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PLIOCENE FOSSILS FROM BALTRA (SOUTH  
SEYMOUR) ISLAND, GALÁPAGOS ISLANDS

By

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INTRODUCTION

The present paper deals chiefly with invertebrate fossils which I collected while a member of the first Expedition of the *Velero III* to the Galápagos Islands in 1931-1932. A general account of the itinerary of this expedition appeared in a report by Fraser (1943, pp. 50, 260, 262, 272-273). A report dealing with fossils of Pleistocene age collected on this expedition was published by Hertlein and Strong (1939) and in a later paper the same authors (1955) reported on the Recent shells. Fossils believed to be of Pliocene age, chiefly mollusks, were collected during January, 1932. The pressure of other duties delayed completion of the present paper.

In addition to the collection which I assembled, Joseph R. Slevin collected a few fossils of Pliocene age in 1927 when he visited the island on Captain G. Allan Hancock's *Oaxaca*. A few other specimens received through the courtesy of Dr. A. Myra Keen of Stanford University, are included in the present paper.

The author is grateful for having had the opportunity to accompany the expedition offered by the late G. Allan Hancock, owner of the *Velero III*. The author acknowledges aid received from two other individuals, now deceased: A. M. Strong, who identified the micro-gastropods and E. H. Quayle who contributed information concerning the corals. Mr. Barry Roth, Department of Geology, California Academy of Sciences, furnished information concerning the identification of the species in the family Marginellidae, contributed helpful comments concerning certain other species, and also aided in the preparation of

the plates. The identifications of the corals listed in this paper were furnished by Dr. J. W. Durham, Department of Paleontology, University of California, Berkeley. The author is grateful to Carmen Angermeyer and to Jacqueline De Roy, residents of Academy Bay, Santa Cruz Island, Galápagos Islands, who presented many specimens of Recent shells from those islands to the California Academy of Sciences. These specimens have been very useful for comparison with fossil forms from that archipelago.

Photographs used to illustrate the fossils were prepared by Mr. Maurice Giles, Photographer, California Academy of Sciences. Margaret M. Hanna kindly retouched some of the photographs. The manuscript was typed by Enid Cook.

One new subspecies, *Diplodonta subquadrata baltrana*, is described in the present paper.

#### GENERAL REMARKS

Darwin visited the Galápagos Islands during the voyage of the *Beagle* in 1835. He mentioned (1844, p. 115; see ed. 3, 1896, p. 130) sea shells belonging to modern genera, apparently on Chatham Island, "embedded several hundred feet above the sea, in the tuff of two craters, distant from each other." Later Wolf (1895, pp. 250, 254, 265) reported the occurrence of fossil shells in the islands in palagonite tuff at a height of 100 meters above sea level.

W. H. Ochsner, during an expedition of the California Academy of Sciences to the Galápagos Islands on the schooner *Academy*, spent most of one year in the islands and discovered fossils on Isabela (Albemarle), Santa Cruz (Indefatigable), and Baltra (South Seymour) islands. On this expedition Ochsner collected the fossils of Pliocene age on Baltra (South Seymour) Island mentioned by Dall (1924) and later reported upon by Dall and Ochsner (1927, see especially pp. 94-99). They listed 28 species (and four others identified only as to genus) from beds believed to be of Pliocene age, 24 species from the "upper zone" and 4 in the "lower zone". Chesterman (1963, p. 344) reported on rocks of the Galápagos Islands and mentioned fossiliferous limestone and "fossiliferous tuffaceous sandstone" on Baltra (South Seymour), collected by Ochsner. He also described a specimen of andesite from the south end of the island.

Baltra Island is composed chiefly of lava and other pyroclastic material with very minor amounts of intercalated limestone and fossiliferous tuffaceous beds.

This island experienced faulting in comparatively recent time, the lines of fracture trending approximately east-northeast. This faulting resulted in alternating raised and depressed blocks. A depressed block separates Baltra (South Seymour) from Santa Cruz (Indefatigable) Island and a similar depressed block separates Baltra from Seymour (North Seymour) Island. Lewis (1956, p. 290) remarked on the relatively recent faulting as did Williams (1966, pp. 55-70)

who discussed the general geology of the Galápagos Islands. More recently, McBirney and Williams (1969, pp. 17-20, fig. 7) discussed the geology and petrology of Baltra, as well as that of other islands in the archipelago.

The fossil-bearing bed on the south end of the bay on the west side of the island is about 3 meters (10 feet) thick and dips about 5° or 6° south. Large angular blocks of lava in the lower portion of the bed offer evidence of deposition very near the shore.

The majority of the species in the present list were taken from the tuffaceous ashy bed. A number of small specimens were obtained by passing some of the white ashy material through a sieve.

#### COLLECTING STATIONS

Locality 1305 (CAS), cliff on southwest side of Baltra (South Seymour) Island, Galápagos Islands. Joseph R. Slevin collector, December 16, 1927. Pliocene.

Locality 27249 (CAS), white and yellowish tuffaceous strata interbedded with lava on the south side of the bay on the west side of Baltra (South Seymour) Island, Galápagos Islands. Leo G. Hertlein collector, January 16-18, 1932. Pliocene.

Locality 27251 (CAS), strata about 1.5 meters (5 feet) thick on the northern side of the bay, about the middle of the west side of the island, near the top of the plateau, Baltra (South Seymour) Island, Galápagos Islands. Leo G. Hertlein collector, January 14-15, 1932. Pliocene.

Locality 31838 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Fossils received by Dr. A. Myra Keen who presented them to the California Academy of Sciences, March 22, 1943.

#### LIST OF FOSSILS FROM BALTRA (SOUTH SEYMOUR) ISLAND\*

An asterisk \* indicates that the species is extinct.

##### COELENTERATA

*Pavona gigantea* Verrill

*Psammodora* (*Stephanaria*), species indeterminate

##### ECHINOIDEA

*Encope micropora galapagana* H. L. Clark, locs. 1305<sup>1</sup>; 27249 (CAS)

*Euclidaris thouarsii* Valenciennes, loc. 1305 (CAS)

##### PELECYPODA

*Anatina* (*Raëta*) *undulata* Gould, loc. 31838 (CAS)

\* *Anodontia spherica* Dall and Ochsner, locs. 1305; 27251 (CAS)

*Anomia peruviana* d'Orbigny, loc. 27249 (CAS)

<sup>1</sup> Reported from this locality as *Encope micropora* L. Agassiz by Grant and Hertlein (Publ. Univ. Calif. Los Angeles Math. Phys. Sci., vol. 2, p. 98, 1938).

- Arca pacifica* Sowerby, loc. 1305 (CAS)  
*Arca (Arcopsis) solida* Broderip and Sowerby, loc. 27249 (CAS)  
*Atrina* cf. *A. tuberculosa* Sowerby, loc. 27249 (CAS)  
*Barbatia reeveana* d'Orbigny, loc. 27249 (CAS)  
*Cardium elenense* Sowerby, loc. 27249 (CAS)  
*Chama* species, loc. 1305 (CAS)  
*Chione undatella* Sowerby, loc. 27249; (cf.) 31838 (CAS)  
*Chione* species, loc. 1305 (CAS)  
*Chlamys (Argopecten) circularis* Sowerby, loc. 27249 (CAS)  
*Chlamys (Nodipecten) magnifica* Sowerby, loc. 27249 (CAS)  
*Ctena galapagana* Dall, locs. 1305; 27249 (CAS)  
*Cuminga* cf. *C. lamellosa* Sowerby, loc. 27249 (CAS)  
*Diplodonta subquadrata baltrana* Hertlein, new subspecies, loc. 27249 (CAS)  
*Florimetus cognata* Pilsbry and Vanatta, loc. 27249 (CAS)  
*Glycymeris maculata* Broderip, loc. 27249 (CAS)  
*Megapitaria* cf. *M. aurantiaca* Sowerby, loc. 27249 (CAS)  
*Megapitaria squalida* Sowerby, loc. 31838 (CAS)  
*Modiolus capax* Conrad, loc. 27249 (CAS)  
*Nioche* cf. *N. zorriventis* Olsson, loc. 27249 (CAS)  
*Ostrea megodon* Hanley, loc. 27249 (CAS)  
*Ostrea palmula* Carpenter, loc. 1305 (CAS)  
*Ostrea* species, loc. 27249 (CAS)  
\* *Pecten (Pecten) slevini* Dall and Ochsner, loc. 27249 (CAS)  
*Protothaca (Tropithaca) grata* Say, locs. 27249; 31838 (CAS)  
\* *Protothaca (Tropithaca)* cf. *P. (T.) seymourensis* Dall and Ochsner, loc. 27249 (CAS)  
*Tagelus* cf. *T. dombeii* Lamarck, loc. 27251 (CAS) (cast)  
*Tagelus* species, locs. 27249; 31838 (CAS)

## GASTROPODA

- Acanthina grandis* Gray, loc. 1305 (CAS)  
*Acteocina infrequens* C. B. Adams, loc. 27249 (CAS)  
*Alaba supralirata* Carpenter, loc. 27249 (CAS)  
*Alvania* cf. *A. galapagensis* Bartsch, loc. 27249 (CAS)  
*Alvania* cf. *A. halia* Bartsch, loc. 27249 (CAS)  
*Alvania* cf. *A. hoodensis* Bartsch, loc. 27249 (CAS)  
*Alvania* cf. *A. nemo* Bartsch, loc. 27249 (CAS)  
*Amphithalmus trosti* Strong and Hertlein, loc. 27249 (CAS)  
*Anachis* cf. *A. tabogaensis* Bartsch, loc. 27249 (CAS)  
*Balcis* cf. *B. berryi* Bartsch, loc. 27249 (CAS)  
*Bulla punctulata* A. Adams in Sowerby, locs. 27249; 31838 (CAS)  
*Cancellaria* cf. *C. ovata* Sowerby, loc. 27249 (CAS)  
*Cantharus janellii* Kiener, locs. 1305; 27249 (CAS)  
\* *Cantharus* cf. *C. scissus* Olsson, loc. 27249 (CAS)  
*Cerithiopsis curtata* Bartsch, loc. 27249 (CAS)  
*Cerithiopsis* cf. *C. galapagensis* Bartsch, loc. 27249 (CAS)  
*Cerithium adustum* Kiener, locs. 1305; 27249 (CAS)  
*Cheila equestris* Linnaeus, loc. 27249 (CAS)  
*Conus fergusonii* Sowerby, loc. 27249 (CAS)  
*Conus* cf. *C. lucidus* Wood, loc. 27249 (CAS)

- Cylichna* cf. *C. defuncta* Baker and Hanna, loc. 27249 (CAS)  
*Cymatium lineatum* Broderip, loc. 1305 (CAS)  
*Cypraea nigropunctata* Gray, locs. 1305; 27249 (CAS)  
*Cytharella camarina* Dall, loc. 27249 (CAS)  
*Diodora alta* C. B. Adams, loc. 27249 (CAS)  
*Engina pyrostoma* Sowerby, loc. 27249 (CAS)  
*Erato (Hespererato) marginata galapagensis* Schilder, loc. 27249 (CAS)  
*Eulimostraca* cf. *E. galapagensis* Bartsch, loc. 27249 (CAS)  
*Fissurella* cf. *F. macrotrema* Sowerby, loc. 27249 (CAS)  
*Fissurella virescens* Sowerby, loc. 27249 (CAS)  
*Fusinus dupetitthouarsii* Valenciennes, loc. 27249 (CAS)  
*Gastrocopta munita* Reibisch, loc. 27249 (CAS) [a land snail]  
*Granula* cf. *G. minor* C. B. Adams, loc. 27249 (CAS)  
*Granula* cf. *G. polita* Carpenter, loc. 27249 (CAS)  
*Granula* species, loc. 27249 (CAS)  
*Granulina margaritula* Carpenter, loc. 27249 (CAS)  
*Hipponix pilosus* Deshayes, locs. 1305; 27249 (CAS)  
*Hipponix pilosus* Deshayes, loc. 1305; 27249 (CAS)  
*Iselica* cf. *I. kochi* Strong and Hertlein, loc. 27249 (CAS)  
*Malea ringens* Swainson, loc. 1305 (CAS)  
\* *Mangelia* cf. *M. hancocki* Hertlein and Strong, loc. 27249 (CAS)  
*Mitra gausapata* Reeve, loc. 1305 (CAS)  
*Mitra lens* Mawe, loc. 1305 (CAS)  
*Modulus cerodes* A. Adams, loc. 27249 (CAS)  
*Nassarius nodicinctus* A. Adams, loc. 27249 (CAS)  
\* *Nerita oligopleura* Dall and Ochsner, loc. 27249 (CAS)  
*Odostomia (Meneitho) aequisculpta* Carpenter, loc. 27249 (CAS)  
*Odostomia (Miralda) galapagensis* Dall and Bartsch, loc. 27249 (CAS)  
*Odostomia (Chrysallida) rinella* Dall and Bartsch, loc. 27249 (CAS)  
*Oliva* species, locs. 27249; 31838 (CAS)  
*Pedipes angulatus* C. B. Adams, loc. 27249 (CAS)  
*Persicula imbricata* Hinds, loc. 27249 (CAS)  
*Persicula* cf. *P. phrygia* Dall, loc. 27249 (CAS)  
*Persicula* species, loc. 27249 (CAS)  
*Polinices dubius* Récluz, loc. 27249 (CAS)  
*Polinices uber* Valenciennes, loc. 27249 (CAS)  
*Pyramidella (Triptychus) cf. P. (T.) olssoni* Bartsch, loc. 27249 (CAS)  
*Pyramidella (Voluspa)* species, loc. 27249 (CAS)  
*Pyrene castanea* Sowerby, locs. 1305; 31838 (CAS)  
*Pyrene fuscata* Sowerby, loc. 27249 (CAS)  
*Pyrene haemastoma* Sowerby, loc. 27249 (CAS)  
*Rissoina* cf. *R. firmata* C. B. Adams, loc. 27249 (CAS)  
*Rissoina signae* Bartsch, loc. 27249 (CAS)  
*Strombina gibberula* Sowerby, loc. 27249 (CAS)  
*Tectarius galapagensis* Stearns, loc. 27249 (CAS)  
\* *Tegula forbesi* Dall and Ochsner, loc. 27249 (CAS)  
*Tegula snodgrassi* Pilsbry and Vanatta, locs. 1305; 27249 (CAS)  
*Triphora* cf. *T. galapagensis* Bartsch, loc. 27249 (CAS)  
*Triphora* cf. *T. panamensis* Bartsch, loc. 27249 (CAS)

*Trivia pacifica* Gray, loc. 27249 (CAS)

*Trivia radians* Lamarck, loc. 27249 (CAS)

*Turbo agonistes* Dall and Ochsner, loc. 27249 (CAS)

\* *Turbo vermiculosus* Dall and Ochsner, locs. 27249; 31838 (CAS)

*Turbonilla (Chemnitzia) housei* Dall and Bartsch, loc. 27249 (CAS)

*Turritella broderipiana marmorata* Kiener, loc. 27249 (CAS)

*Vermicularia eburnea* Reeve, loc. 27249 (CAS)

*Volvarina taeniolata* Mörch, loc. 27249 (CAS)

#### REMARKS ON THE AGE AND RELATIONSHIPS OF THE FAUNA

This list contains 102 identified species, 1 coral, 2 echinoids, 26 pelecypods, and 73 gastropods. Of these, 7, and probably 8, are extinct. Twenty-eight species are only provisionally identified but are compared with known species. In addition to the 102 species, 8 forms are identified only as to genus.

The percentage of extinct species in the present faunal assemblage is approximately 7.8 percent. However, a greater number of extinct species evidently occur at the present locality as Dall and Ochsner described additional extinct species from apparently the same locality. They also described a number of extinct species from what they believed to be approximately correlative strata on Santa Cruz (Indefatigable) Island. Dall and Ochsner considered the age of the fauna which they reported from those two islands to be of probable Pliocene age. Five of the eight extinct species in the present faunal list have not been reported from fossil assemblages of Pleistocene age from either Isabela (Albemarle) or from San Salvador (James) Island. Furthermore, the occurrence of the fossils in ashy beds (which in some places are decidedly indurated), interbedded with volcanic flows, lends support to the viewpoint that these beds are of Pliocene rather than of Pleistocene age. McBirney and Williams (1969, p. 19) mentioned two lavas on Baltra Island reported to be 1.47 million years old.

Another factor contributing to the belief that the present fauna is of Pliocene age is the fact that *Anodontia spherica* Dall and Ochsner (reported from strata of Pliocene age in the Galápagos Islands) was reported by Pilsbry and Olsson (1941, p. 57) to occur abundantly and to be a characteristic species of their "Zone H" in strata referred to Pliocene age at Punta Blanca, Ecuador. Ten species in the present faunal list were included among those reported from that locality.

Most of the Recent species in this assemblage are known living in Galápagos waters. Those not known from there are chiefly elements of the Panamic fauna, but further collecting may reveal their presence in the Galápagos Archipelago. A consideration of the habitat of the Recent species in this fauna leads one to infer that the fossil forms lived under conditions similar to those now prevailing in the Galápagos Islands, namely, warm, shallow water.

An interesting occurrence among the fossil forms is that of a land snail, *Gastrocopta munita* Reibisch. This species now lives on Baltra (South Seymour) Island (Hertlein, 1932b, p. 69) as well as on most of the other larger islands in the Archipelago.

## SYSTEMATIC PALEONTOLOGY

### PELECYPODA

#### *Chlamys (Nodipecten) magnifica* Sowerby.

(Figures 5, 15, 25.)

*Pecten magnificus* SOWERBY, variety *a*, Proc. Zool. Soc. London for 1835, p. 109, issued October 9, 1835. "Hab ad Insulas Gallapagos." "A single specimen of var. *a* was found in a coral sand at a depth of six fathoms." SOWERBY, Thes. Conch., vol. 1, p. 65, pl. 15 (*Pecten*, pl. 5), fig. 114, 1842. "East Columbia." [lapsus calami for West "Columbia." Locality doubtful.] REEVE, Conch. Icon., vol. 8, *Pecten*, species 9, pl. 2, fig. 9, 1852. "Isle of Plata, West Columbia (in coral sand at a depth of from six to seventeen fathoms); Cuming." [Locality doubtful.] KOBELT, Syst. Conch.—Cab. von Martini und Chemnitz, *Spondylus* und *Pecten*, Bd. 7, Abt. 2, p. 164, pl. 46, fig. 1, 1888. (Description and illustration from Reeve.)

*Pecten (Lyropecten) magnificus* Sowerby, GRANT and GALE, Mem. San Diego Soc. Nat. Hist., vol. 1, p. 182, pl. 9, fig. 1; pl. 10, fig. 6, 1931. Galápagos Islands.

*Nodipecten magnificus* Sowerby, GRAU, Allan Hancock Pac. Exped., vol. 23, p. 132, pl. 44, 1959. "Galápagos Islands. (Ecuador doubtful.)"

*Lyropecten (Nodipecten) magnificus* Sowerby, OLSSON, Mollusks of the Tropical Eastern Pacific (Paleo. Res. Inst.: Ithaca, New York), p. 161, pl. 22, fig. 1, 1961. (Illustration from Reeve, 1852).

Two left valves, one nearly complete, the other only one half of a valve were collected at locality 27249 (CAS). The larger specimen is 126 mm. long and 122.3 mm. high. There are 13 or 14 radial ribs. The entire valve is covered with radial striae of which about 5 or 6 occur in each interspace. The ribs are decidedly nodose. The nodes are hollow and develop in the areas of "ledges" (Moore, 1934, p. 216) between concentric constrictions of the valve. The nodosity on the east American species, *Chlamys (Nodipecten) nodosa* Linnaeus, increases from north to south in its range into warmer waters.

A small left valve of *C. magnifica* 49 mm. high, was reported by Hertlein and Strong (1939, p. 369) from a raised beach on San Salvador (James) Island.

Two Recent right valves in the collections of the California Academy of Sciences, the larger one 127 mm. high, were collected by Ochsner on the beach at Baltra (South Seymour) Island. These are devoid of nodes. The color is bright red.

One right valve 59.8 mm. long and 60 mm. high, in the Academy's collection, received from Jacqueline De Roy, was dredged in 9 to 18 meters (5 to 10 fathoms) off Santa Fé (Barrington) Island.

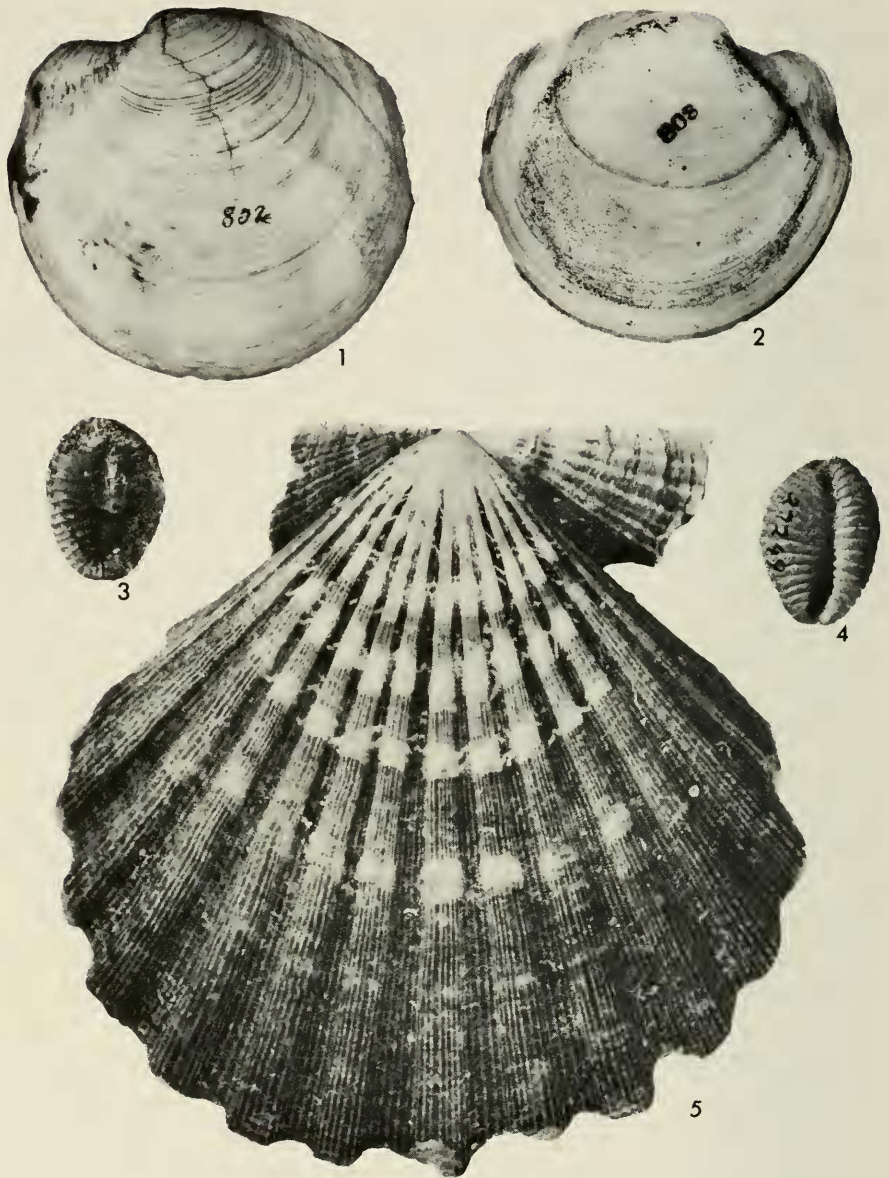


FIGURE 1. *Anodontia spherica* Dall and Ochsner. Hypotype, left valve, no. 13653 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 802 (CAS), about  $1\frac{1}{4}$  miles northeast of the settlement of Vilamil, Isabela (Albemarle) Island, Galápagos Islands, elevated beach deposit, about 12 meters (40 feet) above sea level. Pleistocene. Length 65 mm. FIGURE 2. *Anodontia spherica* Dall and Ochsner. Hypotype, right valve, no. 13654 (Calif Acad. Sci. Dept. Geol. Type Coll.), from locality 803 (CAS), from virtually the same locality as the



**Anodontia spherica** Dall and Ochsner.

(Figures 1, 2, 6, 7.)

*Lucina spherica* DALL AND OCHSNER, Proc. Calif. Acad. Sci., Fourth Ser., vol. 17, no. 4, p. 121, pl. 3, fig. 8; pl. 4, figs. 2, 7, June 22, 1928; "from upper horizon (zone D) on east shore of Indefatigable Island, Galapagos Group. Probably Pliocene."

*Loripinus (Pegophysema) spherica* Dall and Ochsner, PILSBRY AND OLSSON, Proc. Acad. Nat. Sci. Philadelphia, vol. 93, p. 57, 1941. Pliocene of Punta Blanca, Ecuador.

*Anodontia (Lissosphaira) spherica* Dall and Ochsner, OLSSON, Mollusks of the tropical eastern Pacific (Paleo. Research Inst.: Ithaca, New York), p. 222, pl. 30, fig. 2, 1961. (Figured specimen from Cabo Blanca, Ecuador, Pliocene. Reported as Recent from "Lower California to Ecuador. Columbia: Isla del Gallo.") Also earlier records.

Specimens assigned to this species in the present collection [locs. 1305 and 27251 (CAS)] are casts. Olsson reported this species living from Baja California to Ecuador but it has not been reported from the Panamic Province by other authors. I have not seen Recent specimens.

The deeply depressed posterior dorsal area on *Anodontia spherica* easily serves to separate it from *A. edentuloides* from the Gulf of California. The presence of well differentiated, deeply impressed, dorsal areas was the basis for the proposal of the subgenus *Lissosphaira* Olsson.

Large specimens of *A. spherica* are 74 mm. long. Berry (1968, p. 71) mentioned specimens of *A. edentuloides* which are 75 mm. long.

Marks (1951, pp. 67-70), discussed the shell characters of *Anodontia* and *Pegophysema*, and some of the species referred to those groups. Apparently, the species cited by Marks (p. 69) as "*C. densata*" Dall and Ochsner is referable to *A. spherica*.

A large globose species, 82 mm. long, *Anodota sphericula* Basedow, was reported by Ludbrook (1959, p. 227, pl. 3, figs. 1, 2, 3; pl. 5, figs. 1, 4) from strata of Pliocene age in Australia. The posterior dorsal portion of the shell of that species lacks a depressed area: it is a typical *Anodontia* believed to be related to *A. philippiana* Reeve in the western Pacific.

**Diplodonta subquadrata baltrana** Hertlein, new subspecies.

(Figures 8 and 11.)

DESCRIPTION. Shell subquadrate, somewhat anteriorly attenuated, thin, beaks very low, anterior dorsal margin only slightly sloping; sculptured only

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specimen shown in figure 1. Length 58 mm. FIGURE 3. *Trivia radians* Lamarck. Hypotype no. 13668 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Length 18 mm. FIGURE 4. *Trivia radians* Lamarck. Ventral view of the specimen shown in figure 3. FIGURE 5. *Chlamys (Nodipecten) magnifica* Sowerby. Hypotype, right valve, no. 13652 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 23167 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Recent. W. H. Ochsner Collector. Height 85 mm.

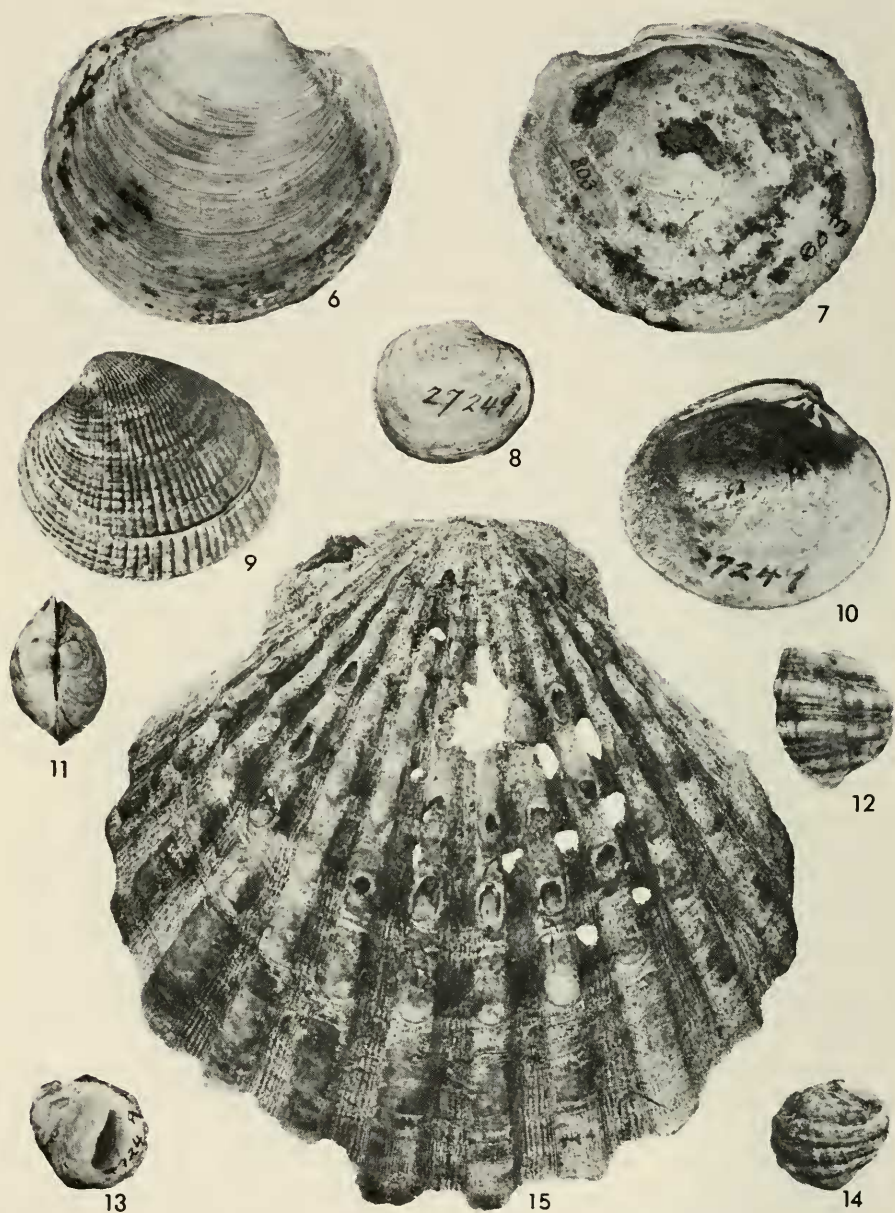


FIGURE 6. *Anodontia spherica* Dall and Ochsner. Hypotype, right valve, no 13655 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 803 (CAS), about  $1\frac{1}{4}$  miles northeast of the settlement of Vilamil, Isabela (Albemarle) Island, Galápagos Islands, elevated beach deposit, about 12 meters (40 feet) above sea level. Pleistocene. Length 54.5 mm. FIGURE 7. *Anodontia spherica* Dall and Ochsner. View of the interior of the specimen shown in figure

with fine concentric lines of growth. Dimensions: length 22.6 mm., height 20 mm., convexity (both valves) 14.6 mm.

Holotype, no. 13656, and paratype, a left valve, no. 13657 (California Academy of Sciences Department of Geology Type Collection), from locality 27249 (CAS), white and yellowish tuffaceous strata interbedded with lava, on the south side of the bay on the west side of Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. L. G. Hertlein, collector.

COMMENTS. Specimens of this new subspecies, in general features, resemble fossil forms of *Diplodonta subquadrata* Carpenter (see illustrations by Durham, 1950, pl. 19, figures 4, 4a, 1950) from Santa Inez Bay, Baja California, Mexico. The present fossils from Baltra Island differ from Carpenter's species in the narrower, somewhat attenuated anterior end and in the more nearly horizontal anterior dorsal margin. The general shape of the type specimen of the new subspecies resembles that of the Recent specimen of *D. subquadrata* from the Galápagos Islands illustrated by Hertlein and Strong (1947, plate 1, figure 11), more than it does that of the fossils illustrated by Durham.

The paratype, 21.2 mm. long, is less attenuated anteriorly than the holotype. An imperfectly preserved right valve also was collected at the type locality.

### **Protothaca (Tropithaca) cf. P. (T.) seymourensis** Dall and Ochsner.

(Figures 38, 39.)

Twenty-one single valves of a venerid varying from 11 mm. to 39.4 mm. in length are present in the collection from locality 27249 (CAS), Baltra (South Seymour) Island. These vary greatly in shape and sculpture.

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6. FIGURE 8. *Diplodonta subquadrata baltrana* Hertlein, new subspecies. Holotype no. 13656 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Length 22.5 mm. FIGURE 9. *Nioche* cf. *N. zorritensis* Olsson. Hypotype, left valve, no. 13658 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Length 39.5 mm. FIGURE 10. *Nioche* cf. *N. zorritensis* Olsson. View of the interior of the specimen shown in figure 9. FIGURE 11. *Diplodonta subquadrata baltrana* Hertlein, new subspecies. Dorsal view of the specimen shown in figure 8. FIGURE 12. *Nerita oligopleura* Dall and Ochsner. Hypotype no. 13666 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 14.5 mm. View showing fine threadlets between major concentric cords. FIGURE 13. *Nerita oligopleura* Dall and Ochsner. Hypotype no. 13667 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from the same locality as the specimen illustrated in figure 12. Apertural view. Height 17.5 mm. FIGURE 14. *Nerita oligopleura* Dall and Ochsner. Dorsal view of the specimen shown in figure 13. FIGURE 15. *Chlamys (Nodipecten) magnifica* Sowerby. Hypotype, left valve, no. 13676 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 128 mm.

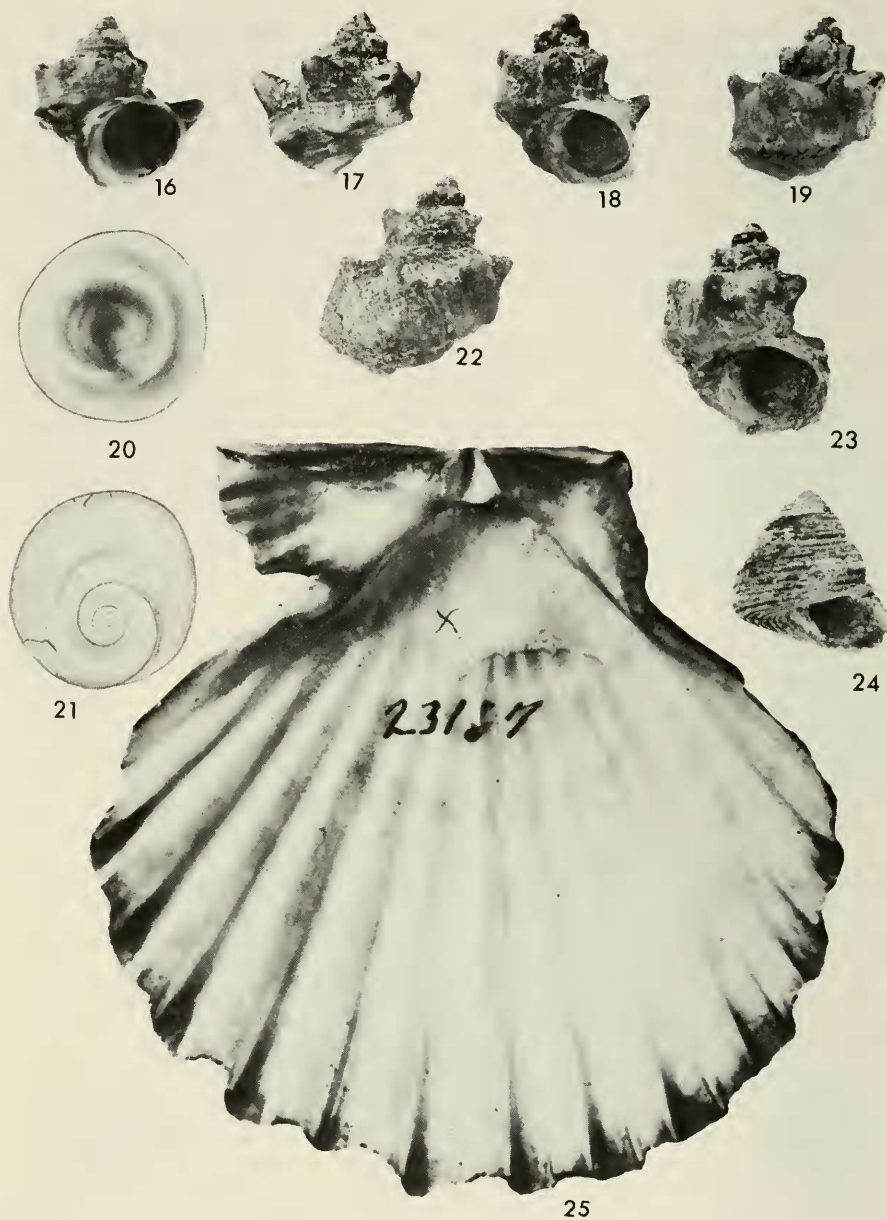


FIGURE 16. *Turbo agonistes* Dall and Ochsner. Hypotype no. 13671 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 38977 (CAS), Baranco, Punta Nuñez, Santa Cruz (Indefatigable) Island, Galápagos Islands. Recent. Jacqueline DeRoy collector. Height 21 mm. FIGURE 17. *Turbo agonistes* Dall and Ochsner. Dorsal view of the specimens shown in figure 16. FIGURE 18. *Turbo agonistes* Dall and Ochsner. Hypotype no. 13672 (Calif.

One small specimen in the present series is quite similar in outline and sculpture to the early stage of growth of the type specimen of *Chione seymourensis* Dall and Ochsner from the same area.

The type specimen of *Chione seymourensis* Dall and Ochsner (1928, p. 123, pl. 3, figs. 1 and 5) was described "from upper horizon, Seymour Island, Galapagos Group. Probably Pliocene." It is a right valve, ovately rectangular in outline (see figs. 36, 37), lacks an escutcheon, and the radial sculpture is somewhat reduced in strength as a result of erosion. Dall and Ochsner mentioned a similarity between their species and *Chione pertincta* Dall, a Recent species living in the Galápagos Islands. Compared with *C. pertincta*, the type specimen of *C. seymourensis* is in general, more elongated, thinner, and it has finer radial sculpture.

Compared with *Protothaca grata* Say, the type specimen of *C. seymourensis* is more elongate in outline, the radial sculpture is coarser, the lunule is narrower, and the median cardinal tooth in the right valve is larger.

The variation in shape and sculpture in the present series of specimens is similar to that in a series of Recent specimens of *Protothaca grata* Say (the type species of the subgenus *Tropithaca* Olsson), and most of them are here referred to Say's species.

#### GASTROPODA

##### **Tegula forbesi** Dall and Ochsner.

(Figures 24, 29.)

*Tegula forbesi* DALL AND OCHSNER, Proc. Calif. Acad. Sci., Fourth Ser., vol. 17, no. 4, p. 116, pl. 2, fig. 13, June 22, 1928; "from upper horizon on Seymour Island, Galapagos Group. Probably Pliocene."

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Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 28.5 mm. FIGURE 19. *Turbo agonistes* Dall and Ochsner. Dorsal view of the specimen shown in figure 18. FIGURE 20. *Turbo agonistes* Dall and Ochsner. View of the exterior of the operculum of the specimen shown in figures 16 and 17. FIGURE 21. *Turbo agonistes* Dall and Ochsner. View of the interior side of the operculum shown in figure 20. FIGURE 22. *Turbo agonistes* Dall and Ochsner. Hypotype no. 13673 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from the same locality as the specimen shown in Figures 18 and 19. Height 33 mm. Dorsal view of an unusually large specimen. FIGURE 23. *Turbo agonistes* Dall and Ochsner. Apertural view of the specimen shown in figure 22. FIGURE 24. *Tegula forbesi* Dall and Ochsner. Hypotype no. 13660 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Galápagos Islands. Late Pliocene. Height 26 mm. FIGURE 25. *Chlamys (Nodipecten) magnifica* Sowerby. Hypotype no. 13652 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 23167 (CAS), Baltra (South Seymour) Island, Galápagos Islands. W. H. Ochsner Collector. Recent. Height 85 mm. View of the interior of the specimen shown in figure 5.

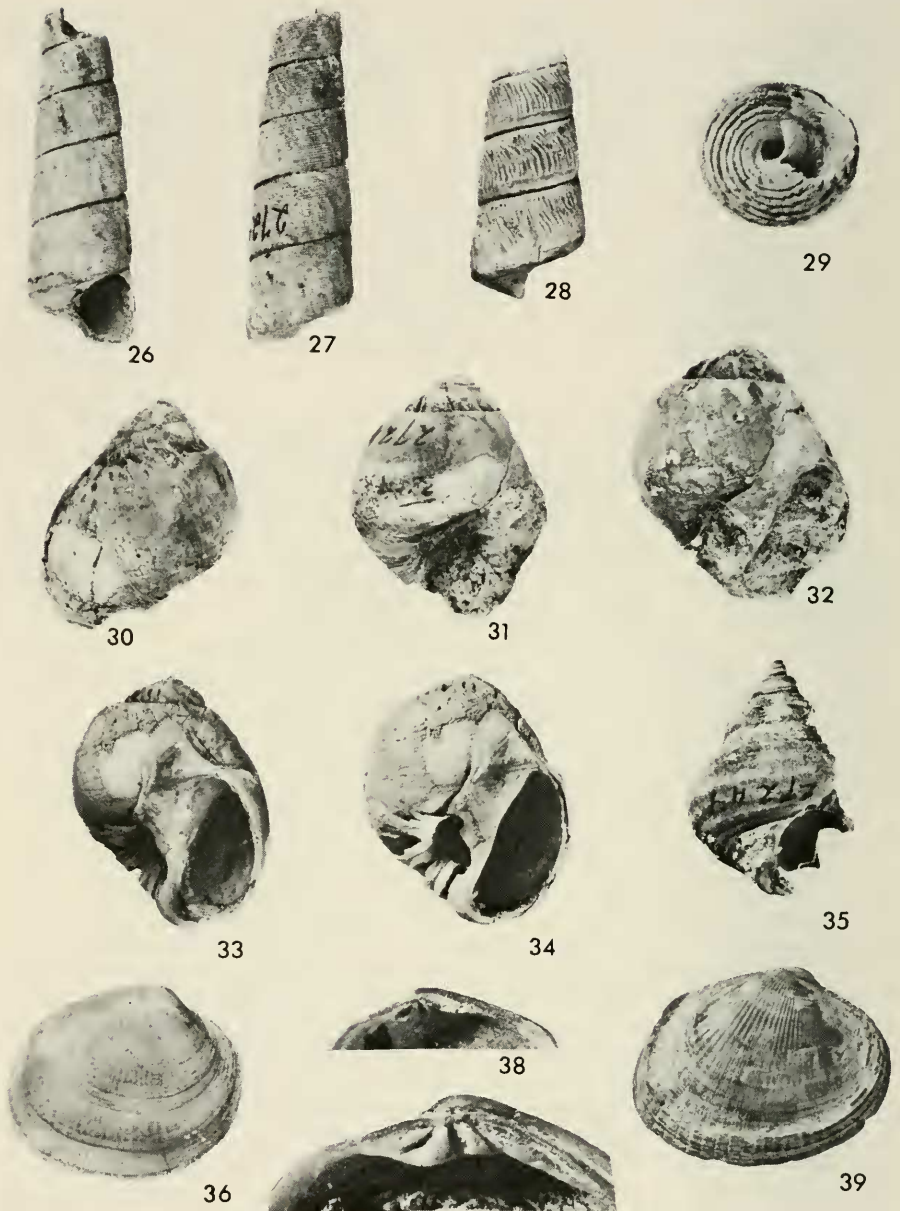


FIGURE 26. *Turritella broderipiana marmorata* Kiener. Hypotype no. 13669 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height (incomplete) 53 mm. FIGURE 27. *Turritella broderipiana marmorata* Kiener. Dorsal view of the specimen shown in figure 26. FIGURE 28. *Turritella broderipiana marmorata* Kiener. Hypotype no. 13670 (Calif. Acad. Sci. Dept.

A few specimens of this species were collected at locality 27249 (CAS). The largest specimen is about 31 mm. in height, the last whorl is 48 mm. in maximum width. The concentric sculpture is much finer than that of *Tegula aureotincta* Forbes from California. This sculpture is more pronounced and regular on the upper surface of the whorls, and on the base much coarser, than that on specimens of *T. rugosa* A. Adams from the Gulf of California.

### **Turbo agonistes** Dall and Ochsner.

(Figures 16, 17, 18, 19, 20, 21, 22, 23.)

*Turbo agonistes* DALL AND OCHSNER, Proc. Calif. Acad. Sci., Fourth Ser., vol. 17, no. 4, p. 115, pl. 2, figs. 12, 16, June 22, 1928; "on east shore of Indefatigable Island, Galapagos Group. Probably Pliocene."

A number of fossil specimens of this species were collected at locality 27249 (CAS). The shell of this species is quite different from any other described form.

Recently this species was found living in Galápagos waters. Four specimens from off Santa Cruz (Indefatigable) Island collected by Jacqueline De Roy; and one taken by Carmen Angermeyer 1½ miles west of Baltra (South Seymour) Island, were presented to the Academy. Recent shells are attractively colored, purplish on the base of the body whorl and orange or greenish above.

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Geol. Type Coll.), from the same locality as the specimen shown in figures 26 and 27. Height (incomplete) 40 mm. FIGURE 29. *Tegula forbesi* Dall and Ochsner. Hypotype no. 13660 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Width 24 mm. Basal view of the specimen shown in figure 24. FIGURE 30. *Polinices dubius* Récluz. Hypotype no. 13662 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 37.5 mm. FIGURE 31. *Polinices dubius* Récluz. Apertural view of the specimen shown in figure 30. FIGURE 32. *Polinices dubius* Récluz. Hypotype no. 13663 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 804 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 40.5 mm. FIGURE 33. *Polinices dubius* Récluz. Hypotype no. 13664 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from the same locality as the specimen shown in figure 32. Height 39.4 mm. Apertural view. FIGURE 34. *Polinices dubius* Récluz. Apertural view of the specimen shown in figure 33, showing notch in callus of inner lip. FIGURE 35. *Turbo vermiculosus* Dall and Ochsner. Hypotype no. 13661 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Height 34.6 mm. FIGURE 36. *Chione seymourensis* Dall and Ochsner. Holotype, right valve, no. 2970 (Calif. Acad. Sci. Dept. Geol. Type Coll.), "from upper horizon, Seymour Island, Galapagos Group Probably Pliocene." Length 34 mm. FIGURE 37. *Chione seymourensis* Dall and Ochsner. View of the hinge of the specimen shown in figure 36. FIGURE 38. *Protothaca (Tropithaca)* cf. *P. (T.) seymourensis* Dall and Ochsner. Hypotype, right valve, no. 13659 (Calif. Acad. Sci. Dept. Geol. Type Coll.), from locality 27249 (CAS), Baltra (South Seymour) Island, Galápagos Islands. Late Pliocene. Length 21 mm. FIGURE 39. *Protothaca (Tropithaca)* cf. *P. (T.) seymourensis* Dall and Ochsner. View of the hinge of the specimen shown in figure 38.

**Turbo vermiculosus** Dall and Ochsner.

(Figure 35.)

*Turbo vermiculosus* DALL AND OCHSNER, Proc. Calif. Acad. Sci., Fourth Ser., vol. 17, no. 4, p. 115, pl. 2, fig. 15, June 22, 1928; "from upper horizon, Seymour Island, Galapagos Group. Probably Pliocene."

Three specimens of this species, none perfectly preserved, are present from locality 27249 (CAS), Baltra (South Seymour) Island. The largest specimen (figure 35) is 34.8 mm. high, the maximum diameter 23 mm.

This species has an unusually high spire for the genus. The surface microsculpture "minutely vermiculately granulate and punctate," as mentioned by Dall and Ochsner, is quite different from any described species of *Turbo* from the western Americas.

The shape and sculpture of the present species somewhat resemble that of *Turbo caboblanquensis* Weisbord (1962, p. 84, pl. 6, figs. 4, 5) described from strata of Pliocene age in Venezuela but the shell of that species is umbilicate.

**Polinices dubius** Récluz.

(Figures 30, 31, 32, 33, 34.)

*Natica dubia* RÉCLUZ, Proc. Zool. Soc. London for 1843, p. 209, issued June, 1844 "Hab. Chile? H. Cuming." SOWERBY, Thes. Conch., vol. 5, p. 86, pl. 458 (*Natica*, pl. 5), fig. 56, 1883. "Chili." REEVE, Conch. Icon., vol. 9, *Natica*, species 41, pl. 10, figs. 41a, 41b, 1855. "Hab. Chili?" TRYON, Man. Conch., vol. 8, p. 47, pl. 16, fig. 50, 1886. "Chili, Peru." *Polinices dubia* Récluz, STEARNS, Proc. U. S. Nat. Mus., vol. 16, no. 942, pp. 401, 446, 1893. "Indefatigable Island."

One fairly well preserved specimen and four rather imperfect ones were collected at locality 27249 (CAS). These specimens agree exactly with the specimens identified by Dall and Ochsner under the name "*Neverita cf. reclusiana* Deshayes" (see figs. 32, 33, 34), from locality 804 (CAS). That locality is approximately equivalent to locality 27249 (CAS).

One of the specimens from locality 804 (CAS) retains most of the umbilical pad. The shape of the shell as well as the details of the callus agree closely with illustrations of *Polinices dubius*, a species reported by Stearns from the Recent fauna of the Galápagos Islands. Ranson (1959, p. 68) reported this species from an elevated beach at Guadalupito, Peru.

The general shape of the Galápagos fossils is similar to that of the fossil species described as "*Natica solida*" by Sowerby (1846, p. 255; see ed. 3, 1896, p. 612, pl. 3, figs. 40, 41.) from "Navidad, Chile; Santa Cruz, Patagonia?" [Miocene: Herm, 1969, p. 87] but the callus on the Galápagos species is much more extensive and with an indentation on the umbilical margin. Sowerby's species was renamed *Natica darwini* by Hutton (1886a, p. 334; see also 1886b, p. 214) because of an earlier usage of the name *Natica solida* by Blainville (1825, p. 251).



***Nerita oligopleura* Dall and Ochsner.**

(Figures 12, 13, 14.)

*Nerita oligopleura* DALL AND OCHSNER, Proc. Calif. Acad. Sci., Fourth Ser., vol. 17, no. 4, p. 114, pl. 2, fig. 11; pl. 6, fig. 15, June 22; "upper horizon, Seymour Island, Galapagos Group. Probably Pliocene."

About 30 specimens of this species were collected at locality 27249 (CAS). The smallest one is 6 mm. high, the largest one 20.5 mm. high and 21 mm. wide.

There are four coarse spiral ridges on the shell and, on well preserved specimens, two small spiral threads are visible in the interspaces between the ribs.

The shell of this species is quite different from any described west American species, as pointed out by Dall and Ochsner. The Galápagos fossil species bears a general resemblance to *Nerita asperata* Dujardin from the Helvetian, Middle Miocene, of France, illustrated by Cossmann and Peyrot (1917, pl. 7, figures 83, 84). However, close relationship with that species is not postulated.

***Turritella broderipiana marmorata* Kiener.**

(Figures 26, 27, 28.)

*Turritella marmorata* KIENER, Spéc. Gén. et Icon. Coq. Viv., Famille Turbinacées, *Turritella*, p. 23, pl. 8, fig. 1 (two figs.), 1843-1844. "Habite."

Over a dozen specimens of a *Turritella*, mostly incomplete, were collected at locality 27249 (CAS). These agree closely with Kiener's illustrations of *Turritella marmorata*.

Kiener's figures depict a rather slender, elongated shell, the whorls nearly flat-sided, sculptured with fine, concentric threads, cream-colored with narrow wavy longitudinal brownish-violet lines or flecks.

Reeve (1849, species 6, plate 2, figures 6a, 6b) placed *T. marmorata* in the synonymy of *T. broderipiana* under which name two figures were shown. One (6a) represents a shell with fairly wide whorls, somewhat wider posteriorly below the suture, resulting in a slightly sinuous outline of the outer lip of the last whorl. The form shown in this illustration is similar to *T. gonostoma* Valenciennes. The other figure (6b) represents a slender, elongated shell with nearly flat-sided whorls comparable to Kiener's illustrations of *T. marmorata*.

*Turritella broderipiana* d'Orbigny (1840, p. 388), was originally described but not illustrated from "les environs de Payta, où elle a été pêchée sur les fonds de sable." The type specimen illustrated by Keen (1966, p. 3, pl. 1, fig. 21) reveals a slender, elongated shell with slightly concave whorls. Earlier, Keen (1958, p. 290) considered *T. marmorata* to be a variant of the extremely variable *T. gonostoma* Valenciennes (1832, p. 275; Kiener, 1843-1844, pp. 21-22, pl. 10, fig. 1). That species was originally described but not illustrated from "Habitat ad oras Americae australis in portum Acapulco Mexicanorum." The posterior portion of the whorls on *T. gonostoma* is often the widest; the color

of rather dense gray-black mottled markings in contrast to the much narrower flammules of *T. broderipiana* and *T. b. marmorata*.

A Recent specimen in the collections of the California Academy of Sciences, closely resembling Kiener's illustrations of *T. marmorata*, collected by D. L. Frizzell at Cabo Blanco, Peru, is 116 mm. long (incomplete), the body whorl 22.9 mm. in diameter. Other specimens collected at the same locality and at Paita Bay, and at the mouth of the Brazos River at San Ramon south of Sechura, Peru, have similar color markings but the shells are much less tapering with correspondingly wider apical angle. One such shell collected by J. G. Marks at San Pedro, Ecuador, is 133 mm. long (incomplete), the diameter of the last whorl 38 mm. Evidently the slender and the broad shells either represent elements of a very variable series, or two distinct forms are living in the region of Ecuador and Peru.

The fossils from the Galápagos Islands closely resemble the slender form with flat-sided whorls shown in Kiener's illustrations of *T. marmorata*. In this character they differ from the type specimen of *T. broderipiana* (with slightly concave whorls) shown in Keen's (1966) illustration. On that basis, in the present paper, the form described by Kiener is treated as a subspecies of *T. broderipiana*.

Pilsbry and Olsson (1941, p. 43) mentioned that *Turritella alturana* Spieker, described from strata of Miocene age in Peru is "so close to the recent species [*T. broderipiana*] that they cannot be consistently separated."

The subgenus *Broderiptella* Olsson was proposed to include the *T. broderipiana* group represented in the northern South American region at least since middle Miocene time. This group of turritellas was discussed by Merriam (1941, pp. 50-51) and by Woodring (1957, pp. 110-112).

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