

Some Western American
Cenozoic Gastropods
of the Genus *Nassarius*

GEOLOGICAL SURVEY PROFESSIONAL PAPER 503-B



Some Western American Cenozoic Gastropods of the Genus *Nassarius*

By W. O. ADDICOTT

CONTRIBUTIONS TO PALEONTOLOGY

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Pacific coast nassariids, useful in biostratigraphic correlation of upper Cenozoic formations, are reviewed and classified subgenerically. One new subgenus is described, and one is newly named



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CONTRIBUTIONS TO PALEONTOLOGY

SOME WESTERN AMERICAN CENOZOIC GASTROPODS OF THE GENUS *NASSARIUS*

By W. O. ADDICOTT

ABSTRACT

The gastropod genus *Nassarius*, characteristic of late Cenozoic molluscan faunas of the Pacific Coast States, is among the most useful molluscan taxa for stratigraphic correlation of marine Tertiary and Quaternary formations of western North America. It first appeared in California during the early Miocene and by middle Miocene time had diversified into at least three supraspecific groups, defined on apertural morphology. These groups, which have continued into Recent time as the principal nassariid subgenera in the northeastern Pacific Ocean, are: *Demondia*, new name for *Schizopyga* Conrad, 1856 (not Gravenhorst, 1829) (type: *Schizopyga californiana* Conrad); *Caesia* (type: *Nassa perpinguis* Hinds); and *Catilon*, new subgenus (type: *Nassa arnoldi* Anderson).

Demondia, the smallest of the three subgenera, is first represented in strata of middle Miocene age by *Nassarius lincolnensis* from the Astoria Formation of coastal Oregon and Washington. Other taxa referable to this subgenus are: *californianus*, *mendicus*, *mendicus* forma *cooperi*, and *mendicus* forma *indisputabilis*.

Taxa included in the subgenus *Caesia* are: *whitneyi*, *grammatus*, *grammatus* n. subsp.?, *coalingensis*, *perpinguis*, *moranianus*, *delosi*, *fossatus*, *cerritensis*, and *rhinetes*. An evolutionary sequence useful in stratigraphic correlation in California is formed by the species *whitneyi*, *grammatus*, and *moranianus*. *Nassarius whitneyi* ranges from middle to late Miocene. *N. grammatus* (Dall, 1917), a poorly known species long treated as a synonym of *N. moranianus* (Martin, 1914), is characteristic of Pliocene formations. It can be distinguished from the descendent late Pliocene to early Pleistocene species, *N. moranianus*, by its nonangulated, uniformly sculptured body whorl. The modern species representing this lineage, *N. fossatus*, first appears in beds of early Pleistocene age.

Fossil species included in the subgenus *Catilon* are: *churchi*, *arnoldi*, *smooti*, *antiselli*, *andersoni*, *pabloensis*, *stocki*, *hamlini*, *salinasensis*, *iniquus*, and *hildegardae*. The subgenus first appears in beds of early Miocene age in California. It becomes locally extinct after the Pliocene but is well represented in the modern Panamic molluscan province of the tropical eastern Pacific Ocean.

Nassarius ocoyanus, a middle Miocene species not referable to any of the preceding subgenera, is tentatively placed in a fourth, unnamed subgenus.

INTRODUCTION

A review of some fossil species of *Nassarius* from the Pacific coast was undertaken as an adjunct to the identification and biostratigraphic classification of Pliocene

molluscan assemblages from central California. Two nassariids that characterize many of these assemblages, *N. californianus* (Conrad) and *N. grammatus* (Dall), appeared to be diagnostic of Pliocene strata. Yet their actual stratigraphic ranges were obscured because of the identification of the species under other names and the use of *N. californianus* for a number of Pliocene to Recent nassariids belonging to three subgenera. At one time *N. grammatus* was commonly identified as *N. californianus*, and *N. californianus* presumably was identified as the Pleistocene to Recent species *N. mendicus*. A systematic review of these and related species became requisite to determining their actual stratigraphic distribution. As a result, perhaps half of the named fossil species of *Nassarius* were studied and compared with these species. The resulting compilation emphasized the potential usefulness of nassariids in stratigraphic correlation of upper Cenozoic strata and thereby prompted expansion of the study to a general review of the known fossil western American species.

In terms of their known stratigraphic distribution and an apparent evolutionary sequence within one subgenus, the fossil nassariids can be ranked with the pectinids and turritellas as one of the more useful molluscan genera in correlation of upper Cenozoic strata of the Pacific coast. The genus first appeared in southern California during the early Miocene and by middle Miocene time had diversified into several species of restricted stratigraphic distribution. The stratigraphic utility of many of the nassariids is favored by their intricate sculpture, which permits an unusual degree of refinement in species recognition. Most species also are sufficiently numerous, in at least a few collections, to give a reasonably good idea of the amount of individual variation.

With but one exception—an unusual species from the middle Miocene of California, *Nassarius ocoyanus* (Anderson and Martin)—the known fossil nassariids from the Pacific coast can be classified in three taxonomic units. These taxa, defined wholly on apertural

morphology, are recognized under the following sub-generic names: *Demondia*, new name, *Caesia* Adams, and *Catilon*, new subgenus.

Stratigraphic allocation of collections in which nassariids occur is based primarily upon the Pacific coast provincial metazoan chronology of Weaver and others (1944). Use of the epoch names Miocene, Pliocene, and Pleistocene, and subdivisions thereof, is made in a provincial sense, with explicit reference to the Weaver chart as modified by Durham (1954, p. 24). Although nowhere defined in detail, the early and middle Miocene molluscan stages of this scheme are based, in large part, on biostratigraphic data compiled by Loel and Corey (1932) and, in particular, on the biozones of certain pectinids and turritellas. The biostratigraphic data of Clark (1915), Nomland (1917b), and Weaver (1949) form a composite basis for recognition of a generalized upper Miocene stage. Subdivisions of this upper Miocene stage have been made upon the basis of clypeasteroid echinoids, including *Astrodapsis*, but the subdivisions cannot be recognized, at least at present, on the basis of late Miocene mollusks. The data of Nomland (1917a) and of Woodring and others (1940) form the primary basis for correlation of deposits of Pliocene age in California. Although superpositional control for these stages is not nearly as objective as for the Pacific coast foraminiferal sequence and although the stages have nowhere been formally defined as time-stratigraphic units, their intrinsic value in correlation and classification of shallow marine strata of the Pacific coast is manifested by their generally successful use over the years and by their agreement with the chronologies based upon other fossil groups. The standard of reference generally used for the Pleistocene of the Pacific coast is the Los Angeles Basin section at San Pedro, most recently studied by Woodring and others (1946). Although the relationship of this section to the Pliocene section of the San Joaquin Valley is speculative, there is sufficient evidence for recognizing provincial molluscan faunas of each epoch (Woodring, 1952). The requirement of superpositional control could perhaps be satisfied by a thorough biostratigraphic study of the Pliocene and Pleistocene mollusks of the western Ventura basin.

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and making available several specimens for figure illustrations. L. G. Hertlein and A. M. Keen kindly provided access to the collections of the California Academy of Sciences and Stanford University, respectively. W. P. Popenoe, of the University of California, Los Angeles, and G. P. Kanakoff, of the Los Angeles County Museum, furnished specimens of *Nassarius* for figure illustrations. George Hughes, of the University of California, Santa Barbara, loaned specimens from his collections from the Santa Barbara Formation. J. A. McLean loaned negatives of photographs of some Recent nassariids, and these negatives have been used in the preparation of this paper. All the fossil specimens were photographed by Kenji Sakamoto, of the U.S. Geological Survey.

SYSTEMATIC PALEONTOLOGY

With few exceptions the Tertiary and Quaternary species of *Nassarius* from the Pacific coast of the United States can be placed in three distinctive supraspecific groups on the basis of apertural characteristics. These groups are treated as subgenera in the following discussion.

All the exclusively fossil species of *Nassarius* from upper Cenozoic strata of the Pacific coast of the United States are treated systematically in the following section. Most of the living western American species that also are known from the fossil record are figured and discussed briefly. The Recent nassariids of the Pacific coast of North America have been figured and reviewed by Demond (1952). Most synonymies herein are limited to citations accompanied by figured specimens.

References to institutions at which type material or important collections are housed are abbreviated as follows:

- CAS—California Academy of Sciences, San Francisco, Calif.
- LACMIP—Los Angeles County Museum, Los Angeles, Calif.
- SDSNH—San Diego Society of Natural History, San Diego, Calif.
- SU—Stanford University, Stanford, Calif.
- UCLA—University of California, Los Angeles, Calif.
- UCMP—University of California Museum of Paleontology, Berkeley, Calif.
- USGS—U.S. Geological Survey, Washington, D.C.
- USGS M—U.S. Geological Survey, Menlo Park, Calif. (coll. and loc. data).
- USNM—U.S. National Museum, Washington, D.C.
- UW—University of Washington, Seattle, Wash.

An age designation accompanying a locality description or plate explanation refers to the rocks at the specified locality and not necessarily to the formation in its entirety.

Class **GASTROPODA**
Order **NEOGASTROPODA**
Family **NASSARIIDAE**

Genus **NASSARIUS** Duméril

Nassarius Duméril, 1806, Zoologie Analytique, p. 166 [new name for *Nassa* Lamarck (1799), not Bolten (1798)].

Type (of *Nassa* Lamarck, by monotypy).—*Buccinum mutabile* Linné. Recent, Mediterranean.

Key to some fossil western American subgenera of Nassarius

1. Outer lip of aperture thickened externally by a varix..... 2
Outer lip not varicose..... 3
2. Body whorl has narrow incised basal fossa; whorl profile rounded; sculpture cancellate or papillose..... *Catilon*
Body whorl has broad, nearly obsolete basal fossa; whorl profile turreted; sculpture obsolete on body whorl Subgenus?
3. Apertural callus narrow, parietal border sharply defined. Callus has a single posterior tooth and one or two anterior denticles..... *Demondia*
Apertural callus spreading outward onto parietal wall, parietal border not sharply defined. Callus has many irregular spiral plaits..... *Caesia*

Subgenus **DEMONDIA** Addicott, n. name

Type (of *Schizopyga* Conrad, 1856, not Gravenhorst, 1829, by monotypy).—*Schizopyga californiana* Conrad. Pliocene, western Santa Clara County, Calif.

This taxon is characterized by a rather small, slender shell that shows reticulate or papillose sculpture and has a subcircular aperture. The inner margin of the aperture is bordered by a narrow, well-defined callus. There is a prominent parietal tooth near the posterior edge of the callus and, on some species, one or two denticles just above the anterior margin. The outer lip is thin but generally denticulate and slightly thickened within.

Western American species of *Demondia* include *Nassarius lincolnensis* (Anderson and Martin), a middle Miocene species from Oregon (pl. 1, figs. 20–22); *californianus* (Conrad) from the Pliocene of California (pl. 1, figs. 1–10, 31); *N. mendicus* (Gould) (pl. 1, figs. 14–16) and *N. mendicus* forma *cooperi* (Forbes) (pl. 1, figs. 17–19), living taxa which appear in the late Pliocene of Southern California; and *N. mendicus* forma *indisputabilis* (Oldryod) (pl. 1, figs. 11–13), a variant of *N. mendicus* that ranges from late Pleistocene to Recent.

Key to some western American species of Demondia

1. Body whorl angulated near midpoint, flat or concave above, convex below; axial sculpture of widely spaced nodes..... *Nassarius mendicus* forma *cooperi*¹

¹ Generally treated as variants of *N. mendicus* but seem to have at least local stratigraphic significance.

- Body whorl not angulated near midpoint; axial sculpture continuous across body whorl..... 2
2. Axial sculpture of coarse folds; spiral sculpture subdued..... 3
Axial and spiral ribs about equal in strength..... 4
3. Spire slender; body whorl evenly rounded, secondary spiral ribs generally present on upper part... *N. mendicus*
Spire broad and short; summit of body whorl subtabulate, tabulation sculptured by row of enlarged nodes..... *N. lincolnensis*
4. Sculpture evenly papillose or closely cancellate, no secondary spirals; spire of medium height... *N. californianus*
Axial sculpture becoming obsolete on final whorls, secondary spirals on body whorl; high spired... *N. mendicus* forma *indisputabilis*¹

Nassarius (Demondia) californianus (Conrad)

Plate 1, figures 1–10, 31

Schizopyga californiana Conrad, 1856, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 315.

Conrad, 1857, U.S. 33d Cong., 2d sess., Senate Exec. Doc. no. 78, v. 6, pt. 2, no. 2, p. 69, pl. 2, fig. 1.

Schizopyga californica Conrad. Tryon, 1882, Manual of Conchology, v. 4, p. 55, pl. 3, fig. 32.

Nassarius californianus (Conrad). Hanna and Hertlein, 1943, California Div. Mines Bull. 118, p. 176, text fig. 65, nos. 8, 9.

Nassa waldorfensis Arnold, 1907, Smithsonian Misc. Colln., v. 50, p. 434, pl. 54, fig. 17. Figure reprinted in Arnold and Anderson, 1907, U.S. Geol. Survey Bull. 322, pl. 21, fig. 17.

"*Nassa*" cf. "*N.*" *waldorfensis* Arnold. Stewart in Woodring, Stewart, and Richards, 1940, U.S. Geol. Survey Prof. Paper 195, p. 87, pl. 39, fig. 4.

"*Nassa*" *waldorfensis* Arnold. Woodring and Bramlette, 1950, U.S. Geol. Survey Prof. Paper 222, p. 75, pl. 8, fig. 14; pl. 10, fig. 9; pl. 15, fig. 4; pl. 19, figs. 3, 5.

?*Nassarius* cf. *N. parvinguis* (Hinds) [typographical error for *N. perpinguis* (Hinds)]. Touring in Touring, Cummings, and Brabb, 1962, California Div. Mines Bull. 181, photo 16, fig. 2.

Shell of medium size, moderately slender and high spired. Spire of four whorls, including slightly submerged nucleocoenoch of about 1½ whorls. Sculpture of first postnuclear whorl eroded; final two whorls of spire gently rounded, sculptured by four or five coarse spiral cords crossed by slightly retractive axial ribs of lesser strength. Intersection of ribs papillose, interspaces pitted. Suture impressed, minutely undulatory. Body whorl large, gently rounded; summit subtabulate on some specimens; base bordered by a deep fossa. Exterior sculptured by nine papillose spiral cords and narrower, channeled interspaces; axial ribs are relatively weaker and more widely spaced. Aperture ovate, has seven internal spiral cords which terminate as denticles a short distance from the thin outer lip. Base truncate, inner lip bordered by conspicuous narrow callus that has a spiral plait near the posterior edge and a weaker plait near the base of the columella. Anterior canal short, bordered by a strong denticle

within the base of the outer lip and by a smooth spiral ridge at the base of the columella. Siphonal fasciole sculptured by concentric growth ridges and weak radial ribs.

Height 14 mm, width 7.5 mm.

Neotype (here designated): USNM 648596.

Neotype locality: USGS Cenozoic loc. M1715. Poorly consolidated sandstone unconformably overlying Miocene siltstone in trench on north side of Arastradero Road, 1,200 ft. west of Page Mill Road. Palo Alto 7½-minute quadrangle. Merced(?) Formation, late Pliocene.

The name *Nassarius californianus* has been applied to at least six other late Cenozoic nassariids from California: *N. coalingensis* (Arnold), *N. delosi* (Woodring), *N. grammatus* (Dall), *N. iniquus* (Stewart), *N. moranianus* (Martin), and *N. rhinetes* Berry. These nassariids, however, can be differentiated at the subgeneric level, as well as specifically, from the taxon that is here identified as *N. californianus* (Conrad). In western Santa Clara County, Calif., two species of *Nassarius* occur in Pliocene strata probably stratigraphically equivalent to, if not identical with, the type locality of *Schizopyga californiana* Conrad, "12 miles back from Santa Clara" (Newberry, 1857, p. 67). Comparison of these species with Conrad's figure and description (1857, p. 69, pl. 2, fig. 1) reproduced herein (pl. 1, fig. 3), suggests that the smaller, more slender of the two species should be identified as *N. californianus*. The other species (pl. 2, figs. 15, 16, 26) is identified as *N. grammatus* (Dall).

The axial ribbing of *Nassarius californianus* varies in strength and spacing, the resultant sculpture ranging from fine papillae to coarse knobs that are somewhat elongate in a horizontal direction. *N. californianus* can be easily distinguished from *N. grammatus*, with which it frequently occurs, in all stages of growth. It has a more slender spire, relatively smaller body whorl, and coarser axial sculpture. It is a smaller species than the Pleistocene and Recent *N. perpinguis* (Hinds) (pl. 3, figs. 29, 32), which it seems to resemble most closely in sculpture. Further differences from *N. perpinguis* are its coarser sculpture, the presence of 9 rather than about 12 spiral ribs on the body whorl, and a narrow apertural callus having only two or three plaits. From *N. mendicus* (Gould) (pl. 1, figs. 14-16), which it resembles closely in size and apertural characteristics, *N. californianus* can be distinguished by its more numerous, much finer axial ribs and broader profile. It is closer in some respects to the finely sculptured, high-spired variant of *N. mendicus* (pl. 1, figs. 11-13) which has been named *N. mendicus indisputabilis* Oldroyd

(1927, pl. 26, fig. 4).¹ *Nassarius californianus* differs from this taxon by having evenly formed sculpture on all whorls as well as fewer primary spiral cords. Certain of the early identifications of *N. mendicus*, and possibly *N. perpinguis*, from Pliocene strata in central California (Arnold, 1908; Martin, 1916) almost certainly refer to *N. californianus*. It is difficult, however, to relate some of the early check-list occurrences to original material. Probably *N. californianus* is the lineal antecedent of *N. mendicus*.

Hanna and Hertlein (1943, p. 176, figs. 65-8, 65-9) are the only authors to clearly identify Conrad's species with published figures. Their specimens from a well core of the Etchegoin Formation near Tipton, Tulare County, Calif., are very similar to material from the neotype locality near Stanford, Calif., although one specimen has 10 spiral cords on the body whorl. This characteristic was observed in only one of the specimens from the neotype locality. Hanna and Hertlein's specimens are sculptured much like *N. iniquus* (Stewart), which was found in a core 80 feet higher in the same well (Grant and Gale, 1931, p. 679, pl. 26, figs. 28a, b, as *N. arnoldi* var. *whitneyi* (Trask)). Their specimens of *N. californianus* differ, however, from *N. iniquus* by having a larger rib count and by lacking a varicose outer lip.

The sculpture and profile of a small, rather high-spired species from the basal part of the Quinault Formation, western Washington, *Nassarius andersoni* (Weaver) (pl. 3, figs. 16-18), approach *N. californianus* very closely. This Pliocene nassariid can be differentiated from *N. californianus* by its varicose apertural lip and the absence of regularly spaced lirations within the outer lip. Although specimens from the Quinault Formation do not seem to have been confused with *N. californianus*, they have been identified as *N. mendicus* (Gould) by Arnold and Hannibal (1913, p. 594) and as *N. arnoldi* (Anderson) by Weaver (1916, p. 216).

Nassarius waldorfensis (Arnold, 1907a, p. 434, pl. 54, fig. 17) from the Pliocene of Santa Maria Basin is a synonym of *N. californianus*. The most southerly recorded occurrence of this species is in the eastern Ventura basin (Woodring and Bramlette, 1950, p. 105), although Arnold (1907, p. 434) states that this species is "found abundantly in the Pliocene throughout southern California."

Incomplete external molds of a very small nassariid characterized by eight finely noded spiral ribs and a simple outer apertural lip occur at a few localities in

¹ This figured, but otherwise undescribed, taxon is characterized by progressively finer axial sculpture on the final whorls that is subordinate to the spiral sculpture on the body whorl. The spiral sculpture consists of about 11 primary cords and random secondaries. The variant is as distinct sculpturally from *N. mendicus* as is *N. mendicus forma cooperi* (Forbes) and should be considered a complementary end member.

the lower Pliocene Pancho Rico Formation of the southern Salinas Valley, California (USGS Cenozoic loc. M982, M996, and M1455). These specimens are tentatively identified as *Nassarius* aff. *N. californianus*.

As far as is known *Nassarius californianus* is restricted to beds of Pliocene age in the standard Pacific coast mega-invertebrate chronology (Weaver and others, 1944). Glen's *N. cf. N. californianus* (1959, p. 157) from a locality in the upper part of the Merced Formation, considered by most investigators to be of early Pleistocene age, is probably a coarsely sculptured, immature specimen of *N. moranianus* (Martin).

The *Nassarius californianus* of Dickerson (1922, p. 550) and Weaver (1949, p. 95) from the Merced Formation on Wilson Ranch near Forestville, Sonoma County, Calif., is presumed to be correctly identified. This species (pl. 1, fig. 1) and *N. grammatus* (identified as *N. moranianus*) are the only *Nassarius* in collections from Wilson Ranch at the University of California and Stanford University.

Range: Pliocene.

Occurrence: Merced Formation: Sonoma County to northern San Mateo County (UCMP, SU, and CAS colln.), Merced(?) Formation, south of Stanford, Santa Clara County. Purisima Formation: east of Año Nuevo Creek, San Mateo County, and Capitola, Santa Cruz County (SU colln.); Pajaro River, northernmost San Benito County (USGS Cenozoic loc. M1805). Etchegoin and San Joaquin Formations: Kettleman Hills (Woodring and others, 1940). Etchegoin Formation: subsurface near Tipton, Tulare County (Hanna and Hertlein, 1943). Foxen and Careaga Formations: Santa Maria Basin (Woodring and Bramlette, 1950). Middle or upper Pliocene strata: eastern Ventura basin (Woodring and Bramlette, 1950).

Nassarius (*Demondia*) *lincolnensis* (Anderson and Martin)

Plate 1, figures 20-22

Nassa lincolnensis Anderson and Martin, 1914, California Acad. Sci. Proc., ser. 4, v. 4, p. 77, pl. 7, figs. 14a, b.

Nassarius lincolnensis (Anderson and Martin). Weaver, 1942, Washington Univ. Pub. Geology, v. 5, p. 462, pl. 89, fig. 25.

Hinia? lincolnensis (Anderson and Martin). Moore, 1963, U.S. Geol. Survey Prof. Paper 419, p. 38-39, pl. 5, figs. 8-10, 13, 15.

Holotype: CAS 167.

Type locality: CAS loc. 39. Sea cliff exposure immediately south of Nye Beach or a short distance north of the entrance to Yaquina Bay, Lincoln County, Oreg. (probably equivalent to locality A-14 of Vokes and others, 1949). Astoria Formation, middle Miocene.

Nassarius lincolnensis is a small, stout species that has a strongly noded spiral cord that defines a subsutural tabulation on the body whorl. There is a slight constriction in the body-whorl profile below the noded posterior spiral.

It should be noted that the four different Miocene localities from which Anderson and Martin (1914) de-

scribed eight new species of gastropods were incorrectly equated to University of Washington locality 691 "on south side of Yaquina Head * * * 5½ miles north of the entrance to Yaquina Bay" by Weaver (1942, p. 626). Yet Anderson and Martin's original descriptions indicate that two of the localities are north of Yaquina Head and that the other two are south of the head.

Range: Middle Miocene.

Occurrence: Astoria Formation: western Washington (Moore, 1963), Clatsop and Lincoln Counties, Oreg. (Anderson and Martin, 1914; Moore, 1963).

Subgenus *CAESIA* H. and A. Adams

Caesia H. and A. Adams, 1853, The genera of Recent Mollusca, v. 1, p. 120.

Type (by subsequent designation, Wenz, 1943, Handbuch der Paläozoologie, v. 6, p. 1235).—*Nassa perpin-guis* Hinds. Recent, northeastern Pacific Ocean.

Zaphon H. and A. Adams (type, by monotypy: *Buccinum elegans* Reeve=*Nassarius fossatus* (Gould)) can be treated as a synonym of *Caesia*. The two names were proposed in the same publication. *Caesia* is here selected on the basis of page priority.

Cossmann's placement (1901, p. 205-207) of these names under *Uzita* is not justified on morphologic grounds. The apertural characteristics clearly differ from those of the type of *Uzita* (*Buccinum migum* Bruguière). "*Buccinum*" *migum* has a narrow, sharply delimited parietal callus, whereas the callus of *Caesia* covers an extensive area of the body whorl as a thin film. A further difference is the externally thickened outer lip of "*Buccinum*" *migum*.

The subgenus *Caesia* first appears in middle Miocene strata of the northeastern Pacific Ocean area. It is represented by a very few species until about the beginning of the Pleistocene.

Key to some western American species of *Caesia*

- | | |
|---|---------------------------|
| 1. Axial sculpture limited to upper part of body whorl..... | 2 |
| Axial sculpture continuous across body whorl..... | 4 |
| 2. Body whorl angulated near midpoint; adult shell large (> 25 mm)..... | 3 |
| Body whorl not angulated near midpoint; adult shell small (generally < 15 mm)..... | <i>Nassarius whitneyi</i> |
| 3. Angulation sharp; axial sculpture of coarse, widely spaced folds which are swollen on the angulation..... | <i>N. fossatus</i> |
| Angulation rounded; axial sculpture of closely spaced, nodose ribs which are not swollen on the angulation..... | <i>N. moranianus</i> |
| 4. Axial ribs widely spaced, interspaces between ribs on body whorl rectangular with long dimension perpendicular to axis of shell..... | 5 |
| Axial ribs closely spaced, interspaces nearly square or rectangular with long dimension parallel to axis of shell..... | 6 |

5. Interspaces about twice as wide as high; axial and spiral ribs of about equal strength..... *N. delosi*
Interspaces about three times as wide as high; axial sculpture of coarse folds, spiral ribs subdued. *N. cerritensis*
6. Profile smoothly tapered from base of body whorl to apex; sutures usually tabulate..... *N. coalingensis*
Whorl profile rounded; sutures not tabulate..... 7
7. Aperture smooth within..... *N. rhinetes*
Aperture has strong internal spiral ribs..... 8
8. Spiral sculpture of coarse, straplike primary ribs, no secondary ribs; axial ribs subdued, frequently obsolete on body whorl..... *N. grammatus*
Spiral sculpture of primary and secondary ribs..... 9
9. Secondary spiral ribs present on upper part of body whorl of mature specimens; adult shell of medium size (< 25 mm), relatively slender..... *N. perpinguis*
Three-fourths or more of body whorl sculptured with alternating primary and secondary spiral ribs; adult shell large (> 30 mm), body whorl inflated, spire short..... *N. grammatus* n. subsp.?

***Nassarius* (*Caesia*) *grammatus* (Dall)**

Plate 2; figures 1, 2, 7, 8, 13-16, 26

- Nassa californiana* Conrad. Arnold in Arnold and Anderson, 1907. U.S. Geol. Survey Bull. 322, p. 150, pl. 24, fig. 4.
Arnold, 1908, U.S. Natl. Mus. Proc., v. 34, pl. 36, fig. 6.
Arnold in Branner, Newsom, and Arnold, 1909, U.S. Geol. Survey Geol. Atlas, Santa Cruz Folio, no. 163, illus. 2, fig. 73.
- ?*Nassarius* (*Schizopyga*) *californianus* (Conrad). Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 672-673, in part, pl. 26, fig. 49.
- ?*Nassarius californianus* (*Nassa*). Howard, 1935, California Oil Fields, v. 20, no. 4, pl. 9, fig. 6.
- Nassa moraniana* Martin. Martin, 1916, California Univ., Dept. Geology Bull., v. 9, p. 229?, 231, 233, 243, not p. 230.
- "*Nassa*" *moraniana* Martin. Stewart in Woodring, Stewart, and Richards, 1940, U.S. Geol. Survey Prof. Paper 195, p. 86-87, pl. 34, figs. 5, 6.
Woodring and Bramlette, 1950, U.S. Geol. Survey Prof. Paper 222, p. 74-75, pl. 14, figs. 13, 14; pl. 17, figs. 7, 8; pl. 19, fig. 4.
- Schizopyga moraniana* (Martin). Schenck and Keen, 1940, 1950, California fossils for the field geologist, pl. 51, fig. 2.
- Alectrion grammatus* Dall, 1917, U.S. Natl. Museum Proc., v. 61, p. 575.

Original description.—"About the same size as [*Nassarius*] *fossatus*, but more regular and compact, with a uniform sculpture of flat spiral cords separated by narrow channels without intercalary minor spirals" (Dall, 1917, p. 575).

Supplementary description.—(Based on syntypes labeled USNM catalog No. 101721.) Moderately large, inflated; strong spiral sculpture. Spire of about five convex whorls. Protoconch and earliest whorls of spire worn smooth. Body whorl large, profile smoothly rounded, about two-thirds height of shell. Sculptured by 14 evenly spaced, straplike spiral cords crossed by closely spaced, retractive axial threads. Rib intersec-

tions faintly noded on penultimate whorl but generally smooth on body whorl. Base of body whorl set off by a deeply channeled fossa. Aperture subovate, broadest near base. Outer lip relatively thin, sculptured internally by about 12 strong, frequently papillose spiral ridges, which correspond to the interspaces between external spiral cords. Inner lip bordered by broad deposit of callus extending upward onto parietal wall. Lower part of the callus border conceals about half of the siphonal fasciole. Callus armed with many irregularly spaced spiral plaits. Anterior canal short, deeply notched. Siphonal fasciole very broad, depressed medially.

Height 35.9 mm, width 25.3 mm (type).

Lectotype (here selected from four syntypes constituting USNM catalog No. 101721): USNM 648566.

Type locality: Pleistocene (Dall, 1917) [Pliocene], Santa Barbara, Calif. (presumably from the lower part of the Santa Barbara Formation).

Although Dall's obscure name "*Alectrion grammatus*" (1917, p. 575) may not seem particularly well suited as a standard bearer for this important Pliocene species, it is available and must be used. The type material consists of four specimens labeled "Santa Barbara, Cal., Pleistocene, Stearns Coll." One of the syntypes is here selected as lectotype and figured on plate 2 (figs. 1, 2). Woodring and Bramlette (1950, p. 74) express doubt that the type material is from the Santa Barbara Formation because, in 1950, no additional specimens were known from this formation. The presence of *Nassarius grammatus* in the Santa Barbara Formation, however, has been definitely established by a few small specimens collected recently from exposures north of Goleta (USGS Cenozoic loc. M1918). The largest of these specimens (pl. 2, figs. 7, 8) has 13 nodose spiral cords on the body whorl. Other smaller specimens from this formation which seem to represent *N. grammatus* are in the collection of George Hughes of the University of California, Santa Barbara. Because of the disparity in size between the small specimen of *N. grammatus* definitely known to be from the Santa Barbara Formation and the much larger syntypes, there still remains an element of doubt as to the origin of the syntypes.

Nassarius grammatus is characterized by a large, globose body whorl having uniform spiral and axial sculpture, the latter being somewhat variable in strength but always weaker than the the spiral sculpture. It is ancestral to the late Pliocene-early Pleistocene species *N. moranianus* Martin (1914, p. 183-184, pl. 22, figs. 1a-c) with which it has been generally identified in recent years. Specimens constituting the type lot of *N. moranianus* from the Merced Formation at Bolinas

Bay, Marin County, Calif., moreover, differ significantly from *N. grammatus*. They have a medially angulated body whorl sculptured by coarse axial ribs and secondary spiral ribs on the upper half but only smooth spiral cords on the lower half (pl. 2, figs. 3, 4). The presence of these characters on the type material links *N. moranianus* more closely with the Pleistocene and Recent species *N. fossatus* than with Pliocene specimens of *N. grammatus*. Although identification of immature specimens is usually difficult, juvenile specimens of *N. moranianus* from the type locality have relatively coarser axial ribs than immature specimens of *N. grammatus* from western Santa Clara County (pl. 2, fig. 26); in addition, they have the medial angulation on the body whorl. Grant and Gale's figure of *N. californianus* (1931, pl. 26, fig. 49) appears to be an immature specimen of *N. grammatus*.

Specimens identified as "*Nassarius moranianus*" (*N. grammatus*) but having well-rounded, nonangulated body whorls sculptured by regularly alternating primary and secondary spiral ribs are sculpturally distinct and may warrant a new name. They seem to be closely related to *N. grammatus* but are here referred to as *N. grammatus* n. subsp.? (pl. 2, fig. 12). There are insufficient specimens from localities where this taxon occurs, however, to confidently rule out the possibility that it is a sculptural variant rather than a subspecies. Crushed specimens of *N. grammatus* n. subsp.? are fairly common in the Merced Formation southeast of the type area (USGS Cenozoic loc. M1661). Other specimens in the Pliocene collections at the University of California, Berkeley, are from the basal part of the type Merced Formation south of the San Andreas fault; Coalinga quadrangle (UCMP loc. A1304); and the Rio Dell Formation of Ogle (1953), Humboldt County, Calif. (UCMP loc. B7642; pl. 2, fig. 12). There are three specimens referable to this taxon in a collection at Stanford University labeled "Pacific Beach" (San Diego Formation, Pliocene). The fossil from the Tinaquaic Sandstone Member of the Sisquoc Formation of the Santa Maria basin, California, figured by Woodring and Bramlette (1950, pl. 7, figs. 3, 4) as "*Nassa*" sp. probably is referable to this taxon, judging by the strong, alternating primary and secondary internal spiral ribs on the internal mold. "*Nassa*" sp. is widespread in this member of the Sisquoc Formation and reportedly does not range into younger strata. Most of the known occurrences of *N. grammatus* n. subsp.? are from strata which have been classified in part as "middle" Pliocene by various workers on differing criteria, principally stratigraphic position.

This species probably evolved from the small Miocene species, *Nassarius whitneyi* (Trask, 1922, p. 154,

pl. 7, figs. 3, 6) from the Sobrante and Briones Sandstones of Contra Costa County, Calif. A suggested lineage of the late Cenozoic species of *Caesia* from the Pacific coast of North America which are believed to have evolved from *N. whitneyi* through *N. grammatus* is outlined in figure 1. A broad callus deposit borders the inner lip of the aperture of these species and in mature individuals is characteristically armored with several spiral plaits. The outer lip is usually strongly lirated within.

A slender Pliocene species from the San Joaquin Valley, *Nassarius coalingensis* (Arnold, 1909, p. 88-89, pl. 27, fig. 9), was originally described as a variety of "*Nassa californiana*" (*N. grammatus*). This species (pl. 2, figs. 17, 18) is similar to *N. grammatus* but can be distinguished from it and other related late Cenozoic nassariid gastropods by its smoothly tapered, bullet-shaped profile and tabulate sutures.

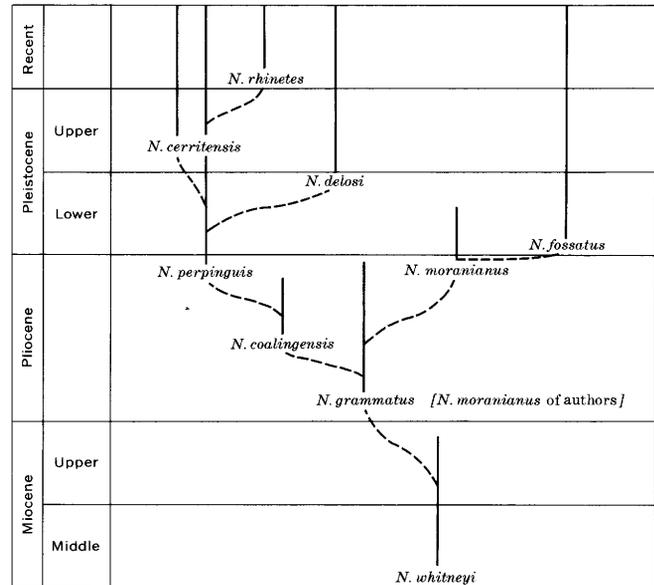


FIGURE 1.—Stratigraphic occurrence and possible evolution of western American Cenozoic nassariid gastropods of the subgenus *Caesia*. Subdivisions of the Tertiary and Quaternary Systems are those of Weaver and others (1944).

A Pliocene record of "*Alectrion californica* var." (B. L. Clark in Santillán and Barrera, 1930) from an unspecified locality north of El Rosario in northwestern Baja California, Mexico, may represent *N. grammatus*. A recent investigation of Pliocene strata of this area (Hertlein and Allison, 1959), however, failed to recover additional specimens or to locate the material upon which Clark's identification was made.

Nassarius grammatus is one of the more widespread and characteristic mollusks which occur in formations generally considered to be Pliocene in the standard Pa-

cific coast provincial classification of Weaver and others (1944). Its presence in the Santa Barbara Formation can be regarded, therefore, as evidence for placement of part of the formation in the Pliocene, as that term has been used in the Pacific coast molluscan chronology. Another important Pliocene species, *Patinopecten healyi* (Arnold), has been recently collected from near the base of the formation (USGS Cenozoic loc. M1717). These and other previously unreported Pliocene taxa are in stratigraphic collections made by George Hughes of the University of California, Santa Barbara, from new exposures of the Santa Barbara Formation northwest of the type locality. These collections are from strata that conformably underlie a bryozoan biostrome which may be correlative with the lowest strata exposed in the type area, a bryozoan-rich mudstone and marl. The age of the Santa Barbara Formation, considered to be early Pleistocene by some workers, can therefore be regarded as late Pliocene and early Pleistocene.

Range: Pliocene.

Occurrence: Characteristic of Pliocene formations from Humboldt County, northern California (W. G. Cooper Colln., SU) to San Diego (F. Stephens Colln., SU) and possibly northern Baja California, Mexico (Santillán and Barrera, 1930).

***Nassarius* (*Caesia*) *moranianus* (Martin)**

Plate 2, figures 3, 4, 9–11, 29

Nassa moraniana Martin, 1914, California Univ., Dept. Geology Bull., v. 8, p. 183–184, pl. 22, figs. 1a–c.

Martin, 1916, California Univ., Dept. Geology Bull., v. 9, p. 230.

Nassarius (*Schizopyga*) *moranianus* (Martin). Grant and Gale, 1931, San Diego Soc. Nat. History Mem., v. 1, p. 676, in part.

Glen, 1959, California Univ., Dept. Geol. Sci. Bull., v. 36, p. 180.

Nassarius moranianus (Martin). Hertlein, 1951, California Div. Mines Bull. 154, p. 191, text fig. 2, no. 9.

Nassarius (*Schizopyga*) cf. *N.* (*S.*) *californianus* (Conrad). Glen, 1959, California Univ., Dept. Geol. Sci. Bull., v. 36, p. 180.

Holotype: UCMP 12338.

Type locality: UCMP loc. 1549, Bolinas Bay, Marin County, Calif., Merced Formation, late Pliocene.

This species closely resembles *Nassarius fossatus* (Gould), a common Pleistocene and Recent species in California and Oregon. It has a stouter, less high spired shell than that species and a generally more finely sculptured, less strongly angulated body whorl. Adult specimens of *N. fossatus* characteristically have widely spaced axial folds on the later whorls, which are strongest on the angulation (pl. 2, figs. 5, 6). Differentiation of *N. moranianus* from the Pliocene species *N. grammatus* is less difficult owing to the uniform sculpture on the body whorl of *N. grammatus* as well as to the absence of a medial angulation. Most Pliocene

records of *N. moranianus* can be referred to *N. grammatus*.

Nassarius moranianus probably evolved from *N. grammatus* near the end of what in California is generally considered by most workers to be Pliocene time. *Nassarius fossatus* may have evolved from *N. moranianus* shortly thereafter (fig. 1). The presence of secondary spiral cords on the upper part of the body whorl of juvenile and adult specimens of *N. moranianus* from the upper part of the type Merced Formation (pl. 2, figs. 3, 4) seems to link this species with similar Pleistocene specimens of *N. fossatus* on which secondary spiral cords are nearly as strong as the primaries. Another point of similarity is the frequent absence of strong axial folds on early Pleistocene species of *N. fossatus*. There are very few Pliocene records of *N. fossatus*. Most are either tentative identifications (Howe, 1922; Woodring and Bramlette, 1950) or identifications that preceded the recognition of *N. moranianus* as distinct from *N. fossatus* (Cooper, 1888, p. 253). Cooper's Miocene records of *N. fossatus* (1888) presumably are of *N. whitneyi* (Trask, 1922).

The age of the small Merced assemblage from the type locality of *Nassarius moranianus* (Martin, 1916, p. 230) at Bolinas Bay is Pliocene as used in the Pacific coast molluscan chronology. *Scutellaster interlineatus*, *Clinocardium meekianum*, and *Ophiodermella mercedensis*, three of the eighteen invertebrate taxa listed by Martin, are generally regarded as Pliocene species. The assemblage occurs about 20 miles to the northwest of the type area of the Merced Formation. A large specimen in the type lot (pl. 2, fig. 29) approaches the slender, high-spired late Pleistocene variant of *N. fossatus* (pl. 2, figs. 30, 31) named *N. fossatus* forma *coiloterus* (Woodring).

There are two known early Pleistocene occurrences of *Nassarius moranianus*. One is from the upper part of the type Merced Formation near San Francisco, Calif. (pl. 2, fig. 11). The other is from the Saugus Formation (Waterfall, 1929, chart opposite p. 78) of the western Ventura basin (pl. 2, fig. 10).

The Recent occurrence of *Nassarius moranianus* reported in Grant and Gale (1931, p. 676) is not necessarily a range extension, as it is based upon fossil material in the Stanford University collections labeled with the manuscript name "*N. gouldii*," according to Keen (in Burch, 1945, no. 51, p. 7).

Range: Upper Pliocene to lower Pleistocene.

Occurrence: Upper Pliocene: Merced Formation, Bolinas, Calif. (Martin, 1914). Lower Pleistocene: upper part of Merced Formation, San Francisco area (Glen, 1959); Saugus Formation of Waterfall (1929), western Ventura basin UCMP loc. 7071, 7078, 7091, 7092.

***Nassarius* (*Caesia*) *coalingensis* (Arnold)**

Plate 2, figures 17, 18

Nassa californiana Conrad var. *coalingensis* Arnold, 1909, U.S. Geol. Survey Bull. 396, p. 88-89, pl. 27, fig. 9.

Arnold and Anderson, 1910, U.S. Geol. Survey Bull. 398, pl. 49, fig. 9.

"*Nassa*" *coalingensis* Arnold. Woodring, Stewart, and Richards, 1940, U.S. Geol. Survey Prof. Paper 195, p. 87, pl. 15, fig. 3.

Holotype: USNM 16551.

Type locality: USGS loc. 4758. Bed C, near top of section at Henry Spring, 4 miles south of Coalinga, Calif., in SW $\frac{1}{4}$ sec. 18, T. 21 S., R. 15 E. Etchegoin Formation (unrestricted) of Arnold (1909), Pliocene.

This species is characterized by a smoothly tapered profile which can be described as bullet shaped. The point of maximum diameter of the body whorl is near the base. The sculpture is most similar to that of *N. grammatus* but the sides of the whorls are nearly flat and the summits are generally tabulate.

Range: Pliocene.*Occurrence*: Etchegoin Formation (unrestricted) of Arnold (1909) (including San Joaquin Formation of later workers), Coalinga district, California. San Joaquin Formation, Kettleman Hills, Calif. (Woodring and others, 1940). Pancho Rico Formation, Salinas Valley, Calif. (USGS Cenozoic loc. M979).***Nassarius* (*Caesia*) *whitneyi* (Trask)**

Plate 2, figures 19-25, 27

Nassa whitneyi Trask, 1922, California Univ., Dept. Geol. Sci. Bull., v. 13, p. 154, pl. 7, figs. 3, 6.*Nassarius whitneyi* (Trask). Clark, 1929, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 34, fig. 9.

Schenck and Keen, 1940, California fossils for the field geologist, pl. 45, fig. 1, 2.

Lutz, 1951, California Univ., Dept. Geol. Sci. Bull., v. 28, p. 392, pl. 18, fig. 8.

?*Nassa* sp. Whiteaves in Mackenzie, 1916, Canada Geol. Survey Mem. 88, p. 75.?*Caesia* sp. K. Arnold in Mackenzie, 1916, Canada Geol. Survey Mem. 88, p. 76.?*Nassarius antiselli* (Anderson and Martin). Weaver, 1953, Washington Univ. Pub. Geology, v. 7, p. 64.*Type*: UCMP 12387.*Type locality*: UCMP loc. 3524. On west side of San Ramon Valley, 281 mm E., 223 mm S. from northwest corner Concord 15 minute quadrangle (coordinates meet in sec. 2, T. 1 S., R. 2 W.), Contra Costa County, Calif. Briones Sandstone, late Miocene.

Although *Nassarius whitneyi* does not seem to have been recorded in the literature as *Nassarius californianus*, it has been confused with the middle Miocene species *N. arnoldi*, presumably because of poorly illustrated and incomplete type material. The species is here reviewed to record new data on its stratigraphic range and geographic occurrence.

Nassarius whitneyi is one of the more distinctive fossil nassariids from the Pacific coast of North America. It has a unique combination of small adult size, weak axial sculpture confined to the upper one-third of the body whorl, and numerous, closely spaced spiral ribs. These characteristic are not present, as a group, in any other known western American species of *Caesia*. Specimens from the upper Miocene of Contra Costa County, Calif., in collections at the University of California, including type material, are internal and external molds, completely devoid of shell material and frequently deformed. It should be noted that the types and other specimens of *N. whitneyi* show no evidence of the originally described varicose outer lip, although the mold from which the holotype was cast was excavated in such a manner that a false swelling is present. The reported varix may have led some workers (Grant and Gale, 1931, p. 679) to include this taxon in the subgenus *Uzita*. The strong spiral ribs on internal molds of *N. whitneyi*, the deep fossa, and the general profile are characteristic of some subsequent species in the western American lineage of *Caesia*, namely, *N. grammatus*, *N. moranianus*, and *N. fossatus* (fig. 1).

The earliest occurrence of this species is from the "Sobrante" Formation (Lutz, 1951, p. 392, pl. 18, fig. 8) of the Pacheco syncline, Contra Costa County, Calif., a unit which contains a small but characteristic middle Miocene fauna. Weaver's identification (1953, p. 64) of *Nassarius antiselli* (Anderson and Martin) from this formation presumably is *N. whitneyi*. The type locality of *N. whitneyi* is in the Briones Sandstone, a unit which has been included as the lowest of three formations in the San Pablo Group. In a recent study of the San Pablo Group in western Contra Costa County,² the range of *N. whitneyi* has been extended upward to a position near the top of the overlying lower member of Doumani's San Pablo Formation (UCMP loc. B4739). This unit presumably is equivalent to the Cierbo Sandstone of some workers.

Considerable variation in the number of spiral ribs has been noted in specimens of *Nassarius whitneyi* from the Briones Sandstone of Contra Costa County. According to Trask (1922, p. 154), spiral ribs range from 11 to 13 on the body whorl, yet small specimens from UCMP locality B4749 (pl. 2, figs. 25, 27) have from 12 to as many as 17 spirals on the body whorl. Specimens from the "Sobrante" Formation and Briones Sandstone of the Pacheco syncline (pl. 2, figs. 23, 24), several miles north of the type locality, have a fairly constant count of 15 spirals on the body whorl.

² Doumani, G. I., 1957, Stratigraphy of the San Pablo Group, Contra Costa County, California: California Univ., Berkeley, M.A. Thesis, 72 p.

A small nassariid from the Skonun Formation (MacKenzie, 1916, p. 73) of northern Graham Island, British Columbia (pl. 2, figs. 19–22), is here identified as *Nassarius whitneyi*. Of the six specimens in a collection from Skonun Point (UCLA loc. 4674), five have 12 spiral cords on the body whorl, and one has 13. They cannot be differentiated from some of the smaller, coarsely ribbed specimens of *N. whitneyi* from Contra Costa County, Calif. The fauna of the Skonun Formation is poorly known, and the age is uncertain, although probably within the range of Miocene or Pliocene as given by MacKenzie (1916), if one judges by the collection from UCLA locality 4674.

Range: Middle to upper Miocene.

Occurrence: Middle Miocene: Sobrante Formation of Lutz (1951), Contra Costa County, Calif. Middle or upper Miocene: upper part of Branch Canyon Formation of Hill and others (1958), eastern San Luis Obispo County, Calif. (J. G. Vedder field loc. F28 7K-34). Upper Miocene: Briones Sandstone, Contra Costa County, Calif. (Trask, 1922; Weaver, 1949, 1953; Ham, 1952); lower member of the San Pablo Formation.³ Upper Miocene or Pliocene: Skonun Formation, Skonun Point, northern Graham Island, British Columbia (UCLA loc. 4674).

***Nassarius (Caesia) delosi* (Woodring)**

Plate 1, figures 23–25, 28–30

Nassa californiana (Conrad). Arnold, 1903, California Acad. Sci. Mem., v. 3, p. 231, in part, pl. 4, fig. 3.

"*Nassa*" *delosi* Woodring in Woodring, Bramlette, and Kew, 1946, U.S. Geol. Survey Prof. Paper 207, p. 74, pl. 35, figs. 12–15.

Holotype: USNM 498653.

Type locality: USGS loc. 12135. East side of 48-foot mesa, 1,000 ft southeast of intersection of Harbor Boulevard and Pacific Electric tracks, San Pedro, Calif. Palos Verdes Sand, late Pleistocene.

Nassarius delosi (Woodring) is a large high-spired species that has a broadly cancellate sculpture. It most closely resembles *N. rhinetes* Berry (1953, p. 415–416, pl. 28, fig. 7), a recent species long known as *N. californianus* (Conrad) of Dall (1921). From *N. rhinetes*, *N. delosi* differs by being more slender and by having widely spaced, stronger axial ribs which intersect the spiral ribs to form rectangular interspaces. The interspaces on the body whorl of adult specimens of *N. rhinetes* are nearly square. Very young individuals of the two species are difficult to differentiate (Woodring and others, 1946, p. 74). Another species sculptured somewhat like *N. delosi* is *N. cerritensis* (Arnold, 1903, p. 231–232, pl. 4, fig. 1). This late Pleistocene to Recent taxon (pl. 1, figs. 26, 27) differs from *N. delosi* by being more slender and by having coarser, extremely widely spaced axial folds on the later whorls.

Since *Nassarius delosi* was originally described, it has been found in most of the known upper Pleistocene ter-

race deposits in Southern and Baja California, although it is commonly represented by only a few individuals at any one locality. Some records of *N. californianus* from late Pleistocene faunas of California prior to about 1946, such as occurrences in the Millerton Formation at Tomales Bay, Calif. (Dickerson, 1922; Weaver, 1949), probably represent *N. delosi*. Recently, individual specimens of *N. delosi* have been found living in the intertidal zone at Balboa (Newport Beach) and Mission Bay, Southern California (Chace, 1957, 1962). These specimens are here figured (pl. 1, figs. 23, 30) through the kindness of James McLean of Stanford University, who photographed them at the San Diego Museum of Natural History.

Range: Lower Pleistocene to Recent.

Occurrence: Lower Pleistocene: Saugus Formation west of Ventura, Calif. (USGS Cenozoic loc. M1723). Upper Pleistocene: marine terrace deposits from Tomales Bay, Calif. (Valentine, 1961), to Punta Baja, Baja California (Emerson and Addicott, 1958). Recent: Balboa (Newport Beach), Calif., to Mission Bay, Calif. (Chace, 1962).

***Nassarius (Caesia) rhinetes* Berry**

Plate 2, figure 28

Nassa californiana (Conrad). Rivers, 1891, Zool., v. 2, p. 70–72, 1 text fig.

Berry, 1907, Nautilus, v. 21, p. 40.

Schizopyga californiana Conrad. Dall, 1921, U.S. Natl. Museum Bull. 112, p. 102, pl. 11, fig. 4. Figure reproduced by Oldroyd, 1927, as *Alectrion californianus* (Conrad), Stanford Univ. Pub., Univ. Ser. Geol. Sci., v. 2, pt. 1, p. 264, pl. 26, fig. 13.

Nassarius californianus (Conrad). Demond, 1952, Pacific Sci., v. 6, p. 306–307, pl. 2, fig. 6.

Nassarius (Schizopyga) rhinetes Berry, 1953, San Diego Soc. Nat. History Trans., v. 11, p. 415–416, pl. 28, fig. 7.

Holotype: S. S. Berry personal collection No. 1182 (Redlands, Calif.).

Type locality: Dredged from 40 fathoms off Moss Landing, Monterey Bay, Calif.

This species is similar to both *Nassarius delosi* (Woodring) and *N. perpinguis* (Hinds). It has more numerous, weaker axial ribs than *N. delosi*. To distinguish it from *N. perpinguis* is more difficult. The body whorl of *N. rhinetes* appears to be relatively larger than that of *N. perpinguis*, and specimens of *N. rhinetes* at hand and published figures show no evidence of secondary spirals on the body whorl such as are present on many of the larger specimens of *N. perpinguis* (pl. 3, fig. 29). The number of primary spiral ribs, 11 or 12, is the same on both species.

There are no verified late Pleistocene occurrences of *Nassarius rhinetes*. Burch's statement (1945, no. 51, p. 7) to the effect that this species ("*N. californianus*") is characteristic of "the Del Rey Pleistocene deposit in the Baldwin Hills" probably refers to the later named

³ See footnote 2.

N. delosi. Most bathymetric records of this species (Rivers, 1891, p. 71; Smith and Gordon, 1948, p. 187; Demond, 1952, p. 307; Berry, 1953, p. 416) are from moderate depths, 25–40 fathoms, in the sublittoral zone. This is a far greater depth than the maximum measurable relief of the terrace platforms upon which late Pleistocene mollusks lived and may account for its absence in these assemblages. There is, however, one occurrence in moderately shallow water (15 fathoms) in Monterey Bay, listed by Burch (1945, no. 51, p. 7).

Range: Recent.

Occurrence: Squaw Creek, Oreg., to Magdalena Bay, Baja California (Burch, 1945, no. 51, p. 7).

Subgenus CATILON Addicott, n. subgen.

Type.—*Nassa arnoldi* Anderson. Middle Miocene, California and Oregon.

Shell commonly small, rather low spired. Body whorl stout, smoothly rounded, relatively large. Sculpture reticulate to somewhat papillose; closely set axial and spiral ribs of variable strength; axial sculpture retractive. Aperture ovate, interrupted anteriorly by fairly wide siphonal notch, base subtruncate. Outer lip thickened externally by varix, bearing about seven recessed denticles. Parietal callus narrow, leading edge broadly rounded and clearly delimited from surface of body whorl. Callus armed with a strong posterior parietal plait and, usually, one weaker plait above the basal spiral fold. The name *Catilon* is formed by an arbitrary combination of letters.

Several small Miocene and Pliocene nassariids from the Pacific coast of the United States form a natural group typified by *Nassarius arnoldi*. Living species of *Catilon* seem to be restricted to the Panamic molluscan province of the eastern Pacific Ocean (southern Baja California, Mexico, to Peru). These species are characterized by a narrow, sharply delimited apertural callus, an externally thickened outer lip, and reticulate or papillose sculpture. Many of these species have been placed in *Uzita* H. and A. Adams, presumably because of similarity to well-illustrated late Cenozoic nassariids from the tropical western Atlantic Ocean area, which are customarily placed in that taxon. Western American species of *Catilon* differ from these species placed in *Uzita* and from specimens of the type of *Uzita*, "*Buccinum*" *migum* Bruguière, in the Recent collections at Stanford University by lacking the row of fine plaits on the inner lip of the aperture, the numerous fine spiral plaits within the outer lip, and, in anterior view, the constricted opening for the anterior siphon at the apertural face. More importantly, "*Buccinum*" *migum* differs from species here included in *Catilon* by having coarse protractive axial folds, which are rather strongly

curved on the spire and sinuous on the body whorl, and an attendant wavy suture.

A highly variable late Pliocene to Recent nassariid which may be referable to *Uzita* is *Nassarius insculptus* (Carpenter). A variant or subspecies of this normally smooth species, *N. insculptus eupleura* (Dall) figured by Demond (1952, pl. 2, fig. 1), has fairly strong, coarse axial folds which resemble those of "*Buccinum*" *migum* in appearing to be both sinuous and protractive. The outer lip of *N. insculptus* is thickened and the inner lip bears a vertical row of fine spiral plaits. This species and its subspecies or variants, *N. insculptus* forma *eupleura* and *N. insculptus* forma *gordanus* (Hertlein and Strong, 1951, p. 81–82, pl. 8, fig. 6), range from Point Arena, northern California, to the southern part of the Gulf of California, Mexico.

The subgenus first appears in strata classified as lower Miocene in the Pacific Coast molluscan chronology. It seems to have become extinct on the west coast of the United States after the Pliocene Epoch. A living representative of *Catilon* originally described from material dredged from deep water off Panama, *Nassarius catallus* (Dall), is known to range as far north as the west coast of Mexico (A. M. Keen, written commun. 1963). *N. catallus* has been recorded from moderately deep water in the vicinity of San Miguel Island (lat 34° N.) off the coast of Southern California (Strong in Burch, 1945, no. 51, p. 4; Demond, 1952, p. 312); however, this record is regarded as doubtful by some workers.

Several nassariids from the modern Panamic molluscan province of the tropical eastern Pacific Ocean seem to belong in this subgenus. They are: *Nassarius catallus* (Dall), *N. gallegosi* Strong and Hertlein, *N. guaymasensis* (Pilsbry and Lowe), *N. miser* (Dall), *N. polistes* (Dall), *N. versicolor* (C. B. Adams), and *N. wilsoni* (C. B. Adams).

Key to some western American Tertiary species of Catilon

- | | |
|---|--|
| 1. Body whorl sculptured by 10 or more spiral cords..... | 2 |
| Body whorl sculptured by nine or fewer spiral cords.... | 6 |
| 2. Spiral sculpture of irregularly alternating straplike ribs..... | <i>Nassarius salinasensis</i> ¹ |
| Spiral sculpture of uniform spiral cords..... | 3 |
| 3. Axial sculpture stronger than spiral sculpture..... | 5 |
| Axial and spiral sculpture about equally strong..... | 4 |
| 4. Stout, spire much shorter than body whorl..... | <i>N. arnoldi</i> |
| Slender, spire nearly as high as body whorl..... | <i>N. pabloensis</i> ² |
| 5. Axial ribs narrow, widely spaced; spiral ribs subdued; moderately high spired, apex blunt..... | <i>N. hamlini</i> |
| Axial sculpture of broad folds which become obsolete toward base; spiral ribs strong; low spired..... | <i>N. smooti</i> |
| 6. Sculpture papillose or of strong axial ribs, eight or less spiral cords on body whorl..... | 7 |
| Sculpture reticulate, nine spiral cords on body whorl.... | 9 |

See footnotes at end of table.

7. Basal fossa weak or indistinct..... 8
 Basal fossa strongly incised..... *N. iniquus*
8. Very small (<5 mm), stout; body whorl with anterior tabulation and basal fossa; sculptured by coarse axial ribs and finer spiral cords..... *N. churchi*
 Small, rather slender; body whorl not tabulate, basal fossa indistinct; sculpture papillose..... *N. antiselli*¹
9. Shell medium- to high-spired..... 10
 Shell, low spired; aperture characteristically sculptured by paired anterior and posterior parietal denticles... *N. stocki*
10. Body whorl evenly rounded; high spired..... 11
 Body whorl with narrow subsutural tabulation, spire of medium height..... *N. andersoni*
11. Adult shell of medium size (about 15 mm or larger); rib intersections coarsely noded, interspaces deeply pitted..... *N. pabloensis*²
 Adult shell small (<10 mm); rib intersections weakly noded, interspaces not deeply pitted..... *N. hildegardae*

¹ Species questionably assigned to *Catilon*.

² Although *Nassarius pabloensis* commonly has 9 spiral cords, a few large specimens have 10 spirals.

***Nassarius (Catilon) churchi* (Hertlein)**

Alectrion churchi Hertlein, 1928, Jour. Paleontology, v. 2, p. 156, pl. 22, fig. 2.

Nassarius churchi (Hertlein). Loel and Corey, 1932, California Univ., Dept. Geology Sci. Bull., v. 22, p. 241, pl. 48, fig. 2.

Holotype: CAS 4149.

Type locality: CAS loc. 1150, sea cliff exposure about 0.5 kilometer west of mouth of Arlington Canyon, Santa Rosa Island, Calif. Vaqueros Formation, early Miocene.

This minute species is known only from the holotype, a slender specimen that has strong axial ribs crossed by about nine finer spiral threads. A specimen from the shale member of the so-called Temblor Formation of Santa Cruz Island figured by Bremner (1932, pl. 2, fig. 4) as *Nassarius churchi* (Hertlein) is a small, rotund species of *Cancellaria* that has cancellate sculpture quite unlike that of the holotype of *N. churchi*.

Occurrence: Vaqueros Formation, early Miocene, Santa Rosa Island.

***Nassarius (Catilon) arnoldi* (Anderson)**

Plate 3, figures 1-3, 10, 15

Nassa arnoldi Anderson, 1905. California Acad. Sci. Proc., ser. 3, v. 2, p. 204, pl. 16, figs. 70, 71.

Nassarius (Hima) arnoldi (Anderson). Etherington, 1931, California Univ., Dept. Geol. Sci. Bull., v. 20, p. 99, pl. 12, figs. 15, 19.

Nassarius arnoldi (Anderson). Weaver, 1942, Washington Univ. Pub. Geology, v. 5, p. 461, pl. 89, fig. 14.

Uzita? arnoldi (Anderson). Moore, 1963, U.S. Geol. Survey Prof. Paper 419, p. 39, pl. 5, figs. 14, 16-20.

Small, commonly low spired; sculpture cancellate. Spire conical, consisting of about four whorls. Nucleoconch of about two smooth whorls. Body whorl globose, sculptured by 10-13 spiral cords crossed by slightly retractive axial ribs of variable strength. The subsutural pair of spiral cords are more sharply noded

than the lower spirals. Base of body whorl bordered by a narrow, incised fossa. Aperture subovate, base subtruncate. Outer lip thickened externally by a varix, coarsely denticulate within. Columellar lip has a narrow, fairly thick callus bordered anteriorly by a strong fold and bearing an anterior and a posterior spiral plait. Siphonal fasciole sculptured by about five spiral cords.

Height 7.4 mm, width 4.6 mm (neotype).

Holotype lost during the 1906 San Francisco fire. *Neotype* (here designated): USNM 648577.

Type locality: In the vicinity of Barker's Ranch (formerly located near the center of sec. 5, T. 29 S., R. 29 E., Bakersfield quad.). This and other newly described species were collected "chiefly north of the [Kern] river" (Anderson, 1905, p. 187). The neotype is from USGS Cenozoic loc. M1597, which is within Anderson's generalized description of the original type locality. Olcese Sand of Diepenbrock (1933), middle Miocene.

Nassarius arnoldi is characterized by its small, stout shell and finely reticulate sculpture and by the pair of strongly nodose spiral cords at the top of the body whorl. The outer lip is always thickened by a varix, and other varices appear randomly at earlier resting stages on a few specimens. Specimens from the vicinity of the type locality are characteristically very small, low spired, and not particularly variable. At other localities, however, there is considerable variation in ornamentation and spire height. The axial sculpture ranges from very strong on some specimens to nearly obsolete on the body whorl of other specimens. Occasional high-spired specimens are present in collections from the Kern River area, California.

Middle Miocene species with which *Nassarius arnoldi* occurs are *N. antiselli* (Anderson and Martin) and *N. smooti* Addicott, n. sp. *N. antiselli* differs from *N. arnoldi* by having eight coarsely papillose spiral cords on the body whorl and only three spirals on the penultimate whorl. The base of *N. antiselli* is not strongly constricted as in *N. arnoldi* nor does it have a particularly well-defined fossa. *Nassarius smooti* differs from *N. arnoldi* by having a thick apertural callus, excavated sutures, and coarse axial folds.

This species occurs in the Astoria Formation in Oregon and Washington and is one of the taxa used to correlate that formation with deposits of middle Miocene age in California. It also occurs with middle Miocene species in strata conformably underlying the Astoria Formation; these strata have been mapped as the Lincoln Formation of Weaver (1912) (Gower and Pease, 1964) in the Montesano Quadrangle, Grays Harbor County, Wash. (pl. 3, fig. 15). In California, *Nassarius arnoldi* is known only from strata that are classified as middle Miocene.

Range: Middle Miocene.

Occurrence: Uppermost part of Lincoln Formation of Weaver

(1912), Grays Harbor County, Wash. (USGS Cenozoic locs. M1496, M1514). Astoria Formation: Grays Harbor County, southwestern Washington (Etherington, 1931; Weaver, 1942); coastal Oregon (Arnold and Hannibal, 1913; Moore, 1963). Monterey Group: Point Reyes area, Sonoma County, and San Pablo Bay area, both in California (Weaver, 1949). Temblor Formation: La Panza area, San Luis Obispo County, Calif. (Loel and Corey, 1932). Reef Ridge area, California (Stewart, 1946). Round Mountain Silt and other Olcese Sand of Diepenbrock (1933), Kern River district, California. Altamira Shale Member of Monterey Shale, Palos Verdes Hills, California (Woodring and others, 1946, p. 27) as "*Nassa*" aff. "*N.*" *arnoldi*.

Nassarius (Cation) *smooti* Addicott, n. sp.

Plate 3, figures 7-9

Shell small, stout, low spired. Nucleus consisting of two smooth whorls. Whorls of spire slightly convex, sculptured by 10 or 11 broad axial ribs and 5 spiral cords. Sutures deeply excavated, wavy. Body whorl sculptured by coarse axial folds and 12 or more spiral cords separated by narrow interspaces. Basal fossa separated anteriorly from siphonal fasciole by strong spiral cord and groove. Apertural lip varicose externally, denticulate within. Very thick, narrow parietal callus bearing a posterior plait and a single denticle above the spiral fold at the base of the columella. Base of aperture subtruncate.

Height 7.2 mm, width 4.3 mm (type).

Holotype: USNM 648578.

Type locality: USGS Cenozoic loc. M1597. In abandoned roadbed at mouth of small gully, 1,300 ft S., 350 ft W. from NE. cor. sec. 5, T. 29 S., R. 29 E., Oil Center quadrangle. Upper part of Olcese Sand of Diepenbrock (1933), middle Miocene.

This species differs from the known eastern Pacific *nassariids* included in *Cation* by its distinctive sculpture, extremely thick yet narrow parietal callus, and wavy, deeply excavated sutures. On the three available specimens, all from the type locality, there seems to be considerable variation in spiral sculpture. A fragmentary specimen has wellformed secondary spiral threads on the body whorl. The axial folds become obsolete on the lower half of the body whorl. *Nassarius smooti* most nearly resembles *N. arnoldi*, with which it occurs at the type locality.

Occurrence: Upper part of Olcese Sand of Diepenbrock (1933), middle Miocene, Kern River area, Kern County, Calif.

Nassarius (Cation?) *antiselli* (Anderson and Martin)

Plate 3, figures 13, 14

Nassa antiselli Anderson and Martin, 1914, California Acad. Sci. Proc., ser. 4, v. 4, p. 76-77, pl. 7, fig. 16.

Nassarius pabloensis (Clark). Clark, 1929, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 34, fig. 13.

Holotype: CAS 165.

Type locality: CAS loc. 126, in the bed of a small creek near the center of sec. 34, T. 28 S., R. 15 E., San Luis Obispo County, Calif., Middle Miocene.

Nassarius antiselli is a small, rather slender species characterized by coarsely papillose sculpture, a very weak basal fossa, and fewer spiral cords than in similar species from the Miocene of the Pacific coast. There are three spiral cords on the penultimate whorl of the type specimen and 8 on the body whorl. It differs in this respect from *N. arnoldi*, with which it sometimes occurs, which has 4 or 5 spirals on the penultimate whorl and 10-13 on the body whorl.

The coarse sculpture and rather slender profile of *N. antiselli* might be taken to suggest a link with the early Miocene species, *N. churchi* (Hertlein), but specimens of the latter are insufficient to permit more than speculation as to possible relationships.

This middle Miocene species is questionably placed in *Cation* because of the lack of a well-defined basal fossa and the uncertainty of the apertural characteristics.

Clark (1929, pl. 34, fig. 13) reproduced Anderson and Martin's original figure of *Nassa antiselli* (1914, pl. 7, fig. 16) as *Nassarius pabloensis* (Clark).

Range: Middle Miocene.

Occurrence: Monterey Group or Monterey Shale: Sonoma County and northern Contra Costa County, Calif. (Weaver, 1949)⁴; Sobrante Sandstone, Contra Costa County, Calif. (Weaver, 1953)⁴. Temblor Formation, La Panza Range, San Luis Obispo County, Calif. (Anderson and Martin, 1914). Branch Canyon Formation and Saltos Shale Member of the Monterey Formation (Hill and others, 1958), Caliente Range, San Luis Obispo County, Calif. (Repenning and Vedder, 1961). Round Mountain Silt of Diepenbrock (1933), Kern River area, Calif. (Keen, 1943).

Nassarius (Cation) *pabloensis* (Clark)

Plate 3, figures 22-25

Nassa pabloensis Clark, 1915, California Univ., Dept. Geology Bull., v. 8, p. 493-494, pl. 65, figs. 8, 9.

Nassarius pabloensis (Clark). Clark, 1929, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 34, fig. 17, not fig. 13.

Holotype: UCMP 11637.

Type locality: UCMP loc. 1947, south side of highest hill south of and parallel to Shell Ridge, southeast of the town of Walnut Creek, alt 500 ft, Concord quadrangle, Contra Costa County, Calif. Upper part of San Pablo Group, late Miocene.

Nassarius pabloensis is a slender, high-spined *nassariid* of medium size. It has equally strong spiral and axial sculpture that varies from coarsely cancellate to nodose. The body whorl commonly has nine spiral cords.

⁴ These occurrences have not been verified and may possibly be misidentifications of *Nassarius whitneyi* (Trask), a locally abundant species in middle Miocene strata in this part of central California.

This species is similar to some of the high-spired variants of *Nassarius andersoni* (Weaver) from the Quinault Formation of western Washington (pl. 3, figs. 17, 18). It is, however, generally more slender and lacks the tabulate whorl profile of the northern species. From *N. iniquus* (Stewart), a Pliocene species from central California, it can be readily differentiated by its finer sculpture and well-rounded, nontabulate whorls. Some large specimens from the Santa Margarita Formation at Comanche Point, Kern County, Calif., have 10 spirals and a deeply excavated interspace between the two uppermost cords (pl. 3, fig. 24).

The suggested inclusion of this species and *Nassarius andersoni* in the synonymy of *N. antiselli* (Anderson and Martin) (Grant and Gale, 1931, p. 678), a species questionably included in the subgenus *Catilon*, can be disregarded. *N. antiselli* has only a vague indication of a basal fossa, virtually no siphonal fasciole, and very coarsely nodose sculpture very different from that of either *N. pabloensis* or *N. andersoni*. In view of this treatment, it seems probable that Gale's identification (in Preston, 1931, p. 16) of "*Nassarius (Uzita) antiselli* (Anderson and Martin) (*pabloensis* Clark)" from well cores of the Santa Margarita Formation near Bakersfield, Calif., is in fact, *N. pabloensis*.

Range: Upper Miocene.

Occurrence: Upper part of San Pablo Group (Clark, 1915), or Neroly Formation (Weaver, 1949), northern Contra Costa County, Calif. Santa Margarita Formation: well cores from Fruitvale oil field, Bakersfield, Calif. (Gale in Preston, 1931); Comanche Point, Kern County, Calif. (Addicott and Vedder, 1963).

***Nassarius (Catilon) stocki* Kanakoff**

Plate 3, figures 4, 5

Nassarius stocki Kanakoff, 1956, Southern California Acad. Sci. Bull., v. 55, p. 110-112, pl. 30, figs. A-C.

Holotype: LACMIP 1109.

Type locality: LACMIP loc. 291, gully in center of the S½ sec. 27, T. 4 N., R. 15 W., exactly one-half mile south of Humphreys Station of the Southern Pacific RR., Los Angeles County, Calif. Pico Formation [=Towsley Formation (Jahns and Muehlberger, 1954)] early Pliocene.

This small, stout species is characterized by a well-rounded body whorl, short spire, and evenly cancellate sculpture. There is a narrow excavated area at the base of the whorls of the spire.

Nassarius stocki seems to be most similar to the middle Miocene *N. arnoldi* (Anderson) but it differs from that species by having only nine spiral cords on the body whorl and by having four fine denticles on the parietal callus which characteristically occur as anterior and posterior pairs (Kanakoff, 1956, p. 111). A species that has been named *N. hildegardae* Kanakoff (1956) (pl. 3, figs. 11, 12) from the same locality may be a slender, high-spired variant of this species.

This species has been recognized in two localities in the eastern part of the Ventura basin, Calif. The type locality of *Nassarius stocki* occurs in a unit that has been recently mapped as the Towsley Formation by Jahns and Muehlberger (1954). The age of the Towsley Formation in this area is early Pliocene based upon the record of *Trophosycon ocoyana* var. and *Patinopecten lohri* that Grant and Gale (1931, p. 30) reported from exposures on the first ridge west of the type locality of *N. stocki*.

Range: Upper Miocene to lower Pliocene.

Occurrence: Upper Miocene: Castaic Formation of Crowell (1955), eastern Ventura basin, California.⁵ Lower Pliocene: Pico [Towsley] Formation (Kanakoff, 1956), eastern Ventura basin, California.

***Nassarius (Catilon) andersoni* (Weaver)**

Plate 3, figures 16-18

Nassarius andersoni Weaver, 1912, Washington Geol. Survey Bull. 15, p. 75, pl. 6, fig. 56.

Nassarius (Hima) andersoni (Weaver). Etherington, 1931, California Univ., Dept. Geol. Sci. Bull., v. 20, p. 100, pl. 12, figs. 4, 16.

Nassarius andersoni (Weaver). Weaver, 1942, Washington Univ. Pub. Geology, v. 5, p. 461-462, pl. 89, figs. 15-18.

Holotype: UW 75.

Type locality: UW loc. 117, in bank of Wishkah River, sec. 30, T. 20 N., R. 8 W., Grays Harbor County, Wash. (locality occurs in area mapped as Montesano Formation by Weaver (1916) and as undifferentiated Miocene-Pliocene on the Washington State Geologic Map, 1961).

Nassarius andersoni is characterized by strongly reticulate sculpture, tabulate whorls, usually nine spiral ribs on the body whorl, and an ovate aperture. The holotype and species figured by Etherington (1931, pl. 12, figs. 4, 16) are moderately low spired and vary from nodose to evenly cancellate in sculpture. Other specimens from the Quinault Formation of western Washington (pl. 3, figs. 17, 18) are moderately high spired and characteristically have rather coarse axial ribs. The species from the type section of the Quinault Formation between Point Grenville and the Quinault River has been incorrectly identified as *N. mendicus* (Gould) by Arnold and Hannibal (1913, p. 594) and as *N. arnoldi* (Anderson) by Weaver (1916, p. 216). It differs from these species by having a subsutural tabulation, only nine spiral ribs on the body whorl, and, in the specimen identified as *N. mendicus*, a varicose apertural lip.

Similar late Miocene and early Pliocene species from California, such as *Nassarius pabloensis* and *N. hildegardae*, also have nine spiral ribs on the body whorl but can be differentiated from *N. andersoni* by their evenly

⁵ Stanton, R. J., Jr., 1960, Paleogeology of the Upper Miocene Castaic Formation, Los Angeles County, California: California Inst. Technology, Pasadena, Ph. D. Thesis, 332 p.

rounded, nontabulate whorls and generally more slender, higher spired shells.

Until a definitive investigation of the molluscan biostratigraphy of Weaver's Montesano Formation (1912) and related strata of presumed late Miocene to Pliocene age in western Washington is made, the chronologic-stratigraphic range of *Nassarius andersoni* will remain uncertain. As far as is known, this species has not been collected from the lowermost conglomeratic sandstones of the type Montesano Formation in the Aberdeen-Montesano area. The fauna from this part of the formation has stronger affinities to the middle Miocene molluscan fauna of the Astoria Formation than to Pliocene mollusks of the Empire Formation⁶ of Oregon and therefore is tentatively considered to be late Miocene. Collections that are presumed, however, to be stratigraphically higher in the Montesano Formation, such as those from the Wishkah River in the vicinity of the type locality of *N. andersoni*, have many species in common with the Empire Formation and, accordingly, have been classified as Pliocene.⁷ Inasmuch as the known occurrences of *N. andersoni* seem to be from strata above the basal sandstone beds, the range is tentatively considered to be Pliocene.

An incomplete external mold of a small *Nassarius* in a beach stone collected by George Moore (loc. AMe 62-154) from the northern part of Chirikof Island, southwestern Alaska, is tentatively referred to this species. It has the slightly angulated body whorl, similar sculpture, and the same number of spiral ribs as specimens of *N. andersoni* from the Quinault Formation of western Washington. It cannot be classified, however, subgenerically because the apertural side is missing. If, as seems most likely, the Alaskan specimen is correctly assigned to *Catilon*, then it is the northernmost occurrence of the subgenus in Cenozoic strata of Western North America.

Range: Pliocene?

Occurrence: Pliocene?, Montesano Formation, Grays Harbor County, Wash. (Weaver, 1912, 1916; Etherington, 1931); Quinault Formation, Jefferson County, Wash., (USGS Cenozoic loc. M1827). Beach stone of unknown age, Chirikof Island, Alaska (collected by George Moore, loc. AMe 62-154).

***Nassarius (Catilon) hamlini* (Arnold)**

Plate 3, figures 20, 21

Nassa hamlini Arnold, 1907, U.S. Natl. Museum Proc., v. 32, p. 537-538, pl. 50, fig. 9.

⁶ The molluscan fauna of the Empire Formation was considered Pliocene by Howe (1922), an age that has been generally accepted by subsequent investigators.

⁷ *Nassarius andersoni* occurs in the basal sandstone beds of the type section of the Quinault Formation immediately north of Point Grenville. Foraminifera that have been classified as Pliocene by Cushman and others (1949) are from localities higher in the section.

Eldridge and Arnold, 1907, U.S. Geol. Survey Bull. 309, pl. 40, fig. 9.

"*Nassa*" *hamlini* Arnold. Woodring, 1938, U.S. Geol. Survey Prof. Paper 190, p. 25-26, pl. 5, fig. 16.

Holotype: USNM 164946.

Type locality: USGS loc. 3426, Third Street tunnel, Los Angeles, Calif. Repetto Formation of common usage, early Pliocene.

This species can be readily distinguished from other late Cenozoic nassariids of the subgenus *Catilon* by its blunt apex and its prominent, widely spaced axial ribs that are nearly vertical. The spiral ribs are much subdued; they number 10 or 11 on the body whorl of most specimens and are much more closely spaced than the sharp axial ribs.

Range: Lower Pliocene.

Occurrence: Towsley Formation and Pico Formation, eastern Ventura basin, California (Winterer and Durham, 1962). Repetto Formation, Los Angeles Basin, Calif. (Arnold, 1907b; Woodring, 1938). Unnamed sandstone (Vedder and others, 1957), east of the Narrows, Newport Bay, Calif. (USGS Cenozoic loc. M1921).

***Nassarius (Catilon?) salinasensis* Addicott, n. sp.**

Plate 3, figures 30, 31

Shell of medium size, moderately high spired. Nuclear whorls missing. Whorls of spire gently convex, sculptured by about four straplike spiral ribs and random secondaries. Suture impressed, subtabulate on later whorls. Body whorl sculptured by sinuous axial folds of variable strength that become obsolete toward base. Spiral sculpture of 14 or more irregularly alternating straplike ribs. Base bordered by well-formed fossa. Siphonal fasciole sculptured by three strong cords. Aperture missing.

Height (incomplete) 16.9 mm, width 9.6 mm.

Holotype: USNM 648597.

Type locality: USGS Cenozoic loc. M977. On south side of Pancho Rico Creek, 100 ft N., 3,100 ft W. of SE cor. sec. 11, T. 22 S., R. 10 E., San Ardo quadrangle, Monterey County, Calif. Type Pancho Rico Formation, early Pliocene.

Nassarius salinasensis is represented by three incomplete specimens from the type locality. All are external molds from which latex rubber casts have been prepared. Although the apertural characteristics are preserved in none of the specimens, this species is tentatively assigned to *Catilon* on the basis of the varicose outer lip of one specimen (pl. 3, fig. 31).

The sculpture of irregular straplike spiral cords upon which are superimposed broad, sinuous axial folds is unique among the known late Cenozoic nassariids of the Pacific coast. Considerable variation in the number and arrangement of spiral cords and the strength of axial folds is suggested by the three specimens from the type locality.

This species occurs with an early Pliocene molluscan assemblage that includes *Turritella cooperi*, *T. vanvlecki*, *Forreria belcheri*, *Calicantharus kettlemanensis*, *Ostrea atwoodi*, *Lyropecten terminus*, and other species.

Occurrence: Pancho Rico Formation, early Pliocene, Pancho Rico Creek, Monterey County, Calif.

***Nassarius (Catilon) hildegardae* Kanakoff**

Plate 3, figures 11, 12

Nassarius hildegardae Kanakoff, 1956, Southern California Acad. Sci. Bull., v. 55, p. 112-113, pl. 31 (two views).

Holotype: LACMIP 1110.

Type locality: LACMIP loc. 291, gully in center of the S½ sec. 27, T. 4 N., R. 15 W., exactly one-half mile south of Humphreys Station of the Southern Pacific Railroad, Los Angeles County, Calif. Pico Formation [=Towsley Formation (Jahns and Muehlberger, 1954)], early Pliocene.

This small, slender nassariid is known only from the type locality at which it occurs with *Nassarius stocki* (Kanakoff). Although smaller and somewhat higher spired than *N. stocki*, it has the same number of spiral cords on the body whorl, nine, and a similar whorl profile. In view of the known variation in spire height of other species of *Nassarius*, there is a strong possibility that *N. hildegardae* should be treated as a high-spired variant of *N. stocki*.

Occurrence: Pico [=Towsley] Formation, early Pliocene, eastern Ventura basin, California (Kanakoff, 1956).

***Nassarius (Catilon) iniquus* (Stewart)**

Plate 3, figure 6

Nassa californiana (Conrad). Arnold, 1910, U.S. Geol. Survey Bull. 396, p. 160, pl. 27, fig. 8. Figure reprinted in Arnold and Anderson, 1910, U.S. Geol. Survey Bull. 398, p. 334, pl. 49, fig. 8. Figure reproduced in Roberts, 1927, California Oil Fields, v. 12, no. 10, pl. 3, fig. 1.

Nassarius (Uzita) arnoldi (Anderson) var. *whitneyi* (Trask) Grant and Gale, 1931. San Diego Soc. Nat. History Mem., v. 1, p. 679, pl. 26, figs. 48a, b.

"*Nassa miser* (Dall) var. *iniqua* Stewart in Woodring, Stewart, and Richards, 1940. U.S. Geol. Survey Prof. Paper 165, p. 87, pl. 34, fig. 8.

Holotype: USNM 495836.

Type locality: USGS loc. 14129, below road west of El Tolete, 900 ft northwest of USGS loc. 14131 (1,200 ft N., 1,840 ft W. from SE cor. sec. 7, T. 22 S., R. 18 E., MDB&M, Kettleman Hills, Calif.), *Patinopecten* zone, Etchegoin Formation, Pliocene.

The body whorl of *Nassarius iniquus* is sculptured by seven coarsely papillose spiral cords. Occasional specimens have eight spirals. The summits of the whorls are tabulate, and there is a deep spiral fossa at the base of the body whorl. Other species of *Catilon* from the late Miocene and Pliocene of California and Washington are much more delicately sculptured than *N. iniquus* and have a larger number of spiral ribs.

A Pliocene nassariid from a well core near Tipton, Calif., figured by Grant and Gale (1931, pl. 26, figs. 48a, b) as *Nassarius arnoldi* var. *whitneyi* (Trask) has the tabulate whorl profile and sculpture of *N. iniquus* and is here included in the synonymy of this species. It need not be compared with *N. whitneyi*, a species that has been incorrectly diagnosed as having a varicose outer lip. The suggested varietal relationship with *N. arnoldi* seems doubtful in view of the thick, coarsely papillose shell which is characteristic of *N. iniquus*.

A variant of *Nassarius iniquus* occurs in a collection of early Pliocene mollusks from Elsmere Canyon, Los Angeles County, Calif. (C. M. Carson Colln., SU). These specimens are more weakly noded and considerably more elongate than is typical of *N. iniquus*.

The varietal relationship to *Nassarius miser* (Dall) suggested by Stewart (in Woodring and others, 1940) is doubtful. The bathymetric range of that species, 140-320 fathoms (Keen, 1958, p. 410), is not compatible with the relatively shallow water aspect of molluscan assemblages of the Etchegoin Formation in which *N. iniquus* occurs.

Range: Pliocene.

Occurrence: Etchegoin Formation: Alcalde Canyon south of Coalinga, Calif. (Arnold, 1909); Kettleman Hills (Woodring and others, 1940), well core near Tipton, Calif. (Grant and Gale, 1931); Diablo Range, San Benito quadrangle (UCMP colln.), Towsley(?) Formation, Elsmere Canyon, Los Angeles County (C. M. Carson Colln., loc. 16; SU).

SUBGENUS?

***Nassarius ocoyanus* (Anderson and Martin)**

Plate 3, figures 19, 26-28

Nassa ocoyana Anderson and Martin, 1914, California Acad. Sci. Proc., ser. 4, v. 4, p. 75-76, pl. 7, fig. 17.

?*Nassa blakei* Anderson and Martin, 1914, California Acad. Sci. Proc., ser. 4, v. 4, p. 76, pl. 7, figs. 15a, b.

Nassarius ocoyanus is a distinctive but variable species of rare occurrence at a few middle Miocene localities in California. The turreted spire is sculptured by coarse axial folds. The body whorl is slender and has relatively smooth, parallel sides. Most specimens have weak spiral cords on the anterior and posterior shoulders of the body whorl. On some individuals there are faint axial folds on the uppermost part of the body whorl. The basal fossa is broad and nearly obsolete on most specimens. The aperture is bordered internally by a thick parietal callus bearing a spiral plait anterior to the strong posterior notch. There are weak denticles within the varicose outer lip on at least one specimen.

Holotype: CAS 163.

Type locality: CAS loc. 64, in bottom of small creek, 1¼ miles due north from Barker's Ranch House (near top of Olcese Sand

of Diepenbrock (1933), middle Miocene). Probably in SE $\frac{1}{4}$ sec. 31, T. 28 S., R. 29 E., Oil Center quadrangle, California.

Holotype of "*Nassa*" *blakei*: CAS 180.

Type locality: CAS loc. 65, on west bank of small canyon 1 $\frac{1}{4}$ miles northeast of Barker's Ranch House (near top of Olcese Sand of Diepenbrock (1933), middle Miocene).

This species appears to show considerable variation in the height of the spire and inflation of the whorls. The body whorl profile varies from gently convex to parallel sided in specimens from UCMP locality B1637 near the top of the Olcese Sand. Specimens from Diepenbrock's (1933) overlying Round Mountain Silt, UCMP locality B1639, which are somewhat abraded and mildly deformed, have parallel to concave sides. The degree of variation in whorl profile and spire height seems to be sufficient enough to include *Nassarius blakei* (Anderson and Martin, 1914, p. 76, pl. 7, figs. 15a, b), a low-spired species described from a single specimen, as a synonym. *N. blakei* was collected from a locality less than a mile southeast of the type locality of *N. ocoyanus* and is from approximately the same stratigraphic position.

Range: Middle Miocene.

Occurrence: Round Mountain Silt and upper part of Olcese Sand of Diepenbrock (1933), Kern River district, California. Temblor Formation, eastern San Luis Obispo County, Calif. (Loel and Corey, 1932). Saltos Shale Member of the Monterey Formation (Hill and others, 1958), Caliente Range, eastern San Luis Obispo County (USGS Colln.).

LOCALITY DESCRIPTIONS

WASHINGTON LOCALITIES

USGS Cenozoic locality:

- M1496. Cut on south side of logging road at topographic saddle west of small hill near E $\frac{1}{4}$ cor. SE $\frac{1}{4}$ sec. 23, T. 17 N., R. 7 W., Montesano quadrangle. Astoria Formation, middle Miocene. Collected by H. D. Gower and W. O. Addicott, 1962.
- M1514. 1,800 ft W., 2,700 ft S. of NE. cor. sec. 1, T. 16 N., R. 8 W., Montesano quadrangle. Immediately below top of Lincoln Formation of Weaver (1912), middle Miocene. Collected by H. D. Gower, 1959.
- M1545. Cut on south side of Still Creek logging road, 2,200 ft W., 400 ft N. of SE. cor. sec. 5, T. 18 N., R. 7 W., Wynoochee Valley quadrangle. Montesano Formation of Weaver (1912), Pliocene(?). Collected by W. O. Addicott, 1962.
- M1827. Sea cliff exposure on beach north of Point Grenville, 3,450 ft W., 1,250 ft S. of NE. cor. sec. 13, T. 21 N., R. 13 W., Taholah quadrangle. Quinault Formation, Pliocene. Collected by W. O. Addicott, 1962.

OREGON LOCALITIES

USGS Cenozoic locality:

18284. Dredgings from ship channel between mile 3.5 and mile 4.0, Coos Bay, Oreg., deposited northwest of the channel alongside of North Spit opposite Cape Arago Pulp Mill, about 1 $\frac{1}{4}$ miles southwest of Empire, Oreg. Miocene. Collected by E. J. Moore, 1949-54.

18907. Shale and siltstone exposed in beach at low tide just south of Yaquina Head, Yaquina quadrangle. Astoria Formation, middle Miocene. Collected by M. P. James, 1953.

University of Washington (UW) locality:

691. Stratified medium-grained sandstone exposed on beach on south side of Yaquina Head, 5 $\frac{1}{2}$ miles (3 $\frac{1}{2}$ miles) north of entrance to Yaquina Bay, Lincoln County. Astoria Formation, middle Miocene.

California Academy of Sciences (CAS) locality:

39. Sea cliff immediately south of Nye Beach and a short distance north of entrance to Yaquina Bay, Lincoln County. Astoria Formation, middle Miocene.

CALIFORNIA LOCALITIES

USGS Cenozoic locality:

- M979. Pancho Rico Creek east of San Ardo, 700 ft S., 1,200 ft W. of NE. cor. sec. 15, T. 22 S., R. 10 E., San Ardo quadrangle. Type area of the Pancho Rico Formation, early Pliocene. Collected by D. L. Durham, 1960.
- M982. Cut on west side of U.S. Route 101, 150 ft N., 2,525 ft W. of SE. cor. sec. 25, T. 23 S., R. 10 E., Wunpost quadrangle. Pancho Rico Formation, early Pliocene. Collected by Vedder and Reppenning, 1960; Vedder and Addicott, 1963.
- M996. Pine Creek east of San Lucas, 900 ft S., 150 ft E. of NW. cor. sec. 15, T. 21 S., R. 10 E., San Ardo quadrangle. Pancho Rico Formation, early Pliocene. Collected by Charles Rice.
- M1017. Marine terrace deposit now covered by houses, approximately 19,850 ft N., 19,750 ft W. of SE. cor. Laguna Beach quadrangle (1949 ed.) or approximately 1,125 ft east-northeast of Abalone Point triangulation station. Late Pleistocene. Alt 50-60 ft. Collected by J. G. Vedder, 1954.
- M1455. Cut on west side of San Antonio River road, 2,975 ft N., 650 ft E. of SW. cor. sec. 36, T. 23 S., R. 8 E., Williams Hill quadrangle. Pancho Rico Formation, early Pliocene. Collected by D. L. Durham, 1962.
- M1597. 1,300 ft S., 350 ft W. of NE. cor. sec. 5, T. 29 S., R. 29 E., Oil Center quadrangle. Upper part of the Olcese Sand of Diepenbrock (1933), middle Miocene. Collected by W. O. Addicott, 1962. Same as UCMP loc. B1598.
- M1619. Near head of second Ely-trending gully due north of Hill 1039, in NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 24, T. 32 S., R. 29 E., Arvin 7 $\frac{1}{2}$ -minute quadrangle. Santa Margarita Formation, late Miocene. Collected by J. G. Vedder and W. O. Addicott, 1962, 1963.
- M1661. Large cut in hillside 950 ft S. 61° W. of intersection of Junipero Serra Boulevard and Arroyo Drive, 1,434,850 ft E., 423,600 ft N. (California coordinate system, zone 3), San Francisco South quadrangle. Merced Formation, late Pliocene. Collected by M. G. Bonilla and G. O. Gates, 1962.
- M1690. Sea cliff exposure of upper Pleistocene marine terrace deposit above small sandy beach 0.5 mile east-northeast of Point Año Nuevo and 1,100 ft south of road head shown on map, in projected T. 9 S., R. 4 W., Año Nuevo quadrangle. Collected by W. O. Addicott, 1962.

- M1715. Cut and pipeline trench on north side of Arastradero Road, 1,200 ft west of intersection with Page Mill Road, Palo Alto 7½-minute quadrangle. Merced(?) Formation, late Pliocene. Collected by E. H. Pampeyan, J. G. Vedder, and W. O. Addicott, 1963.
- M1717. Cut in hillside at northernmost edge of Santa Barbara County dump on south side of Foothill Boulevard approximately 1,000 ft due west of entrance to Federated Sportsmans Field and three-fourths of a mile west of intersection of Foothill Boulevard and State Highway 150, Goleta quadrangle. Santa Barbara Formation, late Pliocene. Collected by W. O. Addicott, 1963.
- M1720. Cut on south side of highest building site for American Institute for Research buildings on southwest side of Arastradero Road, 2,200 ft due east of intersection with Alpine Road, Palo Alto 7½-minute quadrangle. Merced(?) Formation, late Pliocene. Collected by M. Crittenden and W. O. Addicott, 1962.
- M1723. "New lumber yard" across from Sun Lumber Co., 1800A Wilmington Road, San Pedro, Calif. Palos Verdes Sand, late Pleistocene. Collected by Mark Rogers.
- M1728. Arnold's lumber yard locality (1903) on Harbor Boulevard, San Pedro, Calif. Palos Verdes Sand, late Pleistocene. Collected by Mark Rogers.
- M1733. Cut on north side of Highway 101, 6,000 ft west-northwest of east boundary of Rancho Cañada de San Miguelito. West edge of exposure is due north of BM 26, east edge truncated by Pleistocene terrace gravels, Ventura 7½-minute quadrangle. Saugus Formation, early Pleistocene. Collected by W. O. Addicott and J. G. Vedder, 1962.
- M1805. Cut on south side of Riverside Road approximately 6,000 ft east-southeast of Chittenden Station, San Juan Bautista 15-minute quadrangle. Purisima Formation, Pliocene. Collected by W. O. Addicott, 1962. Probably same as UCMP loc. 1766.
- M1918. Cut on west side of Fairview Road immediately north of high-angle reverse fault, 1,050 ft S., 100 ft E., of NW cor. of Rancho La Goleta land grant, Goleta quadrangle. Santa Barbara Formation, late Pliocene. Collected by W. O. Addicott, 1963.
- M1921. Near base of bluff on east side of Palisades Road, 2,625 ft SE., 2,975 ft of NE. cor. Irvine block 52, Newport Beach quadrangle (1951 ed.). Alt about 15 ft. Unnamed sandstone of Pliocene age. Collected by J. G. Vedder, 1954.
- M1922. On southwest side of northwest-trending gully near intersection of State Highway 55 and U.S. Highway 101 alt., 2,150 ft E., 1,875 ft S. of NW cor. sec. 28, T. 6 S., R. 10 W., Newport Beach quadrangle (1951 ed.). Palos Verdes Sand, late Pleistocene. Collected by J. G. Vedder, 1961.
- M1923. Concretionary bed 3,025 ft S., 850 ft W. of NE. cor. sec. 30, T. 11 N., R. 26 W., Wells Ranch quadrangle (1954 ed.). Saltos Shale Member of Monterey Formation (Hill and others, 1958), middle Miocene. Alt about 2,850 feet. Collected by J. G. Vedder, 1960.
4758. Bed C near top of section at Henry Spring, 4 miles south-southwest of Coalinga, on east side of 1,900-foot hill in SW¼ sec. 18, T. 21 S., R. 15 E. Etchegoin Formation, Pliocene. Collected by Ralph Arnold and Robert Anderson.
12359. Arroyo Degollado, North Dome, Kettleman Hills, 320 ft S., 780 ft W. of NE. cor. sec. 22, T. 22 S., R. 18 E. *Pecten* zone and *Trachycardium* zone of the San Joaquin Formation, Pliocene. Collected by Ralph Stewart.
- USNM Catalog Number:*
101721. Pleistocene [Pliocene], Santa Barbara, Calif. Stearns colln.
University of California Museum of Paleontology, Berkeley, (UCMP) locality:
1549. Exposures on beach south of Bolinas, Marin County, Calif. Merced Formation, late Pliocene.
7033. On east bank of Russian River at Wilson Ranch, 3½ miles southwest of Windsor, Sonoma County, Calif. Merced Formation, Pliocene.
7071. In creek bottom 1¼ miles north of mouth of canyon located 1 mile east of Harmon Canyon, Santa Paula quadrangle. Saugus Formation, early Pleistocene(?). Collected by L. N. Waterfall.
7078. From about ½-mile zone extending northward from mouth of first large canyon east of Ventura River, located at head of Kalorama Street, Ventura, Calif., Ventura quadrangle. Saugus Formation, early Pleistocene(?). Collected by L. N. Waterfall.
7091. Artificial cut in low ridge near SW cor. sec. 34, T. 3 N., R. 21 W., Ventura County. Saugus Formation, early Pleistocene(?). Collected by L. N. Waterfall.
7092. Second ridge east of farmhouse on south side of South Mountain near NW cor. sec. 3, T. 2 N., R. 21 W., Ventura County. Saugus Formation, early Pleistocene(?). Collected by L. N. Waterfall.
A1304. Roadcut in Alcalde Canyon, southwest of Coalinga, in SE¼SE¼ sec. 7, T. 21 S., R. 15 E., *Glycymeris* zone of the Etchegoin Formation, Pliocene.
A3166. "*Merriamaster coalingensis* zone" in NW¼ sec. 8, T. 22 S., R. 18 E., La Cima quadrangle, San Joaquin Formation, Pliocene.
A4920. In large rock quarry 1 mile south of Pacheco, 1,400 ft W., 200 ft S., of junction of quarry road with Pacheco Boulevard, Concord quadrangle. Briones Sandstone, late Miocene. Collected by G. C. Lutz.
A4925. In subcanal 30 ft west of main canal at point where canal swings eastward to bypass small hill, Concord quadrangle (locality subsequently covered by concrete). Sobrante Formation of Lutz (1951), middle Miocene. Collected by G. C. Lutz.
B1639. *Polinices* biostrome 31 ft stratigraphically below B1613, SW¼SE¼ sec. 26, T. 28 S., R. 29 E., Caliente quadrangle. Round Mountain Silt of Diepenbrock (1933), middle Miocene. Collected by W. O. Addicott, 1954.
B4739. One and seven-tenths miles north of northeast end of spillway 456, Lafayette Reservoir and 1,700 ft north of intersection of Happy Valley Road and Panorama Drive, Briones quadrangle (1949 ed.). Alt 925 ft. San Pablo Formation, late Miocene. Collected by G. I. Doumani.
B4749. Two and one-fourth miles north of northwest end of spillway 456, Lafayette Reservoir below the 1,345-foot peak on Lafayette Ridge, Briones quadrangle (1949 ed.). Alt 1,250 ft. Lower part of Briones Sandstone, late Miocene. Collected by G. I. Doumani.

B4810. Exposures in long landslide on Seven Mile Beach, about 2,000 ft N. 75° W. of intersection of Alemany Boulevard and Skyline Boulevard, San Francisco South quadrangle (1947 ed.). Upper part of the type Merced Formation, early Pleistocene. Collected by William Glen, 1957.

B7642. Railroad-cut 2,011–2,219 ft southwest of Nanning Creek crossing, between 2,163 ft and 2,309 ft stratigraphically above the base of the Rio Dell Formation (2,142–2,288 ft below top of Rio Dell Formation), Scotia quadrangle (1951 ed.). Rio Dell Formation of Ogle (1953), Pliocene. Collected by W. Faustman, Jr., 1960.

California Academy of Sciences (CAS) locality:

36827. Gully in center of S½ sec. 27, T. 4 N., R. 15 W., half a mile south of Humphreys Station, Los Angeles County, Pico Formation [=Towsley Formation], early Pliocene. Collected by G. P. Kanakoff, 1954. Same as LACMIP loc. 291.

Los Angeles County Museum, Invertebrate Paleontology (LACMIP) locality:

59. Immediately south of point where Lincoln Avenue crosses the Los Angeles Outfall Sewer, about 2 miles northeast of Playa Del Rey, Los Angeles County. Palos Verdes Sand, late Pleistocene. Collected by George Willett, 1935, 1936.

219. Gully in center of S½ sec. 27, T. 4 N., R. 15 W., one-half mile south of Humphreys Station, Los Angeles County. Pico Formation [=Towsley Formation], early Pliocene. Collected by G. P. Kanakoff, 1954.

BRITISH COLUMBIA LOCALITY

University of California, Los Angeles (UCLA) locality:

4674. Skonun Point, 5 miles east of Masset on north coast of Graham Island, Queen Charlotte Islands. Skonun Formation, Miocene or Pliocene. Collected by Richfield Oil Co. field party, 1958.

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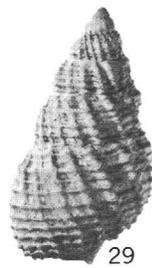
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PLATE 1

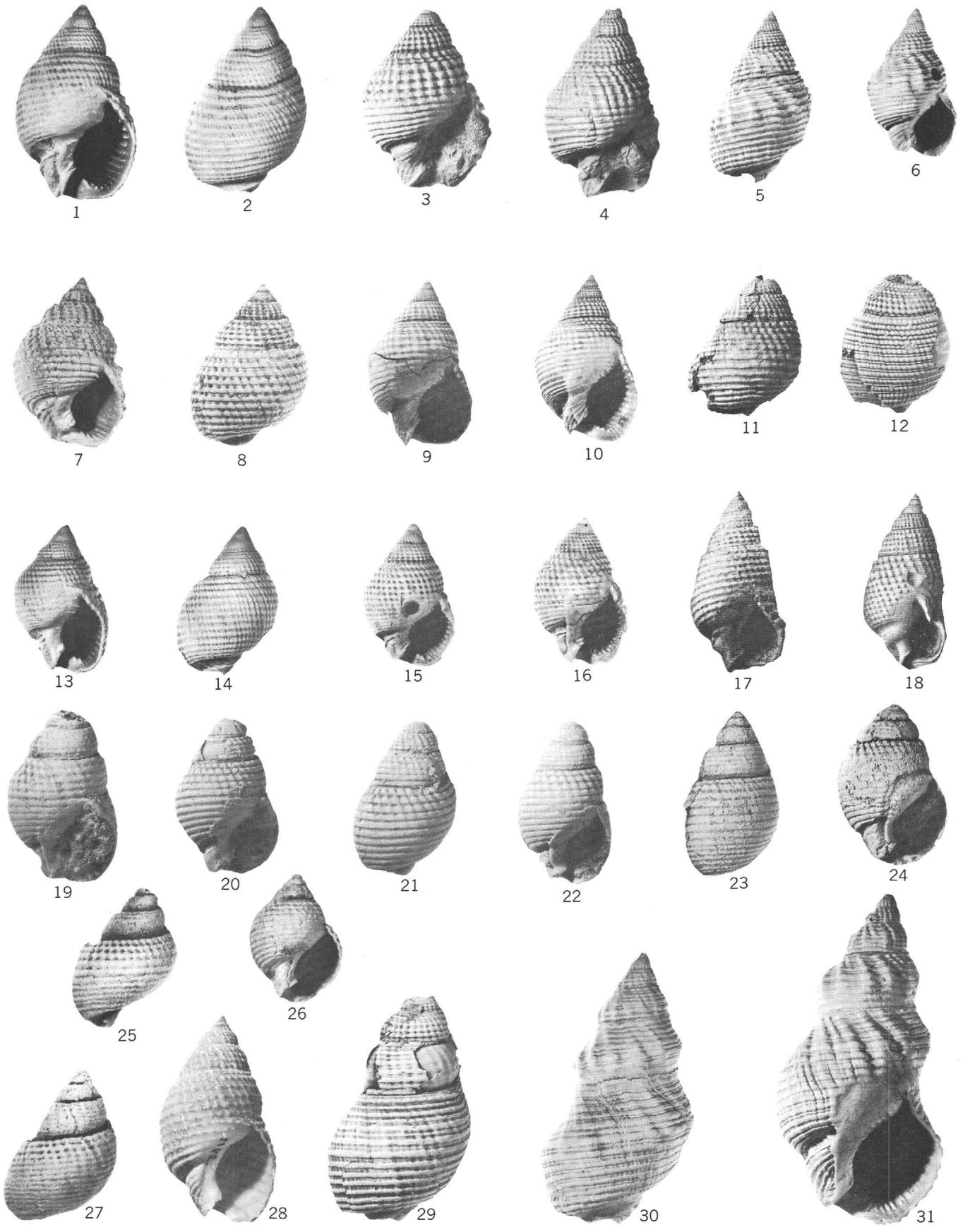
- FIGURES 1-10, 31. *Nassarius (Demondia) californianus* (Conrad) (p. B3).
1. Height 16.3 mm, width 9.8 mm, UCMP 30809. Merced Formation, Pliocene, Wilson Ranch, Sonoma County, Calif., UCMP loc. 7033.
 - 2, 4-6, 9, 10. Merced(?) Formation, late Pliocene, Santa Clara County, Calif., USGS Cenozoic loc. M1715.
 2. Height 16 mm, width 8.6 mm, USNM 648591.
 4. Height 15.8 mm, width 8.6 mm, USNM 648548.
 - 5, 6. Neotype. Height 14 mm, width 7.5 mm, USNM 648596.
 9. Height 4.9 mm, width 3.2 mm, USNM 648549.
 10. Height 15 mm, width 8.3 mm, USNM 648550.
 - 7, 8. Cebada Fine-grained Member of the Careaga Sandstone, late Pliocene, Casmalia Hills, Santa Barbara County, Calif., USGS Cenozoic loc. 14608.
 7. Height 12 mm, width 6.4 mm, USNM 649001.
 8. Height 9.8 mm, width 5.8 mm, USNM 649002.
 3. Reproduction of original figure of *Schizopyga californiana* Conrad (Conrad, 1857, pl. 2, fig. 1). Santa Clara, Calif., specimen lost.
 31. Height 13.8 mm, width 7.7 mm, USNM 648551. Merced(?) Formation, late Pliocene, Santa Clara County, Calif., USGS Cenozoic loc. M1720.
- 11-13. *Nassarius (Demondia) mendicus* forma *indisputabilis* Oldroyd (p. B3). Unnamed marine terrace deposit, late Pleistocene, Point Año Nuevo, San Mateo County, Calif., USGS Cenozoic loc. M1690.
11. Height 20.1 mm, width 9.2 mm, USNM 648552.
 - 12, 13. Height 19.7 mm, width 9.7 mm, USNM 648553.
- 14-16. *Nassarius (Demondia) mendicus* (Gould) (p. B3).
- 14, 15. Palos Verdes Sand, late Pleistocene, San Pedro, Calif., USGS Cenozoic loc. M1723.
 14. Height 14 mm, width 7.4 mm, USNM 648554.
 15. Height 13.4 mm, width 6.8 mm, USNM 648555.
 16. Height 16.6 mm, width 7.8 mm, UCMP 15108. Upper part of Merced Formation, Early Pleistocene, one-fourth mile west of Thronton Station, San Mateo County, Calif., UCMP loc. 1727.
- 17-19. *Nassarius (Demondia) mendicus* forma *cooperi* (Forbes) (p. B3).
- 17, 18. Palos Verdes Sand, late Pleistocene, Arnold's lumber yard locality, San Pedro, Calif., USGS Cenozoic loc. M1728 (same as USGS loc. 12135).
 17. Height 13.8 mm, width 6.7 mm, USNM 648556.
 18. Height 17 mm, width 8.2 mm, USNM 648557.
 19. Height 12.7 mm, width 7.2 mm, USNM 648558. Santa Barbara Formation, late Pliocene, about 1¼ miles north of Goleta, Calif., USGS Cenozoic loc. M1918.
- 20-22. *Nassarius (Demondia) lincolnensis* (Anderson and Martin) (p. B5).
- 20, 21. Height 10.2 mm, width 6.5 mm, USNM 648559. Astoria Formation, middle Miocene, south side of Yaquina Head, Lincoln County, Oreg., USGS loc. 18907.
 22. Height 8.3 mm, width 5.4 mm, USNM 648560. Astoria Formation, middle Miocene, Lincoln County, Oreg., USGS Cenozoic loc. 18284.
- 23-25, 28-30. *Nassarius (Caesia) delosi* (Woodring) (p. B10).
23. Height 29 mm, width 17 mm, SDSNH 42927. Recent, Mission Bay, San Diego County, Calif. Photographed by James McLean.
 24. Height 28.5 mm, width 17.4 mm, USNM 648561. Saugus Formation, early Pleistocene, 1 mile west of Ventura, Calif., USGS Cenozoic loc. M1733.
 25. Height 34.4 mm, width 19.5 mm, USNM 648562. Marine terrace deposit, late Pleistocene, Laguna Beach, Calif., USGS Cenozoic loc. M1017.
 - 28, 29. Height 36 mm, width 19.1 mm, USNM 648563. Palos Verdes Sand, late Pleistocene, Newport, Calif., USGS Cenozoic loc. M1922.
 30. Height 36.5 mm, width 19.5 mm, SDSNH 11485. Recent, Balboa [Newport Beach], Calif. Photographed by James McLean.
- 26, 27. *Nassarius (Caesia) cerritensis* (Arnold) (p. B6). Palos Verdes Sand, late Pleistocene, San Pedro, Calif., USGS Cenozoic loc. M1723.
26. Height 21.5 mm, width 11.7 mm, USNM 648564.
 27. Height 22.2 mm, width 13.4 mm, USNM 648565.



NASSARIUS

PLATE 2

- FIGURES 1, 2, 7, 8, 13-16, 26. *Nassarius (Caesia) grammatus* (Dall) (p. B6).
- 1, 2. Lectotype. Height 35.9 mm, width 22.6 mm, USNM 648566. Santa Barbara Formation, late Pliocene, Santa Barbara, Calif., USNM catalog No. 101721.
 - 7, 8. Height 16.3 mm, width 11 mm, USNM 648567. Santa Barbara Formation, late Pliocene, 1¼ miles north of Goleta, Calif., USGS Cenozoic loc. M1918.
 - 15, 16, 26. Merced(?) Formation, late Pliocene, Santa Clara County, Calif., USGS Cenozoic loc. M1715.
 15. Height 27.9 mm, width 7.9 mm, USNM 648569.
 16. Height 29.3 mm, width 18.7 mm, USNM 648570.
 26. Height 6.1 mm, width 4.4 mm, USNM 648571.
 - 13, 14. Syntype. Height 28.1 mm, width 18.4 mm, USNM 648572. Santa Barbara Formation, late Pliocene, Santa Barbara, Calif., USNM catalog No. 101721.
- 3, 4, 9-11, 29. *Nassarius (Caesia) moranianus* (Martin) (p. B8).
- 3, 4, 9, 29. Merced Formation, late Pliocene, Bolinas, Calif., UCMP loc. 1549.
 3. Topotype. Height 17.3 mm, width 12.4 mm, UCMP 15069.
 4. Topotype. Height 25.4 mm, width 16.2 mm, UCMP 15070.
 9. Holotype. Height 30.6 mm, width 20.2 mm, UCMP 12338.
 29. Topotype. Height 44.4 mm, width 26.5 mm, UCMP 15071.
 10. Height 31 mm, width 18.7 mm, UCMP 15072. Saugus Formation, early Pleistocene(?), Ventura County, Calif., UCMP loc. 7091.
 11. Height 26.8 mm, width 19.8 mm, UCMP 15073. Upper part of the Merced Formation, early Pleistocene, northwestern San Mateo County, Calif., UCMP loc. B4810.
- 5, 6. *Nassarius (Caesia) fossatus* (Gould) (p. B5).
5. Height 31.7 mm, width 18.3 mm, USNM 648573. Saugus Formation, early Pleistocene, 1 mile west of Ventura, Calif., USGS Cenozoic loc. M1733.
 6. Height 29.7 mm, width 17 mm, USNM 648574. Palos Verdes Sand, late Pleistocene, San Pedro, Calif., USGS Cenozoic loc. M1723.
12. *Nassarius (Caesia) grammatus* (Dall) n. subsp.(?) (p. B7). Height 26.6 mm, width 20 mm, UCMP 15074. Rio Dell Formation of Ogle (1953), Pliocene, Humboldt County, Calif., UCMP loc. B7642.
- 17, 18. *Nassarius (Caesia) coalingensis* (Arnold) (p. B9).
17. Reproduction of holotype figured by Arnold (1909, pl. 27, fig. 7), about $\times 1\frac{1}{2}$ natural size, USNM catalog No. 165508. Etchegoin Formation of Arnold (1909), Pliocene, 4 miles south of Coalinga, Calif., USGS loc. 4758.
 18. Reproduction of specimen figured by Woodring and others (1940, pl. 15, fig. 3), height 33 mm, width 16 mm, USNM 495757. San Joaquin Formation, late Pliocene, Kettleman Hills, Calif., USGS loc. 12359.
- 19-25, 27. *Nassarius (Caesia) whitneyi* (Trask) (p. B9).
- 19-22. Skonun Formation, Miocene or Pliocene, northern Graham Island, British Columbia, Canada, UCLA loc. 4674.
 19. Height 8.1 mm, width 5.2 mm, UCLA 34540.
 - 20, 21. Height 10 mm, width 6.4 mm, UCLA 34541.
 22. Height 10.1 mm, width 6 mm, UCLA 34542.
 23. Height 12.5 mm, width 7.6 mm, UCMP 15075, a rubber cast. Briones Sandstone, late Miocene, Contra Costa County, Calif., UCMP loc. A4920.
 24. Height 11.7 mm, width 7.1 mm, UCMP 15076, a rubber cast. Sobrante Formation of Lutz (1951, middle Miocene, Contra Costa County, Calif., UCMP loc. A4925.
 - 25, 27. Briones Sandstone, late Miocene, Contra County, Calif., UCMP loc. B4749.
 25. Height 9.2 mm, width 5.9 mm, UCMP 15077, a slightly crushed internal mold.
 27. Height 10.3 mm, width 6.8 mm, UCMP 15078, a slightly crushed internal mold.
28. *Nassarius (Caesia) rhinetes* Berry (p. B10). Holotype. Height 28 mm, width 19 mm, S. S. Berry, personal collection No. 1182. Recent, dredged from 40 fathoms in Monterey Bay, Calif., photographed by James McLean.
- 30, 31. *Nassarius (Caesia) fossatus* forma *coiloterus* (Woodring) (p. B8). Palos Verdes Sand, late Pleistocene, Playa del Rey, Calif., LACMIP loc. 59.
30. Height 52.3 mm, width 27.5 mm, LACMIP 1129.
 31. Height 62.6 mm, width 34.1 mm, LACMIP 1130.



NASSARIUS

PLATE 3

FIGURES 1-3, 10, 15. *Nassarius (Catilon) arnoldi* (Anderson) (p. B12).

- 1, 2. Height 7 mm, width 4.5 mm, USNM 648575. Round Mountain Silt of Diepenbroek (1933), middle Miocene, Kern County, Calif., USGS Cenozoic loc. M1604.
- 3, 10. Upper part of the Olcese Sand of Diepenbroek (1933), Kern River district, California, USGS Cenozoic loc. M1597.
3. Topotype. Height 7.1 mm, width 4.6 mm, USNM 648576.
10. Neotype. Height 7.2 mm, width 4.6 mm, USNM 648577.
15. Height 4.9 mm, width 3.7 mm, USNM 648949. Uppermost part of the Lincoln Formation of Weaver (1912), middle Miocene, Grays Harbor County, Wash. USGS loc. M1514.
- 4, 5. *Nassarius (Catilon) stocki* Kanakoff (p. B14). Topotypes. Pico Formation [=Towsley Formation], early Pliocene, eastern Ventura basin, California, CAS loc. 36827.
4. Height 9 mm, width 5.6 mm, CAS 12599.
5. Height 8.4 mm, width 5 mm, CAS 12600.
6. *Nassarius (Catilon) iniquus* (Stewart) (p. B16). Height 17.7 mm, width 9.3 mm, UCMP 15079. San Joaquin Formation, Pliocene, Kings County, Calif., UCMP loc. A3166.
- 7-9. *Nassarius (Catilon) smooti* Addicott, n. sp. (p. B13). Upper part of the Olcese Sand of Diepenbroek (1933), middle Miocene, Kern River district, California, USGS Cenozoic loc. M1597.
- 7, 8. Holotype. Height 7.3 mm, width 4.2 mm, USNM 648575.
9. Topotype. Height 8.9 mm, width 5.3 mm, USNM 648579.
- 11, 12. *Nassarius (Catilon) hildegardae* Kanakoff (p. B16). Topotypes. Pico Formation [=Towsley Formation], early Pliocene, eastern Ventura basin, California, LACMIP loc. 291.
11. Height 6.2 mm, width 3.2 mm, LACMIP 1131.
12. Height 5.7 mm, width 3.1 mm, LACMIP 1132.
- 13, 14. *Nassarius (Catilon?) antiselli* (Anderson and Martin) (p. B13). Height 8.5 mm, width 4.4 mm, USNM 648580. Saltos Shale Member of Monterey Formation of Hill, and others (1958), middle Miocene, San Luis Obispo County, Calif., USGS Cenozoic loc. M1923.
- 16-18. *Nassarius (Catilon) andersoni* (Weaver) (p. B14).
16. Height 9.6 mm, width 6.4 mm, USNM 648581. Montesano Formation of Weaver (1912), Pliocene(?), Grays Harbor County, Wash., USGS Cenozoic loc. M1545.
- 17, 18. Height 12.8 mm, width 7 mm, USNM 648582. Quinault Formation, Pliocene, north of Point Grenville, Wash., USGS Cenozoic loc. M1827.
- 19, 26-28. *Nassarius* (subgenus?) *ocoyanus* (Anderson and Martin) (p. B16). Near base of the Round Mountain Silt of Diepenbroek (1933), middle Miocene, Kern River district, California, UCMP loc. B1637.
19. Height 12.9 mm, width 6.5 mm, UCMP 15080.
- 26, 27. Height 10.2 mm, width 5 mm, UCMP 15081.
28. Height 10.5 mm, width 4.9 mm, UCMP 15082.
- 20, 21. *Nassarius (Catilon) hamlini* (Arnold) (p. B15). Unnamed sandstone of Pliocene age, upper Newport Bay, Orange County, Calif., USGS Cenozoic loc. M1921.
20. Height 16.7 mm, width 9.3 mm, USNM 648583, a rubber cast.
21. Height 13.4 mm, width 6.0 mm, USNM 648584, a rubber cast.
- 22-25. *Nassarius (Catilon) pabloensis* (Clark) (p. B13). Santa Margarita Formation, Comanche Point, Kern County, Calif., USGS Cenozoic loc. M1619.
22. Height 9.4 mm, width 5.5 mm, USNM 648585, a rubber cast.
23. Height 9.1 mm, width 6 mm, USNM 648586, a rubber cast.
24. Height 15 mm, width 7.6 mm, USNM 648587, a rubber cast.
25. Height 11.7 mm, width 5 mm, USNM 648588, a rubber cast.
- 29, 32. *Nassarius (Caesia) perpinguis* (Hinds) (p. B6).
29. Height 20.4 mm, width 11.9 mm, USNM 648589. Palos Verdes Sand, late Pleistocene, San Pedro, Calif., USGS Cenozoic loc. M1723.
32. Height 14.5 mm, width 8.7 mm, USNM 648950. Saugus Formation, early Pleistocene, 1 mile west of of Ventura, Calif., USGS Cenozoic loc. M1733.
- 30, 31. *Nassarius (Catilon?) salinasensis* Addicott, n. sp. (p. B15.) Pancho Rico Formation, early Pliocene, Monterey County, Calif., USGS Cenozoic loc. M977.
30. Holotype. Height 16.9 mm, width 9.6 mm, USNM 648597, a rubber cast.
31. Height 17.8 mm, width 8.9 mm, USNM 648598, a rubber cast.



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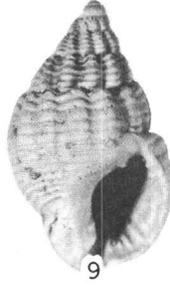
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