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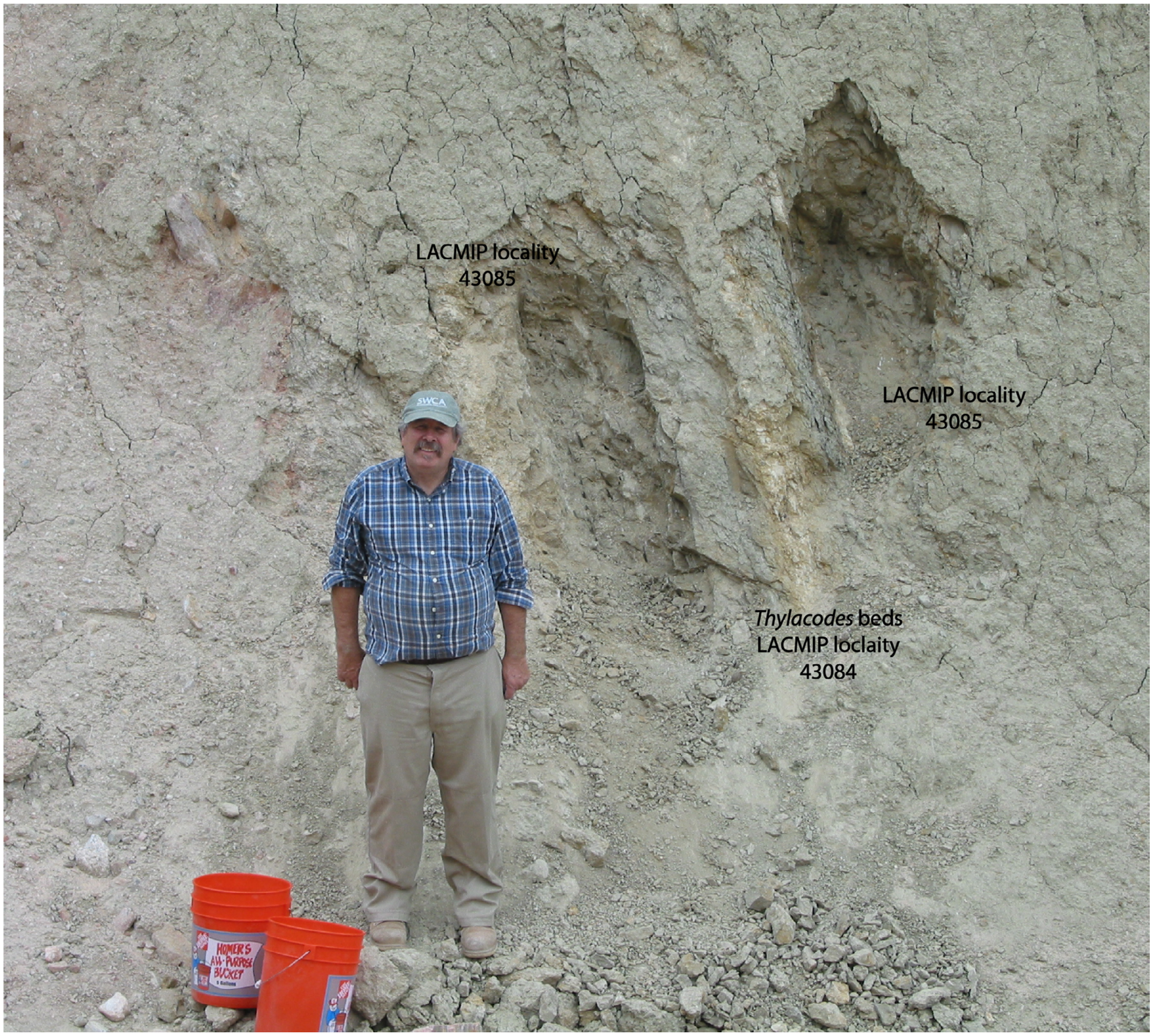

Bret RAINES, Charles L. POWELL, II, & Patrick LaFOLLETTE. 2023.

Caecidae (Mollusca: Gastropoda) from late Miocene exposures of the "Imperial" Formation in Riverside County, California

Cover: Mark Roeder, photographed by Patrick LaFollette, May 16, 2010 at the boundary between the lower and upper members of the "Imperial" Formation along Super Creek, Riverside County, California, which yielded all the specimens discussed here.

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Caecidae (Mollusca: Gastropoda) from late Miocene exposures of the "Imperial" Formation in Riverside County, California

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Three Caecidae species from two genera have been recovered from the late Miocene "Imperial" Formation exposed in Super Creek, north and slightly east of Whitewater, Riverside County, southern California. These specimens record the first fossil Caecidae from California older than Pleistocene. The three taxa are *Caecum brasilicum* de Folin, 1874, *Meioceras nitidum* (Stimpson, 1851), and a new species of *Caecum* named *C. roederi* n. sp., in honor of friend and colleague Mark Roeder. *Caecum brasilicum* and *M. nitidum* occur today in the central-western Atlantic Ocean and their previous fossil occurrences are also there. The occurrence of these Atlantic species in the "Imperial" Formation is not surprising as > 8% of the Super Creek fauna has a Caribbean origin at the species level because of the then submerged Panama seaway that allowed water from the western Atlantic to flow freely into the eastern Pacific.

Keywords: Gastropoda, Caecidae, *Caecum*, *Meioceras*, California, Miocene, "Imperial" Formation

INTRODUCTION

Small and well-preserved fossil mollusks occur in remarkable numbers in some of the late Miocene Super Creek exposures of the "Imperial'' Formation north of Palm Springs, Riverside County, California. Among these are three members of the family Caecidae which are the first fossils record of the family from the Tertiary of California (Keen and Bentson 1944, Groves and Squires 2021), although a few authors have recorded modern species in Pleistocene deposits along coastal California (Woodring et al. 1946, Valentine, 1959, 1989).

The three species discussed are from exposures of the "Imperial" Formation exposed along Super Creek in Riverside County, California. Two of these species are known previously only from the western Atlantic. The modern western Atlantic species include *Caecum brasilicum* de Folin, 1874, which has a modern occurrence from Florida; Cuba: North Matanzas, North Las Tunas; Virgin Islands; Brazil: Maranhao, Paraiba, Pernambuco, Alagoas, Bahia, Abrolhos Islands, Espirito Santo, Trindade Island, Rio de Janeiro, Sao Paulo, Santa Catarina (Rosenberg 2000). The other species, *Meioceras nitidum* (Stimpson, 1851), occurs from USA: Florida, Florida Keys, Texas; Mexico: Tamaulipas, Veracruz, Campeche State, Yucatan State, Alacran Reef, Quintana Roo, Cozumel; Costa Rica; Panama; Colombia; Cuba: North Havana Province, Cienfuegos, North Camaguey, Granma; Jamaica; Puerto Rico; Virgin Islands: St. Croix; Brazil: Paraiba, Pernambuco, Alagoas, Bahia, Abrolhos Islands; Uruguay (Rosenberg 2000). It has been previously reported from the Pliocene (Mansfield 1930) and Pleistocene (Olsson and Harbison 1953, DuBar 1962, Kittle and Portell 2010) of Florida. In addition, it has been reported under synonyms. *M. amblyoceras* Woodring (1959) has been reported in the Miocene Gatun Formation in Panama (Woodring 1959); as *M. apanium* Woodring (1928) it occurs from the

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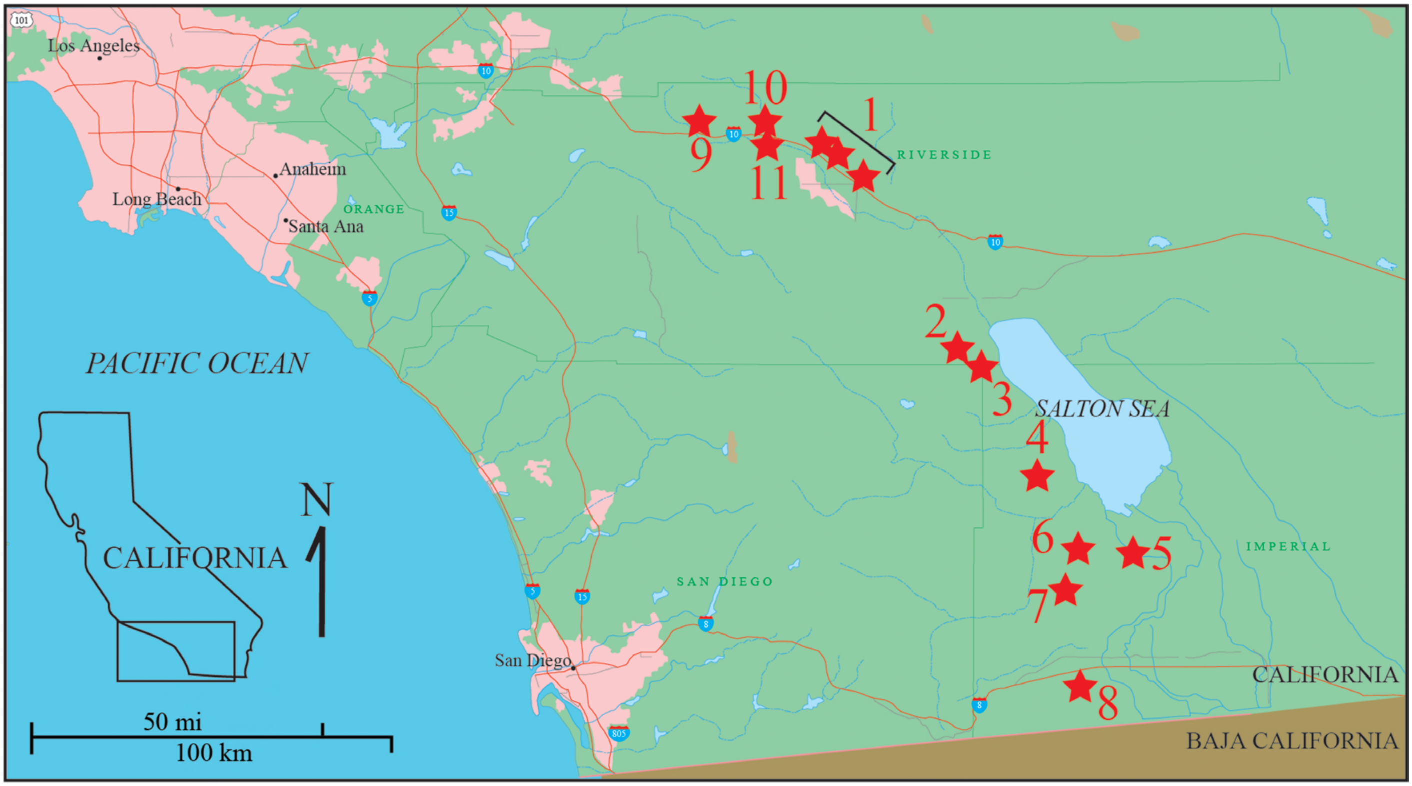

Figure 1. Locality map showing outcrops of the Imperial Formation s.l. in southern California. Outcrops of the late Miocene to Pliocene Imperial Formation s.s. include: 1) Edom Hill/ Indio Hills/Willis Palms/Thousand Palms Canyon (Powell 1985, Powell 1986, Powell et al. 2011), 2) the southern Santa Rosa Mountains (King et al. 2002), 3) Travertine Point (Powell 2008), 4) Ocotillo Wells State Vehicle Recreation area (Powell 1993), 5) Superstition Mountain (Morton 1977), 6) Fish Creek Mountains (Dibblee 1954, Morton 1977), 7) Coyote Mountains (Hanna 1926), and 8) Yuha Buttes (Hanna 1926). Outcrops of the late Miocene "Imperial" Formation s.l. occur at 9) Lions Canyon (Bramkamp 1935, Powell 1986), 10) Super Creek (Bramkamp 1935, Powell 1985, Powell 1986, Powell and LaFollette 2012), and 11) Garnet Hill (Powell 1985, Powell 1986, Rymer et al. 1995, Powell 1995).

Pliocene Bowden beds in Jamaica; and as *M. cingulatum* Dall (1892) was reported from the Pliocene of Florida (Dall 1892, Moore 1972). These species occurrences in south-central California record major extensions to their geographic and chronostratigraphic ranges. The new species is restricted to the Super Creek exposures of the "Imperial" Formation in Riverside County, California.

The "Imperial" Formation in and around Super Creek, on the southern slope of San Gorgonio Mountain, near Whitewater, Riverside County, California has become important to our understanding of the early history of the proto–Golfo de California and movement along the southern part of the San Andreas fault system. These deposits include coarse to fine-grained terrigenous sediments with occasional breccia beds, especially near the base of the section. The fine-grained sediments allow for exceptional preservation in places. These deposits are a lagerstätten, which is a sedimentary deposit that exhibits extraordinary fossils with exceptional preservation. This excellent preservation accounts for the large number of new species (about 24%) found in these deposits, nearly all under one centimeter in size (Powell and LaFollette 2012, n>40 out of a fauna of about 170 identified taxa).

GEOLOGIC SETTING

The Imperial Formation *sensu lato* represents at least two sea-level highstands into the proto-Golfo de California (Powell 1987). These sea-level highstand deposited sediments occur in different parts of the Salton Trough and they are separated here so as to develop a better understanding of the geologic history of the Salton Trough. Here the name Imperial Formation (without quotes; *sensu stricto* or *s.s.*) is used for proto–Gulfo de California related marine sediments mostly of Pliocene age (some are as old as late Miocene), related to and lithologically correlated with the type Imperial Formation in

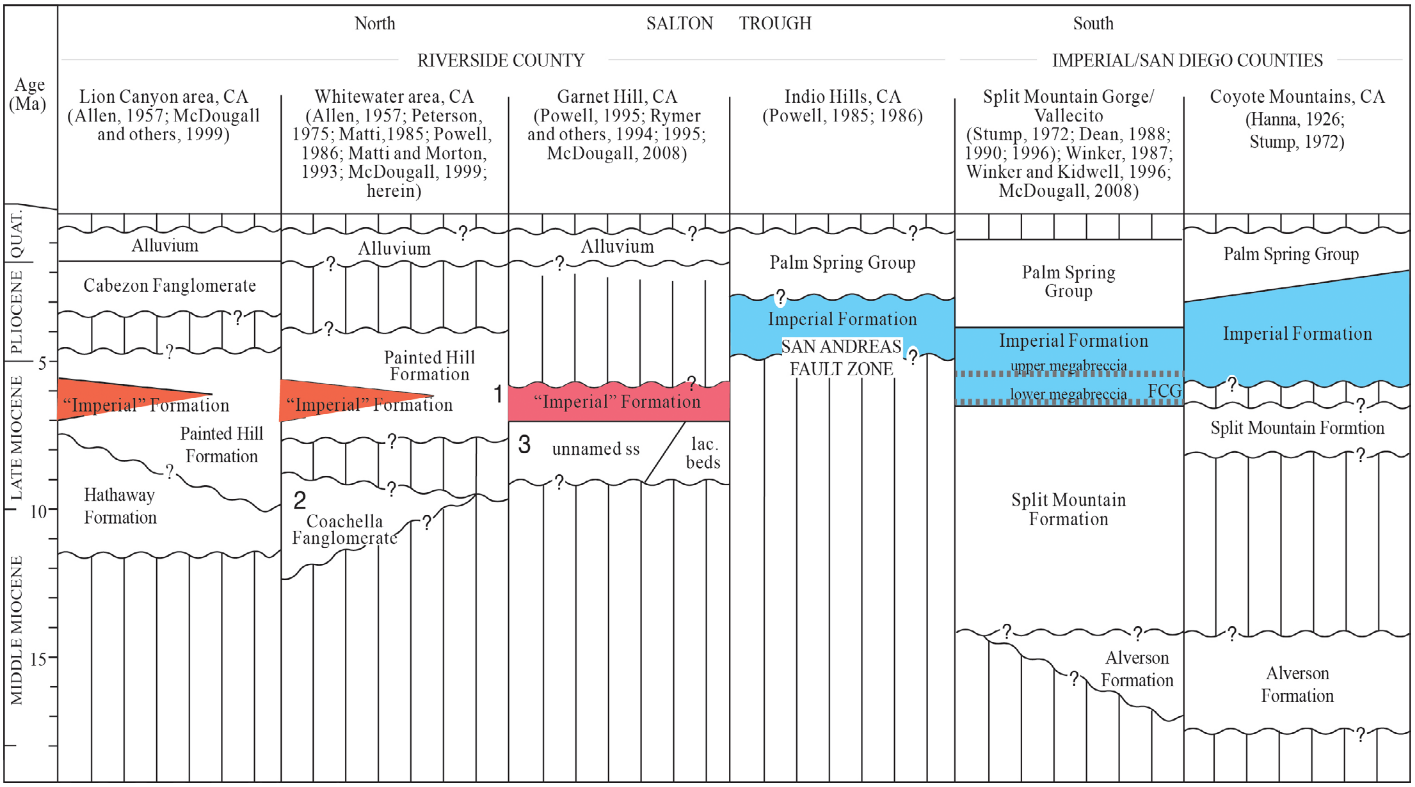

Figure 2. Correlation chart of the stratigraphic sections including the "Imperial" Formation s.l. from west to east, at Lion Canyon, Super Creek, Garnet Hill, and the Imperial Formation s.s. in the Indio Hills, Riverside County, and in Imperial and San Diego counties from Split Mountain Gorge/Vallecito area, and the Coyote Mountains. Note the age difference between the "Imperial" Formation in Riverside County (exception for the Indio Hills) and the Imperial Formation in Imperial and San Diego counties. The Imperial Formation in the Indio Hills correlates with the type exposures in Imperial and San Diego counties. The ages of all boundaries are approximate. Numbers represent numerical age determinations: 1) Matti et al., 1985 (6.04±0.18 Ma and 5.94±0.18 Ma); 2) Peterson, 1975 (about 10 Ma); 3) Rymer et al., 1994, 1995 (between 8 and 7.6 Ma); 4) McNabb et al. 2017 (3.0-2.6 Ma); 5) Ruisaard 1979 (24.8 to about 15 Ma). Abbreviations: cong. = conglomerate; fm=formation; lac beds = unnamed lacustrine beds; ss = sandstone. In part after McDougall (2008).

the Alverson Canyon (= Shell Canyon, = Fossil Canyon; Hanna 1926) in the southern Coyote Mountains, Imperial County. Outcrops attributed to the Imperial Formation *s.s.* (Fig. 1) also occur, from north to south, at 1) Indio Hills (Powell et al. 2011), especially near Willis Palms (Powell 1985, Powell 1986, Powell et al. 2011), 2) the southern Santa Rosa Mountains (King et al. 2002), 3) Travertine Point (Powell 2008), 4) Ocotillo Wells State Vehicle Recreation area (Powell 1993), 5) Superstition Mountain (Morton 1977), 6) Fish Creek Mountains (Dibblee 1954, Morton 1977), 7) Coyote Mountains (Hanna 1926), and 8) Yuha Buttes (Hanna 1926). In contrast, "Imperial" Formation (in quotes; *sensu lato* or *s.l.*) refers to the older sea-level highstand deposits and is used here to refer to any proto–Gulfo de California–related marine sediments in south–central California previously attributed to the Imperial Formation, usually based on its tropical mollusk and (or) coral fauna. However, these deposits differ in age, and (or) provenance of sediments, and (or) lithology. Exposures of the "Imperial" Formation (Fig. 1) occur in Riverside County in and around 9) Lions Canyon (Bramkamp 1935, Powell 1986), 10) Super Creek (Bramkamp 1935, Powell 1985, Powell 1986, Powell and LaFollette 2012), and 11) Garnet Hill (Powell 1985, Powell 1986, Rymer et al. 1995, Powell 1995).

The rocks from which the Caecidae described here were collected are from the Super Creek area (Fig. 1, locality 10) in Riverside County. Five sections were measured through the "Imperial" Formation exposures in this area by Powell (1986), and their positions are illustrated in Figure 4. These sections indicate a composite thickness for the "Imperial" Formation of about 105 m (Figure 5). In Super Creek the "Imperial" Formation is divided into a lower breccia and coarse to fine-grained sandstone unit, which occurs in small synclinal deposits in the basement in the southern part of the outcrop area. These synclines

Figure 3. Exposures of the "Imperial" Formation along and adjacent to Super Creek, Riverside County, California as mapped by Matti et al. (1985). SC2–SC6 represents measured sections used to compile the composite stratigraphic section used here. The Caecidae described here are all from a narrow stratigraphic interval marked by a star.

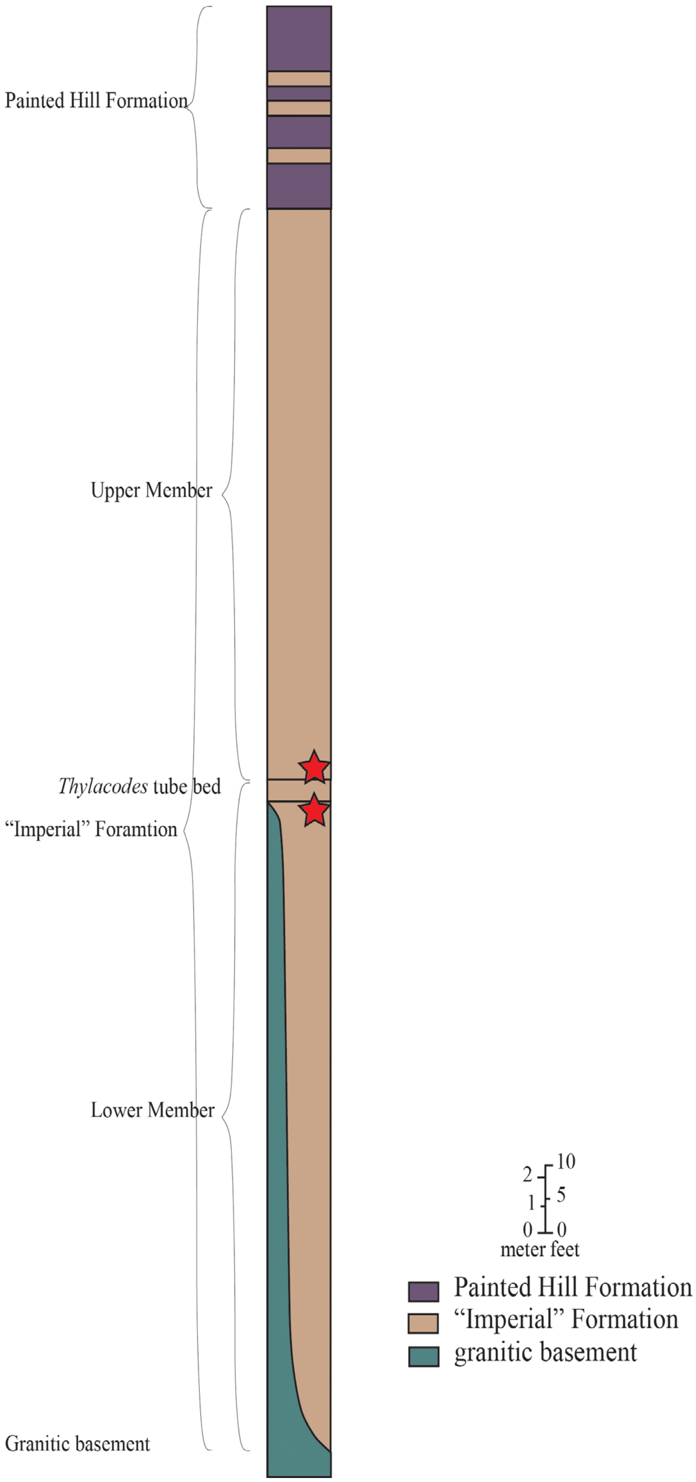

Figure 4. Composite section of "Imperial" Formation in and around Super Creek, east of Whitewater Canyon, Riverside County, CA (LACMIP loc. 43085). Stratigraphy in this section is approximate as different sections show slightly different sequences of rocks. The red stars mark where in the section the specimens were collected by Patrick LaFollette and Mark Roeder between 2010 and 2015.

consist of fossiliferous interbedded sandstone and breccia beds up to 30 m thick. The lower member occurs only in these synclines and the unit does not occur in the northern part of the outcrop area. The upper unit is thicker, finer grained sandstone with subaerial breccia/conglomerate beds interfingering near its top. These two units are separated in most places by a broken layer(s) of *Thylacodes* (Mollusca: Gastropoda) *fide* LaFollette (2012) (Powell 1986) although in the northern part of the outcrop area fine-grained sediments are found on both sides of the *Thylacodes* beds. All the specimens described here were recovered from section SC3 along the Super Creek from an interval about 0.5 m thick in and around the *Thylacodes* bed(s) (Powell 1986).

MATERIALS AND METHODS

Collection and processing of several tons of sediment from the late Miocene "Imperial" Formation at section SC3, Super Creek, just east of Whitewater Canyon, north of Palm Springs, Riverside County for micro-mollusks and fish otoliths by Mark Roeder and Patrick LaFollette over a period of several years have collected a remarkable microfauna. The otoliths are deposited in SDSNH. Five-gallon buckets were loaded with sediment from immediately above and below the *Thylacodes* rubble bed in the field and transported to where they could be washed and processed. The samples collected were washed through screens, dried, and stored by size fraction until they could be picked, sorted, and identified. The few larger specimens were not washed but prepared and stabilized by hand.

Measurements are defined as follows: maximum arc (Arc), length from the aperture to the point of maximum arc (Larc), diameter of posterior end (Dpe), diameter of aperture (Da), and total length (Tol). Species descriptions in the present work are that of the specimens collected from the "Imperial" Formation only and may not represent all the known shell morphologies throughout the species distribution.

Institutional abbreviations

LACMIP–Invertebrate Paleontology, Natural History Museum of Los Angeles County; **SDSNH**–Paleontology Department, San Diego Society of Natural History; **FLMNH**–Florida Museum of Natural History; **UF**–Florida Museum of Natural History

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758
Class GASTROPODA Cuvier, 1795
Subclass CAENOGASTROPODA Cox, 1960
Order LITTORINIMORPHA
Golikov & Starobogatov, 1975
Superfamily TRUNCATELLOIDEA Gray, 1840
Family CAECIDAE Gray, 1850
Subfamily CAECINAE Gray, 1850
Genus *Caecum* Fleming 1813
Type species (SD: Gray, 1847) *Dentalium trachea* Montagu, 1803, northeastern Atlantic.

Diagnosis— Shell minute; teleoconch tubular, slightly curved, smooth or crossed by axial ribs, longitudinal grooves, lines, cords, or a combination. Posterior end closed by conical septum. Protoconch planispirally coiled.

Caecum roederi Raines, Powell and LaFollette n. sp.
Fig. 5A–I

Zoobank LSID—urn:lsid:zoobank.org:act:24C0A351-D532-4B57-9368-6B0D73A84767

Diagnosis—Teleoconch cylindrical. Surface smooth, creamy white in color. Posterior end with well-defined constriction. Septum mucronate, slightly inflated. Mucro with low rounded point. Aperture with axial rings and slight swelling followed by constriction.

Holotype— LACMIP 43085.1, LACMIP Type 14894, a complete adult shell.

Paratypes—Seven paratypes of which three are complete adult shells, LACMIP 43085.2, LACMIP Type 14895, LACMIP 43085.3, LACMIP Type 14896, UF 330224 and four are shell fragments, LACMIP 43085.4, LACMIP Type 14897, LACMIP 43085.5, LACMIP Type 14898, UF 330225, UF 330226.

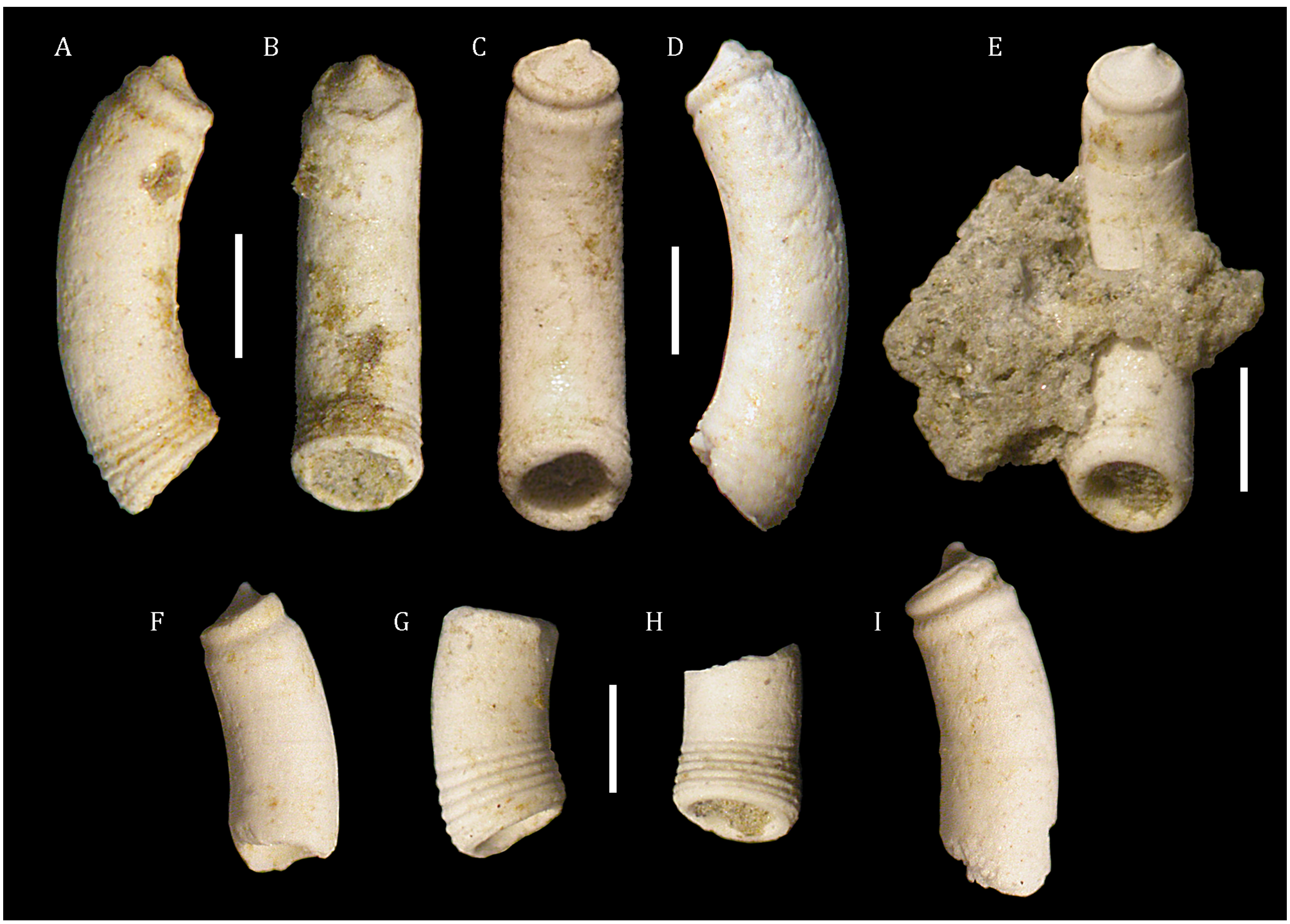

Figure 5A–I. *Caecum roederi* Raines, Powell and LaFollette n. sp.: **A–B**, Holotype, LACMIP 43085.1, LACMIP Type 14894; **A**, profile view; **B**, ventral view; **C**, Paratype, UF 330224, ventral view; **D**, Paratype, LACMIP 43085.2, LACMIP Type 14895, profile view; **E**, Paratype, LACMIP 43085.3 Scale bar=500µm.

Referred Specimens—LACMIP 43085.6 (1 specimen).

Occurrence—Known only from immediately above and below the *Thylacodes* beds near the base of section SC3 in Super Creek, Riverside County, California.

Etymology—Named in honor of the late Mark Roeder, who was a member of the team which collected the material

Description—Protoconch and subadult stages not observed. Teleoconch, average size for genus [Tol: 1.90–2.30 mm], tubular, regularly arched [Larc: 0.60–0.82 mm; Arc: 0.18–0.22 mm], creamy white in color. Surface smooth except for 5–7 regularly spaced axial rings near aperture. Posterior [Dpe: 0.36–0.40 mm] with thick edge, rounded shoulder followed by deep, sulcus-like constriction. Septum mucronate, slightly inflated. Mucro with low rounded point positioned on dorsal margin. Aperture perpendicular [Da: 0.45–0.55 mm], with slight swelling followed by constriction. Lip smooth. Periostracum and operculum not observed.

Discussion—*Caecum roederi* is similar to the eastern Pacific extant species *C. semicinctum* de Folin, 1867. However, *C. semicinctum* is much smaller with 3–4 rounded posterior rings. The only western Atlantic species that is remotely similar is *C. striatum* de Folin, 1868. Although *C. striatum* may display a posterior constriction, it is much weaker and not always present. *Caecum roederi* is also larger and has apertural axial rings, which are absent in *C. striatum*.

Caecum brasilicum de Folin, 1874
Fig. 6A–C

Caecum brasilicum de Folin, 1874: 212, pl. 9, fig. 6, 19 syntypes MNHN-IM-2000-25785, Brazil.

Caecum brasilicum —Kisch, 1959: 39; Mello & Maestrati, 1986: 151, fig. 6; Rios, 1994: 56, pl. 18, fig. 1994; Gomes & Absalão, 1996: 515, figs. 1–3; Oliveira & Almeida, 1999: 2, fig. 4; Costa et al. 2021: 84, fig. 2A–C.

Original diagnosis— "Testa tubularia, subcylindrica, satis arcuata, crystallina, nitidissima; annulis XX-XXIV, quadratis, satis prominentibus et latis, interstitiis latis separatis, cincta; striae longitudinales annulos et interstitia decussantes; interdum annuli primi acuti vel subrotundati, haud longitudinaliter strigis decussati; aperturam versus contracta; apertura saepe marginata, parum declivis; septum ungulatum, interdum submucronatum vel subacutum, margine laterali undulato. Operculum bruneo-flavum concavum, suturae distinctae, anfractus subconvexi." de Folin (1874: 212).

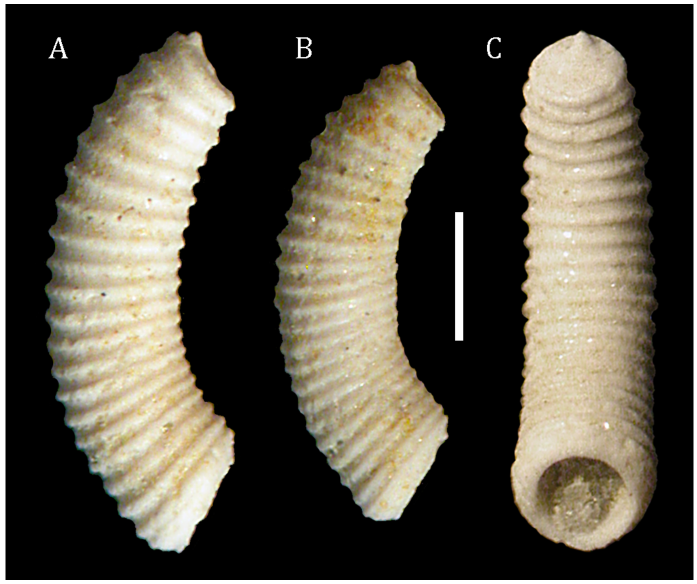

Figure 6A–C. *Caecum brasilicum*: **A–B**, LACMIP 43085.7, LACMIP 43085.8, profile views; **C**, LACMIP 43085.9, ventral view. Scale bar=500µm

English translation— "Shell tubular, subcylindrical, quite curved, crystal like, shiny; 20-24 annular rings, squarish, quite prominent and broad, separated by wide intervals, encircled; longitudinal striae covering rings and intervals; sometimes rings are first sharp or somewhat rounded, without lengthwise striae; distally spaced, often widening toward the aperture, somewhat sloping; septum hoof-like, sometimes submucronatus or subacute, lateral margin wavy. Operculum brownish-yellow convex, sutures distinct, whorls subconvex."

Referred Specimens—LACMIP 43085.10 (1 specimen); LACMIP 43085.11 (7 specimens); LACMIP 43085.12 (66 specimens).

Occurrence—Known only from immediately above and below the *Thylacodes* beds near the base of section SC3 in Super Creek, Riverside County, California.

Description— Protoconch and subadult stages not observed. Teleoconch average size for genus [Tol: 1.80–2.05 mm], tubular, strongly and regularly arched [Larc: 0.50–0.60 mm; Arc: 0.20–0.25 mm], subcylindrical with increase in diameter from posterior to aperture, creamy white. Axial sculpture consists of 20–22 rings, which may vary from triangular in posterior region becoming squared toward aperture. Axial interspaces about the same width as rings. Posterior [Dpe: 0.32–0.36 mm] with squared shoulder. Septum mucronate, flattened to recessed. Mucro with projected rounded point, positioned along dorsal margin. Aperture [Da: 0.46–0.52 mm] with slight downturn, mildly constricted. No varix. Lip smooth, weakly developed, with slightly deflected peristome.

Discussion— As pointed out by de Folin (1874: 212) and Gomes & Absalão (1996: 527), *Caecum brasilicum* will often feature two types of rings (triangular and quadrangular) on a single specimen.

Genus *Meioceras* Carpenter (1859)
Type species (SD: Cossmann, 1912) *Meioceras cornucopiae* Carpenter, 1859, West Indies

Diagnosis— Shell minute; teleoconch tubular, with adult stage having narrow posterior end, inflated middle region and contracted apertural end. Early teleoconch stages twisted to form helical spiral. Posterior end closed by conical septum. Protoconch planispirally coiled.

Meioceras nitidum (Stimpson, 1851)
Fig. 7A–C

Figure 7A–C. *Meioceras nitidum*: **A–B**, LACMIP 43085.13, LACMIP 43085.14, profile views; **C**, LACMIP 43085.13, ventral view. Scale bar=500µm.

Caecum nitidum Stimpson, 1851: 112, (original type material destroyed), Florida.

Caecum (*Meioceras*) *nitidum* —Dall, 1892: 302; Morse, 1919: 76, pl. V, fig. 6; Moore, 1972: 892, fig. 11; Abbott, 1974: 94, fig. 895; Keller, 1981: 71, fig. 22; Vokes & Vokes, 1983: 16; Mello & Maestrati, 1986: 161, fig. 16; Lightfoot, 1992: 29, fig. 33; Rios, 1994: 58, pl. 19, fig. 217; Bandel, 1996: 63, pl. 5, fig. 1–6; Gomes & Absalão, 1996: 524, fig. 14; Oliveira & Almeida, 1999: 3, fig. 13; Daccarett and Bossio 2011: 73, fig. 244.

Meioceras nitidum (Stimpson, 1851) —Gomes, 1999: 27; Redfern, 2013: 71, fig. 211A–E; Lester, 2017: 27, fig 9; Lamy & Pointier, 2017: 203, fig. 12, Egger et al. 2020: 14, fig. 5A–D; Costa et al. 2021: 84, fig. 2I.

Caecum rotundum de Folin, 1868: 49, pl. 5, fig. 2 —Lester, 2017: 27.

Meioceras bitumidum de Folin, 1869a: 25, fig. 4 —Kisch, 1959: 39; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 19, fig. 14; Lester, 2017: 27.

Meioceras carpenteri de Folin, 1869a: 24, fig. 3 —Kisch, 1959: 39; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 20, fig. 15; Lester, 2017: 27.

Meioceras coxi de Folin, 1869a: 29, fig. 9 —Kisch, 1959: 39; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 20, fig. 16; Lester, 2017: 28.

Meioceras crossei de Folin, 1869a: 27, fig. 7 —Kisch, 1959: 39; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 21, fig. 17.

Meioceras deshayesi de Folin, 1869a: 27, fig. 6 —Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 19, fig. 13; Lester, 2017: 27.

Meioceras moreleti de Folin, 1869a: 26, fig. 5 —Kisch, 1959: 40; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 21, fig. 18–19; Lester, 2017: 27.

Meioceras subinflexum de Folin, 1869b: 165, pl. 23, fig. 8 —Abbott, 1974: 94; Gomes, 1999: 22, fig. 20; Lester, 2017: 27.

Meioceras undulosum de Folin, 1869a: 28, fig. 8 —Kisch, 1959: 40; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 22, fig. 21–22; Lester, 2017: 27.

Meioceras fischeri de Folin, 1870: 188, pl. 26, fig. 3–4 —Kisch, 1959: 40; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 24, fig. 26; Lester, 2017: 28.

Meioceras imiklis de Folin, 1870: 189, pl. 26, fig. 5–6 —Kisch, 1959: 40; Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 24, fig. 27; Lester, 2017: 28.

Meioceras contractum de Folin, 1874: 213, pl. 9, fig. 7 —Lester, 2017: 28.

Meioceras leoni Bérillon *in* de Folin, 1874: 251, pl. 10, fig. 4 —Moore, 1972: 892; Abbott, 1974: 94; Gomes, 1999: 25, fig. 28–29.

Meioceras elongatum de Folin, 1881: 17, fig. 9 —Vannozzi, 2019: 35, fig. 1–4.

Meioceras cingulatum Dall, 1892: 302, pl. 16, fig. 6–7 —Moore, 1972: 892; Lester, 2017: 28.

Caecum (*Meioceras*) *lermondi* Dall, 1924: 7 —Lester, 2017: 28; Moore, 1972: 892; Gomes, 1999: 26, fig. 31.

Meioceras apanium Woodring, 1928: 351, pl. 26, fig. 11–12 —Moore, 1972: 892.

Meioceras amblyoceras Woodring, 1959: 163, pl. 31, fig. 1 —Moore, 1972: 892.

Original diagnosis— "Shell arcuated, thin, pellucid; surface white, shining, glabrous, with indistinct striae of growth; aperture very oblique, in diameter about two thirds that of the shell at its broadest part, which is at the middle. The shell is contracted at its posterior extremity. Thus, the inner outline is much shorter and less curved than the outer one." Stimpson (1851: 112).

Referred Specimens—LACMIP 43085.15 (1 specimen), LACMIP 43085.16 (5 specimens), LACMIP 43085.17 (6 specimens), LACMIP 43085.18 (94 specimens).

Occurrence—Known only from immediately above and below the *Thylacodes* beds near the base of section SC3 in Super Creek, Riverside County, California.

Description—Protoconch and subadult stages not observed. Teleoconch average size for genus [Tol: 1.74–2.40 mm], tubular, strongly arched dorsal profile, mildly arched or bulbous ventral profile [Larc: 0.52–0.80 mm; Arc: 0.08–0.22 mm], narrow posterior end, inflated middle region and contracted apertural end, creamy white. Surface smooth except for occasional growth lines. Posterior [Dpe: 0.30–0.39 mm] with thin edge. Septum mucronate, slightly raised to recessed. Mucro with prominent rounded point, positioned along dorsal margin. Aperture [Da: 0.40–0.54 mm] simple, strongly oblique. Lip smooth, well defined.

Discussion—*Meioceras nitidum* is extremely variable in the degree of mid-teleoconch swelling. Slender forms can be difficult to distinguish from *M. cornucopiae* Carpenter, 1859. However, the sides of *M. cornucopiae* are more parallel regardless of how pronounced the dorsal arch.

CONCLUSION

The occurrences of *Caecum brasilicum* and *Meioceras nitidum* in the “Imperial” Formation at Super Creek mark a significant geographic and chronostratigraphic range extension for both the living species. Given the abundance of material collected to date, it is reasonable that further collecting will provide additional species with an affinity to the Caribbean region.

ACKNOWLEDGMENTS

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LITERATURE CITED

Abbott, R.T. 1974. *American Seashells*. Van Nostrand Reinhold, New York. 663 pp.

Bandel, K. 1996. Phylogeny of the Caecidae (Caenogastropoda). *Mitteilungen aus dem Geologisch- Paläontologisches Institut der Universität Hamburg* 79:53–115.

Bérillon, M. 1874. Pp. 250-251, *in* de Folin, Côtes du Mexique (Pacifique et mer des Antilles). Mollusques. *Les Fonds de la Mer* 2:250–251.

Bramkamp, R.A. 1935. Stratigraphy and molluscan fauna of the Imperial Formation of San Gorgonio Pass, California. Ph.D. dissertation, University of California, Berkeley.

Carpenter, P.P. 1858–1859. First steps towards a monograph of the Caecidae, a family of rostriferous Gastropoda. *Proceedings of the Zoological Society, London* 26:413–444.

Cossmann, M. 1912. *Essais de Paléoconchologie Comparée* 9:215 pp. Cossmann & Lamarre, Paris.

Costa, F.M.P., A.M.S. Pires-Vanin, and S.F.B. Lima. 2021. Caecidae (Gastropoda: Truncatelloidea) associated with unconsolidated carbonate substrates of the Abrolhos coral bank (Bahia State, Brazil). *American Malacological Bulletin* 38(2):83–88.

Cox, L.R. 1960. Thoughts on the classification of the Gastropoda. *Proceedings of the Malacological Society of London* 33:239–261.

Cuvier, G. 1795. Second Mémoire sur l'organisation et les rapports des animaux à sang blanc, dans lequel on traite de la structure des Mollusques et de leur division en ordre, lu à la société d'Histoire Naturelle de Paris, le 11 prairial an troisième [30 May 1795]. *Magazin Encyclopédique, ou Journal des Sciences, des Lettres et des Arts* 2: 433-449.

Daccarett, E.Y., and V.S. Bossio. 2011. *Colombian Seashells from the Caribbean Sea*. L'Informatore Piceno, 384 pp.

Dall, W.H. 1892. Contributions to the Tertiary fauna of Florida, with special reference to the Miocene silex-beds of Tampa and the Pliocene beds of the Caloosahatchie River. Part II. Streptodont and other gastropods, concluded. *Transactions of the Wagner Free Institute of Science of Philadelphia, Philadelphia* 3:201–473.

Dall, W.H. 1924. A remarkable caecid from Florida. *The Nautilus* 38(1):7–8.

Dibblee, T.W., Jr. 1954. Geology of the Imperial Valley region, California. Pp. 21–28 *in* R.H. Jahns, ed. *Geology of southern*

California, chapter 2.

DuBar, J.R. 1962. Neogene biostratigraphy of the Charlotte Harbor area in southwestern Florida. *Bulletin of the Florida Geological Survey* 43:1–83

Egger, C., T.P. Neusser, J. Norenburg, F. Leasi, B. Buge, A. Vannozzi, R.L. Cunha, C.J, Cox, C.J., and K.M. Joerger. 2020. Uncovering the shell game with barcodes: diversity of meiofaunal Caecidae snails (Truncatelloidea, Caenogastropoda) from Central America. *Zookeys* 968:1–42.

Fleming, J. 1813. Conchology. Pp. 55–107, pls. 203–206, *in* Brewster, D. (ed.), The Edinburgh Encyclopaedia, VII. Blackwood, Edinburgh.

Folin, L. de. 1868. Baie de Bahia. *Les Fonds de la Mer* 1:48–51.

Folin, L. de. 1869a. Le genre *Meioceras*. *Annales de la Société Linnéenne de Maine et Loire*, 11:17–31.

Folin, L. de. 1869b. Addition aux mollusques de la Nouvelle-Providence. *Les Fonds de la Mer* 1: 163–165.

Folin, L. de. 1870. Vera-Cruz et Carmen. *Les Fonds de la Mer* 1:181–191.

Folin, L. de. 1874. Sur les côtes du Brésil. *Les Fonds de la Mer* 2:210–214.

Folin, L. de. 1881. Quelques Caecidae des mers de Chine. Pp. 16–17, in L. de Folin, and L. Périer, eds., *Les Fonds de la Mer* 4(1–2).

Golikov, A.N. and Y.I. Starobogatov. 1975. Systematics of prosobranch gastropods. *Malacologia* 15(1):185–232.

Gomes, R.S. 1999. As espécies recentes reportadas para o Gênero *Meioceras* Carpenter, 1858 (Mollusca: Caenogastropoda: Caecidae) no Atlântico Oeste. *Universidade Federal do Rio de Janeiro, Brasil*, 69 pp.

Gomes, R.S. and R.S. Absalão. 1996. Lista comentada e ilustrada dos Caecidae (Mollusca, Prosobranchia, Mesogastropoda) da Operação Oceanográfica Geomar XII. *Revista Brasileira de Zoologia* 13(2):513–531.

Gray, J.E. 1840. Shells of molluscous animals. Pp. 105–152, *in Synopsis of the contents of the British Museum*. G. Woodfall, London.

Gray, J.E. 1847. List of genera of recent Mollusca, their synonyms and types. *Proceedings of the Zoological Society of London* 129–219.

Gray, J.E. 1850. *Catalogue of the Mollusca in the collection of the British Museum*. Part 2. Pteropoda. Printed by order of the Trustees, London, 45 pp.

Groves, L.T., and R.L. Squires. 2021. Checklist of California Paleogene–Neogene marine Mollusca since Keen and Bentson (1944). Paleobios 38:1–360.

Hanna, GD. 1926. Paleontology of Coyote Mountains, Imperial County, California. *Proceedings of the California Academy of Sciences*, 4th series, 14(18):427–503.

Hendy, A., L. Walker, and W. Mertz. 2020. LACM Invertebrate Paleontology. Version 1.9. Natural History Museum of Los Angeles County. Occurrence dataset (https://doi.org/10.15468/6nxzen accessed via GBIF.org on 2021-06-21).

Keeler, J.H. 1981. Minute shells: western Atlantic caecids. *The Festivus* 13(6):67–72.

Keen, A.M., and H. Bentson. 1944. Check list of California Tertiary marine Mollusca. *Geological Society of America Special Paper* 56:280 pp.

King, T., B.F. Cox, J.C. Matti, C.L. Powell, II, L.E. Osterman, and L.M. Bybell. 2002. Previously unreported outcrops of Neogene Imperial Formation in southern Santa Rosa Mountains, California, and implications for tectonic uplift. *Geological Society of America Abstract with Program* 34(6):124.

Kisch, B.S. 1959. La Collection de Caecidae Marquis de Folin au Muséum National d'Histoire Naturelle. *Journal de Conchyliologie* 99:15–42.

Kittle, B.A., and R. W. Portell. 2010. Mollusca: Fort Thompson Formation (Late Pleistocene). *Florida Fossil Invertebrates* 12:1–32

LaFollette, P.I., 2012. "Shell rubble beds of the mollusk *Thylacodes* (Gastropoda: Vermetidae) in the upper Miocene Imperial Formation near Whitewater, Riverside County, California, previously called the 'worm tube bed.'" *Desert Symposium Field Guide and Proceedings 2012*:65–68.

Lamy, D., and J.P. Pointier. 2017. *Marine and Freshwater Molluscs of the French Caribbean*. PLB Editions. 784 pp.

Lester, A.S. 2017. Caecidae (Mollusca: Gastropoda) in Broward County, Florida. M.S. thesis, Nova Southeastern University.

Lightfoot, J. 1992. Caecidae of the Western Atlantic, Part II. *Of Sea & Shore* 15:23–32.

Linnaeus, C. von. 1758. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum caracteribus, differentiis, synonymis, locis*. Tomus I. Editio decima, reformata. Laurentius Salvius: Holmiae. 824 pp.

Mansfield, W.C. 1930. Miocene gastropods and scaphopods of the Choctawatchee Formation of Florida. *Florida State Geological Survey Bulletin* 3:1–240.

Matti, J.C., D.M. Morton, and B.F. Cox. 1985. Distribution and geologic relations of the fault systems in the vicinity of the central Transverse Ranges, southern California. *U.S. Geological Survey Open-File Report* 85-365:1-23+4 unnumbered pages, two oversize map sheets, scale 1:250,000.

McDougall, K.A. 2008. Late Neogene marine incursions and the ancestral Gulf of California. Pp. 355–373, *in* M. Reheis, R. Herschler, and D. Miller, eds., Late Cenozoic drainage history of the southwestern Great Basin and lower Colorado River region: geologic and biotic perspective. Geological Society of America Special Paper 439.

McNabb, J.C., R.J. Dorsey, B.A. Housen, C.W. Dimitroff, and G.T. Messé. 2017. Stratigraphic record of Pliocene–Pleistocene basin evolution and deformation within the southern San Andreas fault zone, Mecca Hills, California. *Tectonophysics* 719/720:66–85.

Mello, R. de L.S. & P. Maestrati. 1986. A Familia Caecidae Gray, 1850 no nordeste do Brasil. *Cadernos Omega da Universidade Federal Rural de Pernambuco, Série Ciências Aquáticas*. Recife. 2:145–166.

Montagu, G. 1803. *Testacea Britanica or Natural History of British shells, marine, land and the freshwater, including the* *most minute: systematically arranged and embellished with figures*. Romsey, London. 497 pp.

Moore, D.R. 1972. Ecological and Systematic notes on Caecidae from St. Croix and Virgin Islands. *Bulletin of Marine Science*, Coral Gables 22(4):881–899.

Morse, E. 1919. New forms of *Caecum* in New England. *The Nautilus*, 32(3):73–77.

Morton, P.K. 1977. Geology and mineral resources of Imperial County, California. *California Division of Mines and Geology County Report* 7:104 pp.

Oliveira, M.P., and M.N. Almeida. 1999. Contribuição ao conhecimento da família Caecidae (Mollusca, Gastropoda) no Brasil. *Strombus*, São Paulo, 4:1–12.

Olsson, A.A. and A. Harbison. 1953. Pliocene Mollusca of Southern Florida. *Monograph of the Academy of Natural Sciences of Philadelphia* 8:1–457.

Peterson, M.S. 1975. Geology of the Coachella Fanglomerate. Pp. 119–126, *in* Crowell, J.C., ed. *San Andreas fault in southern California — a guide to San Andreas fault from Mexico to Carrizo Plain*. California Division of Mines and Geology, Special Report 118.

Powell, C. L., II. 1985. Bivalve molluscan paleoecology of northern exposures of the marine Neogene Imperial Formation in Riverside County, California. *Western Society of Malacologists Annual Report* 17:29–32 (reprinted in *Shells and Sea Life*, 17(9):211–213, 1986).

Powell, C.L., II. 1986. Stratigraphy and bivalve molluscan paleontology of the Neogene Imperial Formation in Riverside County, California. San Jose, CA. MS thesis, San Jose State University.

Powell, C. L., II. 1987. Correlation between sea-level events and deposition of marine sediments in the proto-Gulf of California during the Neogene [abs.]. *Geological Society of America Abstracts with Programs* 19(7):809.

Powell, C. L., II. 1993. Macrofossils from the Imperial Formation in the Ocotillo Wells State Vehicle Recreation area, Imperial and San Diego counties, California. *U.S. Geological Survey Open-File Report* 93-562:1–7.

Powell, C. L., II. 1995. Paleontology and significance of the Imperial Formation at Garnet Hill, Riverside County, California. *U.S. Geological Survey Open-File Report* 95-489:1–10.

Powell, C.L., II. 2008. Pliocene invertebrates from the Travertine Point outcrop of the Imperial Formation, Imperial County, California. *U.S. Geological Survey Scientific Investigations Report* 2008-5155:1–25. http://pubs.usgs.gov/sir/2008/5155/sir2008-5155.pdf

Powell, C.L., II, and P.I. LaFollette. 2012, Preliminary review of the molluscan fauna from the Super Creek exposures of the "Imperial" Formation (late Miocene), north of Palm Springs, Riverside County, California. *CalPaleo 2012 abstracts with program*:16-17.

Powell, C.L., II, M. Roeder, and K. McDougall. 2011. A preliminary report on the paleontology of the Imperial Formation (ancestral Gulf of California; Pliocene) in the Indio Hills, Riverside County, southern California. *CalPaleo 2011 abstracts with program*:22.

Redfern, C. 2013. *Bahamian Seashells 1161 Species from Abaco, Bahamas*. Bahamian Seashells, Inc, Boca Raton. 501 pp.

Rios, E.C. 1994. *Seashells of Brazil*. Fundação Universidade do Rio Grande, Rio Grande. 368 pp.

Rosenberg, G. 2009. Malacolog 4.1.1: A Database of Western Atlantic Marine Mollusca. [WWW database (version 4.1.1)] http://www.malacolog.org/.

Ruisaard, C.L. 1979. Stratigraphy of the Miocene Alverson Formation, Imperial County, California. MS thesis, San Diego State University.

Rymer, M. J., A.M. Sarna-Wojcicki, C.L. Powell, II, and J.A. Barron. 1994. Stratigraphic evidence for late Miocene opening of the Salton Trough in southern California. *Geological Society of America Abstracts with Programs* 26(2):87.

Rymer, M. J., C.L. Powell, II, A.M. Sarna-Wojcicki, and J.A. Barron. 1995. Late Miocene stratigraphic and paleogeographic setting of Garnet Hill in the northwestern Salton Trough, southern California. A.*A.P.G., S.E.P.M., S.E.G., A.E.G., S.P.W.L.A., D.P.A., D.E.G., E.M.D., A.W.G, 1995 Pacific Section convention (San Francisco, CA), schedule and abstracts*:43.

Stimpson, W. 1851. Monograph of the genus *Caecum* in the United States. *Proceedings of the Boston Society of Natural History* 4:112–113.

Valentine, J.W. 1959. Pleistocene Molluscan Notes. I. The Bay Point Formation at Its Type Locality. *Journal of Paleontology* 33 (4): 685–688.

Valentine, J.W. 1989. How good was the fossil record? Clues from the Californian Pleistocene. PaleoBios 15(2):83–94.

Vannozzi, A. 2019. The identity of *Meioceras elongatum* de Folin, 1881 (Gastropoda, Caenogastropoda, Caecidae). *Basteria*, 83(1–3):35–38.

Vokes, H.E., and E. H. Vokes. 1983. *Distribution of shallow-water marine Mollusca, Yucatan Peninsula, Mexico*. Middle American Research Institute Publication, New Orleans, 54:1–183.

Woodring, W.P. 1928. Miocene Mollusks from Bowden, Jamaica. Part II. Gastropods and discussion of results. *Carnegie Institute of Washington Publication*, Washington 385:564 pp.

Woodring, W.P. 1959. Geology and paleontology of Canal Zone and adjoining parts of Panama: Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae). *U.S. Geological Survey Professional Paper* 306-B:147–239.

Woodring, W.P., M.N. Bramlette, and W.S.W Kew. 1946. Geology and paleontology of Palos Verdes Hills, California. *U.S. Geological Survey Professional Paper* 207: 1-145.