On the Growth Stages of *Conus fergusoni* Sowerby, 1873, the Reinstatement of *Conus xanthicus* Dall, 1910, and a New Species of *Conus* from the Galápagos Islands

BY

JAMES H. McLEAN

Natural History Museum of Los Angeles County, Los Angeles, California 90007

AND

JAMES NYBAKKEN

Moss Landing Marine Laboratories of the Central California State Universities and Colleges
Moss Landing, California 95039

(3 Plates; 4 Text figures)

INTRODUCTION

In reviews of eastern pacific *Conus* species, Nybakken (1970: 25; 1971: 97) reported markedly different radula morphology between specimens considered adults and juveniles of *C. fergusoni* Sowerby, 1873. Nybakken suggested 3 possible explanations for this apparent anomaly: 1) dimorphism in *C. fergusoni*, 2) change in radula morphology with growth, 3) confusion between 2 species. Too few specimens were then available to allow resolution of the problem. Since that time additional specimens have enabled us to reach new conclusions.

Mature specimens of *Conus fergusoni*, largest of the tropical eastern Pacific species of *Conus*, have readily been recognized by previous workers. The juvenile shell of the species has not been understood, however. Recent authors (Hanna & Strong, 1949; Keen, 1958; Emerson & Old, 1962; Hanna, 1963; Nybakken, 1970, 1971; Keen, 1971) have considered the taxon *C. xanthicus* Dall, 1910, to represent the immature form of *C. fergusoni*. We now show that *C. xanthicus* is separable from *C. fergusoni* on both shell and radula morphology. The true juvenile of *C. fergusoni* is described and figured for the first time.

During this study, we found that some specimens from the Galápagos Islands thought to be *Conus xanthicus* had a radula unlike that of either *C. xanthicus* or *C. fergusoni*. We describe these specimens as a new species. *C. **kohni*** McLean & Nybakken.

In this account we give comparative descriptions of the 3 taxa and figure a number of specimens to illustrate growth stages and some of the variation in each species. We have examined all previously illustrated specimens in the California Academy of Sciences and the American Museum of Natural History collections. The figure citations in our synonymies are based upon new determinations of the identity of these specimens. Our radular descriptions employ the terminology used by Nybakken (1970). The accounts of the radula are based on the following number of examined specimens: *Conus fergusoni* 5, *C. xanthicus* 10 (including the holotype); *C. **kohni*** 6 (including the holotype).

Museum abbreviations used in the text are as follows: AHF, Allan Hancock Foundation, University of Southern California (collection housed at LACM); CAS, California Academy of Sciences, San Francisco; LACM, Los Angeles County Museum of Natural History; USNM, United States National Museum of Natural History, Washington.

ACKNOWLEDGMENTS

We are especially grateful to Mr. Leroy H. Poorman, Westminster, California, who was much involved in the discussions that led to the recognition of the growth stages of these species. He has also donated specimens (Figures 6, 11, and 15) important to this work. Mr. Gerald Wellington, University of California, Santa Barbara, contributed specimens

from the Galápagos Islands, including the type lot of the new species. Additional specimens have been loaned by Mr. Alex Kerstitch of Tucson, Arizona. We thank curators and staff at the American Museum of Natural History, California Academy of Sciences, and the National Museum of Natural History for the loan of the specimens.

William K. Emerson, A. Myra Keen, Alan J. Kohn, Patrick I. LaFollette, and Leroy H. Poorman critically read the manuscript and offered helpful suggestions. We are grateful to Dr. Kohn for allowing us to compare the new species with his collection of type photography, specimens, and radula slides. The photographs are the work of Mr. Bertram C. Draper, Los Angeles.

SPECIES ACCOUNTS

Conus fergusoni Sowerby III, 1873

(Figures 1, 2, 5-11)

Conus fergusoni SOWERBY III, 1873: 145; plt. 15, fig. 1 – 1887: 256; plt. 508, fig. 675 – DALL, 1910: 218 – HANNA & STRONG, 1949: 294; plt. 7, fig. 3 – KEEN, 1958: 485; fig. 938 – EMERSON & OLD, 1962: 26; fig. 14 – HANNA, 1963: 42; plt. 4, fig. 2; plt. 9, fig. 10 – NYBAKKEN, 1970: 13; figs. 18, 19 (radula), figs. 40, 41 – NYBAKKEN, 1971: 97; fig. 4 – KEEN, 1971: 667; fig. 1511 left.

Diagnosis: Coronations persisting through 10th whorl, spire whorls slightly concave; large specimens white, small specimens yellow-orange, with lighter, even banding; shells under 25 mm in length with widely spaced spiral rows of dark brown spots; spire lacking color pattern.

Description: Shell large (maximum length 153 mm, with 12 to 13 teleoconch whorls); spire low to moderately elevated; spire outline concave in small specimens to nearly straight in large specimens; shoulder sharply angulate in small specimens, less angulate in large specimens; the angulation with low coronations in small specimens, the coronations often persisting through a shell length of 50 mm; coronations indistinct and undulating in large specimens; spire whorls slightly concave, spire sculptured with fine spiral striae and growth lines; suture produced at the shoulder, deeply and narrowly incised; whorl profile more or less straight except convex below the shoulder; surface smooth except for 10-15 spiral striae on lower third of whorl; aperture moderately broad, of about the same width throughout and conforming to whorl profile. Protoconch homeostrophic, 3-whorled, smooth, dark; shoulder of early teleoconch whorls angulate; suture produced well below the angulation; suture rising to meet the shoulder by the 6th whorl; coronations on the shoulder angulation persisting to at least the 8-whorled stage. Color light yellow-orange, paler in medium-sized specimens, fading to white in large specimens; small specimens with a distinct lighter spiral band about the middle of the shell and usually a second light band at the shoulder; spire lacking color pattern; small specimens with spiral rows of dark brown dots on body whorl; aperture white within. Periostracum thin

Explanation of Figures 5 to 12

(Figures are scaled to render a shell 60 mm in length at life size and a 15 mm shell at a length of 35 mm, with intermediate-sized shells proportionally scaled. Spire views are oriented perpendicular to a plane touching the apex and the shoulder and are enlarged to a diameter of 2/3 the length of the frontal view.)

Conus fergusoni Sowerby III, 1873

Figure 5: AHF 395-35, 26-29 m, rocky, off Isla Lobos de Afuera, Peru. Radula verified specimen, length 61 mm, periostracum intact.

Figure 6: LACM 35506, 73 m, muddy, Bahía Bocochibampo, Guaymas, Sonora, Mexico. Length 52.6 mm, periostracum removed (spire with persistent coronations; largest specimen examined showing juvenile spotted pattern).

Figure 7: LACM 72-73, 40-55 m, Golfo Dulce, Puntarenas Prov., Costa Rica. Length 52.4 mm, periostracum intact (spire coronations relatively faint).

Figure 8: AHF 431-35, 82 m, sand & gravel, off Rocas Octavia, Colombia. Radula verified specimen, length 43.5 mm, periostracum intact (spire coronations prominent).

Figure 9: CAS 12310, 77 m, off Punta Judas, Costa Rica. Length 42.8 mm, periostracum removed from body, intact on spire (spotted specimen figured by HANNA, 1963, plt. 9, fig. 10).

Figure 10 LACM 72-12, 53-26 m, mud, Bahía Elena, Guanacaste Prov., Costa Rica. Radula verified specímen (see Figure 2), length 26.1 mm, periostracum removed (spotted juvenile; smallest radula-verified specimen).

Figure 11: LACM 36563, 20 m, Bahía Santiago, Colima, Mexico. Length 14.0 mm, dead specimen, periostracum worn away (spotted juvenile, smallest specimen examined).

Conus virgatus Reeve, 1849

Figure 12: CAS 39174, vicinity of Guaymas, Sonora, Mexico (from shrimp boats). Length 41 mm, periostracum removed, surface eroded (example of banded form; note lack of coronations; specimen previously misidentified as *C. fergusoni*).

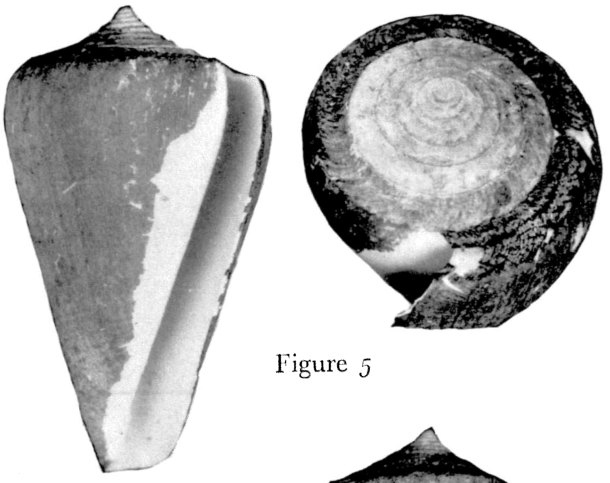


Figure 5

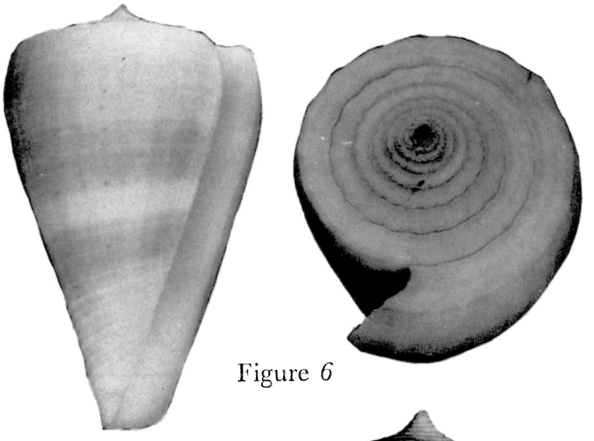


Figure 6

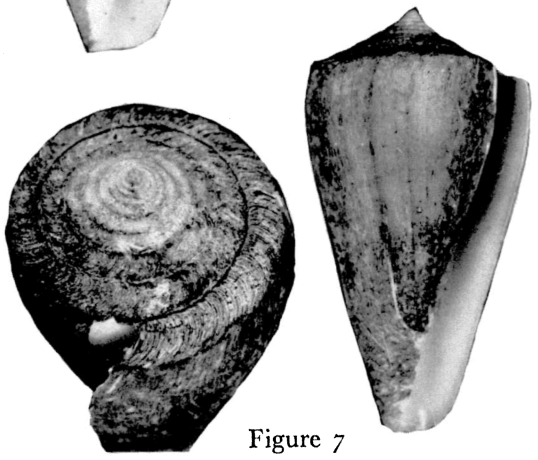


Figure 7

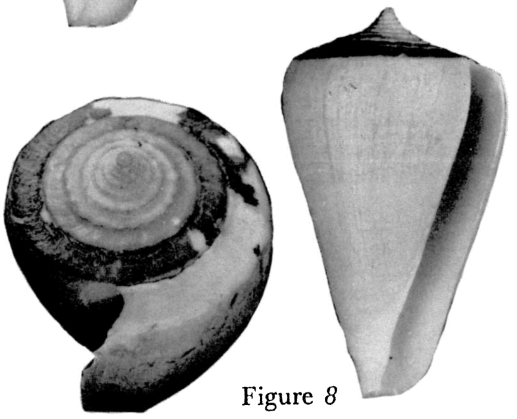


Figure 8

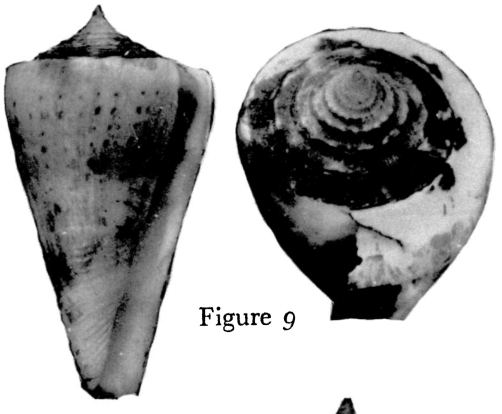


Figure 9

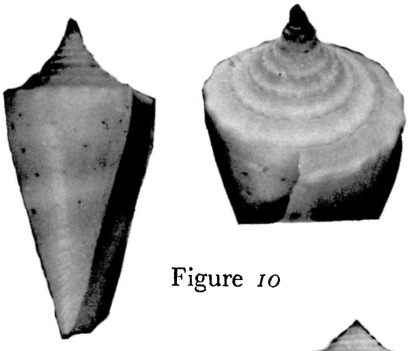


Figure 10

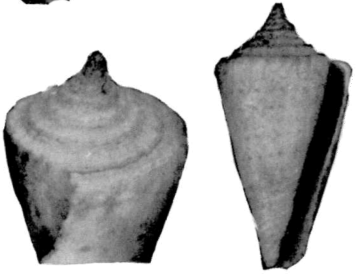


Figure 11

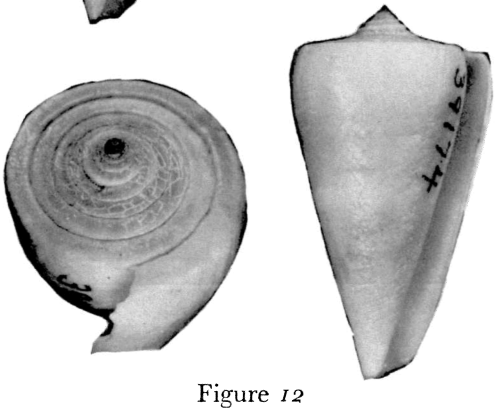


Figure 12

and light colored in small specimens, thick and dark brown in large specimens, produced in closely set, concave ridges on the spire. Operculum bluntly unguiculate, about 4 times longer than wide.

Radula (Figures 1, 2): Tooth from mature specimens

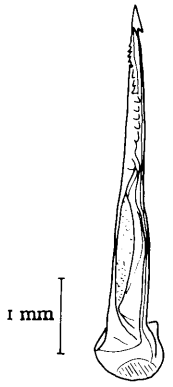


Figure 1

Conus fergusoni, from 26.1 mm specimen (shell: Figure *10*). Radular tooth (scale = 0.1 mm)

(Figure 2) long; serration extending half the length of the tooth, terminating proximally in a pointed or rounded cusp; barbs 2, one at the tip, the other on the opposite side; blade and waist lacking, base enlarged, rounded, bearing a pointed spur. Tooth from the smallest specimen examined (Figure 1) (shell length 26.1 mm, Figure *10*), proportionately shorter, the 1st barb weaker, 2nd barb undeveloped; waist indistinct, the proximal portion of the shaft wider than the distal; base enlarged, rounded, with prominent spur.

Radula preparations were made from 5 specimens, including those illustrated in Figures *5*, *8*, and *10*. Except for the radula from the smallest specimen (Figure *10*), there was no significant variation in tooth morphology.

Distribution and occurrence: Bahía Tortuga, Baja California, Mexico (HANNA & STRONG, 1949), north in the Gulf of California to Guaymas, Sonora, south to Isla Lobos de Afuera, Peru; Galápagos Islands, Ecuador. *Conus fergusoni* is uncommon at the Galápagos Islands; we have received specimens collected by Gerald Wellington at Isla Isabela and HANNA & STRONG (1949) mentioned a specimen of 128 mm in length collected at Caleta Tagus, Isla Isabela. Near the northern and southern range extremes, the entrance to Bahía Magdalena, Baja California, Mexico, in the north, and Isla Lobos de Tierra and Isla Lobos de Afuera, Peru, in the south. McLean observed *C. fergusoni* on rocky bottoms at shallow subtidal depths. At localities in the central part of the range it is less common and is known only from dredged records. The species is not restricted to a rocky substrate; McLean has observed large numbers taken on soft bottoms on the shrimp fishing ground in the Gulf of Guayaquil off northernmost Peru.

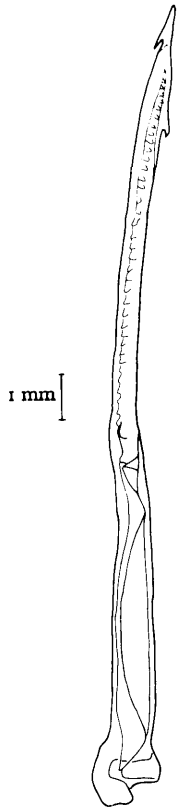


Figure 2

C. fergusoni, from 51.9 mm specimen (Gulf of Panama, Univ. of Miami, uncatalogued). Radular tooth (scale = 0.1 mm)

Comparisons: Immature specimens of *Conus fergusoni* differ from *C. xanthicus* and *C. **kohni*** in having prominent coronations on the early whorls. The coronations persist through at least the 8-whorled stage and may be observed in spire view on specimens of any size, including shells with

intact periostraca. Similar persistent coronations characterize *C. patricius* Hinds, 1843, but that species differs in having a rounded shoulder and a marked concavity of the lower body whorl profile, features particularly apparent in young shells. The color patterns of young shells of *C. fergusoni* differ from those of both *C. xanthicus* and *C. kohni* in lacking mottling on the spire and in having even banding, and in younger stages, rows of dark spots, instead of mottled banding with jagged edges.

An uncommon color form of *Conus virgatus* Reeve, 1849, has also been a source of confusion. This form, an example of which was described as *C. signae* Bartsch, 1937, lacks axial flammules and may have a central band of lighter color intensity. However, such specimens of *C. virgatus* (Figure *12*) lack coronations on the spire and the whorls are not as rapidly expanding as in *C. fergusoni*.

Variability: *Conus fergusoni* is moderately variable in shell proportion and height of spire. For example, shells in Figures *6* and *7* are of about the same length but that in Figure *6* is lower spired, broader at the shoulder and has a more pronounced bulge below the shoulder. Young shells lose the typical coloration of banding and spotting at different sizes. All of the 5 smallest shells examined (none exceeding 26 mm in length) are spotted. Spots have been observed on one shell as large as 52.6 mm in length (Figure *6*); the smallest shell observed on which spots are lacking is 43.5 mm in length (Figure *8*).

Remarks: The original illustration of *Conus fergusoni* is an accurate rendition of a large, white-shelled specimen lacking the periostracum, 145 mm in length, apparently life size, no dimensions being given. The description consisted of a brief Latin diagnosis. The source of the original material was given as follows: "Several specimens . . . collected at Panama by Mr. Ferguson." The present location of type material is unknown; specimens have not been located in the British Museum (Alan J. Kohn, personal communication).

Previous accounts of *Conus fergusoni* have included *C. xanthicus* Dall, 1919, as a synonym, thereby attributing excessive variability to the species. This confusion is no doubt due to scarcity of juvenile specimens of *C. fergusoni*. In all the museum and private collections examined by us, we have located only five specimens under 40 mm in length. McLean can attest to the apparent absence of juveniles, having seen numbers of mature specimens at Isla Lobos de Afuera, Peru, but none under 55 mm in length, despite having taken many gravel samples from crevices and under rocks.

HANNA & STRONG (1949: 295) and HANNA (1963: 43) claimed that "a magnificent series of growth stages has enabled us to state with assurance that *C. xanthicus* is the young of *C. fergusoni*." We have examined all small specimens in the California Academy collection previously identified as *C. fergusoni* and find that the smallest authentic specimen studied by Hanna is the 42.8 mm shell figured in

Explanation of Figures *13* to *23*

Conus xanthicus Dall, 1910

Figure *13*: USNM 111236, Holotype of *C. xanthicus*, 130 m, sand, off Guaymas, Sonora, Mexico. Radula verified specimen, length 42.5 mm, periostracum removed.

Figure *14*: Berry Collection, Holotype of *C. chrysocestus*, 55-82 m, off Morro Colorado, Sonora, Mexico. Length 45.3 mm, periostracum removed (relatively low-spired specimen).

Figure *15*: LACM 11345, 73 m, off La Paz, Baja California, Mexico. Radula verified specimen, length 53.4 mm, periostracum removed (relatively low-spired specimen).

Figure *16*: AHF 1118-40, 108-126 m, coarse gray sand, Banco Gorda, Baja California, Mexico. Length 40.0 mm, periostracum removed on ventral side, intact on dorsal side (relatively high-spired specimen).

Figure *17*: CAS 17809, 29 m, Bahía Chamela, Jalisco, Mexico. Length 41.9 mm, periostracum intact (relatively low-spired specimen; spiral sculpture on spire whorls especially prominent).

Figure *18*: AHF 300-34, 73 m, sand, Bahía Azufre, Isla Clarion, Revillagigedo Islands, Mexico. Radula verified specimen, length 24.3 mm, periostracum removed.

Figure *19*: AHF 431-35, 82 m, sand & gravel, off Rocas Octavia, Colombia. Radula verified specimen, length 39.1 mm, periostracum removed (relatively slender specimen).

Figure *20*: AHF 325-35, 146 m, rocky, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Length 46.8 mm, periostracum removed (largest specimen examined from Galápagos Islands).

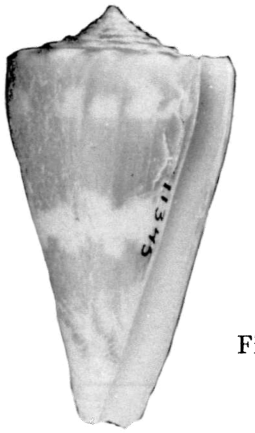
Figure *21*: AHF 792-38, 128-146 m, off Isla Daphne Chica, Galápagos Islands, Ecuador. Radula verified specimen, length 35.7 mm, periostracum intact.

Figure *22*: CAS 38975, 18-37 m, off Isla Rabida, Galápagos Islands, Ecuador. Length 32.2 mm, periostracum removed.

Figure *23*: AHF 324-35, 82 m, rock, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 14.3 mm, periostracum partially intact (smallest specimen examined).

Figure 13

Figure 14



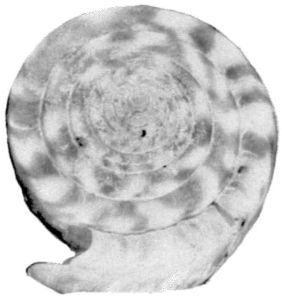


Figure 15

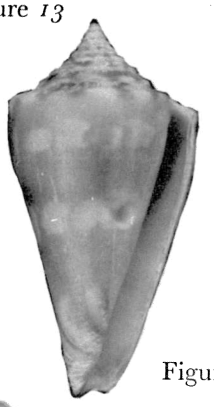


Figure 16

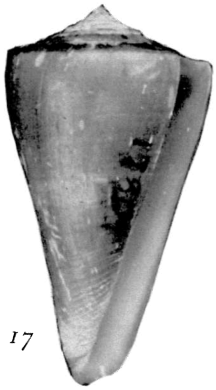
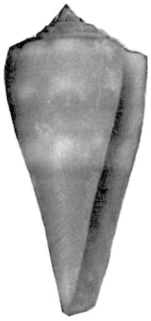


Figure 17



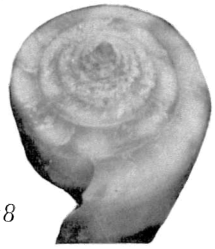


Figure 18

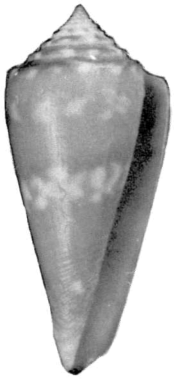


Figure 19

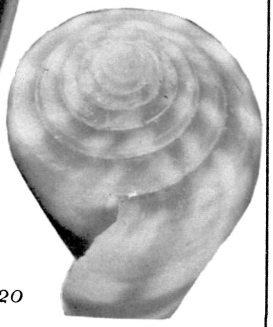


Figure 20

Figure 21

Figure 22

Figure 23

color (HANNA, 1963: plt. 9, fig. 10), our Figure 9. Other small specimens in the Academy collection are identified by us as *C. xanthicus*. There is no indication of intergradation with *C. fergusoni*. EMERSON & OLD (1962: 27) considered specimens resembling *C. xanthicus* "to be merely a highly colored deep water ecotype of *C. fergusoni*," but did not document any depth-related distinctions. They noted coronations in the one authentic specimen of *C. fergusoni* they illustrated but did not question the lack of this character in the other specimens so identified.

Conus fergusoni is one of few species in which a young specimen of *Conus* has been shown to have a radular tooth morphology differing from that of the adult. We treat this further in the discussion section of this paper.

Conus xanthicus Dall, 1910

(Figures 3, *13-23*)

Conus xanthicus DALL, 1910: 225 – HANNA & STRONG, 1949: 294 (as syn. of *C. fergusoni*), plt. 7, figs. 1, 2, 4 (holotype) – KEEN, 1958: 485 (as syn. of *C. fergusoni*) – EMERSON OLD, 1962: 26 (as syn. of *C. fergusoni*), figs. 13 left 13 right, 15 left, 15 right – HANNA, 1963: 42 (as syn. of *C. fergusoni*), plt. 2, fig. 4, plt. 5, fig. 5 (holotype), plt. 7, fig. 9 – NYBAKKEN, 1970: 25 (status uncertain); fig. 20 (radula), figs. 42, 43 – NYBAKKEN, 1971: 97 (as possibly valid species); fig. 5 – KEEN, 1971: 667 (as syn. of *C. fergusoni*); fig. 1511 right (holotype of *C. chrysocestus*).

Conus chrysocestus BERRY, 1968: 157 – NYBAKKEN, 1971: 99 (as syn. of *C. fergusoni* – KEEN, 1971: 667 (as syn. of *C. fergusoni*); fig. 1511 right (holotype).

Diagnosis: Coronations present only at very early stage, spire whorls slightly concave, aperture narrow; color yellow-orange, lighter color bands irregular, mottled; spire whorls mottled; spire color darker than that of body whorl.

Description: Shell medium-sized (maximum length 54 mm, with 10 teleoconch whorls); spire varying from low to moderately elevated; spire outline straight to somewhat concave; shoulder distinctly ridged, not coronated in mature stages; spire whorls flat to slightly concave, spire sculptured with faint growth lines and microscopic spiral striae; suture produced below the shoulder ridge, well defined but not deeply channeled; anal sinus of medium depth; body whorl profile with a faint convexity below the shoulder, basal profile variable from straight to convex or concave; surface smooth except for 10-15 spiral striae on base; aperture relatively narrow, of same width throughout and conforming to whorl profile. Protoconch homeostrophic, 3-whorled, smooth, light colored; shoulder of early teleoconch whorls coronated, coronations lost by 3rd to 6th teleoconch whorl; early juvenile shells with 2-3 incised spiral striae below the shoulder. Color dark yellow to orange brown, with two irregular, often interrupted white bands; basal area variegated with white; white mottling at the shoulder produces light and dark radial markings on spire; ground color on spire of greater intensity than that of body whorl; aperture white within. Periostracum brownish, thin over body whorl, thicker on spire and produced in closely set, thin, arched ridges. Operculum bluntly unguiculate, about two times longer than wide.

Radula (Figure 3): Tooth of the "*Conus regularis* type" (NYBAKKEN, 1970), with single barb at the tip, a well-developed opposite blade extending about 1/3 the length of the tooth; serration prominent and extending about the same distance as the blade; waist slight; base enlarged with a small spur on one side.

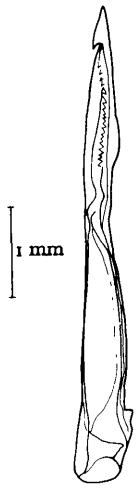


Figure 3

C. xanthicus, from 35.7 mm specimen (shell, Figure *21*). Radular tooth (scale = 0.1 mm)

Radula preparations were made from ten specimens, ranging in shell length from 14.2-54.3 mm, including those illustrated in Figures *13* (holotype), *15*, *18*, *19*, *21*, and *23*. There was no significant variation in tooth morphology among the examined specimens.

Distribution and occurrence: Morro Colorado, Sonora, Mexico (type locality of *Conus chrysocestus*), to Rocas Octavia, Colombia (6°47'N; AHF 431-35); Revillagigedo Islands, Mexico, and Galápagos Islands, Ecuador. All oc-

currences are well offshore, chiefly in the 50-140 m depth range. We have examined 4 lots from Sonora, 14 lots from the southeastern side of Baja California from Isla Carmen to the Gorda Banks off Cape San Lucas, 12 lots from Isla Clarion, Revillagigedo Islands, 1 lot from southern Mexico, 1 lot from the Perlas Islands, Panama, 1 lot from Colombia (Figure *19*) and 10 lots from the Galápagos Islands. The Rocas Octavia locality in Colombia is both the southernmost record known for *C. xanthicus* and the only station from which both *C. xanthicus* and *C. fergusoni* have been collected together.

Comparisons: Although *Conus xanthicus* could not be confused with large, fully mature specimens of *C. fergusoni*, it has been confused with immature specimens of the latter. Mature *C. xanthicus* differ from immature *C. fergusoni* in lacking coronations, producing the suture below (rather than at) the shoulder, having a narrower aperture, having an irregular, mottled (rather than even) banding pattern on the body whorl, and having a mottled (rather than unmarked) pattern on the spire. Juvenile *C. xanthicus* do not have the regular rows of spots of juvenile *C. fergusoni*. *Conus xanthicus* has a general resemblance to *C. virgatus* Reeve, 1849, but has a more angulate shoulder and does not have the axial color markings of that species. Like *C. fergusoni*, *C. virgatus* also produces the suture at the shoulder. Comparisons with *C. **kohni*** are given under the treatment of that species.

Variability: *Conus xanthicus* is highly variable in breadth and in spire profile. Too few specimens are available to fully document the range of variation, but some generalizations may be made. Those seen from Sonora are relatively low spired, although the spire of the holotype of *C. xanthicus* (Figure *13*) is higher than that of the holotype of the synonymous *C. chrysocestus* (Figure *14*). Those from the southeastern side of Baja California are similarly variable, but some higher spired forms are known from the region (Figure *16*). Specimens from Isla Clarion are rather small and uniform (Figure *18*). The Colombian specimen (Figure *19*) is rather narrow and high spired. Galapagan specimens (Figures *20-23*) are rather uniformly narrow and moderately high spired.

Remarks: The holotype of *Conus xanthicus* (USNM 111236, Figure *13*), from 130 m off Guaymas, Sonora, Mexico, was not originally figured. The taxon was apparently not discussed again until HANNA & STRONG (1949) figured the holotypes and placed the name in the synonymy of *C. fergusoni*. The holotype of the synonymous *C. chrysocestus* Berry remains in the private collection of S. Stillman Berry, Redlands, California (Figure *14*). It is also from Sonora, Mexico: "trawled in 30 to 45 fms., off Morro Colorado, Sonora; Antonio Luna, Dec. 1965." It is a large, brightly colored specimen which was not compared by Berry to *C. xanthicus*. He apparently did not question the long-held view of other authors concerning the validity of *C. xanthicus*.

*Conus **kohni*** McLean & Nybakken, spec. nov.

(Figures 4, *24-29*)

Diagnosis: Coronations present only at very early stage, spire whorls markedly concave, aperture relatively broad; color yellow-orange, with mottled, lighter colored banding; spire with radial markings of same intensity as that of rest of shell.

Description: Shell medium-sized (maximum length 52.5 mm, with 9 teleoconch whorls); spire moderately elevated; spire outline slightly concave to straight; shoulder distinctly ridged, not coronated in mature specimens; spire whorls

Explanation of Figures *24* to *29*

*Conus **kohni*** McLean & Nybakken, spec. nov.

Figure *24*: LACM 1885, holotype, 18-37 m, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 35.3 mm, periostracum removed ventrally, intact on spire.

Figure *25*: AHF 788-38, 101 m, coral & shell bottom, off Isla Daphne, Galápagos Islands, Ecuador. Length 52.3 mm, periostracum removed, lip broken back (largest specimen examined).

Figure *26*: AHF 788-38, same locality as Figure *25*. Length 43.5 mm, periostracum intact.

Figure *27*: LACM 72-200, 40-45 m, coralline algal rubble, Bahía Academia, Isla Santa Cruz, Galapagos Islands, Ecuador. Radula verified specimen, length 40.0 mm, periostracum removed.

Figure *28*: CAS 46379, Isla Santa Cruz, Galápagos Islands, Ecuador. Length 33.6 mm, periostracum removed.

Figure *29*: AHF 324-35, 82 m, rock, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador. Radula verified specimen, length 15.0 mm, periostracum partially intact (smallest specimen examined).

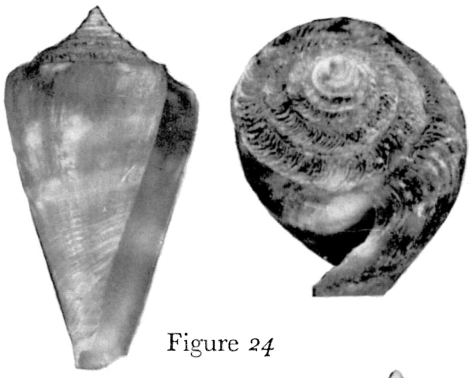


Figure 24

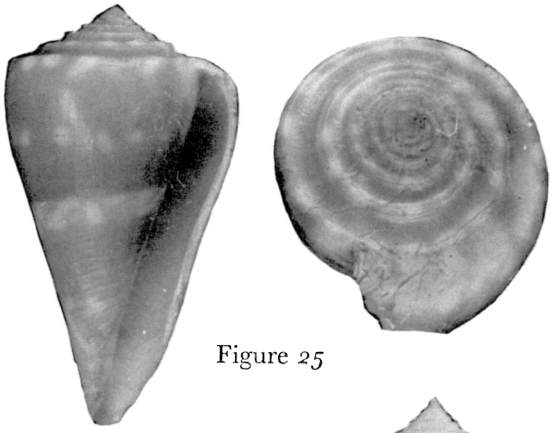


Figure 25

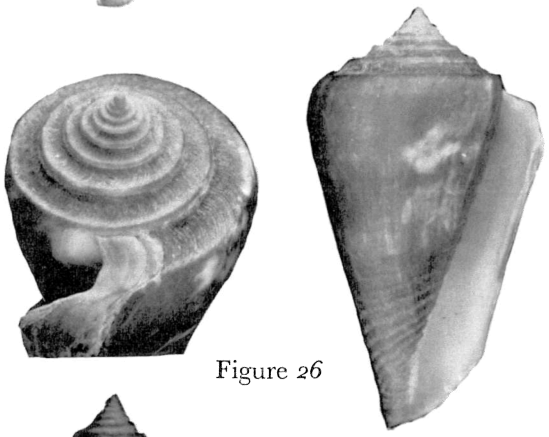


Figure 26

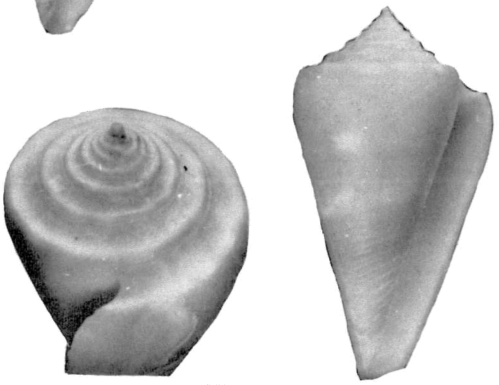


Figure 27

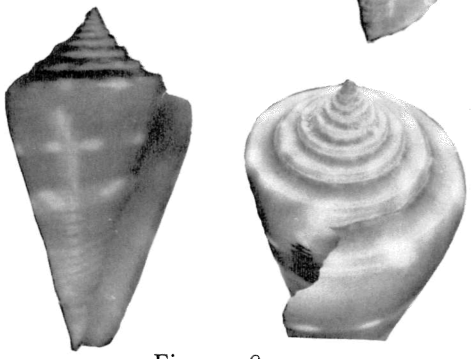


Figure 28

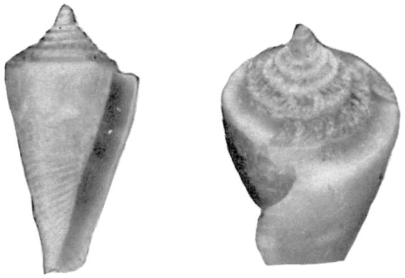


Figure 29

markedly concave, sculptured with faint growth lines; suture produced below the shoulder ridge, well defined but not deeply channeled; anal sinus of medium depth; outer lip thin, arcuate; body whorl profile with a convexity 1/8 the distance below the shoulder and a slight concavity at 1/3 the distance from the base; surface smooth except for 10-12 spiral lirae on the lower third of body whorl; aperture relatively wide, of same width throughout and conforming to the body whorl profile. Protoconch homeostrophic, 3-whorled, smooth, light colored; shoulder of first three teleoconch whorls weakly coronated, coronations lost by the 5th whorl. Color yellow to orange, with 2 more or less distinct spiral bands of white or less intense ground color, bands often narrow and bearing smaller white spots; the basal area may have some lighter mottling or less intense coloration; the shoulder bears another series of whitish spots that extend across the spire; ground color on the spire of equal intensity to that on the body whorl, aperture white within. Periostracum brownish, thin over body whorl, thicker on the spire and produced in closely set, thin, arched ridges. Operculum bluntly unguiculate, margins unserrated, about 3 times longer than wide. Dimensions of holotype: length 35.3 mm, width 18.7 mm, length of operculum 6.5 mm.

Radula (Figure 4): Tooth with 3 barbs, one near the tip and 2 on the opposite side; the first 2 barbs sharply pointed, the 3rd more rounded; serration lacking; the narrowest part of the tooth posterior to the 3rd barb and marked by a more or less abrupt step or shelf; posterior to the waist the shaft diameter expands to a maximum and then constricts slightly before the base; the base is large and bears a prominent spur.

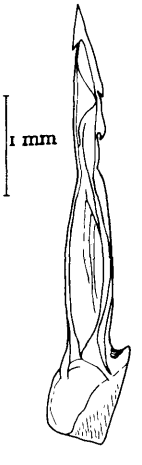


Figure 4

*C. **kohni**,* from 35.3 mm holotype specimen (shell: Figure *24*)
Radular tooth (scale = 0.1 mm)

Radula preparations were made from 6 specimens, including those illustrated in Figures *24* (holotype), *27*, and *29*. No variation was noted.

Type locality: 18-37 m, mud-silt bottom, Caleta Tagus, Isla Isabela, Galápagos Islands, Ecuador (0°24.5′S, 90° 23′W), 3 specimens collected by Gerald Wellington, 15 January 1975.

Type material: Holotype, LACM 1885; 1 paratype, CAS 59690; 1 paratype, USNM 758900.

Referred material (all Galápagos Islands, Ecuador): AHF 201-34, 46-64 m, Isla Espanola, 31 January 1934, 3 specimens; AHF 324-35, 82 m, Isla Isabela, 10 December 1934, 1 specimen; AHF 788-38, 101 m, Isla Daphne, 19 January 1938, 4 specimens; LACM 66-210, 34 m, Isla San Salvador, 24 September 1966, 1 specimen; CAS 46379, 100 m, Isla Santa Cruz, June 1969, 1 specimen; LACM 72-205, 40-45 m, Isla Santa Cruz, 31 January 1972, 3 specimens.

Distribution and occurrence: Galápagos Islands, Ecuador, on a variety of bottom types at depths of 18-100 m. At stations AHF 324-35 and 788-38 it occurred with *Conus xanthicus*. It may eventually be shown to occur elsewhere in the tropical eastern Pacific, although this now seems unlikely, considering that the region has been well sampled.

Etymology: We are pleased to name the species in honor of Dr. Alan J. Kohn of the University of Washington, who has contributed greatly to knowledge of the genus *Conus* over the past 20 years.

Comparisons: *Conus **kohni*** is similar to *C. xanthicus* in size and color pattern but may be distinguished on radula and shell characters. The radula tooth of *C. **kohni*** (Figure 4) differs from that of both *C. xanthicus* (Figure 3) and *C. fergusoni* (Figures 1, 2) in completely lacking a serration and having 3 barbs. The chief shell difference is the broader aperture of *C. **kohni,*** which increases the rate of expansion and results in mature shells of similar length having one less whorl. Mature shells typically have 10 whorls in *C. xanthicus* and 9 whorls in *C. **kohni***. Additionally, shells of *C. **kohni*** are broader, the lower portion of the body whorl is more concave, the lip is more arcuate, and the spire whorls are more concave. The ground color and the color patterns are remarkably similar, although the lighter bands of *C. **kohni*** tend to be narrower. Comparison of specimens with the periostracum removed shows the ground color on the spire to be darker than the ground color of the body whorl in *C. xanthicus,* whereas in *C.*

kohni the ground color on the spire and on the body whorl is identical.

Variability: The 16 available specimens of *C. **kohni*** are uniform in proportions. Ground color varies from dark yellow to yellow-orange.

Remarks: Although specimens of *Conus **kohni*** were first collected over 40 years ago, the species has escaped notice until now, having no doubt been dismissed along with *C. xanthicus* as representative of the juvenile stage of *C. fergusoni*. Unlike *C. xanthicus*, however, misidentified specimens have not previously been illustrated. We were first alerted to its existence by discovery of an apparent discrepancy in radular characters among specimens thought to be *C. xanthicus*. Only after we had confirmed the presence of two species on radular characters were we able to recognize the associated shell characters that separate the 2 species.

Unfortunately we have not observed living examples of either *Conus xanthicus* or *C. **kohni***, so we do not know if there are body color differences between the 2 species. Similarly we do not know if there are differences in habitat or bottom type preference. The bottom type data available for both species ranges from mud, sand, coralline algal rubble, to rock, suggesting that both have a wide range of substrate occupancy.

DISCUSSION

*Conus **kohni*** is the only species of the genus at present considered endemic to the Galápagos Islands. Most mollusks known from the Galápagos Islands also occur in the tropical eastern Pacific, although there is a major endemic element and a small percentage of trans-Pacific migrants with Indo-Pacific faunal affinity.

Two Indo-Pacific species of *Conus* are known from the Galápagos: *Conus ebraeus* Linnaeus, 1758, and *C. chaldaeus* (Röding, 1798). These two species have also been reported from the mainland (see references in EMERSON, 1978). *Conus tessulatus* Born, 1778 is an Indo-Pacific species known from the Revillagigedo Islands and the mainland (EMERSON, 1978). It is possible that *C. **kohni*** is in this category, but if this is so, it remains to be discovered in the Indo-Pacific.

If *Conus **kohni*** is an eastern Pacific species, it may yet be found to occur elsewhere in the Panamic province, or it could represent a relict population surviving at the Galápagos Islands and extinct on the west American mainland. Few of the eastern Pacific Conidae, especially those that occur offshore such as *C. xanthicus*, are known from the fossil record.

We have no data as to the food of *Conus fergusoni*, *C. xanthicus*, or *C. **kohni***, but would anticipate that prey items would be different in all 3, based on major differences in tooth morphology. *Conus xanthicus* has a radula tooth morphology that is the most common in the genus, a type that NYBAKKEN (1970) termed "regularis." At least nine other Panamic species have a similar tooth (NYBAKKEN, *op. cit.*). The food of these species, where known, consists of errant polychaetes (NYBAKKEN, 1979). *Conus fergusoni* has a radula tooth similar to that of *C. princeps* Linnaeus, 1758, and *C. patricius* Hinds, 1843. Again, errant polychaetes should be the preferred food for species with a similar tooth (Nybakken, in press). The tooth of *C. **kohni*** is of an uncommon type for which no food data are available for any species with a similar morphology. It is most similar to that of the eastern Pacific species *C. recurvus* Broderip, 1833, and *C. arcuatus* Broderip & Sowerby, 1829.

The similarity between the tooth of *Conus **kohni*** and *C. recurvus* leads us to compare the shell morphology of the 2: proportions are similar; both have the concave shoulder and a markedly arcuate lip, but a very different color pattern. If other evidence can be found to support the theory that *C. **kohni*** and *C. recurvus* are closely related, it will imply that the similarity of color pattern between *C. xanthicus* and *C. **kohni*** is coincidental and convergent and that tooth structure is a conservative character. An alternative possibility is that the similar color pattern of *C. **kohni*** and *C. xanthicus* is the conservative feature and that the tooth structure has diverged in response to changes in diet.

Small specimens of *C. fergusoni* evidently have a different radula tooth morphology from that of large specimens. The tooth of a 26.0 mm long specimen is shown in Figure 1. The next smallest specimen from which we have obtained a radula is 43.5 mm in length. Its tooth, as in others from shells of larger sizes we have prepared (shell lengths, 85.1, 61.0, 60.7, and 51.9 mm) is similar to that of Figure 2. The tooth of the smallest specimen is proportionately shorter, lacks the second barb and has the first barb very weakly developed. The fact that the serration is the same, running half the length of the tooth, enables us to consider the transition to be reasonable, in the absence of intermediate-sized examples.

This is the second known species of *Conus* in which a change in radular tooth morphology has been demonstrated. NYBAKKEN (1970: 13) found that the radula tooth of a specimen of *C. patricius* 27.1 mm in length was

proportionately shorter than that of the adult and entirely lacked the blade, barb, and serration. That, however, probably represented an earlier stage of tooth development than in our example with *C. fergusoni*. NYBAKKEN (1970) found that other *Conus* species examined did not show any significant change in tooth morphology between young and mature specimens. Both species reach large sizes – changes in tooth morphology with growth may prove to be a feature of only those species that attain the largest sizes.

In addition to large size and similar tooth morphology, both *Conus fergusoni* and *C. patricius* have coronations in immature stages that are not formed in fully mature stages. The subgenus *Pyruconus* Olsson, 1967, was proposed for *C. patricius* (type species) and fossil species with a similar pyriform shape (OLSSON, 1967: 21). Although *C. fergusoni* is not similarly pyriform, it is evidently related and may also be tentatively assigned to the subgenus. However it is premature to attempt assignment of the other species treated here.

CONCLUSIONS

Two of the 3 possible explanations originally suggested by NYBAKKEN (1970) to account for different radula tooth morphologies in the then understood *Conus fergusoni* have proven to be the case: 2 species were being confused, and tooth morphology in *C. fergusoni* does change with growth. Change of tooth morphology with growth is evidently unusual in the genus and its occurrence in other species should be further documented.

Recognition of *Conus xanthicus* has long been delayed because of confusion with immature specimens of *C. fergusoni,* due no doubt to the rarity of the earliest stages of *C. fergusoni* – for reasons not apparent. Previous authors had not realized that coronated early whorls are a feature of *C. fergusoni* and that small specimens have spiral rows of dark spots. *Conus fergusoni* is not highly variable, whereas *C. xanthicus* is unusually variable in elevation of the spire.

Conus xanthicus and the herein described *C. **kohni*** have been confused because of a nearly identical color pattern. The two may be separated on radula and shell characters. It remains to be demonstrated whether they are closely related or are more nearly related to other species having corresponding tooth morphologies.

Despite a spate of recent papers on the systematics of Eastern Pacific *Conus*, none of these papers contain rigorous comparative diagnoses of the shells, nor do we have information about the color of living animals or food habits for many of the species. Progress has been made with documentation of tooth morphologies. Future systematic work on the genus should include a discussion of radula characters.

NOTE ADDED IN PROOF

After this paper was submitted, we received "Cone Shells: A Synopsis of the Living Conidae," by Jerry G. Walls, 1011 pages, T. F. H. Publications, Inc., Neptune, N.J., published March 6, 1979. Our conclusions about the validity of *Conus xanthicus*, the synonymy of *C. chrysocestus*, and the spotted juveniles of *C. fergusoni* were also reached by Walls. However, he included *C. fulvocinctus* Crosse, 1873, in the synonymy of *C. fergusoni*, an opinion not shared by us. The locality for *C. fulvocinctus* was originally given as West Africa, and the 75 mm long specimen was said to have a thin periostracum. The original figure shows strong spiral cords extending from the base to the mid-whorl, spire whorls that are convex rather than concave, and no trace of coronations in early stages. We agree, however, that *C. consanguineus* E. A. Smith, 1880, locality unknown, is a probable junior synonym of *C. fergusoni*.

Literature Cited

BERRY, SAMUEL STILLMAN
1968. Notices of new eastern Pacific Mollusca. VII. Leafl. in Malacology 1 (25): 156 - 157

DALL, WILLIAM HEALEY
1910. Summary of the shells of the genus *Conus* from the Pacific coast of America in the United States National Museum. Proc. U. S. Natl. Mus. 38 (1741): 217-228 (6 June 1910)

EMERSON, WILLIAM KEITH
1978. Mollusks with Indo-Pacific faunal affinities in the eastern Pacific Ocean. The Nautilus 92 (2): 91 - 96

EMERSON, WILLIAM KEITH & WILLIAM ELWOOD OLD, Jr.
1962. Results of the Puritan-American Museum of Natural History expedition to western Mexico, 16. The recent mollusks: Gastropoda, Conidae. Amer. Mus. Novitates no. 2112: 44 pp.; 20 figs.

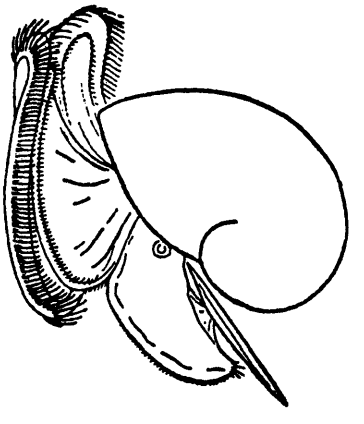
HANNA, G DALLAS
1963. West American mollusks of the genus *Conus*, II. Occ. Papers Cal. Acad. Sci., no 35: 103 pp.; 11 plts.; 4 text figs.

HANNA, G DALLAS & ARCHIBALD MCCLURE STRONG
1949. West American mollusks of the genus *Conus*. Proc. Cal. Acad. Sci. (4) 26: 247 - 322; plts. 5 - 10; 4 text figs.

KEEN, A. MYRA
1958. Sea shells of tropical west America; marine mollusks from Lower California to Colombia. Stanford Univ. Press, Stanford, Calif. i - xi + 624 pp.; 1700 text figs.; 10 colored plts. (5 Dec. 1958)
1971. Sea shells of tropical West America: marine mollusks from Baja California to Peru, 2nd ed. Stanford Univ. Press, Stanford, Calif. i-xiv+1064 pp.; ca. 4000 text figs.; 22 col. plts. (21 September 1971)

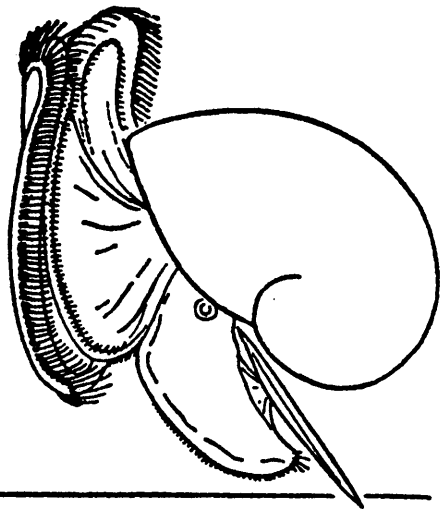
NYBAKKEN, JAMES WILLARD
1970. Radular anatomy and systematics of the west American Conidae (Mollusca, Gastropoda). Amer. Mus. Novitates no. 2414: 29 pp.; 45 figs.
1971. The Conidae of the Pillsbury Expedition to the Gulf of Panama. Bull. Mar. Sci. 21 (1): 93 - 110; figs. 1 - 26
1979. Population characteristics and food resource utilization of *Conus* in the Galápagos Islands. Pacif. Sci. 32 (3): 271 - 280
in press Population characteristics and food resource utilization of *Conus* in the Sea of Cortez and West Mexico. Journ. Mollusc. Stud.

OLSSON, AXEL ADOLF
1967. Some Tertiary mollusks from South Florida and the Caribbean. Paleontol. Res. Inst., Ithaca, N. Y. 61 pp.; 9 plts.
SOWERBY, GEORGE BRETTINGHAM (3rd)
1873. Descriptions of five new cones. Proc. Zool. Soc. London 1873: 145 - 146; plt. 15
1887. Thesaurus conchyliorum, or monographs of genera of shells. London, vol. 5: *Conus* suppl., 249 - 279; plts. 29 - 36 (507 - 512)



ISSN 0042-3211

THE VELIGER



A Quarterly published by
CALIFORNIA MALACOZOOLOGICAL SOCIETY, INC.
Berkeley, California

VOLUME 22 OCTOBER 1, 1979 NUMBER 2

CONTENTS

The Family Epitoniidae (Mollusca : Gastropoda) in the Northeastern Pacific. (6 Plates; 3 Text figures)
HELEN DUSHANE 91

Reprint → On the Growth Stages of *Conus fergusoni* Sowerby, 1873, the Reinstatement of *Conus xanthicus* Dall, 1910, and a New Species of *Conus* from the Galápagos Islands. (3 Plates; 4 Text figures)
JAMES H. MCLEAN & JAMES W. NYBAKKEN 135

The Familiy Lepidopleuridae (Mollusca : Polyplacophora) in the Eastern Pacific. (4 Plates; 8 Text figures)
ANTONIO J. FERREIRA 145

A Statistical Study of *Cypraea tigris* in the Central Pacific. (2 Text figures)
RICHARD E. BROCK 166

Pholadomya candida Sowerby: The Last Cadaver Unearthed. (1 Plate; 1 Text figure)
BRUCE RUNNEGAR 171

The Ultrastructure and Evolutionary Significance of the Ocelli in the Larva of *Katharina tunicata* (Mollusca : Polyplacophora). (3 Plates; 2 Text figures)
MARC DAVID ROSEN, CHARLES R. STASEK & COLIN O. HERMANS 173

New Information Concerning *Humboldtiana taylori* Drake, 1951 (Gastropoda : Pulmonata : Helminthoglyptidae). (1 Plate; 1 Text figure)
ARTIE L. METCALF & DAVID H. RISKIND 179

[Continued on Inside Front Cover]

Distributed free to Members of the California Malacozoological Society, Inc.
Subscriptions (by Volume only) payable in advance to Calif. Malacozool. Soc., Inc.
Volume 22: $30.- plus $1.50 for postage (U. S. A. only)
For ALL foreign countries: Swiss Francs 60.- plus SF 7.- for postage
Single copies this issue $22.00. Postage additional.
Send subscription orders to California Malacozoological Society, Inc.
1584 Milvia Street, Berkeley, CA 94709, U. S. A.
Address all other correspondence to Dr. R. STOHLER, *Editor*, Department of Zoology
University of California, Berkeley, CA 94720

Examination of a Reproductive Cycle of *Protothaca staminea* Using Histology, Wet Weight-Dry Weight Ratios, and Condition Indices. (4 Text figures)
HOWARD M. FEDER, JAMES C. HENDEE, PAT HOLMES, GEORGE J. MUELLER & A. J. PAUL 182

Life-Cycle Completion of the Freshwater Clam *Lasmigona compressa* (Bivalvia: Unionidae) in an Experimental Host, *Lebistes reticulatus.*
ALEX S. TOMPA 188

Philippia (Psilaxis) radiata: Another Indo-West-Pacific Architectonicid Newly Found in the Eastern Pacific (Colombia). (1 Plate; 1 Map)
ROBERT ROBERTSON 191

The Packaging of Ova in the Egg Cases of *Aplysia californica.* (5 Text figures)
PAUL KANDEL & THOMAS R. CAPO 194

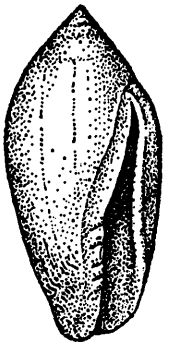
Modiolus aurum Osorio, spec. nov., from Juan Fernández Archipelago, Chile. (Mollusca : Bivalvia : Mytilidae). (9 Text figures)
CECILIA OSORIO R. 199

Range Extensions of Mollusk Species Found on the Tropical Coast of El Salvador.
MARCO ANTONIO HERNÁNDEZ 204

A Re-Evaluation of the Northwestern Range of the *Melongena corona* Complex. (3 Text figures)
ISABEL C. LEVY 206

Rediscovery of the Holotype of *Cymatium (Cymatium) ranzanii* (Bianconi, 1850). (1 Plate)
BRUNO SABELLI, MARCO TAVIANI & STEFANO TOMMASINI 210

BOOKS, PERIODICALS & PAMPHLETS 212



Note: The various taxa above species are indicated by the use of different type styles as shown by the following examples, and by increasing indentation.

ORDER, Suborder, DIVISION, Subdivision, SECTION,
SUPERFAMILY, FAMILY, Subfamily, *Genus, (Subgenus)*
New Taxa

THE VELIGER is open to original papers pertaining to any problem concerned with mollusks.

This is meant to make facilities available for publication of original articles from a wide field of endeavor. Papers dealing with anatomical, cytological, distributional, ecological, histological, morphological, physiological, taxonomic, etc., aspects of marine, freshwater or terrestrial mollusks from any region, will be considered. Even topics only indirectly concerned with mollusks may be acceptable. In the unlikely event that space considerations make limitations necessary, papers dealing with mollusks from the Pacific region will be given priority. However, in this case the term "Pacific region" is to be most liberally interpreted.

It is the editorial policy to preserve the individualistic writing style of the author; therefore any editorial changes in a manuscript will be submitted to the author for his approval, before going to press.

Short articles containing descriptions of new species or lesser taxa will be given preferential treatment in the speed of publication provided that arrangements have been made by the author for depositing the holotype with a recognized public Museum. Museum numbers of the type specimens must be included in the manuscript. Type localities must be defined as accurately as possible, with geographical longitudes and latitudes added.

Short original papers, not exceeding 500 words, will be published in the column "NOTES & NEWS"; in this column will also appear notices of meetings of the American Malacological Union, as well as news items which are deemed of interest to our subscribers in general. Articles on "METHODS & TECHNIQUES" will be considered for publication in another column, provided that the information is complete and techniques and methods are capable of duplication by anyone carefully following the description given. Such articles should be mainly original and deal with collecting, preparing, maintaining, studying, photographing, etc., of mollusks or other invertebrates. A third column, entitled "INFORMATION DESK," will contain articles dealing with any problem pertaining to collecting, identifying, etc., in short, problems encountered by our readers. In contrast to other contributions, articles in this column do not necessarily contain new and original materials. Questions to the editor, which can be answered in this column, are invited. The column "BOOKS, PERIODICALS, PAMPHLETS" will attempt to bring reviews of new publications to the attention of our readers. Also, new timely articles may be listed by title only, if this is deemed expedient.

Manuscripts should be typed in final form on a high grade white paper, 8½″ by 11″, double spaced and accompanied by a carbon copy.

A pamphlet with detailed suggestions for preparing manuscripts intended for publication in THE VELIGER is available to authors upon request. A self-addressed envelope, sufficiently large to accommodate the pamphlet (which measures 5½″ by 8½″), with double first class postage, should be sent with the request to the Editor.