Bulla 46
      Esperanza 46

Guayubin 46
Jánico 46
Los Quemados 46
Mao 46
Moca 46
Moncion 46
Navarrete 46
Río Amina 46,47,50,52
Potrero Dam 47
Río Cana 46,47,50,52,53,55,56,60,67–75
Cañada de Zamba 74
Río Guayubin 46
Río Gurabo 46,47,50,52–56,60,67–75
Río Mao 46,47,50,55,56,67,68,70–75
Maury's Bluff 1 47,68,72
Maury's Bluff 2 47,67,74
Maury's Bluff 3 47,74
Río Verde 46,50,53,57,68–70
Río Yaque del Norte 46,47,50,53,67–72,74
Angostura Gorge 47
Arroyo Hondo 47
Arroyo López 47
Baitoa Cliff 47
La Barranca 47
La Boca 47
López 47
Santiago 46,47
Santiago Rodriguez 46
Valverde 46
Zamba 46
Haiti 55,71,73,74
Jamaica 47,54,61,69
Puerto Rico 73,74
southern 45,60
Trinidad 47,51–56,60,61,70
Caribbean Sea 45,48,49,54–57,60,61,73,74
carolinus, Prionotus ..... **12** *70*
Casier (1958) 47
Casier (1966) 47,61
cauda [defined] 49
Central America 45,47,51,52,55,56,60
Mexico,
Acapulco 70
Veracrúz 61
Panama 61
Centropomidae 50
Centropomus 59
sp. ..... **12** 50,*61*,70
Centropristis 59
philadelphica (Linnaeus, 1758) ..... **13** *71*
sp. ..... **13** 50,*61*,71
Cercado Formation 45,47,50,52,53,55–59,67–75
cf. [defined] 49
Chao (1978) 56
Chao, L. N. 56
chaoi, Menticirrhus ..... **16** 45,50,*56*,62,74
Chaunacidae 50
Chaunax sp. ..... **11** 50,*61*,69
chickarney, Otophidium 53
Chipola Formation 46,55,61
Chirichigno (1969) 55
chrysurus, Ocyurus ..... **13** 59,*71*
chrysurus (aff.), *Ocyurus* ..... **13** 50,*62*,71
clarkae, Brotula 51
clarkae (aff.), *Brotula* ..... **11** 50,*51*,61,69
Clarke and Fitch (1979) 46,47,61
Clinidae 50
Clupeidae 50,61
indet. ..... **9** 50,*61*,67
Cocco (1838) 50,68
Coelorinchus caribbaeus (Goode and Bean, 1885) ..... **11** 50,59,*61*,69
Cohen, Daniel M. 48
Collete, Bruce B. 48
colliculum [defined] 49
Congridae 46,50,60,61
Conodon Cuvier *in* Cuvier and Valenciennes, 1830 ..... *54*,55,59
moreauxi, n. sp. ..... **15** 45,50,*54*,55,61,73
nobilis (Linnaeus, 1758) ..... **15** *55*,73
serrifer Jordan and Gilbert, 1883 ..... **15** *55*,73
crista inferior [defined] 49
crista superior [defined] 49
Ctenosciaena Fowler and Bean, 1923 ..... *55*,59,60
gracilicirrhus (Metzelaar, 1919) 55
latecaudata, n. sp. ..... **16** 45,50,*55*,61,74
peruviana Chirichigno, 1969 55
Curaçao 74
Cuvier (1816) 60
Cuvier (1829) 50,51,55,60,72
Cuvier and Valenciennes (1828–1849) .. 45,50,54,56,58,60,61,74
Cynoglossidae 50
indet. ..... **17** 50,*61*,75
Cynoscion Gill, 1861b 60

Dactyloscopidae 50,61
indet. ..... **17** 50,*61*,75
Dactyloscopus byersi Dawson, 1969 ..... **17** *75*
davidsonii, Anisotremus ..... **14** *72*
Dawson (1969) 75
Delaroche (1809) 50,67
Dermatopsis Ogilby, 1896 54
Diaphus Eigenmann and Eigenmann, 1890 ..... *51*,58,59
brachycephalus Tåning, 1928 ..... **10** *51*,59,68
aff. *D. brachycephalus* Tåning, 1928 ..... **10** 50,*51*,62,68
sp. 1 ..... **10** 50,*51*,62,68
sp. 2 ..... **10** 50,*51*,62,68
Dinematichthyini *53*,54,58,60
"genus Dinematichthyinorum" *sauli*, n. sp. ..... **12** 45,50,*53*,54,62,70
"genus Dinematichthyinorum" *smithvanizi*, n. sp. ..... **12** 45,49,50,*54*,62,70
Diplectrum 59
bivittatum (Valenciennes, 1828) ..... **13** *71*
sp. ..... **13** 50,*62*,71
dormitator, Otophidium ..... **11** 53,*53*,69
dorsal rim [defined] 49

Eastman (1904) 46
Eigenmann and Eigenmann (1890) 51,58
Engraulidae 50,61
indet. ..... **9** 50,*62*,67
Epigonus 59
sp. ..... **13** 50,*62*,71
Epinephelus 59
sp. ..... **13** 50,*62*,71
striatus (Bloch, 1792) ..... **13** *71*
epipelagic taxa 59

Equetus Rafinesque, 1815 56
lanceolatus (Linnaeus, 1758) ..... **16** *56*,74
punctatus (Bloch and Schneider, 1801) ..... **16** *56*,74
Eucinostomus 59
havana (Nichols, 1912) ..... **14** *72*
lefroyi (Goode, 1874) ..... **14** *72*
sp. 1 ..... **14** 50,*62*,72
sp. 2 ..... **14** 50,*62*,72
Euleptorhamphus 59
sp. ..... **12** 50,*62*,70
velox Poey, 1868 ..... **12** *70*
Europe 54
France, southwest, Aquitaine 54
Portugal 54
euryhaline taxa 59
excissura [defined] 49

Fitch and Lavenberg (1983) 46,52,61
Fitch, John 46,47
flava, Hildebrandia ..... **9** 50,59,*62*,67
Florida Strait 70
fontinalis, Salvelinus 48
Formalin® 55
Fowler (1900) 52
Fowler (1946) 54
Fowler and Bean (1923) 55,60
Frizzell and Dante (1965) 46
Frizzell and Lamber (1961) 46
Frizzell and Lamber (1962) 46

Gadoididae 61
Garman (1899) 69
Gerreidae 50,61
Gibbs, Robert H. 48
Gill (1861a) 49,56,60
Gill (1861b) 56,60
Gill (1862a) 56,60
Gill (1862b) 58
Gill (1863) 56,58
Gill (1895) 52,53
Gillette (1984) 47
gillii, Neobythites ..... **12** 50,*53*,59,62,70
Girard (1854) 51
Globigerinoides trilobus fistulosus Zone 47,50
Globorotalia exilis Zone 47,50
Globorotalia margaritae Zone 47,50
Glororotalia miocenica Zone 47,50,70
Gobiidae Bonaparte, 1832 ..... 50,*56*,57,61
sp. 1 ..... **17** 50,*57*,62,75
sp. 2 ..... **17** 50,*57*,62,75
sp. 3 ..... **17** 50,*57*,62,75
Goode (1874) 72
Goode (1876) 56,58,60
Goode and Bean (1885) 50,53,58,69,70
Goode and Bean (1886) 50,53,70
Goode and Bean (1896) 50,58,67,72
gracilicirrhus, Ctenosciaena 55
Greenwood *et al.* (1966) 49
Greenwood, P. Humphrey 48
Gulf of California 55,73,75
Gulf of Guinea 67
Gulf of Mexico 71
Gulf of Thailand 68
Günther (1878) 50,69
Gurabo Formation 45,47,50,52–55,57,58,67–75

Haemulidae 45
Haemulon Cuvier, 1829 ..... *55*,59,60
sp. ..... **14** 50,*55*,62,72
steindachneri (Jordan and Gilbert, 1883) ..... **14** *72*
Hartel, Karsten 48
havana, Eucinostomus ..... **14** *72*
Hemiramphidae 50
Hemiramphus
brasiliensis (Linnaeus, 1758) ..... **12** *70*
aff. *H. brasiliensis* (Linnaeus, 1758) ..... **12** 50,*62*,70
Heterenchelyidae 50
Hildebrand and Barton (1949) 52
Hildebrandia flava (Goode and Bean, 1896) ..... **9** 50,59,*62*,67
Holbrook (1860) 56,74
Holocentridae 50
Holocentrus Scopoli (*ex* Gronow), 1777 58,59,61
sp. ..... **12** 50,*62*,70
Hubbs (1944) 50,51,69
Hubbs and Schultz (1939) 51
hygomi, Hygophum ..... **10** *68*
Hygophum
benoiti (Cocco, 1838) ..... **10** 59,*68*
aff. *H. benoiti* (Cocco, 1838) ..... **10** 50,*62*,68
hygomi (Lütken, 1892) ..... **10** *68*
Hyporhamphus
brasiliensis [= *Hemiramphus brasiliensis*] 59
unifasciatus (Ranzani, 1842) ..... **12** 59,*70*
aff. *H. unifasciatus* (Ranzani, 1842) ..... **12** 50,*62*,70

indefatigable, Otophidium 53
indet.,
Bothidae ..... **17** 50,*61*,75
Clupeidae ..... **9** 50,*61*,67
Cynoglossidae ..... **17** 50,*61*,75
Dactyloscopidae ..... **17** 50,*61*,75
Engraulidae ..... **9** 50,*62*,67
? Pleuronectidae ..... **17** 50,*57*,62,75
Scorpaenidae ..... **12** 50,*62*,70
Soleidae ..... **17** 50,*62*,75
Indo-Pacific region 51,52,54
Ireland 69
IRSNB [Royal Belgian Institute of Natural Sciences, Brussels, Belgium] 45,48,66–75
Isopisthus Gill, 1862a 60

Johnson, G. David 48
Jones (1874) 50,69
Jordan (1885) 52
Jordan and Bollman (1890) 53
Jordan and Gilbert (1883) 53,55,72,73
Jung, Peter 48

kallion, Lepophidium 52
Koken (1888) 46

Labrisomus Swainson, 1839 58,59
sp. ..... **17** 50,*62*,75
Lacepède (1798–1803) 45,51,54,60,61

LACM [Los Angeles County Museum of Natural History, Los Angeles, California, U.S.A.] 48,74,75
Fitch Collection 74,75
Lactariidae 50
Lactarius Valenciennes *in* Cuvier and Valenciennes, 1833 ..... 45,*54*,59,60
sp. ..... **13** 50,*54*,62,71
lanceolatus, Equetus ..... **16** *56*,74
Larimus Cuvier *in* Cuvier and Valenciennes, 1830 ..... *56*,60,61
breviceps Cuvier *in* Cuvier and Valenciennes, 1830 ..... **16** 50,*56*,59,62,74
latecaudata, Ctenosciaena ..... **16** 45,50,*55*,61,74
latesulcatum, Lepophidium ..... **11** 45,50,*52*,62,69
Lavenberg, Robert 48
Lee *et al.* (1980) 58
lefroyi, Eucinostomus ..... **14** *72*
Lepophidiini 60
Lepophidium Gill, 1895 ..... *52*,53,59
kallion Robins, 1959b 52
latesulcatum, n. sp. ..... **11** 45,50,*52*,62,69
staurophor Robins, 1959a 52
Leriche (1938) 47,61
Liem, Karl 48
Linnaeus (1758) 50,55,56,60,70,71,73,74
Linnaeus (1771) 70
littoralis, Menticirrhus ..... **16** *56*,74
liza, Mugil ..... **15** *73*
Lonchopisthus Gill, 1862b 58
micrognathus (Poey, 1861) ..... **15** 50,59,*62*,73
lonchurus, Opistognathus ..... **15** *73*
longus, Nes ..... **17** *56*,57,75
Lutjanidae 50
Lutjanus
campechanus Poey, 1861 ..... **13** 59,*71*
aff. *L. campechanus* Poey, 1861 ..... **13** 50,*62*,71
Lütken (1892) 68

Macrodon Schinz, 1822 60
Macrouridae 50,58
macrurus, Pythonichthys ..... **9** *67*
Manzanilla Formation 55,56
Mao Formation 45,47,50,53,57–59,68,69,70,75
Mao Adentro Limestone 47
marginatus, Neobythites ..... **12** 50,*53*,59,62,70
Mauritania 68
Mayer (1974) 58
MCZ [Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.] 48
Menticirrhus Gill, 1861b *56*,59,60
americanus (Linnaeus, 1758) ..... **16** *56*,74
chaoi, n. sp. ..... **16** 45,50,*56*,62,74
littoralis (Holbrook, 1860) ..... **16** *56*,74
saxatilis (Bloch and Schneider, 1801) ..... **16** *56*,74
Merluciidae 61
mesopelagic taxa 59
Metzelaar (1919) 55
micrognathus, Lonchopisthus ..... **15** 50,59,*62*,73
microphthalmus, Pythonichthys ..... **9** *67*
Mississippi embayment 60
Mitchill (1814) 48
Moharra Poey, 1875 58,59
rhombea (Cuvier, 1829) ..... **14** 50,*62*,72
Moreaux, F. 55
moreauxi, Conodon ..... **15** 45,50,*54*,55,61,73
Morocco, Marrakech 68
Mugil
liza Valenciennes, 1836 ..... **15** *73*
sp. ..... **15** 50,*62*,73
Mugilidae 50
Müller and Trotschel (1845–1849) 50,70
multibarbata, Brotula 51
Myctophidae 50,51
Myctophum 59
affine (Lütken, 1892) ..... **10** *68*
nitidulum Garman, 1899 ..... **11** *69*
sp. ..... **10** 50,*62*,68
mykiss, Onchorhynchus 48
myriaster, Porichthys 51
Myripristidae 46

Nariva Formation 51
Nebris Cuvier *in* Cuvier and Valenciennes, 1830 60
Neobythites Goode and Bean, 1885 ..... *53*,58
gillii Goode and Bean, 1885 ..... **12** 50,*53*,59,62,70
marginatus Goode and Bean, 1886 ... **12** 50,*53*,59,62,70
sp. of Nolf (1976) 53
Neobythitini 60
neritic taxa 59
Nes longus (Nichols, 1914) ..... **17** *56*,57,75
New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico, U.S.A. 48
Nezumia aequalis (Günther, 1878) ..... **11** 50,59,*62*,69
Nichols (1912) 72
Nichols (1914) 56,75
nitidulum, Myctophum ..... **11** *69*
NMB [Naturhistorishes Museum Basel, Basel, Switzerland] 48,52–57,61,62,66–75
nobilis, Conodon ..... **15** *55*,73
Nolf (1976) 47,49,51–56
Nolf (1980) 51–54
Nolf (1985) 49,50,53–56,60,61
Nolf and Capetta (1989) 51
Nolf and Lapierre (1979) 55
Nolf and Steurbaut (1988) 51
Nolf and Steurbaut (1989) 51
Nolf, Dirk 54,60
North America 47,61

Ocyurus
chrysurus (Bloch, 1791) ..... **13** 59,*71*
aff. *O. chrysurus* (Bloch, 1791) ..... **13** 50,*62*,71
Odontoscion Gill, 1862a 56
Ogilby (1896) 54
Oken (1817) 56
omostigmum, Otophidium 53
Onchorhynchus mykiss (Walbaum, 1792) 48
Ophidiidae 45,50,60,61
Ophidiini 60
Ophioscion Gill, 1863 ..... *56*,58,59
sp. 1 ..... **16** 50,*56*,62,74
sp. 2 ..... **16** 50,*56*,62,74
Opisthognathidae 50,61
Opisthonema sp. ..... **9** 50,*62*,67
Opistognathus lonchurus Jordan and Gilbert, 1883 . **15** *73*
ordwayi, Brotula 52
ostial rim [defined] 49
ostium [defined] 49
Otophidium Gill *in* Jordan, 1885 ..... *52*,53,59
chickarney Böhlke and Robins, 1959 53

Otophidium
dormitator Böhlke and Robins, 1959 ..... **11** 53,*53*,69
dormitator Böhlke and Robins, 1959 ..... **11** 53,*53*,69
indefatigable Jordan and Bollman, 1890 53
omostigmum (Jordan and Gilbert, 1883) 53
robinsi, n. sp. ..... **11** 45,50,*52*,53,62,69
robustum, n. sp. ..... **12** 45,50,*53*,62,70

Pachypops Gill, 1861b 60
Pacific Ocean,
eastern 45,46,51,52,55
southeastern 60
western 52
Pacific plate 51
paracanthopterygian saccular otolith, morphology of 49
Pareques Gill *in* Goode, 1876 ..... *56*,58,60
acuminatus (Bloch and Schneider, 1801) ..... **16** *56*,74
sp. ..... **16** 50,*56*,62,74
Parophidion aff. *P. schmidti* (Woods and Kanazawa, 1951) .....
..... **12** 50,*62*,70
Patterson, Colin 48
peruviana, Ctenosciaena 55
philadelphica, Centropristis ..... **13** *71*
Plagioscion Gill, 1861b 60
Pleuronectidae Rafinesque, 1815 ..... 50,*57*
? Pleuronectidae indet. ..... **17** 50,*57*,62,75
Plotosidae 50
Plotosus Lacepède, 1803 ..... 45,*51*,54,59,60,62
anguillaris (Bloch, 1794) ..... **10** *51*,68
sp. ..... **10** 50,*51*,68
Poey (1858–1861) 50,71,73
Poey (1866–1868) 58
Poey (1868) 70
Poey (1875–1877) 58
Poll (1953) 58
Poll (1954) 58
Poll (1959) 58
Polyclemus Berg, 1895 60
Polydactylus 59
sp. ..... **15** 50,*62*,73
virginicus (Linnaeus, 1758) ..... **15** *73*
Polyipnus 59
sp. ..... **10** 50,*62*,68
Polymixia 59
sp. ..... **12** 50,*62*,70
Polymixiidae 50
Pomadasyidae 50,60,61
Pomadasys Lacepède, 1803 60
sp. ..... **14** 50,*62*,72
Porichthys Girard, 1854 ..... *51*,59
myriaster Hubbs and Schultz, 1939 51
sp. ..... **11** 50,*51*,62,69
posterior rim [defined] 49
Priacanthidae 50
Prionotus
carolinus (Linnaeus, 1771) ..... **12** *70*
sp. ..... **12** 50,*62*,70
Pristigenys 59
sp. ..... **13** 50,*62*,71
Pristipomoides Bleeker, 1852 58,59
aquilonaris (Goode and Bean, 1896) ..... **14** *72*
sp. ..... **14** 50,*62*,72
punctatus, Equetus ..... **16** *56*,74
Pythonichthys Poey, 1867 58,59
macrurus (Regan, 1912) ..... **9** *67*
microphthalmus (Regan, 1912) ..... **9** *67*
sp. ..... **9** 50,*62*,67

Rafinesque (1815) 56,57
Ranzani (1842) 50,70
Regan (1912) 67
Reid (1934) 50,58,67
Rhechias tysanochila (Reid, 1934) ..... **9** 50,59,*62*,67
rhombea, Moharra ..... **14** 50,*62*,72
Robins (1959a) 52
Robins (1959b) 52
Robins *et al.* (1980) 56
Robins, C. Richard 48,52,63
Robins, Ray, and Douglass (1986) 56–58
robinsi, Otophidium ..... **11** 45,50,*52*,53,62,69
robustum, Otophidium ..... **12** 45,50,*53*,62,70
ronchus, Bairdiella ..... **16** 50,59,*61*,74
Rosen and Greenwood (1970) 48
Rosenblatt and Rubinoff (1972) 58
rostrum [defined] 49

Salvelinus fontinalis (Mitchill, 1814) 48
Sample KR 11862 of Nolf (1976) 51
sample size [discussed] 57
Saul, William G. 48,53
sauli, "genus Dinematichthyinorum" .....
..... **12** 45,50,*53*,54,62,70
Saunders, Jung, and Biju-Duval (1986) 46,47,50,57,58,61
Saurida caribbaea Breder, 1927 ..... **10** 50,59,*62*,68
saxatilis, Menticirrhus ..... **16** *56*,74
Schinz (1822) 60
schmidti (aff.), *Parophidion* ..... **12** 50,*62*,70
Schubert (1909) 47,61
Sciaena Linnaeus, 1758 60
Sciaenidae 45,47,50,56,60,61
Scopoli (1777) 58,61
Scorpaenidae 50
indet. ..... **12** 50,*62*,70
selenops, Ariosoma ..... **9** 59,*67*
selenops (aff.), *Ariosoma* ..... **9** 50,58,*61*,67
Serranidae 50
serrifer, Conodon ..... **15** *55*,73
Sirembini 60
Smith and Kanazawa (1977) 58
Smith, C. Lavett 63
Smith-Vaniz, William F. 48,54
smithvanizi, "genus Dinematichthyinorum" .....
..... **12** 45,49,50,*54*,62,70
Soleidae 50
indet. ..... **17** 50,*62*,75
South America 47
Brazil 56
Fortaleza 72
Rio de Janeiro 74
Colombia 61
French Guyana 69
Guyana 72
Venezuela 68
Margarita Island 70,73,74
sp.,
Albula ..... **9** 50,*61*,67
Anisotremus ..... **14** 50,*61*,72
Arius ..... **10** 50,*61*,68
Bregmaceros ..... **11** 50,*61*,69
Brotula ..... **11** 50,*51*,61,69
Brotulina 54

Centropomus ..... **12** 50,*61*,70
Centropristis ..... **13** 50,*61*,71
Chaunax ..... **11** 50,*61*,69
Diplectrum ..... **13** 50,*62*,71
Epigonus ..... **13** 50,*62*,71
Epinephelus ..... **13** 50,*62*,71
Euleptorhamphus ..... **12** 50,*62*,70
Haemulon ..... **14** 50,*55*,62,72
Holocentrus ..... **12** 50,*62*,70
Labrisomus ..... **17** 50,*62*,75
Lactarius ..... **13** 50,*54*,62,71
Mugil ..... **15** 50,*62*,73
Myctophum ..... **10** 50,*62*,68
Neobythites 53
Opisthonema ..... **9** 50,*62*,67
Pareques ..... **16** 50,*56*,62,74
Plotosus ..... **10** 50,*51*,68
Polydactylus ..... **15** 50,*62*,73
Polyipnus ..... **10** 50,*62*,68
Polymixia ..... **12** 50,*62*,70
Pomadasys ..... **14** 50,*62*,72
Porichthys ..... **11** 50,*51*,62,69
Prionotus ..... **12** 50,*62*,70
Pristigenys ..... **13** 50,*62*,71
Pristopomoides ..... **14** 50,*62*,72
Pythonichthys ..... **9** 50,*62*,67
Sphyraena ..... **17** 50,*62*,75
Umbrina ..... **16** 50,*62*,74
sp. 1,
Apogon ..... **13** 50,*54*,61,71
Diaphus ..... **10** 50,*51*,62,68
Eucinostomus ..... **14** 50,*62*,72
Gobiidae ..... **17** 50,*57*,62,75
Ophioscion ..... **16** 50,*56*,62,74
sp. 2,
Apogon ..... **13** 50,*54*,61,71
Diaphus ..... **10** 50,*51*,62,68
Eucinostomus ..... **14** 50,*62*,72
Gobiidae ..... **17** 50,*57*,62,75
Ophioscion ..... **16** 50,*56*,62,74
sp. 3,
Apogon ..... **13** 50,*54*,61,71
Gobiidae ..... **17** 50,*57*,62,75
sp. 4, *Apogon* ..... **13** 50,*54*,61,71
Sparidae 61
Sphyraena 59
sp. ..... **17** 50,*62*,75
Sphyraenidae 50
Springvale Formation 51
State University of Ghent, Belgium 48
staurophor, Lepophidium 52
Steindachner (1875) 72
steindachneri, Haemulon ..... **14** *72*
Stellifer Oken (*ex* Cuvier), 1817 56
Sternoptychidae 50
Steurbaut (1984) 54
stipes, Atherinomorus ..... **12** 50,59,*61*,70
striatus, Epinephelus ..... **13** *71*
Stringer (1979) 46
Stringer (1986) 46
Stringer, Gary L. 54,55,61
sulcus [defined] 49
Swainson (1838–1839) 58
Synodontidae 50

Tamana Formation 56
Tåning (1928) 50,51,68
Temminck and Schlegel (1842–1850) 51
Tethys 45,51,54,60
Thompson (1840) 58
townsendi, Brotula 52
Triglidae 50,61
TU [Tulane University, New Orleans, Louisiana, U.S.A.] 47,48,52–59,61,62,67–75
tysanochila, Rhechias ..... **9** 50,59,*62*,67

Umbrina Cuvier, 1816 59,60
sp. ..... **16** 50,*62*,74
UMML [University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, Miami, Florida, U.S.A.] 48,53
unifasciatus, Hyporhamphus ..... **12** 59,*70*
unifasciatus (aff.), *Hyporhamphus* ..... **12** 50,*62*,70
United States,
Alabama 60
Mobile 72
California 46,72
Florida 55,67
Miami 52,63
northwestern 61
Tallahassee 46
Georgia 70,71
Gulf Coast 45,46,54,60,71
Louisiana 46
West Monroe 45
Mississippi 60
North Carolina 52,61
Lee Creek Mine 46,61
Pennsylvania, Philadelphia 53,54
Texas 71
University of Brno, Czechoslovakia 48
USNM [United States National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A.] 48

Valenciennes (1828) 71
Valenciennes (1836) 73
velox, Euleptorhamphus ..... **12** *70*
ventral furrow [defined] 49
ventral rim [defined] 49
virginicus, Polydactylus ..... **15** *73*
Vokes, Emily 48
Vokes, Harold 48

Walbaum (1792) 48
Weiler (1959) 47,61
Weitzman, Stanley H. 48
Whitehead *et al.* (1984–1986) 58
Whitehead, Peter J. P. 48
Woods and Kanazawa (1951) 50,70

Zidek, Jiri 48

PREPARATION OF MANUSCRIPTS

Bulletins of American Paleontology usually comprises two or more separate monographs in two volumes each year. This series is a publication outlet for significant longer paleontological monographs for which high quality photographic illustrations and the large quarto format are a requisite.

Manuscripts submitted for publication in this monograph series must be typewritten, and double-spaced *throughout* (including direct quotations and references). All manuscripts should contain a table of contents, lists of text-figures and (or) tables, and a short, informative abstract that includes names of all new taxa. Format should follow that of recent numbers in the series. All measurements must be stated in the metric system, alone or in addition to the English system equivalent. The maximum dimensions for photographic plates are 178 mm × 229 mm (7″ × 9″; outlined on this page). Single-page text-figures should be drafted for reproduction as single column (82 mm; 3¼″) or full page (178 mm; 7″) width, but arrangements can be made to publish text-figures that must be larger. Any lettering in illustrations should follow the recommendations of Collinson (1962).

Authors must provide three (3) copies of the text and accompanying illustrative material. The text and line-drawings may be reproduced xerographically, but glossy prints at publication scale must be supplied for all half-tone illustrations and photographic plates. These prints should be identified clearly on the back.

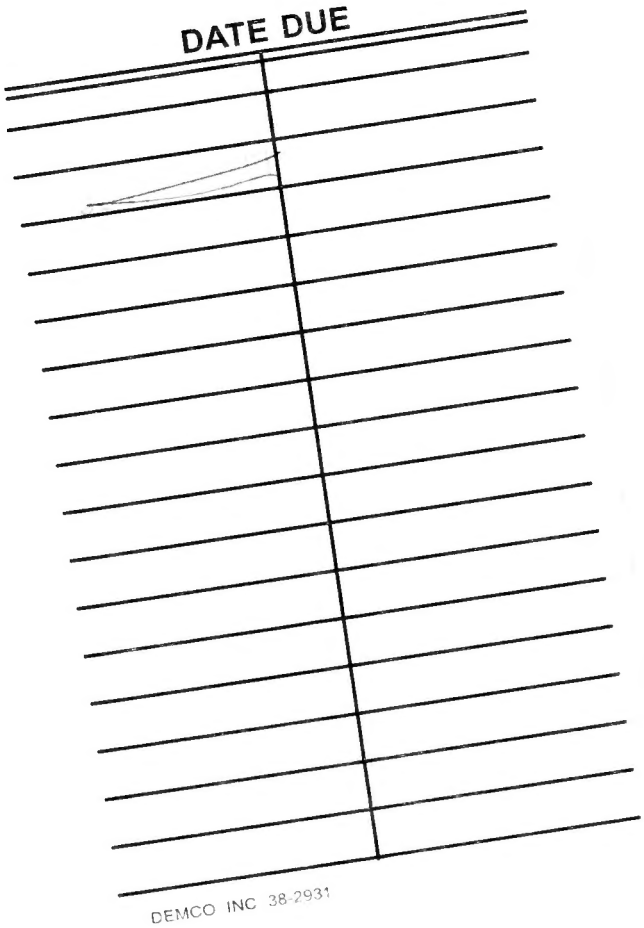
All dated text-citations must be referenced. Additional references may be listed separately if their importance can be demonstrated by a short general comment, or individual annotations. Referenced publication titles must be spelled out in their entirety. Citations of illustrations within the monograph bear initial capitals (*e.g.*, Plate, Text-figure), but citations of illustrations in other articles appear in lower-case letters (*e.g.*, plate, text-figure).

Original plate photomounts should have oversize cardboard backing and strong tracing paper overlays. These photomounts should be retained by the author until the manuscript has been formally accepted for publication. Explanations of text-figures should be interleaved on separate numbered pages within the text, and the approximate position of the text-figure in the text should be indicated. Explanations of plates follow the Bibliography.

Authors are requested to enclose $10 with each manuscript submitted, to cover costs of postage during the review process.

Collinson, J.

1962. *Size of lettering for text-figures*. Journal of Paleontology, vol. 36, p. 1402.


DATE DUE
DEMCO INC 38-2931