

Groves, LT
1997

A REVIEW OF CYPRAEIFORM GASTROPODS FROM NEOGENE STRATA OF NORTHWESTERN ECUADOR, WITH THE DESCRIPTION OF TWO NEW SPECIES

LINDSEY T. GROVES*

MALACOLOGY AND INVERTEBRATE PALEONTOLOGY SECTIONS
NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
LOS ANGELES, CALIFORNIA

I. ABSTRACT

Six cypraeacean species, two of them new, and one unidentified triviid specimen are reviewed from Neogene strata of northwestern Ecuador. New species of *Zonaria* s.s. and *Z. (Pseudozonaria)* are described from the lower Pliocene Esmeraldas beds of the Onzole Formation. These new species and *Jenneria (Jenneria) panamensis* (Olsson, 1967) are the first cypraeaceans reported from the Esmeraldas beds. The unidentified triviid is the first of its kind reported from the Neogene of Ecuador. Three previously described cypraeid species are also included in this review.

II. INTRODUCTION

Cypraeid, ovulid, and triviid gastropods are rare in the Neogene rock record of northwestern Ecuador. Herein are the first reports of these groups from the lower Pliocene Esmeraldas beds of the Onzole Formation and a review of the species from the upper Miocene Angostura and Guayacan formations and the lower Pliocene Jama Formation. All six of the species included here are extinct; however, all of the genera and/or subgenera are represented in the living fauna of either the tropical eastern Pacific Ocean or the Caribbean Sea.

Pilsbry and Olsson (1941) described *Cypraea cayapa* from the lower Pliocene Jama Formation, the first reported Neogene cypraeid from Ecuador. Marks (1951) identified poorly preserved single specimens from the "Blue siltstone" member of the upper Miocene Daule Formation [= Guayacan Formation] as *Cypraea* cf. *C.*

henekeni and *Cypraea* sp. Unfortunately, these specimens are unavailable for examination. In 1964, Olsson described *Cypraea (Pseudozonaria) telembiensis* from the upper Miocene Angostura Formation near Telembi, Río Cayapas. From the same formation he reported two poorly preserved specimens of *Siphocypraea (Muracypraea) henekeni* from Cueva de Angostura, Río Santiago. Most recently Olsson (1967) described *Jenneria panamensis* from the upper Pliocene Charco Azul Formation, Río Blanco, Chiriquí Province, Panamá and it is herein reported from the Esmeraldas beds of the Onzole Formation at Quebrada Camarones. Two new species, *Zonaria (Zonaria) pittorum* and *Z. (Pseudozonaria) cathyae*, are the first cypraeids described from the Esmeraldas beds of the Onzole Formation (Text-figure 1). An incomplete specimen of *Pusula (Pusula)* sp. from these same beds is the first reported fossil triviid from Ecuador.

III. STRATIGRAPHIC NOMENCLATURE AND AGE

Because much has been published recently concerning the age of the Neogene formations of northwestern Ecuador (Haman and Kohl, 1986; Hasson and Fischer, 1986; DuShane, 1988; Vokes, 1988; 1989; 1990; Whittaker, 1988; Pitt and Pitt, 1989; 1992; 1997), only a brief overview of stratigraphic nomenclature and age will be discussed.

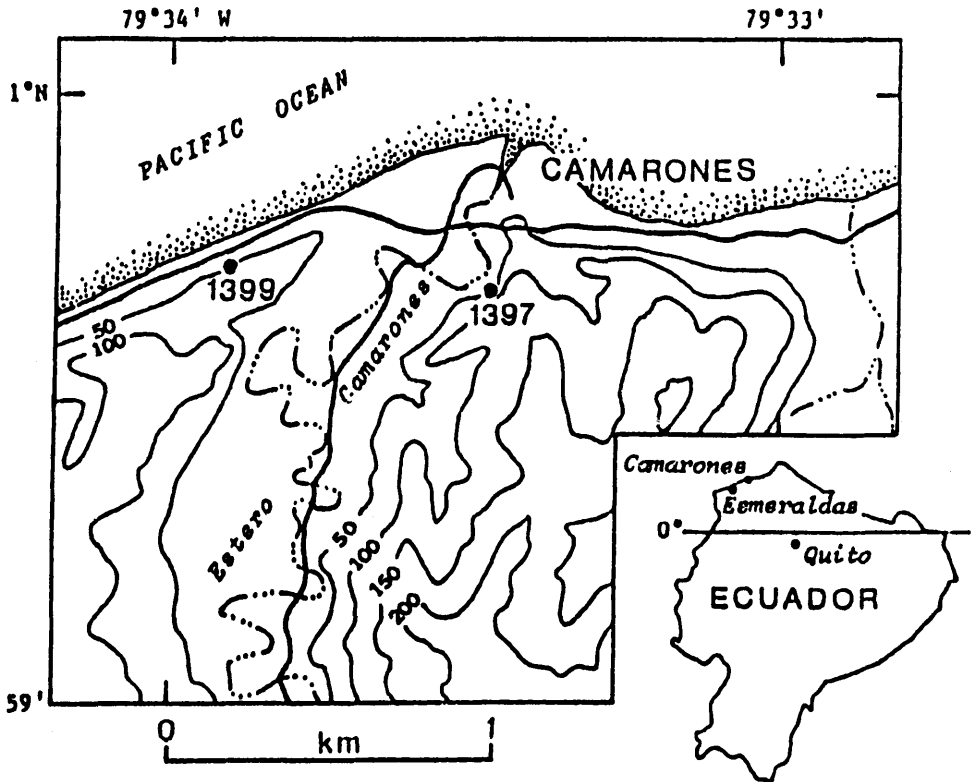
Miocene Units

The upper Miocene Angostura Formation of Stainforth (1948:142), named for outcrops along the Río Santiago, Esmeraldas Province, is the Ecuadorian equivalent of the Gatun Formation of Panamá (Pitt and Pitt, 1992). However,

* 900 Exposition Boulevard, Los Angeles, California 90007 USA, lgroves@nhm.org

EDITORIAL COMMITTEE FOR THIS PAPER:

JAMES H. MCLEAN, Natural History Museum, Los Angeles, California
RICHARD L. SQUIRES, California State University, Northridge



Text-figure 1. Index map of northwestern Ecuador showing type localities (TU 1397 and 1399 [=LACMIP localities 16944 and 16822 respectively]) of new species described herein [modified from DuShane, 1988]. Contour interval 50 m.

the uppermost part of the Gatun Formation may be of lower Pliocene age (Vokes, 1990). Olsson (1964:8) stated that this formation "is largely barren, but at a few places there are lenses or interbeds filled with finely preserved fossils." He also noted a close faunal relationship between the Angostura and Gatun formations.

Whittaker (1988) formally proposed the term Guayacan Formation [= the Blue Siltstone Member of the Daule Formation of Marks (1951)] for widespread upper Miocene strata in the Manabí Basin, as Mark's terminology did not conform to international guidelines for the naming of lithostratigraphic units (Hedberg, 1976). Additionally, the formational names of Bristow's (1976) Daule Group, which were derived from the Borbón Basin, were replaced by Whittaker's (1988) terminolo-

gy based on Manabí Basin strata. The age of the Guayacan Formation is based on age-diagnostic planktic foraminifera.

Pliocene Units

Olsson (1942) proposed the name "Esmeraldas formation" for "the highly foraminiferal, tuffaceous shales so extensively exposed along the coast of Esmeraldas and along the Esmeraldas River itself" and thought it equivalent to the Borbón Formation. However, the Esmeraldas Formation is, in fact, correlative to the Onzole Formation of Stainforth (1948) (Pitt and Pitt, 1989). Bristow (1976) stated that the Esmeraldas Formation was improperly defined by Olsson (1942) and that the name Onzole Formation should be retained. Vokes (1988) suggested usage of "Esmeraldas beds" for "the mollusk-rich, shallow water

gravity flows" in the upper part of the Onzole Formation. This usage is retained herein. Haman and Kohl (1986) based the age of strata at Quebrada Camarones (= Esmeraldas beds of the Onzole Formation) on the presence of the benthic foraminiferal genus *Montfortella*. Micropaleontologic analyses by Hasson and Fischer (1986) yielded a lower Pliocene (= Zancian Stage of Seguenza, 1868) age for the Esmeraldas beds. Whittaker (1988) cited the age of the Onzole Formation as between upper Miocene and early Pliocene but considered the upper part of the Onzole, presumably including the Esmeraldas beds, to be entirely Pliocene as dated by benthic foraminifera.

Based upon a rich molluscan fauna, the lower Pliocene Jama Formation was proposed by Pilsbry and Olsson (1941) for exposures along Bahía Jama, Manabí Province. Benthic foraminifera within the formation indicate littoral to sublittoral depositional environments. Whittaker (1988) equated the Jama Formation with his lower Pliocene Bahía Formation [= Upper Calcareous member of Marks (1951)], both within the Manabí Basin, and he separated them on lithologic and faunal differences.

IV. ACKNOWLEDGMENTS

William D. and Lois J. Pitt, Sacramento, California, kindly donated personally collected specimens, provided stratigraphic and paleontologic information about the Onzole and Angostura formations, and reviewed an early version of the manuscript. Emily H. Vokes (TU), Elana Benamy and Gary Rosenberg (ANSP), Jean F. DeMouthe, Elizabeth Kools, and the late Tony Summers (CAS), Paul Jeffrey (BMNH), David R. Lindberg, Christopher P. Meyer, and Karen Wetmore-Grycewicz (UCMP), and Warren H. Blow, Jann Thompson, and Thomas R. Waller (USNM) granted numerous requests for specimen loans and locality information from their respective institutions. Librarians Donald W. McNamee and Mark Herbert (LACM Research Library) and Suzanne Henderson, Jean Crampon, and Melinda Hayes (Alan Hancock Foundation, University of

Southern California) processed numerous interlibrary loan requests and aided in locating rare and obscure references. James H. McLean (Natural History Museum of Los Angeles County, Malacology) and Richard L. Squires (California State University, Northridge) reviewed the manuscript and offered helpful criticisms.

ABBREVIATIONS CITED

- ANSP: Academy of Natural Sciences of Philadelphia
 BM(NH): The Natural History Museum, London
 CAS: California Academy of Sciences, San Francisco
 LACMIP: Natural History Museum of Los Angeles County (Invertebrate Paleontology Section)
 P: Collecting locality numbers of W.D. and L.J. Pitt
 TU: Tulane University, New Orleans
 UCMP: University of California, Museum of Paleontology, Berkeley
 USNM: National Museum of Natural History, Smithsonian Institution, Washington, D.C.

V. SYSTEMATICS

For the most part, the classification scheme of Schilder and Schilder (1971) is utilized for generic and higher level taxonomy. The notable exception is that the *Siphocypraea* (*Muracypraea*) group is accepted as a full genus, as proposed by Kay (1995). Synonymy citations are limited to original descriptions, material examined, and all records of each species from Ecuador. Measurement parameters are defined as follows: length = greatest distance between anterior and posterior ends; width = greatest distance between lateral margins; and height = greatest distance between base and dorsum.

- Superfamily VELUTINACEA Gray, 1840
 Family TRIVIIDAE Troschel, 1863
 Subfamily TRIVIINAE Troschel, 1863
 Tribe PUSULINI Schilder, 1936

Genus PUSULA Jousseau, 1884
Pusula JOUSSEAU, 1884, Bull. Soc. Zool.
 France, v. 9, p. 99.
 Type Species: *Cypraea radians* Lamarck,
 1810, by original designation; Recent, Panamic
 Province.

Subgenus PUSULA Jousseau, 1884
 PUSULA (*PUSULA*) sp.
 Plate 1, figure 1

Occurrence: Lower Pliocene Esmeraldas beds,
 Onzole Formation.

Figured Specimen: LACMIP hypotype 12429,
 TU locality 1399 (= locality P-101; LACMIP
 locality 16882), 16.8 mm length, 11.7 mm
 width, 10.4 mm height, H.E. and E.H. Vokes
 collectors (pl. 1, fig. 1).

Discussion: Only a single incomplete
 specimen of *Pusula* (*Pusula*) sp. is known
 from the Esmeraldas beds of the Onzole

Formation. This fragment most closely
 resembles the Recent Panamic species *P.*
(P.) radians (Lamarck, 1810) but has more
 numerous, finer ribs. This is the first pub-
 lished report of a fossil triviid from the
 Neogene of Ecuador.

Superfamily CYPRAEACEA
 Rafinesque, 1815

Family CYPRAEIDAE Rafinesque, 1815
 Subfamily BERNAYINAE Schilder, 1927
 Tribe BERNAYINI Schilder, 1927
 Genus MURACYPRAEA Woodring, 1957

Muracypraea WOODRING, 1957, The Nautilus,
 v. 70, p. 89 (subgenus of *Cypraea*).

Type Species: *Cypraea mus* Linnaeus, 1758,
 by original designation; Recent, Panamá,
 Colombia, and Venezuela.

MURACYPRAEA CAYAPA (Pilsbry and
 Olsson, 1941)

PLATE 1

Figures	Page
1. <i>Pusula</i> (<i>Pusula</i>) sp.	150
LACMIP 12429 (hypotype); 16.8 mm length, 11.7 mm width, 10.4 mm height (x2.3). Locality: TU 1399 (= P-101; LACMIP 16882), Esmeraldas beds, Onzole Formation, Ecuador.	
2,3. <i>Muracypraea cayapa</i> (Pilsbry and Olsson, 1941)	150
ANSP 13665 (holotype); 64.3 mm length, 52.7 mm width, 42.4 mm height (x0.62). Jama Formation, Ecuador.	
4-6. <i>Muracypraea "henekeni"</i> (Sowerby, 1850)	152
4. LACMIP 12430 (hypotype); 50.5 mm length, 21.9 mm width, 31.2 mm height (x0.94). Locality: TU 1507 (= P-102; LACMIP 16943), Angostura Formation, Ecuador.	
5,6. LACMIP 12431 (hypotype); 42.1 mm length, 34.4 mm width, 23.2 mm height (x0.95). Locality: TU 1507 (= P-102; LACMIP 16943), Angostura Formation, Ecuador.	
7,8. <i>Zonaria</i> (<i>Zonaria</i>) <i>pittorum</i> Groves, n.sp.	153
LACMIP 12432 (holotype); 40.1 mm length, 27.3 mm width, 20.9 mm height (x1.0). Locality: TU 1399 (= P-101; LACMIP 16882), Esmeraldas beds, Onzole Formation, Ecuador.	
9,10. <i>Zonaria</i> (<i>Pseudozonaria</i>) <i>cathya</i> Groves, n.sp.	154
LACMIP 12433 (holotype); 22.3 mm length, 15.8 mm width, 12.8 mm height (x1.8). Locality: TU 1397 (= P-100; LACMIP 16944), Esmeraldas beds, Onzole Formation, Ecuador.	
11,12. <i>Zonaria</i> (<i>Pseudozonaria</i>) <i>telembiensis</i> (Olsson, 1964)	154
USNM 644048 (holotype); 19.5 mm length, 13.4 mm width, 10.1 mm height (x1.9) Locality: Angostura Formation, Ecuador.	
13,14. <i>Jenneria</i> (<i>Jenneria</i>) <i>panamensis</i> (Olsson, 1967)	155
LACMIP 12434 (hypotype); 25.8 mm length, 16.9 mm width, 11.8 mm height (x1.5) Locality: TU 1397 (= P-101; LACMIP 16944), Esmeraldas beds, Onzole Formation, Ecuador.	

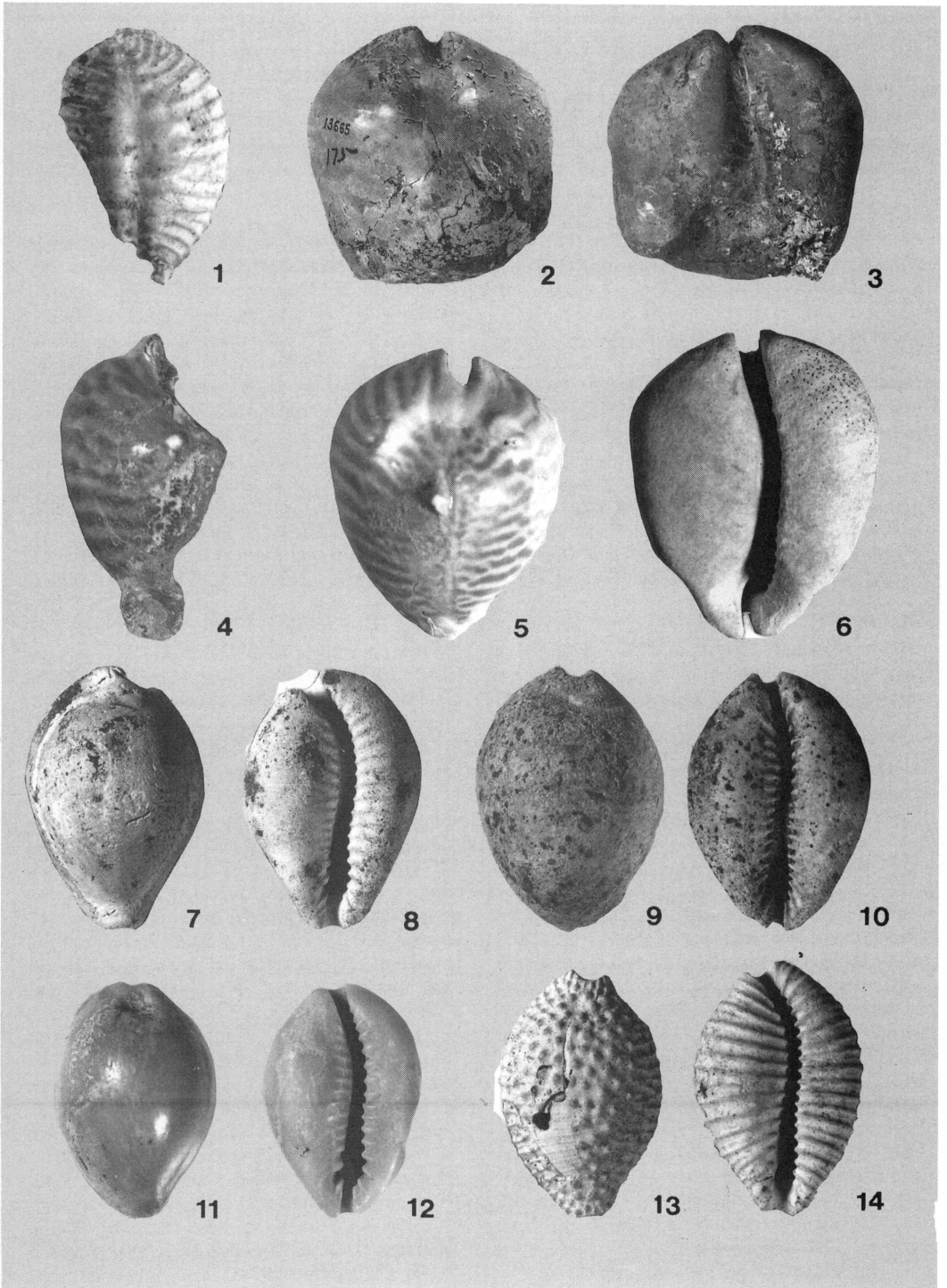


PLATE 1

Plate 1, figures 2, 3

Cypraea cayapa PILSBRY and OLSSON, 1941, Proc. Acad. Nat. Sci. Philadelphia, v. 93, p. 41-42, pl. 7, fig. 4; INGRAM, 1947, Bulls. Amer. Paleontology, v. 31, no. 120, p. 60-61, 89-90; INGRAM, 1947, Bulls. Amer. Paleontology, v. 31, no. 122, p. 145; WOODRING, 1959, U.S. Geol. Surv. Prof. Paper 306-B, p. 194; RICHARDS, 1968, Spec. Pub. Acad. Nat. Sci. Philadelphia, v. 8, p. 113.

Siphocypraea cayapa (Pilsbry and Olsson). SCHILDER, 1961, Arch. Moll., v. 90, no. 4/6, p. 148; PETUCH, 1979, Bull. Mar. Sci., v. 29, no. 2, p. 217; PETUCH, 1988, Neogene Hist. Trop. Amer. Moll., p. 100.

Siphocypraea (Muracypraea) cayapa (Pilsbry and Olsson). SCHILDER and SCHILDER, 1971, Inst. Roy. Sci. Nat. Belgique, Mem. 85, p. 29, 104.

Barycypraea (Muracypraea) cayapa (Pilsbry and Olsson). GROVES, 1993, West. Soc. Malac., Ann. Rept., v. 25, p. 12.

Muracypraea cayapa (Pilsbry and Olsson). GROVES, 1997, West. Soc. Malac., Ann. Rept., v. 29, p. 8.

Type Material: Holotype ANSP 13665; 64.3 mm length (incomplete), 51.7 mm width, 42.4 mm height, A.A. Olsson collector (pl. 1, figs. 2, 3).

Type Locality: Puerto Jama, Manabí Province, Ecuador; lower Pliocene, Jama Formation.

Occurrence: Known only from a single incomplete specimen from the type locality (Pilsbry and Olsson, 1941).

Discussion: Although approximately one-third of the anterior of this large specimen is missing, it unlikely to be confused with any other cypraeid species from Ecuador. Similar large *Muracypraea* specimens from Venezuela, Baja California Sur, Mexico, and Imperial County, California, were compared to *M. cayapa* and together might represent a separate lineage based on their shared prominent pair of posterior dorsal tubercules, highly angular shape, and highly arched dorsum.

MURACYPRAEA "HENEKENI"
(Sowerby, 1850)

Plate 1, figures 4, 5, and 6

Cypraea henikeri SOWERBY, 1850, Geol. Soc. London, Quart. Jour., v. 6, p. 45, pl. 9, fig. 3

[error for *henekeni*].

Cypraea cf. *C. henekeni* Sowerby. MARKS, 1951, Bulls. Amer. Paleontology, v. 33, no. 139, p. 376.

Siphocypraea (Muracypraea) henekeni (Sowerby). OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 176-177, pl. 31, figs. 3-3a.

Type Material: Lectotype (designated by Pflug, 1961:21) BM(NH) G83940; paralectotypes, here recognized, BM(NH) GG20023, GG20024, GG20025, GG20026 and GG20027.

Type Locality: Río Yaque, northern Dominican Republic (Woodring, 1959); late Miocene, presumably Cercado or Gurabo Formation.

Occurrence: PANAMÁ: Gatun Formation (Woodring, 1959; Pitt and Pitt, 1993); ECUADOR: Angostura Formation (Olsson, 1964); Blue Siltstone Member, Daule Formation [= Guayacan Formation] (Marks, 1951); COLOMBIA: Nariño Department (herein).

Figured Specimens: LACMIP 12430, TU locality 1507 (= P-102; LACMIP locality 16943), 50.5 mm length, 21.9 mm width, 31.2 mm height [incomplete] (pl. 1, fig. 4), H.E. and E.H. Vokes collectors; LACMIP 12431, TU locality 1507 (= LACMIP locality 16945), 42.1 mm length, 34.4 mm width, 23.2 mm height (pl. 1, figs. 5, 6), H.E. and E.H. Vokes collectors.

Material Examined: ECUADOR: 1 partial specimen, locality P-102, Angostura Formation, Punta Verde, Esmeraldas Province (Coll. W.D. and L.J. Pitt); 1 specimen, TU locality 1507, Angostura Formation, Río Verde, Esmeraldas Province (Coll. H.E. and E.H. Vokes); 1 specimen, USNM 644046, Angostura Formation, Río Santiago, Esmeraldas Province; and 1 specimen, USNM 644047, Angostura Formation, Río Santiago, Esmeraldas Province; PANAMÁ: 1 specimen, locality P-95, Gatun Formation, Cativa, Colón Province (Coll. W.D. and L.J. Pitt); 1 specimen, ANSP 315087, Gatun Formation, Cativa, Colón Province (Coll. W.C. Gruff); 3 specimens, TU locality 1432, Gatun Formation, Cativa, Colón Province (Coll. H.E. and E.H. Vokes); 2 specimens, TU locality 960 [= locality 139E of Woodring (1959)], Gatun Formation, Isla Payardi, Colón Province (Coll. H.E. and E.H. Vokes); 5 specimens, TU locality 958, Gatun Formation, east of Cativa, Colón Province (Coll. H.E. and E.H. Vokes); 5 specimens, TU locality 757, Gatun Formation, east of Cativa, Colón Province (Coll. H.E. and E.H. Vokes); 1 specimen, TU locality 1433, Gatun

Formation (Coll. H.E. and E.H. Vokes); 1 specimen, LACMIP locality 16936, Gatun Formation (Coll. T. Bratcher); and COLOMBIA: 1 partial specimen, UCMP locality C-14311, Nariño Department (Coll. Tropical Oil Company).

Two of Woodring's (1959) hypotypes [USNM 562581 and 562582] from the Gatun Formation of Panamá and a single specimen from the San Ignacio area, Baja California Sur, Mexico [USNM collection], may also represent *M. "henekeni"*.

Discussion: Numerous forms and/or varieties identified as *M. henekeni* were synonymized by Woodring (1959). However, specimens from Panamá and Ecuador (and a single partial specimen from southwestern Colombia) differ significantly enough to justify splitting from the nominal species. They are generally smaller, have a distinct triangular or arrowhead shape, possess prominent pairs of dorsal tubercules, and in some instances have a central "spike-like" dorsal tubercle. Many of the specimens also display original color striping and blotching of dull reddish brown and yellowish orange uncommonly found in the nominal species. Woodring (1959) acknowledged the variability of *M. henekeni* and the excess of names applied to this species, and he stated that "some of the names in the synonymy may prove to be useful for local populations when adequate samples are available." Groves and Arnold (in preparation) will provide further justification in splitting the western Caribbean and Ecuadorian specimens from *M. henekeni* of the Dominican Republic, Trinidad, Venezuela, and northern Colombia. Specimens herein therefore are referred to *M. "henekeni"* in the interim. Pilsbry and Olsson (1941:42) mentioned that "a smaller, undescribed species occurs in the Miocene of the Río Santiago, northern Ecuador, but none are known in the present west coast fauna." This form might represent *M. "henekeni"* of this present study, however, their whereabouts are unknown.

Subfamily ERRONEINAE Schilder, 1927
Tribe ZONARIINI Schilder, 1932
Genus ZONARIA Jousseau, 1884

Zonaria JOUSSEAU 1884, Bull. Soc. Zool. France, v. 9, p. 92-93.

Type Species: *Cypraea zonata* Lamarck, 1810 (not Chemnitz, 1788) [= *Cypraea zonaria* Gmelin, 1791], by original designation; Recent, West Africa.

Subgenus ZONARIA Jousseau, 1884

ZONARIA (ZONARIA) PITTORUM
Groves, n.sp.

Plate 1, figures 7, 8

Zonaria (Zonaria) n.sp. GROVES, 1997, West. Soc. Malac., Ann. Rept., v. 29, p. 8.

Diagnosis: A *Zonaria* s.s. with lengthened anterior, weak teeth on anterior canal, and smooth narrow fossula.

Description: Shell shape pyriform, medium in size; spire covered; dorsum prominently arched; maximum height slightly posterior of midpoint; aperture slightly curved posteriorly toward columella; denticulation strong with smooth interstices; labial lip with 19 teeth; columellar lip with 17 teeth; strong anterior canal teeth, weak posterior canal teeth; fossula smooth and narrow; basal marginal callus moderate to prominent; deep and well developed terminal canals.

Type Material: Holotype LACMIP 12432; length 40.1 mm, width 27.3 mm, height 20.9 mm, H.E. and E.H. Vokes collectors (pl. 1, figs. 7, 8).

Type Locality: TU locality 1399 (= P-101; LACMIP locality 16882), lower Pliocene Esmeraldas beds, Onzole Formation; roadcut on west side of village of Camarones, 20 km east of bridge over Río Esmeraldas, Esmeraldas Province, Ecuador.

Occurrence: Esmeraldas beds, Onzole Formation, Ecuador; TU locality 1399 [= P-101; LACMIP locality 16882] (1 specimen).

Discussion: The new species is most similar to *Zonaria (Zonaria) porcellus cocconii* (Mayer, 1875) from the middle to upper Pliocene (= Piacenzian Stage of Mayer-Eymar, 1857) rocks of northern Italy. *Zonaria (Z.) pittorum*, n.sp., has a more sinuous aperture and fewer, stronger apertural teeth that extend further onto the labial and columellar surfaces than in *Z. (Z.) porcellus cocconii*. Both species differ from *Z. (Z.) porcellus* (Brocchi, 1814), also from the middle to upper Pliocene rocks of northern Italy, by having a more inflated columella, a higher arched dor-

sum, and a more prominent basal marginal callus. Inzani (1995) figured specimens that display a range of minor shell differences, but all are consistent with the subspecies *Z. (Z.) porcellus cocconii*.

Etymology: This new species is named for William D. and Lois J. Pitt, Sacramento, California, in recognition of their numerous important paleontological works on the Tertiary of Ecuador and Panamá.

Subgenus PSEUDOZONAIRA
Schilder, 1927

Pseudozonaria SCHILDER, 1927, Arch. Naturges., v. 91A, p. 115.

Type Species: *Cypraea arabicula* Lamarck, 1810, by original designation; Recent, Panamic Province.

ZONARIA (PSEUDOZONARIA) CATHYAE
Groves, n.sp.

Plate 1, figures 9, 10

Zonaria (Pseudozonaria) n.sp. GROVES, 1997, West. Soc. Malac., Ann. Rept., v. 29, p. 8.

Diagnosis: A *Zonaria (Pseudozonaria)* with oval shape, strong teeth on terminal canals, and wide, denticulated fossula.

Description: Shell oval in shape, medium in size; spire covered, with prominent pit near spire callus; dorsum highly arched, maximum height slightly posterior of midpoint; wide straight aperture slightly curved posteriorly toward columella; denticulation fine and incised with smooth interstices; labial lip with 18 teeth; columellar lip with 16 teeth; strong teeth on terminal canals; wide fossula crossed by columellar teeth; basal marginal callus prominent; deep and well developed terminal canals.

Type Material: Holotype LACMIP 12433; length 22.3 mm, width 15.8 mm, height 12.8 mm, H.E. and E.H. Vokes collectors (pl. 1, figs. 9, 10).

Type Locality: TU locality 1397 (= P-100; LACMIP locality 16944), lower Pliocene Esmeraldas beds, Onzole Formation; Quebrada Camarones, cut-bank on east side of canyon, east of the village of Camarones, 20 km east of bridge over Río Esmeraldas, Esmeraldas, Esmeraldas Province, Ecuador.

Occurrence: Esmeraldas beds, Onzole Formation; TU locality 1397 [= P-100; LACMIP locality 16944] (1 specimen).

Discussion: The new species is most similar to *Z. (P.) portelli* (Petuch, 1990) from the Pleistocene Bermont Formation, Dade County, Florida and the Recent Panamic *Z. (P.) robertsi* (Hidalgo, 1906). *Zonaria (Pseudozonaria) cathyae*, n.sp., has finer and more numerous apertural teeth than both similar species, a more prominent basal marginal callus, and a thicker more prominent labial lip with incised teeth. The upper Miocene *Zonaria (Pseudozonaria) telembiensis* differs from *Z. (P.) cathyae* by its smaller size, fewer and coarser apertural teeth, and a weaker basal marginal callus.

Etymology: This new species is named for my wife Cathy L. Groves, of the Echinoderms Section of Invertebrate Zoology, Natural History Museum of Los Angeles County.

ZONARIA (PSEUDOZONARIA) TELEMBIENSIS
(Olsson, 1964)

Plate 1, figures 11, 12

Cypraea (Pseudozonaria) telembiensis OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 175, pl. 31, figs. 6a-b.

Zonaria (Pseudozonaria) telembiensis (Olsson). SCHILDER and SCHILDER, 1971, Inst. Roy. Sci. Nat. Belgique, Mem. 85, p. 46, 162; GROVES, 1993, West. Soc. Malac., Ann. Rept., v. 25, p. 12; GROVES, 1997, West. Soc. Malac., Ann. Rept., v. 29, p. 8.

Type Material: Holotype USNM 644048, 19.5 mm length, 13.4 mm width, 10.1 mm height, A.A. Olsson collector (pl. 1, figs. 11, 12).

Type Locality: Río Cayapas, Telembi, Esmeraldas Province, Ecuador; upper Miocene, Angostura Formation.

Occurrence: Known only from a single specimen from the type locality (Olsson, 1964).

Discussion: *Zonaria (Pseudozonaria) telembiensis* is the earliest known species of its subgenus.

Family OVULIDAE Fleming, 1822

Subfamily EOCYPRAEINAE

Schilder, 1924

Tribe CYPROGLOBININI Schilder, 1924

Genus JENNERIA Jousseau, 1884

Jenneria JOUSSEAU, 1884, Bull. Soc. Zool. France, v. 9, p. 98-99.

Type Species: *Cypraea pustulata* [Lightfoot, 1786], by original designation; Recent, Panamic Province.

Subgenus JENNERIA Jousseau, 1884

JENNERIA (JENNERIA) PANAMENSIS
(Olsson, 1967)

Plate 1, figures 13, 14

Cypropterina pustulata (Lamarck, 1810). OLSSON, 1942, *Bulls. Amer. Paleontology*, v. 27, no. 106, p. 21. Not *Cypraea pustulata* [Lightfoot, 1786].

Jenneria panamensis OLSSON, 1967, *Notulae Naturae*, p. 9, pl. 1, figs. 3-3a.

Cypropterina (Jenneria) panamensis (Olsson). SCHILDER and SCHILDER, 1971, *Inst. Roy. Sci. Nat. Belgique, Mem.* 85, p. 71, 141; GROVES, 1993, *West. Soc. Malac., Ann. Rept.*, v. 25, p. 12; GROVES, 1997, *West. Soc. Malac., Ann. Rept.*, v. 29, p. 8.

Type Material: Holotype NSP 31312, missing (E. Benamy, pers. commun., 1990).

Type Locality: Upper Pliocene, Charco Azul Formation, Río Blanco, Burica Peninsula, Chiriquí Province, Panamá (Olsson, 1967).

Figured Specimen: LACMIP 12434, TU locality 1399 (= P-101; LACMIP locality 16882); length 25.8 mm, width 16.9 mm, height 11.8 mm, H.E. and E.H. Vokes collectors; roadcut on west side of village of Camarones, 20 km east of bridge over Río Esmeraldas, Esmeraldas, Esmeraldas Province, Ecuador.

Occurrence: Charco Azul Formation, Panamá (Olsson, 1967); Esmeraldas beds, Onzole Formation, Ecuador (herein).

Discussion: *Jenneria (Jenneria) panamensis* is the only species of fossil ovulid from the Neogene of Ecuador. The Pleistocene through Recent Panamic species *J. (J.) pustulata* [Lightfoot, 1786] appears to be more closely related to the "Florida group" of pustularias of Olsson (1967), based on shell characteristics than to *J. (J.) panamensis* and is the sole surviving species of this genus.

VI. LOCALITY REGISTER
OF FIGURED SPECIMENS

ANSP 13665. Jama Formation, Puerto Jama, Manabí Province, Ecuador. Early Pliocene.

TU 1397. Esmeraldas beds, Onzole Formation, Quebrada Camarones, cut-bank on east side of canyon, which is at east edge of village of Camarones, 20 km (by road) east of bridge over Río Esmeraldas, Esmeraldas Province, Ecuador. Early Pliocene. [= P-100; LACMIP 16944].

TU 1399. Esmeraldas beds, Onzole Formation, road-cut on west side of village of Camarones, which is 20 km (by road) east of bridge over Río Esmeraldas, Esmeraldas Province, Ecuador. Early Pliocene. [= P-101; LACMIP 16882]

TU 1507. Angostura Formation, large point just east of Río Verde, or approximately 30 km east of Río Esmeraldas, Esmeraldas Province, Ecuador. Late Miocene. [= P-102; LACMIP 16943].

USNM 644048. Angostura Formation, Telembi, Río Cayapas, Manabí Province, Ecuador. Late Miocene.

VII. LITERATURE CITED

- BRISTOW, C.R., 1976, The Daule Group, Ecuador (middle Miocene-Pliocene): *Newsl. Stratigr.*, v. 5, no. 2/3, p. 190-200, figs. 1-2.
- BROCCHI, G., 1814, *Conchilogia fossile subapennina con osservazioni geologiche*. Milano, v. 2, p. 241-712, pls. 1-16.
- DUSHANE, H., 1988, Pliocene Epitoniidae of the Esmeraldas Beds northwestern Ecuador (Mollusca: Gastropoda): *Tulane Stud. Geol. Paleont.*, v. 21, no. 1, p. 51-58, figs. 1-12.
- FLEMING, J., 1822, *The philosophy of zoology; or a general view of the structure, functions, and classification of animals*, v. 2. Archibald and Company, Edinburgh, Scotland, 618 p.
- GMELIN, J.F., 1791, *Caroli a Linne Systema naturae per regna tria naturae, edito decima tertia, reformata, vermes Testacea*. Leipzig, v. 1, no. 6, p. 3021-3910.
- GRAY, J.E., 1840, *Mollusks in Synopsis of the Contents of the British Museum*, 41st ed. G. Woodfall and Son, London, p. 82-84 [ii] + 302 p.
- GROVES, L.T., 1993, Fossil and Recent species of eastern Pacific Cypraeacea (Pediculariidae, Cypraeidae, and Ovulidae): *West. Soc. Malac., Ann. Rept.*, v. 25, p. 11-14.
- GROVES, L.T., 1997, Fossil and Recent species

- of eastern Pacific Cypraeacea (Cypraeidae and Eocypraeinae [Ovulidae]): An update: West. Soc. Malac., Ann. Rept., v. 29, p. 7-10.
- HAMAN, D., and B. KOHL, 1986, Early Pliocene *Montfortella* (Foraminiferida) from Ecuador: Tulane Stud. Geol. Paleont., v. 19, no. 4, p. 181-182, pl. 1.
- HASSON, P.F., and A.G. FISCHER, 1986, Observations on the Neogene of northwestern Ecuador: Micropaleo., v. 32, no. 1, p. 32-42, pl. 1.
- HEDBERG, H.D. (ed.), 1976, International stratigraphic guide. A guide to stratigraphic classification, terminology, and procedure. John Wiley and Sons, New York, xvii + 200 p.
- HIDALGO, J.G., 1906-1907, Monografía de las especies vivientes del género *Cypraea*: Mem. Real Acad. Cien. Madrid, v. 25, p.i-xv + 1-240 [1906]; 241-588 [1907].
- INGRAM, W.M., 1947a, Fossil and Recent Cypraeidae of the western regions of the Americas: Bulls. Amer. Paleontology, v. 31, no. 120, p. 47-124, pls. 5-7.
- INGRAM, W.M., 1947b, Check list of the Cypraeidae occurring in the Western Hemisphere: Bulls. Amer. Paleontology, v. 31, no. 122, p. 141-161.
- INZANI, A., 1995, The Cypraeidae family in the Italian Pliocene. I: World Shells, v. 12, p. 41-45, pls. 1-2.
- JOUSSEAUME, F., 1884, Étude sur la famille des Cypraeidae: Bull. Soc. Zool. France, v. 9, p. 81-100.
- KAY, E.A., 1996, Evolutionary radiations in the Cypraeidae in J. TAYLOR (ed.), Origin and Evolutionary Radiation of the Mollusca. Oxford University Press, London, p. 211-220, figs. 18.1-18.5.
- LAMARCK, J.B.P.A. de M., 1810, Sur la détermination des espèces parmi les animaux sans vertèbres, et particulièrement parmi les mollusques testacés: Ann. Mus. Nat. Hist., Paris, v. 15, 443-454 [Porcelaine (*Cypraea*)]; v. 16, p. 89-114 [Suite du genre *Porcelaine*].
- [LIGHTFOOT, J., 1786], A catalogue of the Portland Museum, lately the property of the dutchess Dowager of Portland. London, 194 p.
- LINNAEUS, C., 1758, Systema naturae per regna tria naturae, editio decima, reformata. Stockholm, v. 1, 824 p.
- MARKS, J.G., 1951, Miocene stratigraphy and paleontology of southwestern Ecuador: Bulls. Amer. Paleontology, v. 33, no. 139, p. 277-433, pls. 43-51, 12 text-figs.
- MAYER, C., 1875, Description de Coquilles fossiles des terrains Tertiaires supérieurs (suite): Jour. de Conch., 3rd ser., v. 23, p. 66-67, pl. 2.
- MAYER-EYMAR, K., 1857, Versuch einer neuen klassifikation der Tertiär-Gebilde Europa's: Verhand. Schweiz. Ges. Natur. Trogen, 1857, p. 165-199.
- OLSSON, A.A., 1942, Tertiary deposits of northwestern South America and Panama: Proc. Eighth Amer. Sci. Cong., v. 4, p. 231-287.
- OLSSON, A.A., 1964, Neogene mollusks from northwestern Ecuador. Paleontological Research Institution, Ithaca, New York, 256 p., 38 pls.
- OLSSON, A.A., 1967, Pustularias (*Jenneria*) in the American Neogene: Notulae Naturae, no. 403, p. 1-13, pls. 1-2.
- PETUCH, E.J., 1979, A new species of *Siphocypraea* (Gastropoda: Cypraeidae) from northern South America with notes on the genus in the Caribbean: Bull. Mar. Sci., v. 29, no. 2, p. 216-225, figs. 1-2.
- PETUCH, E.J., 1988, Neogene history of tropical American mollusks. The Coastal Education and Research Foundation, Charlottesville, Virginia, 217 p., 39 pls., 23 text-figs.
- PETUCH, E.J., 1990, New gastropods from the Bermont Formation (middle Pleistocene) of the Everglades Basin: The Nautilus, v. 104, no. 3, p. 96-104, figs. 1-22.
- PFLUG, H.D., 1961, Mollusken aus dem Tertiär von St. Domingo: Acta Humboldt, (Ser. Geol. Paleo.), v. 1, p. 1-107, pls. 1-26, 1 text-fig.
- PILSBRY, H.A., and A.A. OLSSON, 1941, A Pliocene fauna from western Ecuador: Proc. Acad. Nat. Sci. Philadelphia, v. 93, p. 1-79, pls. 1-19.
- PITT, W.D., and L.J. PITT, 1989, A new species of *Trichotropis* (Gastropoda: Mesogastropoda) from the Esmeraldas Beds, Onzole Formation, northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 22, no. 4, p. 131-136, pl. 1.
- PITT, W.D., and L.J. PITT, 1992, Naticidae (Mollusca: Mesogastropoda) from the Neogene of northwestern Ecuador: Tulane Stud. Geol. Paleont., v. 25, no. 4, p. 109-138, pls. 1-5, 1 text-fig.
- PITT, W.D., and L.J. PITT, 1993, Ultra-violet light as a useful tool for identifying fossil mollusks, with examples from the Gatun Formation, Panama: Tulane Stud. Geol. Paleont., v. 26, no. 1, p. 1-13, pls. 1-4.
- PITT, W.D., and L.J. PITT, 1997, *Nassarius*

- (Mollusca: Neogastropoda) from the Neogene of northwestern Ecuador: *Tulane Stud. Geol. Paleont.* v. 29, no. 4, p. 135-140, pl. 1.
- RAFINESQUE, C.S., 1815, *Analyse de la nature, ou tableau de l'univers et des corps organisés*. Palermo, 224 p.
- RICHARDS, H.G., 1968, *Catalogue of invertebrate fossil types at the Academy of Natural Sciences of Philadelphia: Spec. Pub. Acad. Nat. Sci. Philadelphia*, v. 8, 222 p.
- SEGUENZA, J., 1868, *La formation zancleenne, ou recherches sur une nouvelle formation Tertiaire: Bull. Soc. Géol. France, ser. 2*, v. 25, p. 465-486, figs. 1-4.
- SCHILDER, F.A., 1924, *Systematischer index der rezenten Cypraeidae: Arch. Nat.*, v. 90A, p. 179-214.
- SCHILDER, F.A., 1927, *Revision der Cypraeacea: Arch. Nat.*, v. 91A, p. 1-65.
- SCHILDER, F.A., 1932, *Cypraeacea in W. QUENSTEDT (ed.), Fossilium Catalogus, 1: Animalia, pt. 55*. W. Junk, Berlin, 276 p.
- SCHILDER, F.A., 1936, *Anatomical characters of the Cypraeacea which confirm the conchological classification: Proc. Malac. Soc. London*, v. 22, no. 2, p. 75-112, pls. 11-12.
- SCHILDER, F.A., 1961, *Nachträge zum Katalog der Cypraeacea von 1941: Arch. Moll.*, v. 90, no. 4/6, p. 145-153.
- SCHILDER, M., and F.A. SCHILDER, 1971, *A catalogue of living and fossil cowries: Inst. Roy. Sci. Nat. Belgique, Mem. 85*, p. 1-246.
- SOWERBY, G.B., 1850, *Descriptions of new species of fossil shells found by J.S. Heniken Esq.: Geol. Soc. London, Quart. Jour.*, v. 6, p. 44-53, pls. 9-10.
- STAINFORTH, R.M., 1948, *Applied micro-paleontology in coastal Ecuador: Jour. Paleont.*, v. 22, no. 2, p. 113-151, pls. 24-26, 1 text-fig.
- TROSCHEL, F.H., 1856-1863, *Das gebiss der schnecken zur begründung einer natürlichen classification*, v. 1. Nicolaische Verlagbuchhandlung, Berlin, 252 p., 20 pls.
- VOKES, E.H., 1988, *Muricidae (Mollusca: Gastropoda) of the Esmeraldas Beds, northwestern Ecuador: Tulane Stud. Geol. Paleont.*, v. 21, no. 1, p. 1-50, pls. 1-6, 15 text-figs.
- VOKES, E.H., 1989, *Muricidae (Mollusca: Gastropoda) of the Angostura Formation, northwestern Ecuador: Tulane Stud. Geol. Paleont.*, v. 22, no. 4, p. 107-118, pl. 1, 7 text-figs.
- VOKES, E.H., 1990, *On the occurrence of the gastropod genus Cassis in the Esmeraldas fauna, northwestern Ecuador: Tulane Stud. Geol. Paleont.*, v. 23, no. 4, p. 121-126, pls. 1-2.
- WHITTAKER, J.E., 1988, *Benthic Cenozoic foraminifera from Ecuador. British Museum (Natural History), London*, xi + 194 p., 25 pls., 16 text-figs.
- WOODRING, W.P., 1957, *Muracypraea, new subgenus of Cypraea: The Nautilus*, v. 70, no. 3, p. 88-90.
- WOODRING, W.P., 1959, *Geology and paleontology of Canal Zone and adjoining parts of Panama: Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae): U.S. Geol. Surv. Prof. Paper 306-B*, p. iii + 147-239, pls. 24-38.

THE TULANE GEOLOGICAL COLLECTIONS

In 1956 when Harold E. Vokes came to Tulane University to build up the Geology Department and institute a graduate program in Geology and Paleontology, the collections of fossil and Recent material consisted of the remnants of what originally had been exhibited at the Louisiana Cotton Centennial Exposition. This exposition, which marked the 100-year anniversary of the shipment of the first bale of cotton from the port of New Orleans, was held in what is now Audubon Park, across St. Charles Avenue from the present Tulane campus. Like all such expositions at this time, fossils, minerals, zoological specimens, etc., were sent by countries all over the world (there was a beautiful mineral collection from Uruguay, for example). After the exposition ended the material was donated to Tulane University and for the next 70 years comprised a "natural history museum" in the attic of the main administration building, Gibson Hall. However, in 1956, coinciding with Vokes's arrival, the University disbanded the museum and distributed the specimens between the Geology and Biology departments.

In this collection there were beautiful European ammonites and such, but almost no American fossils. Professor Vokes's first order of priority was to establish a collection of stratigraphic guide fossils for the purposes of teaching Stratigraphic Paleontology. To this end, 49 of the first 50 TU fossil localities are Paleozoic.

But soon Professor and Mrs. Vokes turned to the Cenozoic outcrops of the Gulf and Atlantic Coastal Plain, and in 1962 drove from New Orleans to Isla Mujeres, Quintana Roo, Mexico, beginning their fascination with the Tertiary formations of the Isthmus of Tehuantepec. In 1968 a longer drive from New Orleans to Panama introduced them to the beautiful outcrops in Panama and Costa Rica, which were subsequently revisited many times. In 1976 political stability finally permitted collecting in the Dominican Republic and for the next eight years this was the scene of greatest interest.

Other trips added localities in France, Australia, New Zealand, South America, and other sites throughout the world. By 1995, when Mr. Vokes's health ended their activities, the Tulane collection numbered 1545 localities, that last number being, of all places, a hitherto undiscovered locality on the Chipola River, in an area where they already had 55 localities.

At the same time the fossils were being collected, Recent mollusks were also being added to the collections, with a total of 666 localities ranging from Iceland to Antarctica, although the vast majority were more tropical in nature -- especially from the Yucatan Peninsula, as a result of the Vokes's publication on the fauna of that area.

But in 1996 Emily Vokes retired from Tulane, Harold having already been required to retire at the then mandatory age of 70 in 1978. With the realization that no one at the Tulane Geology Department any longer had any interest in these collections it was agreed that the material be placed in institutions where it would be conserved (hopefully) in perpetuity. Therefore, the collections have been dispersed to three institutions. All of the Dominican Republic material, as well as the Paleozoic and most of the Mesozoic localities are now at the Paleontological Research Institution, Ithaca, New York. The rest of the non-U.S. Tertiary, as well as a few Mesozoic localities, are now at the U.S. National Museum of Natural History, Washington, D.C. But the bulk of the collection, including almost all of the U.S. Cenozoic localities, as well as all of the Recent mollusks (except for Australia and New Zealand localities, which were given to the USNM) are now in the Florida Museum of Natural History, Gainesville, Florida.