



THE Festivus

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Inside:

New Turrid Species from the Pacific Ocean

New Subspecies of *Chicoreus* from Sri Lanka

World Record *Haliotis* Species from the Western North America

Review of Caribbean *Dalliconus* and a New Brazilian Species

Quarterly Publication of the San Diego Shell Club



THE FESTIVUS

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Editor Emerita Carole Hertz (1979–2014)

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REGULAR CLUB MEETINGS

Club meetings are held every month on the third Thursday of the month, except April, September and December, at either 7:30 p.m. in Room 104, Casa del Prado, Balboa Park, San Diego, or at 12:00 noon at Holiday Inn Express, 751 Raintree Drive, Carlsbad, conference room as noticed.

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Submit comments or suggestions regarding our website to our Webmaster David Waller at dwall@dbwipmg.com.

FRONT COVER:

Hemilenardia ocellata (Philippines), *Lienardia rubida* (Philippines), and *Veprecula vepreatica* (Philippines)
 Photos courtesy of Shawn G. Wiedrick. (Cover artistic credit: **Martin Schuler**)

MISSION STATEMENT

The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, promote the study and promote the conservation of Mollusca, and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, amateurs and scientists, divers, underwater photographers and dealers.

THE FESTIVUS is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Review Board (which are of a scientific nature, including new taxa articles), as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field and preference. Available by request or on our website are:

- Guidelines for Authors
- Guidelines for the Description of New Taxa

Submit articles to Editor, David Berschauer, at shellcollection@hotmail.com

All correspondence pertaining to articles, including all submissions and artwork should be addressed to the Editorial Board.

ADVERTISING in *The Festivus* is presented as a service to our membership and to supplement publication costs. Advertising does not imply endorsement by the San Diego Shell Club, Inc. or its officers. Advertising space is available at the following rates: Black and White – ½ page \$300, ¼ page \$150, or ⅛ page \$75, Color – ½ page \$500, ¼ page \$205, or ⅛ page \$125. Deadline for submitting advertisements is the 15th of the month prior to publication, as follows: #1 by January, #2 by April, #3 by July, or #4 by October. Submit advertisements to the Advertising Director, David Waller at dwall@dbwipmg.com

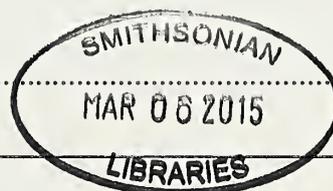
UPCOMING CLUB EVENTS:

Auction: 4/25/2015
 Shell Bazaar: 6/13/2015
 Shell Show & Sale: 8/15/2015
 September Party: 9/12/2015
 Holiday Party: 12/12/2015

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TABLE OF CONTENTS

President's Corner	p. 3
Peer Reviewed Articles	
• Review of the genus <i>Carinapex</i> Dall, 1924 with the description of ten new species (Gastropoda: Conoidea: Horaiclavidae) from the Pacific Ocean By Shawn Gregory Wiedrick	p. 5
• Description of a new subspecies of <i>Chicoreus (Triplex) cnissodus cnissodus</i> (Euthyme, 1889) (Gastropoda, Muricidae) from Sri Lanka By Roland Houart	p. 29
• Taxonomic note - new species: <i>Latiaxis nippooleifera</i> Chino, 2014	p. 35
By Spyridon Pavlividis	
• "World Record" Specimens of <i>Haliotis</i> Species of the West Coast of North America - a Brief Description and Photo Study By Buzz Owen	p. 36
• Description of a New Species from the Brazilian Province: <i>Dalliconus edpetuchi</i>	p. 51
By Éric Monnier, Loïc Limpalaër, Christophe Roux, and David P. Berschauer	
Club News	p. 67
Articles of General Interest	
• Recollections of a Neophyte Shell Collector	p. 68
By Bill Schramm	
• Book review: Biogeography and Biodiversity of Western Atlantic Mollusks	p. 71
By David P. Berschauer	
• Red Abalone, Candidate for State Mollusk	p. 72
By Larry Buck	
• Taxonomic note - new species: <i>Chicomurex globus</i> and <i>C. pseudosuperbus</i>	p. 73
Houart, Moe & Chen, 2015 By Chong Chen	
• In Memoriam Carole Christine Skoglund, 1924 - 2015	p. 74
By Carole Hertz	



San Diego Shell Club Student Award

The San Diego Shell Club is offering a \$1,000 award for the best student presentation given at the monthly Club meeting in 2015.

Requirements: (1) Only students may apply (2) The presentation must be focused on mollusks and address biology/ecology/surveys, biogeography, or taxonomic work. (3) Selection for presentations will be based on an abstract or detailed outline and letter from your major professor. (4) Research must be sufficiently mature, so that the majority of the results may be presented. For specific details and judging criteria, contact Dr. Paul Tuskes at tuskes@aol.com The Subject line of your e-mail should be (Student Award) plus your last name. Entries for 2015 must be received by April 1st unless special arrangements are made.

PRESIDENT'S CORNER

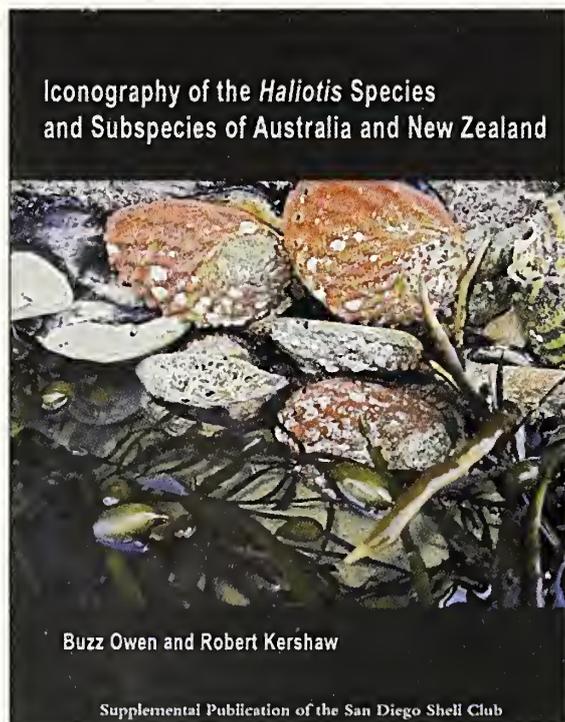
The first order of the day, if somewhat belatedly, is to wish all a happy and healthy 2015. Let's reflect. . . . By the end of 2014, in one year, a 50% increase in Club membership. Indeed a happy new year. . . . 2014 was a resplendent year, though practically consumed with finding our way. It's been laborious at times, a year of satisfying necessities, of accomplishing that which needed to be accomplished, all in order to accomplish that which we wanted to accomplish.

2014 was a year of needs before wants, as anathema to the hearts of true collectors as such a concept may be. And folks don't just come waltzing through the doors. Ours is to provide a reason for members to attend Club meetings, and to participate in Club functions. Ours is a Club of impassioned mollusk enthusiasts, of one brand or another, which makes it your Board's duty to govern accordingly that which lays ahead. Our task is to create a convincing environment, as in "build it and they will come".



What lays ahead? Shells and books from old collections have been and will be making an appearance. Attending the Club's most recent auction, after having had a blast scanning the dollar table with his sister Layla, both grinning from ear to ear, my grandson Jimmy persevered and won his first auction conquest - an exceptional *Chlamys swifti*, trawled off Siberia. "Where is Siberia, Boppa?" Dr. Bertsch (Hans), would chime in that it's all about teaching. An honorary member taking the job seriously.

SUPPLEMENTAL PUBLICATION



The San Diego Shell Club has just published a supplemental publication, Iconography of the *Haliotis* Species and Subspecies of Australia and New Zealand, by Buzz Owen and Robert Kershaw. Copies will be made available for \$35 from the Club, or directly from the authors. Excellent photography. A spectacular treatment of the *Haliotidae*. We know you will approve.



THE SAN DIEGO FAIR 2015

June 5, through July 5, mark your calendars. Imagine seashells now amongst the mind-blowing gems and minerals, nature's fascinators competing for attention, seashells receiving justice, their rightful place in the sun. Back in the 1960s the San Diego Shell Club last participated in the San Diego County Fair. Four months away and counting, we will be there again. Jeez, "the Fair", do you need an invite?

THE RED ABALONE PROJECT



Julian Lee and 11" plus red abalone, or" the big one that didn't get away."

Folks contemplating a visit to our state never fail to ask about earthquakes, wanting to avoid "the big one". Out here in the dusty climate challenged Old West ... I'm dubbing in coyotes howling romantically in the distance ..."Yeah earthquakes. Stay away." Julian's sentiment, with a predatory, gunslinging-type wryness ... Those tremors are giant red abalone caroming off each other, actual monsters inhabiting California's turbulent northern waters. There's a big one, all right, and Julian is after it. No question that California is the epicenter when speaking of the world's abalone, family *Haliotidae*. My question is why no one has seemed to have noticed? Read on to hear what your Club has in store for its world champion reds.

And lastly, the vote ... my sincerest appreciation for your vote of confidence. The support has been overwhelming. I mean - much obliged partners (tipping my hat). Now come on horse - giddyup! Got some terrain to cover.

Adios,
Buckaroo
aka Larry Buck, President

Review of the genus *Carinapex* Dall, 1924 with the description of ten new species (Gastropoda: Conoidea: Horaiclavidae) from the Pacific Ocean

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KEYWORDS Gastropoda, Horaiclavidae, *Carinapex albarnesi* n. sp., *Carinapex alisonkayae* n. sp., *Carinapex amirowlandae* n. sp., *Carinapex cernohorskyi* n. sp., *Carinapex chaneyi* n. sp., *Carinapex johnwiedricki* n. sp., *Carinapex lindseygrovesi* n. sp., *Carinapex mooreorum* n. sp., *Carinapex philippinensis* n. sp., *Carinapex solomonensis* n. sp., Fiji, Hawaiian Islands, Japan, Philippines, Solomon Islands, Indo-Pacific Ocean.

ABSTRACT Material examined in the LACM collection and the author's collection has resulted in ten species of *Carinapex* new to science. Two known *Carinapex* Dall, 1924 species, *Carinapex papillosa* (Garrett, 1873) and *C. minutissima* (Garrett, 1873), are compared with ten new species from the Indo-Pacific, *Carinapex albarnesi* n. sp., *C. alisonkayae* n. sp., *C. amirowlandae* n. sp., *C. cernohorskyi* n. sp., *C. chaneyi* n. sp., *C. johnwiedricki* n. sp., *C. lindseygrovesi* n. sp., *C. mooreorum* n. sp., *C. philippinensis* n. sp. and *C. solomonensis* n. sp.

INTRODUCTION

The species within the turrid genus *Carinapex* Dall, 1924 has been frequently overlooked by previous authors who published on the group. Due to the isolated ranges of some new *Carinapex* species, it is speculated that there are possibly more new species that inhabit the Indo-Pacific complex and are yet to be named. As a case in point, several additional new species were omitted from this paper due to the poor condition of samples taken. Historically, authors have identified specimens and figured them with the assumption that they were either one of the two known species. An array of species exists from this genus and can only be identified by close inspection of material from various locations throughout the Indo-Pacific region. Micromolluscan material taken by Lumun Lumun nets has become a recent trend for Philippine fisheries. The exportation of material to various researchers in recent years has accounted for a myriad of new turrid species new to science by Chino & Stahlschmidt (2009), Chino & Stahlschmidt (2010), Fedosov (2011), Fedosov & Puillandre (2012), and Stahlschmidt, Chino & Kilburn (2012). Additionally, some processed material from the Hawaiian Islands has brought to light additional species described in this paper.

Material examined at LACM from various localities has also been beneficial to this research.

Abbreviations

ANSP: The Academy of Natural Sciences of Drexel University, Philadelphia, Pennsylvania, U.S.A.

LACM: Natural History Museum of Los Angeles County, California, U.S.A.

SW: collection of the author

SYSTEMATICS

Most recent studies by use of molecular phylogeny of the Conoidea by Bouchet & others (2011) and Puillandre & others (2011) arrange the placement of genera within this complex.

Family **HORAICLAVIDAE** Bouchet, Kantor, Sysoev & Puillandre, 2011

Genus *Carinapex* Dall, 1924

Carinapex Dall, 1924: 88 (as a subgenus of *Daphnobela* Cossmann, 1896). Type species (o. d.): *Drillia minutissima* Garrett, 1873, Viti Isles, Fiji.

Diagnosis. The genus *Carinapex* Dall, 1924 (Type: *Drillia minutissima* Garrett, 1873) was assigned without a description and only a type species designation. Since the original description, authors Hedley (1922), Dall (1924), Wenz (1943), Kuroda & Habe (1952), Cernohorsky (1983), Tröndle & Boutet (2009) have mistakenly placed this genus in a variety of generic and subgeneric headings. Genus resembling a microscopic *Drillia* with nodules, apex bulbous, converging into carinate cords, with ribbing occasionally on remaining portion of whorl. Parietal callus of aperture strong, apertural lip thin, thick bulging rib prior to final lip.

Key to species described and cited

1. Over 5.0 mm*solomonensis*
Under 5.0 mm.....2
2. Erect apex.....3
Bluntly acute apex.....4
3. Dark brown.....*chaneyi*
White, brown marks.....*cernohorskyi*
4. Dark spot on final nodule.....*johnwiedricki*
Dorsal spot absent.....5
5. Over 3.8 mm.....6
Under 3.8 mm.....7
6. Peripheral nodules large.....*albarnesi*
Nodules dash-like.....*papillosa*
7. Color white.....*mooreorum*
Color markings.....8
8. Small, white initial protoconch whorl.....
.....*minutissima*
Protoconch large, bulbous.....9
9. Base color white or tan.....10
Base color brown.....11
10. Small, rhomboid shaped.....*alisonkayae*
Large, shape elongate.....*philippinensis*
11. Color dark brown.....*amirowlandae*
Color red-brown to tan*lindseygrovesi*

***Carinapex solomonensis* n. sp.**

Plate 1, figs. 9-12

Type Material. Holotype, LACM 3290, height 5.5 mm, width 2.4 mm.

Distribution. Known only from the type locality, holotype [LACM 3290], from sand pockets on leeward reef slopes, Kicha Island, east of Nggatokae

Island, south Marovo Lagoon, off southeast side Vangunu Island, Solomon Islands (8° 46' S, 158° 19' E) in 15-20 m, collected by H. W. Chaney, March 23, 1989 [= LACM 89-78].



Image 1. *Carinapex solomonensis* n. sp., holotype

Diagnosis. *Carinapex solomonensis* n. sp. is characterized by its extremely large size, relatively erect protoconch and angulate ribs.

Description. Shell extremely large for genus, slender, rhomboid shaped, color cream with faint, orange tint at upper portion of whorls. Protoconch somewhat erect, first protoconch whorl domed, slightly flattened, distorted to one side, remaining one-and-a-half whorls carinate in middle. Five teleconch whorls, first three with two rows of large nodules, somewhat connected, angulate, forming faint ribs. Proceeding two whorls with three rows of nodules, bottom row weak, faint cords connecting nodules in row, suture heavily indented in all teleconch whorls. Final whorl with two strong nodule rows, followed by eight moderate spiral cords below periphery to anterior. Parietal callus relatively large, aperture elongate, somewhat large.

Discussion. *Carinapex solomonensis* n. sp. is similar to two other new species described herein, *C. albarnesi* n. sp. and *C. cernohorskyi* n. sp. Relative differences in *C. solomonensis* n. sp., heavily

indented suture and extreme size. The smaller, spindle shaped *C. albarnesi* n. sp., exhibits obese peripheral nodules, horizontally ovate, opaque, white with brown bands at suture and base of whorls making them readily separable. The acute, erect protoconch of *C. cernohorskyi* n. sp., bulging, large, pustule-like nodules, caramel color banding, rhomboid shape and slightly brown protoconch also separate it from *C. solomonensis* n. sp.

Etymology. Named in reference to the type locality, Solomon Islands.

***Carinapex chaneyi* n. sp.**

Plate 1, figs. 17-23

Carinapex minutissima.—Bouchet & others, 2011: 294, fig. 17-M.



Image 2. *Carinapex chaneyi* n. sp., holotype

Type Material. Holotype, LACM 3293, height 2.8 mm, width 1.3 mm.

Type Locality. Off exposed side of Karunjou Island, off Marovo Lagoon, east side Vanguna Island, Solomon Islands (8° 39' S, 158° 14' E) in rubble at 20-25 m.

Material Examined. Holotype [LACM 3293], (Pl. 1, figs. 20-23); one specimen from Karunjou Island,

off Marovo Lagoon, east side Vanguna Island, Solomon Islands (8° 39' S, 158° 14' E) in rubble at 20-25 m, collected by H. W. Chaney, March 21, 1989 [= LACM 89-76]; two specimens from northern Punto Engano, Mactan Island, Cebu Province, Philippines in tangle nets at 100-250 m, January 2009 [SW09-33]; one specimen from Linapacan Island, Palawan Province, Philippines in 150 m, April, 2005 [SW05-67]; one specimen from 0.5 km east southeast Zampa-misaki (Bolo Point), Okinawa, Japan (26° 26.1' N, 127° 42.5' E), in sand and coral rubble at 46 m, collected by R. F. Bolland, August 25, 1978 [LACM 78-25]; one specimen from 0.5 km east southeast Zampa-misaki (Bolo Point), Okinawa, Japan (26° 26.1' N, 127° 42.5' E), in sand and coral rubble at 49 m, collected by R. F. Bolland, October 25, 1978 [LACM 78-100].

Distribution. *Carinapex chaneyi* n. sp. is known from Japan, the Philippines, Solomon Islands (type locality), and New Caledonia (Bouchet & others, 2011). Map insert (fig. 1) shows distribution of material recorded from the LACM and SW collections.



Figure 1. Distribution of *Carinapex chaneyi* n. sp.

Diagnosis. *Carinapex chaneyi* n. sp. is characterized by its pupoid shape, dark brown coloration, moderately erect apex, nodules round, evenly spaced.

Description. Mature specimens range from moderately large to small, pupoid shaped, somewhat rhomboid, color dark brown, protoconch cream colored, large cream blotch on periphery of dorsal side on final whorl. Color lighter in worn specimens. Apex erect, narrow, acute, angle progressively constant downward, four protoconch whorls, first

whorl domed, flattened, proceeding one half whorl carinate at periphery, proceeding whorls with two carinate cords at periphery and near suture, microscopic ribs on vertical wall under peripheral cord. Three-and-a-half to four-and-a-half teleoconch whorls with two rows of large, round, tightly spaced nodules at suture and periphery, sutural row slightly weaker, final whorl with two rows of large, bead-like nodules, followed by four additional smaller, strongly beaded rows at base, progressing anteriorly, two final spiral cords on siphonal canal. Aperature ovate, elongate near anterior, sinus restricted, parietal callus strong and projecting downward.

Discussion. *Carinapex chaneyi* n. sp. is similar to only one other species, *Carinapex lindseygrovesi* n. sp. *Carinapex chaneyi* n. sp. has a rhomboid shape, ovate, pupoid, apex distinctly erect, acutely domed, narrow, nodules exaggerated, round, large, bulbous, final whorl with seven spiral cords. *Carinapex lindseygrovesi* n. sp. has an elongate shape, narrow, turreted, apex domely flattened, projecting to one side, nodules large, widely spaced, rib-like on final whorl, four spiral cords.

Etymology. Named after malacologist Henry W. Chaney of The Santa Barbara Museum of Natural History, who collected the holotype specimen.

***Carinapex cernohorskyi* n. sp.**

Plate 1, figs. 13-16

Clavus papillosus.—Cernohorsky, 1983: 201, fig. 34, 35.

Carinapex papillosus.—Severns, 2011: 386, fig. 2.

Type Material. Holotype, LACM 3294, height 4.2 mm, width 1.9 mm.

Type Locality. 5 km west Tsuken-Jima (= Admiral's Island), Okinawa, Japan (26° 16.1' N, 127° 55.2' E), in sand and coral rubble at 18 m.

Material Examined. Holotype [LACM 3294], (Pl. 1, Figs. 13-16); 5 km west Tsuken-Jima, Okinawa, Japan (26° 16.1' N, 127° 55.2' E), in sand and coral rubble at 18 m, collected by R. F. Bolland, June 3, 1978 [= LACM 78-21]; one specimen from 0.5 km

east southeast Zampamisaki (Bolo Point), Okinawa, Japan (26° 26.1' N, 127° 42.5' E), at 49 m, collected by R. F. Bolland, October 27, 1978 [LACM 78-100]; one specimen 1 km north northwest Oku, Okinawa, Japan (26° 50.8' N, 128° 17.2' E), in sand in channels and caves among coral at 12-20 m, collected by R. F. Bolland, October 8, 1977 [LACM 77-64]; one specimen from Leone Bay, Tutuila Island, American Samoa (14° 20.3' S, 170° 47.06' W) in 15.2 m, collected by G. Hendler, April 26, 1999 [LACM 99-89]; one specimen from outer reef slope, off Arutanga, west side Altutaki, Cook Islands, West Pacific (18° 52.3' S, 159° 47.5' W), in rubble and Halimeda at 18-26 m, collected by J. H. McLean & S. Zinn, May 12-13, 1987 [LACM 87-79]; one specimen from Ahe Atoll, Tuamotu Archipelago, French Polynesia (14° 28.' S, 146° 22' W) in 1 m, collected by D. E. Koontz on yacht "Constitution", October 14-15, 1973 [LACM 73-94].



Image 3. *Carinapex cernohorskyi* n. sp., holotype

Distribution. Records from Japan, French Polynesia and Makena Bay, Maui, Hawai'i (Severns, 2011: 386). Map insert (fig. 2) shows distribution of material recorded from the LACM and SW collections.

Diagnosis. *Carinapex cernohorskyi* n. sp. is characterized by its large size, extremely erect protoconch, uniquely large, bulging nodules and distinct caramel coloration.



Figure 2. Distribution of *Carinapex cernohorskyi* n. sp.

Description. Shell large for the genus, rhomboid shaped, stout, inflated, apex extremely erect, acute, color cream-white with caramel banding between nodules at suture, base and faintly between peripheral nodules. Three protoconch whorls, very erect, first whorl domed, sunken into second carinate whorl, keel low, base nearly vertical in last two whorls. First four teleoconch whorls with two rows of large white nodules, lower row more pronounced, rapidly progressing outward as they expand downward. Final two whorls more vertically aligned, whorls previous offset, peripheral nodules obese, expanding past general profile, exaggerated. Final whorl with four rows of nodules, siphonal canal with four thick cords. Parietal callus thick, caramel colored, aperture ovate, small, narrow at anterior.

Discussion. Examination of the drawing by Garrett (1873: 218) of *Carinapex papillosa*, one could easily confuse the specimen figured by Cernohorsky (1983: 201) as synonyms. A comparison of the *C. papillosa* holotype and the figured specimen by Cernohorsky has yielded a variety of different characteristics. Although close in size, the color of *C. cernohorskyi* n. sp. has a caramel brown series of bands at the suture, base and between nodules, bulging, large peripheral nodules, erect protoconch. In *C. papillosa* bands are orange and nodules much less distinct, protoconch acutely domed. The superficially similar, *C. albarnesi* n. sp. is slender, spindle shaped, nodules horizontally ovate, large at periphery, apex widely domed, slightly flattened. *Carinapex solomonensis* in general shape resembles *C. cernohorskyi* but differs in the larger size, less erect apex, less pronounced peripheral nodules and overall shape of ribs and indented suture. Severns

(2011: 386) identified a large *Carinapex* species as *C. papillosus* which is conspecific with the species here described.

Etymology. Named after the late malacologist Walter O. Cernohorsky (New Zealand), a great contributor to the understanding of Indo-Pacific molluscan faunas and who first recognized a specimen of the species now new to science.

***Carinapex johnwiedricki* n. sp.**

Plate 2, figs. 36-38, 45

Carinapex papillosus.—Sysoev in Poppe, 2008: 762, figs. 1-2.



Image 4. *Carinapex johnwiedricki* n. sp., holotype

Type Material. Holotype, LACM 3296, height 2.7 mm, width 1.2 mm.

Type Locality. Punta Engano, Mactan Island, Cebu Province, Philippines (10° 19' 39.81" N, 124° 0' 50.59" E) in tangle nets at 200-250 m.

Material Examined. Holotype [LACM 3296], (Pl. 2, figs. 36-38, 45); from Punta Engano, Mactan Island, Cebu Province, Philippines (10° 19' 39.81" N, 124° 0' 50.59" E) in tangle nets at 200-250 m, December, 2008 [= SW08-57]; three specimens from Linapacan Island, Palawan Province, Philippines in tangle nets

at 150 m [SW05-67]; one specimen from Mactan Island, Cebu Province, Philippines in tangle nets at 90-100 m, February, 2007 [SW07-70]; four specimens from Mactan Island, Cebu Province, Philippines in 100-250 m [SW09-33].

Distribution. Known only from the Philippine Islands.

Diagnosis. *Carinapex johnwiedricki* n. sp. is characterized by its small size, ovately rhomboid shape, dark brown spot on final two peripheral nodules, strong projecting, tightly spaced peripheral nodules, relatively small parietal callus.

Description. Shell small sized, stout, ovately rhomboid, color light brown with lighter nodules, final whorl with dark blotch on final two peripheral nodules, faint brown mark on lower portion of final lip. First protoconch whorl obese, widely domed, proceeding two whorls smooth with carinate keel slightly below middle of whorl. Three-and-a-half teleoconch whorls with very tightly spaced, strongly projecting peripheral nodules, smaller, subtle, row above near suture, final whorl with two strong nodule rows, connecting with basal row creating long, tightly spaced ribs, following row beaded, four spiral cords on siphonal canal. Aperture ovate, large, one third the size of shell, anterior canal open, slightly curved outward, sinus relatively open, parietal callus relatively small, outward projecting.

Discussion. Due to its small size, finely ornamented sculpture and the dark brown spot on the last peripheral nodules of the final whorl of the dorsal side, *C. johnwiedricki* n. sp. is unlike any other *Carinapex* species. Sysoev in Poppe (2008:762) did not recognize the distinct features of this species and inadvertently misidentified the figured specimens. *Carinapex johnwiedricki* n. sp. is relatively rare in samples studied from tangle nets in the Philippines.

Etymology. Named after my father, John Wiedrick, Huntington Beach, California, who encouraged and fostered my appreciation for conchology/malacology since a young age, has been a travel companion on many malacological excursions abroad, and has been an inspirational support to my studies in the field.

***Carinapex albarnesi* n. sp.**

Plate 2, figs. 27-29, 43

Turridrupa papillosa.—Kuroda & Habe, 1952: 95.—Higo & Goto, 1993: 290.

Carinapex papillosa.—Zhenguo, 1995: 278, pl. 1, fig. 15.—Habe & Tuchiya, 1998: 23.—Higo & others, 1999: 307.—Chang & Wu, 1999: 64, fig. 10.—Chang, 2001a: 10, figs. 5a-d.—Chang & Thorsson, 2001: 8.—Thorsson & Chang, 2001: 192, 3 figs.—Chang & Wu, 2007: 6, fig. 1307A-D.



Image 5. *Carinapex albarnesi* n. sp., holotype

Type Material. Holotype LACM 3298, height 4.8 mm, width 2.0 mm.

Type Locality. Two hundred meters off northeast Mactan Island, Cebu Province, Philippines (10° 20' 4.45" N, 124° 2' 54.27" E) in tangle nets at 90-100 m.

Material Examined. Holotype [LACM 3298], (Pl. 2, figs. 27-29, 43) from Mactan Island, Cebu Province, Philippines (10° 20' 4.45" N, 124° 2' 54.27" E) in tangle nets at 90-100 m, February, 2007 [= SW07-70]; one specimen from Mactan Island, Cebu Province, Philippines in 100-250 m [SW09-33]; one specimen from 1 km southwest of Onna Village, Horseshoe South, Okinawa-jima, Okinawa-shoto, Ryukyu-shoto, Okinawa Prefecture (26° 30' N, 129°

50' E), in sand and coral rubble at 30 m, collected by R. F. Bolland, May 29, 1978 [LACM 1978-20].

Distribution. *Carinapex albarnesi* n. sp. is known from Japan (Kuroda & Habe, 1952; Higo & Goto, 1993; Habe & Tuchiya, 1998; Higo & others, 1999; here cited), Taiwan (Chang & Wu, 1999; Chang & Thorsson, 2001; Chang, 2001a; Thorsson & Chang, 2001; Thorsson & Chang & Wu, 2007) and the Philippines (here cited). Map insert (fig. 3) shows distribution of material recorded from the LACM and SW collections.



Figure 3. Distribution of *Carinapex albarnesi* n. sp.

Diagnosis. *Carinapex albarnesi* n. sp. is characterized by its very large size, spindle-like, rhomboid profile, brown banding, large, horizontally ovate, widely spaced nodules, apex large, wide, obtaining a total height of 0.5 mm (fig. 43).

Description. Shell spindle-like, very large for the genus, wide, somewhat rhomboid shaped, robust, white with dark caramel brown banding between nodules at suture, faintly at base, subtly between nodules at periphery. Protoconch wide, first protoconch whorl flatly domed, expanding widely outward, two proceeding whorls carinate, low in profile, final whorl with backward crescent forms above peripheral keel, protoconch height 0.5 mm. Five teleoconch whorls, two rows obese, horizontally ovate, opaque nodules, widely spaced, subsutural cord fine but heavy in last one-and-a-half whorls, final whorl with eight spiral cords under primary nodules on base anteriorly to siphonal canal, cords projecting out on final lip. Aperture ovate, elongate near anterior, sinus ill-defined, parietal callus moderate, projecting outward.

Discussion. *Carinapex albarnesi* n. sp. is unlike any other *Carinapex* species other than *C. papillosa* which is smaller, slender, with orange colored bands, apex acute, height of protoconch obtaining 0.3 mm, nodules compacted, moderate in size, horizontally dashed whereas *C. albarnesi* is very large, rhomboid shaped, with brown bands, apex wide, domed, height obtaining 0.5 mm, nodules widely spaced, obese.

Etymology. Named after friend Al Barnes, Long Beach, California who has been a fellow diver and is well versed in marine biology and has contributed greatly to my research on malacology. Al has also been a contributor to the Shawn Wiedrick collection and has donated a great deal of material that has been beneficial to my research and this paper.

***Carinapex papillosa* (Garrett, 1873) n. comb.**

Plate 2, fig. 24-26, 42

Drillia papillosa Garrett, 1873: 218, pl. 2, fig. 29. (Type locality: Viti Isles, Fiji).—Tryon 1884: 207, pl. 12, fig. 33.—Paetel, 1888: 68.—Bouge & Dautzenberg, 1914: 134.—Melvill, 1923: 166.—Dautzenberg & Bouge, 1933: 95.

Mangilia (Glyphostoma) dialitha.—Melvill & Standen, 1896: 287, pl. 9, fig. 26.—Melvill & Standen, 1897: 400.

Glyphostoma dialitha.—Bouge & Dautzenberg, 1914: 176.

Ceritoturris papillosa.—Tröndle & Boutet, 2009: 38.

Type Material. Holotype, Liti Levu, Fiji ANSP 15307, height 3.8 mm, width 1.4 mm (Pl. 2, figs. 24-26, 42).

Material Examined. One specimen from Olowalu, Maui, Hawai'i (20° 48.7' N, 156° 37.5' W) in 1.3-2 m, collected by T. Bratcher, January 25, 1972 [LACM 72-11]; one specimen from outer reef slope, north of Matavera, northeast side Rarotonga, Cook Islands (21° 12.7' S, 159° 43.5' W), in rubble at 18-26 m, collected by J. H. McLean, May 18, 1987 [LACM 87-81]; four specimens from outer reef slope, off Arutanga, west side Altutaki, Cook Islands, West Pacific (18° 52.3' S, 159° 47.5' W), in rubble and Halimeda at 18-26 m, collected by J. H. McLean & S. Zinn, May 12-13, 1987 [LACM 87-79]; one

specimen from Diamond seamount, east of Herald Pass, west of Ndravuni Island, inside Great Astrolabe Reef, Kadavu Group, Fiji (18° 45.8' S, 178° 28.3' E), in 20-25 m, collected by T. Bratcher, June 19, 1991 [LACM 91-188].



Image 6. *Carinapex papillosa* (Garrett, 1873)

Distribution. *Carinapex papillosa* has been listed by various authors (Kuroda & Habe, 1952; Higo & Goto, 1993; Habe & Tuchiya, 1998; Higo & others, 1999; Tröndle & Boutet, 2009) without a figured specimen or a description leaving the exact range questionable. Based on examined *Carinapex* material and the assumption authors had compared specimens to the type specimen, or the original illustration, *C. papillosa* ranges from Fiji (Garrett, 1873), Cook Islands (here cited), French Polynesia (Tröndle & Boutet, 2009) and Hawai'i (here cited). Map insert (fig. 4) shows distribution of material recorded from the LACM and SW collections.

Diagnosis. *Carinapex papillosa* is characterized by its large size, slender spindle-like shape, three rows of tightly spaced, moderately sized, dash-like nodules on final two whorls.



Figure 4. Distribution of *Carinapex papillosa* (Garrett, 1873)

Description. Shell spindle-like, large for the genus, slender, elongate shaped, cream colored with faint, orange bands on suture, base and faintly between sutural nodules. Protoconch acute, narrow, first whorl domed, proceeding one half whorl subtly carinate, following one-and-a-half whorls with strong carination at periphery, final whorl carinate with strong reverse crescent shaped ribs on shoulder, carinate whorl profile 45° on upper portion, lower portion vertical, final carinate whorl terminated at 0.3 mm. Five to six teleoconch whorls, whorl profile elevated, first three whorls with two rows of equally sized, tightly spaced, horizontally ovate, opaque, medium sized, dash-like nodules, final two whorls with three nodulose rows, sutural and basal nodules of equal size. Final whorl with very faint subsutural cord, eight spiral cords on base under primary nodules, aperture ovate, elongate towards anterior end, parietal callus large, anteriorly projecting, sinus restricted.

Discussion. *Carinapex papillosa* (Garrett, 1873) is similar only to *Carinapex albarnesi* n. sp. in which both are spindle-like. *Carinapex papillosa* is large sized, with orange banding, apex acute, narrow, obtaining a height of 0.3 mm (fig. 42), whorl profile elevated at periphery, teleoconch whorls with two equal sized, tightly spaced dash-like nodules, final two whorls with three rows. *Carinapex albarnesi* n. sp. is very large sized, with brown banding, apex wide, first protoconch whorl flatly domed, wide slopes, obtaining a height of 0.5 mm (fig. 43), whorl profile low, sunken, whorls with two widely spaced, large, horizontally ovate nodule rows, sutural row less distinct, peripheral prominent. The description of *Mangilia (Glyphostoma) dialitha* (Melville &

Standen, 1896) appears to be synonymous with *C. papillosa* based on the original description and with regards to the close proximity of the type locality. Kay (1979), Cernohorsky (1983), Sysoev in Poppe (2008), Cox & others (2009) and Severns (2011) all had inadvertently lumped various new species under the name *C. papillosa* without comparison to the known holotype of *C. papillosa*.

***Carinapex mooreorum* n. sp.**

Plate 2, figs. 39-41, 46



Image 7. *Carinapex mooreorum* n. sp., holotype

Type Material. Holotype, LACM 3291, height 2.1 mm, width 0.8 mm.

Type Locality. 'Anaeho'omalulu Point, Kona North District, Hawai'i (19° 55' 3.28" N, 155° 53' 26.38" W) in tide pool rubble at -0.3 m.

Material Examined. Holotype [LACM 3291], (Pl. 2, figs. 39-41, 46) from 'Anaeho'omalulu Point, Kona North District, Hawai'i in tide pool rubble at -0.3 m, collected by S. G. Wiedrick, August 7, 2009 [= SW09-17]; one paratype [LACM 3292] from steep coral slope, off Ajer (Gili Air) and Meno Islets, northwest side Lombok, Indonesia (8° 22' S, 116° 04' E) in rubble at 5-20 m, collected by J. H. McLean & H. W. Chaney, April 15, 1988 [= LACM 88-63].

Distribution. Known from the type locality, Hawai'i and Indonesia.

Diagnosis. *Carinapex mooreorum* n. sp. is characterized by its minute size, strong ribbing on convex teleoconch whorls, blunt apex, ovate aperture and final lip which bulges outward.

Description. Shell minute, elongate-ovate in shape, color cream-white. Initial protoconch whorl bluntly domed, proceeding one half whorl with subtle carination and faint densely spaced fine ribbing at base, proceeding two whorls with carination, thick, moderately spaced ribs on suture, fine, densely spaced ribbing on base. Three-and-a-half teleoconch whorls convexly inflated, thick subsutural cord throughout, first two-and-a-half whorls with six fine spiral cords crossing over robust, back turned ribs, generating a cancellate appearance, final whorl with twelve spiral cords. Aperture somewhat ovate, sinus constricted, parietal callus projecting slightly downward, profile of final lip strongly convex as with previous whorls.

Discussion. *Carinapex mooreorum* n. sp. is unlike other *Carinapex* species in that it is minute, has distinctly convex whorls and strong ribbing versus nodules represented in other *Carinapex* species and may prove to be a different genus. Additionally, the profile displays an extreme bulge in the final whorl which is only indicative of this species.

Etymology. Named after friends Kevin and Ashley Moore who reside in Fullerton, California and have hosted me in Hawai'i on several trips which have resulted in the discovery of this species.

***Carinapex minutissima* (Garrett, 1873)**

Plate 3, figs. 47-68

Drillia minutissima Garrett, 1873: 218, pl. 2, fig. 30. (Type locality: Viti Isles, Fiji).—Tryon 1884: 207, pl. 12, fig. 29.—Paetel, 1888: 66.—Bouge & Dautzenberg, 1914: 133.

Iredalea minutissima.—Hedley, 1922: 258.

Daphnobela (*Carinapex*) *minutissima*.—Dall, 1924: 88.

Zetekia (*Carinapex*) *minutissima*.—Wenz, 1943: 1447, fig. 4095.

- Carinapex minutissima*.—Powell, 1966: 15, fig. C75; 86, pl. 13, fig. 19.—Kay, 1979: 334, 344, fig. 112A, 112G, 114C & 115O.—Vermeij & others, 1983: 48.—Kay, 1990: 83.—Fukuda, 1994: 25, pl. 29, fig. 588.—Kurozumi & Asakura, 1994: 152.—Zhenguo, 1995: 277, pl. 1, fig. 14.—Habe & Tuchiya, 1998: 23.—Kohn, 1998: 848, fig. 15.174G.—Chang & Wu, 1999: 68, fig. 9.—Higo & others, 1999: 307.—Hasegawa & others in Okutani, 2000: 641, pl. 319, fig. 105.—Chang & Thorsson, 2001: 8.—Chang, 2001a: 9, fig. 4E.—Chang, 2001b: 206, fig. 19-5a.—Thorsson & Chang, 2001: 191, 4 figs.—Smith, 2003: 267.—Sasaki, 2008: 179.—Bandel & Dockery, 2012: 112.
- Carinapex minutissimus*.—Taylor, 1975: 431, pl. 72, figs. d-e.—Tröndle & Boutet, 2009: 38.—Thach, 2012: 159, pl. 99, fig. 1165.
- Carinapex* species 5.—Thorsson, 1997: 20-22.
- Carinapex minutissime* [*sic*].—Chang & Wu, 2007: 5, fig. 1306B.
- Carinapex papillosa*.—Cox & others, 2009: 17.
- Carinapex* sp. 1.—Severns, 2011: 386, pl. 176, fig. 1a & 1b.



Image 8. *Carinapex minutissima* (Garrett, 1873)

Type Material. Syntype, Liti Isles, Fiji ANSP 59232, height 2.2 mm, width 1.0 mm (Pl. 3, fig. 62-64, 68).

Type Locality. Liti Isles, Fiji.

Material Examined. 107 specimens from Jackson Reef, Strait of Tiran, south Sinai Peninsula, north Red Sea, Egypt (28° 01' N, 34° 28' E), in clean sand and coral at 2-3 m, collected by T. Bratcher [LACM 85-111]; 171 specimens from "Amphoras" dive site, off Ras Umm Sid, southeast side of Sinai Peninsula, Egypt (27° 52' N, 34° 20' E), in coral rubble at 18 m, collected by J. H. Golden, July 24, 1988 [LACM 88-119]; 53 specimens from Dunraven Reef, Strait of Tiran, south Sinai Peninsula, north Red Sea, Egypt (27° 12' N, 34° 06' E), in clean sand and coral at 25 m, collected by T. Bratcher, November 1, 1985 [LACM 85-112]; one specimen from steep coral slope, off Ajer (Gili Air) and Meno Islets, northwest side Lombok, Indonesia (8° 22' S, 116° 04' E) in rubble at 5-20 m, collected by J. H. McLean & H. W. Chaney, April 15, 1988 [LACM 88-63]; two specimens from outside reef, north end Mermaid Reef, Rowley Shoals, Western Australia (17° 03' S, 119° 36' E), in 18-20 m, collected by T. Bratcher, August 30, 1986 [LACM 86-250]; one specimen from Mactan Island, Cebu Province, Philippines in 90-100 m [SW07-70]; one specimen from Linapacan Island, Palawan Province, Philippines in 150 m [SW05-67]; two specimens from Aliguay Island, Zamboanga del Norte Province, Philippines in 91 m [SW07-72]; 49 specimens from Mactan Island, Cebu Province, Philippines in 100-250 m [SW09-33]; nine specimens from Mactan Island, Cebu Province, Philippines in 200-250 m [SW08-57]; 14 specimens from Horseshoe Cliffs, 1 km west northwest Onna Village, Okinawa, Okinawa-gunto, Japan (26° 29.6' N, 127° 50.5' E), in sand and coral rubble at 46-55 m, collected by R. F. Bolland, January 3, 1979 [LACM 79-75]; one specimen from east end of land strip, south side Maguro Atoll, Marshall Islands (7° 03.2' N, 171° 14.08' E), in coral and sand at 1 m, collected by P. Cross, January 15, 1990 [LACM 90-7]; three specimens from channel between Wongat Island, and barrier reef at Astrolabe Bay, Madang Province, Papua New Guinea (5° 08.1' S, 145° 50.7' E), in sand at 29-30 m, collected by T. Bratcher, September, 1, 1980 [LACM 80-26]; one specimen from Marion Reef, Coral Sea, off Great Barrier Reef, Queensland, Australia (19° 06' S, 152° 12' E), in 8-16 m, collected by A. J. Ferreira, M/V CORALITA [LACM 77-119]; five specimens from reef slopes

and exposed sand pockets, Matiu Island, Kokoana Passage, Marovo Lagoon, northeast side Vangunu Island, Solomon Islands (8° 29.8' S, 158° 12' E), in rubble at 20-25 m, collected by H. W. Chaney, March 22, 1989 [LACM 89-77]; two specimens from Diamond seamount, east of Herald Pass, west of Ndravuni Island, inside Great Astrolabe Reef, Kadavu Group, Fiji (18° 45.8' S, 178° 28.3' E), in 20-25 m, collected by T. Bratcher, June 19, 1991 [LACM 91-188]; one specimen from Leone Bay, Tutuila Island, American Samoa (14° 20.30' S, 170° 47.6' W), at 15.2 m, collected by G. Hendler, April 26, 1999 [LACM 99-89]; one specimen from outer reef slope, off Arutanga, west side Altutaki, Cook Islands, West Pacific (18° 52.3' S, 159° 47.5' W), in rubble and Halimeda at 18-26 m, collected by J. H. McLean & S. Zinn, May 12-13, 1987 [LACM 87-79]; two specimens from "Norwich City" locality, northwest of Nikumaroro Island, Phoenix Islands, Kiribati (4° 40.8' S, 174° 30.91' W), in 28.3 m, collected by M. J. Adams, R/V NAI'A, July 5, 2002 [LACM 2002-53]; 9 specimens from Prince Kuhio's Cove, Koloa District, Kaua'i, Hawai'i in 3-4 m, collected by S. G. Wiedrick [SW06-98]; 49 specimens from Ha'ena Point, Hanalei District, Kaua'i, Hawai'i (22° 13.77' N, 159° 33.5' W), in coral sand at 0-4.6 m, collected by L. Burns, November, 1990 [LACM 90-397]; 63 specimens from near Lighthouse, Lana'i, Hawai'i (20° 57' N, 157° 00' W), at 12-23 m, collected by T. Bratcher, September 4-5, 1974 [LACM 74-66]; 14 specimens from Kea'au Beach Park, Wai'anae District, O'ahu, Hawai'i (21° 00.4' N, 158° 14.6' W), in dead coral and sand at 5-23 m, collected by D. R. Shasky, October 2, 1986 [LACM 86-425]; 39 specimens from end of School Street, Kahului Harbor, Maui, Hawai'i (20° 53.68' N, 156° 28.50' W), in intertidal rocks and sand, collected by P. & B. LaFollette, April 28-May 3, 1984 [LACM 84-156]; 67 specimens from 'Anaeho'omalua Point, Kona North District, Hawai'i in 2-4 m, collected by S. G. Wiedrick [SW09-26]; 18 specimens from Kailua (Old Airport), Kona North District, Hawai'i in 7-11 m, collected by S. G. Wiedrick [SW09-25]; 19 specimens from Kailua (Old Airport), Kona North District, Hawai'i in 6-13 m, collected by S. G. Wiedrick [SW09-23]; 59 specimens from southern Kailua (Old Airport), Kona North District, Hawai'i in intertidal drift at low tide, collected by S. G.

Wiedrick [SW09-21]; 83 specimens from Sheraton Hotel, Keauhou Bay, Kona North District, Hawai'i in 9-13 m, collected by S. G. Wiedrick [SW09-20]; 33 specimens from 'Anaeho'omalua Point, Kona North District, Hawai'i in intertidal drift at low tide, collected by S. G. Wiedrick [SW09-17]; 77 specimens from Honokohau Harbor, Kona North District, Hawai'i in 8-29 m, collected by S. G. Wiedrick [SW09-19].

Distribution. The exact range of *Carinapex minutissima* (Garrett, 1873) is questionable based on authors who did not illustrate the specimens in question. The synonymy above is based on the assumption the authors compared specimens to the type specimen, or the original illustration and were not aware of another similar species, *Carinapex amirowlandae* n. sp. Records range from Gulf of Aqaba, Red Sea (Bandel & Dockery, 2012: 112); Indonesia (here cited), Australia (Hedley, 1922: 258; here cited), Palau (ANSP 283372), Philippines (Sysoev *in* Severns, 2011: 386; here cited), Vietnam (Thach, 2012), Taiwan (Chang & Wu, 1999; Chang & Thorsson, 2001; Chang, 2001a; Thorsson & Chang, 2001; Chang & Wu, 2007; here cited), Japan (Hasegawa & others *in* Okutani, 2000: 641; Higo & others, 1999: 307; here cited), Bonin Islands (Fukuda, 1994: 25), Guam (Smith, 2003), Marshall Islands (Kay, 1990; here cited), Papua New Guinea (here cited), Queensland, Australia (here cited), New Caledonia (Kay, 1979:344), Solomon Islands (here cited), Fiji (Garrett, 1873; here cited), American Samoa (here cited), Cook Islands (here cited), French Polynesia (Tröndlé & Boutet, 2009: 38), Kiribati (here cited) to Hawai'i (Taylor, 1975: 431; Kay, 1979: 344; Severns, 2011: 386; Chang, 2001a: 9; Chang, 2001b: 206; Thorsson & Chang, 2001: 191; here cited). Map insert (fig. 5) shows distribution of material recorded from the LACM and SW collections.

Diagnosis. *Carinapex minutissima* (Garrett, 1873), is characterized by its small size, on average, in comparison to its allied *C. amirowlandae* n. sp. Protoconch of *C. minutissima* with one-and-a-half translucent white whorls, proceeding whorls brown, profile low, proceeding three protoconch whorls with low carination, teleoconch whorls with two

rows of tightly spaced rows of nodules, four spiral cords on final whorl of siphonal canal.

Description. Shell small to medium sized at maturity, shape ovate pupoid, narrow, color red-brown, occasionally with faint blotch on dorsal side of final whorl. Apex low profile, four protoconch whorls, first one to one-and-a-half whorls translucent white, small, compact round bulbous, proceeding three whorls red-brown with low carinate keel, finely beaded, upper section of final whorl with backward crescent shaped ribs. Three-and-a-half to four teleoconch whorls with two rows of tightly spaced, relatively close in sized nodules, sculpture somewhat clathrate, final whorl with very subtle ribs, beaded row at base, four cords on siphonal canal. Aperture very small, slender, ovate, about one fourth the height of shell, parietal callus very large, projecting outward, sinus extremely restricted, nearly sealed.

Discussion. *Carinapex minutissima* (Garrett, 1873) is a very wide spread Indo-Pacific species in the genus, with records from the Red Sea to the Hawaiian Islands. After studying 118 lots from the LACM and SW collections, which included over 3080 specimens, it was concluded that there were two distinct species from the Indo-Pacific. It was also concluded that specimens from the Hawaiian Islands and the Red Sea proved that populations were ample and void of the new, similar species *Carinapex amirowlandae* n. sp. The omission of figured *Carinapex* specimens in Cox & others (2009) brings to question the authenticity of the identification of the proposed two species *Carinapex minutissima* and *C. papillosa* with regards to the numbers recorded in the table provided. On the account of *C. minutissima*, the extremely low record of this species in comparison to a relatively abundant *C. papillosa* does not seem plausible according to personal observations from material observed from Hawai'i, Maui, O'ahu and Kaua'i. It is speculated and here cited in the synonymy above, and for *C. lindseygrovesi* n. sp. below, that both were incorrectly identified and reversed in the table published by Cox & others (2009). The apex of the *C. minutissima* holotype is worn and has a chalky appearance. Specimens in fine condition from

throughout the Indo-Pacific, and especially from near the type locality (Fiji), match the holotype well and show the very small initial white protoconch whorl.

***Carinapex alisonkayae* n. sp.**

Plate 4, figs. 69-71, 87

Carinapex papillosa.—Kay, 1979: 344, fig. 115P.



Image 9. *Carinapex alisonkayae* n. sp., holotype

Type Material. Holotype, LACM 3297, height 2.7 mm, width 1.2 mm.

Type Locality. Honokohau Harbor, Kona North District, Hawai'i (19° 40' 3.18" N, 156° 1' 48.91" W) by hand dredge in 8-29 m.

Material Examined. Holotype [LACM 3297], (Pl. 4, figs. 69-71, 87); five specimens from Honokohau Harbor, Kona North District, Hawai'i, taken by hand dredge in 8-29 m, collected by S. G. Wiedrick, August 4, 2009 [= SW09-19]; one specimen from Kailua (Old Airport), Kona North District, Hawai'i, taken by hand dredge in 6-13 m, collected by S. G. Wiedrick, August 5, 2009 [SW09-23]; one specimen from 'Anaeho'omalu Point, Kona North District, Hawai'i taken by hand dredge in 3-4 m, collected by S. G. Wiedrick, August 7, 2009 [SW09-26]; two

specimens from Ma'alaia Bay, Maui, Hawai'i (20° 46' N, 156° 30' W), taken on pen shell beds and coral reef at 12-20 m, collected by T. Bratcher, July 17-20, 1975 [LACM 75-64]; one specimen from near Lighthouse, Lana'i, Hawai'i, (20° 57' N, 157° 00' W) at 12-23 m, collected by T. Bratcher, September 4-5, 1974 [LACM 74-66]; one specimen from Ha'ena Point, Hanalei District, Kaua'i, Hawai'i (22° 13.77' N, 159° 33.5' W), in coral sand at 0.0-4.6 m, collected by L. Burns, November, 1990 [LACM 90-397]; four specimens from Leone Bay, Tutuila Island, American Samoa (14° 20.30' S, 170° 47.6' W), at 15.2 m, collected by G. Hendler, April 26, 1999 [LACM 99-89]; one specimen from outside of lagoon, north side Nuapapu Island, Vava'a Group, Tonga (18° 42' S, 174° 06' W), in coral sand at 30 m, collected by A. J. Ferreira, July 27, 1985 [LACM 85-89]; one specimen from steep coral slope, south side Bunaken and Siladen Islets, off Manado, north Sulawesi, Indonesia (1° 36.2' N, 124° 46.0' E), in rubble at 5-20 m, collected by J. H. McLean, April, 9-10, 1988 [LACM 88-55]; 3 specimens from Horseshoe Cliffs, 1 km west northwest Onna Village, Okinawa, Okinawa-gunto, Japan (26° 29.6' N, 127° 50.5' E), in sand and coral rubble at 46-55 m, collected by R. F. Bolland, January 3, 1979 [LACM 79-75]; four specimens from Dunraven Reef, Strait of Tiran, south Sinai Peninsula, northern Red Sea, Egypt (27° 12' N, 34° 06' E), in clean sand and coral at 25m, collected by T. Bratcher, November 1, 1985 [LACM 85-112].

Distribution. Records from the Red Sea, Indonesia, Japan, Hawaiian Islands, American Samoa and Tonga. Map insert (fig. 6) shows distribution of material recorded from the LACM and SW collections.

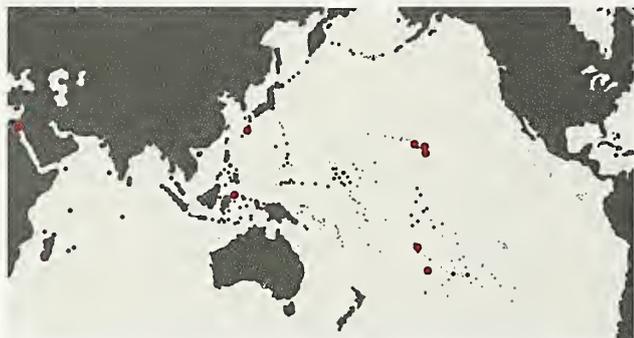


Figure 6. Distribution of *Carinapex alisonkayae* n. sp.

Diagnosis. *Carinapex alisonkayae* n. sp. is characterized by its small size, somewhat rhomboid shape, strongly projecting nodules and outward projecting callus.

Description. Shell small, somewhat rhomboid shaped, color white to cream, faint orange tint on callus and base of final lip. Protoconch relatively acute in profile, first whorl bulbous, sunken into proceeding whorl, second whorl carinate with fine ribs on base, continuously through third and fourth protoconch whorls. Three-and-a-half teleoconch whorls, first one-and-a-half teleoconch whorls with two rows of widely spaced, projecting nodules, peripheral row strongest, remaining one half row subtly showing third row of nodules at base, final whorl with two rows of projecting nodules followed by four rows of spiral cords, faintly nodulose, continued with three strong cords on base of siphonal canal. Aperture elongate, sinus somewhat open, parietal callus projecting outward.

Discussion. The small sized *Carinapex alisonkayae* n. sp. is unlike any other species. The species appears to be widespread in the Indo-Pacific but is not frequently encountered like *C. minutissima* (Garrett, 1873) and *C. amirowlandae* n. sp. Kay (1979: 344) figured a specimen as *C. papillosa* which appears to be identical to the holotype.

Etymology. Named after the late E. Alison Kay whose contributions to the Hawaiian malacology has greatly improved our understanding of the fauna from this region.

***Carinapex philippinensis* n. sp.**

Plate 2, figs. 30-35, 44

Carinapex sp. 2.—Severns, 2011: 386, fig. 4.

Type Material. Holotype, LACM 3295, height 3.5 mm, width 1.4 mm.

Type Locality. Linapacan Island, Palawan Province, Philippines (11° 29'0.12" N, 119° 50'13.82" E) in tangle nets at 150 m.



Image 10. *Carinapex philippinensis* n. sp., holotype

Material Examined. Holotype [LACM 3295], (Pl. 2, figs. 30-32, 44); 64 specimens from Linapacan Island, Palawan Province, Philippines in tangle nets at 150 m, April, 2005 [= SW05-67]; 28 specimens from Mactan Island, Cebu Province, Philippines in 90-100 m [SW07-70]; three specimens from Bantayan Island, Cebu Province, Philippines in 80-100 m [SW05-68]; one specimens from Bataan Island, Bataan Province, Philippines in 10-15 m [SW06-115]; five specimens from Aliguay Island, Zamboanga del Norte Province, Philippines in 91 m [SW07-72]; 56 specimens from Mactan Island, Cebu Province, Philippines in 100-250 m [SW09-33]; nine specimens from Mactan Island, Cebu Province, Philippines in 200-250 m [SW08-57]; one specimen from Horseshoe cliffs, 1 km west northwest of Onna Village, Okinawa-jima, Okinawa-shoto, Ryukyushoto, Okinawa Prefecture, Japan (26° 29.6' N, 127° 50.5' E), collected by R. F. Bolland, November 12, 1978 [LACM 78-101]; one specimen from Diamond seamount, east of Herald Pass, west of Ndravuni Island, inside Great Astrolabe Reef, Kadavu Group, Fiji (18° 45.8' S, 178° 28.3' E), in 20-25 m, collected by T. Bratcher, June 19, 1991 [LACM 91-188]; one specimen from Leone Bay, Tutuila Island, American Samoa (14° 20.3' S, 170° 47.06' W) in 15.2 m, collected by G. Hendler, April 26, 1999 [LACM 99-89].

Distribution. Records from Japan, Philippines, Fiji, American Samoa and Makena Bay, Maui, Hawai'i (from Severns, 2011: 386). Map insert (fig. 7) shows distribution of material recorded from the LACM and SW collections.

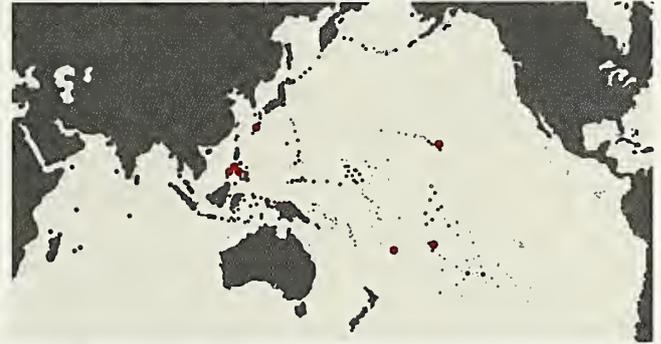


Figure 7. Distribution of *Carinapex philippinensis* n. sp.

Diagnosis. *Carinapex philippinensis* n. sp. is characterized by its medium size, elongate profile, large, round, widely spaced, projecting nodules on periphery, strong spiral cords on base of final whorl.

Description. Shell medium sized, elongate, color light reddish brown with tan band on periphery. First whorl of protoconch bulbously domed, transparent, sunken into second whorl, both smooth, proceeding whorl carinate at periphery, shoulder somewhat tabulate, base nearly vertical, subsequent one half whorl similar, base indented near suture of proceeding whorl. Four-and-a-half teleoconch whorls with translucent nodules, first whorl with two rows of nodules, peripheral row strong, projecting outward, sutural row weak, following two-and-a-half whorls with three nodule rows, peripheral strong, projecting outward, sutural and basal rows weak. Last whorl with weak sutural row, two peripheral rows, lower one somewhat cord-like, seven spiral cords on base of siphonal canal cords, slightly beaded near periphery. Aperture ovate, elongate at anterior end, sinus slightly restricted, parietal callus relatively small, downward pointed.

Discussion. The figured specimen of *Carinapex* sp. 2, from Hawai'i, by Severns (2011) exhibits more closely set nodules but otherwise are conspecific. *Carinapex philippinensis* is unlike other species in the genus by its medium size, slender, ovate profile,

projecting peripheral nodules, profile concavely sloping from nodule to suture and continuing concavely to next whorl nodule.

Etymology. Named after the Philippine Islands as this is where the majority of the samples have been recorded.

Carinapex amirowlandae n. sp.

Plate 4, Figures 72-83, 88-89

Carinapex minutissima.—Chang & Wu, 1999: 64, fig. 7.—Chang, 2001a: 8, fig. 4.

Carinapex minutissimus.—Sysoev in Poppe, 2008: 762, fig. 3 & 4.

Carinapex minutissime [sic].—Chang & Wu, 2007: 5, fig. 1306A.



Image 11. *Carinapex amirowlandae* n. sp., holotype

Type Material. Holotype LACM 3301, height 3.1 mm, width 1.2 mm.

Type Locality. North central Punta Engano, Mactan Island, Cebu Province, Philippines (10° 19' 29.14" N, 124° 1' 45.77" E) in tangle nets at 100-250 m.



Figure 8.

- Exclusively *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 50-99% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 25-49% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 1-24% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.

Material Examined. Holotype [LACM 3301], (Pl. 4, figs. 75-77, 88); 965 specimens from Mactan Island, Cebu Province, Philippines, in tangle nets at 100-250 m, January 2009 [= SW09-33]; two specimens from Hellville, south side Nosy Be, Antseranana Province, Madagascar, (13° 27' S, 48° 15' E) near coral heads and gorgonians at 14 m, collected by J. H. McLean, April 15, 1989 [LACM 89-55]; four specimens from steep coral slope, off Ajer (Gili Air) and Meno Islets, northwest side Lombok, Indonesia (8° 22' S, 116° 04' E) in rubble at 5-20 m, collected by J. H. McLean & H. W. Chaney, April 15, 1988 [LACM 88-63]; one specimen from outside reef, north end Mermaid Reef, Rowley Shoals, Western Australia (17° 03' S, 119° 36' E), in 18-20 m, collected by T. Bratcher, August 30, 1986 [LACM 86-250]; three specimens from between Culebra Island and Malajiboomanoc Island, east of Maricaban Island, Batangas Province, Luzon, Philippines (13° 37.8' N, 121° 57.4' E), in coral and rock bottom at 15-20 m, collected by T. Bratcher, January 11, 1984 [LACM 84-162]; three specimens from Cavile Reef, out of Puerto Princessa, Palawan, Philippines (9° 43' N, 118° 47' E), in intertidal sand and rocks, collected by T. Bratcher, June 1982 [LACM 82-62]; 27 specimens from Mactan Island, Cebu Province, Philippines in 90-100 m [SW07-70]; 52 specimens from Linapacan Island, Palawan Province, Philippines in 150 m [SW05-67]; six specimen from Olango Island, Cebu Province, Philippines in 25-45 m [SW07-71]; four specimens from Bantanyan Island, Cebu Province, Philippines in 80-100 m [SW05-68]; two specimens from Bataan Island, Bataan Province, Philippines in 10-15

m [SW06-115]; eight specimens from Aliguay Island, Zamboanga del Norte Province, Philippines in 91 m [SW07-72]; 164 specimens from Mactan Island, Cebu Province, Philippines in 200-250 m [SW08-57]; one specimen from southeast side Pitou Chiao (=Pitou Nankow), east of Chi-lung (=Keelung), Taipei County, Taiwan (25° 08.0' N, 121° 55.0' E), in rocky intertidal tide pool at 3 m, collected by C. C. Coney and P. F. Liu, May 10, 1988 [LACM 88-80]; 11 specimens from Horseshoe Cliffs, 1 km west northwest Onna Village, Okinawa, Okinawa-gunto, Japan (26° 29.6' N, 127° 50.5' E), in sand and coral rubble at 46-55 m, collected by R. F. Bolland, January 3, 1979 [LACM 79-75]; three specimens from channel between Wongat Island, and barrier reef at Astrolabe Bay, Madang Province, Papua New Guinea (5° 08.1' S, 145° 50.7' E), in sand at 29-30 m, collected by T. Bratcher, September, 1, 1980 [LACM 80-26]; 12 specimens from reef slopes and exposed sand pockets, Matiu Island, Kokoana Passage, Marovo Lagoon, northeast side Vangunu Island, Solomon Islands (8° 29.8' S, 158° 12' E), in rubble at 20-25 m, collected by H. W. Chaney, March 22, 1989 [LACM 89-77]; two specimens from Diamond seamount, east of Herald Pass, west of Ndravuni Island, inside Great Astrolabe Reef, Kadavu Group, Fiji (18° 45.8' S, 178° 28.3' E), in 20-25 m, collected by T. Bratcher, June 19, 1991 [LACM 91-188]; eight specimens from outer reef slope, off Arutanga, west side Altutaki, Cook Islands, West Pacific (18° 52.3' S, 159° 47.5' W), in rubble and Halimeda at 18-26 m, collected by J. H. McLean & S. Zinn, May 12-13, 1987 [LACM 87-79]; 11 specimens from outside reef off Point Hauru (Tehau), Moorea, Society Islands, (17° 29.1' S, 149° 55.2' W), in 18-24 m, collected by D. R. Shasky, July 25-August 5, 1977 [LACM 77-114]; one specimen from Ahe Atoll, Tuamotu Archipelago, French Polynesia (14° 28' S, 146° 22' W), in 1 m, collected by D. E. Koontz, yacht "Constitution", October 14-15, 1973 [LACM 73-94].

Distribution. Records range from Madagascar (here cited), Indonesia (here cited), Australia (here cited), Philippines (Sysoev *in* Poppe, 2008: 762; here cited), Taiwan (Chang & Wu, 1999; Chang, 2001a; Chang & Wu, 2007; here cited), Japan (here cited), Papua New Guinea (here cited), Solomon Islands (here

cited), Fiji (Garrett, 1873; here cited), Cook Islands (here cited), Society Islands (here cited) and French Polynesia (here cited). Map insert (fig. 8) shows distribution of material recorded from the LACM and SW collections.

Diagnosis. *Carinapex amirowlandae* n. sp. is characterized by its tall, somewhat erect apex, symmetrical, elevated keel, peripheral nodules of teleoconch whorls, widely spaced, robust, heavy ribs on final whorl, white blotch on dorsal side of final whorl, dark brown band below, three spiral cords on siphonal canal.

Description. Shell medium sized, seldomly small or minute specimens occur, shape elongate, ovate, sturdy, squat, color light brown to peach, distinct light tan or cream blotch on dorsal side of final whorl, followed below by a dark patch on base. Apex profile tall, acute, somewhat erect, symmetrical, steep angle, about 0.5 mm height, four translucent protoconch whorls, first two whorls large, wide, bulbously domed, brown, proceeding two whorls light with elevated carinate finely beaded cord, low, projecting. Four teleoconch whorls with two rows of widely spaced, large nodules, peripheral row larger, final row with strong ribs, beaded row at base, three spiral cords on siphonal canal. Aperture ovate, one third the length of shell, parietal callus large, sinus slightly restricted, anterior canal twisted outward, siphonal canal long.

Discussion. *Carinapex minutissima* (Garrett, 1873) is historically known as the most widely spread Indo-Pacific species in the genus, with records from Madagascar (here cited) east to Japan through the Pacific to French Polynesia, but no records from Hawai'i. Records of *C. amirowlandae* n. sp. range throughout the Indo-Pacific but there is no evidence the species exists in the Hawaiian Islands. As previously mentioned, it is speculated Cox & others (2009) misidentified *Carinapex papillosa* (Garrett, 1873) and it was described above as *Carinapex lindseygrovesi* n. sp. As for the name *C. minutissima*, it appears the name was used as a substitute to the species described above now known as *Carinapex amirowlandae* n. sp. Hawaiian *Carinapex* material studied appears to support the hypothesis that Cox & others (2009) inadvertently

reversed the numbers in the table according to trends in frequency of occurrence within the Hawaiian Island chain. *Carinapex minutissima* is similar in general appearance to *C. amirowlandae* n. sp. and can be readily separated by an analysis of the average sizes, differing protoconchs, coloration, sculptural differences and general shape. Despite morphological features, distribution records indicate a correspondence between *C. minutissima* and *C. amirowlandae* n. sp. although their respective ranges don't completely overlap and the species is absent from some extreme ends of the range.

Etymology. Named after the uniquely charismatic and powerful friend and work supervisor, Ami Rowland, Irvine, California, whose inspirational support and flexibility enabled the ability for much material to be collected and processed during a three week excursion to O'ahu, Maui and Kaua'i (Hawaiian Islands) that revealed a variety of research material which heavily contributed to the completion of this paper.

***Carinapex lindseygrovesi* n. sp.**

Plate 4, figs. 84-86, 90

Carinapex minutissima.—Thorsson, 1997: 16-19, 23.—Chang & Wu, 1999: 64, fig. 8.—Chang, 2001a: 9, figs. 4b-d.—Chang, 2001b: 206, fig. 19-5b.—Severns, 2011: 386, pl. 176, figs. 3a-b.

Carinapex minutissima.—Cox & others, 2009: 17.

Type Material. Holotype, LACM 3299, height 3.3 mm, width 1.3 mm.

Type Locality. Near Lighthouse, Lana'i, Hawai'i (20° 57' N, 157° 00' W) at 12-23 m.

Material Examined. Holotype [LACM 3299], (Pl. 4, figs. 84-86, 90); seven paratypes LACM 3300 from near Lighthouse, Lana'i, Hawai'i, (20° 57' N, 157° 00' W) at 12-23 m, collected by T. Bratcher, September 4-5, 1974 [= LACM 74-66]; three specimens from Kea'au Beach Park, Wai'anae District, O'ahu, Hawai'i in dead coral and sand at 5-23 m, collected by D. R. Shasky, October 2, 1986 [LACM 86-425]; one specimen from 'Anaeho'omalua Point, Kona North District,

Hawai'i in 3-4 m, collected by S. G. Wiedrick [SW09-26];



Image 12. *Carinapex lindseygrovesi* n. sp., holotype

two specimens from 'Anaeho'omalua Point, Kohala District, Hawai'i in intertidal drift at low tide, collected by S. G. Wiedrick [SW09-17]; five specimens from Kailua (Old Airport), Kona North District, Hawai'i in 6-13 m, collected by S. G. Wiedrick [SW09-23]; four specimens from Sheraton Hotel, Keauhou Bay, Kona North District, Hawai'i in 9-13 m, collected by S. G. Wiedrick [SW09-20]; ten specimens from Honokohau Harbor, Kona North District, Hawai'i in 8-29 m, collected by S. G. Wiedrick [SW09-19]; two specimens from northwest end of Lana'i, Hawai'i, (20° 55' N, 157° 03' W) at 18 m, collected by T. Bratcher, September 6, 1974 [LACM74-67]; one specimen from off Molokini Island, south side Maui, Hawai'i (20° 38' N, 156° 30' W) at 12.5 m, collected by A. Tiedeman, August, 1959 [LACM59-16]; one specimen from Prince Kuhio's Cove, Koloa District, Kaua'i, Hawai'i in 3-4 m, collected by S. G. Wiedrick [SW06-98]; three specimens from Welles Harbor, off west side Sand Island, Midway Islands (28° 12.5' N, 177° 24.3' W) under dead coral at 2-8 m, collected by D. R. Shasky, October 4, 1985 [LACM85-117].

Distribution. *Carinapex lindseygrovesi* n. sp. is known to inhabit the Hawaiian Island chain and Midway Atoll.

Diagnosis. *Carinapex lindseygrovesi* n. sp. is characterized by its moderately large size, flattened apex, projecting to one side, large, widely spaced nodules, dark chocolate brown color and elongate aperture.

Description. Shell moderately large sized, slender, elongate-oblong shaped, turreted, color dark chocolate brown, protoconch orange-brown colored, large orange-brown blotch on periphery of dorsal side on final whorl. Color lighter in worn specimens. First whorl of protoconch domed, flattened, distorted to one side, sunken into second whorl, proceeding two whorls carinate at periphery, shoulder with strong, well spaced backward crescent shaped ribs, base with tightly condensed ribs. Four to four-and-a-half teleoconch whorls with two rows of large, widely spaced nodules at suture and periphery, sutural row weaker, final whorl with four rows of cords creating nodules resembling ribs, four strong, beaded cords below larger rows, descending anteriorly down siphonal canal. Aperture elongate, sinus restricted, parietal callus strong and projecting downward.

Discussion. *Carinapex lindseygrovesi* n. sp. is distinguished by its moderately large size, dark coloration, round, well spaced, large sized nodules, protoconch large, general profile wide and tall, first whorl domed, flattened, distorted to one side, angulate thereafter, subtly ornamented. Although in color, *C. chaneyi* n. sp. and *C. lindseygrovesi* n. sp., have great similarities, *C. chaneyi* n. sp. is squat, pupoid, protoconch, acute, erect with round, tightly spaced, large sized nodules on teleoconch whorls. *C. lindseygrovesi* n. sp. has erroneously been identified by authors Thorsson (1997), Chang & Wu (1999), Chang (2001a; 2001b), Severns (2011) as *C. minutissima* (Garrett, 1873). Superficially, *C. minutissima*, *C. lindseygrovesi* n. sp. and *C. amirowlandae* n. sp. all appear to be similar with little differences. As pointed out by Thorsson (1997), the two Hawaiian species can readily be separated upon close inspection. This is a result of *C. minutissima* having drastically different

morphological features than that of *C. lindseygrovesi* n. sp. In contrast, *C. lindseygrovesi* n. sp. and *C. amirowlandae* n. sp. share some similarities and are separable by their protoconchs, color and general shape. Cox & others (2009) did not figure *Carinapex papillosa* (Garrett, 1873) rather provided the name in a table. It is hypothesized that this species recorded is actually the same species described as *Carinapex lindseygrovesi* n. sp. due to the few specimens reported and common trends within over 100 Hawaiian *Carinapex* lots observed. *C. papillosa* is known from only one Hawaiian specimen and is extremely rare in comparison to *C. lindseygrovesi*. The abundance of *C. minutissima* and scarcity of *C. lindseygrovesi* n. sp. allows me to conclude it is very likely that Cox & others (2009) reversed the numbers in the table provided. Hawaiian *Carinapex* material researched by myself supports this conclusion.

Etymology. Named after malacologist/paleontologist Lindsey T. Groves, Collections Manager of Malacology (LACM) and who has contributed to the science of malacology and paleontology in addition to my personal growth in the field.

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(Plates 1 through 4 follow)

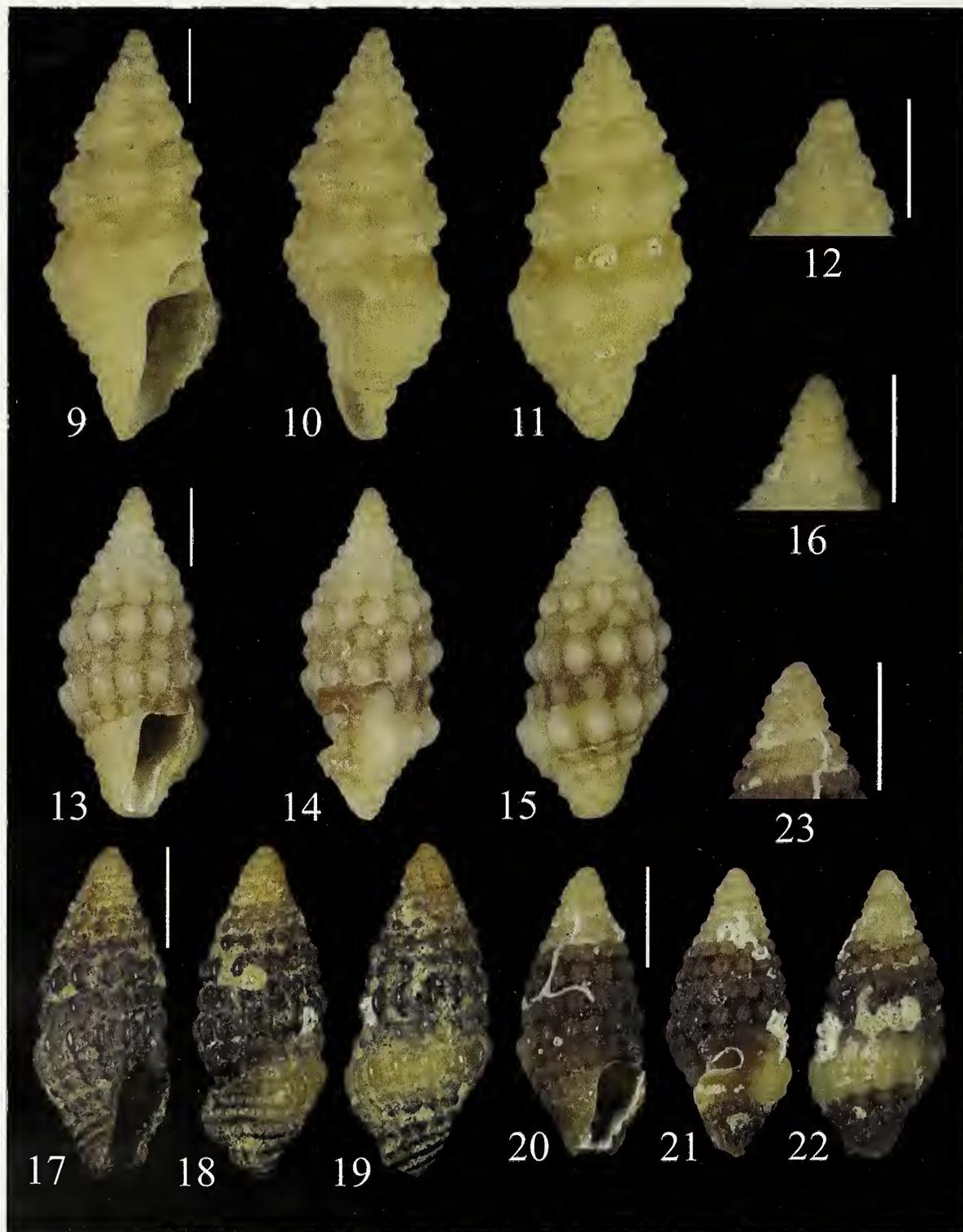


Plate 1, Figures 9-23. 9-12. *Carinapex solomonensis* n. sp., Kicha Island, Solomon Islands, holotype [LACM 3290], 15-20 m [9-11. Height 5.5 mm, width 2.4 mm, 12. Protoconch, scale bar = 1 mm]. 13-16. *Carinapex cernohorskyi* n. sp. west Tsuken-jima, Okinawa, Japan, holotype [LACM 3294], 18 m [13-15. Height 4.2 mm, width 1.9 mm, 16. Protoconch, scale bar = 1 mm]. 17-19. *Carinapex chaneyi* n. sp., Mactan Island, Cebu Province, Philippines, [SW09-33], 100-250 m, height 3.3 mm, width 1.4 mm, scale bar = 1 mm. 20-23. *Carinapex chaneyi* n. sp., Karunjou Island, Solomon Islands, holotype [LACM 3293], 20-25 m [20-22. Height 2.8 mm, width 1.3 mm, 23. Protoconch, scale bar = 1 mm].

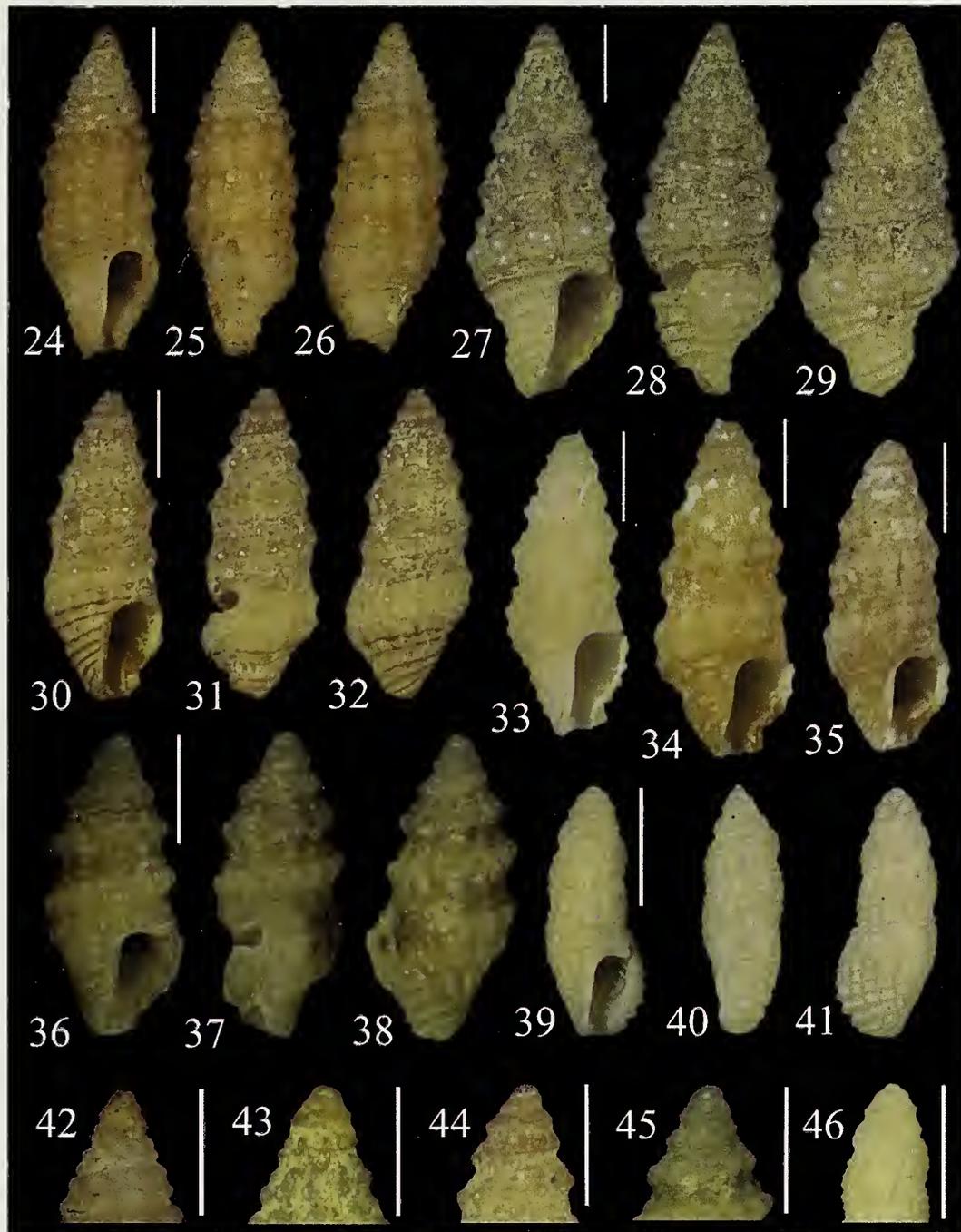


Plate 2, Figures 24-46. 24-26, 42. *Carinapex papillosa* (Garrett, 1873), Liti Isles, Fiji, holotype [ANSP15307]. 24-26. height 3.8 mm, width 1.4 mm, 42. Protoconch, scale bar = 1 mm. 27-29, 43. *Carinapex albarnesi* n. sp. Mactan Island, Philippines, holotype [LACM 3298], 90-100 m, [27-29. Height 4.8 mm, width 2.0 mm, 43. Protoconch, scale bar = 1 mm]. 30-32, 44. *Carinapex philippensis* n. sp., Linapacan Island, Philippines, holotype [LACM 3295], 150 m, [30-32. Height 3.5 mm, width 1.4 mm, 44. Protoconch, scale bar = 1 mm]. 33. *Carinapex philippinensis* n. sp., Horseshoe Cliffs, Okinawa, Japan, [LACM 78-101] 58 m, height 3.4 mm, width 1.3 mm. 34. *Carinapex philippensis* n. sp., Diamond seamount, Great Astrolabe Reef, Fiji, [LACM 91-188] 20-25 m, height 3.7 mm, width 1.5 mm. 35. *Carinapex philippensis* n. sp., Tutuila Island, American Samoa, [LACM 99-89] 15.2 m, height 3.5 mm, width 1.4 mm. 36-38, 45. *Carinapex johnwiedricki* n. sp., Mactan Island, Cebu Province, Philippines, holotype [LACM 3296], in tangle nets at 200-250 m, [36-38. Height 2.7 mm, 1.2 mm, 45. Protoconch, scale bar = 1 mm]. 39-41, 46. *Carinapex moorei* n. sp., 'Anaeho'omalū Bay, Hawai'i, holotype [LACM 3291], in beach drift, [39-41. Height 2.1 mm, width 0.8 mm, 46. Protoconch, scale bar = 1 mm].

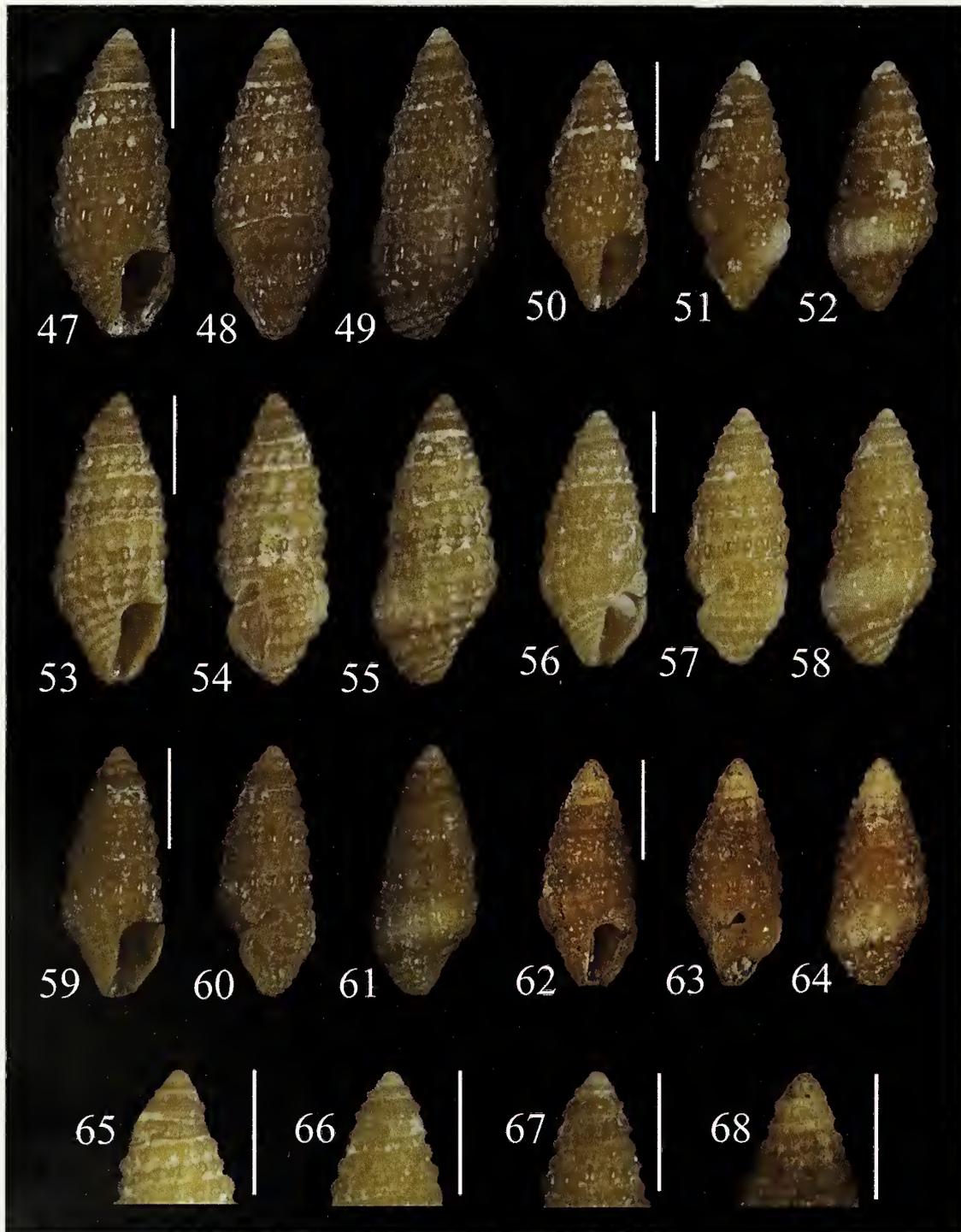


Plate 3, Figures 47-68. 47-49. *Carinapex minutissima* (Garrett, 1873), 'Anaeho'omalū Bay, Kona North District, Hawai'i, [SW09-26], 2-4 m, height 3.1 mm, width 1.2 mm, scale bar = 1 mm. 50-52. *Carinapex minutissima*, Nikumaroro Island, Phoenix Islands, Kiribati, [LACM 2002-53] 28.3 m, height 2.5 mm, width 1.1 mm, scale bar = 1 mm. 53-55, 65. *Carinapex minutissima*, Pitou Nankow, Taipei County, Taiwan, [LACM 88-80], 0-3 m [53-55. Height 2.9 mm, width 1.2 mm. 65. Protoconch, scale bar = 1 mm]. 56-58, 66. *Carinapex minutissima*, Mermaid Reef, Western Australia, [LACM 86-250], 18-20 m. [56-58. Height 2.6 mm, width 1.1 mm. 66. Protoconch, scale bar = 1 mm]. 59-61, 67. *Carinapex minutissima*, Coral Gardens, N. Red Sea, Egypt, [LACM 85-114], 10-15 m [59-61. Height 2.5 mm, width 1.0 mm. 67. Protoconch, scale bar = 1 mm]. 62-64, 68. *Carinapex minutissima* (Garrett, 1873), Liti Isles, Fiji, syntype [ANSP59232]. [62-64. Height 2.2 mm, width 1.0 mm. 68. Protoconch, scale bar = 1 mm].

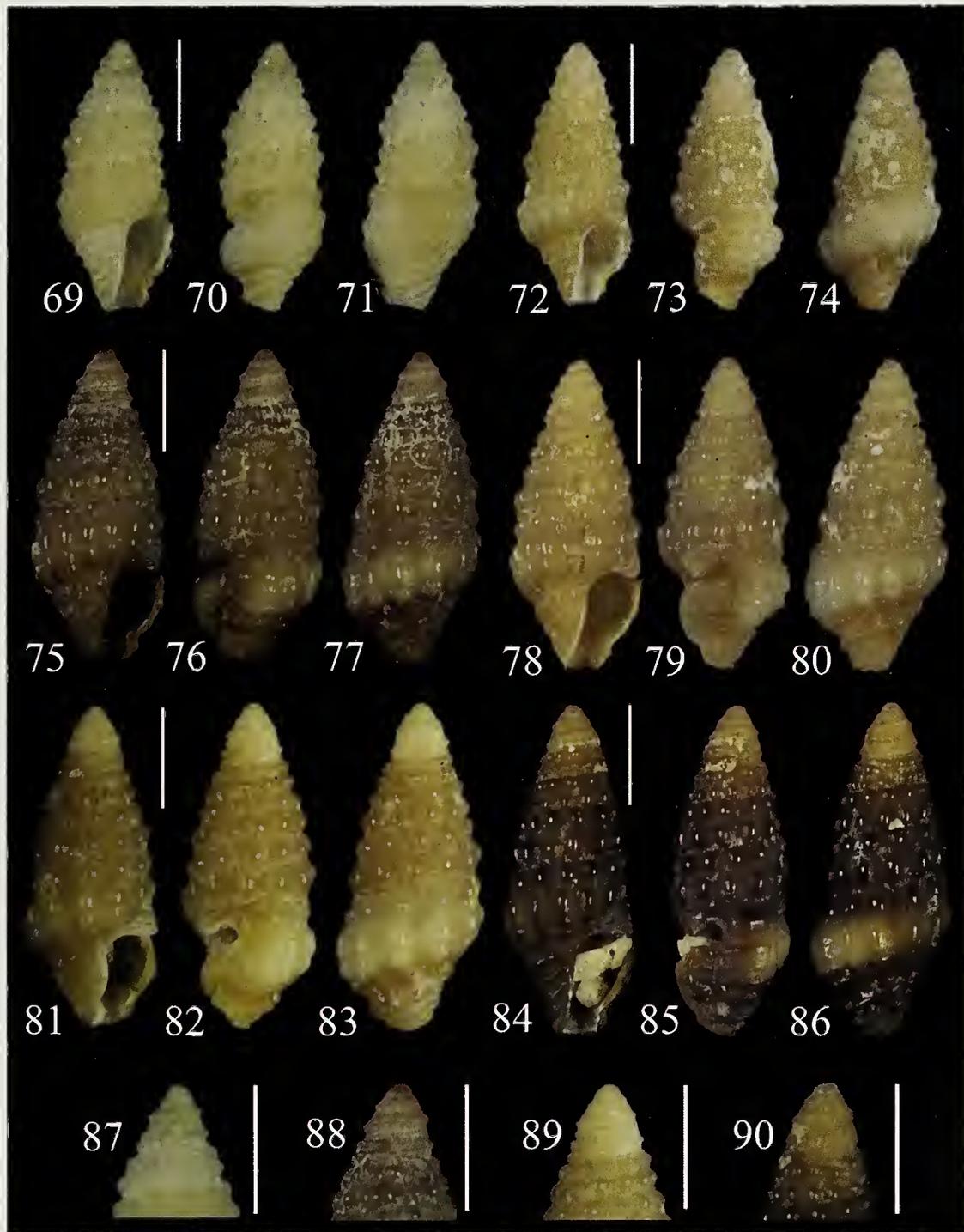


Plate 4, Figures 69-90. 69-71, 87. *Carinapex alisonkayae* n. sp., Honokohau Harbor, Kona North District, Hawai'i, holotype [LACM 3297], 7-12 m, [69-71. Height 2.7 mm, width 1.2 mm, 87. Protoconch, scale bar = 1 mm]. 72-74. *Carinapex amirowlandae* n. sp., Pisok Point, North Celebes, Indonesia, [LACM 82-39] 8-40 m, height 2.6 mm, width 1.2 mm, scale bar = 1 mm. 75-77, 88. *Carinapex amirowlandae* n. sp., Mactan Island, Philippines, holotype [LACM 3301], 100-250 m, [75-77. Height 3.1 mm, width 1.2 mm, 88. Protoconch, scale bar = 1 mm]. 78-80. *Carinapex amirowlandae* n. sp., Nakijin Motobu Peninsula, Japan, [LACM 78-22], 30 m, height 3.1 mm, width 1.3 mm, scale bar = 1 mm. 81-83, 89. *Carinapex amirowlandae* n. sp., Hellville, Antseranana Province, Madagascar, [LACM 89-55] 14 m [81-83. Height 3.2 mm, width 1.3 mm. [89. Protoconch, scale bar = 1 mm]. 84-86, 90. *Carinapex lindseygrovesi* n. sp., Lana'i, Hawai'i, holotype [LACM 3299], 12-23 m, [84-86. Height 3.3 mm, width 1.3 mm, 90. Protoconch, scale bar = 1 mm].

Description of a new subspecies of *Chicoreus (Triplex) cnissodus cnissodus* (Euthyme, 1889) (Gastropoda, Muricidae) from Sri Lanka

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ABSTRACT A new subspecies *Chicoreus (Triplex) cnissodus ceylonensis* is described from Sri Lanka. It is compared with the nominotypical subspecies *C. (T.) cnissodus cnissodus* (Euthyme, 1889) from The Philippines, Vietnam, Taiwan and Japan and with *C. (T.) peledi* Vokes, 1978 from the northern part of the Red Sea. The geographical distribution area of the new subspecies is restricted to Sri Lanka and southeastern India.

INTRODUCTION

The new subspecies here described was compared with *Chicoreus (Triplex) cnissodus cnissodus* by Houart (1992: 78) but was not separated at that time. However, after new specimens were examined, and none of the typical form having been collected in that geographical area, plus constant morphological differences of the shell characters being observed, it is here described as a geographical subspecies.

Methods for morphological taxonomy

The characters here used to describe the shell morphology are the general aspect of the shell, the shape and the size, the color, the shape of the spire and the number of protoconch and teleoconch whorls, the description of the protoconch, the shape of the teleoconch whorls and the description of the suture and of the subsutural band, of the axial and of the spiral sculpture, of the aperture and of the siphonal canal. The species description is based on all the examined specimens.

Abbreviations

Convex part of teleoconch whorl and siphonal canal

ab: abapical (or abapertural);
abis: abapical infrasutural secondary cord (on subsutural ramp);
ABP: abapertural primary cord on the siphonal canal;
ad: adapical (or adapertural);
adis: adapical infrasutural secondary cord (on subsutural ramp);
ADP: adapertural primary cord on the siphonal canal;
IP: infrasutural primary cord (primary cord on subsutural ramp);
MP: median primary cord on the siphonal canal;
P: primary cord;
P1: shoulder cord;
P2-P6: primary cords of the convex part of the teleoconch whorl;
s: secondary cord;
s1-s5: secondary cords of the convex part of the teleoconch whorl (example: s1 = secondary cord between P1 and P2; s2 = secondary cord between P2 and P3, etc.);
t: tertiary cord.

Aperture

D1 to D6 abapical denticles;
ID infrasutural denticle.

Table 1. Terminology used to describe the spiral cords (after Merle, 2001 and 2005) (Fig. 2). Terminology in parentheses: erratic feature

Other abbreviations

EK: collection of Evgeniy Kozlov

RH: collection of the author

juv.: juvenile

sp.: specimen taken alive

Repository

MNHN: Muséum national d'Histoire naturelle,
Paris, France.

SYSTEMATICS

Family **Muricidae** Rafinesque, 1815

Subfamily **Muricinae** Rafinesque, 1815

Genus ***Chicoreus*** Montfort, 1810

Subgenus ***Triplex*** Perry, 1810

Type species by monotypy: *Triplex foliatus* Perry, 1810 (= *Murex palmarosae* Lamarck, 1822), Indo-West Pacific.

Chicoreus (Triplex) cnissodus ceylonensis, n. subsp. Figs 1, 2-3, 6-11, Table 3

Chicoreus cnissodus — Houart, 1992: 78 (in part), fig. 366 (only); Subba Rao & Surya Rao, 1993: 19, text fig. 5, pl. &, figs 7, 8.

Type Material. Holotype MNHN IM-2000-30032; 1 paratype IRSNB MT.3201/IG.32888; 2 paratypes R. Houart.

Type Locality. Trincomalee, Sri Lanka, 6-12 m, 1983.

Material Examined. Trincomalee, Sri Lanka (holotype MNHN and 2 paratypes R. Houart); Tuticorin, southeastern India, 1 paratype IRSNB; Keelakarai (Kilakarai), southeastern India, 25-30 m, 2 sp. coll. E. Kozlov.

Distribution. Sri Lanka, the Bay of Bengal (northeast of Madras) and southeastern India, in 6-30 m (Fig. 1).

Description. Shell medium sized for the subgenus, up to 81.4 mm in length at maturity (coll. E. Kozlov). Length/width ratio 1.9-2.0. Lanceolate, heavy, nodose. Subsutural ramp broad, weakly sloping, convex. Light tan or brown with darker colored bands, approximately between suture and s1, P3-P4 and P5-P6. All spiral cords topped with brown, extending on axial varices. Aperture white or light cream. Spire high with approximately 3 protoconch whorls (all protoconchs examined partially eroded). Teleoconch of 8 or 9 broad, strongly convex, weakly shouldered, nodose whorls. Suture of whorls impressed. Protoconch small, conical; terminal lip unknown. Axial sculpture of teleoconch whorls consisting of moderately high, narrow, nodose ribs and high, narrow, rounded, spinose varices. Each varix with short, frondose, broad, open, primary and secondary spines. First whorl with 4 or 5 narrow ribs and forming first varix; second to last whorl with 3 varices and 2 or 3 intervariceal, narrow ribs. Intervariceal ribs decreasing in strength and height abapically comparatively to size of whorls. Spiral sculpture of low, rounded, narrow, granulose, primary, secondary and tertiary cords and narrower threads. Subsutural ramp with adis, IP and abis from first to last teleoconch whorl with additional threads

starting from fourth whorl. Other spiral cords of last whorl consisting of P1, t, s1, t, P2, t, s2, t, P3, t, s3, t, P4, s4, P5, (s5), P6, s6, t, t, ADP, MP, ABP, with additional narrow threads on the whole shell (Fig. 3). Last teleoconch whorl of adult shell with P1-P5 variceal spines increasing in length and width abapically with exception of shorter P6. Aperture broad, broadly ovate. Columellar lip narrow, smooth with strong parietal tooth at adapical extremity, rim partially erect, adherent adapically. Anal notch deep,

narrow. Outer lip weakly erect, crenulated with weak or moderately strong, elongate denticles within: ID split, D1-D4 split, D5, D6 with D5 occasionally split (Fig. 2). Siphonal canal short, 28-31% of total shell length, broad, weakly abaxially curved, dorsally recurved, narrowly open. Operculum unknown.

Etymology. From the type locality, Ceylon, the ancient name of the Republic of Sri Lanka.

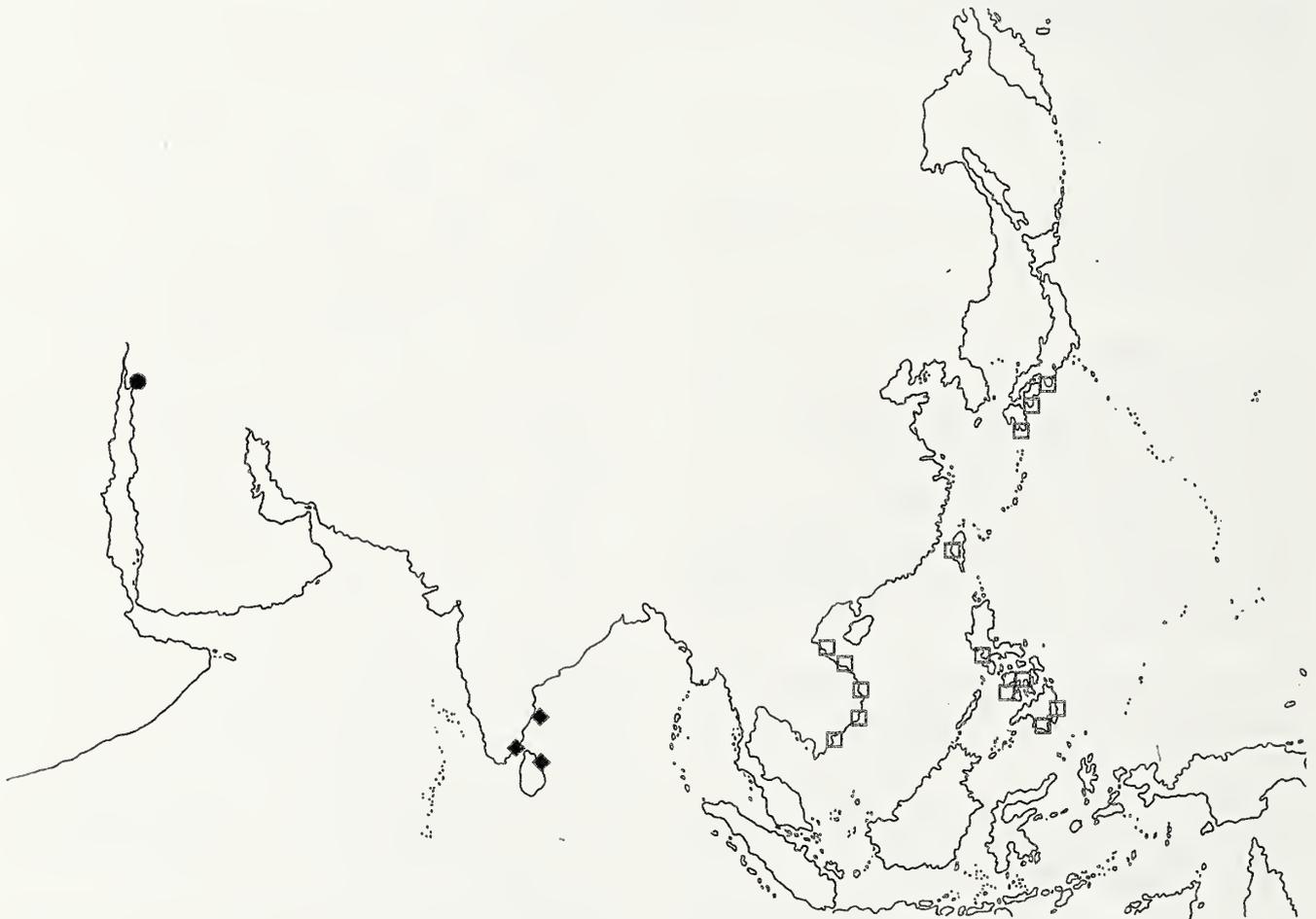


Figure 1. Geographical distribution

- *Chicoreus (Triplex) peledi* Vokes, 1978
- ◆ *Chicoreus (Triplex) cnissodus ceylonensis* n. subsp.
- *Chicoreus (Triplex) cnissodus cnissodus* (Euthyme, 1889)

Remarks. *Chicoreus (Triplex) cnissodus ceylonensis* differs from *C. (T.) cnissodus cnissodus* (Figures 4-5, 12-15) in having shorter spines, a comparatively higher spire, a shorter siphonal canal and a different color pattern. The length/width ratio in adult shells of *C. (T.) cnissodus cnissodus* varies from 1.5 to 1.8 compared with 1.8 to 2.0 in *C. (T.) cnissodus ceylonensis* (less in young specimens in both subspecies). The spire in *C. (T.) cnissodus cnissodus* is 40-45% of the total adult shell length and the siphonal canal 34-38% compared to 44-49% and 28-31% in *C. (T.) cnissodus ceylonensis* (Tables 2 and 3).

Juveniles of the new subspecies tends to have a longer P1 spine and a longer siphonal canal relative to the height of the spire. Such a young shell is illustrated here (Figure 10) and

was also illustrated in Suba Rao and Surya Rao (1993: pl. 1, fig. 7). This longer spine is also obvious in the early teleoconch whorls of the adult shells. However, the longer P1 spine and the longer siphonal canal are also observed in juveniles of *C. (T.) cnissodus cnissodus* (Figure 15) and relatively reduced in adults (see also Tables 2 and 3).

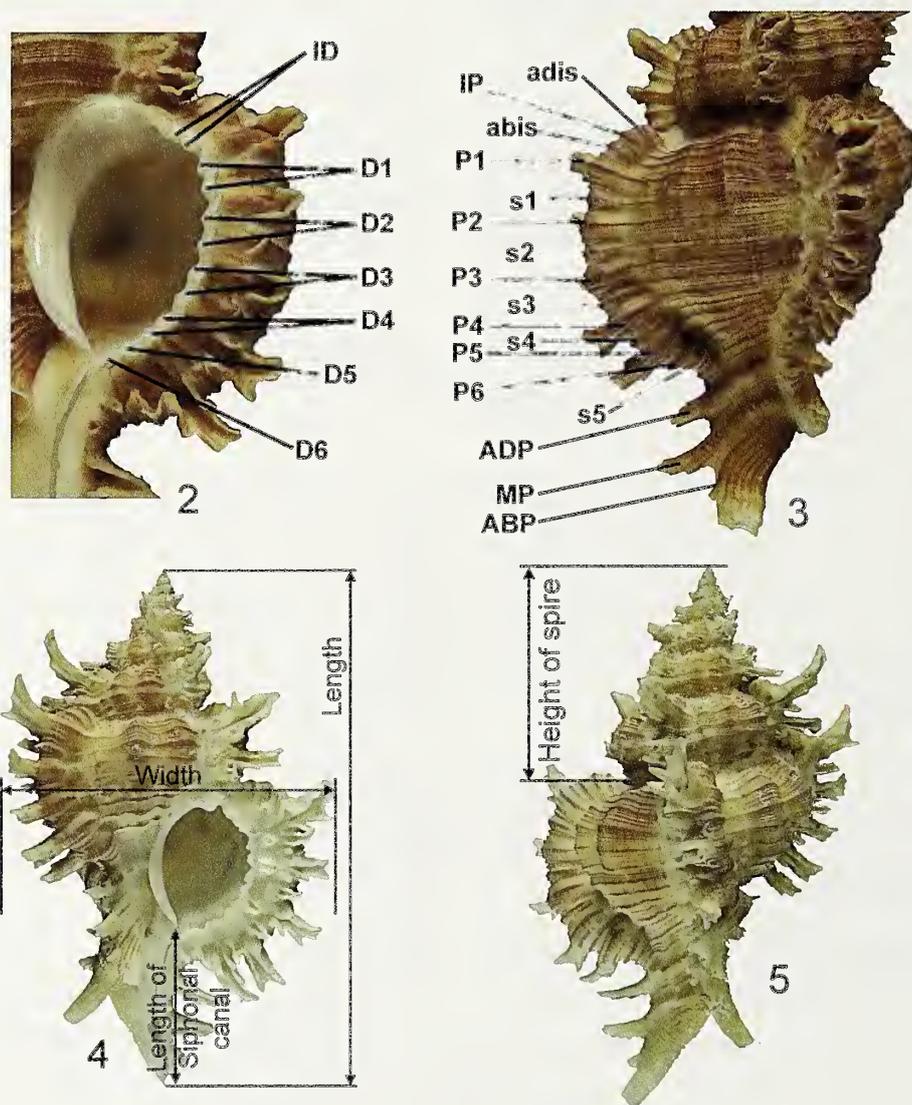
The new subspecies also resembles *Chicoreus (Triplex) peledi* Vokes, 1978 (Figure 16), especially by having a similar ground color and similar darkly pigmented spiral bands. However, *C. (T.) cnissodus ceylonensis* differs constantly in having a comparatively higher spire, a shorter siphonal canal, a more globose shell vs angular in *C. peledi*, less pronounced intervariceal ridges and a relatively narrower aperture with narrower columellar lip.

Locality	Total length	Total width (including spines)		Height of spire		Length of siphonal canal	
			L/W ratio		spire vs. shell length		canal vs. shell length
Taiwan (RH)	87.2	51.8	1.7	35.5	41%	32.2	37%
Taiwan (RH)	76.1	46.3	1.6	32.8	43%	28.1	37%
Taiwan (RH)	78.3	47.4	1.7	35.1	45%	27.1	35%
Taiwan (RH)	81.8	45.3	1.8	36.5	45%	28.0	34%
Taiwan (RH)	76.2	44.1	1.7	32.4	43%	26.9	35%
Taiwan, off An Ping (RH)	70.6	46.2	1.5	29.0	41%	25.5	36%
Taiwan, off An Ping (RH)	71.1	41.6	1.7	28.9	41%	25.0	35%
Japan, Minabe, Wakayama Pref. (RH)	65.2	44.0	1.5	26.2	40%	24.3	37%
Unknown (RH)	76.2	42.8	1.8	31.7	42%	27.3	36%
Japana, Susami, Kii (RH)	72.1	45.1	1.6	30.3	42%	26	36%
China Sea (RH)	84.2	52.5	1.6	34.0	40%	32.4	38%
Philippines, Bohol, Balicasag Is. (RH)	84.7	55.0	1.5	34.7	41%	31.4	37%
<i>Philippines, Mindanao (RH) (juv.)</i>	<i>28.5</i>	<i>21.8</i>	<i>1.3</i>	<i>10.3</i>	<i>36%</i>	<i>11.3</i>	<i>40%</i>
<i>Philippines, Mactan Is. (RH) (juv.)</i>	<i>22.8</i>	<i>16.2</i>	<i>1.4</i>	<i>8.7</i>	<i>38%</i>	<i>8.6</i>	<i>38%</i>

Table 2. Shell measurements (in mm) and count data for *Chicoreus (Triplex) cnissodus cnissodus* (Euthyme, 1889) (juveniles in italics)

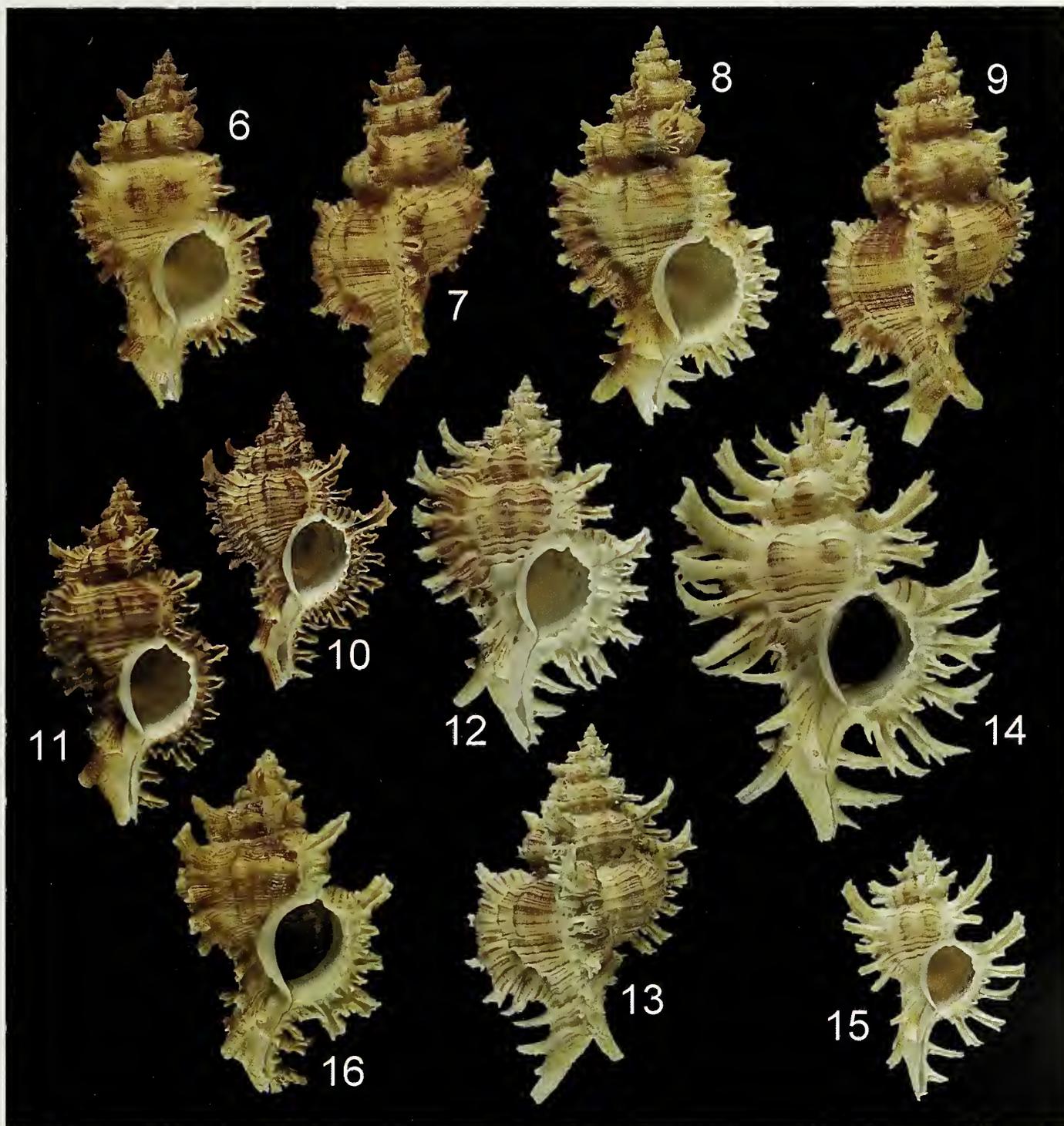
Locality	Total length	Total width (including spines)		Height of spire		Length of siphonal canal	
			L/W ratio		spire vs. shell length		canal vs. shell length
Sri Lanka, Trincomalee (holotype)	68.7	36.0	1.9	31.8	46%	19.5	28%
Sri Lanka, Trincomalee (paratype RH)	79.4	42.4	1.9	38.4	48%	22.6	28%
India, Tuticorin (RH)	67.3	34.0	2.0	30.2	45%	21.1	31%
India, Keelakarai (EK)	81.5	41.4	2.0	40.2	49%	23.0	28%
India, Keelakarai (EK)	62.0	34.4	1.8	27.4	44%	18.8	30%
<i>Sri Lanka, Trincomalee (paratype RH) (juv.)</i>	<i>53.9</i>	<i>34.2</i>	<i>1.6</i>	<i>22.4</i>	<i>42%</i>	<i>17.8</i>	<i>33%</i>

Table 3. Shell measurements (in mm) and count data for *Chicoreus (Triplex) cnissodus ceylonensis* n. subsp. (juvenile in italics)



Figures 2-5. Terminology.

Figure 2. Apertural denticles terminology of *Chicoreus (Triplex) cnissodus ceylonensis*; **3.** Spiral cords terminology of *Chicoreus (Triplex) cnissodus ceylonensis*; **4-5.** *Chicoreus (Triplex) cnissodus cnissodus* (shell measurements used in study)



Figures 6-11. *Chicoreus (Triplex) cnissodus ceylonensis* n. subsp.; 6-7. Sri Lanka, Trincomalee, 6-12 m, 1983, 68.7 mm, holotype MNHN IM-2000-30032; 8-9. Sri Lanka, Trincomalee, 79.4 mm, paratype RH; 10. Sri Lanka, Trincomalee, 53.9 mm (juvenile), paratype RH; 11. India, Tuticorin, 67.3 mm, paratype IRSNB MT.3201/IG.32888; 12-15. *Chicoreus (Triplex) cnissodus cnissodus* (Euthyme, 1889); 12-13. Taiwan, An Ping, 71.1 mm, RH; 14. Philippines, Bohol, Balicasag Is., 140 m, 84.7 mm, RH; 15. Taiwan, An Ping, 42.2 mm (juvenile), RH; 16. *Chicoreus (Triplex) peledi* Vokes, 1978, Israel, Gulf of Aqaba, Eilat, 40 m, April 1980, 65.6 mm.

ACKNOWLEDGMENTS

I am grateful to Evgeniy Kozlov (Kaliningrad, Russia) for having reminded me about this shell, for information, and for fine images of his specimens. Many thanks also to John Wolff (Lancaster, Pennsylvania, USA) for checking the English text.

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Taxonomic note - new species: *Latiaxis nippooleifera* Chino, 2014 This attractive new species of *Latiaxis* was named from eleven specimens found on Norfolk Ridge, New Caledonia. Chino's etymology refers to the sharp yellow color characteristic of the shell which is reminiscent of the color of a spring wild mustard flower in Japan, *Brassica rapa* var. *nippo-oleifera* (Linnaeus, 1758). A lovely species compared with *L. hayashii*, *L. pilsbryi*, and *L. latippinnatus*. (Chino, M. (2014) A new species of *Latiaxis* (Neogastropoda: Muricidae) from New Caledonia and the Norfolk Ridge. *Visaya* 4(2): 9-14.)



***Latiaxis nippooleifera* (Chino, 2014)**

Photo courtesy of:
Spyridon Pavlidis,
Athens, Greece

“World Record” Specimens of *Haliotis* Species of the West Coast of North America - a Brief Description and Photo Study

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INTRODUCTION

This report will be written in a casual, less formal style that seems more appropriate for a discussion of world record shells. It will be primarily of interest for the collection of photo images presented, though collectors of our west coast species will probably find the other information of interest as well. For the purpose of this study, we will consider those species and subspecies distributed from Southern California to Alaska, though the four subspecies found in Baja California, Mexico, will be mentioned briefly as well. The world's three largest members of family Haliotidae are found among these west coast taxa, one in a virtual tie for number three position with *Haliotis madaka* Habe, 1977, a Japanese *Haliotis*, and we will begin this discussion with these three. However, first it might be of interest to explore the most important environmental conditions that coincide with the distribution of giant *Haliotis* taxa. (see also Owen and Dinucci, 2004).

Ecological Conditions found where Large Species of *Haliotis* Exist

In general, the world's largest *Haliotis* species are found in temperate seas that have two major environmental parameters in common. These conditions are, but are not necessarily limited to: 1) Areas where an upwelling of cold nutrient-rich water promotes the growth of copious amounts of the large species of red and brown algae (particularly the latter), which provide an excellent food source or large species of abalone, and: (2) Very

exposed sections of coastline where sea and surface weather (wind) conditions are frequently very rough, often precluding diving. For example, on the north coast of California and Oregon, where the world's largest species (*H. rufescens* Swainson, 1822) grows to massive proportions, some of the most formidable sea conditions on the west coast of North America frequently occur. Huge Pacific Ocean swells often batter the coast in the winter months, and in the spring, strong northwest winds buffet the coastline. These factors promote the major upwelling, circulation and strong ocean currents necessary for the growth and distribution of algal food to drift feeding mollusks like abalone. Similar conditions are found near the southern tip of South Africa and in South Australia, where other large *Haliotis* and species of brown algae are found. In contrast, warm, quiet, tropical seas, such as exist in much of the Indo Pacific Basin, are generally inhabited by very small species of *Haliotis* which feed on tiny forms of algae and other food species. There are additional factors at work which help produce these differences, but cold temperatures caused by strong northwest wind upwelling is the primary factor influencing large size in *Haliotis* of the west coast of North America.

MATERIAL AND METHODS

Abbreviations of Collections. BMC: Bob McMillen Collection; BOC: Buzz Owen Collection; BSC: Bob Spinale Collection; DDC: Dwayne Dinucci Collection; JPC: John Pepper

Collection; LACM: Los Angeles County Museum Collection; PMC: Pete McLaughlin Collection.

The eight taxa found on the West Coast of North America between California and Alaska, will be listed first in the order of their maximum sizes. Following this, the four subspecies endemic to Baja California, Mexico, will be listed similarly. The measurements used will be those taken by the author, or those listed in the most recent version of "Registry of World Record Sized Shells" by Philippe Quiquandon, the standard reference for information on world record size mollusks and gastropods. This text is kept very current, with updates being published regularly. In the present work, measurements are frequently, but not always, listed in both mm and inches, for clarification. Photo images were taken with a Canon G6 digital camera with 7.1 megapixels resolution, and the images processed in Adobe Photoshop Version 4.

RESULTS

The Largest Recorded Specimens of the West Coast *Haliotis* Species:

Haliotis rufescens Swainson, 1822. Pl. 1A; 1B

Common Name: The Red Abalone.

Size: 12 ⁵/₁₆" (313.0 mm).

Taken By: John Pepper.

Date: 5 Sept. 1993.

Locality: Oregon.

2nd Largest: 11 ²⁹/₃₂" (302 mm).

Other: World's largest known abalone shell.

Only specimen known to have reached or exceeded the "mythical" size of 12 inches.

Reference: "Of Sea and Shore" 26:4:103-107.

Provenance: JPC.

Haliotis fulgens fulgens Philippi, 1845. Pl. 1C; 1D

Common Name: The Green Abalone.

Size: 10 ¹/₃₂" (255.0 mm).

Taken By: D. D. "Darrell" Forman.

Date: Early 1950's.

Locality: Asunción Is., Baja Calif., Mexico. Beach shell.

2nd Largest: About 9 ³/₄".

Other: Only specimen known 10" or larger.

Reference: "Of Sea and Shore" 25:3:103-107.

Provenance: BOC.

Haliotis corrugata corrugata Wood, 1828. Pl. 3A; 3B

Common Name: The Pink Abalone.

Size: 9 ⁵/₈" (245.7 mm).

Taken By: Unknown Calif. F&G diver.

Date: Sept. 1954.

Locality: Portuguese Bend, Palos Verdes Peninsula, California.

2nd Largest: About 8 ³/₄" (223.0 mm).

Other: A giant - over ³/₄" larger (22.4 mm) than 2nd largest known specimen. Found just before the destruction of the Palos Verdes area by pollution from Los Angeles/San Pedro Harbor.

References: Geiger & Owen, (2012)

Provenance: LACM.

Haliotis cracherodii cracherodii Leach, 1814. Pl. 2A; 2B

Common Name: The Black Abalone.

Size: 8 ¹/₂" (216.5 mm).

Taken By: Pete McLaughlin.

Date: Aug. 1990.

Locality: Pedro Point, Calif.

2nd Largest: A pair of shells 8 ³/₈".

Other: A little known and previously un-photographed specimen.

References: Geiger & Owen, (2012)

Provenance: PMC.

Haliotis sorenseni Bartsch, 1940. Pl. 3C; 3D

Common Name: The White Abalone.

Size: 8 ¹³/₁₆" (225.1 mm).

Taken By: Bob McMillen.

Date: 1970's.

Locality: Probably Sta. Cruz Is., Calif.
 2nd Largest: Three specimens exist of approx. the same size (see Discussion).
 Other: Several large *H. rufescens* x *H. sorenseni* hybrids have been miss-identified as *H. sorenseni*.
 References: Geiger & Owen, (2012)
 Provenance: BMC.

***H. kamtschatkana assimilis* Dall, 1878. Pl. 4A; 4B**

Common Name: The Threaded Abalone.
 Size: 7 ⁵/₁₆" (187.4 mm).
 Taken By: Unknown commercial diver.
 Date: 1959.
 Locality: Point Conception, Calif.
 2nd Largest: Several known about 6 ⁷/₈" (175 mm).
 Other: Shell is a broken specimen found on the commercial shell pile of A.R. Pierce in Goleta, Calif., in Sept., 1959.
 References: Geiger & Owen, (2012)
 Provenance: BOC.

***H. kamtschatkana kamtschatkana* Jonas, 1846. Pl. 4C; 4D**

Common Name: The Pinto Abalone.
 Size: 6 ³/₈" (162.3 mm).
 Taken by: Unknown diver.
 Date: 2005.
 Locality: British Columbia, Canada.
 2nd Largest: About 6 ¹/₄" (159 mm).
 Other: A very eroded senile specimen which is typical of shells >6" (153 mm).
 References: Geiger & Owen, (2012)
 Provenance: BSC.

***H. walallensis* Stearns, 1899. Pl. 2C; 2D**

Common Name: The Flat Abalone.
 Size: 7 ¹/₃₂" (179 mm).
 Taken By: Dwayne Dinucci.
 Date: 2004.
 Locality: North of Crescent City, Calif.
 2nd Largest: 7" (178 mm).

Other: A number of specimens are clustered at about this size (~7", or specifically 175-176 mm).

References: Geiger & Owen, (2012)
 Provenance: DDC.

The Largest Recorded Specimens of the West Coast *Haliotis* Subspecies Endemic to Baja California, Mexico.

Four *Haliotis* subspecies exist in Baja California, Mexico. Three are endemic to Guadalupe Island, and the fourth is isolated at the extreme point of the southern distribution of the *H. fulgens* complex: Santa Margarita Island, Magdalena Bay. As far less material has been examined from these isolated populations (estimated at two to five thousand of each), the largest specimens found thus far may not provide an accurate appraisal of the maximum sizes which might be found had a larger sample been available for study. For example, I strongly suspect that *H. fulgens guadalupensis* Talmadge, 1964, reaches sizes in excess of the currently largest known specimen (to me) which measures 7 ⁵/₁₆" (186 mm). The reasoning here is that there are more exposed areas on the "weather" (west) side of the island from which I have yet to examine large volumes of material (such areas typically produce the largest individuals). I strongly suspect that the largest abalone from some of these areas might well exceed 8" (203 mm) in size. In any case, the largest specimens of these four subspecies known to me are listed and photographed herein. They are as follows:

***Haliotis fulgens guadalupensis* Talmadge, 1964. Pl. 6A**

Common Name: Guadalupe Island Green Abalone.
 Size: 7 ⁵/₁₆" (186 mm).
 Taken by: Conrad "Connie" Limbaugh.
 Date: April, 1956.

Locality: Near Weather Station, at Melpomene Cove, near Morro Sur, at south end of Guadalupe Island, Baja California, Mexico.

Second Largest: I have seen a number of shells around 7" (est. 8-10).

References: "*Of Sea and Shore*" 27:2:126-131; 3 pl.

Other: A young, very healthy fast growing specimen – would probably have grown to a larger size had it not been collected.

Provenance: BOC.

***Haliotis corrugata oweni* Talmadge, 1966. Pl. 6B**

Common Name: Guadalupe Island Pink Abalone.

Size: 6 5/8" (168 mm).

Taken By: Mexican commercial diver.

Date: 1998.

Locality: Near West Anchorage, Guadalupe Island, Baja California, Mexico.

Second Largest: A number of specimens have been examined very close to this size.

References: "*Of Sea and Shore*" 25:4:272-275, 288; 3 pl.

Other: The larger shells of this subspecies are often not saved by the Mexican commercial *Haliotis* divers due to their usually being badly encrusted and perforated by numerous boring organisms. Were this not the case, it is quite likely that shells 6 3/4" - 7" in diameter (est.) would have been found.

Provenance: BOC.

***Haliotis cracherodii californiensis* Swainson, 1822. Pl. 6C**

Common Name: Guadalupe Island Black Abalone.

Size: 5 3/4" (147 mm).

Taken by: Mexican commercial diver.

Date: 1998.

Locality: "Weather" (West) side of Guadalupe Island, Baja California, Mexico.

Second Largest: Many have been measured within about 6-8 mm of this size.

References: "*Of Sea and Shore*" 26:1:70-75; 3 pl.

Other: From the somewhat stunted population of extremely perforate and deep-proportioned specimens found on the "weather" (west) side of the island.

Note: A gigantic shell was discovered in 2006 that is 42 mm larger than the listed WR specimen. (pl. 7A). This shell was found by a shell dealer searching through material from Guadalupe Island, and is so large it is considered "an aberration" (Geiger & Owen, 2012).

Provenance: CRC.

***Haliotis fulgens turveri* Bartsch, 1942. Pl. 6D**

Common Name: None.

Size: 7 11/16" (196 mm).

Taken By: Mexican commercial diver.

Date: 1959.

Locality: Magdalena Bay, Baja California, Mexico.

Second Largest: Much smaller. Examination of over 650 specimens taken in 1998-1999, yielded none over about 6 1/2" (166 mm).

References: "*Of Sea and Shore*" 27:1:65-68.

Other: This largest recorded shell is truly a giant. None of the other original specimens from 1959 (several thousand shells) approached this size.

Provenance: BOC.

DISCUSSION

The Discussion will be broken down into sections treating each taxon, and will expand on some of the information given above, plus include other bits of data which might be of interest. The four Baja Californian subspecies won't be discussed further, as these are extensively covered in earlier articles in "*Of Sea and Shore*" (see: "References")

THE SPECIES

***Haliotis rufescens*:** The “Red Abalone” is far and away the world’s largest species of *Haliotis* (by well over 2”, or 58 mm). As such, giant specimens have been pursued with gusto and passion for well over 75 years, but to this date (Dec, 2014), so far as is known, only once has the much sought-after 12 inch size barrier been reached or exceeded. This singular specimen, a fast-growing very young male living in optimal environmental conditions, was about 27-30 years old (in the authors opinion) when it was found. It was taken at the precise moment in time when its shell was as large in maximum diameter as it would probably get, as it was about to lose approximately 6-8 mm in length due to sloughing off of the ostracum, or outer layer of shell, at the major measurement point near the posterior margin (spire area). For a more detailed discussion of giant specimens of *H. rufescens*, refer to the earlier article on large red abalone in Vol. 26, No. 4 of “*Of Sea and Shore*” (Owen and Dinucci, 2005).

***Haliotis fulgens fulgens*:** The “Green” Abalone is the 2nd largest species in the world, by about $\frac{3}{8}$ ” (10 mm). This largest recorded specimen exceeds the next largest shell I have measured by approximately $\frac{1}{4}$ ” (8 mm). It was once probably close to $10\frac{1}{4}$ ” in length, but has lost an estimated 6-8 mm of diameter due to erosion at the posterior margin of the shell. Specimens over 9” are extremely rare, and I have measured only 5-6 shells between 9” and $9\frac{3}{4}$ ”. The record specimen was reported to have been found on the beach at Asunción Island, Baja California, Mexico, but this locality is suspect, as most mature specimens of *H. fulgens* from central Baja California are much smaller.

***Haliotis corrugata corrugata*:** The “Pink Abalone” might be considered the “largest” of the West Coast world records, in that it exceeds the 2nd largest known individual by the greatest amount – over $\frac{3}{4}$ ” (20 mm). It is truly a giant. To one familiar with this species, the thought of

a specimen in excess of $9\frac{1}{2}$ ” (242 mm) staggers the imagination. I will never cease to wonder what the ecology of the Portuguese Bend area of the Palos Verdes Peninsula looked like in 1954 – before it was destroyed by pollution coming out of San Pedro and Los Angeles Harbor. The 2nd and 3rd largest specimens that I have knowledge of are a pair of specimens that measure $8\frac{3}{4}$ ” (222 mm). These were both taken (by the author) in 1959 – one at San Nicolas Island, and the other in very shallow water just south of Point Conception. Other than these two shells, I have knowledge of few much over 8” (203 mm) – which is very large for this species. Probably some of the largest “Pinks” ever taken, came from north La Jolla and San Nicolas Island, but whether other big shells from these areas were larger than about $8\frac{1}{2}$ ” is unknown to me.

***Haliotis sorenseni*:** At least three specimens of the “White Abalone” are clustered at approximately $8\frac{3}{4}$ ” (225 to 227 mm). However, two of these I have not examined personally, and they may well represent *H. rufescens* x *H. sorenseni* hybrids – as is frequently the case with large specimens suspected of being *H. sorenseni*. The shell illustrated on Plate 3 is the largest I have personally confirmed to *not* be this hybrid. It measures $8\frac{3}{4}$ ” (225.1 mm). I have several specimens of *H. rufescens* x *H. sorenseni* that measure over $9\frac{1}{4}$ ” (from 235 to 242 mm), plus the “World Record” example that measures just short of 10” (253 mm. Pl. 7A). A number of these hybrid specimens slightly in excess of 9”, have been mistaken for *H. sorenseni* by a number of collectors over the past 50 years. The correctly identified specimen of *H. sorenseni* on Pl. 3, was taken near Santa Barbara by Bob McMillen – in the same general area that Bartsch’s holotype specimen was found when he described the species. Curiously, one of the paratypes listed in the original description was in the personal collection of Andy Sorensen when I visited him at his home

in Carmel in 1959 (he was 97 years old at the time). This paratype is a very typical specimen of *H. rufescens* x *H. sorenseni*. This small episode underscores the problem one might have in correctly identifying *H. sorenseni*. Here we have the man who “discovered” the species and whom it was named after, *and* the man who described it, *both* making the *same* mistake in identification. In fairness though, it should be stressed that few specimens were known in 1940, the year the species was described, so neither Sorensen nor Bartsch were very familiar with it. One of these extremely large hybrids (242 mm) is illustrated on Plate 5 with a 212 mm *H. sorenseni* so this problem can be better understood.

Haliotis cracherodii cracherodii: This largest recorded specimen of the “Black Abalone” exceeds by $\frac{1}{8}$ ” a pair of specimens that both measure $8\frac{3}{8}$ ” (213 mm). I know of few specimens that have reached or exceeded 8” (203 mm). Old-time commercial abalone fishermen from the Morro Bay area have mentioned seeing occasional specimens hit the old 8” “red bar” (measuring device) prior to Sept. 1959 when the size limit for red abalone was reduced from 8” to $7\frac{3}{4}$ ”. These three largest recorded live-taken specimens came from well separated localities in California: Santa Cruz Is., Shell Beach (near San Luis Obispo), and Pedro Point, about 20 miles south of San Francisco. Shells over 7” are not common in collections, and would be considered very large.

H. walallensis: The second largest specimen of the “Flat Abalone” is just 2 mm smaller than the record, at ~178 mm (exactly 7”). A group of 4-5 shells are clustered at $6\frac{15}{16}$ ”- $7\frac{1}{32}$ ” (175-176 mm). Nearly all are from extreme northern California to south-central Oregon. Unlike all the other West Coast species of *Haliotis*, there is a more pronounced clustering of specimens very near this maximum size of approximately 7”. As a small commercial fishery for this species exists in south-central Oregon, large

numbers of individuals have been examined in recent years, and still a specimen over $7\frac{1}{32}$ ” has not been found. In California, specimens over 6” appear to be very uncommon, and even in Oregon, shells over $6\frac{1}{2}$ ” (166 mm) are rare indeed!

THE SUBSPECIES

Haliotis kamtschatkana assimilis: This largest recorded example of the “Threaded Abalone” exceeds by about $\frac{1}{4}$ ” (8 mm) the second largest specimen I have seen and measured. About 4-5 specimens are clustered at approximately 7” (179 mm) in size. All these huge shells came from 1-2 miles southeast of Point Conception in 35-60 feet (12-20 m) and were live taken by the author between 1959 and 1963. In this area were found the largest specimens of this subspecies that I have ever observed. This area has also produced a number of *H. rufescens* x *H. kamtschatkana assimilis* hybrids as well, which unlike *H. rufescens* x *H. sorenseni* hybrids examined earlier, would never be mistaken for either parent species, except possibly as a very small juvenile (without animal present). Specimens of *H. kamtschatkana assimilis* over 6” should be considered very large, and are uncommon.

Haliotis kamtschatkana kamtschatkana: The previous record of the “Pinto Abalone”, in the collection of Gordon Chan, measures $6\frac{1}{4}$ ” (159 mm), and another large specimen in the Bob Spinale collection measures approximately the same size. Most shells approaching 6” (153 mm) are in extremely poor condition due to encrustation and erosion and are not collected or saved by the average shell collector. A specimen measuring 110.3 mm from Sitka, Alaska, is illustrated to give an idea what a large shell with better sculpture detail looks like. Specimens over $5\frac{3}{4}$ ” (>145 mm) are uncommon in my experience. I have a large series (>50) of this subspecies from Sitka, which contains a few specimens about $5\frac{3}{4}$ ”.

This series is of particular interest as it was taken at approximately the northern extreme point of *Haliotis* distribution on the West Coast of North America. These specimens provide an interesting comparison to examples of the southern subspecies *H. kamtschatkana assimilis* from central Baja California, Mexico – some 4,500 km distant!

Final Remarks. As nearly all species of West Coast abalone are no longer taken from natural populations, it is not likely that new records for size are going to be found, unless they exist in old collections, which to me seems doubtful. The exception, of course, is *H. rufescens* which is pursued aggressively. I personally doubt that the 12 $\frac{5}{16}$ " (313 mm) red abalone record is likely to be broken any time soon - almost $\frac{1}{2}$ inch (11 mm) separate this giant shell from the second largest known, and this is a substantial difference. Still, "records are made to be broken", and with time, almost certainly a larger shell will be found – the main question being how much time. I have a specimen that was the largest known *Haliotis* shell for 31 years (1952 to 1983). It measures 293 mm (a fraction of a mm over 11 $\frac{1}{2}$ "), and while it "held the record", about 4-5 other shells challenged it very closely, some being less than 1/32" (<1 mm) smaller. The current record is a true giant, with no other known specimens remotely close to it. Again, aside from Dwayne Dinucci's second largest shell which measures almost half an inch (11 mm) less than 313 mm, the next largest shells are 14-15 mm smaller – a substantial difference. Though I believe it more likely that a new record would be found due to a currently unknown specimen being live-taken from natural populations, there remains the chance that it could come from an old little-known collection. Personally, I seriously doubt this. I believe that if such a spectacularly large shell existed, it would have come to our attention long ago. This belief is reinforced by the many

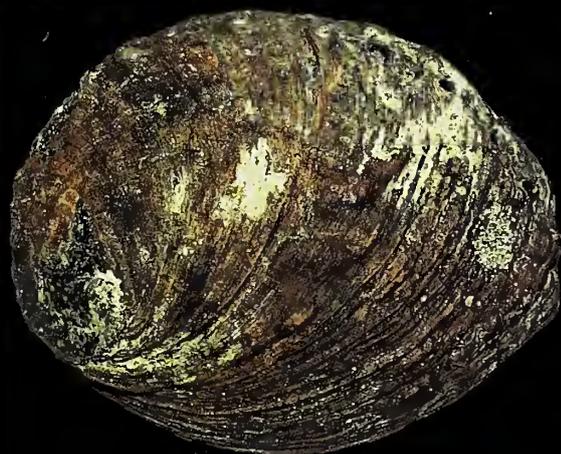
"wild goose chases" that I have participated in since the early 1950's, running down stories of nonexistent "12 inch" shells, and also by an event that happened in 1959, when I visited Andy Sorensen at his home in Pacific Grove, California. On this visit, I had with me the huge 293 mm specimen of *H. rufescens* mentioned earlier in this paragraph. (it was live-taken in August, 1952, at Crook Point, San Miguel Island, California.) It had just come into my possession two weeks earlier, and I wanted to see what his reaction would be upon seeing this giant shell. It was well known to a number of shell collectors and myself, that for many years Mr. Sorensen had offered a reward of \$100.00 to anyone who would bring him a 12-inch abalone shell to measure and confirm that it was indeed that size (or larger). It was equally well known that *no* one had ever succeeded in showing him such a specimen and collecting this reward. Armed with this knowledge, I showed him the 293 mm (11 $\frac{1}{2}$ inch) shell. He held it in his hands, measured it very carefully a number of times, and studied it for several minutes. He then looked up at me, smiled, and said very seriously: "Young man, that is the largest abalone shell I have seen and measured in my life" (a good friend of mine, Chuck Snell, was with me and witnessed this event). Andy Sorensen was very familiar with the Japanese commercial fishery and divers that worked in the Monterey area in the early 1900's, and this observation further strengthened the conclusion that this specimen was with little doubt the largest abalone shell known at that time. Indeed, this shell survived all challenges and remained largest known for 31 years (1952-1983), until a specimen 11 $\frac{3}{4}$ " (298 mm) was taken by Don Thorp at Shelter Cove, California, in September, 1983. With all this in mind, one can see why I am very skeptical that a shell will be found in the near future to displace the current record of 12 $\frac{5}{16}$ " (313 mm).

ACKNOWLEDGEMENTS

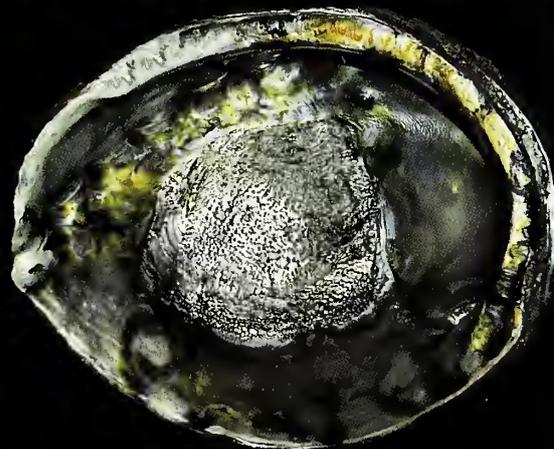
I wish to thank Steve Browning, Tom Grace, and David Leighton for reviewing the manuscript and plates and offering helpful comments and suggestions. I wish to thank Jim McLean for providing photographs of the world record specimen of *H. corrugata corrugata*, and Pete McLaughlin for letting me photograph his world record black abalone (*H. cracherodii cracherodii*). Other collectors permitting me to photograph their world record specimens include Bob McMillen, Dwayne Dinucci, John Pepper, and Bob Spinale, and I wish to express my gratitude to them all.

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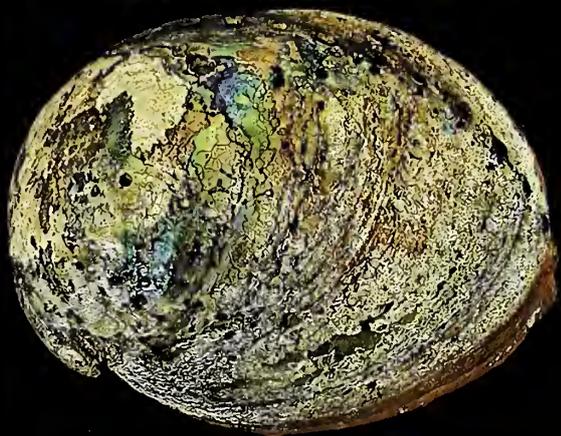
A



B



B: *H. rufescens*. San Miguel Is., Calif. 211.5 mm. (Typical specimen to better illustrate species - not to scale with record)



C



D



D: *H. f. fulgens*. B. C., Mexico. 164.2 mm. (Typical specimen to better illustrate species - not to scale with record)

Plate 1

A: *H. rufescens* Swainson, 1822. W. Record: 313.0 mm (12 5/16"). John Pepper. Oregon. 1993.

C: *H. f. fulgens* Philippi, 1845. W. Record: 255 mm (10 1/32"). Buzz Owen. Baja Calif., Mexico. 1957.



A



B



B: *H. c. cracherodii*. B. C., Mexico. 126.4 mm. (Typical specimen to better illustrate species - not to scale with record)



C



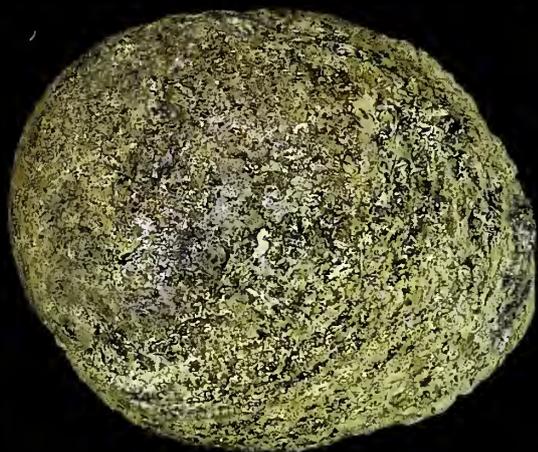
D



D: *H. walallensis*. Cambria, Calif. 118.1 mm. (Typical specimen to better illustrate species - not to scale with record)

Plate 2

A: *H. c. cracherodii* Leach, 1814. W. Record: 216.5 mm (8 1/2"). Pete McLaughlin. Pacifica, Calif. 1990.
 C: *H. walallensis* Stearns, 1899. W. Record: 179 mm (7 1/32"). Dwayne Dinucci. N. California. 2004.

**A****B**

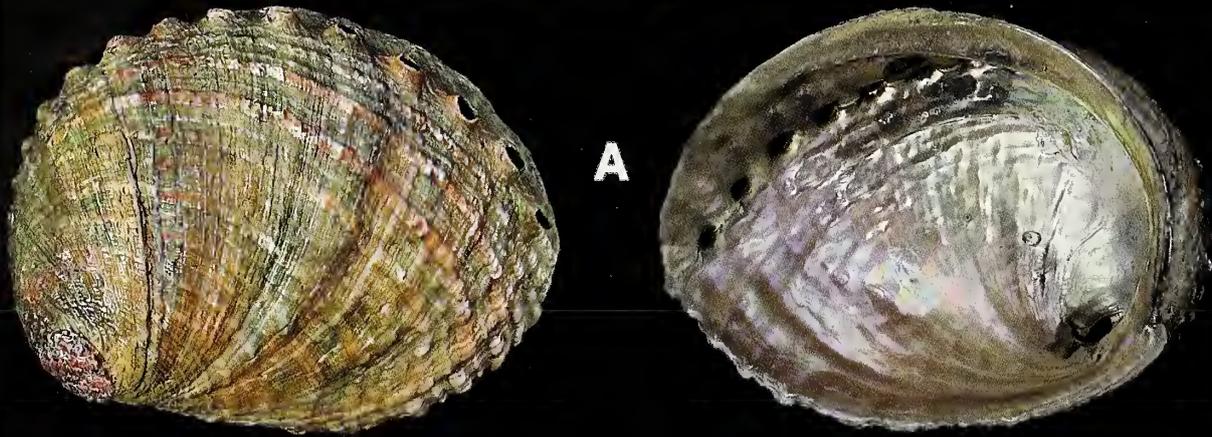
B: *H. c. corrugata*. B. C., Mexico. 153.2 mm. (Typical specimen to better illustrate species - not to scale with record)

**C****D**

D: *H. sorenseni*. Anacapa Is., Calif. 174.5 mm. (Typical specimen to better illustrate species - not to scale with record)

Plate 3

A: *H. c. corrugata* Wood, 1828. W. Record: 245.6 mm (9 21/32"). Calif. F&G. Palos Verdes, Calif. 1954.
C: *H. sorenseni* Bartsch, 1940. W. Record (?): 226.1 mm (8 29/32"). Bob McMillen. S. California. 1974.

**A****B**

B: *H. k. assimilis*. Point Loma, Calif. 126.4 mm. (Typical specimen to better illustrate species - not to scale with record)

**C****D**

D: *H. k. kamtschatkana*. Sitka, Alaska. 110.3 mm. (Typical specimen to better illustrate species - not to scale with record)

Plate 4

A: *H. k. kamtschatkana assimilis* Dall, 1878. W. Record: 187.2 mm (7 3/8"). Buzz Owen. Pt. Conception. 1959.
C: *H. k. kamtschatkana* Jonas, 1845. W. Record: 162.2 mm (6 3/8"). Bob Spinale. Canada. 2000.

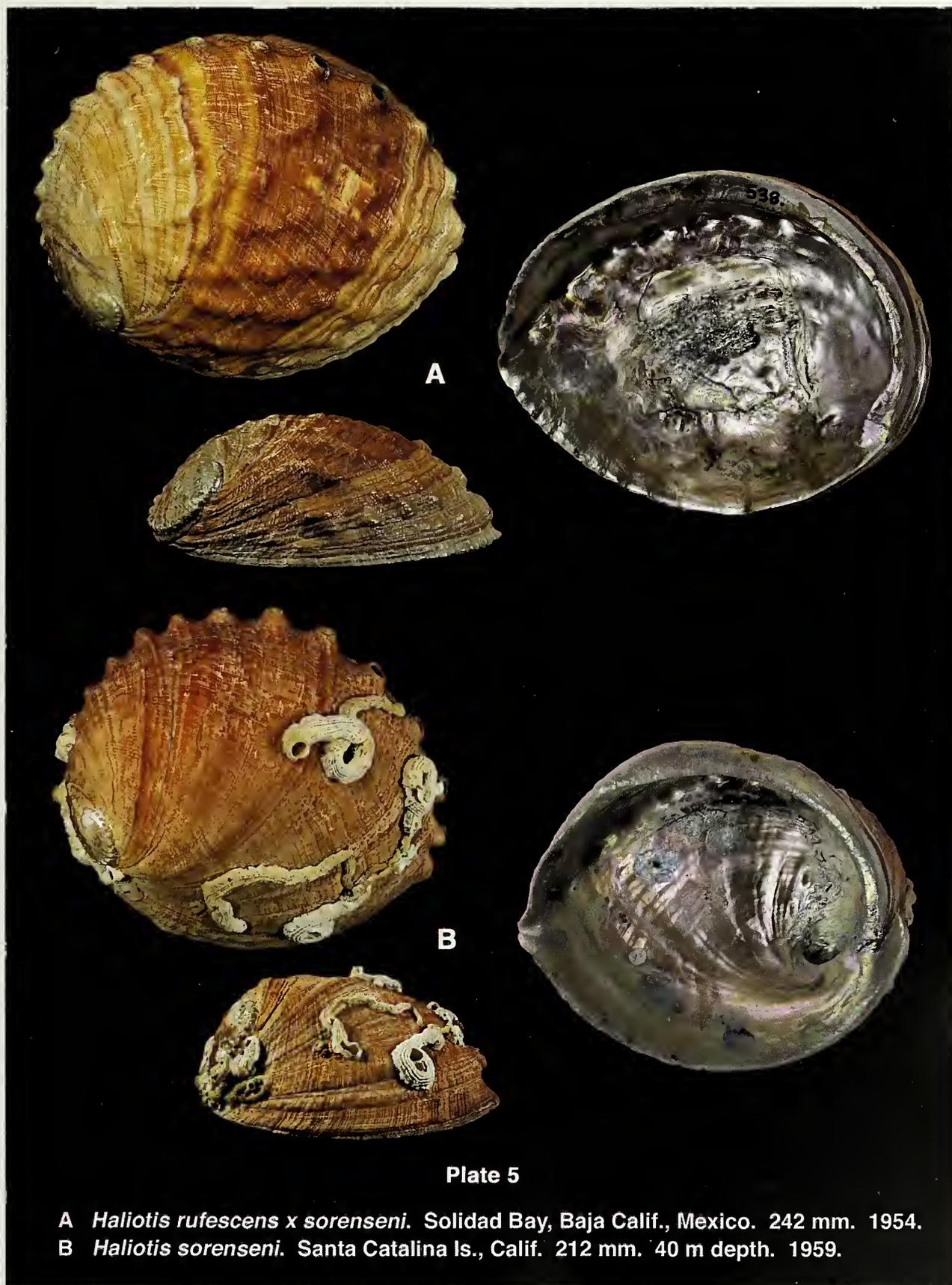
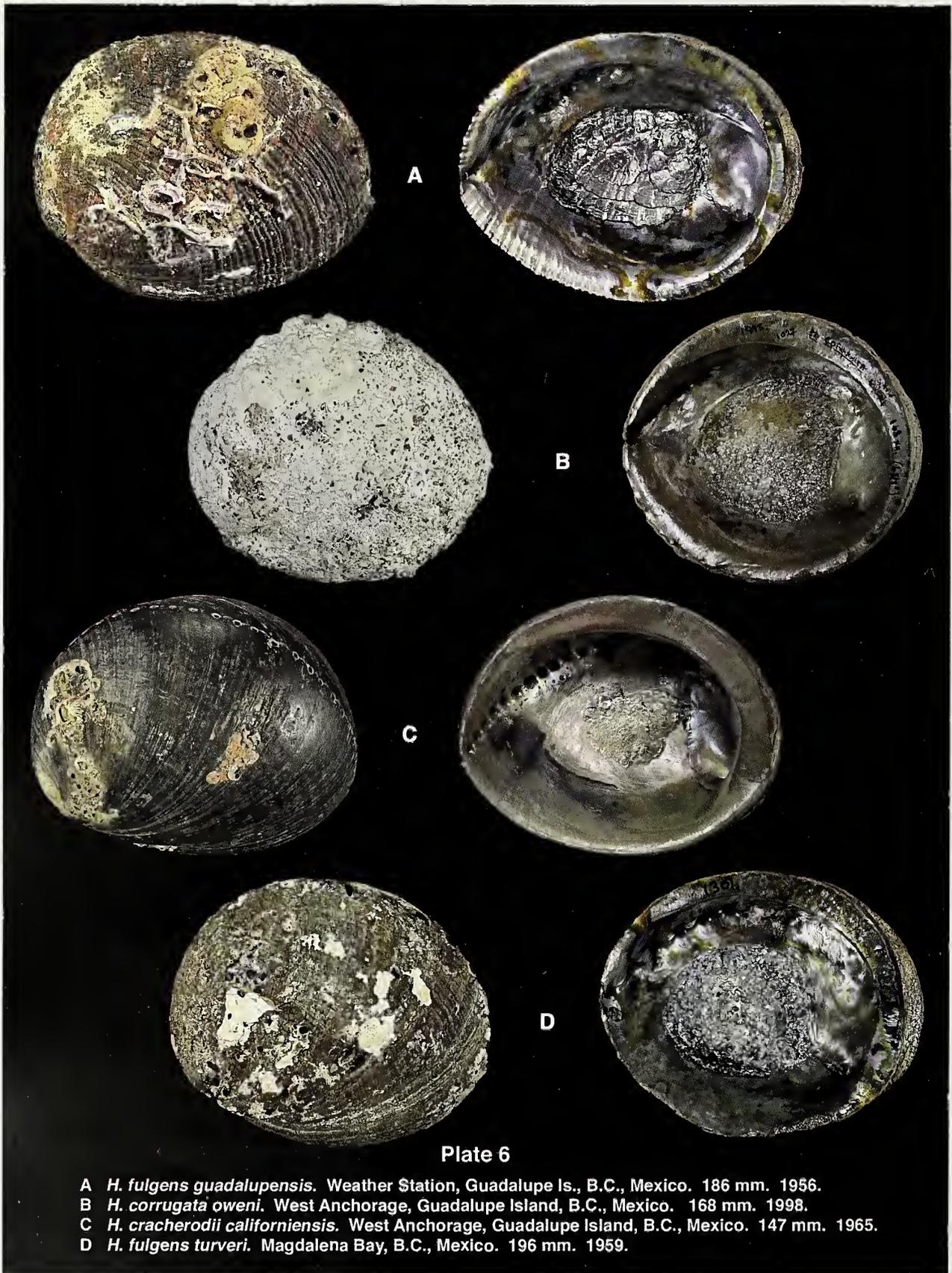
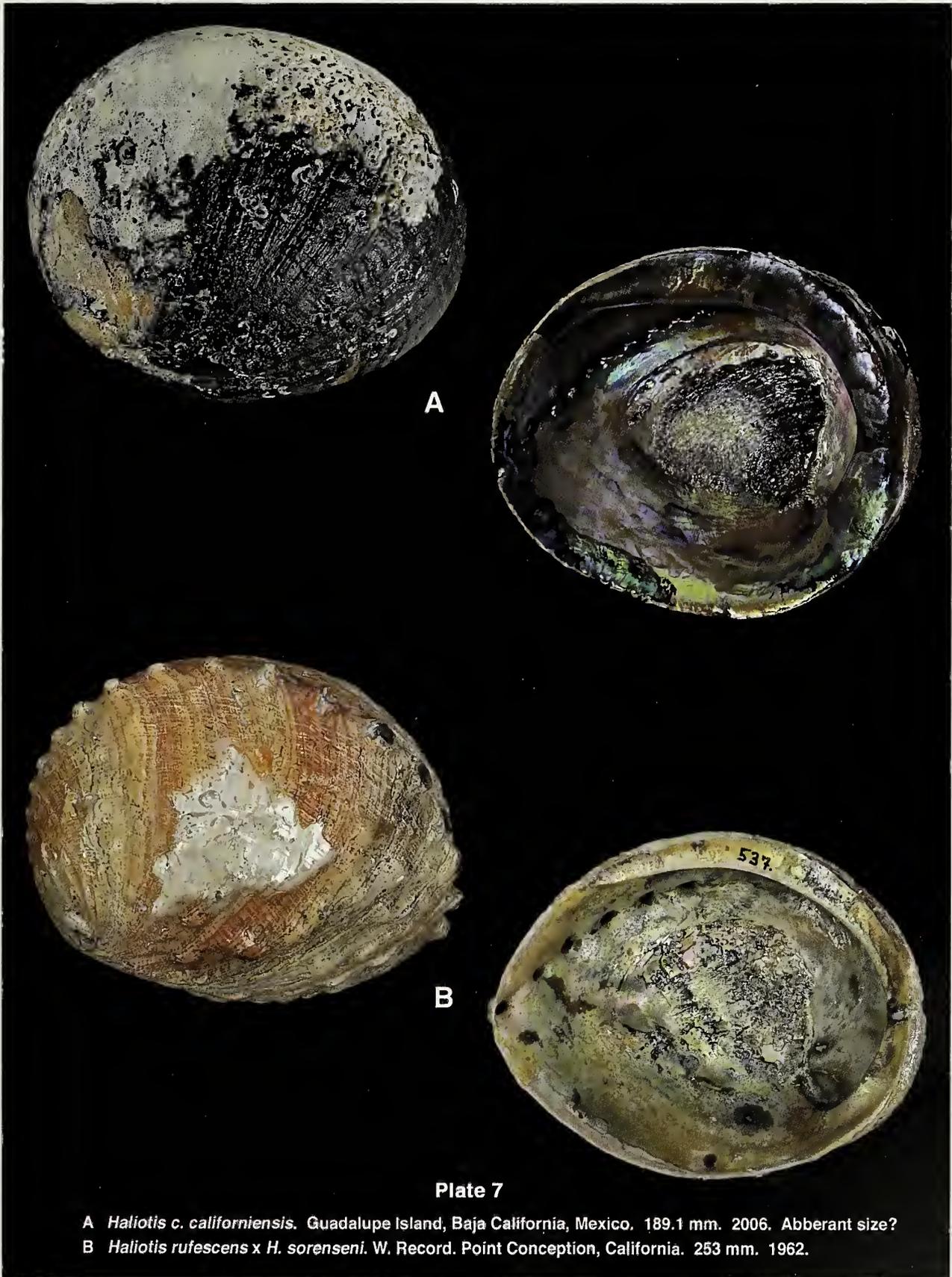


Plate 5

- A *Haliotis rufescens x sorenseni*. Solidad Bay, Baja Calif., Mexico. 242 mm. 1954.
B *Haliotis sorenseni*. Santa Catalina Is., Calif. 212 mm. 40 m depth. 1959.





**Description of a New Species from the Brazilian Province:
*Dalliconus edpetuchi***

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ABSTRACT There has been much confusion regarding the taxonomy of the various species of *Dalliconus* throughout the tropical Western Atlantic. This paper reviews the extant species within the genus *Dalliconus*: *D. armiger* (Crosse, 1858), *D. mazei* (Deshayes, 1874), *D. rainesae* (Mc Ginty, 1953), *D. mcgintyi* (Pisbry, 1955), *D. bajanensis* (Nowell-Usticke, 1968), *D. pseudoaustini* (Nowell-Usticke, 1968) is a junior synonym of the precedent species, *D. guyanensis* (Van Mol, 1973), *D. pacei* (Petuch, 1987), *D. kremerorum* (Petuch, 1988), *D. lenhilli* (Cargile, 1998), *D. sauros* (Garcia, 2006), *D. roberti* (Richard, 2009), *D. coletteae* Petuch, 2013, by biogeographical provinces, ecological bathymetric zones and morphology. *Dalliconus edpetuchi* a new species from Brazil which has been known for a number of years and lumped with *D. mcgintyi* is described.

KEY WORDS *Dalliconus*, *edpetuchi*, *mcgintyi*, *mazei* complex, endemism, Brazil.

INTRODUCTION

Chronological literature review of the genus

Dalliconus (except the *D. armiger* complex)

1874: description of *Conus mazei* by Deshayes in the Journal de Conchyliologie Vol. 22 from a unique specimen collected in Martinique Island. The holotype is in MNHN Paris. Shell is 59 mm. Crosse adds in a footnote attached to Deshayes' description that the shell was crabbed and was collected in a lobster trap in 50 "brasses" (90 m.) depth together with "*Pleurotomaria quoyana*."

1884: Tryon cites the species from deep sea and gives a shell length of 60 mm. He copies Deshayes' figure.

1886: Dall in "Report on the results of dredging by the United States Coast Survey Steamer "Blake" XXIX Part II" reports findings of *Conus mazei* in Grenada (92 fathoms),

Barbados (100 fathoms) and Santa Cruz (Cuba) in 115 fathoms. He describes the shells of the Blake in these words "None of the Blake specimens are smooth. All are strongly and rather uniformly sulcate all over". These specimens belong either to *Dalliconus mcgintyi* or *D. coletteae* but this cannot be checked at present.

1942: Clench in Johnsonia n°6 presents *Conus mazei* but the accompanying pictures, showing two shells from the North of Cuba, are of *D. mcgintyi*. He gives Cuba, Virgin Islands and Lesser Antilles as range.

1953: Mc Ginty describes *Conus rainesae* from 150 miles northeast of Progreso, Yucatan, Mexico. The author carefully differentiates his new species from *C. mazei*: absence of tubercles on the shoulder of the body whorl, smoother last whorl, smaller size, shallower

depth. The author explains that he could compare *C. rainesae* with several personally live dredged specimens of *C. mazei* (indeed *D. mcgintyi* as inferred from the latter description of that species, see *infra*) from off Palm Beach.

1953: Clench in *Johnsonia* n° 32 gives a new locality for his *C. mazei*: Texas, off Padre Island.

1954: Abbott cites and illustrates *C. mazei* in "American Seashells". The picture is of *D. mcgintyi*.

1955: Pilsbry describes *Conus mcgintyi* in *Nautilus* 69 (2). Holotype is from Pensacola (N.W. Florida), paratypes are from Palm Beach, Sombrero Key Light and Key West. Pilsbry traces previous figures of the new species (in *Johnsonia*, 1953, and *American Seashells*). He gives differences between the new species and *C. mazei*. A sketch of the radular tooth is provided together with a photograph of a paratype from Palm Beach.

1964: Marsh & Rippingale show on the plate 23 a somewhat crude painting of *Conus mazei* that is indeed a specimen of *D. mcgintyi* from Florida.

1967: Van Mol, Tursch & Kempf describe (in French) *Conus mcgintyi* from Brazil. They figure one specimen and give a figure of details of the spire of last whorl sculpture. Their specimens were collected from off Northern Alagoas State south to off Porto Alegre in the state of Rio Grande do Sul. It is the first report in literature of *D. edpetuchi* n. sp.

1970: *Johnsonia* Clench and Bullock do not give any new information on *C. mazei* although the descriptions of *D. rainesae* and *D. mcgintyi* have been published since the last update of the West Atlantic Monograph of *Conus*.

1973: Van Mol in "Les Conidae du Surinam" reports the collection of four specimens of "*Conus mazei*" in 94 m. depth. No picture is shown. Shells probably are *D. mcgintyi*.

1976: Kaicher has three cards of members of the complex: *C. mcgintyi*, *C. mazei* and *C. rainesae* that are all considered as valid distinct species.

1977: Lozet & Petron cite *Conus mazei* p.103 but the picture is of *D. mcgintyi* (n° 175). They give a range from Gulf of Mexico, Caribbean south to Brazil. For Lozet & Pétron the species is represented in Brazil by the more rugose form "*macgintyi*". They also cite *C. rainesae* as a valid species that would be restricted to the Yucatan Peninsula.

1979: Walls synonymes *C. mazei* with *C. rainesae* and *C. macgintyi* (*sic*). He proposes to emend the name *mcgintyi* to *macgintyi* (this emendation is uncorrect). Two shells of *D. rainesae* are shown in p.703 and another in colour p.445 together with a typical *D. mcgintyi* from Pensacola, Florida. Walls is far from being certain that *C. mazei* and *C. macgintyi* (*sic*) are the same species but the lack of specimens pushes him to lump them.

1982: Abbott & Dance illustrate *Conus mazei* (p. 269) but pictures are of *D. mcgintyi* and *D. rainesae*. The latter is wrongly considered as a young carinate form.

1982: Röckel issues the card of *Conus rainesae*. He distinguishes it from both *C. mazei* and *C. mcgintyi*. He shows three specimens from the North West Coast of Florida.

1983: Okutani reports *C. mazei* from Surinam, in fact it is a giant *D. mcgintyi* (74 x 21 mm), the same specimen (the biggest known) is illustrated by Kohn (2014) in plate 16 fig. 23-24. Okutani illustrates its radula with "2 barbs distally and a knob proximally".

1984: Röckel issues the card of *Conus mcgintyi*. He distinguishes the species from both *C. mazei* and *C. rainesae*. He illustrates three shells from Yucatan (left correctly identified), Barbados (center that is indeed a *D. coletteae* of 32.5 mm.) and Florida (right correctly identified with a pattern recalling that of *D. mazei*).

1987: Petuch in "New Caribbean Molluscan Fauna" introduces *Conus pacei* from 4 specimens from Grand Bahama Island. He compares his new species with *C. rainesae* (it differs from its white and fully sculptured last

whorl), *C. mazei* and *C. mcgintyi* that he recognizes as valid. He illustrates the four species in plate 7 and specially a typical *C. mazei* from St James, Barbados, 250 m. that appears to be only the second specimen ever illustrated.

1988: Petuch describes *Conus kremerorum* from Barbados. It is compared with the sympatric *C. mazei* and with *C. pacei* from which it differs in its fewer and pitted sulci, presence of a pale orange pattern and coronated shoulder.

1994: a shell named "*Conus kremerorum*" is illustrated by Kevan & Linda Sunderland in the magazine "American Conchologist" vol. 22 (1). It is indeed a fine specimen of *D. coletteae* from St James, Barbados, 70 m.

1994: Paulmier reports *Conus mazei* in Xenophora n°68 "many shells collected between - 200 and - 300 m. outside the Bay of Fort de France (Martinique)" but he illustrates 2 small specimens of *D. mcgintyi*.

1998: Pointier & Lamy in "Guide des coquillages des Antilles" show p. 149, a 40 mm. specimen of *D. mcgintyi* from Les Saintes (Guadeloupe) wrongly identified as *C. mazei*.

1998: Cargile in his description of *Conus lenhilli* shows two specimens of *C. mazei* from Cay Bank and Mouchoir Bank of 42 mm. The specimen from Mouchoir Bank (Turk & Caicos) is most probably *D. mcgintyi*, the other a true *D. mazei*.

2004: Gracia, Ardila and Diaz record *Conus mazei* from Colombia from 40 specimens. They also cite Bayer (1970) with a record from the Gulf of Uraba. No figure nor description is given. It is probably *D. mcgintyi* but this needs confirmation because other species may be involved too.

2006: Garcia describes *Conus sauros* in Novapex Vol 7(2-3). He compares the new species with *C. mazei* and its form *mcgintyi* thus considering these two as synonyms.

2008: Robin in "Encyclopedia of Marine Gastropods" illustrates p. 417 a shell of "*Conus*

mazei mcgintyi" from Brazil. It is indeed *D. edpetuchi*. n.sp. In p. 426, fig. 9 a correctly identified *D. rainesae* is pictured.

2009: Massemin, Lamy, Pointier and Gargominy in « *Coquillages et escargots de Guyane* » represent (p 196-197) a *D. roberti* from Guadeloupe misidentified as a *mcgintyi*.

2009: Richard describes a new species from Guadeloupe, *Conus roberti*. He places it in *Fusiconus* da Motta, 1991 together with *C. mcgintyi (sic)*, *C. mazei*, *C. pacei* and *C. rainesae*. The holotype was found in 300 m. In the plate are shown a specimen of *D. rainesae* from Martinique which represents an important range extension, a specimen of *C. mcgintyi (sic)* again) from Basse Terre and a true *C. mazei* from Marie Galante (Guadeloupe). For Richard, *C. mcgintyi (sic)* is a species ranging from southern Florida to Brasil.

2009: Tucker & Tenorio introduce the genus name *Dalliconus* with *D. mcgintyi* as type species. The genus also contains the following extant species: *armiger*, *bajanensis*, *guyanensis*, *lenhilli*, *mazei*, *pacei* and *rainesae*. It is characterized by an elongate to biconical shape, two or more cords on the early spire whorls, the presence of ridges and sulci on the body whorl and a paucispiral spire. The radular teeth of *D. mcgintyi* and *D. armiger* are illustrated. They observe that the genus is West Atlantic in geographic range. They report that *D. armiger* and *D. mcgintyi* (from Brazil) have been found with remains of Polychaetes in their digestive tract.

2011: Tucker in "The Cone Collector" n°14a reviews Danker Vink's work on West Atlantic Conidae. Unfortunately the latter has not covered the "*mazei* complex". Tucker recognizes as valid species: *D. sauros* (with some doubts), *D. mazei*, *D. mcgintyi*, *D. rainesae*, *D. pacei*. *D. roberti* is made a Brazilian synonym of *D. mcgintyi* (although Richard never cites Brazil among the localities for his new species) and *D. kremerorum* is

lumped with *D. pacei*.

2013: Tucker places within the *Dalliconus* species found in Florida: *D. mcgintyi* and *D. rainesae*. He explains clearly the conchological characters that allow to differentiate the two species. *D. sauros* is absent from Floridan waters.

2013: Petuch in “Biogeography & biodiversity of Western Atlantic Mollusks” describes *Dalliconus coletteae* (p. 220 and fig. 9-6 F & G). He gives the species as endemic from Barbados. Type locality is St James, Barbados. He compares it with *D. mcgintyi* and *D. roberti*.

2013: Tucker & Tenorio recognized *Dalliconus mazei*, *D. mcgintyi*, *D. pacei*, *D. kremerorum*, *D. rainesae*, *D. roberti* and *D. sauros* while *D. coletteae* is a synonym of *D. mcgintyi*.

2014: in Puillandre *et al.* phylogeny of the Conidae, a specimen is identified as *Conasprella (Dalliconus) mazei*. However from the picture of the sampled specimen (in Puillandre’s presentation in the first International Cone Meeting in 2010, Stuttgart) and locality (Yucatan) of the shell it is indeed a specimen of *D. mcgintyi*. The phylogenetic tree places *Dalliconus* as sister to the Indo Pacific group *Fusiconus*.

2014: Alan Kohn considers *C. mazei*, *C. mcgintyi* and *C. roberti* as belonging to the same species. He gives as range: North Carolina, Southern Florida, Gulf of Mexico, Greater and Lesser Antilles, Belize to Panama, and from Colombia to Suriname, then south to Rio Grande do Sul, Brazil. He also accepts *C. rainesae* with *C. pacei* as a synonym. The range of the latter species is Eastern Gulf of Mexico, Yucatan, (*rainesae* sensu stricto) and Bahamas (*pacei*); two shells from Colombia and Venezuela need confirmation (*pacei* type). Finally he recognizes *Conus sauros* as a valid species from scattered localities in the Western Gulf of Mexico.

The *Dalliconus* complexes and their geographical distribution

The named species of *Dalliconus* are all found in moderately deep to deep water, and several of the species appear to be endemic in an ecological subprovince (Petuch, 2013; Tucker & Tenorio, 2013). The observed protoconches of *Dalliconus* members are paucispiral. This probably involves a direct development of the hatchling without pelagic larval stage and dispersal is therefore limited (Tucker & Tenorio, 2009; Tucker & Tenorio, 2013; Petuch, personal communication). In these conditions, it is quite surprising that several species (*D. mcgintyi*, *D. edpetuchi* n. sp. eg.) exhibit ranges extending in several subprovinces. More studies are needed to elucidate these questions.

The tropical Western Atlantic Region from Cape Hatteras, North Carolina, United States, south to Mar del Plata, Argentina, encompasses different marine faunal regions (the Carolinian, Caribbean, and Brazilian), each of which has mainly its own separate fauna of conoidean gastropods (Petuch, 2013). A brief review of the tropical Western Atlantic *Dalliconus* species and their distributions in these marine faunal regions follow.

Carolinian Molluscan Province - continental shelf species

- 1) *Dalliconus armiger* (Crosse, 1858) (22-39 mm) is found in moderately deep water (40- 100 m) from West Florida in the Georgian subprovince to northern Mexico in the Texan subprovince.
Taxonomic status: a valid species.
- 2) *Dalliconus sauros* (Garcia, 2006) (15-30 mm) is found in moderately deep water (28- 140 m) along the Suwannean

subprovince to Campeche, Mexico, in the Texas subprovince.

Taxonomic status: a valid species.

Carolinian & Caribbean Molluscan Provinces - continental shelf & insular species

- 3) *Dalliconus mcgintyi* (Pilsbry, 1955) (24-74 mm) is found in deep water (125-600 m) from Cape Hatteras, North Carolina in the Georgian subprovince to the Yucatan Peninsula, Mexico, in the Yucatanian subprovince to Surinam through the continental Coast of Gulf of Mexico and Central America, Colombia and probably Venezuela and through the entire Antilles (Caribbean Province).

Taxonomic status: a valid species.

- 4) *Dalliconus rainesae* (McGinty, 1953) (14-27 mm) is found in moderately deep water (54-144 m) from Western Florida in the Georgian subprovince to Progreso, Mexico in the Yucatanian subprovince and Martinique (see Richard, 2009) and may be Venezuela (see Kohn, 2014).

Taxonomic status: a valid species.

- 5) *Dalliconus pacei* (Petuch, 1987) (19-20 mm) is found in deep water (125-250 m) off the coast of Grand Bahama Island, Bahamas, in the Bahamian subprovince, in Guadeloupe in the Grenadian subprovince (from shells collected by MNHN, under study by Richard), and in Arrecife Alacranes, Yucatanian subprovince (Kohn, 2014).

Taxonomic status: a valid species.

Caribbean Molluscan Province - insular species

- 6) *Dalliconus mazei* (Deshayes, 1874) (33-59 mm) is a species found in deep water (150-270 m) from the lesser Antilles: Martinique, Guadeloupe, and Barbados

and along the eastern edge of the Granada trough to Curacao in the Grenadian subprovince to Florida Keys (Kohn, 2014) in the Carolinian Province through the Virgin Islands (Antillean subprovince).

Taxonomic status: a valid species.

- 7) *Dalliconus coletteae* Petuch, 2013 (20-33 mm) is an endemic species found in deep water (140- 300 m) off St. James, Barbados, in the Grenadian subprovince.

Taxonomic status: a valid species.

- 8) *Dalliconus kremerorum* (Petuch, 1988) (18 mm) is an endemic species only known to us from the holotype and needs more material to be ascertained in its characters. The holotype was found in 70 m. off St James, Barbados in the Grenadian subprovince.

Taxonomic status: probably a valid species.

- 9) *Dalliconus lenhilli* (Cargile, 1998) (27-40 mm) is a poorly known endemic species found in deep water (440 m) off Mouchoir Bank, Southeast of the Turks and Caicos Islands, in the Bahamian subprovince.

Taxonomic status: a valid species.

- 10) *Dalliconus roberti* (Richard, 2009) (52-69 mm) is a poorly known species found in very deep water (300-550 m) off the coast of Guadeloupe and Virgin Islands in the Grenadian & Antillean subprovinces.

Taxonomic status: a valid species.

- 11) *Dalliconus bajaranensis* (Nowell-Usticke, 1968) (29-31 mm) is an endemic poorly known species found in the South of Barbados (Shrimp trawlers), in the Grenadian subprovince.

Taxonomic status: a valid species.

Brazilian Molluscan Province

- 12) *Dalliconus guyanensis* (Van Mol, 1973) (19-28 mm) is an endemic poorly known

species found in rather deep water (75 m) off Surinam, in the Surinamian subprovince on the northern coast of South America.

Taxonomic status: probably a valid species, very close to *D. bajanensis* from which it is conchologically almost identical.

- 13) *Dalliconus edpetuchi* n.sp. (56-68 mm) is a Brazilian endemic new species found in deep water (150-400 m) from the boundary between Alagoas State and Pernambuco State (in the North) and the Rio Grande do Sul State (in the South).

The *Dalliconus* morphological complexes

The *Dalliconus* species fall into three distinct morphological complexes:

- 1) The *Dalliconus armiger* complex consists of *D. armiger*, *D. bajanensis*, and *D. guyanensis*, and the body whorl of all species in this complex have sides that are strongly convex below a broad shoulder.
- 2) The *Dalliconus rainesae* complex consists of *D. rainesae*, *D. pacei*, *D. kremerorum*, *D. lenhilli*, and *D. sauros*, and all species in this complex have thin, fragile, delicate shells with relatively straight sides. Most are relatively small.
- 3) The *Dalliconus mazei* complex consists of *D. mazei*, *D. mcgintyi*, *D. roberti*, *D. coletteae* and *D. edpetuchi* n. sp. All species in this complex (except *D. coletteae*) have relatively large sizes.

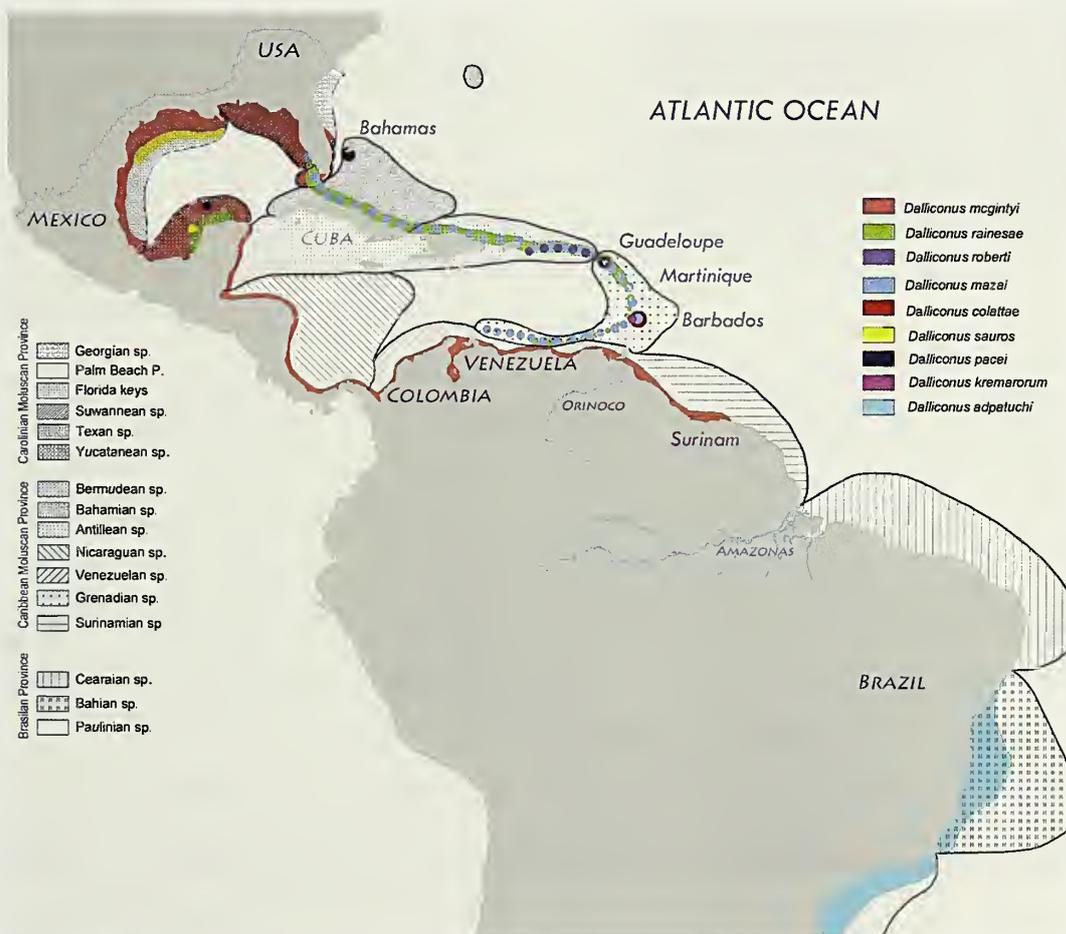


Figure 1. Biogeographical distribution map of the genus *Dalliconus*

DESCRIPTION OF A NEW SPECIES FROM THE BRAZILIAN PROVINCE:***Dalliconus edpetuchi***

	Length	Maximum Diameter	Height of Maximum Diameter	Aperture Height	Relative Diameter of last whorl	Position of Maximum Diameter of last whorl	Relative Spire Height	Deposition & Provenance
	L	MD	HMD	AH	RD = MD/AH	PMD = HMD / AH	RSH = (L-AH) / L	
Holotype	60.32	17.14	40.77	44.14	0.388	0.924	0.268	MNHN IM-2000-30050
Paratype 1	59.91	15.70	40.62	44.32	0.354	0.917	0.260	EM coll.
Paratype 2_∞	65.46	14.80	39.90	42.59	0.347	0.937	0.349	EM coll.
Paratype 3	67.75	18.60	46.86	51.19	0.363	0.915	0.244	LL coll.
Paratype 4	64.77	18.06	43.79	48.40	0.373	0.905	0.253	CR coll.
Paratype 5	57.72	14.63	37.95	42.34	0.346	0.896	0.266	CR coll.
Paratype 6	62.60	17.20	-	-	-	-	-	EP coll.
Paratype 7	56.72	16.12	37.55	40.54	0.398	0.926	0.285	DB coll.
Paratype 8	64.80	18.27 °	42.62 °	46.53 °	0.393	0.916	0.282	AM coll.
Paratype 9	60.00	16.10 °	41.10 °	45.21 °	0.356	0.909	0.247	MHNLR 2015.0.1
Averages	62.0	16.7	41.2	45.0	0.37	0.92	0.27	

Table 1. Morphometric analysis of *Dalliconus edpetuchi* holotype and paratypes.

Types. Studied specimens (measurements are given in millimeters). ° : estimated values ∞ : teratological spire

Description.

The new species is moderately large (56 to 69 mm, average: 62.0 mm) and the spire varies between 24 and 35 % of the total length of the shell (with an average value of relative spire height: RSH = 0.27). The shell shape is very narrowly conical, fusiform / aculeiform with a very high slightly concave turruculate spire (average AH / L = 0.73), narrow shoulders, spiral ribs. None of the examined specimen has a perfect protoconch. Nevertheless it seems to be paucispiral with about two whorls and the new species is probably non planctotrophic. The position of the maximum diameter is 90 to 94 % of the aperture length of the shell (average PMD = 0.92). The relative diameter of the last whorl varies from 0.35 to 0.40 (average RD = 0.37). The teleoconch whorls are piled and detached with about 5 to 6 spiral grooves on the sutural ramps. At two thirds (from top to base of the shell) of each teleoconch whorl, a prominent subsutural ridge is undulated with around 25 to 30 small irregular beadlike nodules. The adult shells have about 13 to 15 whorls. The anal notch is deep and U shaped and the origin of the lip has a receding profile.

The last whorl shape has sigmoid sides, convex between the slightly subcarinated shoulder margin and the mid last whorl then concave between the mid last whorl and the base. The surface of the entire shell is covered by numerous very tight spiral ribs (around 60) separated by deep axially very finely axially striated grooves. The aperture is very long, almost straight to slightly sinusoidal and does not widen anteriorly.

The siphonal lip outline is very straight. The ground color of the shell is white. The pattern of the last whorl is made of spiral bands of irregular interrupted spiral brown blotches (giving the appearance of axial flammules). The

width of these bands is highly variable and vary from 1 mm. to more than 1 cm. The spire is white with same colour blotches rather regularly scattered.



Figure 2. Holotype of *Dalliconus edpetuchi*

Holotype.

The holotype is deposited in MNHN (Paris): MNHN IM-2000-30050. The nine paratypes are in private collections except the paratype 9 deposited in MHNLR 2015.0.1 (La Rochelle, France)

Type Locality. Off Cabo de Santa Marta Grande, Santa Catarina State, Brazil in 300-400 m.

Geographic Range. found in deep water (150-400 m) from the boundary between Alagoas State and Pernambuco State (in the North) and the Rio Grande do Sul State (in the South).

Etymology. Named for Dr. Edward Petuch in recognition of his decades of field work, many



Figure 3 - *Dalliconus edpetuchi* n. sp. **1:** *D. edpetuchi* 60.32 mm, Santa Catarina, -300-400 m, Holotype MNHN IM-2000-30050 **2:** *D. edpetuchi* 59.91 mm, Rio de Janeiro, -150 m, Paratype 1, coll. EM; **3:** *D. edpetuchi* 65.46 mm, Santos, -160-250 m, Paratype 2, coll. EM; **4:** *D. edpetuchi* 64.77 mm, Rio de Janeiro, -150 m, Paratype 4, coll. CR; **5:** *D. edpetuchi* 57.72 mm, Santa Catarina, -300-400 m, Paratype 5, coll. CR; **6:** *D. edpetuchi* 56.72 mm, Santa Catarina, -400 m, Paratype 7, coll. D. Berschauer; **7:** *D. edpetuchi* 64.80 mm, Santa Catarina, -300-400 m, Paratype 8, coll. A. Medvedev; **8:** *D. edpetuchi* 60.00 mm, Rio de Janeiro, Paratype 9, MHNLR 2015.0.1 **9:** *D. edpetuchi* 67.75 mm, Rio de Janeiro, -150 m, Paratype 3, coll. LL

discoveries and major contributions in Malacology throughout the Caribbean and Brazil.

Discussion. *Dalliconus edpetuchi*, a new endemic species described here has been erroneously lumped with *Dalliconus mcgintyi* (Pilsbry, 1955), a species found in the Carolinian and Caribbean provinces. This is the only species of *Dalliconus* living beyond the eastern edge of the Caribbean Plate. It lives in both the Bahian and Paulinian subprovinces of the Brazilian Molluscan Province (Petuch, 2013; Tucker & Tenorio, 2013; Kersten, 2014). It is geographically separated from the Caribbean species of the genus as the Lesser Antilles arc divides the fore arc basin and acts as a geological barrier to sediment passing between the Grenada Basin and South America (Aitken, *et al.*, 2011). It is interesting to notice that no *Dalliconus* is known from the Cearaian subprovince in Northern Brazil.

Dalliconus edpetuchi n. sp. is most similar in morphological shape to *Dalliconus mcgintyi* (Pilsbry, 1955) and is part of the *D. mazei* complex with elongate biconical shells, with narrow shoulders, spiral ribs and axial flammules. The morphological differences between these species from the *D. mazei* complex are as follows:

D. mcgintyi: the new species has a more distinct pattern than *D. mcgintyi*, the relative spire height is a little bit higher. The shells may tend to be twisted with a curved spire more often than in any other *Dalliconus* species. One major difference is in the number of tubercules on each whorl of the spire: the new species counts around 25 to 30 smaller nodules while *D. mcgintyi* counts around 20, giving a less

projecting appearance of the nodules in the new species. The spire of *D. mcgintyi* is somewhat straighter. Moreover the spiral ribs on the last whorl are less prominent, more numerous and somewhat less flat in the new species.

D. mazei: The new species is longer and more elongate than *D. mazei*, which body whorl has a higher gloss and is smooth in bigger shells or covered with low distinct spiral ribs with grooves between them conspicuously pitted in smaller shells. The body whorl is patterned with 8 to 10 rows of very distinct square reddish-brown spots. Whorl margins of *D. mazei* do not have projecting carinae and are flat instead of concave above in the new species.

D. roberti: Similar to *D. mcgintyi* and *D. edpetuchi* n. sp. in overall shape and size. However it has a shorter spire sculptured with axially elongated tubercules and it shows a more pronounced convexity on the posterior end giving the shell a bulging conical form. The body whorl has a densely packed pattern of yellow-brown spots.

D. coletteae: closest to *D. roberti* in shape but with a less elongated shell. It is smaller in size (from 19 mm. to 32.5 mm.) than the new species. It has a more sculptured body whorl with numerous deeply-incised spiral sulci. The pattern is made of scattered small orange brown flammules and spots and the sutural ramp is coloured with comma shaped spots that are diagnostic of the species. *D. edpetuchi* n. sp. is a much darker and more heavily patterned shell.

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The present description could not have been written without the help brought by the following persons:

Edward Petuch who provided us valuable informations on this difficult and very confusing genus. Michael Rabiller, curator of the Cone collection of MHNLR (La Rochelle) for the picture of the paratype 9 of the new species. Alexander Medvedev who provided us the picture of the paratype 8 of the new species. Alain Robin who photographed many of the shells pictured in this study.

Abbreviations

AMNH: American Museum of Natural History, New York City, New York, U.S.A.

MHNLR: Muséum d'Histoire Naturelle de La Rochelle, La Rochelle, France

MNHN: Muséum National d'Histoire Naturelle, Paris, France

SMNS: Staatliches Museum für Naturkunde, Stuttgart, Germany

FLMNH: Florida State Museum of Natural History, University of Florida, Gainesville, Florida, U.S.A.

USNM: Smithsonian Institution, United States National Museum, Washington, D.C., U.S.A.

SBMNH: Santa Barbara Museum of Natural History, Santa Barbara, California, U.S.A.

ANSP: Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, U.S.A.

RMNH: Rijksmuseumvan Natuurlijke Historie, Leiden, The Netherlands

EM: Eric Monnier

LL: Loïc Limpalaër

CR: Christophe Roux

DB: David P. Berschauer

EP: Edward Petuch

AM: Alexander Medvedev

BdM: Bob da Motta

GR: Georges Richard



Figure 4 – *Dalliconus rainesae*. 1: *D. rainesae* 15.5 mm, Florida, coll. EM; 2: *D. rainesae* 18.3 mm, Egmont Ref, Florida, coll. LL; 3: *D. rainesae* 15.3 mm, Egmont Key, Florida, JKT2472; 4: *D. rainesae* 16.3 mm, Dry Tortugas Keys Arch., Florida, coll. CR; 5: *D. rainesae* 19.4 mm, Florida, coll. EM

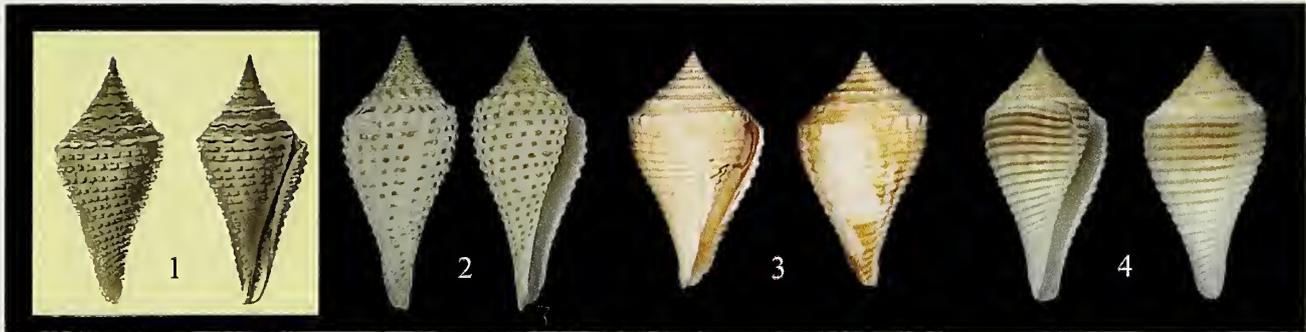


Figure 5 – Dalliconus armiger group. 1: *C. crenulatus* Kiener, 1845 Holotype, renamed *C. armiger* Crosse, 1858; 2: *D. armiger* (Crosse, 1858) 36.2 mm, - 80-120 m, Florida, coll. EM; 3: *D. bajanensis* (Nowell-Usticke, 1968) 31.0 mm Barbados, Lectotype AMNH 195451; 4: *D. guyanensis* (Van Mol, 1758) 28.4 mm Surinam, Holotype RMNH 106718

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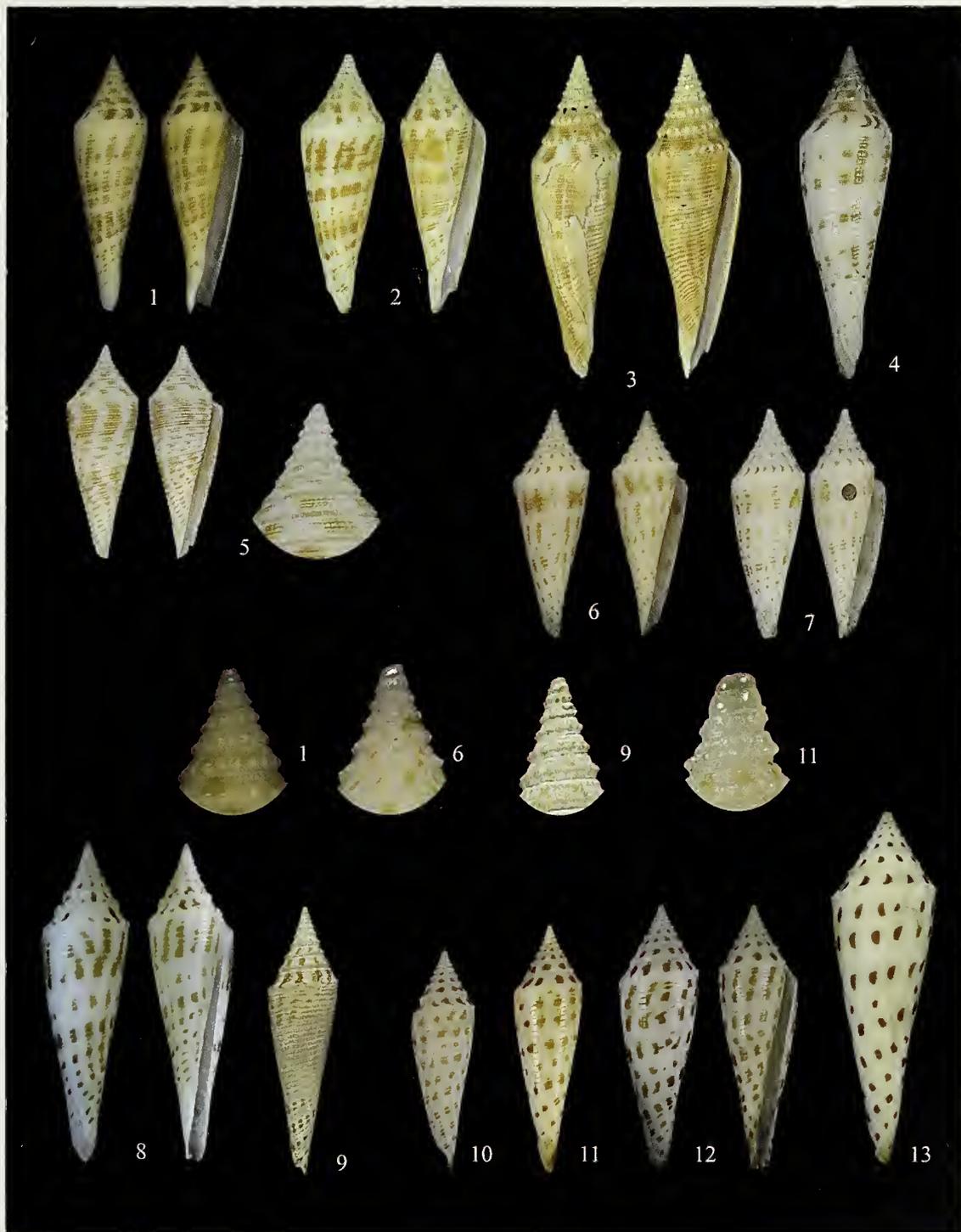


Figure 6 – *Dalliconus*. 1: *D. mcgintyi* 38.62 mm, - 200 m., W. Tampa, Florida, coll. CR; 2: *D. mcgintyi* 36,8 mm, - 201 m., 19°25'N, 95°57'W, Texas, JKT5137d; 3: *D. mcgintyi* 52.1 mm, - 221 m, Desoto Canyon, S. Pensacola, Florida, JKT1002; 4: *D. mcgintyi* 52.0, Florida, DM91208; 5: *D. mcgintyi* 21.7 mm, - 50 m., San Blas, Panama, coll. LL; 6: *D. colettai* 19.9 mm, Coll. EM; 7: *D. colettai* 20.6 mm, - 160 m., Barbados, coll. LL; 8: *D. roberti* 41.6 mm Guadeloupe, Private coll.; 9: *D. roberti* 36.6 mm Guadeloupe, coll. GR; 10: *D. mazei* 28.8 mm, Barbados, DM91211; 11: *D. mazei* 32.7 mm, - 80 m., Marquesas Key, Florida, SMNS ZI 91212, Coll. BdM; 12: *D. mazei* 35.3 mm, Tampa, Florida, Coll EM; 13: *D. mazei* 45.0 mm, Marie Galante, MHNLR Coll. GR



Figure 7 – Dalliconus Types. 1: *D. coletteae* Petuch, 2013, 20 mm, - 300 m., St. James, Barbados, Holotype FLMNH 328436; 2: *D. kremerorum* (Petuch, 1988) 18 mm, - 70 m., St. James, Barbados, Holotype USNM 859947; 3: *D. pacei* (Petuch, 1987) 19 mm, - 240 m., S. Grand Bahama Isl., Bahamas, Holotype USNM 859888; 4: *D. rainesae* (McGinty, 1953) 24.7 mm, - 60-80 m, N. E. Progreso, Yucatan, Mexico, Holotype FLMNH; 5: *D. sauros* (Garcia, 2006) 29.5 mm, - 140 m., SSE Port Aransas, Texas, Holotype; 6: *D. lenhilli* (Cargile, 1998) 39.8 mm, -440 m., Monchoir Bank, SE. Turks & Caicos Is., Holotype SBMNH 144485; 7: *D. mcgintyi* (Pilsbry, 1955) 41.6 mm, Pensacola, Florida, Holotype ANSP 193858; 8: *D. mazei* (Deshayes, 1874) 57.5 mm, - 90 m., Martinique, Holotype MNHN 3307; 9: *D. roberti* (Richard, 2009) 51.2 mm, - 100 m., Basse Terre, Guadeloupe, Holotype MNHN 21376

Have a shell collection you would like to sell?

The San Diego Shell Club is interested in high quality estate collections comprised of any and all types of shells, marine or land, and all genera and species. Your shells will be used to generate income to support the Club's efforts in continuing public education about shells and conservation of marine life throughout the world. If you have considered selling your collection to a dealer and were unhappy with the offer, then please contact Dave Waller, SDSC Acquisition Chairperson, at dwall@dbwipmg.com to schedule a time to review your collection and provide you with another offer to consider.



CLUB NEWS

November 2014 Regular Meeting, Holiday Inn Express, 751 Raintree Drive, Carlsbad, CA.

- Meeting was called to order at 1:15 p.m. The conference room at the Holiday Inn Express was packed with over fifty eager shell collectors and Shell Club members.
- After greetings, Larry announced the day's events. There would be an auction for the first half of the day followed by the "official" meeting in which there would be officer reports and members would vote for the next President for 2015, the nominations being Larry Buck for a second term and Martin Schuler who presided during the previous year as Recording Secretary.
- The auction was started with auctioneer David Berschauer hawking the conchological gems while Dave Waller recorded the winning bidders and their winning bids. Auction paddles were raised in the air as many gorgeous and sought after specimens were displayed before the Club members. Good hearted competitiveness prevailed for the first hour and then there was a break to begin the meeting portion of the afternoon.
- The Treasurer's report was presented, and Dave Waller reported on the Southern California Del Mar Fair display as well as the possible COA convention that is slated for 2018. Afterwards, Presidential nominees Martin Schuler and Larry Buck were both given a few minutes to present their presidential platforms. A verbal vote was then made to accept the nominations for the other offices of the Shell Club. This was unanimously approved by the members. Paul Tuskes, the Club's Parliamentarian and Dave Waller then passed out ballots so that members could circle the names of who they would like to see hold the office of President for the year 2015.
- During this time, David Berschauer talked about *The Festivus* budget as well as the journal exchange that the Shell Club has with other shelling publications, both domestic and abroad.
- When the ballots were finished, Paul Tuskes took them into another room to count with Martin Schuler accompanying him as a witness. Larry Buck declined the offer.
- The ballots were counted and Paul Tuskes announced (with a flair of anticipation) that Larry Buck would retain the presidency for 2015.
- The general meeting was then adjourned at 2:30 p.m. and the second part of the auction continued along with the happy appearance of pizza to feed and fuel the hungry guests eagerly raising their bidding paddles in the hopes of winning a rare *Cypraea*, *Murex*, *Conus*, or *Volute*. The auction and meeting concluded at approximately 3:30 p.m. and Club members and guests continued to socialize during clean up. A good time was had by all.



Recollections of a Neophyte Shell Collector

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As shell collectors we probably still remember how we got started collecting seashells. Quite possibly you went to the beach, walk along the shore and picked up shells as you found them. Ah, fresh air, sunshine, the sand between your toes, and the waves. What a great hobby and it seemed so easy. However, if you advance beyond this stage of collecting then challenging situations will appear with the hobby. One of the first things to happen occurs after you obtain a simple shell collector book. For me it was *Sea Shells of the World* by Tucker Abbott, one of the Golden Nature Guide series of books. Boy, look at those great pictures. How I would love to get one of those 15" Goliath Conches. Oh wow! Look at the 24" Australian Trumpet, and ooh look at that giant 12" Prometheus Cone (*Kalloconus pulcher*). Some day I must obtain one of those shells for my collection. You begin to see what nice specimens look like, and you soon realize that collecting what the waves have brought to shore is not going to hack it. To obtain nice specimens like those in the book you really have only two choices. Either you travel to various shelling locations, which may involve going into the water and diving for them yourself, or purchase shells from dealers.

Obviously, it is less expensive and less time consuming to purchase seashells. While many collectors feel that the experience of finding shells in the wild is a major part of serious collecting you will be faced with the following perplexing problems if you elect to purchase. What's a fair price? Is the proprietor honest? Perhaps even more important is determining the shell quality. Pictures don't always show the detail needed to provide a clear understanding of a shell's condition. Of course you learn quite quickly that shells are graded using letters such as F+, F++, F+++, and GEM but, without years of experience, it's difficult to know what different species should look like for the different grades.



Figure 1. Elephant snout Volute. First shell in author's collection. Confiscated from his future mother in law's house. This is where shell collecting got started for me

Somewhere along the way you learn about a local shell club. So you decide to join hoping that you will learn how to demystify the challenges of collecting. But are the members speaking a foreign language? All those technical words they use like *Echinophoria bituberculosa*,

Homalocantha melanamathos, and *Babelomurex yumimarumai* - yuck. It's ridiculous. You practically needed to have majored in marine invertebrate biology. Some of us are engineers, chemists, or physicists; you know the type, the ones that probably didn't take Latin and who most likely didn't exactly excel at English in school.



Figure 2. Knobbed Whelk. First shell author found and kept for his collection. Long Island, N.Y. 50 years after it was found.

At least I was cognizant enough to know you should keep a record of the various shells as you obtain them. So I procured a notebook, gave each shell a number, and wrote down the common name for each shell in my collection. No, that is not professional. You need to use a computer and also include information such as date of purchase, purchase price and its technical name. No, no, Word is not good enough, you need to use an Excel spreadsheet and also include where the shell was found, who found it, the date it was found, the depth that the shell was taken and you must also include a picture of it. What! I don't know how to do all

that. They didn't even have electronic calculators when I went to school. Well, I guess I can ask my 10-year-old grandson to help me. I wish I didn't have to ask him though - he looks up to me so much. Oh well, he probably will be happy to help, after all we both have a common enemy. Now if I could only get the number of shells in my collection to agree with the number of shells in my listing.

At one of the club's meetings I over heard a conversation that suggested that you should not display your collection in wood cabinets -- all that detrimental whatcha-ma-call it stuff, permeating out of the wood and attacking the shells. What! I just purchased an expensive oak display cabinet. Oh no my hundred-dollar pride and joy will soon be worth only ten dollars. Then the conversation went on and enlightening me further. Be sure not to expose the shells to the sun's light. UV light, it bleaches the shells you know. After trying an all glass cabinet, then a metal cabinet, and finally a plastic cabinet your spouse begins hinting that you might need a second job - honey.

Oil, you think. Oil will come to the rescue. I'll try some silicone oil or perhaps some olive oil on the shells. That should bring them back to life and I'll display them all over the house. Oops, bounce bounce bounce bounce. Slippery little devils. And then there is dust, the stuff tenaciously adhering to the shells. Why didn't they tell me about that before I gave the shells an oil job? Have you ever tried to dust shells that have been oiled?

It's about this point in time that your spouse suggests that you are spending too much time with your new hobby. So you take a week or two off and go out to dinner a few times and smooth the ruffled feathers. The placating seems to be effective so it's definitely time to get back to the more important things in life. You wander over to your display cabinet, open the door and nearly pass out. My gosh! What is that? It smells like a combination of "fragrances" that emanate from the

big cat and the primate buildings at the local zoo. I didn't think that there was going to be an occupational type hazard involved with being a shell collector. Perhaps a daily airing out will alleviate this problem.

And then that special day arrives when one of the board members, who you swear you never saw before, comes over to you during intermission at a club meeting, slaps you on the back and says "howdy buddy". "Boy, you sure have come a long way since becoming a member". You think to yourself wasn't that only the month before last? He continues, "how about giving the talk next month at the general meeting?" Not having the sense that God gave an ant you say "err". "Great" he replies, "I'll put you down as next month's speaker". What! Doesn't he know that engineers, chemists or physicists don't make good public speakers? And "oh yea" he calls out to you, as he starts to walk away, "and don't forget to write an article, about your talk, for the monthly newsletter". Boy, if I had to do this all over again I think I would take up amateur astronomy.



Figure 3. The Oak cabinet: Author's General collection



Figure 4. The plastic cabinet: Author's Cowrie collection



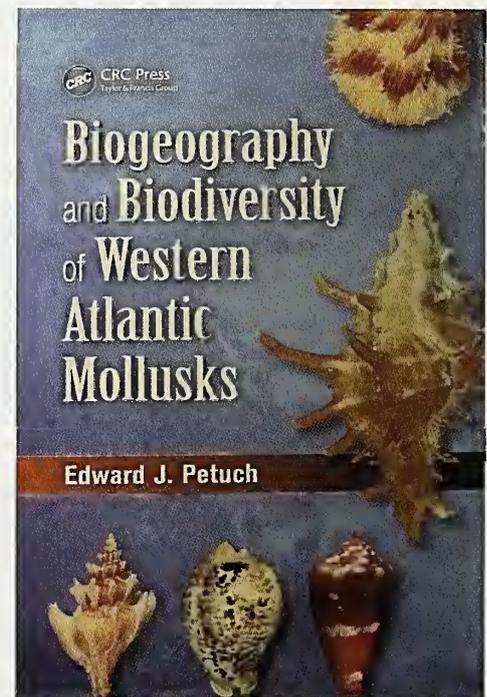
Figure 5. Author holding his Prometheus Cone and Australian Trumpet

Biogeography and Biodiversity of Western Atlantic Mollusks by Edward J. Petuch

Published 2013, CRC Press - Taylor & Francis Group, Boca Raton, Florida, ISBN 13: 978-1-4665-7979-8 in hardcover with laminated board case binding, 234 pp., illustrated in high color resolution photographs by Dennis Sargent, about \$160

Review by David P. Berschauer
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This book is the true successor to Dr. Petuch's famous work *Cenozoic Seas: The View from Eastern North America* (2003) wherein he chronicled the past thirty million years of molluscan biodiversity in a succession of fossil assemblages on the Atlantic and Gulf coasts of North America. In this newest book Dr. Petuch places the diversity of extant molluscan species into distinctive communities of mollusks in ecological assemblages over a broad array of distinctive regions. In this book, Dr. Petuch draws on his many decades of field study and personal experiences working with both recent and fossil mollusks in the western Atlantic and southern Caribbean and traces the development of a biogeographic framework for the temperate and tropical faunas of the region. Both qualitative and quantitative analyses are used to define three molluscan faunal provinces and fifteen subprovinces using a concise quantitative model based upon a Provincial Combined Index (using ten gastropod families and subfamilies based upon relative endemism) and Valentine's 50% rule. Illustrations of the species from each subprovince throughout the text make these communities easy to visualize and understand.



Despite being a thorough scientific work, complete with all data, formulas, and mathematical calculations which provide a testable and repeatable hypothesis, the work is highly readable, clear and flows well. Each province and subprovince is discussed in an interesting, and enjoyable detailed chapter accompanied by biogeographic maps and beautiful illustrations of the index species and other endemic species. The ecological limitations and distributions of these molluscan assemblages are described and placed in context with their evolution from the past epochs of the Cenozoic Era. Throughout the book Dr. Petuch repeatedly demonstrates that the tropical western Atlantic is a dynamic region that has undergone rapidly occurring extinctions and evolutionary explosions to produce one of the richest molluscan faunas to be found. Provinciatones, primary and secondary relict pockets are defined, discussed and woven into the fabric of the ecological and natural history of these fascinating molluscan faunas making molluscan biogeography an understandable and fascinating topic.

New taxa are named in this book including 31 new species and subspecies, and 11 new genera and subgenera illustrated in context of their biogeographic subprovinces the chapters, and set forth in detailed descriptions in the back of the book. While undoubtedly not everyone will agree with all of the taxonomy presented, as is common with all taxonomic works, this book presents testable hypotheses and is detailed, thorough, and contains both the data and formulas to provide a solid basis for future biogeographic and taxonomic work. I found this book to be both an enjoyable read and a useful and valuable reference guide. If you collect western Atlantic or Caribbean shells this book is a fantastic addition to your shell library.

Red Abalone, Candidate for State Mollusk

By Larry Buck

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In California waters north of San Francisco, and places like San Miguel Island, the current state of California's red abalone population is good -- healthy, and it's due to successful proven management practices. Abalone health in general is improving elsewhere in the State-- excellent news because red abalone, *Haliotis rufescens*, is a valued harvestable and replenishable State resource. Offering proof of my statement is our Club member Julian Lee and his friend Dwayne Dinucci, both divers are displaying properly tagged gargantuan "reds" taken from California's cold northern waters. See photo with Julian's "I-got-abs" smile.



Figure 1. Julian Lee and friend Dwayne Dinucci each with an 11" plus red abalone

The red abalone is the undisputed title holder. It's the world's largest abalone, though not to diminish in value California's six other abalone species.... I'm looking up at a trail of "ab" shells across the wall here in my study, ... a veritable shrine to abalone.... Some of these other "abs" get right up there in size. Methinks I've been lucky. The Golden State, California, is a lucky State, total, seven species of *Haliotidae*. A gift. And I think we Californians have a responsibility. For the record, the current biggest red, the world record, is 12 ⁵/₁₆" -- a behemoth.

So what is this about? It's now more than idle talk. The San Diego Shell Club has set a course that will, in effect, leave our mark for posterity.

With the support and backing of their Club, Layla Marie and Cole James (Jimmy) Nash, are petitioning the legislature of the great State of California to declare red abalone, *Haliotis rufescens*, the State mollusk. In the minds of many of us, an honor well deserved. And if their Club is successful, sometime following red abalone being awarded the prestigious distinction, your Board will sit and ponder further world champ-worthy considerations, perhaps efforts to generate some measure of support for our State's other *Haliotis* species. The "white" abalone, *H. sorrenseni* would come to mind.

Speaking for the Club, I know we would all be proud of such an accomplishment. I am hopeful, even confident, that history will register these efforts as having succeeded in furthering the dual causes of education and awareness of our natural world, and draw attention to family *Haliotidae*, to what is arguably the upper echelon of phylum Mollusca -- abalone. Not only is the red abalone, *Haliotis rufescens*, the most recognizable shell in California but it has a long history as the most commercially and recreationally fished mollusk. If you've ever eaten them, you know there's no equivalent.

Cheers,
Larry Buck, President



Figure 2. Layla Marie and Cole James Nash

Taxonomic note - new species:



Chicomurex pseudosuperbus



Chicomurex globus

Chicomurex globus and *C. pseudosuperbus* Houart, Moe & Chen, 2015 (Description of Two New Species of *Chicomurex* from the Philippine Islands (Gastropoda: Muricidae) with Update of the Philippines Species and Rehabilitation of *Chicomurex gloriosus* (Shikama, 1977), Venus 73(1-2:) 1-14).

Photos courtesy of Chong Chen

IN MEMORIAM CAROL CHRISTINE SKOGLUND

1924 - 2015

The world has lost a very special person.

Carol Skoglund was a close friend of mine and of the many who knew her. She was very bright, kind, fun, and humble. She is known throughout the malacological world for her knowledge of Panamic mollusks and her willingness to share information on mollusks and help kindred workers, amateur or professional.

Carol was born in Long Beach, California, on November 25, 1924 and passed away at age 90 on January 6, 2015. She graduated from Lincoln High School in Los Angeles, California in June 1941. After meeting her future husband, Paul Skoglund, who she married in October 1942, they relocated to Phoenix, Arizona, for his job, and where she and Paul raised two children, Stan and Christine. Once the children were grown she decided to complete her education at Phoenix College in Phoenix, Arizona, where she majored in zoology receiving an Associate in Arts Degree in June 1966. She then continued in zoology at Arizona State University in Tempe, Arizona, earning her Bachelor of Science Degree in June 1968 and her Master of Science Degree in August 1974. During this time she became very interested in mollusks. She was working as a graduate teaching assistant in the Zoology Laboratory at ASU (1968-70) and began collecting intertidally, publishing her first scientific study in 1965 on the *Gastropods of Cholla Bay, Sonora, Mexico*. By 1970, Carol was already publishing in professional journals on aspects of intertidal Panamic mollusks.

She co-founded (with Beatrice Burch) the Southwestern Malacological Society of which she was president in 1967 and 1989. She also became active in the Western Society of Malacologists as Secretary 1969-1970, Member-at-large 1975-1976, Treasurer 1977-1979, 1st Vice President 1980-1981 and President 1981-1982. It was at about this time that Jules and I became fast friends with Carol and Paul. We were all at the 1975 AMU-WSM meeting at San Diego State University and at the next WSM conference at SDSU in 1981 at which Carol was elected president of the organization.



Figure 1. Carol Skoglund, when she became president of the WSM at the WSM conference at SDSU in 1981. Photo: D. Mulliner.

As a result of her collecting which brought in many intertidal and mid-tide shells, the Skoglunds started deep-water collecting with a dredge that Paul designed (*The Festivus* 32(10):106-109). With her collection growing quickly, including considerable duplicate material, Carol decided to start a retail mail-order shell business *Panamic Specimen Shells*, which she ran successfully from 1974-1987. We still have several of the terrific, small catalogues she sent out seasonally to collectors. This business also helped defray expenses of their travels while collecting in many areas of México, Ecuador, Costa Rica and Panamá.

The Skoglunds were very generous and invited us beginners to collect in Sonora, México, where they had a little cabin on Cholla Bay. It was great fun. We hadn't collected there and Carol showed us areas that were new to us. There's nothing like being out in a low tide late at night with just a lantern and a bucket, trying to find your way back to a dark shore.

We soon met many of Carol's friends, all "shell nuts" who collected intertidally and/or by dredging and diving. Carol, Kirstie Kaiser, Jules and I traveled together so often we called ourselves "The Three Musketeers and D'Artagnan." Every trip was a new adventure, with Carol knowing the areas, the particular beaches and what we might find there. It was great fun collecting and identifying our new acquisitions. Information gleaned from all these collectors was considerable and Carol felt that this information needed to be shared.



Figure 2. Carol Skoglund, June 2000. "The Three Musketeers" and D'Artagnan. Kirstie, Carol, Carole & Jules at the WSM meeting in Santa Barbara. Photo: D. Mulliner.



Figure 3. The weary group coming back to the Skoglund's cabin after low tide near Sandy Beach in Bahía la Cholla, Sonora, March 1992. With Skoglunds, Hertz, Ed and Pat Boyd and Bob Koch. Photo: W. Koch.

By the year 1990, Carol decided that it was important that there be an update to Keen's (1970) historic volume on the molluscan fauna of the Panamic Province. It was the good fortune of *The Festivus* that Carol decided to work with this publication. Her first two supplements were published on the Opisthobranchia followed by the Bivalvia in 1991, and the Gastropoda in 1992, updating Keen to 1990 and 1992. These supplements were perfect bound, were extremely popular and sold out quickly.

Her final two supplements published in 2001 on Bivalvia and Polyplacophora and in 2002 on the Gastropoda were spiral bound, protected with plastic illustrated covers, and updated Keen (1970) to 2001 and 2002. After Carol sent each of the mollusk sections of the supplements to professionals for review, she and the editor and business manager of *The Festivus* worked for days and weeks editing, correcting and perfecting the compilations. The work was both excruciating and a joy, knowing that these supplements were needed by researchers and would be a major accomplishment. As this is written, most all of her supplements were sold, with requests still coming in from time to time, especially for the Gastropoda.

In 2010, Carol, a Research Associate at the Santa Barbara Museum of Natural History, donated her world-class Panamic mollusk collection of over 50,000 mostly self-collected specimens to the SBMNH. Her passing is a great loss to many. She is survived by her daughter Christine Aye; son Stan Skoglund and his wife Gail; four grandchildren, Andy Aye and his wife Theresa, Jeremy Aye and his partner, Lisle Richards, Erica Skoglund and Keith Skoglund, three great grandchildren, extended family and friends and her beloved dog Lulu.

Literature Published By Carol Skoglund

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Molluscan genera and species named for Carol Skoglund

Bivalvia:

- Crassinella skoglundae* Coan, 1979
Asthenothaerus subgenus *Skoglundia* Coan, 1990

Polyplacophora:

- Ischnochiton carolianus* Ferreira, 1984
Ischnochiton skoglundii Ferreira, 1985

Gastropoda:

- Epitonium (Nitidiscala) skoglundae* DuShane, 1974
Terebra carolae Bratcher, 1979
Cotonopsis (Cotonopsis) skoglundae Jung, 1989
Muricopsis skoglundae Myers, Hertz & D'Attilio, 1993
Zacatrophon skoglundae Houart, 2010
Typhisopsis carolskoglundae Houart & Hertz, 2006
Caecum skoglundae Pizzini, Raines & Nofroni, 2007
Sinezona carolarum Geiger & McLean, 2010
Cirsotrema skoglundae García, 2010



Figure 4. *Typhisopsis skoglundae* Houart & Hertz, 2006. Paratype. MNHM-IM 2000-6991. Bahía Honda, Panamá, in 120 m, Size: 22.9 mm. Photo: R. Houart.



Figure 5. *Zacatrophon skoglundae* Houart, 2010. Holotype. SBMNH 423912. Golfo de California, Baja California Sur México, brought in by San Juanico shrimpers. Size: 72 mm. Photo: R. Houart.

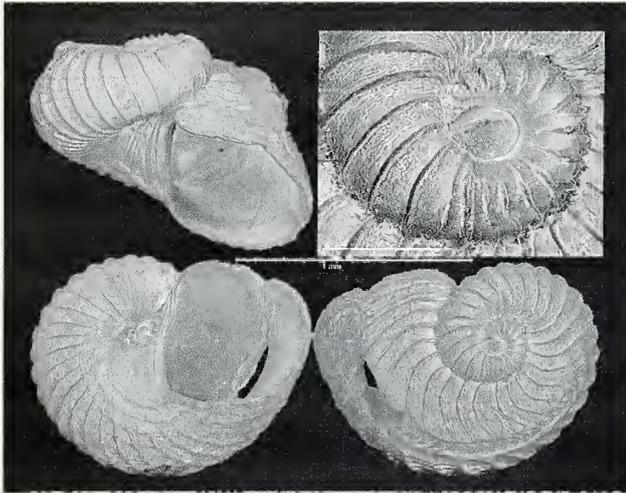


Figure 6. *Sinezona carolarum* Geiger & McLean, 2010. Holotype. East side, Clipperton Island, France in 15-30 m. (10.295°N, 109.201°W. SBMNH 83703. Scale bar shell = 500µm. (Named for both Carole Hertz & Carol Skoglund). Photo: D. Geiger.

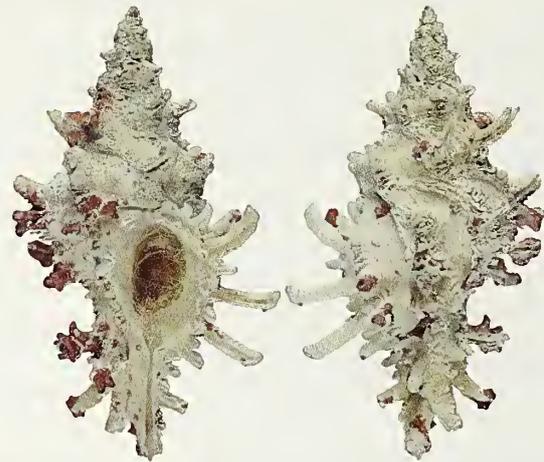


Figure 7. *Muricopsis skoglundae* Myers, Hertz & D'Attilio, 1993. Paratype, Hertz Collection. South of Isla Danzante, Golfo de California, Baja California Sur, México, dredged 100-150 ft. by Skoglund/Hertz on *Hyotissa hyotis*, October 8, 1991. Photo: B. Abela.

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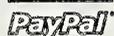
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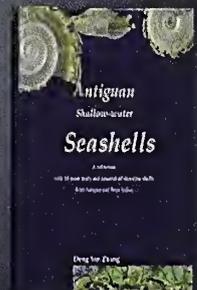
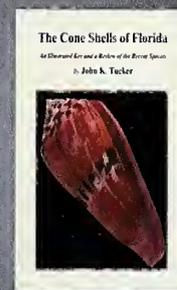
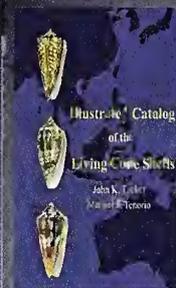
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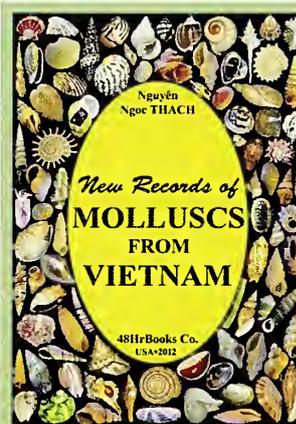
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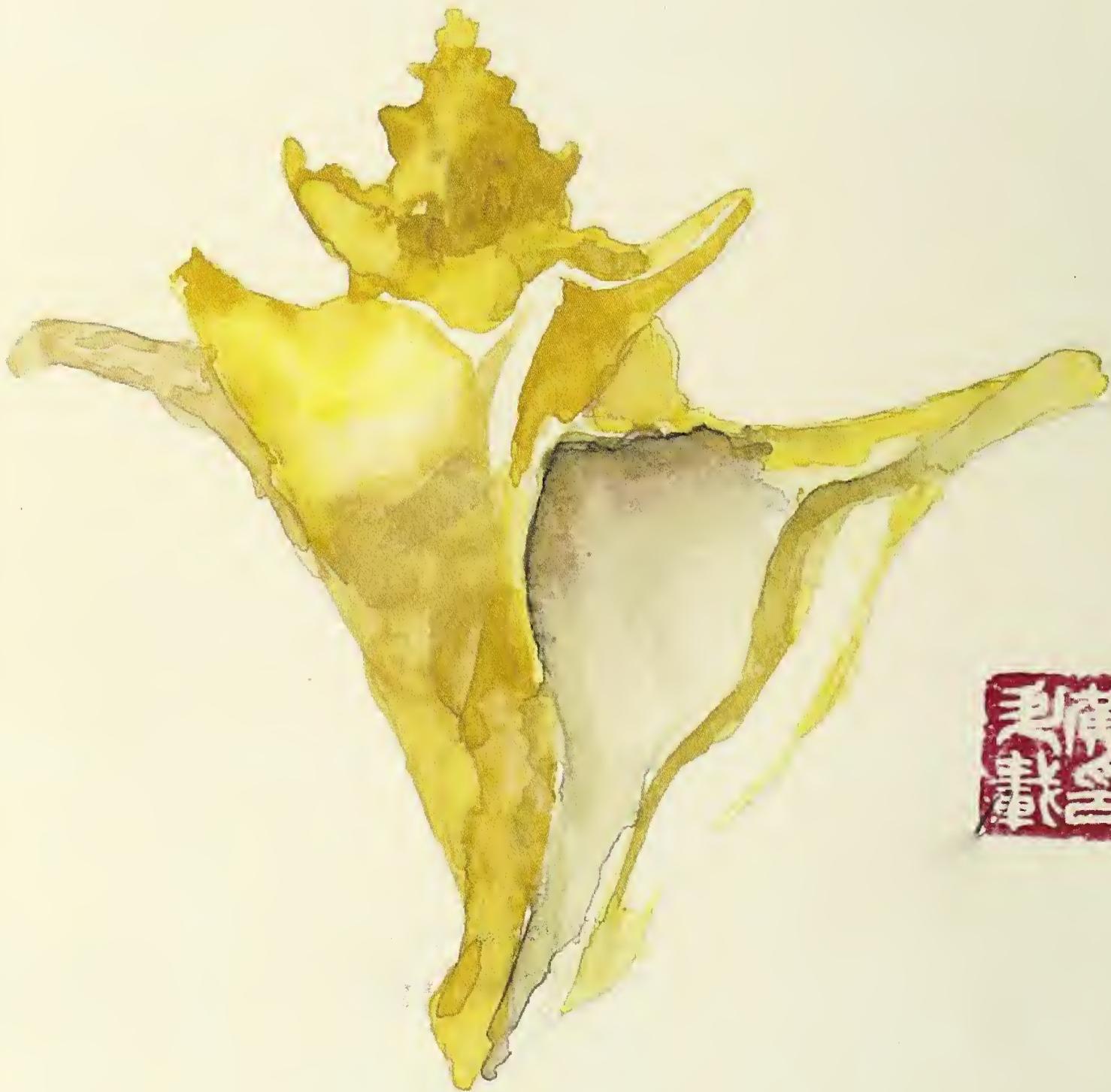
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BACK COVER: Water color painting of *Austrotrophon cerrosensis catalinensis* Oldroyd, 1927, by Ryan Hwang, winner of the chromatic category of the San Diego Shell Club's Art Competition in 2014.





THE Festivus

Vol. 47(2)

MAY 2015



Inside:

Observations of *Pteropurpura trialata*
A New Cockle Species from Vietnam
***Jaspidiconus* in the Tropical West Atlantic**
New Cypraeid and *Morum* from Brazil
Abalone without Respiratory Holes

Quarterly Publication of the San Diego Shell Club



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Volume: 47

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Editor Emerita Carole Hertz (1979–2014)

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REGULAR CLUB MEETINGS

Club meetings are held every month on the third Thursday of the month, except April, September and December, at either 7:30 p.m. in Room 104, Casa del Prado, Balboa Park, San Diego, or at 12:00 noon at Holiday Inn Express, 751 Raintree Drive, Carlsbad, conference room as noticed.

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FRONT COVER:

Image of a live *Pteropurpura trialata* (Sowerby, 1841) in Mission Bay, California, on the jetty by Paul Tuskes.
 (Cover artistic credit: Martin Schuler)

MISSION STATEMENT

The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, promote the study and promote the conservation of Mollusca, and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, amateurs and scientists, divers, underwater photographers and dealers.

THE FESTIVUS is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Review Board (which are of a scientific nature, including new taxa articles), as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field and preference. Available by request or on our website are:

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 County Fair: 6/5 to 7/5/15
 Shell Show & Sale: 8/15/2015
 September Party: 9/12/2015
 Holiday Party: 12/12/2015

Publication date: May 6, 2015



TABLE OF CONTENTS

Peer Reviewed Articles

- Observations Regarding the Biology of Pteropurpura trialata p. 85
By Paul M. Tuskes and Ann Tuskes
Taxonomic note - new species: Lyncina alicae Lum, 2013 p. 94
Vepricardium eichhorsti, a new species from Vietnam (Bivalvia: Cardiidae) p. 95
By Nguyen Ngoc Thach
A comparison of adaptive radiation in Conidae and Conilithidae (Gastropoda: Conoidea) in the Eastern and Western Atlantic, together with an iconography of the conilithid genus Jaspidiconus p. 99
By David P. Berschauer
Errata - "Review of the genus Carinapex Dall, 1924 with the description of ten new species (Gastropoda: Conoidea: Horaiclavidae) from the Pacific Ocean" p. 114
By Shawn G. Wiedrick
A New Cypraeid Subspecies and a New Morum from the Brazilian Molluscan Province p. 115
By Edward J. Petuch and Robert F. Myers
Abalone Without Holes: A Photo Iconography and Study of a Rare Morphological Variant of Haliotis (Gastropoda: Vetigastropoda) p. 126
By Buzz Owen, Brian N. Tissot, and David L. Leighton

Club News p. 137

Articles of General Interest

- Hawaiian Tree Snails p. 139
By David Rolfe
Of Threads And Strings And Little Green Lizards p. 141
By Larry Buck
April Potluck and Shell Auction p. 144
By William Schramm
Taxonomic note - new species: Poremskiconus mariaodetae Petuch & Myers, 2014 p. 145

Note: Shells listed as part of the John K. Tucker cone shell collection (JKT) in last issue's Dalliconus edpetuchi article, The Festivus 47(1) beginning at p. 51, are now part of the extensive molluscan collections at the Illinois Natural History Survey (INHS) in Champaign, Illinois.

San Diego County Fair - June 5th to July 5th, 2015

For the first time in a number of years, the San Diego Shell Club will be presenting an exhibit at the 2015 San Diego County Fair (previously called the Del Mar Fair). We will be featuring the shells of Southern California and a poster discussing our petition to make the Red Abalone (Haliotis rufescens) our State Marine Mollusk. The exhibit will be in the Mission Tower Building in the Gems and Minerals next to the entrance to the fine wood working exhibit. We are also looking for members to man our exhibit during the day for a couple of hours at a time answering questions about shells and our Club. If you are interested, please contact Larry Buck by phone at (760) 580-1726 or by e-mail at larry@glbuckplumbing.com. We look forward to seeing you at the Fair.

Observations Regarding the Biology of *Pteropurpura trialata*

Paul M. Tuskes and Ann Tuskes

3808 Sioux Ave. San Diego, CA 92117 tuskes@aol.com

ABSTRACT The Three-Wing Murex, *Pteropurpura trialata*, is a moderate sized predator that specializes in feeding on the vermetid snail *Serpulorbis squamigerus*. Reproduction occurs from February to August, but peak activity is April through June. Adult growth is not continuous but occurs in brief spurts most commonly when the water is cool between December and April. Shells from San Diego are notably different in both shape and size from those to the north in Los Angeles, California. The population in Orange County between San Diego and Los Angeles is intermediate for these characteristics. Distribution, abundance, habitat, feeding, reproduction, color forms and sub-adults are reviewed in this paper.

INTRODUCTION

The common name of *Pteropurpura trialata* (Sowerby, 1841) is the Three-Wing Murex. The three large varices, which form the wings are one characteristic common to all members in the genus *Pteropurpura*; the shape of the varices is unique to each species. Four species of *Pteropurpura* occur in Southern California; *P. trialata*, *P. macroptera* (Deshayes, 1838), *P. vokesae* (Emerson, 1964), and *P. festiva* (Hinds, 1844). McLean (1978) provides excellent photos of the ventral surface for each of these four species. Three additional species of *Pteropurpura* occur further south in Baja California, Mexico, these include, *P. centrifuga* (Hinds, 1844), *P. erinaceoides* (Valenciennes, 1832) and *P. leeanus* (Berry, 1959). The seven species from California and Baja California, Mexico represent approximately half the members of the genus. The pattern of the radula and operculum place *Pteropurpura* in the Muricidae subfamily Ocenebrinae (D'Attilio & Myers, 1983). Radwin & D'Attilio (1976) illustrate and discuss the shell morphology of all seven species. Until the recent past, species from the Californias have also been placed in the following genera: *Pterynotus*, *Calcitrapessa*, and *Ocenebra*.

Of these seven species, only the biology of *P. festiva* has been published by Tuskes & Tuskes (2009) who reviewed growth, reproduction, feeding, prey selection, resource partitioning, and habitat preference of that species. Although there are some similarities, the biology of *P. trialata* is notably different than that of *P. festiva* which will be compared in the discussion. Of the four species found in California, *P. trialata* is the largest and occurs from the intertidal zone to approximately 25 meters depth. No significant biological information other than the primary prey species of the adult has been published (Williams, 1978).

METHODS

In addition to general observation over many years, a study area on the Mission Bay jetty was selected that measured 130 m in length and 10 m in width. The depth range was intertidal to five meters. The study area was surveyed using SCUBA every month for two consecutive years. Photos were taken, water temperature and conditions recorded, and each snail was scored as to activity and condition of the shell. Fouling organisms begin settling on the shells within a month after a new growth was completed. Categories for condition include (1)

new growth in progress (2) new growth; no fouling on newest growth (3) clean; pattern of shell partially visible (4) old; heavy fouling but apex and siphon intact (5) very old; heavy fouling and the siphon and/or apex eroded. Clusters of egg capsules were photographed allowing for an accurate count. Egg capsules were collected in order to determine their size, the number of embryos/capsule and their developmental time at 70⁰ F. Other information recorded monthly included number of egg clusters observed, prey species, and reproductive activity. Each survey required 70 to 90 minutes underwater. The data was adjusted to observations per hour in order to standardize the catch (observations) per unit effort.

A mark recapture study was attempted. Each shell was measured prior to release with the expectation that if recaptured at a later date, then the rate of growth could be determined. In addition, the shells of mature but dead *P. trialata* were collected to examine fouling rates. These shells were cleaned, dried, and then 10 shells were glued with silicon sealer to each of six small jetty rocks (<30 lb). Each rock was marked "Research do not disturb" and then placed in the habitat. At six month intervals two shells from each rock (randomly selected prior to the dive) would be removed by cutting the binding sealer. The shells would be transported in water, and then all of the fouling material in two 1 cm² areas between varices removed, dried and then weighed. The resulting graph of weight/time was expected to produce a chart that could be used to estimate how long mature shells continued to live and reproduce after growth had stopped. Mature shells could then be collected, and released after 2 cm² area of fouling material was collected. After drying, the weight would be compared to the chart and a rough but adequate estimate of age after shell maturity may be generated.

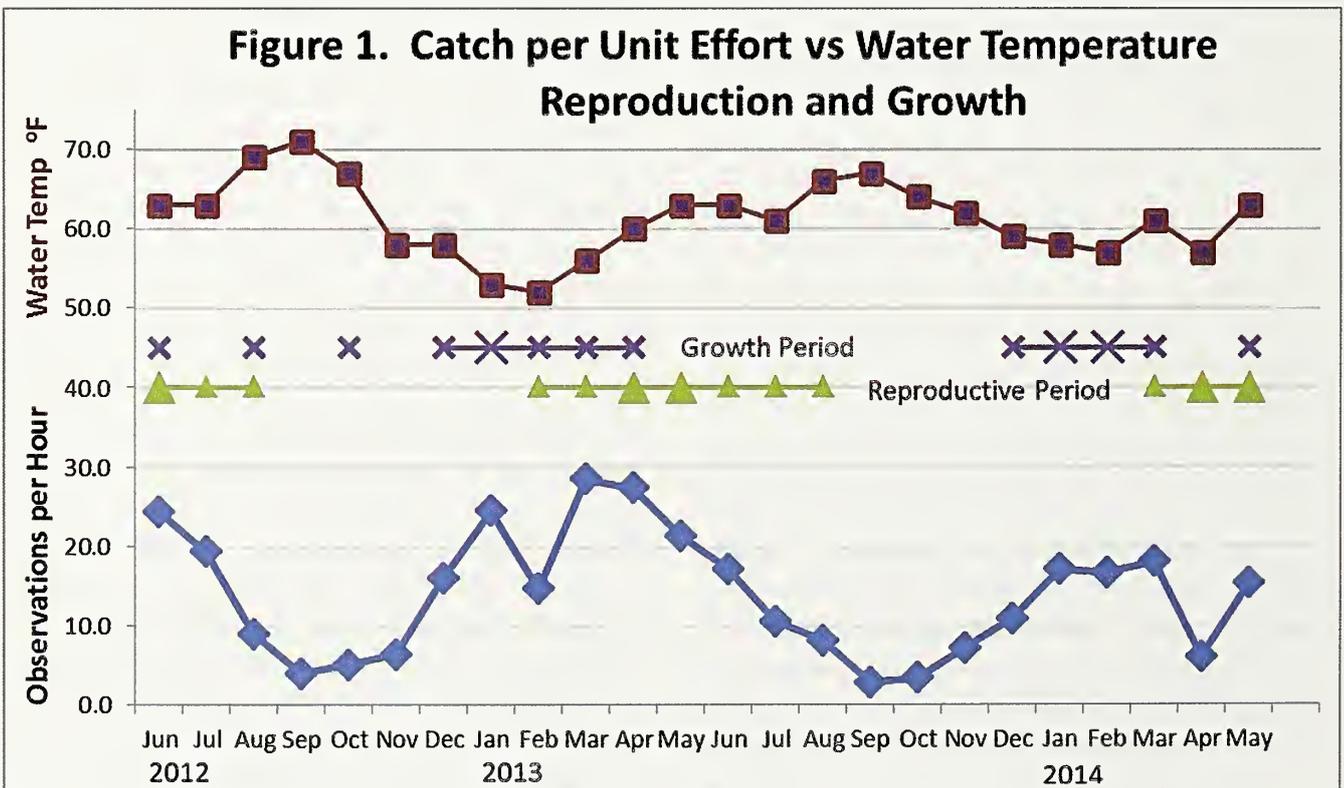
DISCUSSION

Distribution and Habitat. *Pteropurpura trialata* is most numerous from San Diego to Los Angeles, California. The northern limit of the range is currently believed to be Point Conception, which is approximately 45 miles west and slightly north of Santa Barbara, California. Point Conception is the boundary between the cooler Oregonian marine faunal province and the warmer Californian Province to the south. *Pteropurpura trialata* has been mistakenly illustrated as *Ceratostoma foliata* (Gmelin, 1791) on a number of occasions (Gotshall, 1994, McGinitie & McGinitie, 1949), and probably the source of the erroneous assumption by Morris *et al.* (1990) that *P. trialata* occurs in Northern California. McLean (1976) gave the southern record as Cedros Island, Baja California, Mexico. Hertz & Hertz (1984) reported a long list of typical Southern California gastropods found in the area of Punta Asuncion, Baja California Sur, Mexico, including live *P. trialata*. The southern range of *P. trialata* in Baja California is most likely further south than Asuncion, perhaps to the area of Magdalena Bay. Jackson (2001) published a range extension for the cowry *Neobernaya spadicea* from an off shore location just north of Magdalena Bay in Baja California Sur, Mexico. *Neobernaya spadicea* is a common companion species of *P. trialata* in water less than 15 m in depth. There were no southern records in the Scripps Institution of Oceanography collection (per. comm. Haim Cha, Curator SIO). In addition to the computerized data base of the Los Angeles County Museum of Natural History, the collections at both the Santa Barbara and San Diego Natural History Museums and that of the California Academy of Science were visited. Keen (1971) does not list this species from the Panamic region. Adults are associated with rocky habitat and are most commonly observed from the intertidal zone to a depth of 15-20 m, although some occur

deeper. North (1976) suggests they occur to depths of approximately 30 m or more, but the species he illustrated was not *P. trialata*, but rather *P. macroptera* which typically occurs deeper than *P. trialata*. There are no records of deep water specimens having been found in the extensive off shore sampling conducted by the City of San Diego EMTS Laboratory Ocean Monitoring Program (per. comm. Wendy Enright), and McLean & Gosliner (1996) did not include the species in the benthic survey of the Santa Maria Basin.

Abundance. Figure 1 shows the relative abundance of adults based on a catch per unit effort as described in the methods. With minor variation the same cycle is repeated annually. As water temperatures cool in November and December the number of adults observed in the same unit of time steadily increases. During

2013 and 2014 the water temperature reached its minimum in February. Peak adult occurrence is between January and April. As the water warms adults are less commonly observed; and each September during the warmest water, adult occurrence was at its low point. During November through April 2013/2014 winter water temperatures were as much as 6^oF warmer than the same period in 2012/2013, perhaps contributing to few adult observations when compared to the previous winter. Adults are occasionally found on sand close to rocks but they do not typically travel across open sand patches. It is possible that these individuals may have lost their footing on the rock. Night diving on numerous occasions does not suggest a shift in adult activity during darkness, thus the seasonal reduction in observations is most likely from adults moving deep into hidden spaces when not actively feeding.



McLean (1978) implies *P. trialata* is primarily an intertidal species. On the Mission Bay jetty, perhaps one percent of the population may be accessible during minus tides. Based on the shape of *P. trialata*, they are not adapted to live in environments routinely impacted by waves. The rhythmic flow of water from a swell is notably different than the force of waves hitting rocks in the intertidal zone. In Southern California, gastropods that live in the intertidal zone with notable wave action present a low smooth profile such as limpets, or a rounded shell that presents less drag, such as *Mexacanthina lugubris* (Sowerby, 1821), *Acanthina paucilirata* (Sterns, 1971), *A. punctulata* (Sowerby, 1825), *Acanthinucella spirata* (Blainville, 1832), *Roperia poulsoni* (Carpenter, 1864), *Ceratostoma nuttalli* (Conrad, 1837), and juvenile *Pteropurpura festiva*. Negus (1993) found *P. trialata* on rocks intertidally in the calm waters of Agua Hedionda Lagoon. On the Mission Bay jetty *P. trialata* is most abundant at depths from two to nine meters. Some individuals can be found in the lower intertidal zone, especially where there is no wave action on rocky habitat within the bay.

Adult Prey Species. The primary prey species for mature *P. trialata* is the vermetid snail *Serpulorbis squamigerus* (Carpenter, 1857). The common name for *S. squamigerus* is the Worm Snail, and is based on the unusual worm-like shape of their shell. They attach their shells to rocks or other *S. squamigerus* and can form dense colonies. Once these snails settle, they cannot move. As a result, the food must come to them. *Serpulorbis* are particulate feeders and tend to settle in areas with stronger currents; hence their higher than usual density along entry channels and subsequent reports of *P. trialata* being common at entries to bays. Tidal flows through channels produce higher water velocity than in the inner bays or the open ocean.

Serpulorbis occur off shore and in inner bays but their abundance in these areas is greatly reduced and they may be found singly rather than dense clusters.

In captivity, mature *P. trialata* consume a *S. squamigerus* in three to four days. They did not drill the tube of the snails, but rather extended their mouth down the aperture opening of the shell. In captivity, we observed on occasion that they would break away up to 8 mm from the lip of the *Serpulorbis*, presumably to reach deeper into the tube to access the animal. After feeding for three to four days the snail moves off and may wander or hold up in a recess for a week before feeding again. Williams (1976) reported that in captivity they drilled into the side of the *Serpulorbis* tube and consumed the snail. Clearly they have multiple modes of attack.

Growth and Size. When the water begins to cool from December through February the frequency of shells exhibiting new growth is highest. After that, it tapers off as the water warms (Figure 1) and the activity shifts to reproduction. During the actual growth cycle, when a new varices is added the snails are usually reclusive. Although some individuals occasionally display new shell growth during the summer, it is infrequent. McGinitie & McGinitie (1949) illustrate a *P. trialata* that while in captivity added a new inter-node and varices in 3 days. They remarked about the rapidity of growth and amount of calcium carbonate required; unfortunately, the caption in the book is mislabeled as *Ceratostoma foliata*. Mature snails do not put on a new growth each year. Shells that are heavily fouled often show extensive erosion on the apex, and even an inability to maintain the siphon structure. In captivity snails with complete shells typically replace the siphon within a few weeks, even when not in the growth phase. The animals

with eroded shells seldom repair siphons in captivity. These snails are still observed reproducing in the spring but we suspect that they are terminal adults, perhaps 2-3 years after their final growth period, and will not survive another year.

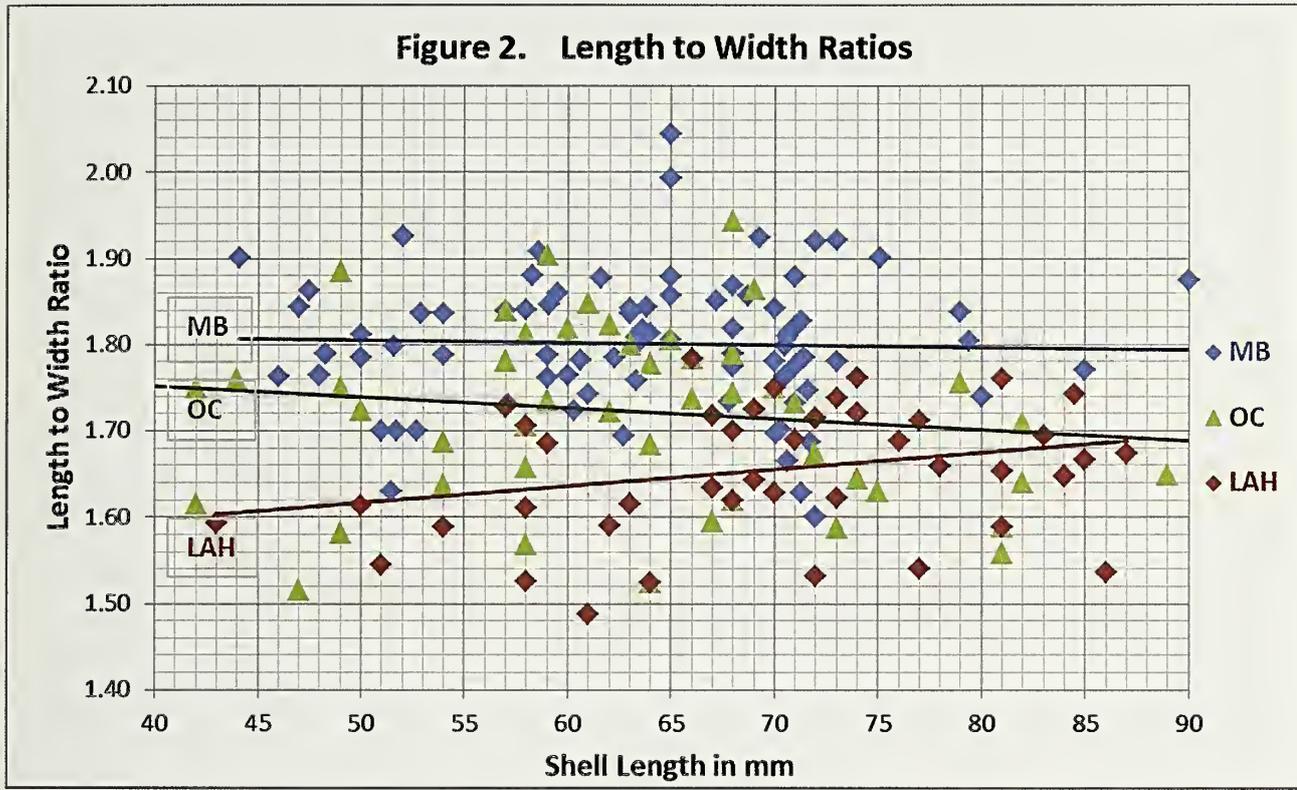
In 2012, three months prior to the start of the study, 158 live *P. trialata* were measured on a section of the Mission Bay (MB) jetty. The sample represented all individuals observed regardless of size. The average length was 62.4 mm, the median was 63.3 mm with a range from 44.1 to 74.7 mm. Shells in the 44-55 mm range added approximately 6.6 mm of length during the previous new growth; larger shells averaged an increase of 7.3 mm. Having surveyed the entire length of both the North and South jetty, shells greater than 75 mm are uncommon and only a few shells between 80 and 90 mm were observed.

Measurements of live individuals in naturally occurring populations may be difficult to compare to specimens in private collections and museums, as collectors typically do not randomly sample the population, but rather often focus on the largest or most attractive specimens. Data from Orange County (OC) and Los Angeles Harbor (LAH) jetty are based on measurements from private collections and museums. The average length of shells from OC was 61 mm ($n = 60$) while material from LAH averaged 70 mm in length ($n = 45$). Having dove the LAH jetty on a number of occasions, I found few *P. trialata* but they were larger than those found further south. To address the probable disparity between museum records and populations that were sampled randomly, the 15 largest specimens for MB, OC, and LAH from collections were compared. Collected material from MB averaged 77.8 mm and OC averaged 77.1 mm. The 15 largest specimens from LAH averaged 83.6 mm and

were statistically larger ($p > 0.025$) than those from MB or OC. The largest specimen measured is in the SBMNH collection and is 105 mm in length and was collected off Santa Barbara Island. The species is far less common in Santa Barbara County than further south. Only 14 museum specimens were located which collectively averaged 65.7 mm with a standard deviation ("STDV") of 9.3.

Adult Variation. There is notable variation in both color patterns and the shape of the shells. A paper by Rick Negus (1993) illustrates a wide range of color forms and discussed a dwarf population of adult *P. trialata* found in Agua Hedionda Lagoon, San Diego Co., CA. In Mission Bay, San Diego, the ratio of normally marked shells to the alba (totally white) forms is approximately 20:1. While alive, white shells typically have far fewer fouling organisms growing on them than shells with the typical brown patterns. The least common color form in MB is a white shell with 2-3 light brown bands and an orange aperture; that phenotype occurs at a frequency of perhaps 400:1. Among the Eastern Pacific *Pteropurpura*, a unique characteristic of *P. trialata* is that the banding on the shell is disrupted by the white varices. In other species such as *P. macroptera* form tremperi, *P. festiva*, *P. centrifuga*, and *P. erinaceoides*, the banding, when present, continues onto the varices.

Most shells from Santa Barbara, San Diego and many from Orange County are characterized by a slightly elongated spire and shorter varices, giving the shell a slender elongated shape (Figure 2 & 3b) when compared to material from Los Angeles Harbor. A 78 mm shell from LAH is 5 mm wider than a 90 mm shell from MB. The length to width ratio from LAH is 1.64. Specimens from OC, located between MB and LAH, had a ratio of 1.76. In MB the length to width ratio was 1.8. The best fit line for the



MB is nearly parallel to the x-axis indicating that length to width ratios changes very little as the mature shells continue to grow. As shells from LAH become larger, they appear slightly more elongated perhaps due to the length of the siphon. There were an insufficient number of shells from the area of Ensenada, Baja California, Mexico for a comparison to be meaningful. A third characteristic is the shape of the varices. Nearly all LAH shells have deeply scalloped varices (Figure 3a). In MB perhaps 50% have little or no scalloping, 40% have some scalloping (Figure 3b) and 10% have scalloping that approaches that of the LAH population. Collectors anecdotally associate smaller and less scalloped varices with rougher water conditions. A comparison in shell morphology between the inside and outside of the LAH jetty might prove or disprove the rough water hypothesis of collectors. Although shells from the LAH are easily distinguished from most MB specimens, there is a cline in

these characters with the OC material being somewhat intermediate to LAH and MB. The cause for this cline in shell shape has not been determined.

Reproduction. Reproductive clusters of *P. trialata* were observed on rocks starting in January or February. Clusters of egg capsules are found from February to August, but the highest frequency each year was when the water starts to warm from April to June (Figure 1); the timing puts the planktonic larvae in some of our warmest water. Females tend to deposit their cluster of egg capsules on vertical or near vertical rock surfaces with usually a minimal amount of red and brown algae present. Based on capsules deposited in captivity, development from the embryos to emergence from the capsule requires 19-21 days when held at 70°F. Development time at 60 to 65 °F may be considerably longer. Determining developmental time *in situ* was not practical as the

initial age of the capsules when found would not be known.

Twenty clusters of eggs were photographed and counted and two egg capsules each were collected from ten clusters. The average number of egg capsules per cluster was 59.8 (STDV of 14.9) and a range from a low of 34 to a high of 82 capsules/cluster (See Table 1). Capsules are yellow and have a short petiole that connects the capsule to the base matrix attached to the rock (See Figure 4a). Capsule length, including petiole, is from 10 to 13 mm, the width is approximately 6 mm and it is about 1.5 mm in thickness (See Figure 4b). The embryos/developing larvae are in a thick clear mucus-like material. Of the 20 capsules, two each from ten clusters, the number of embryos ranged from 255 to a high of 679 and averaged 484.5 (STDV of 127.7) embryos/capsule (See Table 1). Based on an average of 59.8 capsules/cluster and 484.5 embryos/capsule the average number of embryos/cluster is 28,973. It is not known if females are capable of depositing more than one cluster per season. Based on the biomass of the cluster it is unlikely that a second cluster of similar size could be produced. Ninety-two percent of the females observed depositing egg clusters were scored as old to very old, and only eight percent showed signs of recent new growth.

Embryos measure approximately 0.23 mm and are circular. As they develop they enlarge and elongate slightly prior to shell development. The capsules turn a dull brown prior to the larvae emerging. The planktonic larvae exit with a microscopic shell through an opening at the tip of the capsule. Females do not brood the egg capsules and leave the area after depositing them.

Capsules Per Cluster	Capsules Per Cluster	Embryos Per Capsule	Embryos Per Capsule
34	57	1 - 595	6 - 255
39	64	1 - 599	6 - 273
40	71	2 - 570	7 - 408
43	71	2 - 619	7 - 428
45	72	3 - 565	8 - 616
48	76	3 - 597	8 - 679
51	80	4 - 454	9 - 613
54	80	4 - 425	9 - 624
55	81	5 - 421	10 - 333
55	82	5 - 432	10 - 383
Average 59.8 capsules per cluster		Average 484.5 embryos per capsule	

Table 1. Number of Egg Capsules/Cluster and Number of Embryos/ Capsule.

Juveniles and Sub-adults. The location of juveniles and their development is unknown. We observe juvenile *Roperia poulsoni* (Carpenter, 1864), *Pteropurpura festiva* (Hinds, 1844), and *Maxwellia gemma* (Sowerby, 1878) from 8 to 15 mm in length, in the same habitat as adult *P. trialata* but no juvenile *P. trialata*. Night diving, and looking under rocks intertidally has not produced juveniles. We have also not found juveniles on the Dana Point or LA Harbor jetties. If juveniles were present, those that die may become the home of hermit crabs. Multiple dives to collect hermit crabs on the MB jetty have also failed to produce a juvenile shell of *P. trialata*. Conversations with divers/collectors have not turned up juveniles. Juvenile shells are absent from the collections in Southern California museums. The smallest sub adult examined measured 29 mm. From the protoconch the juvenile shell had 25 small rudimentary ridges prior to the first of five enlarging varices; at that size, the shell shape, sculpture and color is that of an adult *P. trialata*. The specimen was taken under a flat rock at 55' N.W. of Bird Rock, Orange County, Ca, by an unknown collector and given to Paul Kanner. A second small sub adult was

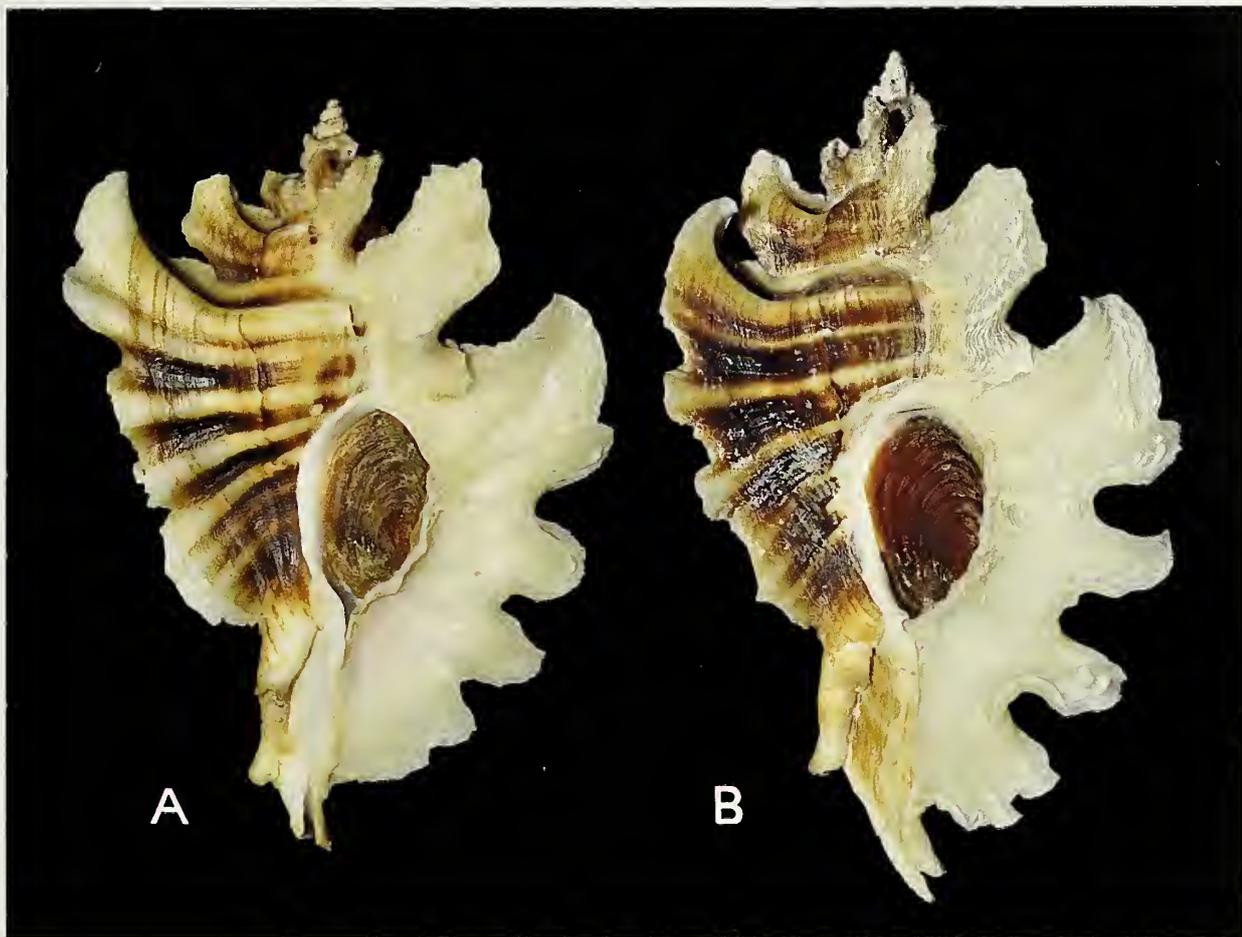


Figure 3. mature *P. trialata*. **A.** from Los Angeles Harbor. **B.** from Mission Bay. Note the difference in the length and orientation of the varices in relation to the apex.

found dead on the LA Harbor jetty by Larry Catarius and measured 30.9 mm. Prior to the development of expanded varices the juvenile shell might look similar to some species of *Ocenebra*. Juveniles and subadults must outnumber adults by multiple orders of magnitude, and therefore their general absence from the adult environment suggests they develop elsewhere, and as they mature move into the reproductive population and shift to a new prey species.

Poorman (1982) published interesting comments regarding the different habitat of juveniles and adults near San Carlos, Mexico. Adult *Cassia centiquadrata* (Valenciennes, 1832) were found in shallow water and intertidally, but in deep water (60 m)

only a few smaller adults were found but juveniles were common. He also noted that *Fusinus dupetitthouarsi* (Kiener, 1840) as small as 10 mm were dredged at 100 m but adults were taken in shallower water and in the intertidal zone.

Similarities and differences between the biology of *P. trialata* and *P. festiva*.

In Mission Bay, female *P. trialata* tend to deposit clusters of egg capsules in isolation and only occasionally close to clusters from another female. *Pteropurpura festiva* often form dense clusters of females all of which are depositing their egg capsules en mass. Both species reproduce as the water begins to warm and

neither species tend their egg clusters. Juvenile *P. festiva* are most commonly found on rocks with sub adults and small adults. Sub adults and small adults feed on limpets, barnacles, and other snails. The largest specimens (50 to 60+ mm) are often on sand, feeding on clams and occasionally bubble snails. Juvenile *P. trialata* do not appear to have been found and sub adults smaller than 40 mm are uncommon, suggesting that these stages must occur in a different habitat and perhaps different depth range. Mature *P. festiva* feed on a variety of gastropods, bivalves, and occasionally scavenge dead crustaceans. Mature *P. trialata* are specialized feeders targeting one species of gastropods, perhaps exclusively.



Figure 4. Egg capsules of *P. trialata*. A. typical cluster of capsules on a vertical rock surface. B. Individual egg capsule.

No Results. The mark recapture effort produced no results as bryozoans quickly overgrow the shell obscuring information, making it impossible to obtain data. The efforts of the fouling study were equally unproductive. Within the first month all shells were obscured by green algae, by the second month they were colonized by more complex brown algae which proved to be the immature stages of the giant kelp *Macrocystis pyrifera* (C. Agardh, 1820). By the third month the rocks and shells were being covered by *Sargassum* sp. and

Macrocystis. This succession of algae species is not observed on shells of living *P. trialata*. The rocks were retrieved and cleaned of algae and placed near the base of the jetty just above the sand at 5 m. Within three days the shells had been attacked and crushed by bat rays and only 5 remained undamaged. These negative results may benefit the design of others efforts.

ACKNOWLEDGMENTS

We would like to thank the staff at San Diego, Santa Barbara, and Los Angeles County Museums of Natural History, and the California Academy of Science for allowing visits to their collection or having placed specimen data online, the San Diego Life Guard Service for permission to dive certain locations, and Paul Kanner and Larry Catarius for making material available.

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Taxonomic note - new species: *Lyncina alicae* Lum, 2013 (Image of Paratype No. 1, by David Lum)

This gorgeous and rare Hawaiian endemic cowrie is compared to *L. schilderorum*, *L. sulcidentata*, and *L. kuroharai*. It has been referred to in the past as a hybrid of *L. schilderorum* and *L. sulcidentata*; however, it is distinct from them and shows a greater consistency of conchological characteristics than either *L. schilderorum* or *L. sulcidentata*. *L. alicae* has short, sharply-cut columellar and labral teeth, similar to those of *L. kuroharai* of the Western Pacific, and a cream colored aperture on a tan base. In comparison, *L. schilderorum* has a mostly white base, a bright white aperture, and very fine columellar and labral teeth restricted to the aperture; and *L. sulcidentata* has very long stout teeth, with the labral teeth reaching up to half way across the labrum, and a light tan colored aperture and base. Finally, *L. alicae* has light tan flecks over a dark tan background on the margins which creates a chatoyant effect with a mild irregular vertical line pattern akin to *L. sulcidentata*, whereas *L. schilderorum* has very distinct and regularly spaced fine vertical lines along the right margin. (Lum, David 2013. A new species of *Lyncina* from Hawaii (Mollusca: Cypraeidae). *Beautifulcowries Magazine* 4: 4-11.)

***Vepricardium eichhorsti*, a new species from Vietnam
(Bivalvia: Cardiidae)**

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KEYWORDS Mollusca, Bivalvia, Cardiidae, *Vepricardium*, Nha Trang, Khánh Hòa, Bình Thuận, Bình Định, Central Vietnam, muddy sand, new.

ABSTRACT A new species of genus *Vepricardium* Iredale, 1929 is described from Nha Trang, Khánh Hòa, Central Vietnam and compared to four other species of this genus.

INTRODUCTION The genus *Vepricardium* is a main genus of the subfamily Cardiinae Lamarck, 1809 with four species collected in Vietnam: *Vepricardium sinense* (Sowerby II, 1839), *Vepricardium coronatum* (Schröter, 1786), *Vepricardium asiaticum* (Bruguère, 1789) and *Vepricardium multispinosum* (Sowerby II, 1839). At the beginning of 2014, an hitherto unknown cockle was found. It was not included in the works by Lutaenko (2000), Hylleberg & Kilburn (2003), Thach (2005, 2007 and 2012). It belongs to *Vepricardium* and is described as new to science.

Abbreviations

ANSP = Academy of Natural Sciences, Philadelphia, USA

MNHN= Muséum National d'Histoire Naturelle, Paris, France

NMNS = National Museum of Nature and Science, Tokyo, Japan

NNT = Collection N.N.Thach

TE = Collection T.Eichhorst

RV = Right valve

SH = Shell height

SL = Shell length

SW = Shell width

SYSTEMATICS

Class Bivalvia Linnaeus, 1758

Family Cardiidae Lamarck, 1809

Subfamily Cardiinae Lamarck, 1809

Genus *Vepricardium* Iredale, 1929

Type species: *Vepricardium pulchricostatum* Iredale, 1929

***Vepricardium eichhorsti* n sp.**

Figures 1-3, 5-7 and 9-11

Diagnosis. Shell with nearly symmetrical shape, long and nearly straight dorsal margin, highly raised and strongly calloused escutcheon and lunule.

Description. Shell subcircular in outline, nearly symmetrical in shape with mean SL 28-35mm in adult size (measured on seven specimens). Anterior margin more curved than posterior one. Dorsal margin long and nearly straight, ventral margin strongly convex and highly crenulated. Shell slightly longer than high with SL 107% SH (see table 1). Valves rather inflated with SW 73.5% SH (table 1) and not closing tightly at both anterior and posterior ends. Sculpture consisting of about 22 rounded radial ribs (table

1) bearing numerous small granules with wide interspaces between ribs. Escutcheon and lunule solid heavily calloused and white in color. Ligament exterior rounded and brown, umbones broad high and nearly touching. Hinge long with strong teeth. Pallial sinus lacking, pallial line entire and well separated from ventral margin. Posterior adductor scar ovate, periostracum moderately thick. Color exteriorly whitish and interiorly white.

Type material.

Holotype 34.8mm long in ANSP (Fig.1). Paratypes: all from type locality, Paratype 1: 33.5mm long in NMNS (Fig.2). Paratype 2: 28.4mm long in MNHN (Fig.3). Paratype 3: 38.1mm long in NNT (Fig.10). Paratype 4:

36.1mm long in NNT (Fig.11). Paratype 5: 34.8mm long in TE (Fig.7). Paratype 6: 38.4mm long in NNT (not illustrated).

Type locality. Nha Trang, Khánh Hòa Province, Central Vietnam.

Range and habitat. along the coast of Central Vietnam, from Bình Thuận to Bình Định Provinces. Type specimens were collected at 5-20m depth on muddy sand.

Etymology. This new species was named in honor of Thomas Eichhorst of USA for his contribution to the development of conchology of the world.

Specimen No	SL (mm)	SH (mm)	SL/SH	Mean SL/SH	SW (mm)	SW/S H	Mean SW/SH	Number of ribs (RV)	Mean Number of ribs
Holotype	34.8	32.5	1.071	1.07 (107%)	24.0	0.738	0.735 (73.5%)	21	21.71 ribs
Paratype 1	33.5	31.4	1.067		22.8	0.726		21	
Paratype 2	28.4	26.8	1.060		18.8	0.701		22	
Paratype 3	38.1	35.0	1.089		25.5	0.729		22	
Paratype 4	36.1	32.8	1.101		24.7	0.753		23	
Paratype 5	34.8	33.0	1.055		25.3	0.767		21	
Paratype 6	38.4	35.5	1.082		26.0	0.732		22	

Table 1. SL/SH, SW/SH and Number of radial ribs of *Vepricardium eichhorsti* n sp.

Discussion. *Vepricardium eichhorsti* n sp. is closest to *Vepricardium sinense* (Sowerby, 1839) but differs in six stable characters that are summarized in Table 2.

- *Vasticardium eichhorsti* differs from *Vepricardium coronatum* (Schröter, 1786) in more symmetrical shape, less numerous radial ribs and lack of long ends of these ribs along margins.

- *Vepricardium eichhorsti* differs from *Vepricardium asiaticum* (Bruguière, 1789) in less swollen shape, smaller adult size, less numerous radial ribs, highly raised lunule and lower umbones.

- *Vepricardium eichhorsti* differs from *Vepricardium multispinosum* (Sowerby II, 1839) in much smaller adult size, rounded radial ribs and lack of strong spines on these ribs.

	<i>Vepricardium eichhorsti</i>	<i>Vepricardium sinense</i>	<i>Vepricardium coronatum</i>	<i>Vepricardium asiaticum</i>	<i>Vepricardium multispinosum</i>
Mean size	28-35mm	30-40mm	25-35mm	45-55mm	50-60mm
Shape	Subcircular, nearly symmetrical	Ovate, narrowing posteriorly	Ovate, tapering posteriorly	Ovate	Ovate
Dorsal margin	Nearly straight	Strongly arched	Descending posteriorly	Slightly arched	Slightly arched
Radial ribs	Rounded and widely spaced	Inverted -V shaped, widely-spaced	Ribs extend over ventral margin	Round topped slightly spinous	Round topped, strongly spinous
Escutcheon & Lunule	Heavily calloused and highly raised	Escutcheon strongly inflated	Calloused and raised	Escutcheon slightly raised, lunule calloused	Escutcheon raised, lunule concave
Posterior adductor scar	Ovate	Elongate ovate	Elongate ovate and red	Elongate ovate	Ovate and not well visible

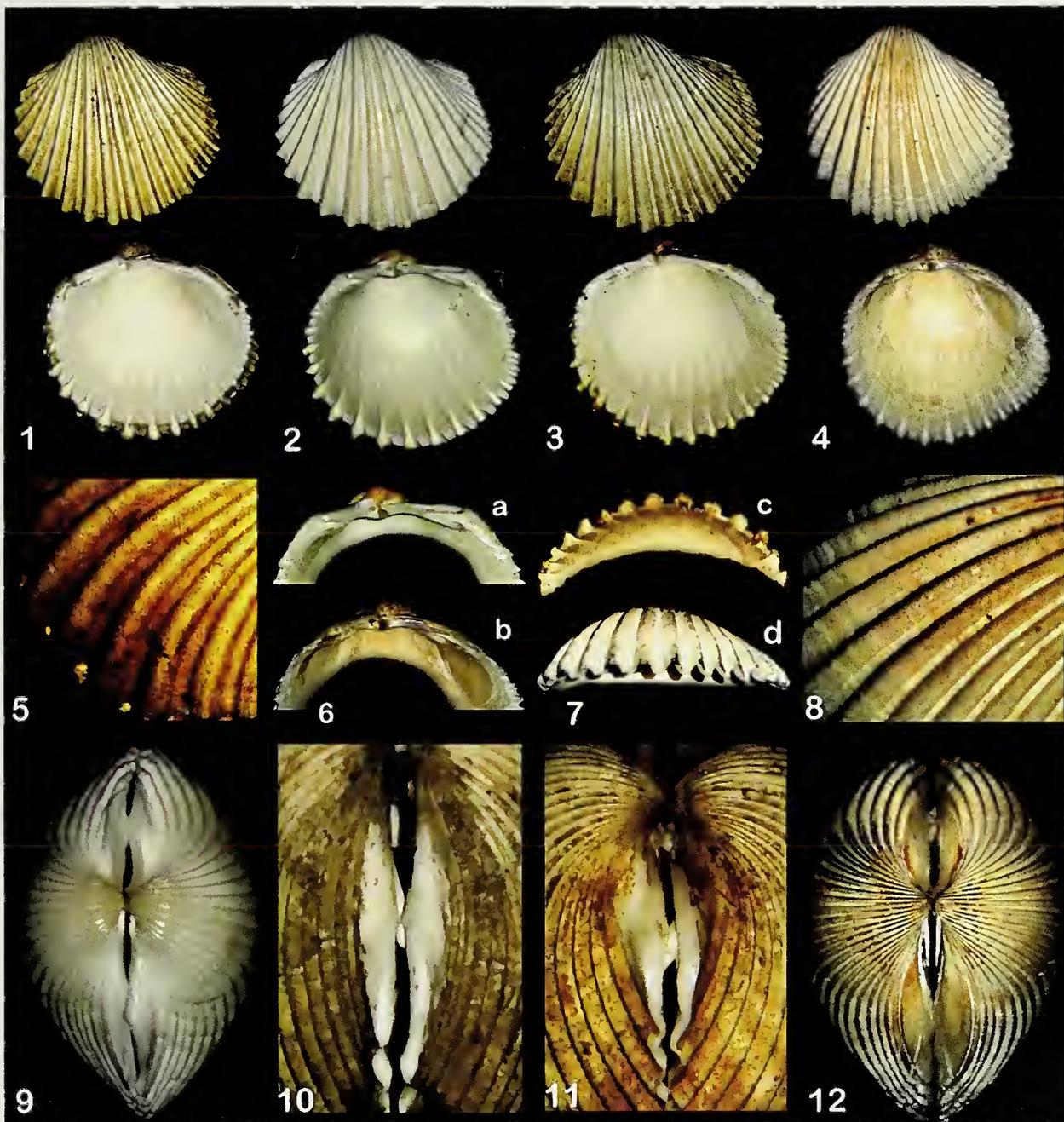
Table 2. Comparison of *Vepricardium eichhorsti* vs. *Vepricardium sinense*, *Vepricardium coronatum*, *Vepricardium asiaticum*, *Vepricardium multispinosum*

ACKNOWLEDGEMENTS

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Figures. 1-3: *Vepricardium eichhorsti* n.sp., Nha Trang, Vietnam- 1: Holotype 34.8mm SL, ANSP- 2: Paratype 1: 33.5mm SL, NMNS. 3: Paratype 2: 28.4mm SL, MNHN- 4: *Vepricardium sinense* 45.2mm SL, Vietnam for comparison- 5-7: *Vepricardium eichhorsti* n.sp.- 5: Detail of radial ribs, specimen 34.8mm SL (Paratype 5)- 6: Hinge of Paratype 1 (a) compared to that of *Vepricardium sinense* (b) - 7: Profile of radial ribs of Paratype 5 (c) compared to those of *Vepricardium sinense* (d)- 8: *Vepricardium sinense* specimen 45.2mm SL with detail of radial ribs for comparison- 9-11: *Vepricardium eichhorsti* n.sp.- 9: Dorsal view of Paratype 1- 10: Escutcheon of Paratype 3- 11: Lunule of Paratype 4- 12: *Vepricardium sinense* 45.2mm SL dorsal view for comparison.

A comparison of adaptive radiation in Conidae and Conilithidae (Gastropoda: Conoidea) in the Eastern and Western Atlantic, together with an iconography of the conilithid genus *Jaspidiconus*

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ABSTRACT Comparison is made between two diverse faunas of conoidean gastropods in the tropical western Atlantic and eastern Atlantic, which have undergone dramatic adaptive radiation in a relatively short geological period. Hypothetical speciation processes of these groups are discussed, compared and contrasted. A complete iconography of the living species of *Jaspidiconus* together with a discussion of biogeographic regions is made to place these species hypotheses in their environmental and ecological context, together with a discussion of the requirement of total evidence and suggestions for further studies.

KEYWORDS Adaptive radiation, evolution, allopatric speciation, sympatric speciation, species flock, iconography, *Jaspidiconus*, *Coltroconus*, *Africonus*, Conidae, Conilithidae.

INTRODUCTION

Conoidean gastropods and their associated conotoxins have rapidly evolved to fill diverse ecological niches. There are over 760 living species of cones, and an estimated 10,000 living species of turrids (Bouchet & Lozouet, 2004; Tucker, 2004; Pulliandre, *et al.*, 2014; Tucker & Tenorio, 2013). This remarkable evolutionary radiation is believed to be due to the dietary specialization and the predator-prey co-evolution of neurotoxins used by conoidean gastropods to subdue their prey (Taylor, *et al.*, 1980; Duda & Palumbi, 2004; Chang & Duda, 2012; Olivera, *et al.*, 2012; Pulliandre, *et al.*, 2014). A comparison of the adaptive radiation of two diverse groups of conoidean gastropods is presented.

DISCUSSION

Species flocks or swarms are rarely reported from marine environments. A species "flock" is defined as an endemic and monophyletic assemblage of taxa that rapidly evolved in a

small defined geographic area with no obvious barriers to dispersal (Duda & Rolan, 2005). Species flocks tend to occur in relatively closed systems following colonization of an isolated area. There are over 70 species of *Africonus* which have evolved in the last few million years that are restricted to the Cape Verde archipelago (Tucker & Tenorio, 2013). These gastropods fit the definition of a species flock with species that originated in limited parts of the archipelago. In some cases, species radiations occurred within a single island (Duda & Rolan, 2005).

Allopatric speciation or geographic speciation occurs when biological populations of the same species become isolated from each other to an extent that interferes with or prevents breeding and genetic exchange. Over time the two populations undergo genotypic or phenotypic divergence as a result of different selective pressures, mutations, or genetic drift, evolving distinctly different characteristics to the point where the two populations are unable to successfully mate with one another (Lande,

1980; Hoskin, *et al.*, 2005). This is based upon Ernst Mayr's "biological species concept" (BSC) which emphasizes reproductive isolation for determining species (Mayr, 1963). The BSC states: "A species is defined as a population or group of populations whose members have the potential to interbreed with one another in nature and to produce viable offspring, but cannot produce viable, fertile offspring with members of other species." (Mayr, 1970). This definition of species does not exclude the occurrence of hybrids, albeit the definition assumes that such hybrids would be sterile and unable to produce viable offspring; cf. the Liger, a hybrid offspring of a male lion (*Panthera leo*) and a female tiger (*Panthera tigris*) which often is fertile (Mott, 2005). Hybridization in the mollusca is believed to be an uncommon event, with recognized hybrids in the Haliotidae and Strombidae; whether such hybrids are fertile or sterile is unknown (Owen, *et al.*, 1971; Kronenberg, 2008). Nevertheless, fertile hybrids challenge the very definition of what constitutes a species.

Sympatric speciation occurs when a new species evolves from an ancestral species while inhabiting the same geographic area; this is a splitting event, *i.e.* at least two species are the end product. Sympatric speciation is thought to be an uncommon but plausible process by which two or more breeding populations of the same species become reproductively isolated and therefore subject to different causal events such as genetic drift due to different mutations, and different selective pressures (Kondrashov, *et al.*, 1999; Fitzpatrick, *et al.*, 2008). While sympatric speciation is controversial and it has been posited that different microhabitats or niches, mating signals or timing, among groups in a species can lead to reproductive isolation (Jiggins, 2006). In other words, if such speciation is truly allopatric, then it is a matter of scale. There are, however, true instances of

sympatric speciation, polyploidy in plants and another mode seen among some insects where breeding behavior is immediately modified. This is at the core of adaptive radiation.

Isolated marine faunas do not typically occur because of the lack of barriers to restrict or define geographic areas within oceans (Palumbi, 1994; Duda & Rolan, 2005). Nonetheless endemic species do occur, and some areas exhibit a high degree of endemism. The majority of conid (Conidae and Colilithidae) species, about 75%, undergo a planktonic development in their life history (Kohn & Perron, 1994), however the Cape Verde endemic species in the genus *Africonus*, and the Western Atlantic species in the conilithid genus *Jaspidiconus* (described by Petuch, 2003), have lechithotrophic benthic development, *i.e.* they are direct developers with no planktonic larval stage. Juveniles hatch directly from egg capsules and dispersal is limited to how far an individual can crawl in its lifetime within their habitat (Trovao, *et al.*, 1990; Duda & Rolan, 2005; Petuch & Myers, 2014). Distances between suitable shallow water habitats on different islands in the Caribbean isolated both by many miles and inhospitable depths, combined with direct development hypothetically severely restrict gene flow between islands. The resulting isolation of breeding populations can facilitate evolution either by adaptive radiation, genetic drift, or fixation of unique traits in a founder population. Endemic species of conoidean gastropods are believed to be relatively common throughout the Western Atlantic, and constitute a significant part of the quantitative analysis of what comprises a marine faunal province or subprovince (Petuch, 2013).

While the Cape Verde archipelago genus *Africonus* has been described as a species flock, some scientists have been reluctant to recognize

the allopatric speciation of the Western Atlantic conids in the genus *Jaspidiconus* either via adaptive radiation, genetic drift, or founder population. Some researchers believe that the apparent biodiversity of the genus is represented in the single type species *J. jaspideus* s.s. (Gmelin, 1791), which they believe to be highly variable (Tucker, 2012; Kohn, 2014, synonymizing most species and recognizing only the single genus *Conus*). This single species hypothesis does not accept the premise that allopatric speciation of *Jaspidiconus* has occurred in the Caribbean throughout geological time.

The tropical and subtropical Western Atlantic Region from Cape Hatteras, North Carolina, United States, south to Mar del Plata, Argentina, encompasses three marine faunal regions (the Carolinian, Caribbean, and Brazilian), each of which has its own separate fauna of conoidean gastropods (Petuch, 2013; Petuch & Myers, 2014a). The conolithid genus *Jaspidiconus* in these marine faunal provinces is thought to include at least 60 species, approximately one-third of which are still undescribed (Petuch, personal communication). *Jaspidiconus* have proportionately large paucispiral protoconchs, have lechithotrophic benthic development, never dispersing far from where they hatch (Petuch, 2013; Petuch & Myers, 2014a). Given the fact that *Jaspidiconus* species have lechithotrophic benthic development, inhabit relatively shallow water, they have limited dispersal capabilities, a high degree of endemism among the myriad islands and coral cays throughout these provinces is believed to be the result (Petuch, 2013; Petuch & Myers, 2014a). The Holocene species in *Coltroconus* are believed to have recently evolved from *Jaspidiconus*, and are included as part of the radiation of this successful group (Petuch, 2013; Petuch & Myers, 2014b included *Coltroconus* as a subgenus of *Jaspidiconus*).

Only one species of *Jaspidiconus* has a broad distribution throughout these three major provinces, *J. mindanus* (Hwass in Bruguiere, 1792), which is found from the Floridian Subprovince of the Carolinian Province south through the Brazilian Province; the remaining species are either endemics, have restricted ranges, or are far southern coastal species such as *J. pusio* or *J. pusillus*. *J. mindanus* may have geographically localized forms or subspecies including: *J. mindanus agassizii* (Dall, 1886), *J. mindanus bermudensis* (Clench, 1942), *J. mindanus karinae* (Nowell-Usticke, 1968), and *J. mindanus lymani* (Clench, 1942); these localized forms or subspecies may reflect the beginning stages of speciation. An iconography of the living *Jaspidiconus* species hypotheses broken down by marine faunal provinces and subprovinces from north to south follows.

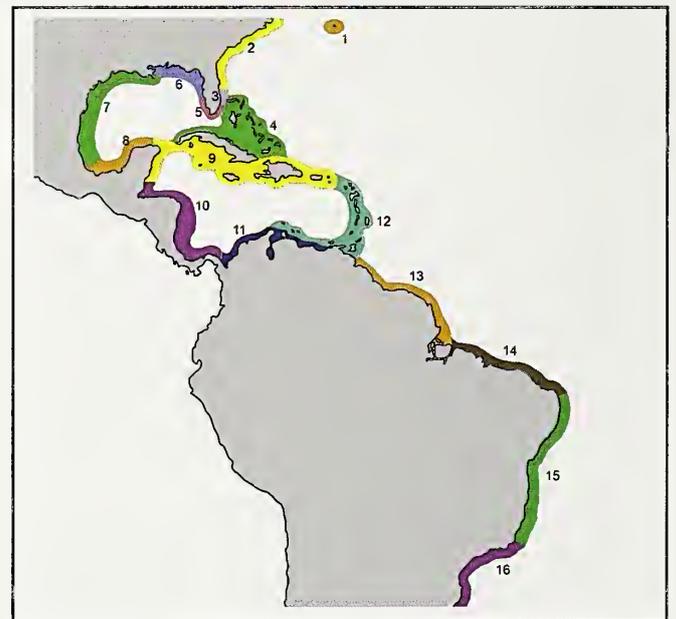


Figure 1. Tropical Western Atlantic biogeographical zones: 1. Bahamian Subprovince, 2. Georgian Subprovince, 3. Palm Beach Provinciatone (of the Georgian Subprovince), 4. Bermudan Subprovince, 5. Floridian Subprovince, 6. Suwannean Subprovince, 7. Texan Subprovince, 8. Yucatanian Subprovince, 9. Antillean Subprovince, 10. Nicaraguan Subprovince, 11. Venezuelan Subprovince, 12. Grenadian Subprovince, 13. Surinamian Subprovince, 14. Cearaian Subprovince, 15. Bahian Subprovince, 16. Paulinian Subprovince.

ICONOGRAPHY OF LIVING *JASPIDICONUS*

Carolinian Province.

Georgian Subprovince

J. pfluegeri Petuch, 2003 (North Carolina to Palm Beach, and also Middle Florida Keys)

Floridian Subprovince

J. fluviamaris Petuch & Sargent, 2011 (Palm Beach to Dry Tortugas)

J. pealii (Green, 1830) (endemic to Florida Keys)

J. vanhyningi (Rehder, 1944) (Palm Beach to Florida Keys)

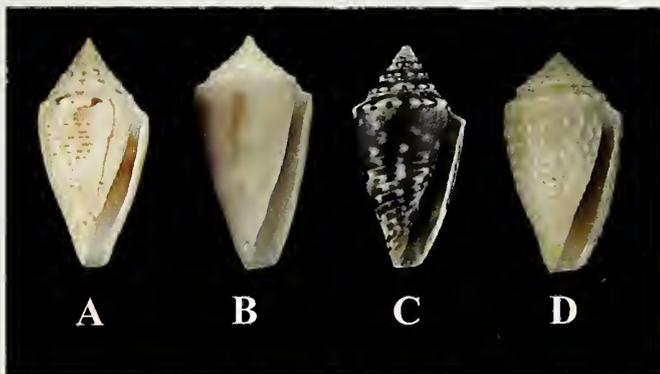


Figure 2. Georgian and Floridian Subprovinces: A = *Jaspidiconus pfluegeri* Petuch, 2003 holotype; B = *J. fluviamaris* Petuch & Sargent, 2011 holotype; C = *J. pealii* (Green, 1830) from the David P. Berschauer Collection (collected by Edward Petuch, Middle Torch Key, Florida); D = *J. vanhyningi* (Rehder, 1944) holotype.

Suwannean Subprovince

J. stearnsii (Conrad, 1869) (endemic to coastal Suwannean Subprovince)

Texan Subprovince

None

Yucatanean Subprovince

Yet unnamed species



Figure 3. Suwannean Subprovince: A = *Jaspidiconus stearnsii* (Conrad, 1869) holotype; B = *J. stearnsii* (Conrad, 1869) from the Alexander Medvedev Collection.

Caribbean Province.

Bermudan Subprovince

J. mindanus bermudensis (Clench, 1942) (endemic to Bermuda)

Bahamian Subprovince

J. branhamae (Clench, 1953) (endemic to the Abacos)

J. exumaensis Petuch, 2013 (endemic to Exuma Sound)

J. herndli Petuch & Myers, 2014a (endemic to S. Bimini Chain, Great Bahama Bank)

J. nodiferus (Kiener, 1847) (Bahamas to Lesser Antilles)

J. oleiniki Petuch, 2013 (endemic to the Bimini Chain)

J. verrucosus (Hwass in Bruguiere, 1792) (Bahamas to Lesser Antilles)

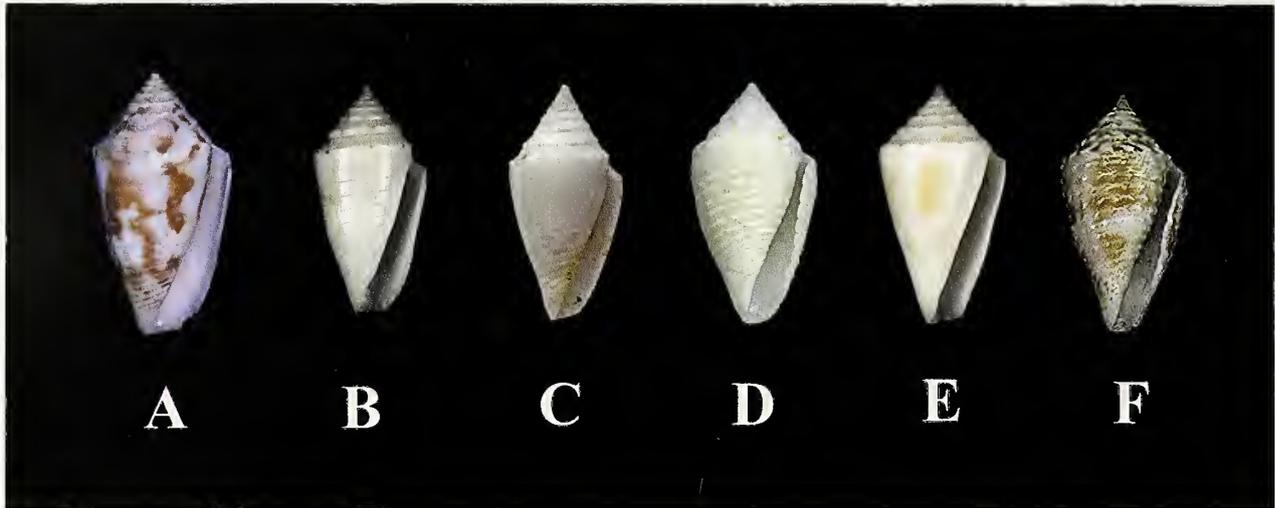


Figure 4. Bahamian Subprovince: A= *Jaspidiconus branhamae* (Clench, 1953) holotype; B= *J. exumaensis* Petuch, 2013 holotype; C= *J. herndli* Petuch & Myers, 2014 holotype; D= *J. nodiferus* (Kiener, 1847) from the Paul Kersten Collection; E= *J. oleiniki* Petuch, 2013 holotype; F= *J. verrucosus* (Hwass in Bruguiere, 1792) from the Paul Kersten Collection.

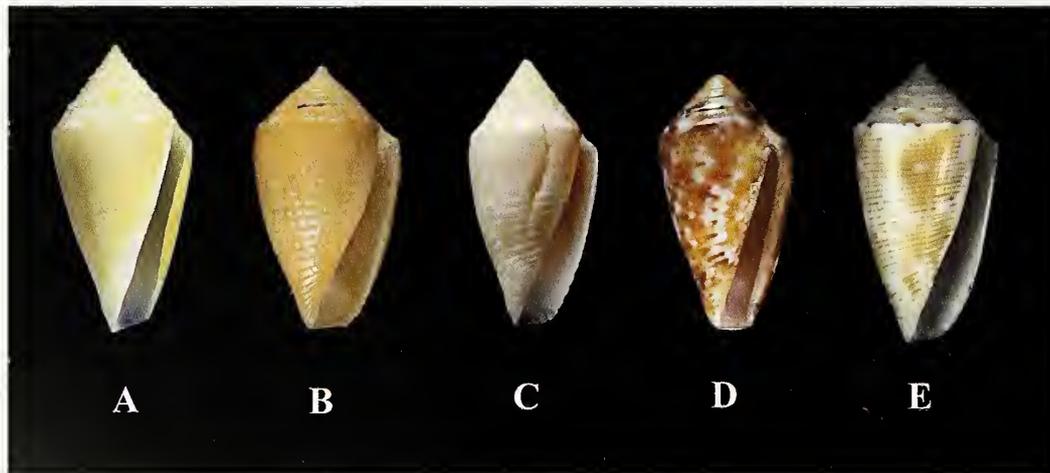


Figure 5. Antillean Subprovince: A= *Jaspidiconus agassizii* (Dall, 1886) lectotype; B= *J. anaglypticus* (Crosse, 1865) holotype; C= *J. berschaueri* Petuch & Myers, 2014 holotype; D= *J. duvali* (Bernardi, 1862) holotype; E= *J. mackintoshi* Petuch, 2013 holotype.

Antillean Subprovince

- J. agassizii* (Dall, 1886) (endemic to St. Croix, US Virgin Islands)
- J. anaglypticus* (Crosse, 1865) (endemic to Puerto Rico)
- J. berschaueri* Petuch & Myers, 2014a (endemic to St. Maartin Island)
- J. duvali* (Bernardi, 1862) (endemic to Guadalupe)
- J. mackintoshi* Petuch, 2013 (endemic to the Virgin Islands)

Nicaraguan Subprovince

- J. alexandremonteiroi* Cossignani, 2014 (endemic to Cayos Miskitos, Nicaragua)^Δ
- J. allamandi* Petuch, 2103 (endemic to Roatan Island)
- J. roatanensis* Petuch & Sargent, 2011 (endemic to Roatan Island)
- J. sargenti* Petuch, 2013 (endemic to Roatan Island)

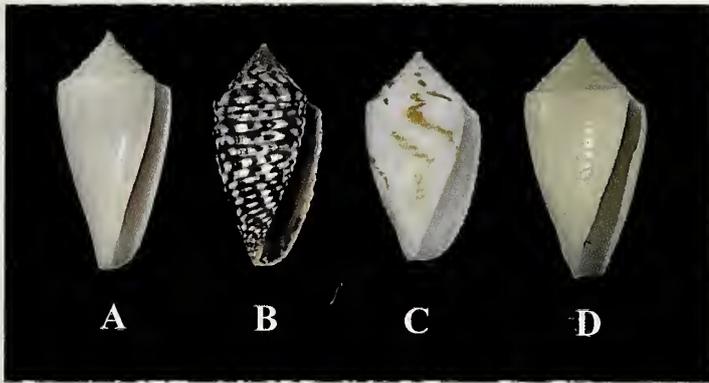


Figure 6. Nicaraguan Subprovince: A= *Jaspidiconus alexandremonteiroi* Cossignani, 2014^Δ holotype; B= *J. allamandi* Petuch, 2013 holotype; C= *J. roatanensis* Petuch & Sargent, 2011 holotype; D= *J. sargenti* Petuch, 2013 holotype.

Venezuelan Subprovince

- J. acutimarginatus* (Sowerby, 1866)
(coastal along Colombia to Venezuela)
J. jaspideus (Gmelin, 1791) (coastal
along Colombia to Venezuela)



Figure 7. Venezuelan Subprovince: A= *Jaspidiconus acutimarginatus* (Sowerby, 1866) holotype; B= *J. jaspideus* (Gmelin, 1791) neotype.

Grenadian Subprovince

- J. arawak* Petuch & Myers, 2014a
(endemic to Central Grenadine Islands)
J. duvali (Bernard, 1862) (endemic to
Guadalupe)

J. jaspideus (Gmelin, 1791) (neotype is
from Monos Island, Trinidad;
Grenadines to Tobago)

J. pusio (Hwass in Bruguiere, 1792)
(Grenada to northern Brazil)

Surinamian Subprovince

J. pusio (Hwass in Bruguiere, 1792)
(Grenada to northern Brazil)

Brazilian Province.

Cearaian Subprovince

- J. damasoi* Cossignani, 2007 (endemic
to Ceara coast, Brazil)
J. damasomonteiroi Petuch & Myers,
2014 (endemic to Ceara coast and
offshore Canopus Bank, Brazil)
J. pusio (Hwass in Bruguiere, 1792)
(Grenada to Brazil)
J. pusillus (Lamarck, 1810) (endemic
to Brazilian Province)

Bahian Subprovince (a localized species swarm reflecting adaptive radiation)

- J. (Coltroconus) bodarti* Coltro, 2004
(endemic to Abrolhos Platform)
J. (C.) delucaii Coltro, 2004 (endemic
to Abrolhos Platform)
J. (C.) henriquei (Petuch & Myers,
2014a) (endemic to Royal Charlotte
Bank, Abrolhos Platform, Brazil)
J. (C.) iansa (Petuch, 1979) (endemic
to Abrolhos Platform)
J. (C.) schirrmeisteri Coltro, 2004
(endemic to Abrolhos Platform)
J. ericmonnieri Petuch & Myers, 2014a
(endemic to Bahian Subprovince,
Brazil)
J. henckesi Coltro, 2004 (endemic to
Todos os Santos Bay, Brazil)
J. marinae Petuch & Myers, 2014b
(endemic to Porto Itaparica Island,
Brazil)

^Δ See Note on page 110, left margin

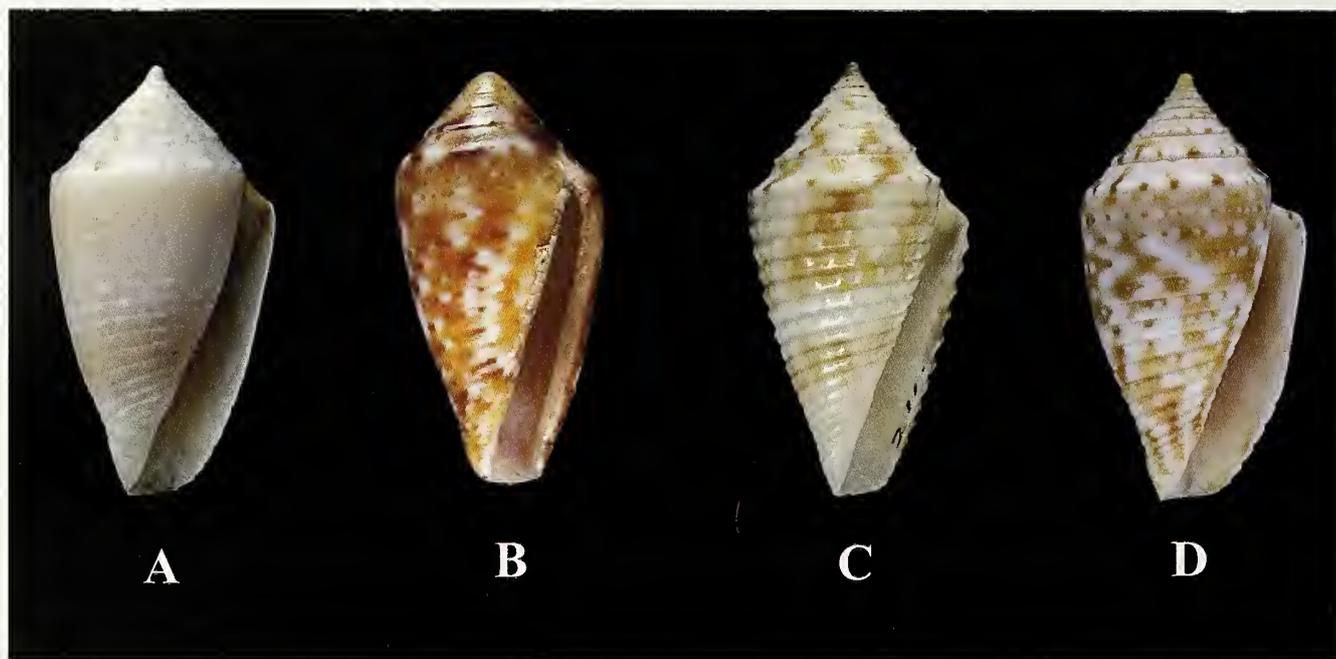


Figure 8. Grenadian Subprovince: A= *Jaspidiconus arawak* Petuch & Myers, 2014 holotype; B= *J. duvali* (Bernard, 1862) holotype; C= *J. jaspideus* (Gmelin, 1791) neotype; D= *J. pusio* (Hwass in Bruguiere, 1792) from the André Poremski Collection.

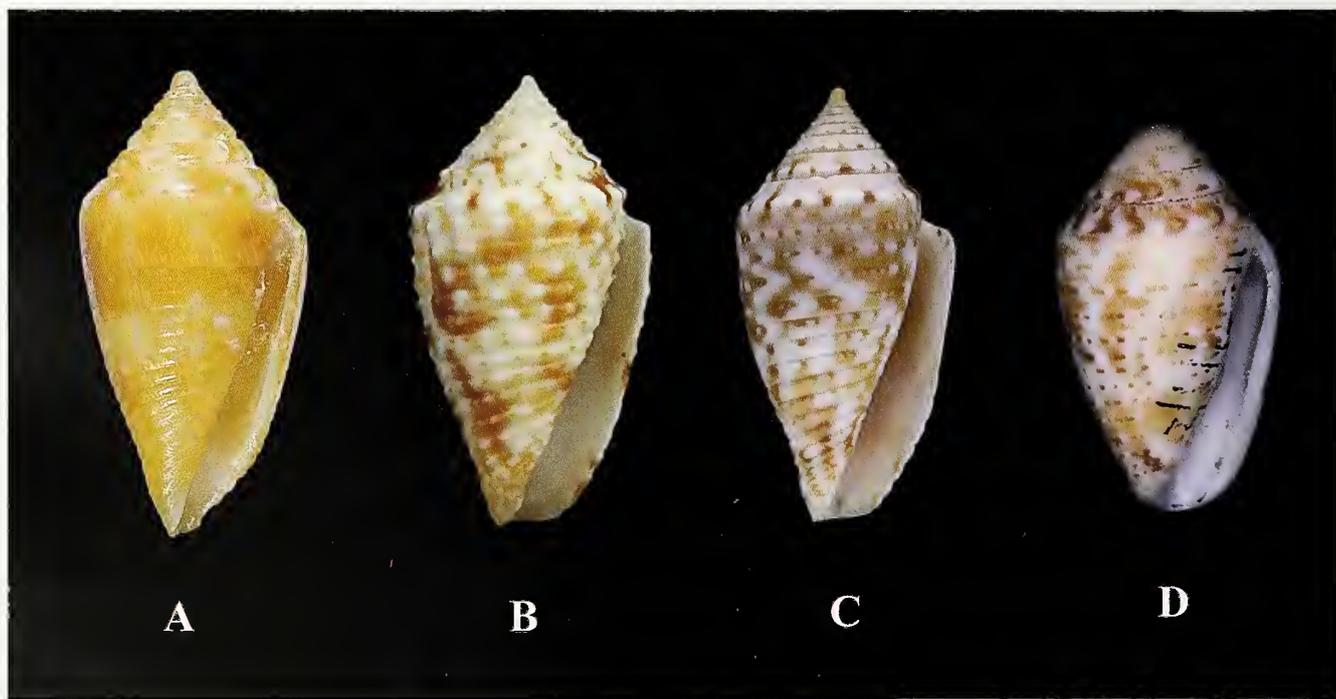


Figure 9. Cearaian Subprovince: A= *Jaspidiconus damasoi* Cossignani, 2007 holotype; B= *J. damasomonteiroi* Petuch & Myers, 2014 holotype; C= *J. pusio* (Hwass in Bruguiere, 1792) from the André Poremski Collection; D= *J. pusillus* (Lamarck, 1810) lectotype.

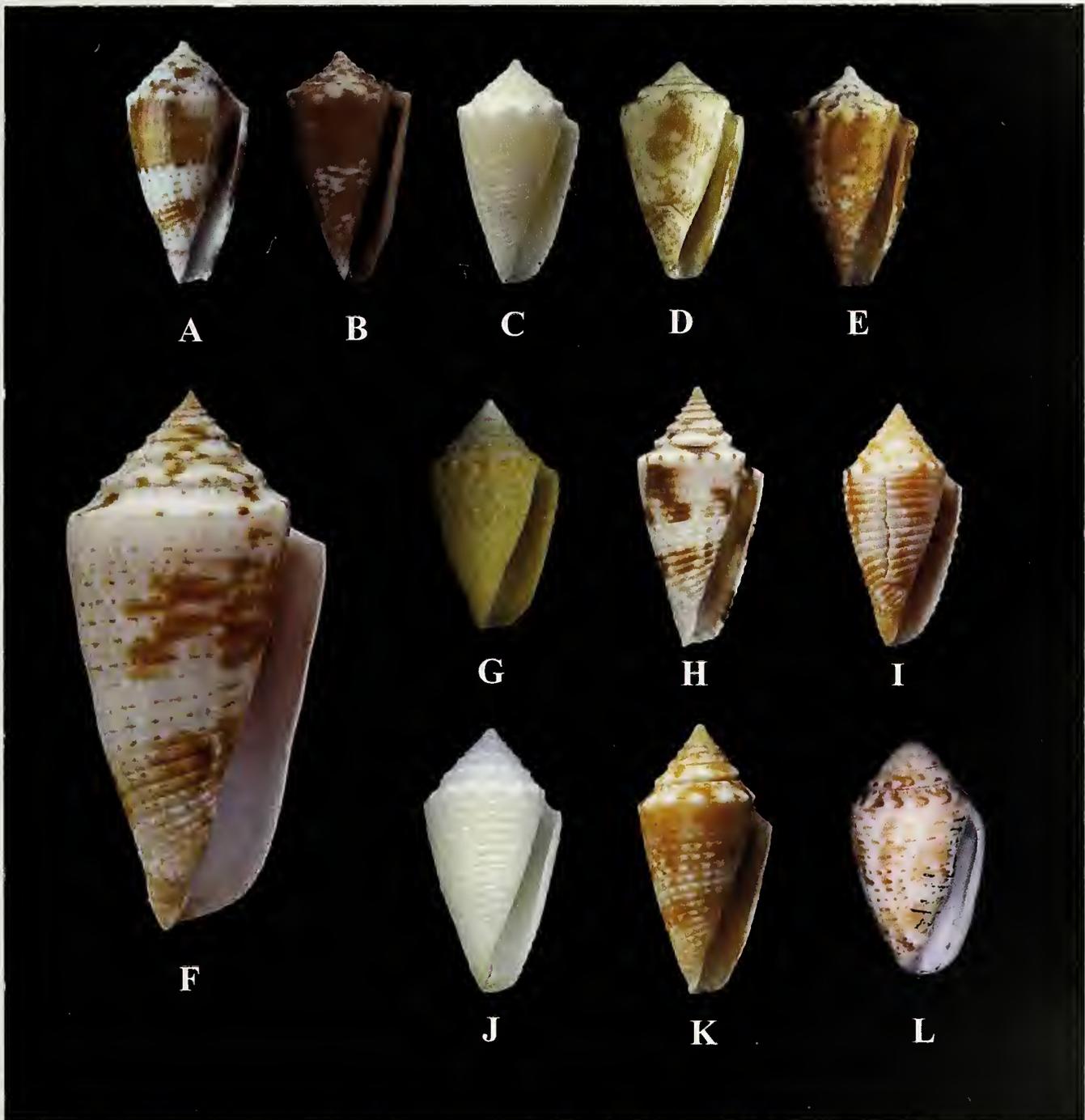


Figure 10. Bahian Subprovince: A= *Jaspidiconus (Coltroconus) bodarti* Coltro, 2004 holotype; B= *J. (C.) delucaii* Coltro, 2004 holotype; C= *J. (C.) henriquei* (Petuch & Myers, 2014) holotype; D= *J. (C.) iansa* (Petuch, 1979) holotype; E= *J. (C.) schirrmeisteri* Coltro, 2004 holotype; F= *Jaspidiconus ericomnieri* Petuch & Myers, 2014 holotype; G= *J. henckesi* Coltro, 2004 holotype; H= *J. marinae* Petuch & Myers, 2014 holotype; I= *J. ogum* Petuch & Myers, 2014 holotype; J= *J. pomponeti* Petuch & Myers, 2014 holotype; K= *J. poremskii* Petuch & Myers, 2014 holotype; L= *J. pusillus* (Lamarck, 1810) lectotype.

J. ogum Petuch & Myers, 2014a
(endemic to Aratuba, Itaparica Island,
Brazil)

J. pomponeti Petuch & Myers, 2014b
(endemic to Ribeira, Todos os Santos
Bay, Brazil)

J. poremskii Petuch & Myers, 2014a
(endemic to Bahia State, Brazil)

J. pusillus (Lamarck, 1810) (endemic
to Brazilian Province)

Paulinian Subprovince

J. pusillus (Lamarck, 1810) (endemic
to Brazilian Province)

J. simonei Petuch & Myers, 2014b
(endemic from Guarapari to central Rio
de Janeiro State, Brazil)

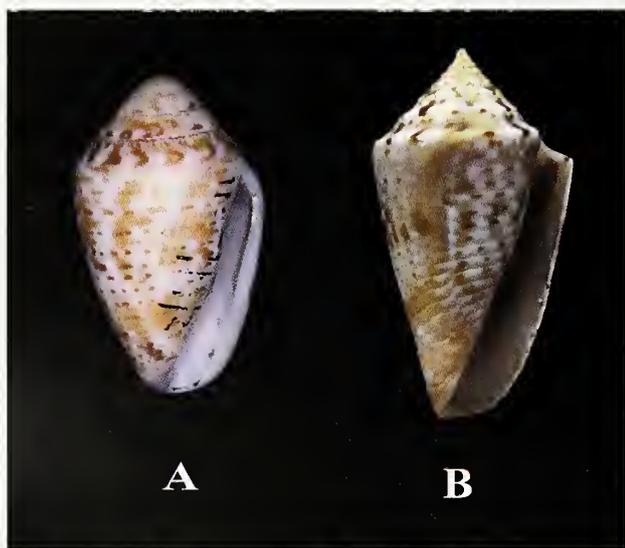


Figure 11. Paulinian Subprovince: A= *Jaspidiconus pusillus* (Lamarck, 1810) lectotype; B= *J. simonei* Petuch & Myers, 2014 holotype.

ANALYSIS

Although the conid genus *Africonus* in the Cape Verde archipelago has been determined to have undergone dramatic adaptive radiation, no such similar finding has previously been made concerning the conilithid genus *Jaspidiconus* in the Western Atlantic. *Africonus* evolved on a

number of small islands close together, some species seem to be restricted to a single bay of an island, and evolved in what has been called “explosive radiation” akin to a species flock (Duda & Rolan, 2005). At present, approximately 80 species of *Africonus* have been described. In comparison, the genus *Jaspidiconus* ranges from the Georgian Subprovince of the Carolinean Province, south to the Southern Paulinian Subprovince of the Brazilian Province - an area encompassing thousands of miles of coastline and hundreds of isolated islands, seamounts, coral cays, and coral reefs. *Jaspidiconus* which do not have a planktonic stage may be predisposed to greater genetic isolation due to their inability to transverse deep marine channels which separate many islands, leading to allopatric speciation. This hypothesis assumes that either (1) the ancestor of modern *Jaspidiconus* had planktonic larvae with wide dispersal abilities and that once in suitable habitats it evolved benthic development, or alternatively that (2) in the geological past sea levels varied as much as 100 meters higher or lower and the ancestral *Jaspidiconus* had a wide range across shallow seas connecting what are now distant islands. Allopatric speciation occurring across such a vast area, together with geographic isolation of *Jaspidiconus* species (both in terms of nautical distance and uninhabitable water depths which constitute reproductive barriers), and the fact that these Conoidean gastropods have benthic development accounts for the incredible biodiversity in the genus. The evolution of so many species of *Jaspidiconus* in these regions of the Western Atlantic is most likely a result of allopatric speciation and should certainly be less controversial than the similar adaptive radiation of *Africonus* which occurred in the shallow waters around the small archipelago of Cape Verde islands - a confirmed case of sympatric speciation; however at the scale of these

individuals, the mechanism is probably allopatric.

There have been very few radular studies (but see the comprehensive analysis of Tucker & Tenorio, 2009), and no morphometric analyses, conotoxin studies, or molecular studies of the various species hypotheses of *Jaspidiconus* (or many other genera of mollusks) to date, likely due to factors including availability of fresh specimens, funding, limited availability of technical experts and laboratory space. Many taxonomists today have been adding these methods into their analyses when comparing populations of mollusks and making a hypothesis by naming taxa, synonymizing taxa, or postulating the evolutionary relationships between species, much like scanning electron microscopes (SEM) were the latest scientific “tool” in the 1980s. This is not to say that mitochondrial RNA (“mRNA”) studies, or nuclear DNA studies are the best or the only approved method to determine species, however such studies are another new “tool” used by scientists in evaluating populations of organisms (Pulliandre, *et al.* 2014). Thoughts such as these constitute “molecular hubris” (Tucker personal communication). In fact, past mRNA molecular phylogenies on Conidae *s.s.* have not been conclusive, and more mRNA loci as well as nuclear DNA also should be included in such studies to obtain comprehensive results. A recent study found that mRNA expression is not always conserved across generations (as assumed in such studies) and is subject to gain and loss, as well as pervasive secondary loss, and these factors combined with significant sampling error collectively render mRNA based phylogeny analysis unreliable at best (Thompson, *et al.*, 2014). Molecular phylogenists proceed to collect mRNA (and occasionally one or two nuclear DNA loci) from dozens to hundreds of species, make unstated assumptions (including

but not limited to species hypotheses) and then after subjecting the data to a multivariate statistical cladistic or Bayesian analysis, some authors have made sweeping phylogenetic conclusions. Such studies based only on nucleic acid sequence data to the exclusion of other relevant properties therefore fail the requirement of total evidence (Fitzhugh, 2006) and constitute an inappropriate methodological hubris.

All species descriptions are a hypothesis. Therefore, whether the biodiversity seen in the Cape Verde Islands in the genus *Africonus*, and throughout the Caribbean in the genus *Jaspidiconus*, cannot be explained as hypothesized speciation events, and instead whether these “so called species” may more properly be called subspecies, phenotypic variation (or forms), or genetic variation within a species, remains to be determined by well reasoned studies that satisfy the scientific requirement of total evidence (Fitzhugh, 2005; Fitzhugh, 2006). There have been no such studies to date, therefore these species hypotheses should stand until proven to the contrary. Tried and true scientific methods of the last two hundred years such as morphology, anatomy, physiology, ecology, biogeography, and morphometric analysis are still the primary methods used by taxonomists to describe and compare species, genera and families, and to postulate about evolutionary relationships between groups. Future research on this fascinating group of rapidly evolving conoidean gastropods should include these primary methods as well as radular studies, conotoxin studies, and comprehensive molecular phylogeny studies to satisfy the requirement of total evidence and help understand the evolutionary relationships between these organisms, as is currently being done, albeit sporadically with a number of conoidean gastropods.

ACKNOWLEDGEMENTS

The iconography portion of this paper could not have been possible without the help and generous assistance of Paul Kersten, Gavin Malcom, Alexander Medvedev, André Poremski, Dennis Sargent, and Robert Myers in allowing the use of their images of *Jaspidiconus* holotypes. Special thanks to Edward Petuch, Manuel Tenorio, John K. Tucker, and Kirk Fitzhugh for discussions, critical review and analysis, and to William Cargile and William Fenzan for discussions about the diverse *Jaspidiconus* group. I also express my gratitude to Leo G. Ros, David DeLucia, Peter Steelman, Manuel Tenorio, Carlos Afonso, Bernardino Monteiro, Nelson Tiago, Ramiro Fiadeiro, and Damaso Monteiro for specimens of these fascinating and diverse cone shells.

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- ^Δ **Note:** *Jaspidiconus alexandremonteiroi* Cossignani, 2014 is believed to be a subadult specimen of *Tukericonus ceruttii* (Cargile, 1997) by some experts, rather than a true *Jaspidiconus*. (Paul Kersten, António Monteiro, Edward Petuch, personal communication)

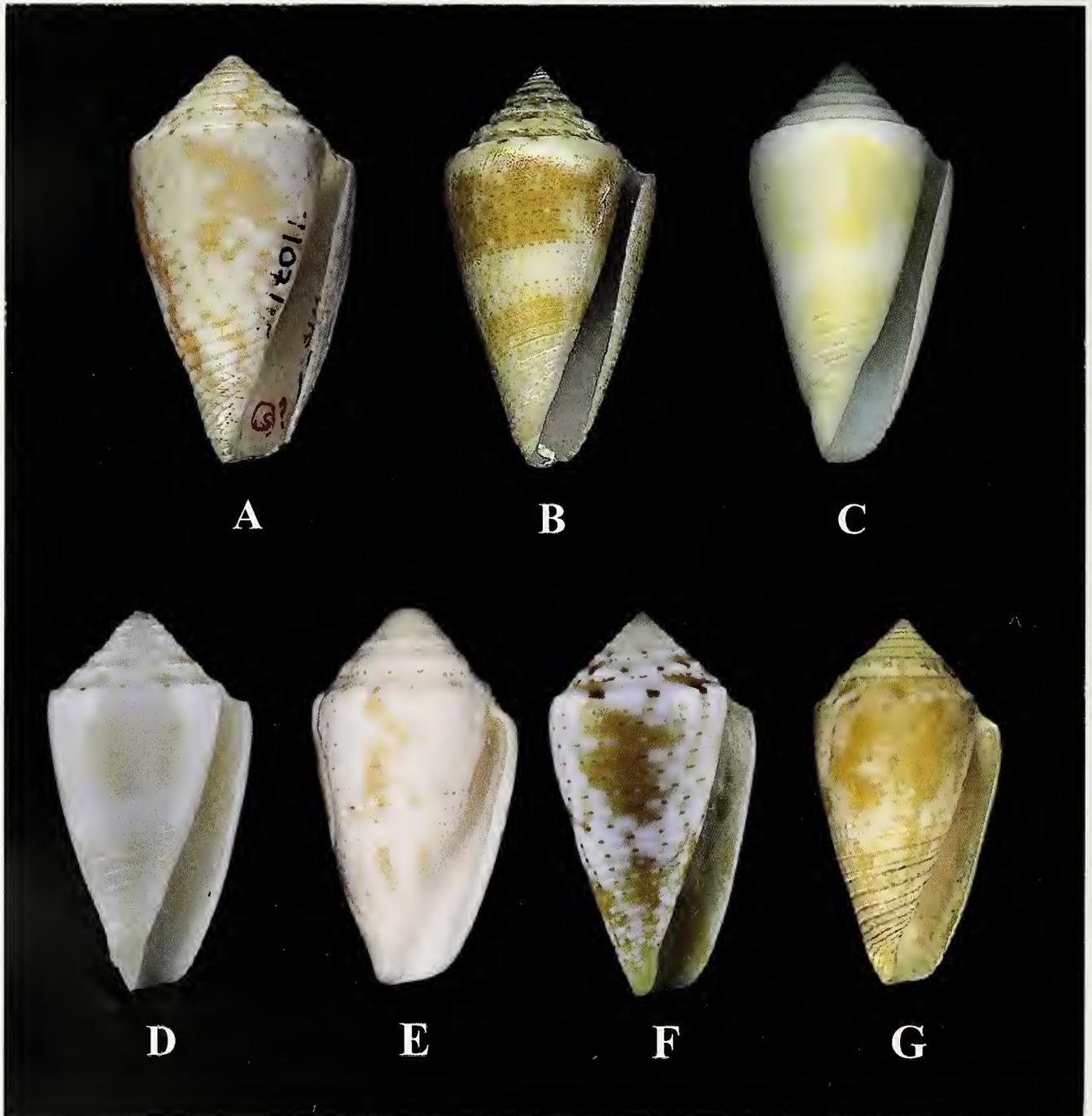


Figure 12. *Jaspidiconus mindanus* subspecies and forms: A= *Jaspidiconus mindanus* (Hwass in Bruguiere, 1792) lectotype; B= *J. ericomnieri* Petuch & Myers, 2014 erroneously known for years as "*J. agassizii*" (see Figure 5a); C= *J. mindanus bermudensis* (Clench, 1942) holotype; D= *J. mindanus* from the David P. Berschauer Collection (collected by Peter Steelman, West Caicos); E= *J. mindanus karinae* (Nowell-Usticke, 1968) holotype; F= *J. mindanus karinae* (Nowell-Usticke, 1968) from the David P. Berschauer Collection (collected by Leo G. Ros, Malmok, Aruba); G= *J. mindanus lymani* (Clench, 1942) holotype.

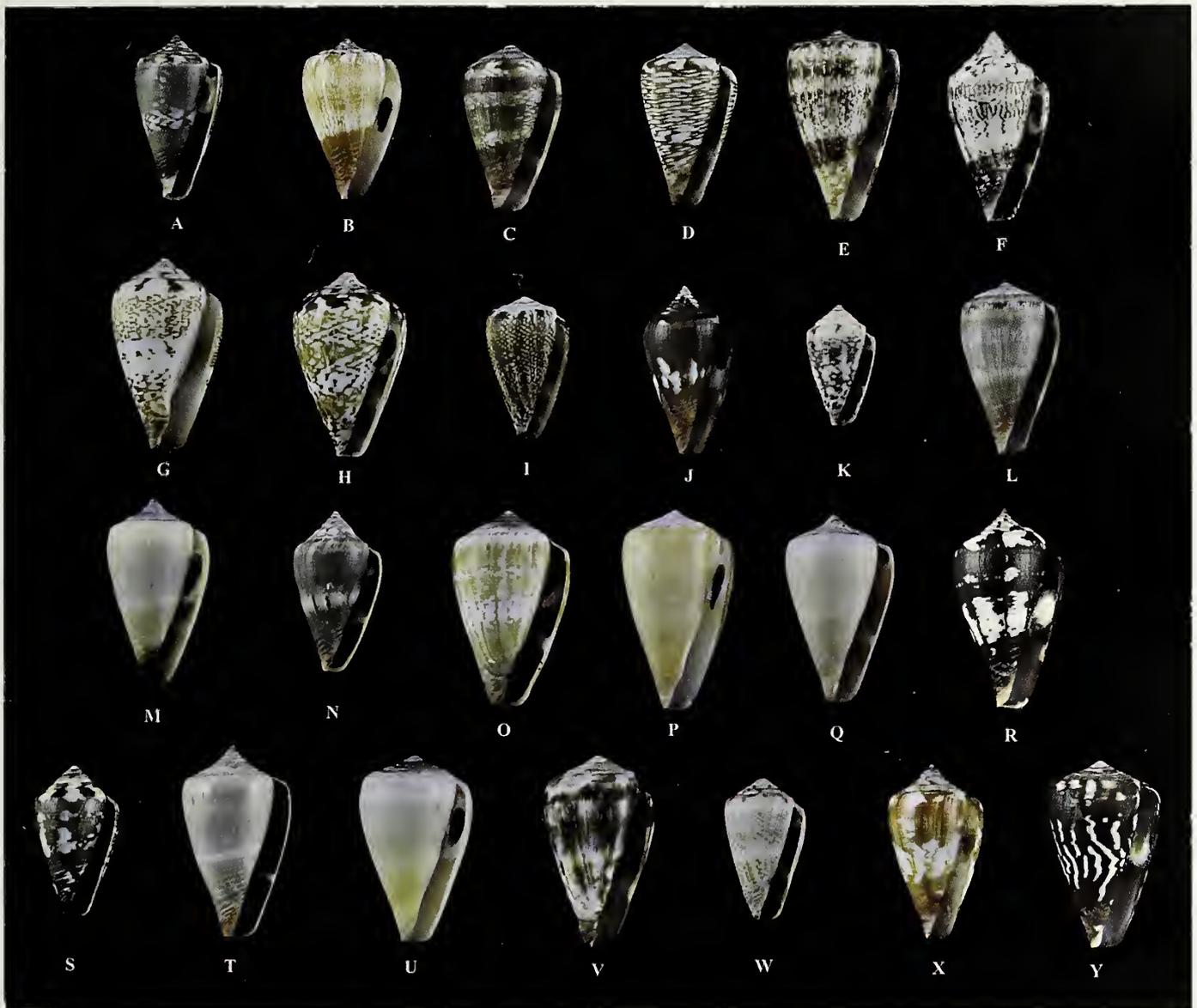


Figure 13. *Africonus* species: Figures A through Y

A = *Africonus antoniomonteriroi* (Rolan, 1990), B = *Africonus borgesii* (Trovao, 1979), C = *Africonus cagarralensis* Cossignani, 2014, D = *Africonus crotchii* (Reeve, 1849), E = *Africonus cuneolus* (Reeve, 1843), F = *Africonus damottai galeao* (Rolan, 1996), G = *Africonus delanoyae* (Trovao, 1979), H = *Africonus derrubado* (Rolan & Fernandes, 1990), I = *Africonus evorai* (Monteiro & Fernandes, 1995), J = *Africonus fantasmalis* (Rolan, 1990), K = *Africonus felitae* (Rolan, 1990), L = *Africonus fontonae* (Rolan & Trovao, 1990), M = *Africonus fuscoflavus* (Rockel, Rolan & Monteiro, 1980), N = *Africonus infinitus* (Rolan, 1990), O = *Africonus irregularis* (Sowerby, 1858), P = *Africonus josephinae* (Rolan, 1980), Q = *Africonus luquei* (Rolan & Trovao, 1990), R = *Africonus maioensis* (Trovao, Rolan & Ildio, 1990), S = *Africonus marccastellazzii* Cossignani & Fiadeiro, 2014, T = *Africonus messiasi* (Rolan & Fernandes, 1990), U = *Africonus raulsilvai* (Rockel, Monteiro & Fernandes, 1998), V = *Africonus regonae* (Rolan & Trovao, 1990), W = *Africonus serranegrae* (Rolan, 1990), X = *Africonus swinneni* Tenorio, Afonso, Cunha & Rolan, 2014, Y = *Africonus verdensis* (Trovao, 1979). [all specimens from the David P. Berschauer Collection]

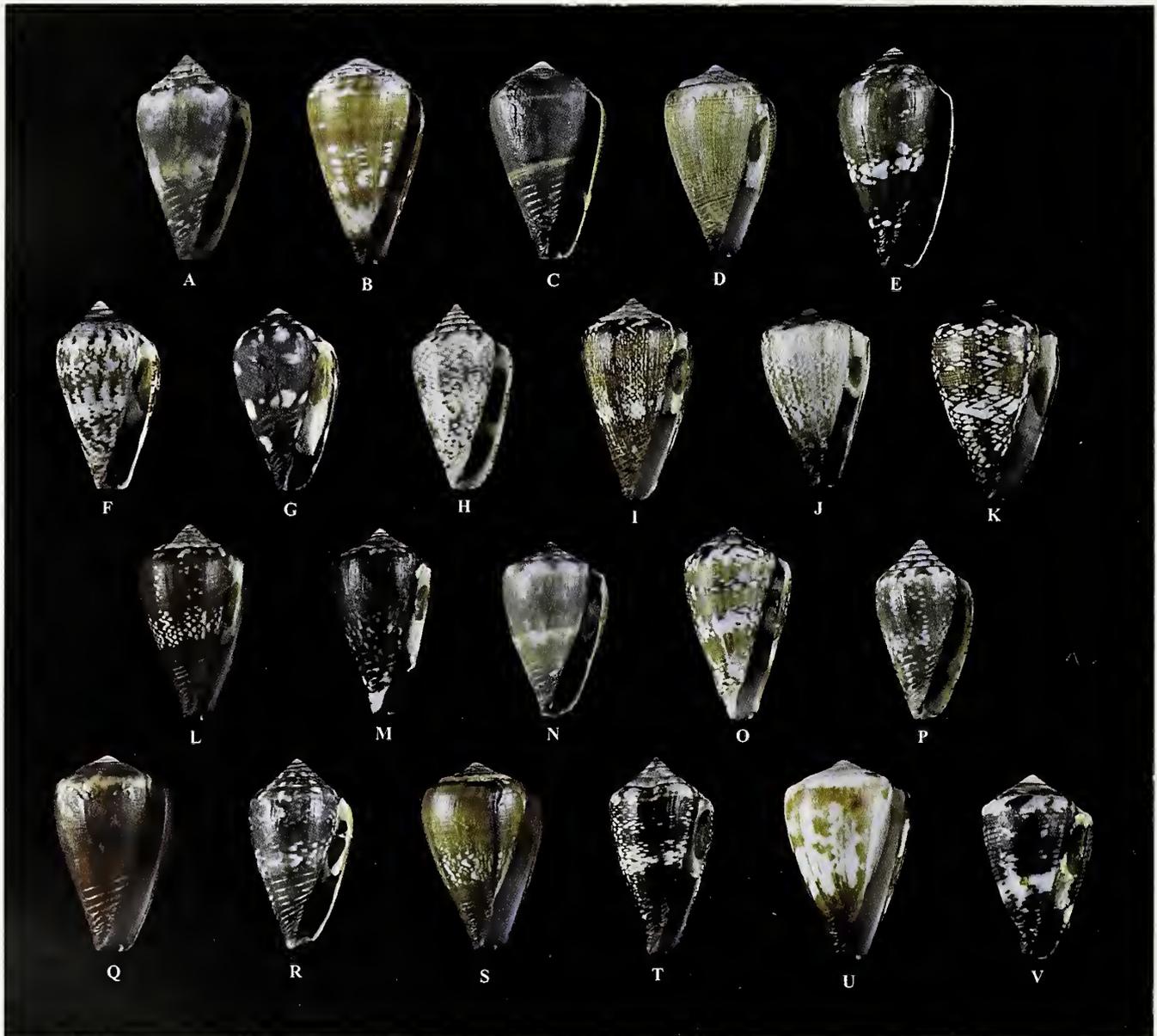


Figure 14. *Africonus* species: Figures A through V

A = *Africonus antoniaensis* Cossignani & Fiadeiro, 2014, B = *Africonus antonioi* Cossignani, 2014, C = *Africonus cabraloi* Cossignani, 2014, D = *Africonus condei* Tenorio & Afonso, 2014, E = *Africonus cossignanii* Cossignani & Fiadiero, 2014, F = *Africonus crioulus* Tenorio & Afonso, 2014, G = *Africonus denizi* Afonso & Tenorio, 2011, H = *Africonus diegoi* Cossignani, 2014, I = *Africonus fiadeiroi* Tenorio, Afonso & Rolan, 2014, J = *Africonus gonsaloi* Tenorio & Afonso, 2014, K = *Africonus isabelarum* (Tenorio & Afonso, 2004), L = *Africonus joserochroi* Cossignani, 2014, M = *Africonus kersteni* (Tenorio, Afonso & Rolan, 2008), N = *Africonus melissae* (Tenorio, Afonso & Rolan, 2008), O = *Africonus mordeirae* (Rolan & Trovao, 1990), P = *Africonus morroensis* Cossignani & Fiadiero, 2014, Q = *Africonus sallaetae* Cossignani, 2014, R = *Africonus santaensis*, Tenorio & Afonso, 2014, S = *Africonus silviae* Cossignani, 2014, T = *Africonus vulcanus* (Tenorio & Afonso, 2004) U = *Africonus wandae* Cossignani, 2014, and V = *Africonus zinhoi* Cossignani, 2014. [all specimens from the David P. Berschauer Collection]

Errata: Corrections to “Review of the genus *Carinapex* Dall, 1924 with the description of ten new species (Gastropoda: Conoidea: Horaiclavidae) from the Pacific Ocean”

Shawn G. Wiedrick

An article by Shawn G. Wiedrick in Volume 47(1) of the *Festivus* included a review of the genus *Carinapex* Dall, 1924 with descriptions of new taxa from the Indo-Pacific. Two similar *Carinapex* species were compared, *C. minutissima* Garrett, 1873 (fig. 1) and *C. amirowlandae* Wiedrick, 2015 (fig. 3) with the distribution map (fig. 2) of *C. minutissima* inadvertently omitted from the article. It is important to note the similarities of the two species which can easily be confused based on the overlap of distribution within both ranges and their morphological affinities. After reviewing 118 lots from the Natural History Museum of Los Angeles County and the Shawn Wiedrick collection, which included over 3080 specimens, it was concluded that two separate species exist. Upon close morphological inspection, *C. minutissima* is primarily much smaller and has one to one-and-a-half initial protoconch whorls, white in color. *C. amirowlandae* is relatively larger, with first two protoconch whorls brown, both species easily distinguishable in fresh specimens. Equally as important is the distribution of *C. minutissima*, which expands to extreme localities (Red Sea and Hawai'i) which are completely absent in the range of *C. amirowlandae* (fig. 4). Additionally, plate 2, figure 39-41, 46 should read *Carinapex mooreorum*, not *C. moorei*.



Figure 1. *Carinapex minutissima* (Garrett, 1873), Hawai'i, USA, height 3.1 mm, width 1.2 mm.



Figure 2. Distribution of *Carinapex minutissima* Garrett, 1873

- Exclusively *Carinapex minutissima* in relation to *C. amirowlandae* n. sp.
- 50-99% *Carinapex minutissima* in relation to *C. amirowlandae* n. sp.
- 25-49% *Carinapex minutissima* in relation to *C. amirowlandae* n. sp.
- 1-24% *Carinapex minutissima* in relation to *C. amirowlandae* n. sp.



Figure 3. *Carinapex amirowlandae* Wiedrick, 2015, Mactan Island, Philippines, height 3.1 mm, width 1.2 mm.

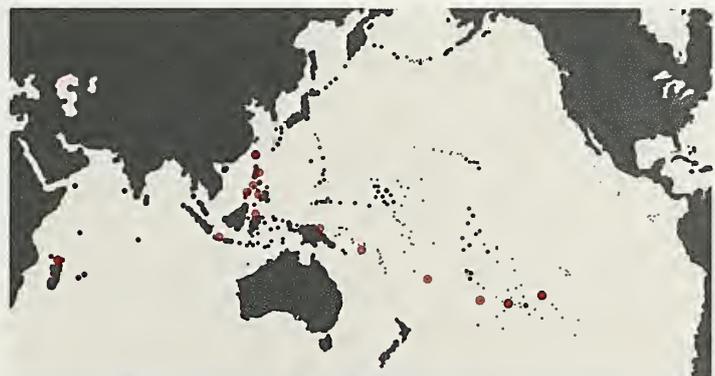


Figure 4. Distribution of *C. amirowlandae* Wiedrick, 2015

- Exclusively *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 50-99% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 25-49% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.
- 1-24% *Carinapex amirowlandae* in relation to *C. minutissima* n. sp.

A New Cypraeid Subspecies and a New *Morum* from the Brazilian Molluscan Province

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ABSTRACT Two new endemic gastropods are named from the Brazilian Molluscan Province; a new cypraeid subspecies, *Erosaria acicularis marcuscoltroi* and a new moruminine harpid, *Morum berschaueri*. The new Brazilian cypraeid can be differentiated from the southeastern United States and Caribbean *Erosaria acicularis acicularis* in being a smaller, narrower, proportionally flatter, and more darkly-colored shell with a pale orange base and pale orange extremities. The new *Morum* is most similar to the widespread southeastern United States and Caribbean *Morum oniscus* but differs in being a much larger, thinner, and proportionally more inflated shell with larger and more prominent knobs on the body whorl, and in having a wider and more flaring aperture. The new cypraeid subspecies ranges from Para and Rio Grande do Norte states in the north to São Paulo State in the south, and is found in the Cearaian, Bahian, and northern Paulinian Subprovinces of the Brazilian Province. The new *Morum* is confined to the Bahian Subprovince and ranges from the Abrolhos Platform south to Guarapari, Espiritu Santo State.

INTRODUCTION

The Brazilian Molluscan Faunal Province, along with its three subprovinces, is still a relatively unknown biogeographical unit that has only been formally defined and described in the past two years (Petuch, 2013). Within the Tropical Western Atlantic Region, the Brazilian Province has been found to contain highly distinctive molluscan faunas with numerous endemic species, many of which are still undescribed and new to science. Over the past year (2014-2015), the authors have investigated the endemic cone shell faunas of the three Brazilian subprovinces, and this led to the descriptions of 13 new species (5 Conidae and 8 Conilithidae; see Petuch and Myers, 2014a and 2014b). The descriptions of these conoidean taxa, along with two other new Brazilian cones (Conidae) and a new Brazilian *Americoliva* species (Olividae) which were described a year earlier (Petuch, 2013), further enhanced the knowledge of the

biodiversity of the Brazilian Province molluscan fauna. Along with these newly-described species, the authors have also been able to acquire a number of other unnamed taxa in several important gastropod families, particularly the Cypraeidae and Harpidae. Because of their biogeographical importance, it was decided to describe two of these new taxa in this paper, including a previously-undescribed subspecies of the Atlantic Yellow Cowrie, *Erosaria acicularis* (Gmelin, 1791), and a distinctive new *Morum*, the largest of its genus in the western Atlantic. These important new endemic taxa are discussed in the following two sections.

1. The *Erosaria* Species Complex in the Tropical Western Atlantic

Until the discovery and recognition of the new Brazilian subspecies described here, the wide-ranging western Atlantic cowrie, *Erosaria*

acicularis (Gmelin, 1791) the “Atlantic Yellow Cowrie”, was thought to have an extremely large biogeographical range, extending from Cape Hatteras, North Carolina and Bermuda, southward along the southeastern United States and Florida Keys, throughout the Gulf of Mexico and Caribbean Sea Basin, and southward to Brazil (Abbott, 1974: 150; Petuch, 2013: 26-27; Tunnell *et al.*, 2010: 172; Warmke and Abbott, 1962: 92). Besides this wide-ranging western Atlantic species, a separate subspecies of *Erosaria acicularis* was also known from the islands of the central South Atlantic. This distinctive subspecies, *E. acicularis sanctaehelenae* (Schilder, 1930), is confined to St. Helena and Ascension Islands and differs from the nominal subspecies in having a more rhomboid shell shape, paler shell color, and a slightly more colored shell base (see Rosewater, 1975). Until recently, these two subspecies were thought to be the sole representatives of the genus *Erosaria* in the central and western Atlantic.

Several specimens of a small cypraeid labeled as “*E. acicularis*” were recently sent to the authors by the renowned Brazilian shell dealer and collector, Marcus Coltro. These specimens were also accompanied by large sets of data for 97 lengths, and collection localities, from the Brazilian coastline between Rio Grande do Norte and Rio de Janeiro states and from the offshore island complexes of Fernando de Noronha, Atol das Rocas, and Trindade. A close examination of these Brazilian specimens revealed several subtle, but consistent, differences between the Brazilian populations of *E. acicularis* and the populations from the southeastern United States, Gulf of Mexico, and Caribbean Region. These consistent differences, which are outlined under the following description, are prominent enough to demonstrate that the populations south of the Amazon River Mouth constitute a previously-

unrecognized subspecies of *E. acicularis*. The new subspecies, *E. acicularis marcuscoltroi*, which is named in this paper, represents the third-known *Erosaria* in the central and western Atlantic areas. This region, comprising the eastern coastlines of tropical and subtropical North and South America and the offshore islands, the Gulf of Mexico, the Caribbean Basin, the West Indian Arc, and the central oceanic islands of St. Helena and Ascension, is now known to house three separate subspecies of *E. acicularis*: the nominate subspecies *E. acicularis acicularis* (Gmelin, 1791) (from North Carolina and Bermuda south to Suriname); *E. acicularis marcuscoltroi* new subspecies (from eastern Para State to Sao Paulo State, Brazil); and *E. acicularis sanctaehelenae* (Schilder, 1930) (from St. Helena and Ascension Islands, central South Atlantic). The new Brazilian endemic subspecies is described here.

SYSTEMATICS

Class Gastropoda

Subclass Orthogastropoda

Superorder Caenogastropoda

Order Sorbeoconcha

Suborder Hypsogastropoda

Superfamily Cypraeoidea

Family Cypraeidae

Subfamily Erosariinae

Genus *Erosaria* Troschel, 1863

Erosaria acicularis marcuscoltroi new subspecies (Figure 3A-F)

Description. Shell of average size for genus, on average smaller than nominate subspecies; shell slightly rhomboid in outline, slightly flattened, with angled marginal calluses that protrude laterally out from shell midline; shell margin thickened, bordered with row of proportionally

large and deep pits and furrows that extend slightly onto the base of shell dorsum; base of shell white, often with faint infusions of pale orange along the columellar area and along columellar dentition; some specimens with large pale orange patch on columellar side of shell base; dentition white, often with pale orange staining between columellar teeth (as seen here on Figure 3B); margins white, marked with numerous small dark brown spots, which are especially prominent within the marginal pittings and furrows; dorsum most often colored dark orange or orange-tan, with numerous small, closely-packed paler orange-yellow spots and ocellations; dorsal spotting often amorphous and anastomosing, producing a blurred appearance; anterior and posterior extremities colored pale orange-tan or brighter yellow-orange (as on holotype); interior of aperture whitish-orange; labrum with 17-18 proportionally large, elongated teeth that extend onto shell base; columella with 14-15 large, thin teeth.



Figure 1. *Erosaria acicularis marcuscoltroi* n. sp., paratype (See Figure 3A)

Type Material. HOLOTYPE: length 19 mm, width 13 mm, thickness (at mid-body) 9 mm, in the type collection of the Zoological Museum of the University of São Paulo, São Paulo, Brazil, number MZSP120184 (shown here on Figure 3D, E, F); PARATYPES: length, 18.2 mm, width 12 mm, thickness (at mid-body) 8 mm, from the type locality, in the research collection of the senior author (shown here on Figure 3A, B, C); length 15 mm, width 10 mm, thickness (at mid-body) 7 mm, from the type locality, LACM 3428 (in the type collection of the Department of Malacology, Los Angeles County Museum of Natural History); length 14 mm, width 9 mm, thickness (at mid-body) 6 mm, from the type locality, in the Berschauer collection, Laguna Hills, California; 3 specimens, length 15.9 mm, from Guarapari, Espírito Santo State, length 16.8 mm, Arraial do Cabo, Rio de Janeiro State, and length 18.5, Alcobaca, Bahia State, in the collection of Marcus Coltro, São Paulo, Brazil.

Type Locality. Collected under a large coral slab by a commercial lobster diver, in 15 m depth off Alcobaca, Abrolhos Platform, southern Bahia State, Brazil (May, 2014).

Range. Restricted to the coast of Brazil, from extreme northeastern Para State and Maranhão State, south to São Sebastião and Ilha Bela, São Paulo State (Simone and Goncalves, 2006), and on the Brazilian offshore archipelagoes of Fernando de Noronha, Atol das Rocas, Abrolhos, and Trindade and Martin Vaz.

Etymology. Named for Marcus Coltro of São Paulo, Brazil and Miami, Florida, well-known shell dealer and renowned shell collector and diver, in recognition of his many important malacological discoveries in Brazil and northern South America.

Discussion. The new Brazilian Province subspecies of the Caribbean Province and

Carolinian Province *Erosaria acicularis* differs from the nominate form in being consistently a smaller, more elongated, and less inflated shell, in having a darker and more intense dorsal color, in having pale orange or yellow-orange colored areas on the shell base and on the columella, and in having orange or yellow-orange extremities (as opposed to the pure white shell base, columella, and extremities of the nominate subspecies, shown here on Figure 3G, H, and J). The orange extremities readily differentiate the Brazilian subspecies from the northern nominate forms, which have distinctly white extremities. While *E. acicularis acicularis* is generally a bright yellow shell with a pure white base, *E. acicularis marcuscoltroi* is almost always a dark orange or orange-tan shell with a pale orange shell base. The orange shell base and the orange extremities are most intensely colored on freshly-collected specimens and fade slightly as the shell dries.

Besides differences in color, *E. acicularis marcuscoltroi* consistently is a more flattened, less globulose shell. This is readily demonstrated when a comparison of the shell morphometrics of the two subspecies is undertaken, utilizing an Index of Shell Inflation **I**, such that:

$$I = l/w (t)$$

where **l** = the **shell length**; **w** = the **shell width** (measured at the mid-body); and **t** = the **shell thickness** (measured at the shell mid-body). When the Index of Shell Inflation for specimens of *E. acicularis acicularis* and *E. acicularis marcuscoltroi* are listed in tabular form, the two subspecies can be seen to group into separate clusters. This clustering of **I** values is demonstrated by the morphometrics of the following eight specimens:

<i>Erosaria acicularis marcuscoltroi</i>	l	w	l/w	t	I
Holotype (MZSP, Brazil)	19 mm	13 mm	1.46	9 mm	13.14
Paratype (Petuch Collection)	18.2 mm	12 mm	1.52	8 mm	12.16
Paratype (LACM)	15 mm	10 mm	1.50	7 mm	10.5
Paratype (Berschauer Collection)	14 mm	9 mm	1.55	6 mm	9.3
Mean I = 11.28					
<i>Erosaria acicularis acicularis</i>	l	w	l/w	t	I
Missouri Key, Fla., (Figure 1G-I)	24.5 mm	18 mm	1.36	13 mm	17.68
Puerto Rico (Figure 1J, K)	25.1 mm	18 mm	1.39	14.8 mm	20.57
Eleuthera, Bahamas	25.5 mm	18 mm	1.41	15.1 mm	21.29
Grand Cayman	22 mm	20.1 mm	1.44	17.5 mm	25.20
(all 4 specimens in the Petuch Collection)	Mean I = 21.19				

Table 1. Morphological comparison of *E. acicularis acicularis* and *E. acicularis marcuscoltroi*

The dichotomy of the shell inflation indices between the Carolinian-Caribbean *Erosaria acicularis* (*sensu lato*) and the Brazilian populations, differing by a factor of two, supports the recognition of two separate and distinct subspecies.

This same biogeographic and evolutionary pattern, with a widespread Carolinian-Caribbean species and a Brazilian offshoot subspecies, is also seen in two other cypraeid genera; *Luria* and *Macrocypraea*. The widespread western Atlantic cowrie, *Luria cinerea* (Gmelin, 1791), ranges from North Carolina to Suriname and has a separate Brazilian subspecies, *Luria cinerea brasiliiana* Lorenz and Hubert, 1993. This southern offshoot differs in having finer apertural dentition than the nominate subspecies and in lacking the prominent dark brown staining between the columellar teeth. Similarly, the Carolinian-Caribbean *Macrocypraea zebra* (Linnaeus, 1758) also has a Brazilian offshoot, the southern subspecies *Macrocypraea zebra dissimilis* Schilder, 1924. This endemic Brazilian cypraeid generally lacks, or has a reduced number of, annular coloration spots along the shell margins and, in shape, closely resembles *Macrocypraea cervinetta* (Kiener, 1843) from the Panamic Molluscan Province (see Petuch, 2013 for a discussion of the biogeographic and evolutionary patterns of these four cypraeids). The wide ecological barrier of the Amazon River Mouth, with its extensive fresh water and brackish areas and organic-rich mud substrates, has genetically isolated the shallow neritic Carolinian and Caribbean *Erosaria acicularis*, *Luria cinerea*, and *Macrocypraea zebra* from their Brazilian counterparts, leading to the formation of three endemic subspecies; *E. acicularis marcuscoltroi*, *L. cinerea brasiliiana*, and *M. zebra dissimilis*.

2. The *Morum* Species Complex in the Tropical Western Atlantic

Within the tropical western Atlantic, the harpid subfamily Moruminae is represented by eight species in two separate genera (*Cancellomorum* Emerson and Old, 1963 and *Morum* Roding, 1798), making it the richest moruminine fauna found in a single region anywhere on Earth. Although thought to contain only seven species (Petuch, 2013), the biodiversity of the Moruminae was recently increased by the discovery of an eighth species in southern Brazil. Like the previously-described new cowrie subspecies, specimens of this new moruminine harpid were sent to the authors by Marcus Coltro, who collected the type lot near Guarapari, Espirito Santo State. Here named *Morum berschaueri*, this southern Brazilian harpid is the largest-known member of its genus and is endemic to the southern part of the Bahian Subprovince of the Brazilian Molluscan Province. The Subfamily Moruminae of the Tropical Western Atlantic Region is now known to contain the following genera and species (arranged here by biogeography):

Widespread Western Atlantic (Carolinian, Caribbean, and Brazilian Provinces)

Cancellomorum dennisoni (Reeve, 1842)
(North Carolina to Bahia, Brazil)

Caribbean Province and Southeastern Florida (Georgian Subprovince) only

Morum purpureum Roding, 1798 (= *Morum lamarcki* Deshayes, 1844)

Carolinian and Caribbean Provinces only

Morum oniscus (Linnaeus, 1767) (Georgian Subprovince to Surinamian Subprovince)

Venezuelan Subprovince (Caribbean Province) only

Cancellomorom lindae (Petuch, 1987)
(endemic to Colombia and Venezuela)

Southern and Western Caribbean Province and northern Brazilian Province

Morum strombiformis (Reeve, 1842)
(Nicaraguan Subprovince to Bahian Subprovince)

Brazilian Province only

Cancellomorom matthewsi (Emerson, 1967)
(Cearaian Subprovince only)
Morum bayeri Petuch, 2001 (Cearian and Bahian Subprovinces)
Morum berschaueri new species (Bahian Subprovince only)

Within the Tropical Western Atlantic Region, the molluscan fauna of the Carolinian Province is now known to contain three moruminine species (*C. dennisoni*, *M. oniscus*, and *M. purpureum*), while the molluscan fauna of the Caribbean Province is known to contain five species (*C. dennisoni*, *C. lindae*, *M. oniscus*, *M. purpureum*, and *M. strombiformis*). Although also containing five species, the moruminine fauna of the Brazilian Molluscan Province has the highest level of endemism, with three geographically-restricted species (*C. matthewsi*, *M. bayeri*, and *M. berschaueri*). These occur together with the widespread western Atlantic *C. dennisoni* and *M. strombiformis*. In this paper, we will be discussing and illustrating only the five members of the genus *Morum* and the new Brazilian species is described here:

SYSTEMATICS

Class Gastropoda
Subclass Orthogastropoda
Superorder Caenogastropoda
Order Sorbeoconcha

Suborder Hypsogastropoda
Infraorder Neogastropoda
Superfamily Muricoidea
Family Harpidae
Subfamily Moruminae
Genus *Morum* Roding, 1798

***Morum berschaueri* new species**
(Figure 4A-F)

Description. Shell large for genus, thin, inflated, broadly conical; spire low, proportionally flattened, with only slightly stepped whorls; shoulder sharply angled, ornamented with 10 large flattened knobs; body whorl ornamented with 3 spiral rows of very large, rounded, evenly-spaced knobs, one at posterior end below shoulder, one around mid-body, and one around anterior end; posterior row of knobs align and combine with shoulder knobs to produce distinctive double row of knobs below shoulder angle; row of knobs around mid-body often bifurcating into 2 parallel rows of smaller knobs; anterior row of knobs proportionally large and always single in number, bordering the body whorl-siphonal canal juncture; 3 rows of body whorl knobs align with 10 low, evenly-spaced, rib-like longitudinal varices that correspond to shoulder knobs; numerous fine spiral cords are present between, and on top of, rows of large rounded knobs, with those on the siphonal canal and between rows of knobs being largest and coarsest; spire whorls ornamented with 3 large, coarse spiral cords; aperture proportionally wide and flaring; columellar area with wide adherent parietal shield, which is covered with numerous small, closely-packed pustules; outer lip thickened, with flattened edge; inner edge of lip ornamented with 18-24 large narrow teeth; shell color uniformly a pale cream-tan or yellow-tan, overlaid with scattered large amorphous patches of dark reddish-tan, particularly on the spire whorls; fine spiral cords on body whorl and spire whorls marked

with rows of small, evenly-spaced reddish-brown dots; edge of suture on spire whorls marked with row of evenly-spaced large, prominent reddish-brown dots and dashes; dorsal edge of lip marked with 4 large reddish-brown patches, one on spire area, two along the mid-body area, and one at the anterior end; parietal shield white, with some specimens having pale orange tones; outer lip and labial teeth white, with some specimens having infusion of pale orange; interior of aperture white; protoconch proportionally large, bulbous, mamillate, composed of 2 whorls, cream-white in color (shown here in Figure 4C, D).



Figure 2. *Morum berschaueri* n. sp., holotype (See Figure 4B)

Type Material. HOLOTYPE: length 31 mm, width 20.5 mm, in the type collection of the Zoological Museum of the University of São Paulo, São Paulo, Brazil, Brazil, number MZSP120186 (shown here on Figure 4A, B);

PARATYPES: length 35.2 mm, width 22 mm, from the type locality, in the research collection of the senior author (shown here on Figure 4C, D); length 35 mm, width 23.4 mm, from the type locality, in the Berschauer Collection, Laguna Hills, California (shown here on Figure 4E, F); length 32 mm, width 20 mm, from the type locality, in the research collection of the junior author.

Type Locality. Collected in algae, sponges and coral rubble, 15 m depth in the Guarapari Channel, Guarapari, Espírito Santo State, Brazil (2013).

Range. At present known only from the type locality, but may range northward to the Abrolhos Platform in southern Bahia State. The species appears to be endemic to the southern part of the Bahian Subprovince of the Brazilian Molluscan Province, particularly Espírito Santo State.

Etymology. The new taxon honors David Berschauer, Esq., of Laguna Hills, California, Co-Editor of *The Festivus* (San Diego Shell Club) and inspired amateur malacologist and naturalist.

Discussion. Of the five known western Atlantic *Morum* taxa, *M. berschaueri* is by far the largest-known species, being on average 10 mm longer than any other congener (averaging around 33 mm). Of the known Brazilian species, *M. berschaueri* is most similar to the widespread southern Caribbean-Brazilian *M. strombiformis* (Reeve, 1842) (Figure 5E, F), but differs in being a much larger, more inflated, and less cylindrical shell with proportionally larger and more prominent rows of rounded knobs on the body whorl. The new species is also similar to *Morum bayeri* Petuch, 2001 from the Cearaian and Bahian Subprovinces (Figure C, D), but differs in having a much larger, more

conical shell with a proportionally wider and more angled shoulder, in having proportionally larger and better-developed knobs on the shoulder and body whorl, and in lacking the black mottling and black color patches seen on *M. bayeri*. It is possible that all three species co-occur on the coral reefs along the outer edges of the Abrolhos Platform in southern Bahia State.

The other two *Morum* species found in the tropical Western Atlantic Region, *M. oniscus* (Linnaeus, 1767) (Figure 5A, B) and *M. purpureum* Roding, 1798 (Figure 5G, H), are morphologically more similar to *M. berschaueri* than are *M. bayeri* and *M. strombiformis*, especially in having three rows of prominent large, rounded knobs around their body whorls. Although having the same basic type of shell sculpture, the Carolinian-Caribbean *M. oniscus* and *M. purpureum* differ from *M. berschaueri* in being much smaller, proportionally more oval, and less-elongated shells. Although much smaller in size, the body whorl and shoulder knobs of *M. oniscus* and *M. purpureum* are proportionally much larger and better-developed than those seen on the specimens of the type lot of *M. berschaueri*. The new Brazilian species is also a less colorful and more poorly-marked species than *M. purpureum*, lacking the characteristic bright pink or purple parietal shield and dark brown color patches on the spire whorls.

ACKNOWLEDGMENTS

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Figure 3. *Erosaria* Cowries from the Tropical Western Atlantic Region.

A, B, C= *Erosaria acicularis marcuscoltroi* Petuch and Myers, new subspecies. Paratype, length 18 mm. 15 m depth, off Alcobaça, southern Bahia State, Brazil. Petuch Collection. **D, E, F**= *E. acicularis marcuscoltroi* Petuch and Myers, new subspecies. Holotype, length 19 mm. 15 m depth, off Alcobaça, southern Bahia State, Brazil. MZSP120184. **G, H, I**= *E. acicularis acicularis* (Gmelin, 1791), length 24.5 mm. 3 m depth, off Missouri Key, Middle Florida Keys, Florida. **J, K**= *E. acicularis acicularis* (Gmelin, 1791), length 25.1 mm. 2 m depth off Boca de Cangrejos, San Juan, Puerto Rico.

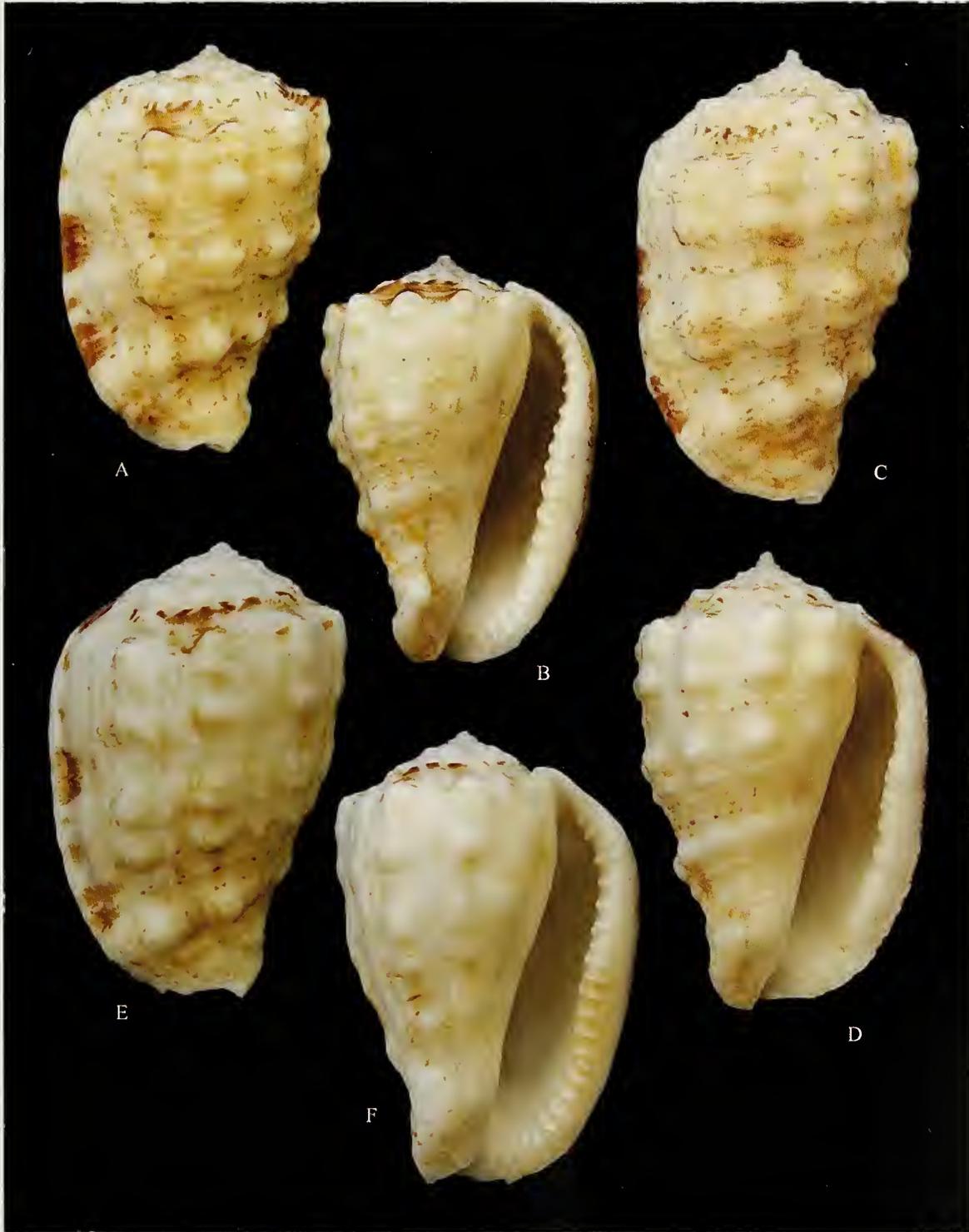


Figure 4. *Morum berschaueri* Petuch and Myers, new species.

A, B= Holotype (MZSP120186), length 31 mm. 15 m depth in the Guarapari Channel, Guarapari, Espírito Santo State, Brazil. C, D= Paratype, length 35.2 mm. Guarapari Channel, Guarapari, Espírito Santo State, Brazil. Petuch Collection. E, F= Paratype, length 35 mm. Guarapari Channel, Guarapari, Espírito Santo State, Brazil. Berschauer Collection.



Figure 5. Other *Morum* Species of the Tropical Western Atlantic Region.

A, B= *Morum oniscus* (Linnaeus, 1767), length 24 mm. 2 m depth off Cape Eleuthera, Eleuthera Island, Bahamas. C, D= *M. bayeri* Petuch, 2001, length 23 mm. 10 m depth off Itaparica Island, Todos os Santos Bay, Bahia State, Brazil. E, F= *M. strombiformis* (Reeve, 1842), length 24 mm. 15 m depth off Alcobaca, southern Bahia State, Brazil. G, H= *M. purpureum* Roding, 1798, length 22 mm. 5 m depth off Malmok, Aruba.

Abalone Without Holes: A Photo Iconography and Study of a Rare Morphological Variant of *Haliotis* (Gastropoda: Vetigastropoda)

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ABSTRACT Three different types of imperforate abalone shell morphologies are discussed and photographed and factors leading to imperforation in *Haliotis* are explored. Three plates illustrate this phenomenon. Additional plates examine the unique situation with *Haliotis elegans* Koch in Philippi, 1845, and the soft parts of an imperforate specimen showing the absence of the pallial cleft, in comparison with a normal *Haliotis*. Additionally, three recently discovered small specimens of the black abalone with nacre-filled holes are also discussed and photographed.

KEY WORDS Pallial cleft, imperforate, *Haliotis*, abalone, gastropod.

INTRODUCTION

Among the defining characteristics of abalone (Haliotidae) are a row of respiratory pores, or tremata, distributed along the left side of the shell. The pores are generally thought to be an evolutionary response in primitive vetigastropods to the consequences of torsion: a developmental rotation of the visceral mass that places the mantle cavity, gills and anus over the head. Garstang (1928) and Yonge (1947) suggested that torsion allowed gastropods a protective retreat into the mantle cavity but subsequently created a "sanitation problem" by placing the anus above the head, potentially fouling the gills and sense organs and preventing the discharge of gametes. Respiratory pores are believed to be one solution whereby wastes and gametes are discharged through the holes away from the head and twin bi-pectinate gills in abalone. Other ancestral adaptations involve slits in the shell (pleurotomarids, scissurellids, temnotropids), and the more derived conditions of the

loss of one gill (trochids), or the loss of gills entirely and the development of secondary gills (patellids) (Geiger *et al.*, 2008).

Thus, it is both unusual and intriguing that imperforate abalone occur naturally, although they are extremely rare. Three imperforated shell types occur in abalone: 1) Tremata never developed, even during the initial growth stage. 2) Initial trema development occurred, but an injury of the mantle and pallial cleft prevented later trema development and instead formed an irregular growth line. 3) Initial trema development occurred, but injury created a highly arched shell and distorted growth line lacking tremata. Only three specimens are currently known of Type 1. Type 2 is far more common. Type 3 is restricted to a few rare specimens of the black abalone, *Haliotis cracherodii cracherodii* Leach, 1814. This paper describes the taxonomy of known imperforate abalone, presents evidence that the loss of tremata is maladaptive, and discusses potential reasons why imperforate abalone are

so rare. All three types are illustrated. Additionally, an intriguing species, *H. elegans* is included which often stops developing tremata as it approaches adult size (usually >45–50 mm). Rarely, a particularly large specimen may retain but a single hole closest to the spire after filling in all the earlier formed tremata, as it continued developing shell increment without holes.

ABBREVIATIONS OF COLLECTIONS

BOC: Buzz Owen Collection, Gualala, California, USA; BSC: Bill Snell Collection, Trinidad, California, USA; BTC: Brian Tissot Collection, Trinidad, California, USA; CASIZ: California Academy of Sciences Collection, San Francisco, California, USA; CRC: Chuck Reitz Collection, San Diego, California, USA; NMNH: National Museum of Natural History (Smithsonian), Washington DC, USA; RKC: Robert Kershaw Collection, Narooma, New South Wales, Australia; JCC: Johnathan Centoni Collection, Trinidad, California, USA; JLC: Julian Lee Collection, Los Angeles, California, USA.

MATERIAL & METHODS

All shells, with the exception of the type and syntype specimens, were lightly moistened with mineral oil, the excess oil being removed to prevent glare during photography. The camera used for photographing the type specimen was a Canon EOS 30D, with a 2.5 s exposure at *f*/29. The remainder of the photography was done with a Canon A650 PowerShot at various exposures at *f*/8.

TAXONOMIC REVIEW

TYPES OF IMPERFORATE *HALIOTIS*

TYPE 1. This designation is used to refer to an abalone whose shell never developed a single open hole. There are currently three known specimens, all being *H. cracherodii cracherodii*. A fourth, an 8-10 mm juvenile *H. rufescens* Swainson, 1822, has been reported (Leighton, 1960) but was lost over 50 years ago. It was found alive in a *Macrocystis pyrifera* kelp holdfast.

The three definitely known examples are listed chronologically by date of discovery: 1) The first was found near Los Angeles, California, and is the type specimen of *Haliotis cracherodii* form *imperfurata* Dall, 1919. It measures 100 mm and is in the NMNH (Pl. 1, top row). 2) The second specimen is a juvenile found fresh dead in a tide pool at Johnson's Lee, Santa Rosa Island, California, in August 1964. It measures 26.5 mm, and is in the BSC (Pl. 1, 3rd row). 3) The third specimen was a live-taken small adult found at San Quintín, Baja California, Mexico, in July 1987, and kept alive in a marine laboratory for 8 months. It measures 86 mm and is in the BTC (Pl. 1, 2nd row). Its growth rate was monitored and compared to other specimens taken simultaneously from the same area. Three normal shells in the bottom row of Plate 1 serve for comparison.

TYPE 2. This designation refers to specimens that were clearly injured in an early stage of growth, which caused injury to the mantle that deposits shell increment. This injury apparently damaged the pallial cleft region of the mantle, which then prevented the animal from depositing normal shell with holes, forming instead a very irregular wavy imperforate "line". Pl. 5 compares such an animal with a normal abalone – note the absence of the pallial cleft. Only specimens with normal shell proportions are placed in this category. Four such specimens are included on Pl. 2. They are also listed chronologically by date of discovery. 1)

Haliotis cracherodii cracherodii. This first specimen was taken near El Rosario, Baja California, Mexico, in 1952, by a Mexican commercial fisherman. It measures 103.5 mm, and is in the BOC (Pl. 2, top row). 2) The second specimen, *Haliotis walallensis* Stearns, 1899, was found near Anchor Bay, California, in June 1954. It was found fresh dead with part of the animal still attached, apparently the victim of an attack by the seastar *Pycnopodia helianthoides* Brandt, 1835. It measures 93.8 mm and is in the BOC (Pl. 2, 2nd row). 3) The third specimen, *Haliotis rufescens*, was found on the south side of Black Point, Sonoma County, California, in 1989. It measures 224.3 mm and is in the BOC (Pl. 2, bottom row). 4) The fourth specimen, *Haliotis fulgens guadalupensis* Talmadge, 1964, was live-taken at Guadalupe Island, Baja California, Mexico, in 1995. It measures 105.2 mm and is in the CRC (Pl. 2, 3rd row). On shell numbers 1, 2, and 4, the abnormal wavy line pattern, where the holes would have been, is clearly visible, while on shell number 3, a more mature specimen, the line is not visible due to an infestation of marine boring organisms.

TYPE 3. This designation refers to an odd morphological variety of *H. cracherodii cracherodii* described as *H. cracherodii* var. *holzneri* Hemphill, 1907. This unusual morphology occurred due to an injury, which caused the angle of shell growth to radically “shift” downward, forming an oblong, somewhat narrow, and highly arched shell, additionally developing a very distorted “twisted” shell increment in the area where holes would normally be formed. All three of Hemphill’s syntypes are Type 3 imperforate. Two additional specimens are known, which also lack holes. Many other examples of similar shape exist, which do have holes, however. Both morphologies are illustrated on Pl. 3. This variety could be described as a “Type 2”

because it stopped forming holes due to an injury, but because it was described as a “var.” and given a name, this designation was chosen. This variety was discussed in more detail elsewhere (Owen, 2005).

Other Imperforate Variants. An intriguing species, *Haliotis elegans*, endemic to Western Australia, normally stops forming holes as it approaches adult size (>75 mm), with occasional specimens forming a barely visible tiny slit mid-dorsum before stopping trema formation entirely. Of 194 specimens examined over 75 mm, 176 (90.7%) were imperforate in later stages of growth. Close examination of these specimens showed clearly that in no instances was this imperforate state caused by an injury (as is the case with Type 2 specimens). This abnormality is found only in this species, and does not occur in other *Haliotis*. Plate 4 illustrates three such specimens compared to a normal adult shell of 50 mm.

Three small black abalone shells (size range 43.8-47.0 mm) purchased from a shell collector in Los Angeles have all of their holes closed with nacre clear to the ventral margin. The specimen on Pl. 4, Figs. 1 & 2, has a normal growing edge (not “ground off”) and the closed holes are formed from concentric rings as the animal filled it with nacre (Plate 4, Fig. 3). Plate 4, Fig. 4, illustrates the identical morphology of the last closed hole of the specimen of the *H. rufescens* Type 2 imperforate illustrated on the bottom row of Pl. 2. Although we don’t know what caused this condition one possibility is that they may have been filled by the animal to protect itself from barnacles, sponges, worms, etc. growing over the holes and the shell collector polished the epibionts off while cleaning them.

BIOLOGICAL REVIEW

As Type I imperforate abalone are exceedingly rare, imperforation may reduce survival during the initial growth stage, greatly slow growth rate, and ultimately reduce evolutionary fitness. That all of the known field specimens belong to one species that occurs in wave-swept intertidal habitats further suggests some adaptive reasons why respiratory pores are crucial for proper abalone growth and development. What then, is the functional significance of the pores?

In addition to the "waste problem" hypothesis, another idea has developed in the last few decades - that of induced water flow through the mantle cavity. Until relatively recently, the pores of abalone were assumed to be exclusively exhalant structures for mantle cavity water propelled by ctenidial cilia and laden with digestive wastes and reproductive products Crofts (1929). However Voltzow (1983) revealed that elevated respiratory pores in the Pinto abalone, *H. kamtschaticana kamtschaticana* Jonas, 1845, facilitate a completely passive circulation of mantle cavity water in response to the dynamics of water flowing over the shell surface. Diversity among abalone in respiratory pore structure, therefore, may be of functional significance in a manner similar to the apical pore of keyhole limpets (Murdock & Vogel, 1978) and the raised ostia of marine sponges (Vogel, 1974). Tissot (1992) investigated induced flows in 13 species of abalone and found that the extent of induced flow varied significantly among species. Overall, large, elevated pores, which are common in subtidally distributed species (e.g., *H. rufescens*) were more efficient at promoting passive mantle cavity circulation than the small unelevated pores of intertidal species like *H. cracherodii cracherodii*. The passive circulation may represent considerable energetic savings as animals don't have to continually pump water

through their gills and out their respiratory pores. Tissot (1992) found that black abalone experienced little induced flow and suggested this was in response to its wave-swept intertidal habitat, which naturally circulated water through the mantle cavity and out the pores. Moreover, Voltzow and Collin (1995) showed that keyhole limpets (*Diodora aspera* Rathke, 1833), whose apical openings were naturally or experimentally blocked, exhibited no evidence of damage to the mantle cavity or associated organs. Instead, water flowing naturally over the gill tips and head, indicated that the apical pore is not necessary for the effective removal of wastes. Thus, the real functional challenge for imperforate abalone is likely to be the energetic disadvantage of not being able to use external currents to move water through the mantle cavity and over the gills. Below we discuss two experiments that test this hypothesis.

Field experiments. Tissot (1991) experimentally tested the idea that the closure of open pores would influence growth and survivorship relative to normal individuals in black abalone. During 1987-1989 at Santa Cruz Island, California, pores were experimentally closed by covering all openings with marine epoxy putty (Z-Spar splash zone compound). Although splash zone compound is toxic while curing, which takes about one hour, fully cured putty is non-toxic. To control for this initial toxic effect epoxy putty was momentarily applied to all pores and subsequently removed on control individuals. Overall a total of 108 individuals in three separate experiments were tagged and followed in the field for two years. Although there were no significant statistical differences among the results of these experiments, trends in the data suggest that individuals with open or experimentally-closed pores had lower survivorship (33% vs. 44%), lower growth rates (1.7 vs. 2.5 mm/month), and a smaller percentage of individuals exhibiting

shell growth (20% vs. 39%) than abalone with naturally open pores, suggesting that tremata may have functional value to black abalone and the lack of open pores may influence growth and survivorship and perhaps evolutionary fitness.

Lab experiments. A group of black abalone were live-taken together with an 86 mm imperforate specimen from San Quintín, Baja California, Mexico, and grown out for eight months in the same aquarium tank at 15C with an *ad libitum* algal diet. The shell growth rate of the imperforate individual was not significantly different than those of other individuals with pores and indicated that in a laboratory environment the pores may not be as functionally important as in their natural environment. Also, the time frame of <1 year may be insufficient to detect effects on animals that can easily live for 20 or more years.

Hatchery observations. An apparently unique phenomenon occurred in a commercial abalone culture facility in the late 1970's. A single spawning of a pair of adult *H. rufescens* produced a number of juveniles that were clearly Type 1 imperforates. The number was not recorded, but was estimated to be as many as 8–10 (Owen, pers. obs.). Conversations with other *Haliotis* aquaculturists of many years experience confirmed the apparent uniqueness of this event (D. Leighton, E. Ebert, J. McMullen, pers. comm., Owen, pers. obs.). Specimens of this group were cultivated at a California Department of F&G lab in addition to their lab of origin (Owen, pers. obs.). To our combined knowledge, no such event has occurred since.

DISCUSSION AND CONCLUSIONS

There are several possible hypotheses that could explain both the occurrence of imperforate

abalone and their rarity in nature. The extreme rarity of Type 1 imperforates, even under laboratory conditions, suggests that the mechanism whereby they occur is unusual. One possibility is that it is caused by a rare recessive gene; a gene not normally expressed but occasional crosses between two individuals that have the gene results in an imperforate individual. This could be one possible explanation for the laboratory cohort of imperforate abalone: both parents had the gene in a heterozygous, non-expressed state.

Another possibility is that some environmental cue or event influences a developmental process, which prevents the growth of normal mantle tissue and a pallial cleft. In this case, it may not be genetic in origin but purely phenotypic.

If the imperforate condition is maladaptive then these individuals would also have a low survival rate as well. Evidence to support the maladaptive nature of the Type 1 imperforate condition include: 1) they have only been observed in the field in black abalone, which occupy wave-swept environments where the tremata may have reduced functional advantage; 2) all known individuals have been relatively small (< 100 mm); 3) Type 2 and 3 imperforates are also uncommon, suggesting they may suffer from the lack of respiratory pores as well.

ACKNOWLEDGEMENTS

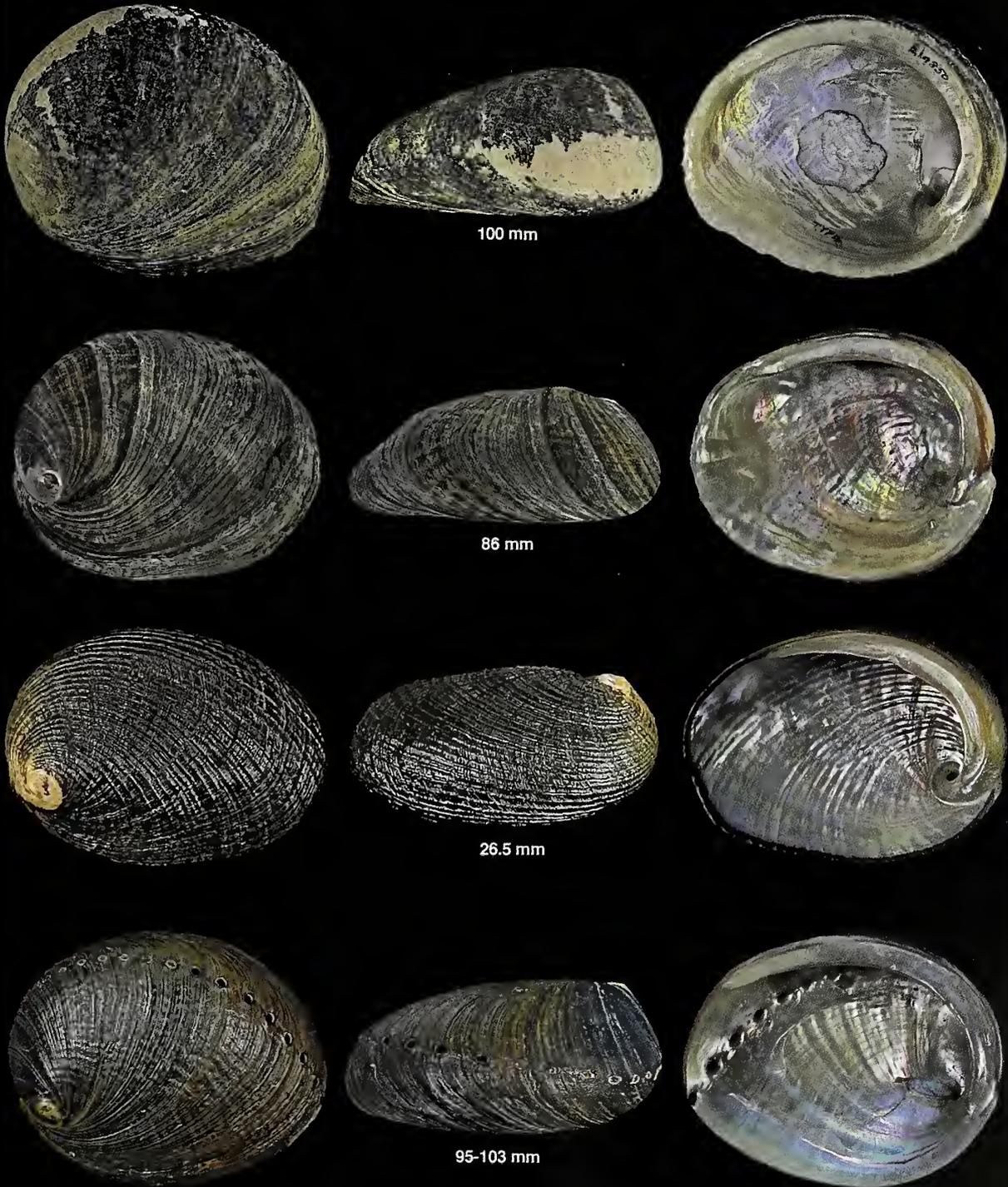
We wish to thank Yolanda Villacampa of the NMNH for photographing the type specimen of *H. cracherodii* form *imperforata*, and Liz Kools of the CASIZ for permitting the photography of the syntype of *H. cracherodii* var. *holzneri*. We acknowledge and thank Daniel Geiger for editing the manuscript and offering helpful suggestions. We also want to thank Aaron Pan for proof reading the manuscript and offering helpful comments and would especially like to

thank Bob "Croc" Kershaw for providing the *H. elegans* images for Plate 4. We also acknowledge Johnathan Centoni and Julian Lee for letting us examine and photograph their three small black abalone shells with nacre-filled holes.

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PLATE 1



Top Row: *H. cracherodii* form *imperforata* Dall, 1919. Type. Coast of Los Angeles County, California. NMNH
 2nd Row: *H. cracherodii* form *imperforata*. San Quintín, Baja California, Mexico. Live-taken intertidally. 1987. BTC
 3rd Row: *H. cracherodii* form *imperforata*. Johnson's Lee, Santa Rosa Is., California. Live-taken intertidally. 1964. BSC
 Bottom Row: *H. cracherodii cracherodii*. La Jolla, California. Live-taken intertidally. 1951. BOC

PLATE 2

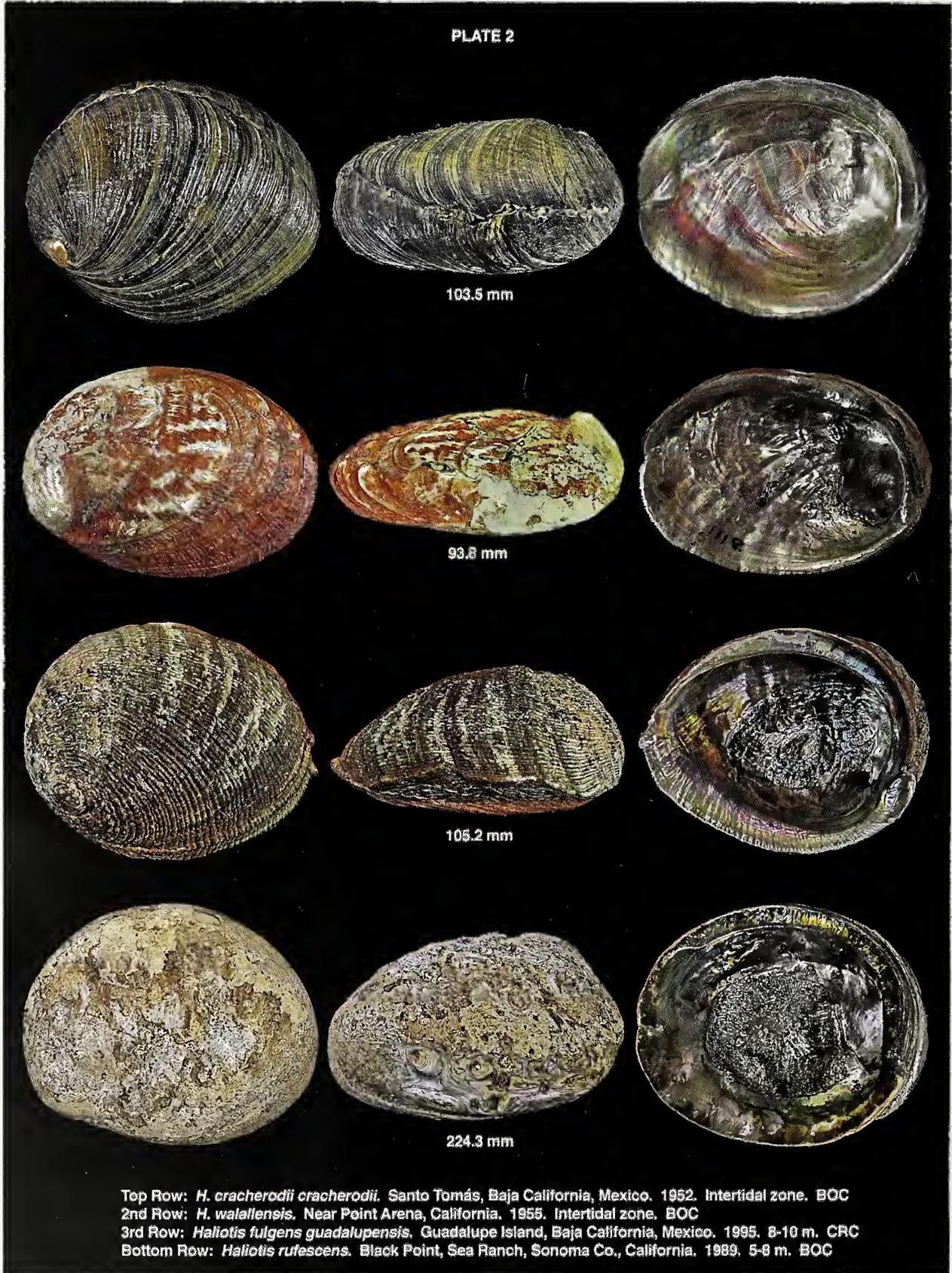
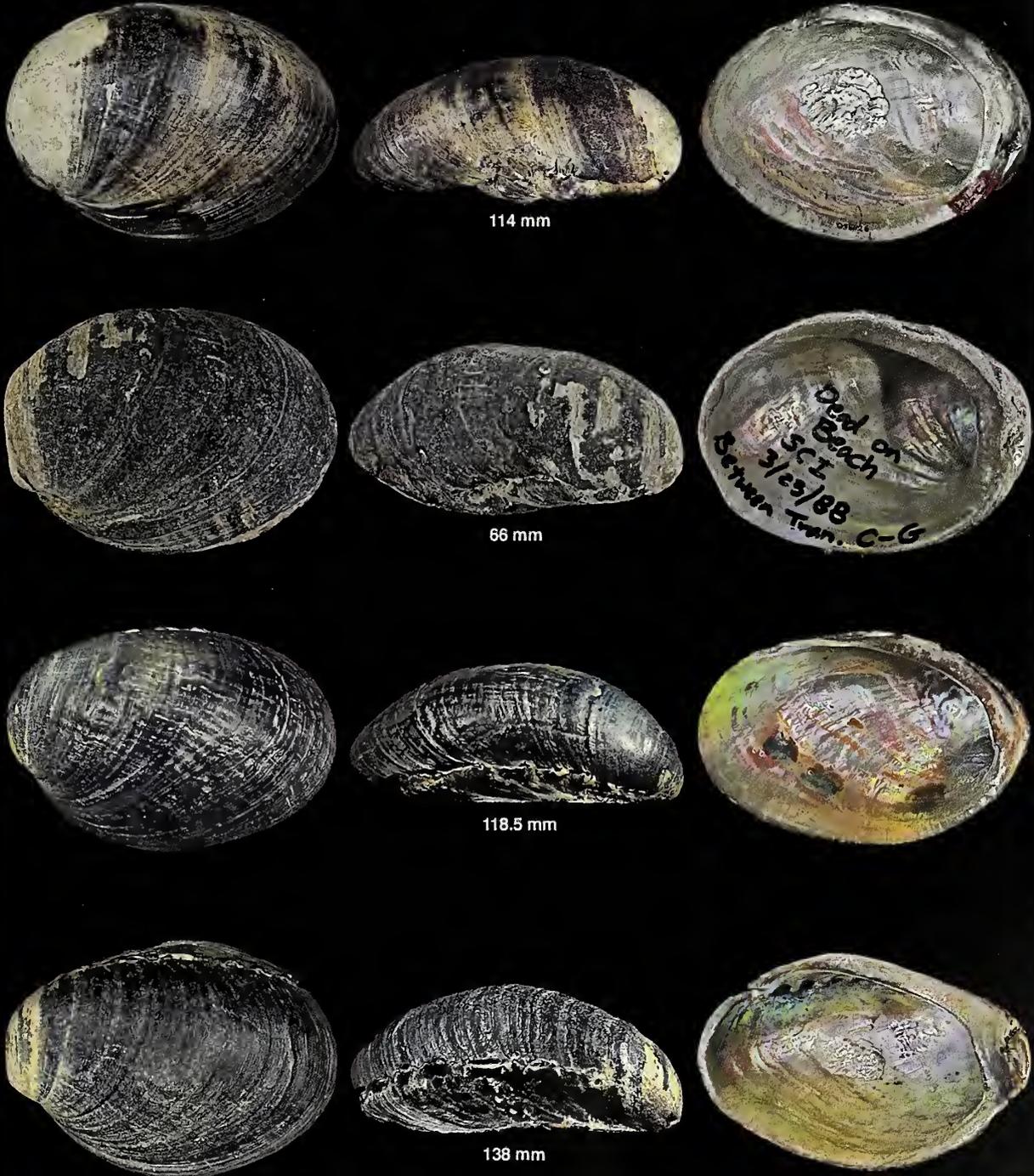
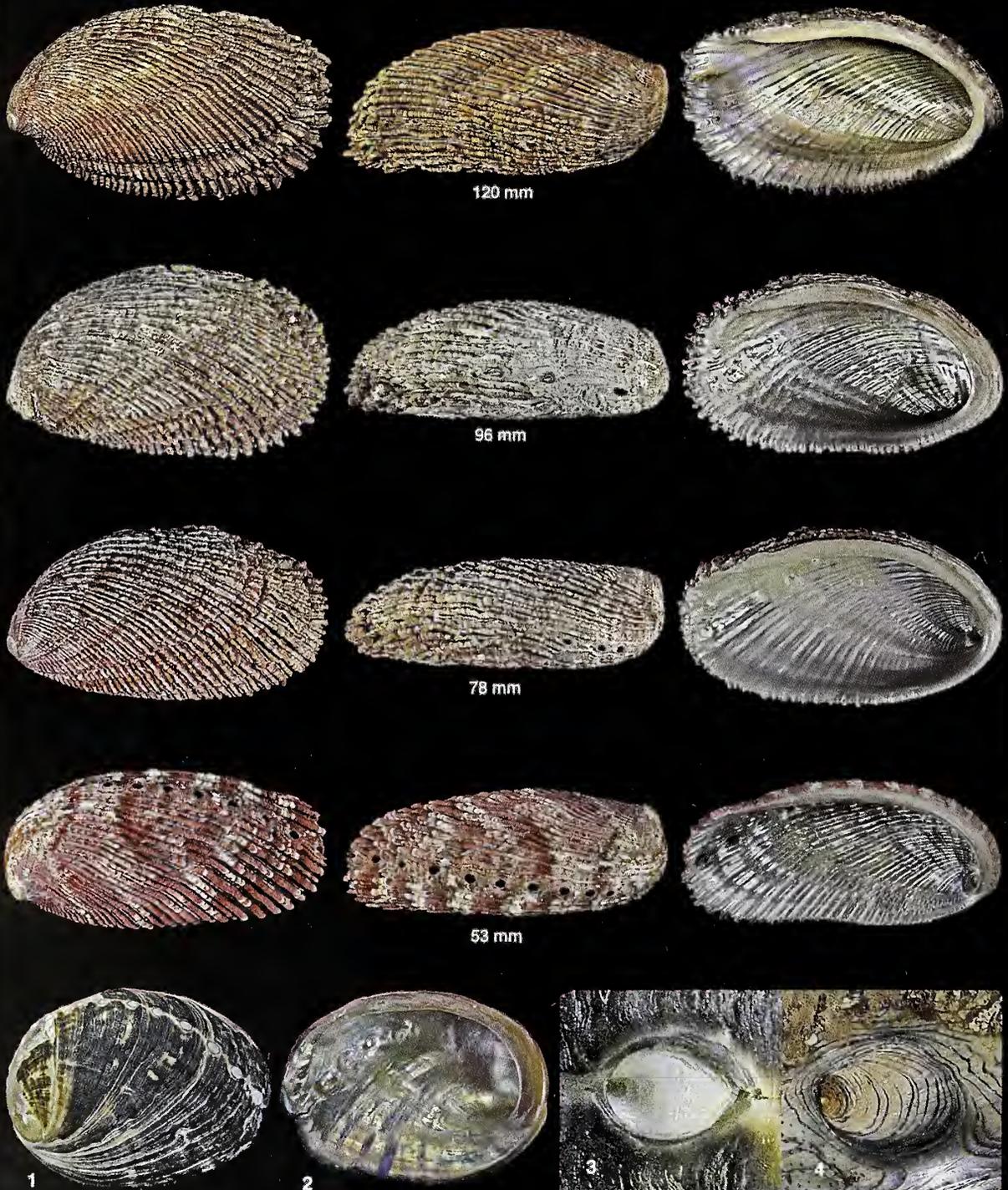


PLATE 3



Top Row: *H. cracherodii* var. *holzneri* Hemphill, 1907. Syntype. Baja California, Mexico. CASIZ
 2nd Row: *H. cracherodii* var. *holzneri*. Imperforate like syntypes. Santa Cruz Island, California. Dead shell. BTC
 3rd Row: *H. cracherodii* var. *holzneri*. Imperforate like syntypes. El Rosario, Baja California, Mexico. 1952. BOC
 Bottom Row: *H. cf. cracherodii* var. *holzneri* (not imperforate). Cuyler Harbor, San Miguel Is., California. 1959. Intertidal. BOC

PLATE 4



Top 4 Rows: *Haliotis elegans*. Between Perth and Fremante, WA, Australia.
 Bottom Row: 1 & 2 - *H. cracherodii cracherodii* with holes filled with nacre by animal. 47.0 mm.
 3 - Closed hole of *H. cracherodii cracherodii*.
 4 - Closed hole of Type 2 imperforate *H. rufescens* (from bottom row of Pl. 2).

PLATE 5



Top: Normal *Haliotis* animal showing pallial cleft where holes are formed (*H. fulgens fulgens* Philippi, 1845. 49 mm)
Bottom: Imperforate *Haliotis* animal showing absence of pallial cleft (*H. fulgens fulgens*. 42 mm)



Have a shell collection you would like to sell?

The San Diego Shell Club is interested in high quality estate collections comprised of any and all types of shells, marine or land, and all genera and species. Your shells will be used to generate income to support the Club's efforts in continuing public education about shells and conservation of marine life throughout the world. If you have considered selling your collection to a dealer and were unhappy with the offer, then please contact Dave Waller, SDSC Acquisition Chairperson, at dwaller@dbwipmg.com to schedule a time to review your collection and provide you with another offer to consider.

CLUB NEWS

January 2015, Regular Meeting, Casa del Prado Room 104, San Diego, CA

Meeting called to order 7:30 p.m.

- David Lum, from the Hawaiian Shell Club, visited and joined the Club.
- Prior minutes were accepted as read.
- Meeting times will change this coming year and discussed by members.
- Paul Tuskes talked about upcoming events, meetings and \$1,000 student award contest.
- Rick Negus talked about shells purchased for the Club from Val Darkin.
- David Berschauer talked about Club news on Facebook.
- Dave Waller and Paul Tuskes are Webmasters with modification capability.
- Need volunteer for Club Historian.
- San Diego County Fair "competition" changed to an exhibit.
- Red abalone for state marine mollusk to be part of the exhibit at the fair.
- 2018 COA to be in San Diego, Anne Joffe head of planning at COA.
- Abalone supplement for sale at meeting for \$35.
- Donations for April Auction solicited from membership.
- Paul Tuskes was the speaker and delivered a program titled "The Best of Baja and Beyond."
- Marylynn Goldhammer won the door prize.

Meeting adjourned at 8:30 p.m.

February 2015, Regular Meeting, Holiday Inn Express, 751 Raintree Drive, Carlsbad, CA

Meeting called to order at 12:00 noon

- Prior minutes were accepted as read.
- Next month's talk will be on shelling in Cuba.
- April potluck and auction will be at Dr. Farmer's club house.
- Treasurer's report given; eBay/PayPal, Website Start-up costs mentioned.
- Auction billing statements to be sent to members ASAP after the auction.
- Marty Schuler to be asked to make new flyers and banner for the San Diego County fair.
- Social media report: 373 members on SDSC Facebook.
- Membership report: 133 paid Club members.
- Festivus, size of articles and price discussed.
- Need volunteers to pick shells for auction at Don Pisor's house.
- Bill Schramm was the speaker and delivered a program titled "Beautiful Cowries".
- Paul Tuskes brought cowries from Hawaii; other members showed cowries from their collections and Dr. Farmer brought models of nudibranchs.
- There was no door prize

Meeting adjourned at 1:45 p.m.

March 2015, Regular Meeting, Casa del Prado Room 104, San Diego, CA

Meeting called to order at 7:30 p.m.

- Dave Waller gave budget overview for 2015.
- San Diego County Fair site described in detail; cabinet costs discussed and how covered in the budget.
- Treasure's report given.
- Library books have been re-organized by Region/Genera.
- The presentation for May's meeting will be on the "Biology of Leopard Sharks".
- Paul Valentich-Scott and Eugene Coan to be presented with the SDSC lifetime award.
- Website to include list of honorary members.
- Discussed that the 2018 COA will be hosted by the Club and held in San Diego.
- Discussed the final version of the bill to make the red abalone the state marine mollusk.
- Discussed "Most Beautiful Shell" competition on SDSC Facebook.
- Paul Tuskes was the speaker and delivered a program titled "Cuban Land Snails".
- David Berschauer won the door prize.

Meeting adjourned at 9:00 p.m.

Hawaiian Tree Snails

David Rolfe

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The shells represented here (in Figure 1) came with a collection I acquired many years ago, they are a group of terrestrial snails endemic to the Hawaiian islands and are mostly now extinct. The few remaining species are listed under the CITES Appendix 1 and are strictly protected, these particular ones were collected in the 1860's in the 'Sandwich Islands', and old name for the Hawaiian islands, and are therefore legal to own. They belong to the family Achatinellidae and were once all classified under the genus *Achatinella* but more recent authorities have split them into two families, Achatinellidae and Mastridae, and split these two into several genera. Shown here are some examples of the family Achatinellidae which comprises of three genera; *Achatinella*, *Partulina* and *Ewcombia*. All species are very localized and arboreal in nature, some forms and subspecies were restricted to a single tree. As in some other families of terrestrial snails some species are sinistral, some dextral and many are both.

The genus *Achatinella* are known as 'Oahu Tree Snails', as they are endemic to that island, and these days are restricted to remote mountain valleys above 3000 feet. They were once very numerous, some species were even abundant, and locals used them in jewelry and to make shell Leis. They were also mentioned in Hawaiian songs and folklore, but now more than 80% of the species are extinct. These extinctions were mainly due to deforestation of the Hawaiian lowlands in the late 19th and early 20th centuries, but also introduced pest species such as the Wolf Snail, *Euglandina rosea*, which, ironically, was introduced to eat the young of the Giant African Land Snail *Achatina fulica*, another non-native species. The Wolf Snail is slowly eating the remaining populations of *Achatinella* and steps are being taken to conserve the remaining colonies. It was hoped that altitude would be a barrier to this species but that does not appear to be the case as it is slowly moving higher up the mountains. A captive breeding program is ongoing, but these snails grow very slowly and only bear a few live young at a time so progress is slow. Their diet is also very exclusive consisting of a thin film of fungus growing on the leaves of some native trees and shrubs. Similar fungi are found on many introduced trees but it is not known if the snails could thrive on these alien species.

The other genera in the family, *Partulina* and *Newcombia*, are similarly threatened and it is thought that 50% of these species are also now extinct. Their habits and lifestyles are similar to *Achatinella* but they are more widely distributed on other Hawaiian islands.

It is hoped that the few remaining species can be saved, but the prognosis is not good for the wild populations. The last known survey of these snails I can find any evidence of was made in the late 1980's so even more species could have disappeared since then, however it is hoped that some species could still be waiting to be rediscovered in some remote, unexplored corner of the Hawaiian islands.

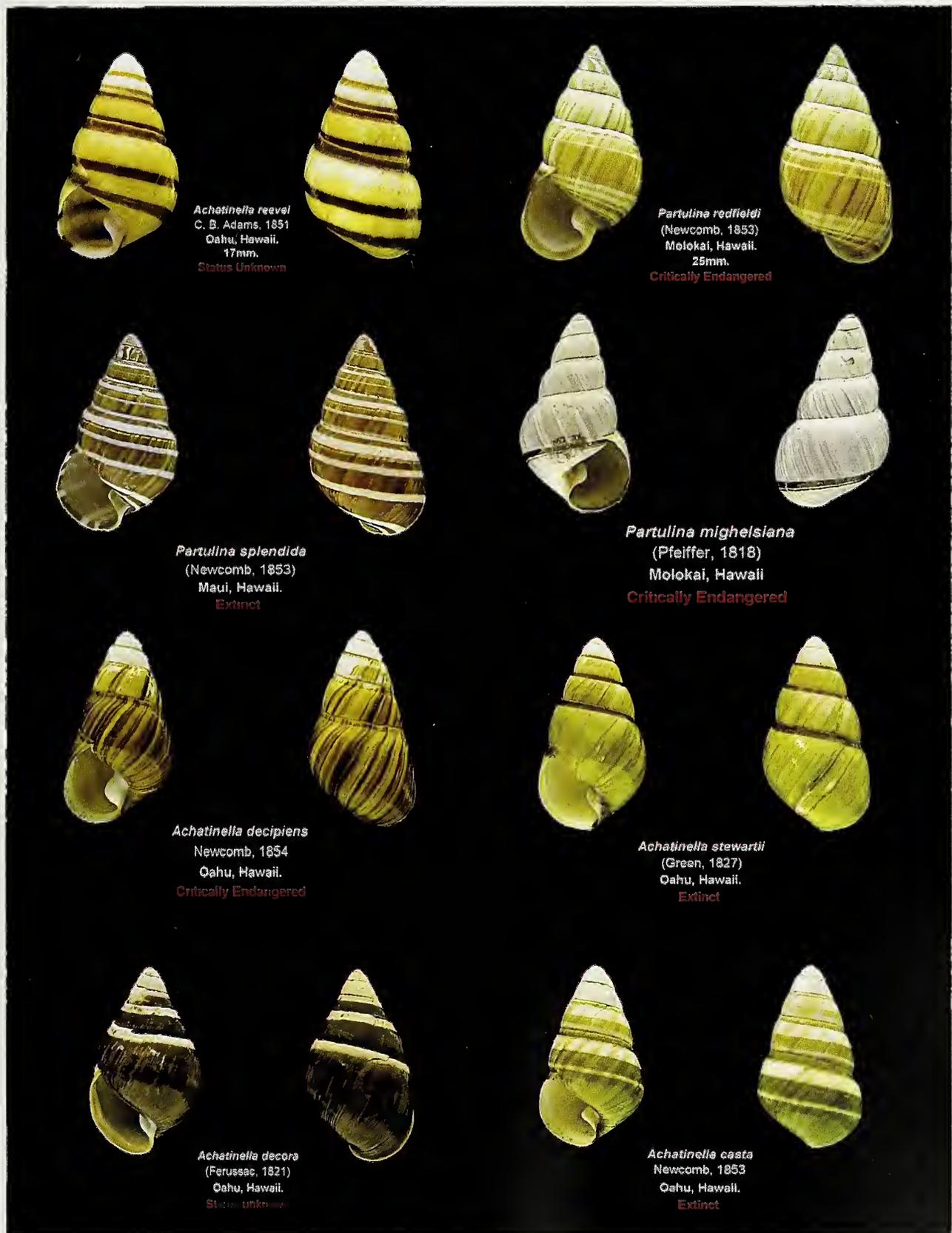


Figure 1. Endemic Hawaiian Tree Snails from Oahu. Photos by David Rolfe

Of Threads And Strings And Little Green Lizards

By Larry Buck

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I firmly believe that truth rules the roost, or it should, honesty should. When one is an impassioned collector of any persuasion, a man or a woman, or if the collector's a child -- anyone with an intense interest in things collectible -- there are those times when one struggles with one's often spitefully stubborn devices. Subsequently, one often finds one's self standing there helplessly, not so innocently, as one's willfulness resists control under any guise. For instance, there have been times when I've observed myself acting like the proverbial bird dog on point. I catch myself thinking, "I've gotta have that!" When in truth, I don't gotta have that. The truth is, I want that. There have been times when basically I've had to grab hold of myself, and tell myself, "Listen Bub, cool it!" Then I both tell and receive the lecture about one rising above such selfishness. Mostly the conversation is one way, chastising in tone. "You're not rising? Then fake it -- pretend!" Then comes another lecture, this one on honestly trying, or not. And what follows is a sort of pseudo benevolent altruism. I do pretend. Forced words, and begrudged compliments flow forth with "practically" honest sincerity. And to whoever, about their whatever, I say, "Nice," -- They can keep their stupid shell. I hate being dishonest. And isn't self control still control? It's all very complex. I just know that passion is good, not bad. And a collector's deep interest, otherwise known as an intense interest, can be both fun and problematic, as one always has competitors to engage in righteous battle. And I'm sure you've surmised -- this isn't going to be your average scientific article.

And one other point. In the struggle against one's devices, the path to victory is paved with temptation, as in reefs to cause one's boat to run aground. "Well, the water looks clear. I suppose there's nothing else to do." I'm putting on my mask and fins -- you see? We're easily distracted, and we find detours, which are literally everywhere to be taken advantage of. And so there is that.

In the case that I'm now about to recount, the temptation "the stupid whatever," was a clam shell, albeit a 19.5 inch clam shell -- big. Recently, to the gentleman who had possession, I remarked in passing "Nice clam." The size of the clam shell in question would suggest a species of giant clam, of the family *Tridacnidae*. I was duly informed that the species was in fact *T. derasa*, a species of which I had never heard, much less laid eyes on. Soon, a bright red vacancy sign begins flashing in a cloud over my head indicating that there is a space eagerly awaiting the species in the collection. I tell myself, "Big deal," that it's not important, and, "Stop wanting stuff!" Then I hear a voice objecting, telling me that it is important, and reminding me that, no matter, the void still requires filling. I'm in control here. Calmly, again I remark, "Nice," my demeanor is "no biggie." Ignoring that I'm also thinking, "Impressive," which means that it actually is a biggie. I'm thinking, "Oh well," while inexplicably I'm counseling myself not



to appear too eager, and stop swallowing. I think, "why?" Because, kind of like unbeknownst to me, I've been negotiating, and I hear applause, that a trade has been consummated. I think, "Really?" And no more vacancy, or so I think. So much for self control.

Meanwhile, later, back at the ranch, the whistle blows. Because it's important to placate my longing for even a small measure, some semblance of structure and order, ingredients sorely missing in my universe, and something a collector such as myself also gains, if not surreptitiously, because of all of that, the whistle blows. "All right, any seashell residing in the G.L. Buck Collection, first a bath." Time to put my new acquisition through her paces. Take it all off, the unsightly dirt, the rust stain, a thorough bleaching. And for a final touch, to spruce up an otherwise listless interior, a smidgeon of silicon oil. And voila! I'm thinking, "Now that's nice." It's time for her debut. But first that proclamation of legitimacy. Let's make it official. Not with a ring, but with a data slip.

To a collector such as myself, data accuracy is an important thing -- the truth, theoretically. I'm reading and digesting the information I was given, and thinking, this is all good. Seems the previous gentleman, by hook or by crook, physically wrested possession from her exploiter, who clammed, I mean claimed, to be a diver, who himself wrested possession of my treasure from the seabed. Anyway, our diver-discoverer tires of her. It happens. Then Mister Good Samaritan stumbles along, sweeps her up in his arms, tires of her too. Then comes my turn. It's sounding like a rescued-from-the-rescuers sort of situation. My collection may not be as exciting -- still I can be her security blanket. I do think that a tabloid-style human interest perspective can add a little spice to one's data slip, as long as it's true. She's going by *T. derasa* -- sexy. From the corner of Hollywood and "Stop it! Actual residence wise guy." Which I read is Bontang Island, Borneo, of wild-man-of-Borneo fame. Could there be more story there? The collecting year to remember -- 1982-1983. Took him two years? There, data-induced legitimacy. . . . Control must be important to me, because often I find myself complaining about the lack of it -- my control. So I would be remiss were I not as well to acknowledge those instances when I find even the tiniest vestige of my world conversely spinning into control. It seems that I observe things predictably bound together, even purposefully, which to me is a kind of order. I guess what I'm really talking about is reliability due to a predesigned interconnectedness. And I'm not running on. Please bear with me.

Practically every day I see threads -- those strings that tie our universes together. Not to be confused with string theory, invisible strings fancied by physicists that minds must strain to imagine, that aren't there to witness each and every day. Though our strings too, if not invisible, are easily overlooked, can be easy to miss. Think about it. Consider the arrangement, that somehow all things manage to be tied together, and at times, tied with an exceedingly stout rope, to our dismay, this tied to that, truth be known. The predictability of interconnectedness tends to boggle the mind.

The current year -- 2015, that too is mind boggling. Who would have ever thought it would turn out that a shell club, of which I am president, is poised to make a comeback appearance at the San Diego County Fair. We're back! And I'm back. And what in the world is he talking about? That just mentioning it, "The fair", evokes memories, fond recollections of those bygone days. . . . I must have fallen asleep. A hand on my shoulder shaking me. Yes, I see strings, the man with his little green lizards on strings for sale, his little herd corralled, their leashes pinned to the board. Suddenly, miraculously, I'm little too! Miracles never cease -- a purchase. The man pins on my lizard. What, no lapels? Ouch! The jerk stuck me! "Here kid, and don't forget your dried flies." Doofus smiles, handing me a little bag. Somewhat reminiscent of raisins as I recall. Back then no one thought to call PITA or the ASPCA -- lizard abuse. Later, out of my sight for just one moment and what do you know? My green lizard is gone. A little Houdini. Supposedly he slipped his noose. I was young, not dumb. I knew someone helped him escape. "I'm sorry! Fess up people!" And none of

their," Poor thing, alas he's escaped" stuff. Yeah, perhaps he got a craving for sushi. I still harbor suspicions -- there were other instances. It was a conspiratorial situation.

In the fifties it was called the Del Mar Fair, and it was filled with wonders, if not filled as well with a wee bit of oppressiveness. Besides be-stringed lizards, there was this vendor -- no warning posted, luring in kids, peddling to those kids, as it turns out, addictive substances -- seashells. The vendor was perhaps Naylor, perhaps the Purdys. Our Club archives mention those members' names -- who were also shell dealers. Whoever, they're gone now. I would have been just one of a passel of kids. I recall a near constant chorus of, "Will you buy me thises?" And I'll concede that one of the loudest voices might have been mine. No matter how sweetly I asked -- "No!" Begging had come highly recommended, "People please?" Only a look. Still no luck. Did they prefer petulance? Mom and Dad had long since mastered their game -- insular, expressionless. I could suggest getting their hearing checked -- it was what they said to me? Heck with their games. If one allows it to happen, reality will try to smother things.

My grandson Jimmy is six. I was about Jimmy's age. And like Jimmy, I especially liked spider conchs. You know spiders for little boys, and sugar and spice and everything nice for girls? My other favorite being sold at the fair's shell booth were the bear paws -- *Hippopus* clams. I remember the colors and textures and shapes like it was yesterday. I'm getting a buzz -- all the stirring of smoldering childhood passions.

When my family journeyed to the fair what it boiled down to was this, buy food -- corn dogs and such, versus buy shells, or whatever. Money being in limited supply, seashells lost out, and rightfully so. Unlike my sisters, I was never able to perfect crying to get what I wanted, though Lord knows I may have tried once or twice. Probably, had my hair been a bit longer they might have thought, you know, "How adorable." Rest assured I wasn't defenseless, not without my strengths. I had been blessed with a loud voice, and persistence. Come back here! No? They weren't. Evidently they can't hear -- damn crowd noise. All right for them. I wasn't leaving without a shell. Dad's stock answer was usually something like -- grunting, where do they sell beer? And a look for me. And dragging his callused knuckles on the ground -- walking on all fours. That might impress girls, but it didn't deter me. I wasn't leaving. Uh-oh -- they were. Parents and entourage, minus me -- burr-head, the troublesome one -- my family was disappearing into the crowd, with no concerns, no sympathy, for a sweet innocent little boy and his seashells. Change that, here comes concern -- sending back their goons. My two big sisters marching back, stretching their fingers, to emphasize sharp fingernails. Their theory being if it bleeds it can be controlled. The rules stated only the arms. No problema. When you're a tough guy, wounds show courage, and one's scars are a thing of honor. Seems my arms were always lacerated, and bleeding. Back then nobody ever thought call CPS, child protection. I'm sure it would have been me being led away in cuffs, "They touched me first!" "Stop kicking kid!" Presumably, and things will go easier on a you if you don't resist. Leave us to say no such drama, and no shells, until later. Anyway, cotton candy was always in question. Even at fairs life has it's disappointments. And deprivation imprints one for life, and spider conchs, and bivalves of the genus *Hippopus*, have hence been some of my favorite seashells. There you go, your data, some background info on the fair.

Skipping forward back to the present. . . My hair is longer. So there I am admiring my newest seashell acquisition. "Stop that!" an incessant shaking of my shoulder, "What now?" Somehow it gets conveyed that I should examine this bad girl more closely, that I should look past the erosion, beneath the encrustations. You know, besides big, the clam has other attributes? It begins to occur to me what it is I'm looking at -- low and behold, it's a *Hippopus*! I could make out the tale-tell features of the genus, including the byssal orifice dentition and smooth, no scales -- *porcellanus*. Not a *Tridacna*, a *Hippopus*, a *H. porcellanus* Rosewater, 1982 to be exact. See photo, and see you at the fair, June 5 -- July 5.

April Potluck and Shell Auction

By William Schramm

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Since I was volunteered to write a short article about the San Diego Shell Club's recent auction I had the brilliant idea that other members of the board could help by each providing me with a paragraph of their thoughts. But then I was contacted by the editor of this journal who informed me that this article was needed like yesterday. Well so much for brilliant thoughts and so I got busy. This was one of the best-attended auctions with 36 participants and over 200 shells on the auction block. Shells were going to their new owners at a rate more than one per minute. There was some fierce bidding at times to the chagrin of some who were hoping to get a shell at bargain basement prices. And unlike recent past years very few shells went without someone bidding for them. Yours truly was volunteered to be the auctioneer's assistant. At the time I wished that I had the courage to say no but a few minutes in the limelight and I began to enjoy this activity. Actually I didn't have to say a thing and just let the auctioneer mispronounce all those peculiar shell names. Good thing there were a few people in the audience who knew a thing or two about shells. Individual shells went for as low as \$1 to as high as \$380. The one dollar and five dollar tables were crowded with people picking out a shell or two during the mid bidding break.

A special thanks goes to all the Club members and participants who provided the food for the delicious potluck lunch. And then there was our fearless leader Larry who was overseeing all of the activities while almost drinking half of all the beer we had, or maybe he was he just nursing the same old bottle all afternoon. People came from nearby Orange and Los Angeles counties and some from even much further north. The event started about twelve noon for viewing the shells, followed with lunch and then four hours of auctioneering. It seemed like everyone had a great time with lots of smiles and laughter. I can hardly wait for the fall auction to arrive.



José and Marcus Coltro

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Taxonomic note - new species: *Poremskiconus mariaodetae* Petuch & Myers, 2014.

Sharply angled broad shoulders edged with small raised carina, a low broadly subpyramidal spire, and a slightly concave outline. Proportionately large protoconch having two large rounded whorls. Early whorls bright reddish-



Poremskiconus mariaodetae Petuch & Myers, 2014

pink, spire whorls white overlaid with dense, closely-packed dark tan-brown crescent-shaped flammules extending onto the edge of the shoulder carina which produces a checkerboard band around the shoulder. Shiny and highly-polished body whorl is a uniform bright orange, orange-tan, or deep red-orange color with 6 to 8 large widely-separated spiral cords around the anterior end, with a single wide white band around the mid-body with 4 to 5 rows of small brown dots and large longitudinal brown flammules; occasionally with faint brown dots overlying the base color of the body whorl. Aperture uniformly narrow and orange on the interior. Endemic to Cerará, Brazil. (Petuch, Edward.J. & Myers R.F. 2014. *New species of Conidae and Conilithidae (Gastropoda: Conoidea)* from the Bahamas, eastern Caribbean, and Brazil. *Xenophora Taxonomy* 3: 26-46.)
Photo credit: David P. Berschauer

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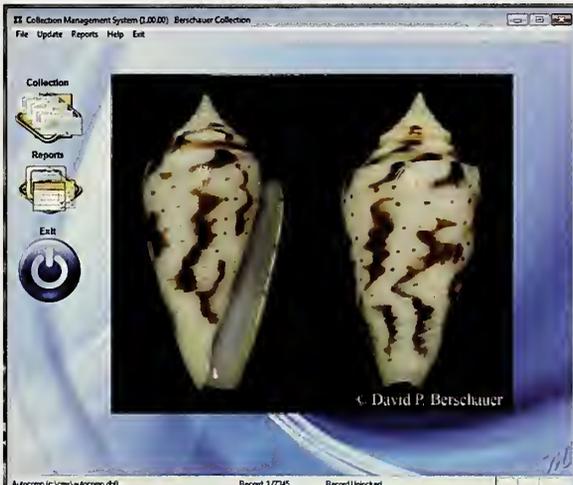
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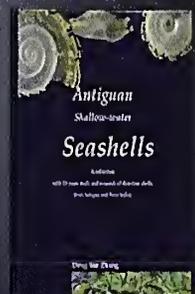
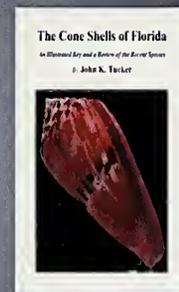
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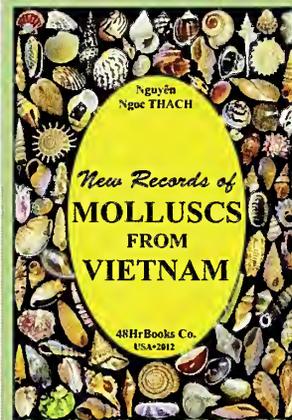
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THE **Festivus**

Vol. 47(3)

AUGUST 2015



Inside:

New Land Snail Species from Thailand

Lab Experiments with Multi-Species

***Haliotis* Hybrids**

Two New Species of *Tenorioconus*

from Aruba

Quarterly Publication of the San Diego Shell Club



THE FESTIVUS

A publication of the San Diego Shell Club

Volume: 47

August 2015

ISSUE 3

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FRONT COVER:

Amphidromus atricallosus temasek from Thailand, taken from a figure in the featured article by Chorchat Gra-tes.
(Cover artistic credit: Martin Schuler)

MISSION STATEMENT

The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, promote the study and promote the conservation of Mollusca, and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, amateurs and scientists, divers, underwater photographers and dealers.

THE FESTIVUS is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Review Board (which are of a scientific nature, including new taxa articles), as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field and preference. Available by request or on our website are:

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Shell Show & Sale: 8/16/2015
September Party: 9/12/2015
November Auction: 11/14/2015
Holiday Party: 12/12/2015

Publication date: August 1, 2015

TABLE OF CONTENTS

Peer Reviewed Articles

- Two New Species and One New Subspecies of *Amphidromus* (Gastropoda: p. 151
Camaenidae) From Thailand
By Chorchat Gra-tes
- Laboratory Studies of Hybridization in California Abalone (*Haliotis*) p. 167
By Buzz Owen and Richard Meyer
- Taxonomic Note - new species: *Haliotis geigeri* Owen, 2014 p. 185
- Two New Species of *Tenorioconus* (Gastropoda: Conidae) from Aruba p. 195
By Edward J. Petuch and David P. Berschauer

Club News p. 206

Articles of General Interest

- Carol Skoglund and *Gradiconus skoglundae* p. 207
By John K. Tucker
- “My Pet Cowrie” - *Macrocypraea cervus* Linnaeus, 1771 p. 208
By Tammy L. Myers
- Mission Bay Mysteries p. 210
By Robyn Waayers
- San Diego Shell Club at the Fair p. 211
By Paul Tuskes

In memoriam - Harrold JJ Jackson

We are all saddened by the death of Harold JJ Jackson on June 8, 2015, in a night diving accident off of Makaha, Hawaii. Affectionately known as “JJ” he was loved by family, friends, and fellow scuba divers and shell collectors throughout the world. “JJ” was a kind and generous man with a larger than life personality. “JJ”’s love and passion for shells will never be forgotten by the leagues of shellers who were fortunate enough to have met him and call him their friend.

Friends and family celebrated his life on June 28, 2015, at Faith Church in Kailua, Hawaii.



**TWO NEW SPECIES AND ONE NEW SUBSPECIES OF
AMPHIDROMUS (GASTROPODA: CAMAENIDAE)
FROM THAILAND**

Chorchat Gra-tes

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ABSTRACT Two new species and one new subspecies of genus *Amphidromus* are described from Chumphon and Prachuab Khiri Khan Province (i), Peninsular Thailand (ii). The first species and the new subspecies are from the small island of Talu Island (iii) off Chumphon in the Gulf of Thailand and the second species is from Kui Buri National Park (iv). *Amphidromus taluensis* sp. nov. and *Amphidromus luangensis* sp. nov. are conchologically differentiated from *Amphidromus atricallosus* (Gould 1843) and other *Amphidromus atricallosus* complex and *Amphidromus taluensi borealis* spp. nov. is differentiated from *Amphidromus taluensis* sp. nov.

KEY WORDS Gastropoda, Camaenidae, *Amphidromus*, *taluensis*, *luangensis*, Thailand.

INTRODUCTION

The genus *Amphidromus* Albers, 1850 is a very attractive and colorful member of family Camaenidae Pilsbry, 1850, and one of the most attractive genera of terrestrial mollusca. *Amphidromus* can be found in dry, moist or wet broadleaf forests and in primary, secondary and re-growth forests from the central parts to the fringes. The distribution ranging from eastern India and southern China to South East Asia and northern Australia (v). In Thailand, there are about 16 described species of *Amphidromus* and *Amphidromus* (*Syndromus*) (vi). *Amphidromus* species in Thailand are distributed in small patches of forest but in a very limited numbers. Expansion of agricultural land and the use of chemicals destroyed critical habitat which may lead to extinction. Other factors include drought, fire and predators, such as primates and snakes. Nevertheless, there are still some unaffected areas that have not yet been explored or recently explored, such as Talu Island and Kui Buri National Park. Exploration of these two sites resulted in the discovery of two new species and one subspecies described herein.

Talu Island is a very small island in the Gulf of Thailand about 10 kilometers from the mainland. It was a hill that was isolated as sea levels rose in the early Holocene. It has an area of about 1.6 square kilometers covered tropical dense forest. *A. taluensis* sp. nov. and *A. taluensis borealis* spp. nov. were separated from related species since the island was formed and evolved for hundreds of years under the different environment from the mainland.

MATERIAL AND METHODS

The types are deposited in the Chulalongkorn University, Museum of Zoology, Bangkok, Thailand.

The description of shell characters and morphological analyses were obtained from dry empty shells. The *A. atricallosus* (Gould 1843) specimens that are used for comparison with new taxa are from my private collection. The specimens collected from Kui Buri National Park, were in the vicinity of Latitude 12° 3' 0" North, Longitude 99° 34' 19.2" East.

Abbreviations:

A. = *Amphidromus*
 CA = Columella Angle
 CD = Columella Deviation
 CGSC = Chorchat Gra-tes Shell Collection
 CNHM = Chicago Natural History Museum
 Colabial = Parallel to the lip
 Coll. = Collected by
 CUMZ = Chulalongkorn University, Museum of Zoology
 D = Dextral
 H = Shell Hight
 Lat. = Lattitude
 Long. = Longitude
 Microthreads = very fine raised lines
 N = Number of whorls
 S = Sinistral
 W = Shell Width

SYSTEMATICS

Family Camaenidae Pilsbry, 1895
 Genus *Amphidromus* Albers, 1850
 Subgenus *Amphidromus* Albers, 1850

***Amphidromus taluensis*, sp. nov.**

(Plate:1 Fig.1, Plate:3 Fig.1, Plate:13, Plate:16 Fig.1-12, Plate:17 Fig.1-12, Plate:22 Fig.1-4, Plate:23 Fig.1-3)

Type Locality.

Southern end of Talu Island, Gulf of Thailand off Chumphon Province, peninsular Thailand. Collected live on leaves of trees in damp dense forest during light rain about 39 meters above sea level.

Material and Methods.

Holotype: 1 D, H 44.74 x W 23.01 mm. (CUMZ 3169). Coll. Chorchat Gra-tes, March 2012 (Plate:16 Fig.1, Plate:17 Fig.1, Plate:22 Fig.1). Paratypes: 41 specimens (D-21, S-20) (15 specimens are shown here) in CGSC. Coll. Chorchat Gra-tes.

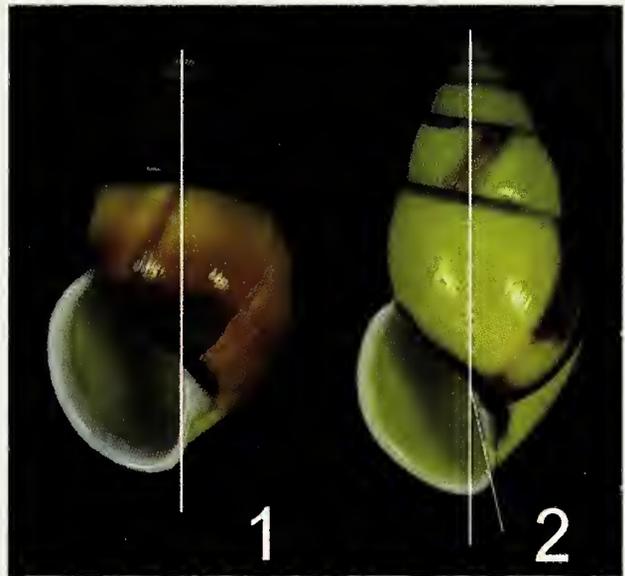


Plate 1: The Columella Deviation or the angle between parietal wall and columella measures the angle between parietal wall and shell axis. The deviation of *A. taluensis* sp. nov. (1) has no deviation but *A. taluensis borealis* spp. nov. (2) has deviation to the right.

Description.

Shell dextral or sinistral. Shell small, thin and light. Surface glossy. Aperture lip reflected and thin. It has Aperture tinted yellow to yellow-white. Parietal dark brown to black. Basic coloration is brownish yellow to brown suffusion on the last whorl with irregular brown longitudinal streaks. Brownish yellow zone below a narrow dark subsutural band with broad brown band on the lower part of the last whorl. Upper whorls differ from the last whorl, some specimens have dark brown spiral band (as in the Holotype) or dark brown suffusion (as in Paratypes). Adult size range of 34 to 47 mm.

Distribution.

This species is endemic to Talu Island.

Etymology.

This species is named after the type locality Talu Island, with Latin suffix *-ensis* denoting place.

Comparison.

Shells of *A. taluensis* sp. nov. on average are smaller, thinner, glossy and more slender when compare to *A. atricallosus* (Gould, 1843). The aperture lip of *A. taluensis* sp. nov. is thin, while that of *A. atricallosus* is thick. The aperture color of *A. taluensis* sp. nov. is tinted yellow to yellow-white, while that of *A. atricallosus* is white. Both species a dark brown to black parietal callus but *A. taluensis* sp. nov. is brownish yellow with brown markings compared with uniform greenish yellow to white in *A. atricallosus*. *A. taluensis* sp. nov. has narrow dark brown subsutural band, which is absent in *A. atricallosus*.

***Amphidromus taluensis borealis*, spp. nov.**

(Plate:1 Fig.2, Plate:3 Fig.2, Plate:18 Fig.1-6,
Plate:19 Fig.1-6, Plate:22 Fig.5-8, Plate:23
Fig.4-6)

Type Locality.

Northern end of Talu Island, Gulf of Thailand off Chumphon Province, peninsular Thailand.

Material and Methods.

Holotype: 1 D, H 44.44 x W 23.43 mm. (CUMZ-3170). Collected live on the leaves of trees in a damp forest located in the northern part of Talu Island, about 39.6 meters above sea level during light rain. Coll. Chorchat Gra-tes, March 2012 (Plate:18 Fig.1, Plate:19 Fig.1, Plate:22 Fig.5).

Paratypes: 47 specimens (D-23, S-24) (8 are shown here) in CGSC. Coll. Chorchat Gra-tes.

Description.

Shell dextral or sinistral, small, rather thin and light. Surface glossy. Aperture lip is rather thin. Aperture yellow-white to yellow. Parietal callus dark brown to black. Shell bright yellow to greenish yellow. Dark brown peripheral band sometimes present on the spire, extending partially onto the last whorl. Narrow dark brown

band below the suture. Adult size range is 36.5 to 41.5 mm.



Plate 2: *A. janus* (Pfeiffer, 1854) from Mergui Islands, Myanmar (vii). When comparing *A. taluensis* sp. nov. (Plate:16 Fig. 1,3,9 and Plate:17 Fig 1,3,9) and *A. taluensis borealis* spp. nov. (Plate:18 Fig. 1,2,3 and Plate:19 Fig 1,2,3) with *A. janus* (Pfeiffer, 1854) in Plate:2, they seem to be very close in size, pattern and shape. They have the same dark brown to black parietal callus but distinctly different in pattern, and coloration - the body and aperture.

Comparison.

A. taluensis borealis spp. nov. on average is smaller, thinner, and more slender compared to *A. atricallosus* (Gould, 1843). *A. taluensis borealis* spp. nov. has a yellow-white to yellow aperture with a dark brown to black parietal callus same as *A. atricallosus* (Gould, 1843) but has a brighter yellow to greenish yellow shell that seems luminous, and is never white. *A. taluensis borealis* spp. nov. has a narrow dark brown subsutural band which is absent in *A. atricallosus* (Gould, 1843). *A. taluensis borealis* spp. nov. when compare with *A. taluensis* sp. nov. is conchologically the same. Both may have a brown peripheral band on the spire that may extend partially onto the last whorl, and one or more brown and/or black varices, except they differ in basic coloration. The coloration of *A. taluensis borealis* spp. nov. differs from *A. taluensis* sp. nov. being bright yellow to greenish yellow and brownish yellow with brown markings respectively. Coloration

around the umbilicus in adult whitish-brown (some specimens completely brown; Plate:18 Figs.2 & 3) while *A. taluensis* sp. nov. is white. The coloration of *A. taluensis borealis* spp. nov. and *A. taluensis* sp. nov. is consistent within their own population.

Distribution.

This species is endemic to Talu Island.

Etymology.

This subspecies is named after the “Northern end” of Talu Island where it was found; *borealis* is the Latin for “northern”.

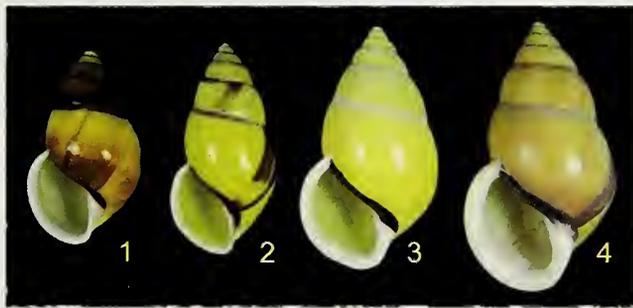


Plate 3: Fig.1: *A. taluensis* sp. nov., 2. *A. taluensis borealis* spp. nov., 3. *A. atricallosus* (Gould, 1843) and 4. *A. luangensis* sp. nov., all from CGSC. Figs. 1 and 2 are from Talu Island, Gulf of Thailand off Chumphon Province, peninsular Thailand. Figs. 3 and 4 are from Kui Buri National Park Prachuap Khiri Khan Province, peninsular Thailand.

Amphidromus luangensis, sp. nov.

(Plate:3 Fig.4, Plate:5, Plate:6 Fig.2, Plate:7

Fig.2, Plate:20 Fig.1-9, Plate:21 Fig.1-9,

Plate:22 Fig.13-16, Plate:23 Fig.10-12, Plate:24 Figs.1 & 5)

Type Locality.

Khao Luang at 11° 40' N, 99° 35' E on the Thailand-Burmese border, Prachuap Khiri Khan (west of Ban Huai Yang). Endemic, only known from the type locality and Kui Buri National Park, Prachuap Khiri Khan in a very small area.



Plate 4: Khao Luang where Hugh M. Smith found the Holotype of *A. luangensis*, sp. nov.

Material and Methods.

Holotype: 1 D (CNHM 109473) Plate:5. This specimen was first found by Hugh M. Smith before 1940 (4 shells, 2 D & 2 S) and discussed as a variant form of *A. atricallosus* with slight brownish suffusion from Khao Luang west of Prachuap Khiri Khan (west of Ban Huai Yang) (viii).



Plate 5: Holotype of *A. luangensis*, sp. nov. (CNHM 109473) (Solem, 1965; Plate:1, Fig. 2) (ix) Paratypes: 50 specimens (D-24, S-26) (12 shown here) in CGSC. They were collected in damp sparse forest in Kui Buri National Park, Prachuap Khiri Khan Province, about 231 meters above sea level. Coll. Chorchat Gra-tes, August 2013.

Description.

Shell dextral or sinistral, small to medium, thick and heavy. Surface glossy. Aperture lip thick. Aperture white to light lavender. Parietal callus dark brown to black. Shell rosy brown with a

wide light rosy brown subsutural band. Upper whorls light yellowish brown to rosy brown but gradually gets darker on the lower whorl. Narrow yellow or white peripheral band sometime present on the spire and last whorl. Adult size range of 39 to 54.5 mm.

Distribution.

Endemic, only known from the type locality in a very small area.

Etymology.

This species is named after the type locality Khao "Luang" where it was first found by Hugh M. Smith before 1940, with Latin suffix *-ensis* denoting place.

Comparison.

Laidlaw & Solem (1961) and Solem (1965) were "very conservative" declaring this brown snail, *leucoxanthus* and *peraknesis* as color forms of *A. atricallosus*. Solem (1965) stated typical *atricallosus* are found at Koh Lak (Prachuap Bay), Prachuap Khiri Khan (p.621 and Table 2, USNM 427292, 5 shells).

Laidlaw and Solem also commented (x);

A. atricallosus (Gould, 1843) has a dark-brown or black callus and varix and a relatively broad white subsutural zone. The shells are generally rather large (50-55 mm. in height). *Bulimus eques* Pfeiffer, 1857, has long been recognized as a synonym. Described from coastal Burma.

A. leucoxanthus (von Martens, 1864) has a white subsutural zone and dark varix of *atricallosus* but lacks the darkened parietal callus. Some examples have a dark apex and various dark markings on the upper whorls. Described from Thailand.

A. perakensis Fulton, 1901, has the white subsutural zone but lacks the varix and darkened callus. It differs from *A. leucoxanthus* in having the columella with distinct twisted plait. Described from Perak.

A. luangensis sp. nov. on average has shell of the same size and characteristics as *A. atricallosus* but it is distinguishable by its rosy brown color, apex, whorl count and columella deviation. It also has its coloration closely related to *A. inversus annamiticus* (Crosse and Fischer, 1863) but *A. luangensis* sp. nov. has a dark-brown or black callus while *A. inversus annamiticus* (Crosse and Fischer, 1863) has white callus.



Plate 6: The apex and whorl count of 1; *A. atricallosus* (Gould, 1843) is 7.25 and 2; *A. luangensis*, sp. nov. is 7



Plate 7: The CD of 1; *A. atricallosus* (Gould, 1843) is larger than 2; *A. luangensis*, sp. nov.



Plate 8: *A. inversus annamiticus* (Crosse and Fischer, 1863) (xi).

A. luangensis sp. nov. has lavender-white aperture and is lavender-white from the lip to deep inside the shell. The color becomes white as the result of increased calcification of the aperture as the snails ages (e.g. Plate:3 Figs.1 & 3, Plate:18 Fig.1, and Plate:22 Fig.10).

There are some streaks on some *A. luangensis* sp. nov. shells (e.g. Plate:3 Fig.4, Plate:21 Figs. 2 & 9) thus making them comparable to *A. comes* (Pfeiffer, 1861), which is said to be from "Siam" in Pilsbry (1900) (Plate 9) (banded shell, Plate:57, Fig.3) and he showed a shell of *comes* that is similar my findings (Plate:57, Fig.3) with the differences in that shell being a yellow band behind the lip, white parietal callus, whitish or flesh colored early whorls usually with a faint or dark brown band above the suture, and the streaks are intensified below the suture to create dark spots; usually *comes* variously banded, streaked or clouded with green or brown and a yellow "varix". But the most distinct characteristic between the two species is the color of parietal callus; *A. comes* (Pfeiffer, 1861) is white while *A. luangensis* sp. nov. is dark brown to black.

There is a yellow or white peripheral band on the ventral side of some *A. luangensis* sp. nov. shells (yellow in Plate:20 Figs.7 & 9; and white, being very faint in Plate:22 Fig.14 and more distinct in Plate:23 Figs.11 & 12), which is clear on the penultimate whorl and fades away on the last whorl; this is called a "girdle" by some authors, and is seen in some *A. comes* (Pfeiffer, 1861) shells.

There is a difference in what is generally called the base or "ground color" of the main body whorl in the *A. luangensis* sp. nov. shells (Plate:20, yellow in Figs.7, 8 & 9; and white in Fig.5); Laidlaw & Solem (1961) and repeated in Solem, (1965) described the overall coloration as a brownish color suffusion on the body whorl that is intensified into vague radial streaks and partially interrupted by a submedian spiral yellow band.



Plate 9: *A. comes* (L. Pfeiffer, 1861) from Laidlaw and Solem: Genus Amphidromus, Fieldiana: Zoology, Volume 41, Plate:57 Fig.3.



Plate 10: *A. comes* (L. Pfeiffer, 1861) from Vietnam (xii).

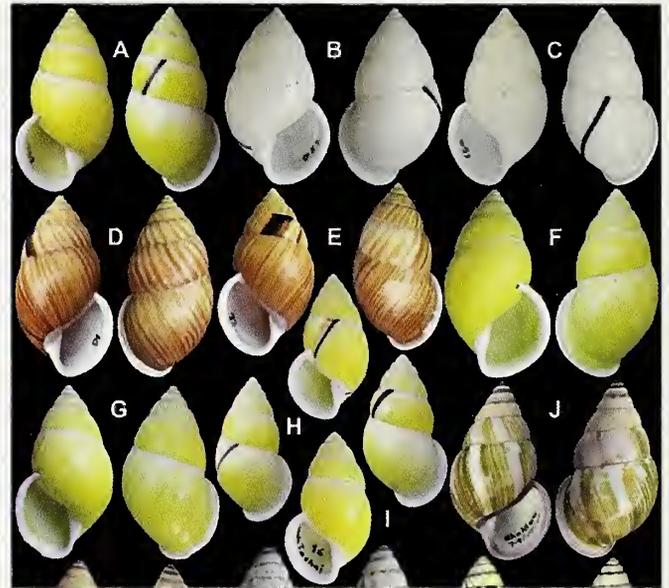


Plate 12: Extract from Figure 4, Sutcharit C. & S. Panha, 2006 ; Shells of some *Amphidromus* species. A–E. *A. atricallosus leucoxanthus*, (A–C) from Makok waterfall, Chantaburi (CUMZ 2162), and (D, E) from Makham District, Chantaburi (CUMZ 2214). F, G. *A. atricallosus perakensis* from Nee Soon, Singapore (CUMZ 2282). H, I. *A. (A.) atricallosus classarius* n. ssp., Koh Tachai, Pangnga, (H) Holotype (CUMZ 2215), and (I) Paratype (CUMZ 2011) (xiv).



Plate 11: Extract from Figure 3, Sutcharit C. & S. Panha, 2006 ; Shells of some *Amphidromus* species Fig. I–N. *A. atricallosus atricallosus*, (I, K, L) from Ban Takhun, Suratthani (CUMZ 2019), (J) from Khao Sok, Suratthani (CUMZ 2021), and (M, N) from Ban Takhun, Suratthani, showing the juveniles specimens with reddish brown spiral band (CUMZ 2191). O. *A. atricallosus*, an uncertain status subspecies from Wat Suwannakhuha, Pangnga (CUMZ 2220). P. *A. atricallosus leucoxanthus* Makok waterfall, Chantaburi (CUMZ 2162) (xiii).

Observations of other authors about variation in ‘yellow’ *A. atricallosus* complex for comparison with new taxa.

Holotype of *A. atricallosus* (Gould, 1843) from Tavoy, British Burma:

- shell imperforate, elongated ovate and sulfur yellow;
- columella white;
- aperture ovate-lunate and slightly effuse (*i.e.* lip is curved dorsally/inward near the columella);
- black band showing the termination of a former stage of growth (*i.e.* ‘varix’ of authors);
- lip widely revolute, not flattened (*i.e.* face of lip rounded and edge recurved);
- nodules may form on the lip of very mature shells; and
- columella white or variously stained with brown and/or black.

Sutcharit C. & S. Panha 2006 have observed variations in yellow *Amphidromus* complex that can be discussed as follows:

A. Yellow shells of *A. atricallosus* (Gould, 1843) can be put into 2 distinct groups based on the width of the white subsutural band, with similar/the same secondary and tertiary variations; and a rare modification of one of these groups (without a **lobe** on the columella).

Group 1; last whorl and spire whorl yellow with a narrow white subsutural band

- yellow is of one tone (as per holotype) (*e.g.* Ranong Province)
- yellow is of two tones
 - distinctly darker base or
 - becomes gradually darker anteriorly; darker toward the umbilicus on the last whorl and darker near the suture on the spire.

Group 2; yellow shells with a wide white subsutural band (*A. leucoxanthus* (von Martens, 1854) has this coloration)

- yellow is of one tone
- yellow is of two tones
 - distinct darker base or
 - gradually darker toward the umbilicus (darker anteriorly).

Group 3; Modification of Group 2; rarely the white zone extends down to the periphery (*e.g.* from Suratthani, Sutcharit C. & S. Panha, 2006 Plate 11: Fig. 3I)

- spire appears white, and
- base is distinctly bipartite, white above the periphery and yellow below.

Group 4; Yellow or white shells may have a reddish brown peripheral band in juveniles (*e.g.* from Suratthani, Sutcharit C. & S. Panha, 2006 Plate 11: Figs. 3M & 3N).

Group 5; Shallow/appressed suture.

Group 6; Slightly flattened whorls.

B. Shells of a unique color pattern = subspecies of uncertain status with a white parietal callus from Pangnga.

Last whorl yellow with a wide white zone below the suture or reaches the periphery

- yellow zone separated from the umbilicus and columella by a very narrow white zone (white umbilical zone is equivalent to white basal patch in Pilsbry, 1900) (Tan, Chan & Panha, 2011 call this a white zone bordering the columella) (Wat Suwannakhuha in Sutcharit C. & S. Panha, 2006 Plate 11: Fig. 3O)
- yellow zone narrows and/or fades toward the lip, while the white umbilical zone appears to widen a little (near Kasom)
- wide yellow peripheral or basal band narrows toward the lip and may fade as well, while the white umbilical zone appears to widen (near Kasom).

Spire whorls

- white
- white above the periphery, yellow below
- yellow with a narrow white subsutural band; yellow is of one or two tones
- as per 3, but a white zone develops above the periphery toward the last whorl.

C. Shells with a black or white parietal callus (one subspecies)

- yellow shells of *A. classiarius* Sutcharit & Panha, 2006 have a narrow to wide white subsutural band
 - shells always sinistral
 - with or without a very narrow white umbilical zone
 - have one or more brown or black 'varices' occurring in pairs or groups (plural form of 'varix')
 - with or without brown spots or short brown lines just below the suture
 - shells never white or streaked with brown.

D. Shells without a black parietal callus (three subspecies)

shells perforate or not, with or without a lobe on the columella

- yellow shells of *A. leucoxanthus* (von Martens, 1854) have a wide white subsutural band
 - with a white parietal callus
 - shells may be white and rarely white with narrow, rather crowded brown streaks
 - generally have one or two brown or black 'varices' (*i.e.* rarely absent).
- pale to dark yellow shells of *A. perakensis* (Fulton, 1901) (shells from Chumporn, Thailand show both types of subsutural band)
 - with a white parietal callus
 - generally have a narrow white subsutural band (*e.g.* Malaysia), *or*
 - sometimes have a wide white subsutural band
 - with or without a brown line bordering the columella (*e.g.* Chumporn, Thailand)
 - have a very narrow white umbilical zone
 - generally lack a brown or black 'varix' (*i.e.* rarely present, some shells with a brown 'varix' are from North Perak, Malaysia)
 - white shells possible, but never streaked with brown.
- pale yellow to orange shells of *A. temasek* Tan, Chan and Panha, 2011 have a very narrow white subsutural band
 - parietal callus usually inconspicuous, rarely calcified and colorless or white
 - some shells have narrow, rather crowded brown streaks

- brown or black 'varices' always absent
- shells never white or streaked with brown.

All new species (*A. taluensis* sp. nov. and *A. luangensis* sp. nov.) and subspecies (*A. taluensis borealis* spp. nov.) described herein are all differs in shells characteristics and morphometric to all variations of *A. atricallosus* complex described above.



Plate 13: Live animal coloration: *A. taluensis* sp. nov. (xv).



Plate 14: Live animal coloration of *A. atricallosus temasek* holotype (ZRC.MOL.3058) Pulau Tulai, West Malaysia (xvi).



Plate 15: Live animal coloration of *A. atricallosus perakensis* (Fulton, 1901), Pulau Tulai, West Malaysia (xvii).

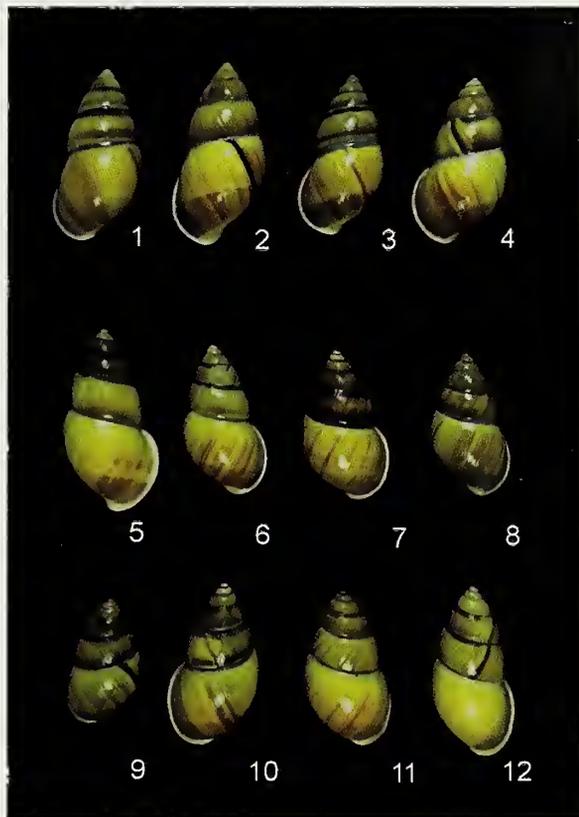


Plate 17: *A. taluensis*, sp. nov.
Fig.1: Holotype; Fig.2-12: Paratype.

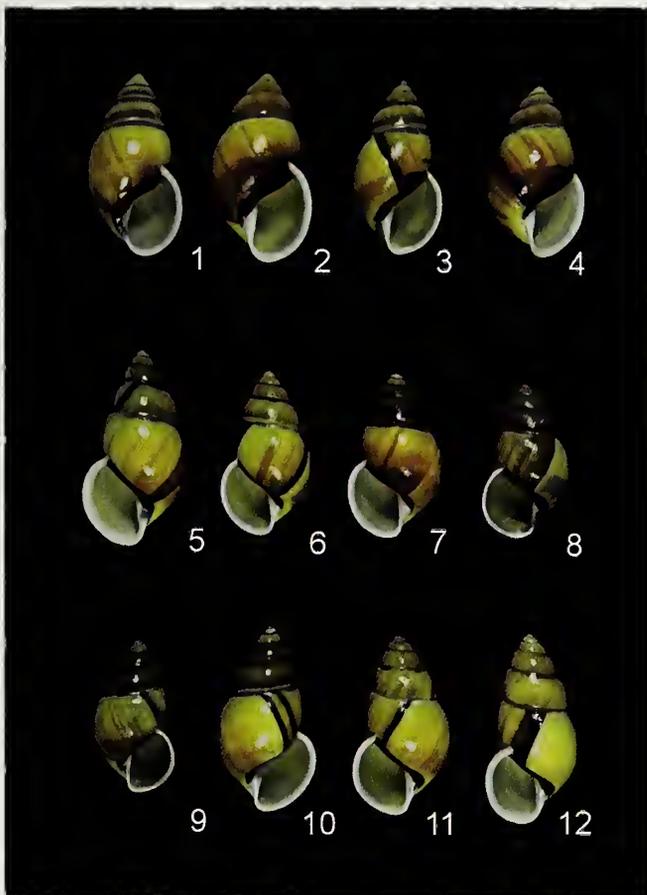


Plate 16: *A. taluensis*, sp. nov.
Fig.1: Holotype; Fig.2-12: Paratype.

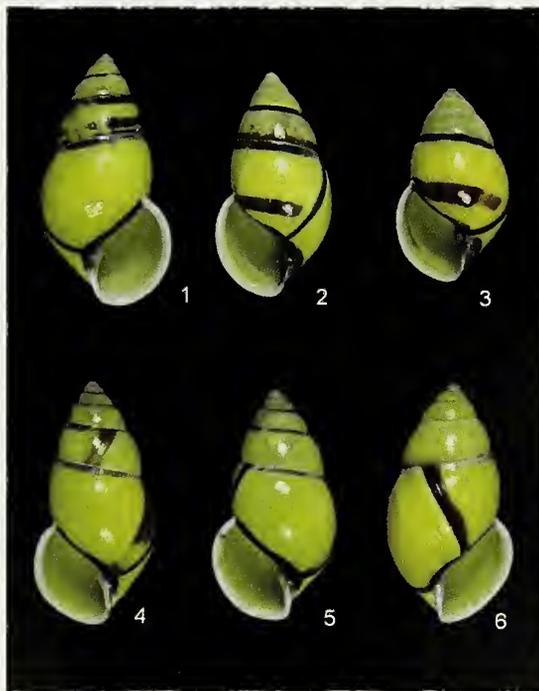


Plate 18: *A. taluensis borealis*, spp. nov.
Fig.1: Holotype; Fig.2-6: Paratype.



Plate 19: *A. taluensis borealis*, spp. nov. Fig.1: Holotype; Fig. 2-6: Paratype.



Plate 20: *A. luangensis*, sp. nov. Fig.1-9: Paratype.

Table 1: Average size H/W of *A. taluensis* sp. nov.

Plate: 16	H	W	H/W
Fig. 1	44.74	23.01	1.944
Fig. 2	46.06	24.99	1.843
Fig. 3	41.05	21.83	1.880
Fig. 4	42.01	23.81	1.764
Fig. 5	47.37	25.06	1.890
Fig. 6	40.13	22.02	1.822
Fig. 7	39.93	23.05	1.732
Fig. 8	37.54	21.37	1.756
Fig. 9	36.81	20.10	1.831
Fig. 10	44.35	23.97	1.850
Fig. 11	42.73	24.31	1.757
Fig. 12	46.04	23.09	1.993
Average			1.838

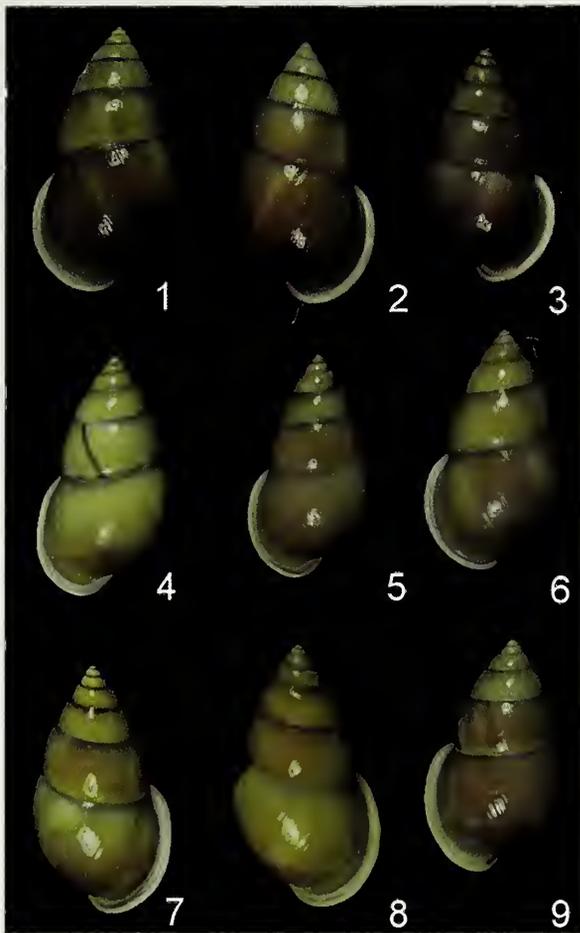


Plate 21: *A. luangensis*, sp. nov. Fig. 1-9 Paratype.

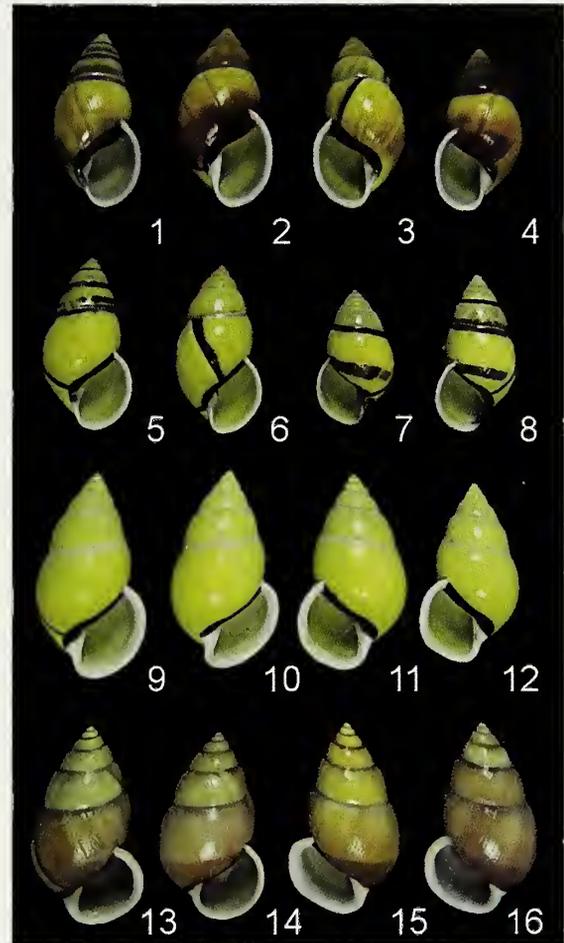


Plate 22: Comparison on shape and color of adult species.

Figs. 1-4: *A. taluensis* sp. nov. Figs. 5-8:

A. taluensis borealis spp. nov. Figs. 9-12: *A. atricallosus* (Gould, 1843) Figs. 13-16: *A. luangensis* sp. nov.

Table 2: Average size H/W of *A. taluensis borealis* ssp. nov.

Plate:18	H	W	H/W
Fig. 1	44.44	23.43	1.896
Fig. 2	39.73	20.83	1.907
Fig. 3	34.38	20.42	1.683
Fig. 4	43.52	21.65	2.010
Fig. 5	41.05	22.51	1.823
Fig. 6	42.65	22.44	1.900
Average			1.870



Plate 23: Comparison on shape and color of juvenile species

Figs. 1-3: *A. taluensis* sp. nov.

Figs. 4-6: *A. taluensis borealis* spp.nov.

Figs. 7-9: *A. atricallosus* (Gould, 1843)

Figs. 10-12: *A. luangensis* sp. nov.

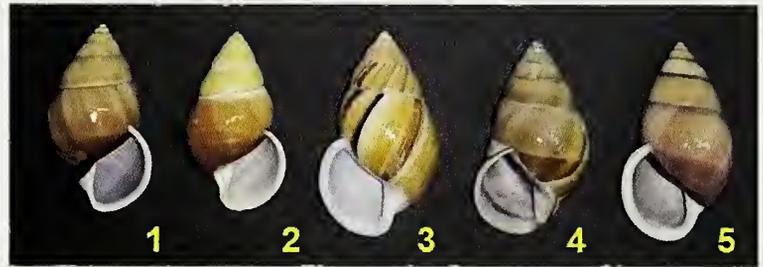


Plate 24: Comparison between *A. luangensis* sp. nov. (with dark brown to black Parietal callus) and other *Amphidromus* sp. (with white parietal callus) (xviii). All from CGSC.

1 *A. luangensis* sp. nov. Kui Buri Elephant Park, Lat. 12° 08' 42.25" North, Long. 99° 38' 00.97" East.

2. *A. enganoensis* Fulton, 1897. Enggaro Island, Sumatra Island, Indonesia.

3. *A. heerianus poecillus* Jutting, 1941. Bangar, West Java, Indonesia.

4. *A. inversus inversus* (Muller, 1774). Mount Rajabasa, South Lampung, Sumatra, Indonesia.

5. *A. luangensis* sp. nov. Kui Buri National Park, Lat. 12° 03' 00.00" North, Long. 99° 34' 19.20" East.

Table 3: Average size H/W of *A. luangensis* sp. nov.

Plate:20	H	W	H/W
Fig. 1	52.86	29.10	1.816
Fig. 2	51.71	28.35	1.823
Fig. 3	46.23	26.42	1.749
Fig. 4	49.66	27.24	1.823
Fig. 5	46.71	25.30	1.846
Fig. 6	49.24	27.88	1.766
Fig. 7	51.62	28.24	1.827
Fig. 8	54.99	30.50	1.802
Fig. 9	47.66	27.45	1.736
Average			1.799

Table 4: Comparison between *A. taluensis* sp. nov., *A. taluensis borealis* spp. nov. and *A. luangensis*, sp. nov.

	<i>A. taluensis</i> sp. nov.	<i>A. taluensis borealis</i> spp. nov.	<i>A. luangensis</i> , sp. nov.
Aperture size	narrow	more narrow	wide
Aperture coloration	tinted yellow to yellow- white	yellow- white to yellow	white to light lavender
Apex coloration	yellow	yellow	white to yellow
CD	nil	to the right on S specimens	to the left on D specimens
Coloration (base or “ground color” of main body whorl)	brownish yellow to brown suffusion on the last whorl with irregular brown longitudinal streaks	bright yellow to greenish yellow	rosy brown with a wide light rosy brown subsutural band
Coloration around the umbilicus in adult	white	whitish-brown (some specimens completely brown; Plate:18 Fig 2 & 3)	white
Coloration around the umbilicus in juvenile	white	whitish-brown	white
Lip width	narrow	narrow	wide
Lip thickness	thin	thin	thick
Lobe	nil	nil	present on some specimens
Microsculpture	colabial, microthreads	colabial, microthreads	colabial, microthreads
Parietal callus coloration	dark brown to black	dark brown to black	dark brown to black
Shape	slender	more slender	slender
Shell orientation (sinstral / dextral)	D and S	D and S	D and S
Subsutural band coloration	dark brown	dark brown	dark brown
Thickness of shell body	very narrow	very narrow	thick
Umbilicus in juveniles	open	open	open
Weight	light	light	heavy

Table 5: Comparison between *A. luangensis*, sp. nov., *A. enganoensis* Fulton, 1897, *A. heerianus poecillus* Jutting, 1941 and *A. inversus inversus* (Muller, 1774).

	<i>A. luangensis</i> , sp. nov.	<i>A. enganoensis</i> Fulton, 1897	<i>A. heerianus poecillus</i> Jutting, 1941	<i>A. inversus inversus</i> (Muller, 1774)
Aperture size	wide	narrow	wide	medium
Aperture coloration	white to light lavender	white and translucent	white	white to light brown
Apex coloration	white to yellow	yellow	yellow	white
CD	to the left on D specimens	to the left on D specimens	nil	to the right on S specimens
Coloration (base or "ground color" of main body whorl)	rosy brown with a wide light rosy brown subsutural band	rosy brown on last whorl and yellow on upper whorl	light yellow base with variation of brown tone growth lines colabialy	brown streaks and brown basal band
Coloration around the umbilicus in adult	white	white	white	white to light brown
Coloration around the umbilicus in juvenile	white	no data	no data	no data
Lip width	wide	narrow	wide	wide
Lip thickness	thick	medium	thick	medium
Lobe	Present on some specimens	present	nil	nil
Microsculpture	colabial, microthreads	colabial, microthreads	colabial, microthreads	colabial, microthreads
Parietal callus coloration	dark brown to black	white	white	white to light brown
Shape	slender	medium	medium	medium
Shell orientation (sinstral / dextral)	D and S	D and S	D and S	D and S
Thickness of shell body	thick	medium	thick	medium
Umbilicus in juveniles	open	no data	no data	no data
Weight	heavy	light	heavy	medium

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LABORATORY STUDIES OF HYBRIDIZATION IN CALIFORNIA ABALONE (*HALIOTIS*)

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ABSTRACT Interspecific hybridizations involving five species of California *Haliotis* were carried out in the laboratory. The following hybrid progeny were successfully produced, cultured, and positively identified on a morphological basis: *H. corrugata* x *H. rufescens*, *H. corrugata* x *H. walallensis*, *H. kamtschatkana assimilis* x *H. walallensis*, *H. sorenseni* x *H. corrugata*, and *H. sorenseni* x *H. kamtschatkana assimilis*. Additionally, more complex multi-species hybrids and backcrosses were cultured and are listed in the text. The interaction between egg and sperm appears to be the principal mechanism controlling the success of hybrid crosses.

KEY WORDS Cultured abalone, Haliotidae, hybrid cross, multi-species hybrid.

INTRODUCTION

Members of the genus *Haliotis*, commonly known in this country as abalones, are large gastropod mollusks that inhabit rocky shores in many parts of the world, including the coast of California. In an earlier paper (Owen *et al.*, 1971), natural hybridization was reported in California abalones, involving six of the seven local species. This paper describes the results of several attempts to cross California *Haliotis* species in the laboratory. The study was performed at a commercial shellfish hatchery (Pacific Mariculture, Inc.) located on the coast at Pigeon Point (37 degrees north), about 80 kilometers south of San Francisco, California. The senior author, employed at the hatchery since its inception in 1965, has successfully reared many different species and hybrids of *Haliotis* in the hatchery system.

The sexes are separate in this genus, and spawning animals broadcast their gametes directly into the water where fertilization occurs by chance meeting of ova and sperm. This paper

presents observations and experiments conducted by Owen on several occasions when "mass spawnings" occurred in the tanks at Pacific Mariculture, Inc. Mass spawnings are those which are apparently spontaneous, generally all-involving, and not artificially induced. Where possible, unfertilized eggs were collected and combined with sperm of homospecific or heterospecific origin. Owen has developed techniques for raising abalone through their planktonic larval stages into adult life. Hybrid progeny were cultured and their development usually compared to the pattern described here for *Haliotis rufescens*.

Identification of the hybrid specimens was made by Owen, and was based largely on the morphology of the shell and epipodium. Detailed morphological characterization of the various hybrid *Haliotis* is described elsewhere (Owen *et al.*, 1971).

Table 1 lists the various *Haliotis* species and hybrids used as spawning stock and the locality where they were collected or cultured.

Table 1. Species and hybrids used as spawning stock with locality of collection:

1. *Haliotis corrugata* (Santa Barbara 34 deg. N)
2. *Haliotis cracherodii* (Pigeon Point 37 deg. N)
3. *Haliotis kamtschatkana assimilis* (Point Conception area 34 deg. N)
4. *Haliotis kamtschatkana kamtschatkana* (Vancouver Island, British Columbia, Canada 49 deg. N)
5. *Haliotis rufescens* (Pigeon Point 37 deg. N)
6. *Haliotis sorenseni* (Santa Barbara 34 deg. N)
7. *Haliotis walallensis* (Point Estero 35 deg. N)
8. Hybrid *Haliotis rufescens* x *H. sorenseni*. Male and female. (Santa Barbara 34 deg. N)
9. Hybrid *Haliotis rufescens* x *H. kamtschatkana assimilis*. Male. (Point Buchon 35 deg. N)
10. Hybrid *Haliotis sorenseni* x *H. kamtschatkana assimilis*. Male. (Point Conception 34 deg. N)
11. Hybrid *Haliotis corrugata* x *H. walallensis*. Male. (produced at Pacific Mariculture, Inc. 37 deg. N)
- *12. Hybrid *Haliotis kamtschatkana assimilis* x *H. walallensis* (produced at Pacific Mariculture, Inc. 37 deg. N)
(* Female spawned normally but eggs not used in culture experiments.)

MATERIALS AND METHODS

Adult abalone used as spawning stock were maintained in the hatchery in four fiberglass lined plywood tanks of approximately 475 liter capacity. A continuous, nonrecirculated supply of unfiltered seawater was delivered to the tanks at ambient temperature ranging from 8 to 15 deg. C. The abalone were regularly fed a mix of kelp (principally *Nereocystis leutkeana* and *Macrocystis pyrifera*) and the tanks were cleaned about once a week. Precautionary measures were taken to assure control in hybridization experiments. Equipment (plastic pails, etc.) used in the routine manipulation of spawning adults and gametes was first sterilized in a strong hypochlorite solution followed by a rinse in hot, fresh tap water. During spawning and for raising of larvae, running filtered water was obtained by using sea water passed through a one micron pressure filter and sterilized by exposure to ultraviolet light.

To collect unfertilized gametes to be used in hybridization attempts, in almost all cases both males and females were removed from a larger tank that contained stock of multiple species as soon as they were observed to spawn. They

were vigorously rinsed in running filtered water, then isolated in a clean plastic pail, and rinsed continuously while they attached to the pail. When attached, the animals were rinsed again for a short time, then the pail was filled with filtered water. Water from the pail into which the male had spawned was used to fertilize eggs. Eggs were collected from the pails on a nylon screen with 48 micron openings (Kressilk Products Inc., Elmsford, N.Y.) and thoroughly rinsed with filtered water. Ordinarily, some eggs of each batch collected were set aside and intentionally not fertilized. Lack of development in eggs of this group was taken as evidence that no unwanted sperm had contacted the eggs. This step is referred to as the "unfertilized control".

Ordinarily, fertilization was carried out in these experiments by adding a small amount of sperm water to eggs that had been rinsed and resuspended in filtered water. Care was taken to limit the amount of sperm added to the eggs. Excessive concentrations of sperm were accompanied by excessive bacterial growth tending to foul incubation water and hamper normal development (*i.e.*, polyspermy). The importance of using limited amounts of sperm has been emphasized by Kikuchi (1964). Water

temperature in egg and larval cultures was maintained in the range of 15 to 18 deg. C., and densities were held between 0.5 and 1.0 per ml. In the case of hybrid crosses, densities were kept well below these levels.

May, 2015: All photography was done by Owen in March through May of 2015, with a Canon A650 IS "PowerShot" digital camera mounted on a tripod. Exposures were usually ½ second, always at f/8. All specimens are in Buzz Owen Collection (BOC).

OBSERVATIONS

Spawning Behavior. In general it was observed that during a mass spawning, all abalones with mature gonads in the hatchery spawned about the same time. On several occasions, as many as five species and three different hybrids were observed spawning simultaneously in the same tank. Without exception, the males spawned first, turning the water milky with sperm. The females released eggs within one to several hours, possibly in response to sperm in the water (though the same stimuli that induces the males to spawn may cause this as well). Release of gametes usually continued for several hours. On several occasions, Owen anticipated a spawning from weather cues, and over two hours before any spawning occurred, removed a female from the tank and isolated it in running one micron filtered water. The isolated females would release eggs a short time after the males in the main tank began spawning, and at the same time as the females in the main tank. As far as could be determined, these isolated females were never exposed to sperm.

The females show a peculiar behavior pattern during spawning. They nearly always become quite active, moving toward the surface where they circle the tank for some 20 minutes before actually releasing eggs. During these periods and for several hours before actual spawning

commences, they showed no interest in food. When they begin to spawn, they normally expelled the eggs in intermittent, violent spasms. They may even leave the tank and discharge the eggs into the air. Males seldom become so active; they release sperm in more or less steady streams.

Development of Fertilized Eggs and Larvae of *H. rufescens*. In the experiments reported here, the events surrounding fertilization were often important in judging the relative success of a hybrid combination of gametes. On some occasions, heterospecific sperm were observed to be slow in their approach to unfertilized eggs. Sluggish interaction of sperm at attempted entry into eggs is usually associated with a low percentage of fertilization. Percentage of fertilization was best estimated about 18 hours after adding sperm since, by this time, normally developing embryos have gone through initial cleavage stages and have become ciliated gastrulae or trochophores rotating within the vitelline envelope (Fig. 1). The fraction of eggs that advanced to rotating trochophores was estimated by counting a sample of several hundred embryos under the microscope. Signs of successful fertilization observable at earlier times were the appearance of the polar bodies (about ten minutes after adding sperm), and the appearance of cleavage stages (beginning within the first hour). Normally 90% or more of eggs fertilized with homospecific sperm advance to the rotating trochophore stage. About 24 hours after fertilization, trochophores break out of the membrane and rise actively to the surface where they swim vigorously. Within the next six to twelve hours the embryo assumes the form of the typical molluscan veliger, with larval shell and ciliated velum. Torsion takes place at about 48 hours. After five to eight days of active swimming they settle to the bottom to assume the benthic habit of the adult. The first

respiratory pore usually appears at 30 to 40 days. These young benthic animals are referred to as "juveniles" until they reach sexual maturity which usually requires one to three or more years, depending on species. Soon after settling, the young abalone begin to feed actively; in these experiments they were given attaching diatoms, primarily *Navicula* sp. and *Nitzschia* sp. **Note:** From the time that the trochophores emerge from the membrane and rise to the surface until the advancement to late veliger stages, there appears to be little mortality, but shortly before or during the transition to the benthic habit there seems to be a substantial die-off. Among the many cultures of *Haliotis* larvae which have been carried through to settling, mortality has often been close to 100% (occasionally 100%), while at other times it has been as low as 10%.

The following is a description of the developmental pattern observed when homospecific gametes were used. It is based largely on observations made while working with *H. rufescens*. We will regard these homospecific crosses as "normal" and then use this pattern of development as a reference by which to compare the development of various hybrid combinations.

The freshly released egg is spherical and about 200 microns in diameter. The yolk is opaque and green to dark gray in color. Surrounding the yolk is the perivitelline space, a transparent envelope bound by an outer membrane, the vitelline envelope. This space is 20 to 25 microns thick (Fig. 1). Additionally, there is a gelatinous coat surrounding the egg, which is approximately 100 microns thick.

Haliotis sperm has a recognizable head and tail and swims actively. If sperm is added to unfertilized eggs under a microscope, one can observe highly motile sperm quickly attach to

and enter the perivitelline space. Often many sperm penetrate the outer membrane to swim actively about the yolk. Presumably only one enters the egg itself to accomplish fertilization. Reduction division (meiosis) of the egg nucleus occurs after entry of the sperm because the pair of polar bodies can be observed, preceding cleavage stages, in those eggs that become fertilized.

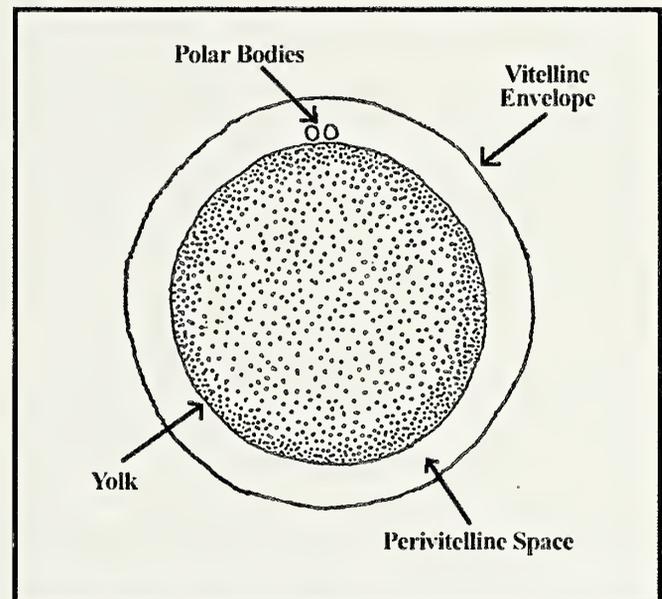


Figure 1. Fertilized egg of *Haliotis*, showing structures mentioned in text (based on Ino, 1952).

Observations of Spawnings. Spontaneous (mass) naturally occurring spawnings appear to be correlated with an increase in temperature (2-3 deg. C.) and pH (to 8.3) of the seawater, conditions that were usually associated with southerly winds, and occur mostly in early to late summer. There was frequently a lunar periodicity about these changes and they often coincided with a full or new moon phase (plus or minus one to three or four days). These changes seemed to initiate an influx of offshore water, the temperature and pH rising as stated above. From cursory observations, this offshore water also seemed to have a different planktonic composition, and is markedly visible: a bold

line separating the blue-colored incoming water mass from the more turbid color of the inshore seawater which it was displacing is often present. Although others report artificial stimulation of spawning by increasing the temperature and/or pH of the seawater (Ino, 1952; Imai, 1967; Leighton, 1972), we have not attempted to utilize these methods as we had more than sufficient naturally induced spawnings to meet our needs.

The mass spawnings reported in this paper occurred on eight separate occasions: October 6 and December 7, 1965; August 23, 1967; October 31, 1968; July 19 and September 14, 1969; and February 13 and June 24, 1970.

Descriptions of Individual Spawnings.

Mass Spawning of October 6, 1965: This was the first time hybridization experiments had been attempted at Pacific Mariculture, Inc. The technique on this occasion was more exploratory and the exact meaning of the results is not as obvious as in some of the later spawnings. It was clear, however, that viable *H. corrugata* x *H. rufescens* hybrids were produced. This hybrid is the second most common found in natural populations (approximately 70 reported cases).

The single cross carried out was with eggs from a single *H. corrugata* female in a tank with mixed species and sperm water from a different tank housing four spawning male *H. rufescens*. When she spawned, the eggs were collected from the tank rather than from the female in an isolated environment (in later spawnings, isolation of the female before collecting gametes was adopted as standard method). There was very little sperm in the tank and the eggs were collected on a 48 micron nylon screen as they were being released by the female. They were then quickly rinsed while in

the screen with running filtered water and then set aside for one hour. After that period, they were examined microscopically and no evidence of fertilization was detected. Later evidence indicated that there probably were some fertilized eggs present, but they went unnoticed. The eggs were then mixed with the *H. rufescens* sperm water and there was prompt microscopic confirmation that fertilization had taken place in the bulk of the eggs.

Development of these "hybrids" appeared to be normal through cleavage, trochophore and veliger stages, judged by comparison with a *H. rufescens* x *H. rufescens* cross made at the same time. However, on the eighth day, when many larvae were beginning to settle, there was a very large mortality, substantially more than the "control" *H. rufescens* batch being cultured at the same time. After 30 days there were approximately 200 survivors of the hybrid cross and after one year they numbered 75. Mortality after the first month was due mostly to human mishandling. As this group of young abalone began to mature, it became clear that most animals were not hybrids as expected, but straight *H. corrugata*. Only about 10% of the group seemed to be the expected *H. corrugata* x *H. rufescens* hybrids, and a single specimen, which didn't seem to fit either category, was later identified as a *H. corrugata* x *H. walallensis* hybrid. At the time of this writing (September, 1971) there are four surviving animals from this spawning: three *H. corrugata* averaging about 35 mm in length, and the one *H. corrugata* x *H. walallensis*, now 59 mm long.

Mass spawning of December 7, 1965: As a result of this spawning, two mature, morphologically identifiable *H. kamtschatkana assimilis* x *H. walallensis* hybrids were produced. Only one such hybrid has been reported from natural populations.

A mass spawning occurred in a 475 liter tank containing male and female *H. corrugata*, *H. walallensis*, *H. sorenseni*, and *H. kamtschatkana assimilis*. There was no attempt to control fertilization. Fertilized eggs were merely collected from the mixed tank and allowed to develop. Survivorship through the benthic stage appeared normal. After one year there were approximately 200 surviving offspring and all showed a morphology that suggested straight *H. kamtschatkana assimilis*. After two years, there were about 35 survivors, and while most still suggested a pure parentage of that subspecies, two specimens were definitely different from the others and were tentatively identified as *H. kamtschatkana assimilis* x *H. walallensis* hybrids on the basis of shell and epipodial characters (one was temporarily placed in another *Haliotis* aquaculture facility on loan). As of September, 1971, sixteen offspring of this spawning survive: fourteen are obvious homospecific *H. kamtschatkana assimilis*, and the single *H. kamtschatkana* x *H. walallensis* at Pigeon Point is a female measuring 107 mm. This specimen was observed releasing eggs in May, 1970 (4.5 years old). The second specimen was later returned to Pigeon Point and measured 90.4 mm when experiments were terminated in 1972.

May, 2015: A third *H. kamtschatkana assimilis* x *H. walallensis* hybrid was later identified, a smaller specimen measuring 47.2 mm. This specimen is not included on Table 2 since it was not recognized at the time.

Mass Spawning of August 23, 1967: Eggs were collected from three *H. kamtschatkana assimilis* females and fertilized with six different types of sperm, including two hybrids. This allowed the opportunity to determine whether at least some hybrids are fertile.

The spawning animals were isolated and thoroughly rinsed with filtered water before the

gametes were collected. In this case, two groups of eggs were collected: one from a single orange banded *H. kamtschatkana assimilis*, and the other from two different specimens of *H. kamtschatkana assimilis* which were also orange banded.

Unfortunately, in this experiment, no eggs were set aside as an unfertilized control. Eggs from the single female were divided among three plastic pails, and each was then fertilized by adding sperm water from a separate, isolated male. One pail was fertilized with sperm from a *H. kamtschatkana assimilis*, another by a *H. walallensis*, and the third by sperm from a *H. rufescens* x *H. sorenseni* hybrid. Eggs from the two females were also divided among three pails, and were fertilized with a *H. sorenseni*, a *H. cracherodii*, and a *H. rufescens* x *H. kamtschatkana assimilis* hybrid respectively. Each of the six combinations of egg and sperm will be discussed separately below.

***Haliotis kamtschatkana assimilis* x *H. kamtschatkana assimilis*.** Fertilization and development progressed normally. About 90% of the eggs became active veligers. There was a high mortality at settling; less than 1% of the veligers underwent successful metamorphosis and became benthic. After 2.5 months, the offspring of this cross were combined in a single aquarium with 75 of the contemporary progeny of the cross to the *H. rufescens* x *H. kamtschatkana assimilis* male. At this time, there were 322 of the suspected straight *H. kamtschatkana assimilis* juveniles. At four years of age, approximately 100 animals remained from this cross, the largest measuring 90 mm.

***Haliotis kamtschatkana assimilis* x *H. walallensis*.** *Haliotis walallensis* sperm did not behave normally in the presence of *H. kamtschatkana assimilis* eggs. Sperm could be

observed attaching to the vitelline envelope, but few penetrated into the perivitelline space. Those that did showed considerably less than normal motility once inside. About 15% of the eggs progressed to rotating trochophores; about one-fourth of these appeared to have developed abnormally, being oddly shaped. A few eggs cleaved abnormally and did not reach the trochophore stage, and the remainder remained unfertilized. Many apparently healthy veligers survived, but all died before becoming benthic.

Haliotis kamtschatkana assimilis X (*H. rufescens* x *H. sorenseni*) hybrid. Sperm from this hybrid were also subdued in their interaction with the *H. kamtschatkana assimilis* eggs, similar to the *H. walallensis* sperm. An estimated 25% of the eggs became rotating trochophores and again, some of these were abnormal. The survivors appeared normal through the larval period, but again, all suddenly died just before becoming benthic.

Haliotis kamtschatkana assimilis x *H. sorenseni*. As with the previous two batches of sperm, that from *H. sorenseni* appeared retarded in its interaction with the *H. kamtschatkana assimilis* eggs. Only about 5% of the eggs appeared fertilized, and the culture was discarded after one day.

Haliotis kamtschatkana assimilis x *H. cracherodii*. This combination showed the most negative interaction of gametes. Sperm did not attach to the vitelline envelope. The *H. kamtschatkana assimilis* eggs seemed to repel *H. cracherodii* sperm: a 30 micron sperm-free halo surrounded the egg. No eggs were observed to be fertilized, although 18 hours later a small number of rotating trochophores were noticed, no more than 2% of the eggs. The identity of these trochophores is not known, but they might represent sperm that did not wash off the female *H. kamtschatkana assimilis* used in this cross.

None of the trochophores emerged from the vitelline envelope and the batch was discarded after 24 hours

Haliotis kamtschatkana assimilis X (*H. rufescens* x *H. kamtschatkana assimilis*) hybrid. This backcross combination seemed to develop normally. An estimated 75% of the eggs became rotating trochophores. As with many crosses, a large mortality occurred at metamorphosis, leaving about 100 animals (less than 1% of the veligers) after one month.

For reasons of technical convenience, 75 surviving juveniles of this backcross were combined with 322 suspected *H. kamtschatkana assimilis* (the first mentioned cross of this spawning) at an age of 2.5 months. They were maintained in a lucite aquarium of special design that had proven successful in the rearing of juvenile abalone. At this point, the two groups could not be distinguished morphologically. At one year of age, 227 animals were counted in the aquarium: 203 were recognizable as straight *H. kamtschatkana assimilis*, having lightly pigmented flesh with darker specks; and 24 were obviously different, having solid dark flesh and averaging a larger size. The pigment and the size resembled *H. rufescens*. The shells of the two groups appeared identical except for the size difference. The latter group was assumed to be the backcross progeny. Once two groups were distinguished, they were placed in separate aquaria for continued observation.

When these two groups were 14 months old, another mass spawning occurred (October 31, 1968). Many males of the straight *H. kamtschatkana assimilis* progeny were observed spawning, although the largest of this group was only 30 mm long at this time. None of the suspected backcross group were observed

spawning. A subsequent visual examination of the gonad area of the young abalone of the two groups revealed that many of the male *H. kamtschatkana assimilis*, some as small as 20 mm, had well developed gonads as judged by the appearance of whitish tissue surrounding the digestive gland of the animal. Only two of the 24 presumed backcrosses showed at most just slight traces of gonad development. Our observations indicate that *H. kamtschatkana assimilis* reaches sexual maturity much younger and at a smaller size than *H. rufescens*, so the later gonad development in the second group (presumed backcrosses) suggests the influence of genes of *H. rufescens*.

Now, at four years of age, 22 of this group of 24 backcrosses survive and are growing well. They range in size from 55 to 103 mm.

May, 2015: The largest specimen measured 114.8 mm when experiments were terminated in mid to late 1972.

Sometimes the shell of *H. kamtschatkana assimilis* has an orange-colored band following inside the row of excurrent apertures (Fig. 2). About 5 to 10% of this subspecies show this trait, but the percentage varies locally. It is not noticeable in other species, except that about one out of four *H. sorenseni* show an orange zone to the right of the aperture row as a juvenile, which fades away after the shell reaches a size of 30 to 35 mm (see Leighton, 1972). Occasionally a similar band may be seen in juvenile *H. rufescens* and *H. walallensis*. Three of the 40 known specimens of *H. rufescens* x *H. kamtschatkana assimilis* have an orange band. The three female *H. kamtschatkana assimilis* that supplied the eggs used in the 1967 experiments were banded, as was the male of that same spawning. The hybrid male *H. rufescens* x *H. kamtschatkana assimilis* was not banded. The frequency of bandedness

in the 1967 progeny, then, can give us some information on the mechanism of inheritance of this banded characteristic.

In the progeny of the straight *H. kamtschatkana assimilis* cross (both parents banded) 152 out of 203 progeny (75%) were banded, and of the backcross progeny (only female banded), 11 out of 24 (46%) were banded (see also Discussion).



Figure 2. Shell of *H. kamtschatkana assimilis*, showing orange band.

The important result from the 1967 spawning is the demonstration that the *H. rufescens* x *H. kamtschatkana assimilis* hybrid proved to be a fertile male parent when backcrossed to a *H. kamtschatkana assimilis* female, suggesting a very close genetic relationship between these two species. This is the first demonstration of hybrid fertility in *Haliotis*. Some shells from natural populations have suggested backcrossing (Owen *et al.*, 1971).

Mass Spawning of October 31, 1968: Many of the males in one of the large 475 liter tanks began to release sperm in the early evening. The water quickly became too milky to see well and it was two or three hours before any female was noticed spawning. A female *H. rufescens* x *H. sorenseni* near the top of the tank was the first observed to release eggs. W. W. Budge was the only person present and he made an attempt to collect the eggs by siphoning with rubber tubing. The female then came partly out of the water and began a series of violent contractions, expelling eggs as high as 25 cm into the air. At that point Budge caught the eggs in a plastic pail. He then filtered some of the water of the same tank through nylon screen to remove any eggs and used this water to fertilize the eggs in the pail. Due to the nature of the way this spawning occurred, an unfertilized control would not have been possible and was not attempted. Owen then carried this set of fertilized eggs through a normal larval period. An estimated 95% of the eggs became active trochophores. There was a high mortality, as usual, at the time of settling. An estimated 2000 animals successfully became benthic.

The probability is quite good, but not absolute, that there were no other eggs present in the pail besides those from the *H. rufescens* x *H. sorenseni* female. The eggs were exposed to very little water from the tank before fertilization. No other females were noticed to be spawning, but visibility in the tank was poor. It is not known precisely which males were releasing sperm into the water, but many were. *Haliotis kamtschatkana assimilis*, *H. kamtschatkana kamtschatkana*, *H. cracherodii*, and a hybrid *H. rufescens* x *H. kamtschatkana assimilis* were positively recorded to be releasing sperm. *Haliotis sorenseni* and a hybrid *H. rufescens* x *H. sorenseni* might also have been, and there is less but still some chance that *H. walallensis* and a *H. sorenseni* x *H.*

kamtschatkana assimilis hybrid were spawning as well. Many bizarre genetic combinations could have resulted from this cross. The progeny are now about three years old, and approximately 150 are still alive. The most striking point about these animals is their variability. Most cannot be identified morphologically, but at least 20 animals can be positively recognized as the three species hybrid, (*H. rufescens* x *H. sorenseni*) X *H. kamtschatkana assimilis*. And even this group, despite being of similar genetic background, show more variation in shell and epipodial characters than the standard two species hybrids. The largest of the 20 identifiable three species hybrids measured 65 mm and of the other 130 specimens, the largest measured 80 mm.

All the male *H. kamtschatkana assimilis* but none of the *H. kamtschatkana kamtschatkana* that were noticed to be spawning were orange banded, and some of the progeny are showing an orange band. In September of 1969, when the animals were nearly one year old, 225 animals were counted and 16 (7%), of unknown genetic background, were banded.

May, 2015: A more careful examination in 1975 of the shells from the 1968 spawning revealed one outlier that was clearly identifiable as a three species cross of a female *H. cracherodii* with a male *H. corrugata* x *H. walallensis* hybrid, both of which were in the single tank where this spawning occurred (Pl. 8). Given this spawning occurred unexpectedly and after hours with only one person present, it is clear that a few fertilized eggs not of the intended cross got into the mixture of gametes even though attempts were made to prevent this.

Mass Spawning of July 19, 1969: Two crosses of interest were performed during this mass spawning: eggs from a single *H. sorenseni* were fertilized with sperm from a *H. corrugata*; and

eggs from one *H. corrugata* were fertilized with sperm from a *H. rufescens* x *H. sorenseni* hybrid. Both females were isolated and thoroughly rinsed before they began releasing eggs.

The eggs from the *H. sorenseni* were collected and separated into two cultures; one was set aside and observed as an unfertilized control, while the other was mixed with sperm water derived from an isolated *H. corrugata*. The following day, the unfertilized batch showed no evidence of development, and about 25% of the eggs fertilized with *H. corrugata* sperm had developed to rotating trochophores. Subsequent development appeared normal, about 10% surviving to the benthic stage. At the age of 60 days there were 943 individuals of this cross, but because of space limitations, most were released. At this writing (September, 1971), 86 of these remain, clearly recognizable as *H. corrugata* x *H. sorenseni* hybrids. The largest of this group are about 50-53 mm in length.

The eggs collected from the isolated *H. corrugata* were mixed with sperm water from an isolated *H. rufescens* x *H. sorenseni* hybrid. None were set aside as unfertilized controls in this case, but the same isolation techniques were employed as in the above *H. corrugata* x *H. sorenseni* cross, which effectively restricted unwanted fertilization. Eighty percent of the eggs developed to rotating trochophores and continued through a normal larval period. Over 90% of the veligers completed metamorphosis by the 10th day. This rate of survival is strikingly much higher than is normally observed, even with homospecific crosses done during these experiments. Many thousands of these suspected three species crosses were carried through the first several months of growth. Some were lost due to mishandling, many were planted on an experimental area of ocean bottom, and a few were kept in the

hatchery for observation. At this time, 16 individuals remain alive from this cross ranging up to 72 mm in length. It is not yet possible to positively identify the *H. corrugata* parentage, but *H. rufescens* and *H. sorenseni* morphology are evident. Since the *H. rufescens* and *H. sorenseni* characters are those of the intended male parent, contaminating sperm was apparently avoided in this cross.

May, 2015: One shell illustrating *H. corrugata* morphology was later identified (Pl. 6).

Mass Spawning of September 14, 1969: During this spawning, eggs were collected from an isolated *H. sorenseni* and fertilized with the sperm water of a *H. kamtschatkana assimilis* male. Some eggs were set aside as an unfertilized control and showed no development, indicating no contaminating sperm were present. Seventy-five percent of the eggs to which sperm were added developed to rotating trochophores. The larvae appeared to do well, and more than 50% advanced to the benthic stage. There was a small, post-benthic mortality, leaving an estimated 20,000 survivors. At about 10 months of age, 8-10 thousand remained. Most of these were transplanted to ocean bottom off Turtle Bay, Baja California, Mexico, leaving about 100 in the hatchery. These measured up to 42 mm in length as of September, 1971. This same batch of *H. sorenseni* eggs was also fertilized with homospecific *H. sorenseni* sperm, and provided an interesting comparison with the above cross. Virtually 100% fertilization was observed in this case and development was normal, very similar in rate to the *H. sorenseni* x *H. kamtschatkana assimilis* culture. However, the straight *H. sorenseni* progeny showed complete pre-benthic mortality on the seventh day. One earlier attempt to produce homospecific *H. sorenseni* also ended in total pre-benthic die-off. This total failure seemed odd as *Haliotis sorenseni* adults feed actively, grow well, seem to spawn normally in the

hatchery, and produced at least one extremely successful hybrid: the *H. sorenseni* x *H. kamtschatkana assimilis* culture, which developed successfully through settling and produced fast-growing juveniles.

In the hybrid combination, the male *H. kamtschatkana assimilis* was orange banded. The *H. sorenseni* female showed no band in the early whorl of the shell. Very close to 50% of the surviving hybrid progeny were orange banded (a random sample of 200 individuals showed 103 banded and 97 unbanded). Sixteen juvenile specimens are illustrated on Pl. 3.

Mass Spawning of February 13, 1970: During this unseasonal, but still very vigorous spawning, a *H. rufescens* female was successfully crossed with a *H. sorenseni* x *H. kamtschatkana assimilis* hybrid, producing another three species hybrid (Pl. 5).

Haliotis rufescens eggs were collected from an isolated female and fertilized with sperm water from an isolated *H. sorenseni* x *H. kamtschatkana assimilis* male. The usual unfertilized control was set aside and showed no development. Fertilization was quite slow; after 45 minutes, an estimated 20% of the eggs showed polar bodies, but after 18 hours, over 90% of the batch had progressed to rotating trochophores. Fertilization thus took place relatively slowly, but at high frequency. This culture of larvae developed especially well, and an estimated 90% of the veligers completed metamorphosis to the benthic stage by the 10th day. An estimated 6,000 progeny from this cross remained at eight months and all but approximately 100 were transplanted to Mexico (along with the *H. sorenseni* x *H. kamtschatkana assimilis* progeny of September, 1969). Of the remainder in the hatchery, the largest measured 56 mm in September, 1971. By that date, morphological characteristics of

all three species involved in the parental cross were easily noticeable. *Haliotis rufescens* is evident from the dark pigmentation; the upper margin of the epipodium shows regularly spaced protuberances typical of *H. sorenseni*; and *H. kamtschatkana assimilis* is evident from the "threaded" pattern of the spiral sculpture in the shell.

May, 2015: The two largest specimens measured 88.6 mm and 95.0 mm when experiments were terminated in mid to late 1972. This was exceedingly rapid growth.

Mass Spawning of June 24, 1970: On this occasion, two hybrids of entirely different ancestry were crossed producing a batch of suspected four species hybrids.

Owen correctly anticipated this spawning from weather cues, and had isolated the prospective parents well in advance of the actual spawning. The male parent was a hatchery-raised *H. corrugata* x *H. walallensis* hybrid (born October 6, 1965), and the female was a *H. rufescens* x *H. sorenseni* collected from natural populations. The female was exposed only to filtered water, and the fact that she spawned suggests that sperm is not always necessary to stimulate the female spawning response (this had been observed on a number of occasions in straight *H. rufescens* spawnings done for commercial purposes as well). As usual, the male parent spawned before the female parent. The eggs were divided into two batches, and one was set aside as an unfertilized control. It showed no subsequent activity. The second batch was mixed with *H. corrugata* x *H. walallensis* sperm. Fertilization was quite feeble. Microscopically, sperm appeared to become immobile after contact with the vitelline envelope. After 45 minutes, no polar bodies were seen, and no sperm were observed within the vitelline space. After 24 hours, about 1% of

the eggs had advanced to rotating trochophores, and at five days there were about 3,000 swimming veligers. About 5% of these successfully became benthic. Currently (September, 1971), at 15 months of age, about 100 of this group remain. The largest are about 41 mm long and beginning to show recognizable characteristics. A great deal of variability is evident in shell details and epipodial and body pigmentation. Many shells strongly suggest *H. corrugata*, and since there were no sexually mature *H. corrugata* males within 300 kilometers of the hatchery at the time of this spawning, this tends to further verify the presumed paternity of the *H. corrugata* x *H. walallensis* hybrid. (Note: The hatcheries single male *H. corrugata* of the July 19, 1969 spawning had died months earlier). Other shells of this group look very much like young *H. rufescens*, and still others have a very mixed appearance (Pl. 7). At least two different epipodial pigmentation patterns seem to be

developing, and these differences do not seem to correlate with variations in the shell.

May, 2015: The two largest specimens measured 74.2 and 71.5 mm when experiments were terminated in mid to late 1972. This was exceedingly rapid growth.

It seems consistently true that when hybrid abalone are used as parents in these artificial crosses, the morphological variability in the progeny is greatly increased. In this particular case, where both parents are hybrids of different background, the variability in the progeny appeared even greater than in previous cases (October, 1968; July, 1969; and February, 1970) where only one of the parents was a hybrid.

Table 2 is a summary of the different crosses performed and the results, assessed as number and size of survivors as of September, 1971. (No information provided within various May, 2015, text sections is incorporated into this historical table.)

Table 2. Summary of crosses performed and results

Date of Mass Spawning	Cross performed Female x Male	Egg-Sperm Interaction	% of eggs becoming "rotating trochophores"	% of veligers becoming benthic	Number and maximum size (in mm) of survivors (Sept., 1971)	Progeny Positively Identified?
October 6, 1965	Co x Co	n.o.	n.o.	n.o.	3 37	yes
	Co x R	n.o.	n.o.	n.o.	0 N/A	yes
	Co x W	n.o.	n.o.	n.o.	1 59	yes
December 7, 1965	Ka x Ka	n.o.	n.o.	n.o.	14 100	yes
	Ka* x W*	n.o.	n.o.	n.o.	2 107	yes
August 23, 1967	Ka x Ka	normal	90	1	~100 90	yes
	Ka x W	subnormal	15	0	0 N/A	N/A
	Ka x Cr	none	2	0	0 N/A	N/A
	Ka x S	subnormal	5	0	0 N/A	N/A
	Ka X (R x S)	subnormal	25	0	0 N/A	N/A
	Ka X (R x Ka)	normal	75	1	22 103	yes
October 31, 1968	(R x S) X Ka	n.o.	n.o.	n.o.	20 65	yes
	(R x S) X **	n.o.	95	n.o.	130 80	no
July 19, 1969	S x Co	subnormal	25	10	86 53	yes
	Co X (R x S)	n.o.	80	90	16 72	R and S (and I Co)
September 14, 1969	S x Ka	normal	75	50	~100 42	yes
	S x S	normal	over 95	0	0 N/A	N/A
February 13, 1970	R X (S x Ka)	subnormal	90	90	~100 56	yes
June 24, 1970	(R x S) X (Co x W)	subnormal	1	5	~100 41	yes

KEY

Co = *H. corrugata*
 R = *H. rufescens*
 W = *H. walallensis*
 Ka = *H. kamtschatkana assimilis*
 Cr = *H. cracherodii*
 S = *H. sorenseni*

(R x S) = *H. rufescens* x *H. sorenseni*
 (R x Ka) = *H. rufescens* x *H. kamtschatkana assimilis*
 (S x Ka) = *H. sorenseni* x *H. kamtschatkana assimilis*
 (Co x W) = *H. corrugata* x *H. walallensis*
 n.o. = not observed
 * = sexes of parent species uncertain
 ** = parent species uncertain

EXPLANATION OF PLATES

Eight plates are included which illustrate the various crosses cultivated. They are arranged in an ascending order of complexity based on information gleaned from all of the spawning events between 1965 and 1970. Dates of specific spawnings are listed in "Conclusions" on pg. 183. All specimens are hatchery cultured unless noted otherwise (on plates or text). Specimens listed being from natural populations are from California, unless otherwise recorded.

May, 2015: A ninth plate illustrating a pair of two species hybrids cultured at other laboratories (after 1972) is included, one which may not have been cited in literature; additionally, some specimens of several crosses were kept alive after these experiments were concluded and reached sizes larger than those listed in Table 2.

Pl. 1 – Illustrates the six species used in the experiments (both *H. kamtschatkana assimilis* and *H. kamtschatkana kamtschatkana* are included). All specimens are from natural populations.

Pl. 2 – Illustrates the five two species hybrids cultivated at Pacific Mariculture, Inc. These mass spawnings occurred on October 6 and December 7, 1965, and July 19 and September 14, 1969.

Pl. 3 – The four bottom rows illustrate sixteen hatchery cultured 7-11 mm juvenile *H. sorenseni* (non-banded female) x *H. kamtschatkana assimilis* (male with genetic orange band). Eight show the orange band, and eight are without band. This mass spawning occurred on September 14, 1969.

Pl. 4 – Illustrates four orange banded backcrosses of a female orange banded *H. kamtschatkana assimilis* crossed with a male *H. rufescens* x *H. kamtschatkana assimilis* hybrid. This mass spawning occurred on August 23, 1967.

Pl. 5 – Illustrates four three species hybrids of a female *H. rufescens* crossed with a male *H. sorenseni* x *H. kamtschatkana assimilis* hybrid. This mass spawning occurred on February 13, 1970.

Pl. 6 – The bottom four rows illustrate fourteen extremely confusing specimens resulting from the eggs of a *H. rufescens* x *H. sorenseni* hybrid being fertilized with sperm water from a tank containing spawning males of at least four or five species and two or three different hybrids. Additionally, there were a few fertilized eggs that came from this tank. Many bizarre genetic combinations resulted from this spawning as this plate demonstrates, including a number of confirmed-with-animal three species crosses of this hybrid female with a male *H. kamtschatkana assimilis*. These latter crosses cannot be differentiated from the remainder of this group by shell morphology and thus cannot be positively identified. The mass spawning that yielded these specimens occurred on October 31, 1968. The top row of this plate illustrates a three species cross of a *H. corrugata* female and a male *H. rufescens* x *H. sorenseni* hybrid. This mass spawning occurred on July 19, 1969.

Pl. 7 – Illustrates sixteen specimens of a four species cross of a female *H. rufescens* x *H. sorenseni* hybrid with a hatchery cultured male hybrid *H. corrugata* x *H. walallensis*. The morphology of all four species is visible throughout this group. This mass spawning occurred on June 24, 1970.

Pl. 8 – Illustrates a bizarre three species cross between a female *H. cracherodii* and a hatchery cultured male *H. corrugata* x *H. walallensis* (from the mass spawning of October 31, 1968). Also compared are a typical southern *H. kamtschatkana assimilis* and a specimen exhibiting the northern *H. kamtschatkana kamtschatkana* morphology of its obvious Canadian male parent. These two animals came from the spawning of December 7, 1965.

Pl. 9 – Includes hatchery cultured hybrids beyond the experiments discussed thus far. More discussion to follow.

DISCUSSION

Culture Techniques. By improving techniques during the first several years that these experiments were carried out, gradually more control was gained over the fertilization step. In the first mass spawning (October, 1965) the eventual results showed that 90% of the surviving progeny represented fertilizations by sperm that were thought not to be present. This indicated that avoiding fertilization by contaminating sperm was more difficult than expected, and led to the adoption of techniques where desired parents were removed from the main tank, rinsed, and held in isolation in filtered water (see Materials & Methods). By 1969, contamination by unwanted sperm could be almost entirely avoided.

Since these larvae had been cultured under hatchery conditions, human factors may be responsible for part or all of the mortality. With more experience the human factors are becoming more controlled, but it still appears that there is a natural variability in survival at settling. This may depend on the genetic makeup of the parents, the nutritional condition of the parents when they spawn, or both. Since a single pair of spawning adults may produce more than a million developing embryos, a low rate of survival through metamorphosis will still allow many progeny to survive under hatchery conditions. In nature, mortality is undoubtedly high due to such additional factors as predation and the chance of settling in an unfavorable environment. Perhaps a high level of genetic variability in abalone offspring may result in high mortality of less well-adapted variants during the larval stage; the unpredictability of this factor complicates the evaluation of relative

success of hybrid combinations. We were unable to determine if the mortality of a group of hybrid larvae was due to a lethal combination of inherited factors or typical mortality rates seen with homospecific crosses.

Egg-Sperm Interaction. One of the results that best seemed to reflect the success of any particular hybrid combination was the relative speed of successful penetration of the egg by sperm. Homospecific gametes show high affinity for each other, since sperm rapidly penetrate the vitelline envelope and swim actively within the perivitelline space of the egg (Fig. 1). Sperm from different species tend to be repelled or blocked at the envelope surface, or suppressed in activity once inside. In the August, 1967, spawning, *H. walallensis*, *H. sorenseni*, and hybrid *H. rufescens* x *H. sorenseni* sperm were all sluggish in their interaction with *H. kamtschatkana assimilis* eggs, although effective fertilization occurred in a small number of eggs. The cross attempted in February, 1970, between a *H. rufescens* female and a *H. sorenseni* x *H. kamtschatkana assimilis* male, showed very slow rates of penetration, but apparently a large fraction of the eggs successfully became fertilized. In the June, 1970, spawning where two hybrids of entirely different genetic background were used as parents, fertilization was slower yet, but about 1% of the eggs eventually developed.

This relative speed of fertilization could be an important factor preventing wholesale hybridization in nature. During a natural mass spawning an egg might be exposed to sperm of a number of different species, and if homospecific sperm in the water could penetrate the eggs faster than others, a small amount of homospecific sperm in the water could virtually ensure homospecific fertilization of all the eggs. Only in circumstances where active males of the

species are absent would hybrids be produced. A possible example of an area of this sort is the coastline three to six miles east of Point Conception (Fig. 3). At least two and perhaps three of the four known *H. sorenseni* x *H. kamtschatkana assimilis* hybrids have been found in this area. It is approximately the northern limit of the distribution of *H. sorenseni*, and a number of years diving in the area show the species to be quite rare. *Haliotis kamtschatkana assimilis* is locally very common and a large spawning of that species in the area of a lone *H. sorenseni* female might provide conditions that would give the slow penetrating *H. kamtschatkana assimilis* sperm sufficient time to penetrate the *H. sorenseni* eggs, free of competition from homospecific sperm.

Figure 3 illustrates Point Conception area.

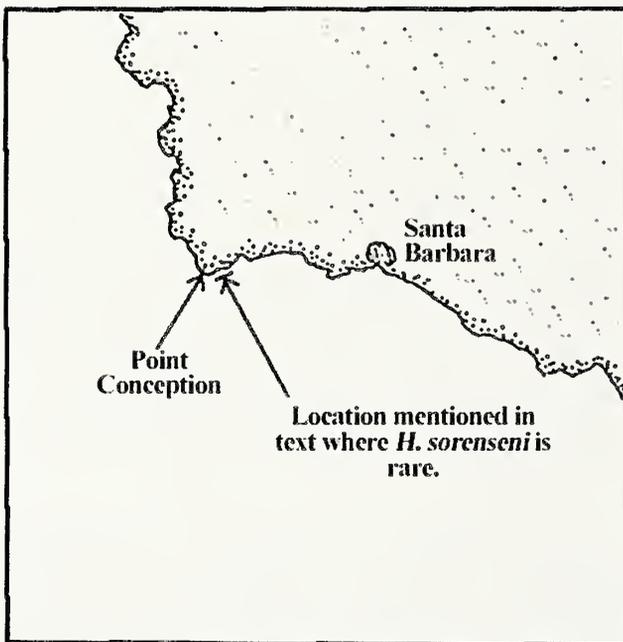


Figure 3. Map of Point Conception area, showing where two of the four known *H. sorenseni* x *H. kamtschatkana assimilis* hybrids have been found.

Among the combinations performed in August 1967, was an attempt to fertilize *H. kamtschatkana assimilis* eggs with *H. sorenseni* sperm. Fertilization percentage was recorded at

less than 5% and no progeny survived past the larval stage. During the September, 1969 spawning, *H. sorenseni* eggs were fertilized with *H. kamtschatkana assimilis* sperm, and good fertilization and larval survival were observed. This represents the only case among all the spawnings reported that could be called a "reciprocal cross", *i.e.*, the same kinds of parents with the sexes reversed. In this case, the results were quite different in the two reciprocal combinations. Imai and Sakai (1961) performed reciprocal fertilizations with different species of the oyster genus *Crassostrea*. They also observed different rates of fertilization when the sexes were reversed.

Failure of *H. cracherodii*. As of September, 1971, *Haliotis cracherodii* is the only species of Eastern Pacific *Haliotis* for which no hybrids have been reported in nature, and in this light, the behavior of *H. cracherodii* sperm in the August, 1967, spawning is of interest. While other heterospecific sperm penetrated slowly, *H. cracherodii* sperm seemed to be actually repelled from *H. kamtschatkana assimilis* eggs, leaving a sperm-free zone around the vitelline envelope. We suspect that there was no fertilization taking place, although a few trochophores were observed in this batch the following day. Considering the methods used during this spawning and what has been learned since, it seems likely to us that there was a low level contamination of this culture by some *H. kamtschatkana assimilis* sperm. Future spawnings are being planned to test more thoroughly whether *H. cracherodii* gametes can successfully combine with those of other Eastern Pacific abalone species.

The one species of Eastern Pacific abalone not used in these experiments is *Haliotis fulgens*. It would have been interesting to use gametes from this species because only *H. cracherodii* is less apt to hybridize than *H. fulgens*. *Haliotis*

fulgens is known to cross only with *H. corrugata* (25 known cases), and *H. rufescens* (2 known cases). Excepting *H. cracherodii*, the three unknown hybrids all involve *H. fulgens*: *H. sorenseni* x *H. fulgens*, *H. kamtschataka assimilis* x *H. fulgens*, and *H. walallensis* x *H. fulgens*. (Owen *et al.*, 1971).

May, 2015: It is now known that *H. cracherodii* hybridizes with *H. corrugata* (unique) and *H. fulgens* (six known currently) and both hybrids have also been cultured in hatcheries (Owen & Leighton, 2002). Additionally, *H. fulgens* has been successfully crossed with *H. sorenseni* in a marine laboratory (Leighton, 2000). The two existing specimens of the latter are illustrated herein (Pl. 9).

Comparison with Hemocyanin Relationships.

Meyer has studied the hemocyanins (oxygen-carrying blood proteins) of the California abalone, comparing immunological properties of these proteins in the different species (Meyer, 1967). Since the hemocyanins might also be taken as a measure of genetic relatedness, it would be interesting to compare genetic interpretations of the hemocyanin results with the laboratory results. Broadly, the hemocyanin data suggest relationships as depicted in Figure 4. First, *H. cracherodii* is the most different from the others. Apart from *H. cracherodii*, there are three more or less equally distinct stems: *H. walallensis* alone, a *H. corrugata-fulgens* line, and a *H. rufescens-sorenseni-kamtschataka assimilis* line. The latter three all have closely related hemocyanins, thus are judged to be a closely related trio. *Haliotis corrugata* and *H. fulgens* are less close to one another, but still closer to each other than they are to other species of California abalone.

Figure 4 illustrates the relationships among the seven species of California *Haliotis*, based on immunochemical comparisons of their hemocyanins.

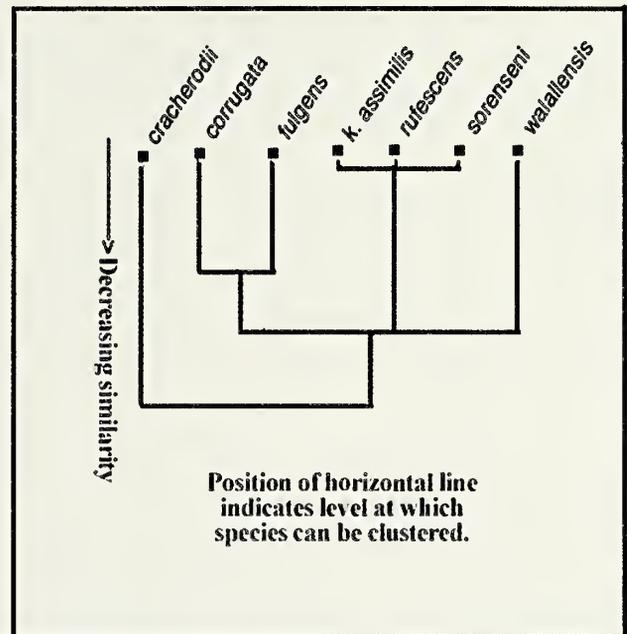


Figure 4. Relationships among the several species of California *Haliotis* as suggested by immunochemical comparisons of hemocyanins.

The very different hemocyanin of *H. cracherodii* points to a genetic difference that is consistent with the behavior of *H. cracherodii* sperm in the 1967 experiments. The success of the backcross in those same experiments indicates close genetic affinity between *H. rufescens* and *H. kamtschataka assimilis*, consistent with the hemocyanin results. However, hemocyanins also point to a close relationship between *H. sorenseni* and *H. kamtschataka assimilis*, yet both *H. sorenseni* and *H. rufescens* x *H. sorenseni* hybrid sperm were classed as “subnormal” in their interaction with *H. kamtschataka assimilis* eggs, similar to *H. walallensis*, which has a hemocyanin quite distinct from *H. kamtschataka assimilis*. The reciprocal combination of *H. kamtschataka assimilis* x *H. sorenseni* performed in September, 1969, however, showed good survival of progeny.

The Orange Band Variant in *H. kamtschatkana assimilis*. The orange banded shell characteristic sometimes found in *H. kamtschatkana assimilis* appears to be an inherited trait and some of the spawnings give information that allows speculation on the pattern of inheritance of the band. The data so far collected fit well with the supposition that the banded character is determined by a single dominant gene, but it should be emphasized that other explanations might also be consistent with the data collected, so that apparent fit with the single gene explanation is not necessarily proof of that interpretation.

In the spawning of August, 1967, a straight *H. kamtschatkana assimilis* cross was performed and both parents were banded. Out of 203 progeny, 153 (75%) were banded and 50 (25%) were unbanded. If both parents were heterozygous for the trait and it were due to a single dominant gene, one would expect three-fourths of the progeny to show the dominant character (banded) and one-fourth the recessive character (unbanded), as occurred here.

In another cross with the above female in the same 1967 spawning, the backcross parent (*H. rufescens* x *H. kamtschatkana assimilis* male) was not banded and 11 of the 24 backcross progeny (46%) were banded. According to the single dominant gene hypothesis, with the banded parent being heterozygous, a cross with an unbanded parent should give half banded and half unbanded progeny, a result not far from the observed one.

In the September, 1969 spawning, a banded male *H. kamtschatkana assimilis* was crossed with a *H. sorenseni* female. The female did not show a band in the early whorls of the shell. Almost exactly one-half (103/200) of the progeny of this cross came out to have banded shells. Assuming the banded male parent here

was heterozygous, the cross would be similar to the backcross combination of 1967, and in accord with the single dominant gene interpretation, half of the progeny would be expected to have a band, as occurred here.

CONCLUSIONS

1. Hybridization of California *Haliotis* can be performed under hatchery conditions.

2. The following two species hybrids have been produced in the hatchery. The offspring have matured sufficiently to be positively identified on a morphological basis (Pl. 2).

Haliotis corrugata x *H. rufescens* (October, 1965)

Haliotis corrugata x *H. walallensis* (October, 1965)

Haliotis kamtschatkana assimilis x *H. walallensis* (December, 1965)

Haliotis sorenseni x *H. corrugata* (July, 1969)

Haliotis sorenseni x *H. kamtschatkana assimilis* (September, 1969)

3. At least some hybrid abalone of both sexes have been shown to be fertile. A *H. kamtschatkana assimilis* female was successfully backcrossed to a *H. rufescens* x *H. kamtschatkana assimilis* hybrid male (August, 1967; Pl. 4). A female *H. rufescens* x *H. sorenseni* hybrid successfully produced three species hybrid progeny with a male *H. kamtschatkana assimilis*, 20 specimens being confirmed by animal morphology (October, 1968; Pl. 6). (Note: A large number of specimens of exceedingly confused identity resulted from this spawning due to an unknown number of different species and hybrid male parents being involved. From shell alone, it is not possible to identify individual specimens of this group). One *H. rufescens* x *H. sorenseni* hybrid proved a successful male parent, combining with *H. corrugata* eggs (July, 1969;

Pl. 6, top row). Another *H. rufescens* x *H. sorenseni* female successfully crossed with a male hatchery-raised hybrid *H. corrugata* x *H. walallensis* (June, 1970).

4. A *H. rufescens* x *H. sorenseni* hybrid female was crossed with a *H. kamtschatkana assimilis* male (October, 1968, Pl. 6) and the progeny have been positively identified as the first known case of a three species hybrid in *Haliotis*. A second attempt at a three species cross, *H. corrugata* X (*H. rufescens* x *H. sorenseni*) was also successful (July, 1969, Pl. 6 top row), and identification was confirmed on at least one of the larger animals when the *Haliotis* experiments were terminated in late 1972. A third example of a three species hybrid has been confirmed, the cross of a *H. rufescens* female with a hybrid *H. sorenseni* x *H. kamtschatkana assimilis* male (February 1970, Pl. 5). Finally, a fourth three species cross was later confirmed with the discovery of a single specimen of *H. cracherodii* X (*H. corrugata* x *H. walallensis*). (Note: This specimen was a byproduct of the October, 1968 spawning. Pl. 8, 2nd row).

5. Viable four species hybrid progeny (*H. rufescens* x *H. sorenseni*) X (*H. corrugata* x *H. walallensis*) were produced during the June, 1970, spawning (Pl. 7).

6. The pattern of inheritance of the orange band in *H. kamtschatkana assimilis* is consistent with the banded character being determined by a single dominant gene.

7. Whatever the factor that induced spawning, it was carried through water that was filtered through a one micron filter and UV sterilized (spawning of June, 1970). During these spawnings, other instances occurred where isolated females spawned copiously in non-UV treated water as well.

8. Behavior of sperm during fertilization is apparently quite important to the fate of a hybrid combination. Many sperm seem to be retarded in activity near eggs from other species.

9. One reciprocal cross was performed. *Haliotis sorenseni* sperm with *H. kamtschatkana assimilis* eggs (August, 1967), was an unsuccessful combination, but *H. kamtschatkana assimilis* sperm with *H. sorenseni* eggs resulted in many thousands of healthy progeny.

10. The morphological variability in a group of progeny was observed to be much greater when hybrid abalone served as parents. The most variable batch of offspring was the presumed four species hybrids, where both parents were hybrids of different genetic background.

ACKNOWLEDGEMENTS

This paper presents the work of Owen Meyer carried out hemocyanin compatibility tests and assisted in the preparation of the manuscript. Our grateful thanks are extended to W. W. Budge and Malcolm Donald, the owners/partners of Pacific Mariculture, Inc., for their interest and patience towards these experiments. We also wish to thank the following people, many who were involved in the commercial abalone industry, for their help in obtaining many of the animals used in this study: (alphabetically) Frank Bernard, Mike DeGarrimore, Gene Hall, Huck Kuzen, Dr. David L. Leighton, Bob McMillen, Ernie Porter, Larry Scherer, Chuck Sites, Chuck Snell, and Dean Tyler.

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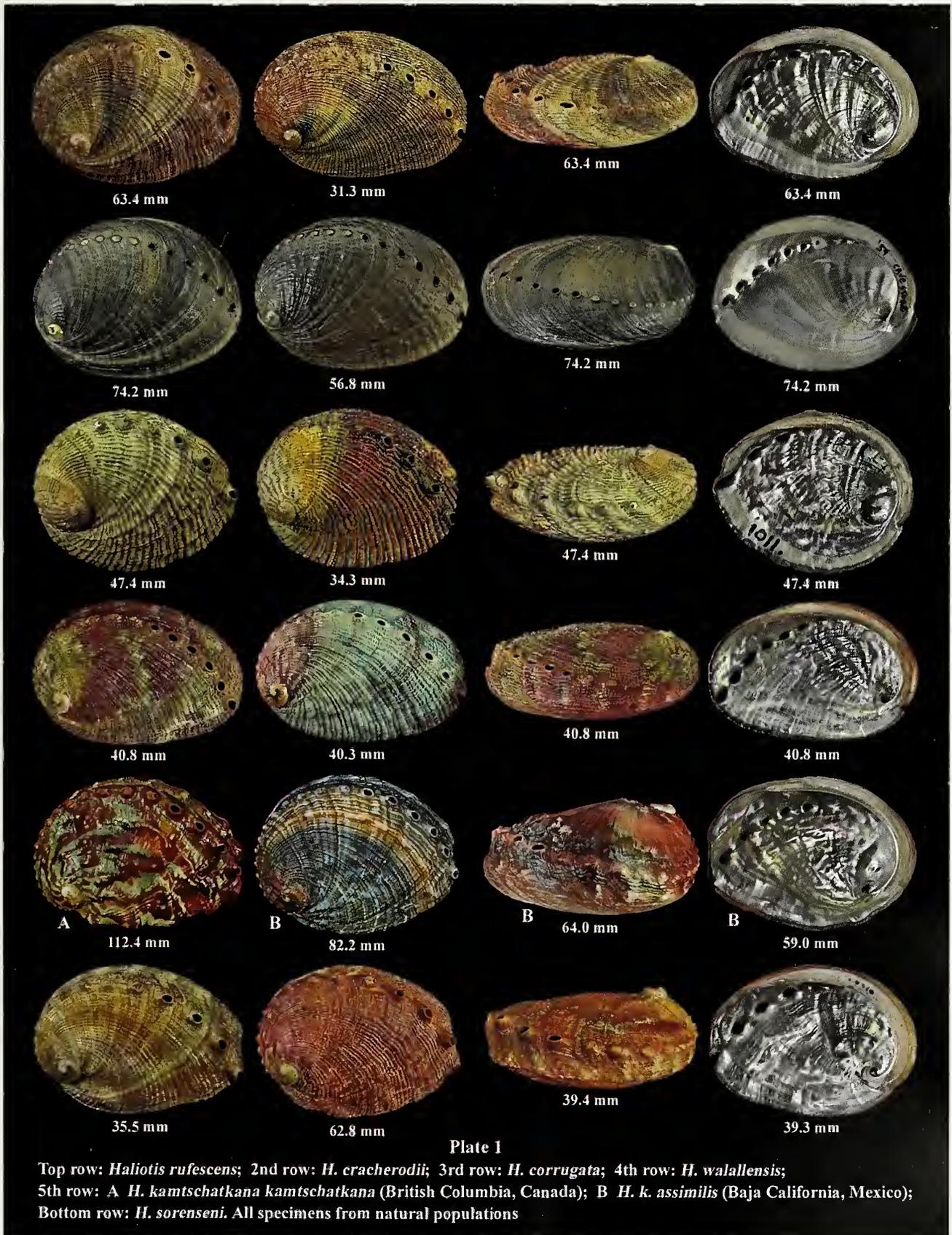
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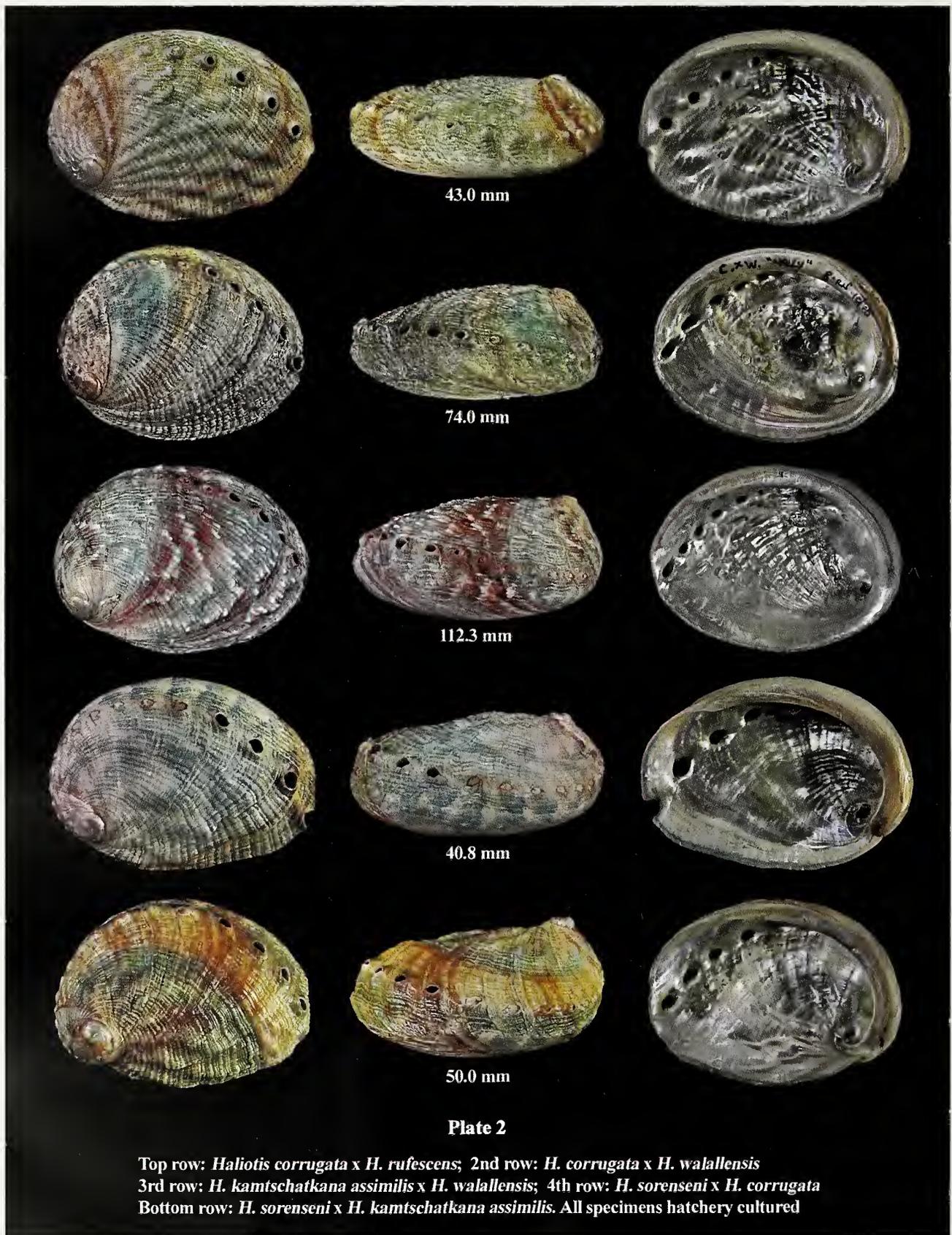
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**Taxonomic Note - new species:
Haliotis geigeri Owen, 2014**

This small species is endemic to São Tomé and Príncipe Islands off the coast of Gabon, West Africa. It is the smallest member of the *Haliotis tuberculata tuberculata* Linnaeus, 1758, group, seldom exceeding 40 mm in length. Little is known of its preferred habitat or biology, and it is uncommon in collections. Figured specimen measures 38.4 mm, and was taken at Lagoa Azul Beach, São Tomé Island, in 3-5 m. (Owen, B. 2014. A new species of *Haliotis* (Gastropoda) from São Tomé & Príncipe Islands, Gulf of Guinea, with comparisons to other *Haliotis* found in the Eastern Atlantic and Mediterranean. *Zootaxa* 3838 (1): 113-119. 2 pls.) (Photo credit: Buzz Owen)





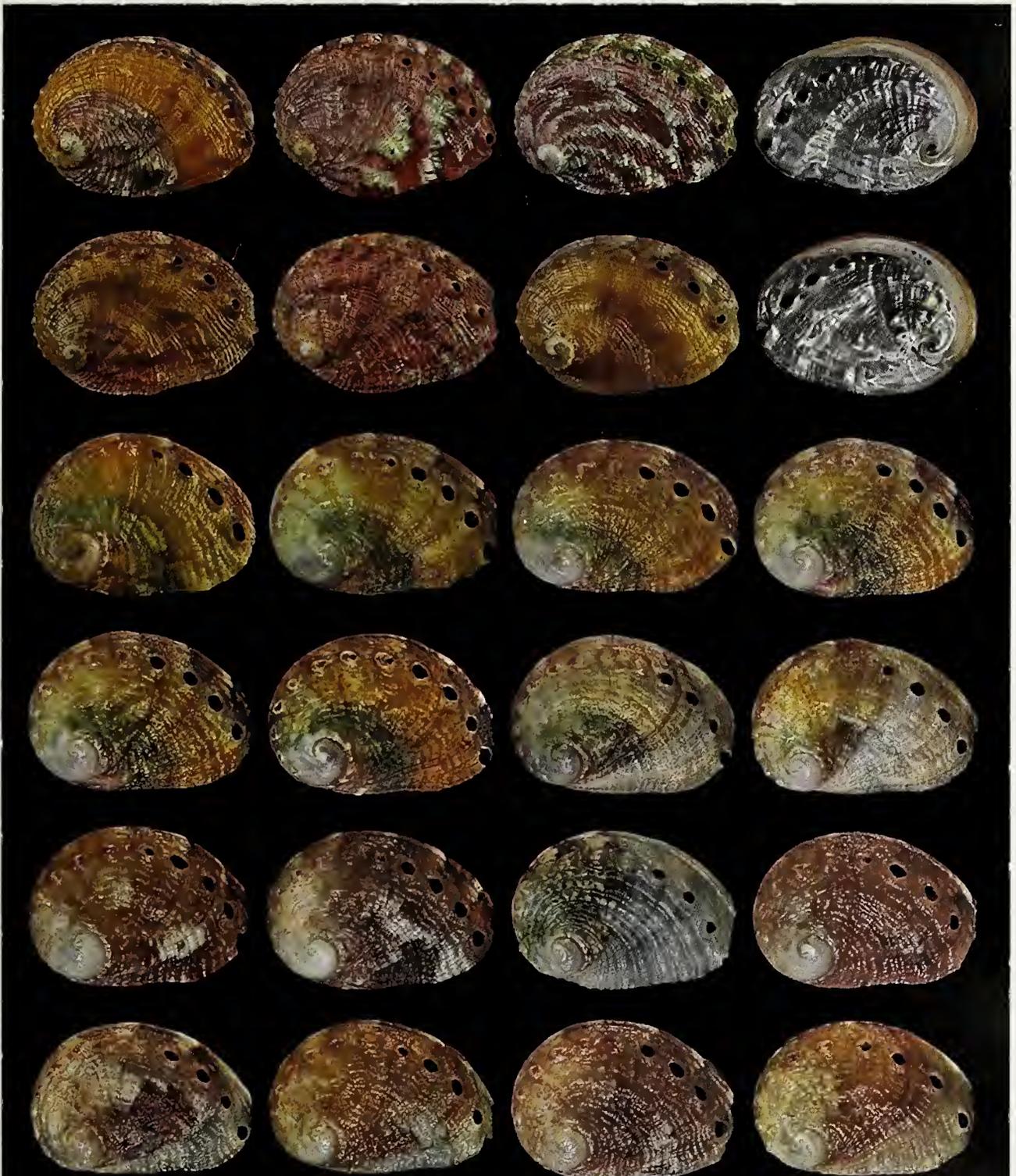
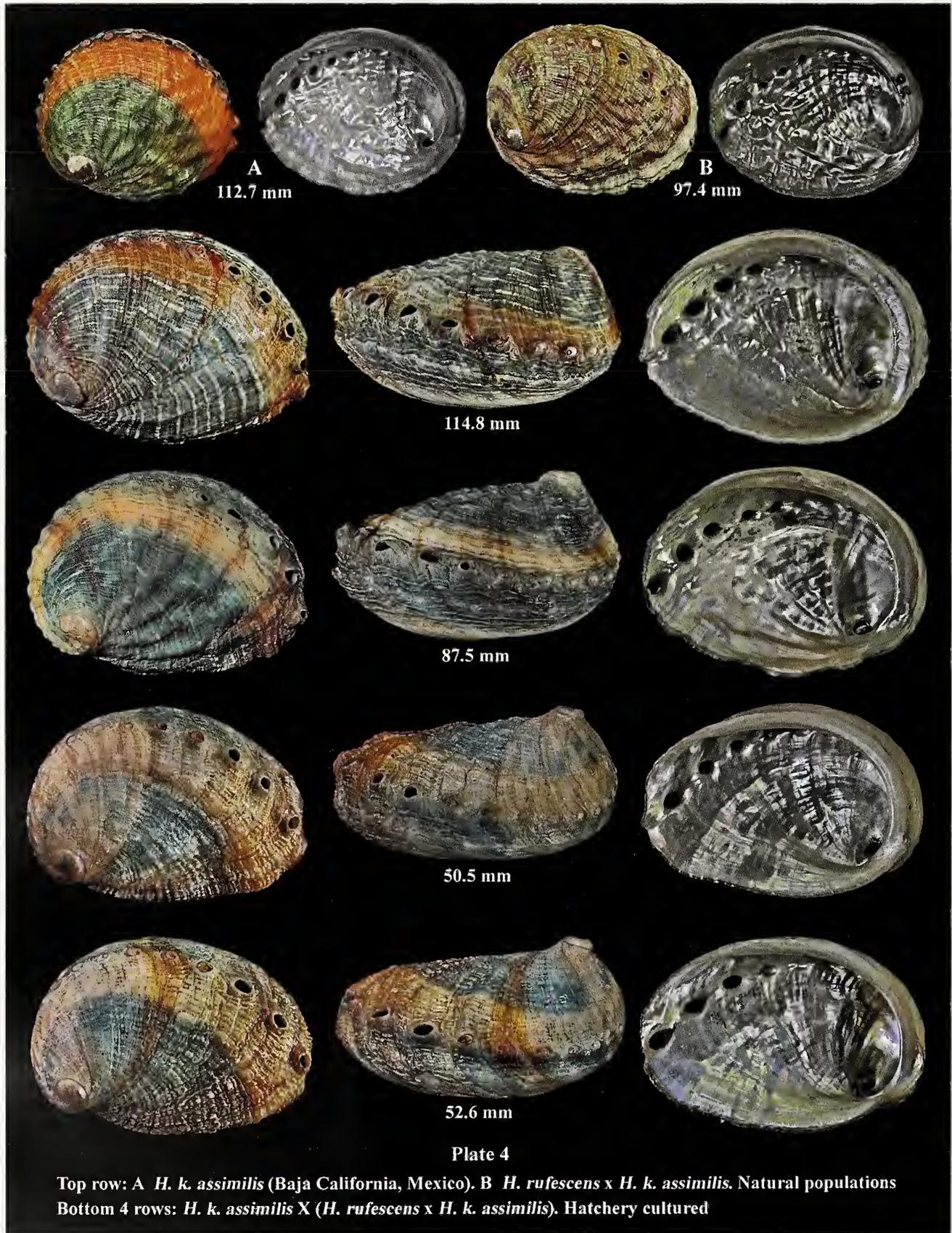


Plate 3

Top row: *Haliotis kamtschatkana assimilis*. 35-40 mm. Natural populations

2nd row: *H. sorenseni*. 26-34 mm. Natural populations

Bottom 4 rows: *H. sorenseni* x *H. kamtschatkana assimilis*. 7.5-11.5 mm. Hatchery cultured



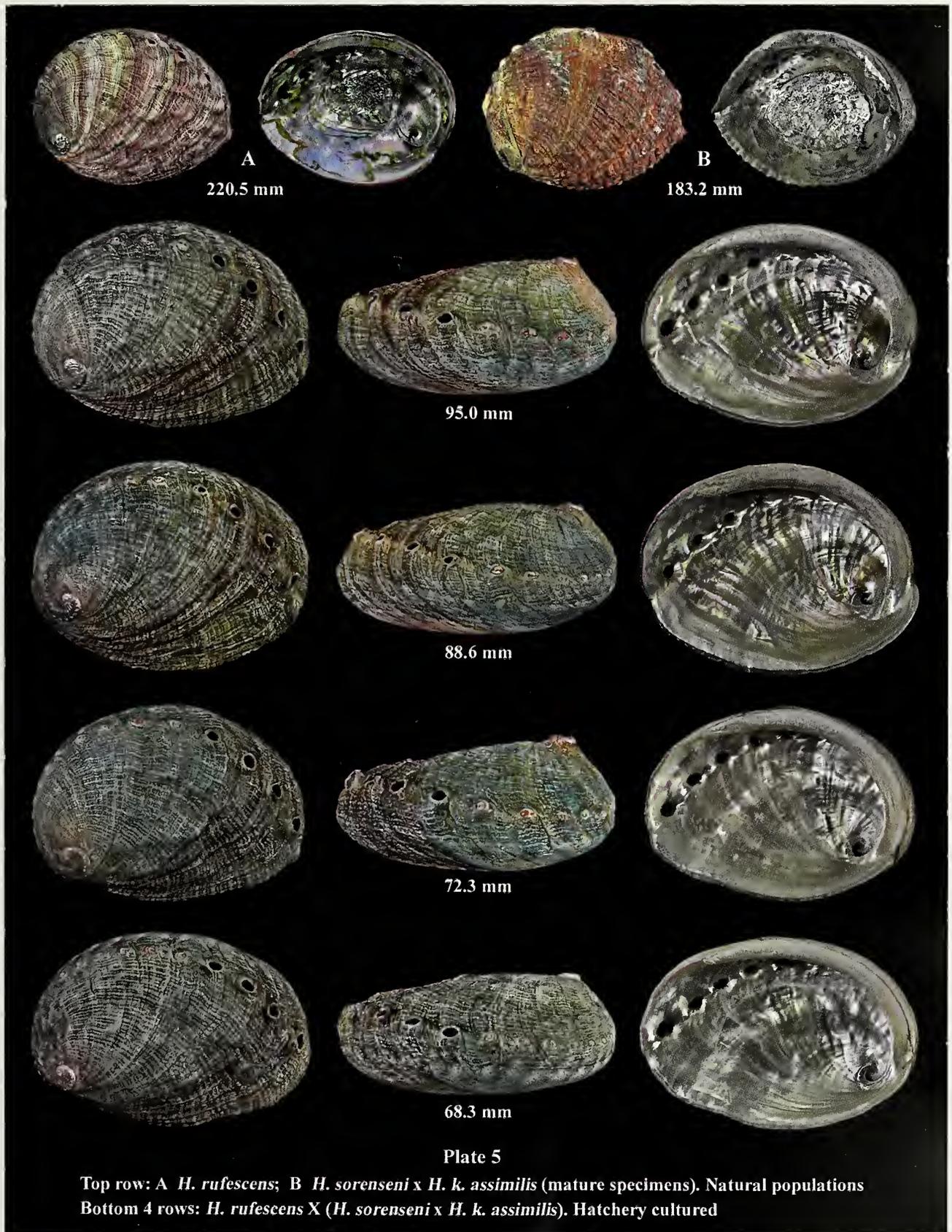
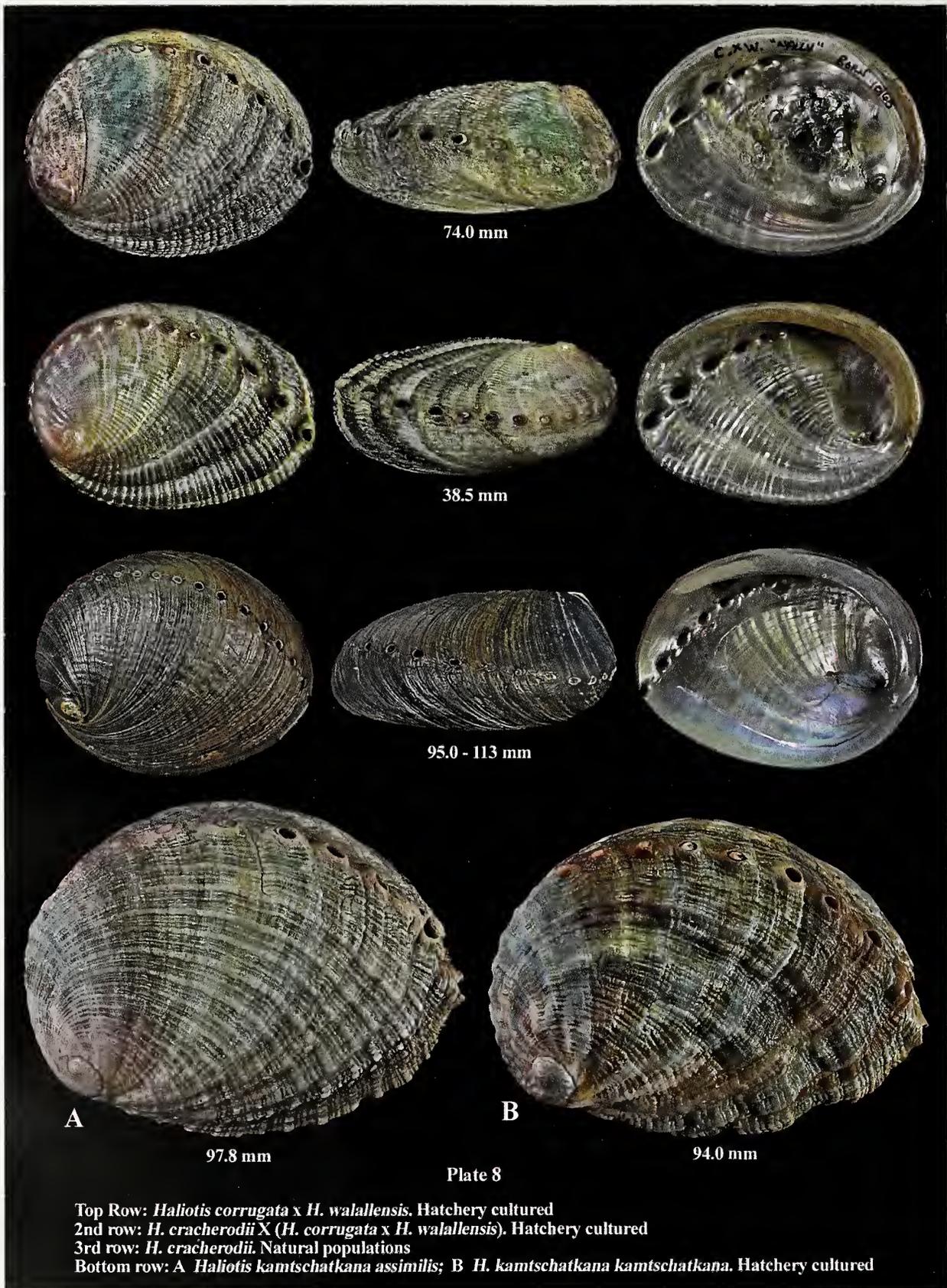


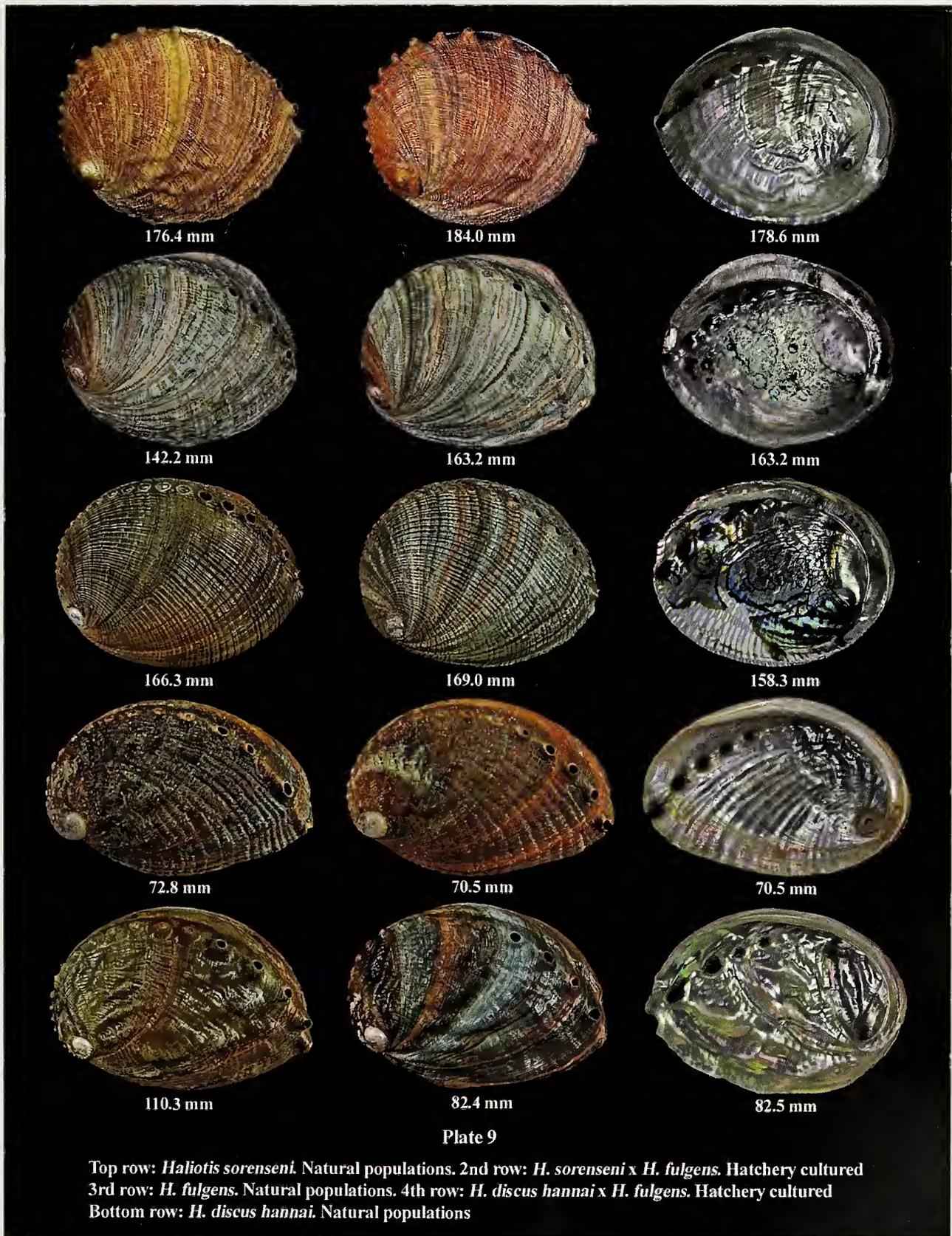


Plate 6

Top Row: *Haliotis corrugata* X (*H. rufescens* x *H. sorenseni*) from hatchery spawning of July 19, 1969
 Bottom 4 rows: Mixed group of specimens from October 31, 1968, spawning illustrating confused morphology







Two New Species of *Tenorioconus* (Gastropoda: Conidae) from Aruba

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ABSTRACT Two new members of the Caribbean Province endemic conid genus *Tenorioconus* Petuch and Drolshagen, 2011 are described from the Netherlands Antilles island of Aruba. One of the new species, *Tenorioconus monicae* n. sp., was found to belong to the *Tenorioconus mappa* species complex and is most similar to the Venezuelan coastal species *T. sanguineus* (Kiener, 1850) and *T. caracanus* (Hwass, 1792). The other new species, *T. rosi* n. sp., was found to belong to the *T. aurantius* species complex and is most similar to the Aruban endemic *T. curassaviensis* (Hwass, 1792) and the Curacao and Bonaire endemic *T. aurantius* (Hwass, 1792). The discovery of these two new taxa demonstrates that three distinct, endemic species of *Tenorioconus* occur in shallow water areas around Aruba.

KEY WORDS Aruba, *Tenorioconus*, endemic species, Grenadian Subprovince, *Tenorioconus monicae*, *Tenorioconus rosi*.

INTRODUCTION

Of the 19 genera of the family Conidae found in the Caribbean Molluscan Province (Petuch, 2013; Tucker and Tenorio, 2013), the genus *Tenorioconus*, Petuch and Drolshagen, 2011 stands out as being one of the most aesthetically-pleasing and beautiful groups of cone shells. Since the mid-18th Century, members of the genus have been considered to be among the most desirable of collectible shells and even the species name of the genotype, *Tenorioconus cedonulli* (Linnaeus, 1767) (meaning "I yield to none"), reflects the high esteem to which these cones were held by early European naturalists. As presently understood, 18 species of *Tenorioconus* are known to inhabit the Nicaraguan and Grenadian Subprovinces of the Caribbean Province, with the westernmost species, *T. harlandi* (Petuch, 1987) being found along the coast of Honduras and the Bay Islands (western Nicaraguan

Subprovince) and with the easternmost and northernmost species, *T. insularis* (Gmelin, 1791) being found on Martinique and St. Lucia Islands in the Windward Islands of the Lesser Antilles (Grenadian Subprovince) (Petuch, 2013: 131, 182). Based on the proportionally-large relative sizes of their protoconchs, *Tenorioconus* species can be seen to have direct development, lacking a dispersing planktotrophic larva and hatching directly into a free-crawling juvenile. This lack of vagility has caused many species to become isolated on widely-separated island groups or islands that are separated by deep trenches, producing a classic allopatric vicariance speciation pattern (Valentine, 1973; Briggs, 1995; Petuch, 2013:131-132).

Within the Grenadian Subprovince, the island of Aruba stands out as being of special interest in that it represents the westernmost end of this biogeographical subdivision and is in direct

contact with the Venezuelan Subprovince (Petuch, 2013: 134). Unlike the intervening islands of the Grenadian Subprovince along the northern coast of Venezuela, which are all separated from the mainland by deep water areas, Aruba is actually part of the Venezuelan continental shelf. Because of this connection to the shallow water malacofauna of Venezuela, many of the resident Aruban gastropods are also shared with Venezuela, including the olivids *Americoliva fulgurator* (Röding, 1798), *Americoliva reclusa* (Marrat, 1871), and *Eburna glabrata* (Linnaeus, 1758), the volutid *Voluta musica* (Linnaeus, 1758), the conid *Lindaconus baylei* (Jousseume, 1872) (= *arubaensis* Nowell-Usticke, 1968), and the conilithid *Perplexiconus punctulatus* (Hwass, 1792). Besides these shared species with the Venezuelan Subprovince, the Aruban malacofauna also contains a distinctive and characteristic component of endemic species, the largest number found on any of the islands of the Grenadian Subprovince. Some of these unique Aruban taxa include the cone shells *Arubaconus hieroglyphus* (Duclos, 1833) (with the genus *Arubaconus* Petuch, 2013 being endemic to the island) and *Tenorioconus curassaviensis* (Hwass, 1792) (Figure 3G, H, and I), the muricid *Murexiella hilli* Petuch, 1987, the olivids *Americoliva sargenti* (Petuch, 1988) and *Eburna balteata* (Sowerby I, 1823), and the conilithid *Perplexiconus wendrosi* (Tenorio and Afonso, 2013).

Until recently, only two species of *Tenorioconus* were known from Aruba; the endemic *T. curassaviensis* (Hwass, 1792), a distinctively-shaped but variably-colored species (Figure 5L, M, and N), and another, smaller species that had been incorrectly referred to the taxon “*aurantius*” by several authors for nearly the past half century (*i.e.* Seamon and Seamon, 1967; Berschauer and Ros, 2014). Within the past few years, however, an

inspired local Aruban-Dutch diver and naturalist, Leo G. Ros, has conducted intensive surveys of relatively unexplored and uncollected areas around the island and has uncovered yet another species of *Tenorioconus*, along with more specimens of the previously-reported Aruban “*Tenorioconus aurantius*”. Subsequent study showed that both species were new to science and these are described in the following sections. The discovery of these new cones by Leo G. Ros brings the combined number of Aruban endemic conoideans to five, the most endemic cone shells found on any one island in the southern Grenadian Subprovince.

Based on differences in overall shell morphology, the genus *Tenorioconus* appears to actually comprise two separate species complexes; one composed of broad, stocky species with an internal constriction along the anterior end of the columella (and are morphologically close to *T. mappa* (Lightfoot, 1786); referred to here as the “*T. mappa* species complex”; Figure 5A, B), and the other composed of thinner, more slender species that lack the internal columellar constriction (Vink and von Cosel, 1985) (and are morphologically similar to *T. aurantius* (Hwass, 1792); referred to here as the “*T. aurantius* species complex”; Figure 5L, M, N). All the known members of these two species groups are listed on Table 1 at the end of this paper. The new species discovered by Leo G. Ros each belong to one of these two separate groups, with one being a member of the *T. mappa* species complex (described next) and other being a member of the *T. aurantius* species complex (described later in this paper). The holotypes of the new taxa are deposited in the type collection of the Department of Malacology, Los Angeles County Museum, and bear LACM numbers.

SYSTEMATICS

Class Gastropoda
Subclass Orthogastropoda
Superorder Caenogastropoda
Order Sorbeoconcha
Infraorder Neogastropoda
Superfamily Conoidea
Family Conidae
Subfamily Puncticulinae
Genus *Tenorioconus* Petuch and Drolshagen, 2011

Tenorioconus monicae Petuch and
 Berschauer, new species
 (Figures 1, 3A, B, C; 6C; 7)

Description: Shell of average size for genus, heavy and thickened, proportionally wide across shoulder, inflated and stocky; shoulders of penultimate whorl and body whorl both smooth and rounded, with broad, slightly raised carina, producing shallowly canaliculate spire whorls; spire proportionally high, protracted, elevated, and broadly pyramidal, with stepped, subscalariform whorls; subsutural areas sloping; early whorls of spire heavily ornamented with 18-20 large rounded knobs; concave spire channel sculptured with 3-4 thin, very fine spiral threads; body whorl smooth and shiny, ornamented with 15-18 very thin, low spiral threads, which become more closely-packed toward anterior end; aperture proportionally narrow, flaring slightly toward anterior end; anterior end of columella with wide, broad cord, producing distinct constriction or narrowing of anterior apertural canal; base shell color pale violet-lavender or bluish-tan, overlaid with variable amounts of amorphous flammules and patches; flammules varying in color from dark reddish-orange (as in holotype), to orange-tan, to dark tannish-yellow, contrasting greatly with the pale violet or blue base color; amorphous flammules and base color overlaid with 52-60

thin, closely-packed lines of dark brown and white dots; edge of spire suture marked with single row of very small, thin, evenly-spaced hairline flammules; spire whorls marked with large, widely-spaced, elongated reddish-brown flammules, which often align in radiating rows; anterior end of body whorl darker purple or purple-tan; interior of aperture lavender-purple or pale lavender-tan; earliest whorls pale orange-tan; periostracum very thin, smooth, pale yellow to transparent.



Figure 1. *Tenorioconus monicae*, n. sp. Holotype

Type Material: HOLOTYPE- length 48.29 mm, LACM 3429 (Figure 3A). Other material studied includes a specimen from the same locality as the holotype, in the research collection of the senior author measuring 42.10 mm, two specimens from the same locality as the holotype, in the research collection of the junior author (shown here on Figure 3 as images B and C) measuring 52.23 and 60.82 mm respectively, as well as photographs of twenty three additional specimens from the same

locality as the holotype in the collection of Leo G. Ros.

Type Locality: Found in 6 m depth, exposed on coarse carbonate sand beneath a filamentous green algal mat, off Malmok, Aruba, Netherlands Antilles.

Range: The new species is endemic to the island of Aruba, Netherlands Antilles.

Ecology: *Tenorioconus monicae* prefers coarse carbonate sediment sea floors, beneath filamentous green algae near Turtle Grass (*Thalassia testudinum*) beds, in depths of 5-10 m (see Figure 7). Here, the new species feeds on amphinomid polychaete sea worms and is one of the dominant vermivores of the Turtle Grass beds and adjacent areas.

Etymology: The taxon honors Monica Moron from Punto Fijo, Venezuela, and Aruba, who is an avid amateur naturalist and one of the co-discoverers of the new species.

Discussion: With its stocky, heavy, and broad-shouldered shell and internal columellar constriction, *Tenorioconus monicae* can be seen to be a member of the *T. mappa* species complex. Of the species within this group that are found along the southern section of the Grenadian Subprovince, *T. monicae* most closely resembles *T. sanguineus* (Kiener, 1850) (Figure 5E, F) from the Venezuelan coastline (Puerto la Cruz, Anzoategui State to Cumana and the Cumana Peninsula, the Golfo de Cariaco, to Isla Margarita, Isla Cubagua, and Isla Coche, Nueva Esparta State). The new species differs from its Venezuelan congener in being a stockier, broader, and heavier shell with a much wider shoulder, in having a much more rounded and less angled shoulder (as opposed to the sharply-angled shoulder of the thinner and narrower *T. sanguineus*), and in having broader

and more distinctly pyramidal spire whorls with noticeably sloping subsutural areas. *Tenorioconus sanguineus* also lacks the distinctive pale lavender or purple shell base color and lavender aperture interior that characterize *T. monicae*, having, instead, a white or pale yellow-white base color and white apertural interior.

In having a proportionally broad, stocky shell, the new Aruban species is also similar to *Tenorioconus caracanus* (Hwass, 1792) (Figure 5J, K) from Margarita Island, Nueva Esparta State, Venezuela and the Isla La Tortuga group off the Venezuelan coast. *T. monicae* differs from *T. caracanus* in being a more slender species with a more elongated shell profile, in having a proportionally higher, more protracted spire, and in being a more colorful shell, with larger and more numerous amorphous flammules and color patches. Like *T. sanguineus*, *T. caracanus* also lacks the pale purple or lavender base color of the body whorl and lavender aperture color of *T. monicae*, having, instead, a white aperture and white shell base color. In having densely-packed rows of dark brown and white dots and a high, pyramidal spire, *T. monicae* is also similar to *T. granarius* (Kiener, 1847) (Figure 5C, D), a wide-ranging southern Caribbean (Venezuelan Subprovince) species that ranges from the Golfo de Uraba, Panama-Colombia border, to the Golfo de Venezuela and Golfo Triste, Venezuela. The new Aruban species differs from its wide-ranging congener in having a stockier, broader shell with distinctly more convex sides, and in having a broader, more pyramidal spire. Some specimens of *T. granarius* have a pale purple or lavender shell base color similar to that of *T. monicae* (the form or subspecies *sanctaemarthae* Vink, 1977 from Colombia), but these specimens never exhibit the dense reddish flammulate color patterns seen on the new Aruban endemic.

***Tenorioconus rosi* Petuch and Berschauer,
new species
(Figures 2, 4A-G; 6D; 7)**

Description: Shell small for genus, averaging only around 21 mm in length, elongated, with very high, protracted spire and almost biconic appearance, and with slightly convex sides; shoulder distinctly angled, ornamented with 15-20 large, elongated, evenly-spaced knobs; subsutural areas of spire whorls slightly sloping; spire scalariform, with distinctly stepped whorls, ornamented with 4-6 extremely fine spiral cords; body whorl shiny, ornamented with 18-24 large, prominent, raised spiral cords; spiral cords, in turn, ornamented with proportionally-large, evenly-spaced, rounded beads, giving shell rough-textured appearance; spiral cords and beaded sculpture become larger on anterior one-third of body whorl; shell color white or pale bluish-white, overlaid with proportionally very large, widely-spaced longitudinal flammules, arranged in a zebra-like pattern; longitudinal flammules, which extend from shoulder to anterior tip, vary in color from dark reddish-brown, to dark brown, to black, with most specimens having dark chestnut-brown markings; white base color and dark brown zebra flammules overlaid with 15-20 evenly-spaced rows of tiny dark brown and white spots, which correspond to raised spiral cords; spire white, sparsely marked with very few widely-spaced dark brown flammules; early whorls dark orange-tan, turning to white on later whorls of teleoconch; aperture narrow and straight, white on interior, often with external brown flammules showing through within the interior; protoconch proportionally very large, bulbous, mammillate, composed of one and one-half whorls, colored dark orange-brown (Figure 6D); periostracum thin, smooth, pale yellow to transparent.

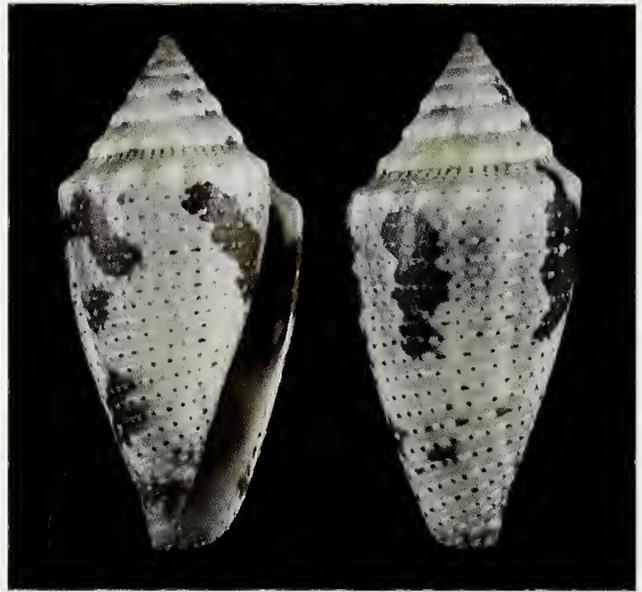


Figure 2. *Tenorioconus rosi* n. sp. Holotype

Type Material: HOLOTYPE- length 22.40 mm, LACM 3430 (Figure 4G). Other material studied includes five specimens from the same locality as the holotype, in the research collection of the senior author measuring 13.87, 14.78, 14.84, 15.06 and 16.88 mm respectively, and eight specimens from the same locality as the holotype, in the research collection of the junior author measuring 13.50, 14.45, 14.65, 15.07, 15.55, 17.76, 18.08, and 21.88 mm respectively (six of which are shown here on Figure 4 as images A through F), as well as photographs of fifteen additional specimens from the same locality as the holotype in the collection of Leo G. Ros.

Type Locality: Found in 6 m depth, exposed on carbonate sediments beneath a filamentous green algal mat, off Malmok, Aruba, Netherlands Antilles.

Range: The new species is endemic to the island of Aruba, Netherlands Antilles.

Ecology: *Tenorioconus rosi* prefers coarse carbonate sediment sea floors, beneath filamentous green algae near Turtle Grass

(*Thalassia testudinum*), in depths of 5-10 m (see Figure 7). Here, the new species feeds on very small amphinomid polychaete sea worms and probably avoids competition with the two larger vermivorous congeners, *T. monicae* and *T. curassaviensis*, by having specialized in feeding on smaller prey.

Etymology: Named for Leo G. Ros, of Noord, Aruba and Scheveningen, Netherlands, an avid naturalist and molluscan explorer who discovered the new species and, through his extensive diving and exploration around the island, has greatly contributed to our knowledge of the Aruban molluscan fauna.

Discussion: This unusual new endemic species represents the smallest-known member of the genus *Tenorioconus*. Because of its slender and elongated shell shape and lack of an internal constriction on the anterior area of the columella, *T. rosi* can be seen to belong to the *T. aurantius* species complex. Of the known members of this group, *T. rosi* is morphologically closest to *T. curassaviensis* (Hwass, 1792) (Figure 5G, H, I), also endemic to Aruba, and shares the same type of shell outline, with slightly convex sides. The new species differs from its co-endemic congener, however, in being consistently a much smaller shell, in having a proportionally narrower, higher, and more stepped spire, in its large bulbous protoconch, in having a rougher-textured shell, ornamented with strong, beaded spiral cords, and in being a drabber, less-colorful shell, with only widely separated dark brown longitudinal zebra flammules on a white background (as opposed to the intense reds, oranges, and purples seen on *T. curassaviensis*). *Tenorioconus rosi* is also similar to *T. aurantius* from Curacao and Bonaire (Figure 5L, M, N), but, again, differs in being a consistently much smaller shell, by having a stockier and less-

slender shell with distinctly more convex sides, in being a rougher-textured shell, being ornamented with coarse spiral cords and beads, in having a proportionally higher spire, and in being a drabber, less-colorful shell, with only brown or black longitudinal zebra flammules on a white base color.

Tenorioconus rosi has been known to exist in the Malmok area for several decades now, and it is undoubtedly the shell that previously had been misidentified, by several authors, as the “Aruban *aurantius*”. Stating that “...Aruba specimens appeared to be smaller...”, Seamon and Seamon (1967: 8) recognized the presence of this distinctive cone on Aruba but referred to it as “*aurantius*”. A single dead specimen of *T. rosi* was found by the junior author in July 2013 while diving at Malmok with Leo G. Ros, and initially identified as *T. aurantius* at the time. (Berschauer and Ros, 2013) Of the three known members of the *T. aurantius* species complex found on the islands of Aruba, Curacao, and Bonaire, the new species is the least variable in coloration, having large flammules that are consistently a dark reddish-brown, dark brown, or black color.

ACKNOWLEDGMENTS

Special thanks to Leo G. Ros and Monica Moron who performed the field work, discovered these new cone species, brought them to the attention of the authors, and supplied the holotypes and study specimens. Thanks to Manuel J. Tenorio and Carlos Afonso for the radular study and radula image of *T. monicae* as Figure 8. We also thank Paul Kersten and Alexander Medvedev for allowing the use of their images of *T. caracanus* (Hwass, 1792), and Rick Negus for the loan of a number of his *Tenorioconus* species specimens to photograph for use in the comparison figure.

TABLE 1. List of Valid *Tenorioconus* Species Arranged by Biogeography

CARIBBEAN PROVINCE

NICARAGUAN SUBPROVINCE

Bay Islands; Coastal Honduras and Nicaragua; Corn Island

Tenorioconus harlandi (Petuch, 1987)

Tenorioconus juliandreae (Cargile, 1995)

San Blas Islands

Tenorioconus panamicus (Petuch, 1990)

VENEZUELAN SUBPROVINCE

Colombia, Gulf of Venezuela, Golfo Triste

Tenorioconus granarius (Kiener, 1847)

Coastal Venezuela, Isla Margarita, Isla Coche, Isla Cubagua

Tenorioconus sanguineus (Kiener, 1850)

Tenorioconus caracanus (Hwass, 1792)

Tenorioconus trinitarius (Hwass, 1792)

GRENADIAN SUBPROVINCE

Aruba

Tenorioconus curassaviensis (Hwass, 1792)

Tenorioconus monicae Petuch and Berschauer n. sp.

Tenorioconus rosi Petuch and Berschauer n. sp.

Curacao and Bonaire

Tenorioconus aurantius (Hwass, 1792)

Los Roques Atoll, Islas Los Testigos, Islas Las Aves

Tenorioconus duffyi (Petuch, 1992)

Trinidad and Tobago, Barbados

Tenorioconus mappa (Lightfoot, 1786)

Grenada, Grenadines

Tenorioconus pseudoaurantius (Vink and von Cosel, 1985)

Tenorioconus dominicanus (Hwass, 1792)

St. Vincent

Tenorioconus cedonulli (Linnaeus, 1767)

St. Lucia, Martinique

Tenorioconus insularis (Gmelin, 1791)

PANAMIC PROVINCE

Tenorioconus archon (Broderip, 1833)

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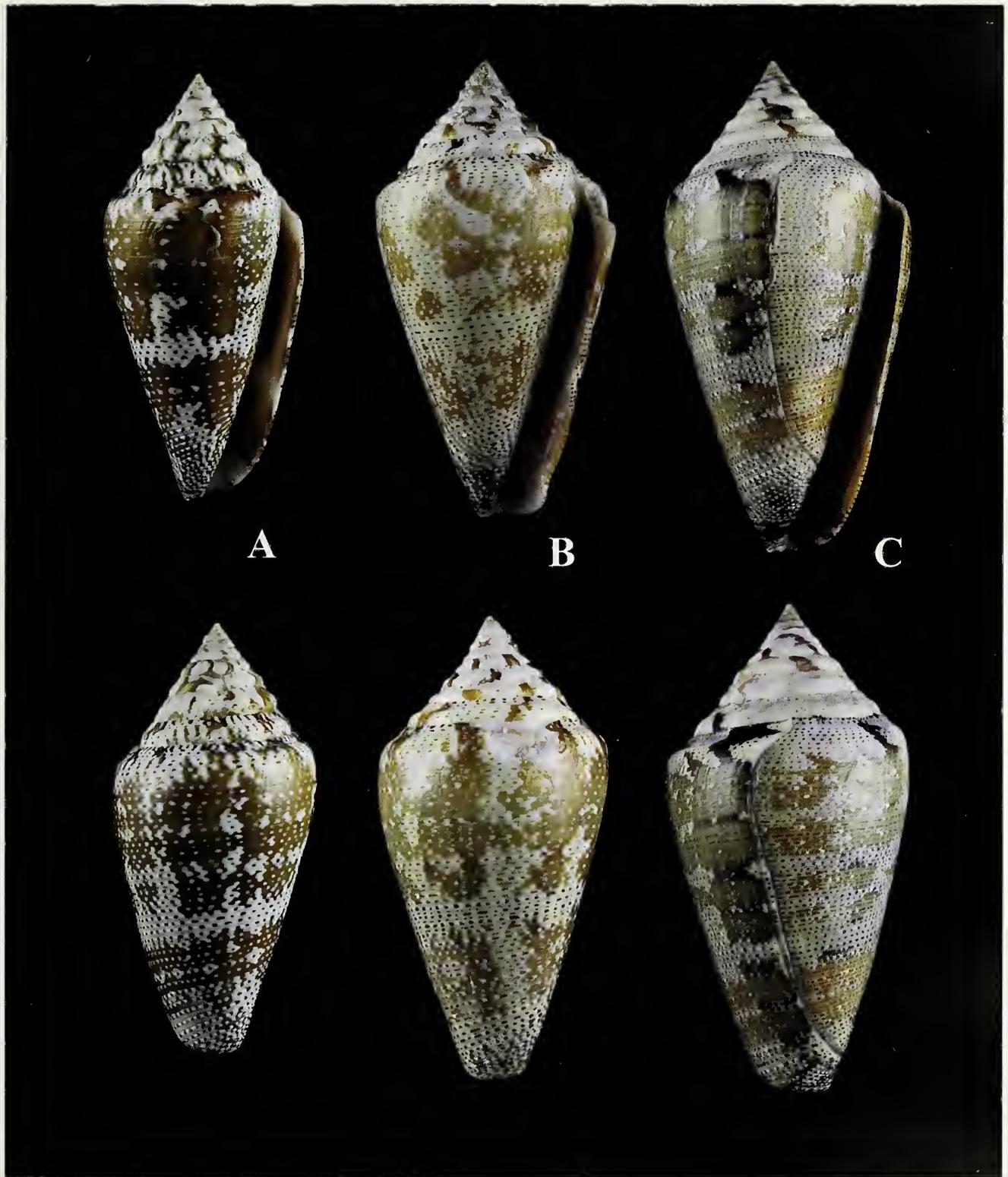


Figure 3: *Tenorioconus monicae* n. sp., A= Holotype (LACM 3429) length 48.23mm; B, C = other material studied, length 52.23 and 60.82 mm respectively, Berschauer Collection.

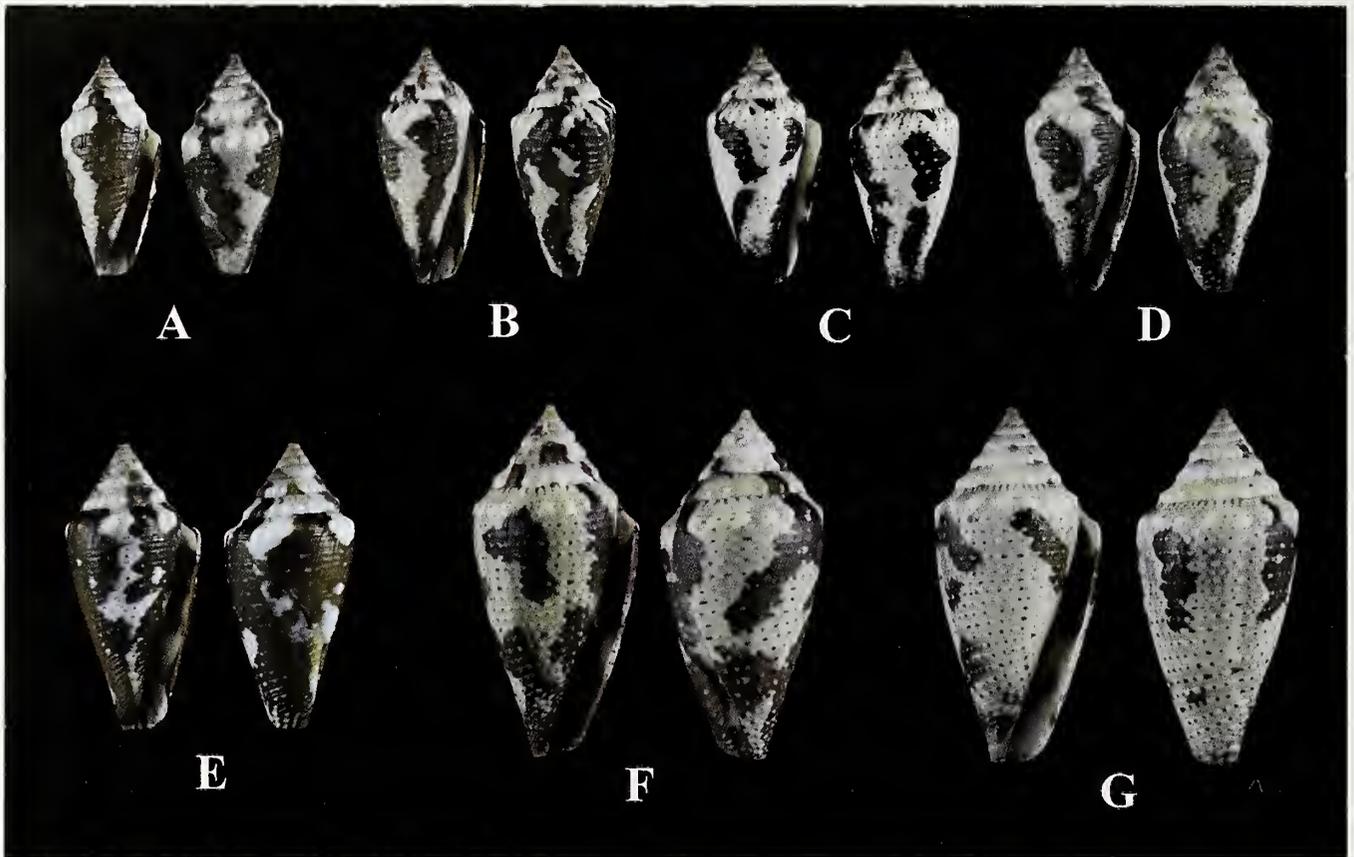


Figure 4: *Tenorioconus rosi* n. sp., G = Holotype (LACM 3430) length 22.40 mm; A-F = other material studied, length 13.50, 14.45, 15.07, 15.55, 17.76, and 21.88 mm respectively, Berschauer Collection. Note the distinctive proportionally-large bulbous protoconch.



Figure 7: Image of live specimens of *Tenorioconus monicae* and *T. rosi* *in situ*, removed from under the filamentous green algae and placed immediately adjacent to their natural habitat. (photo courtesy of Leo G. Ros, taken with a Canon GoPro).

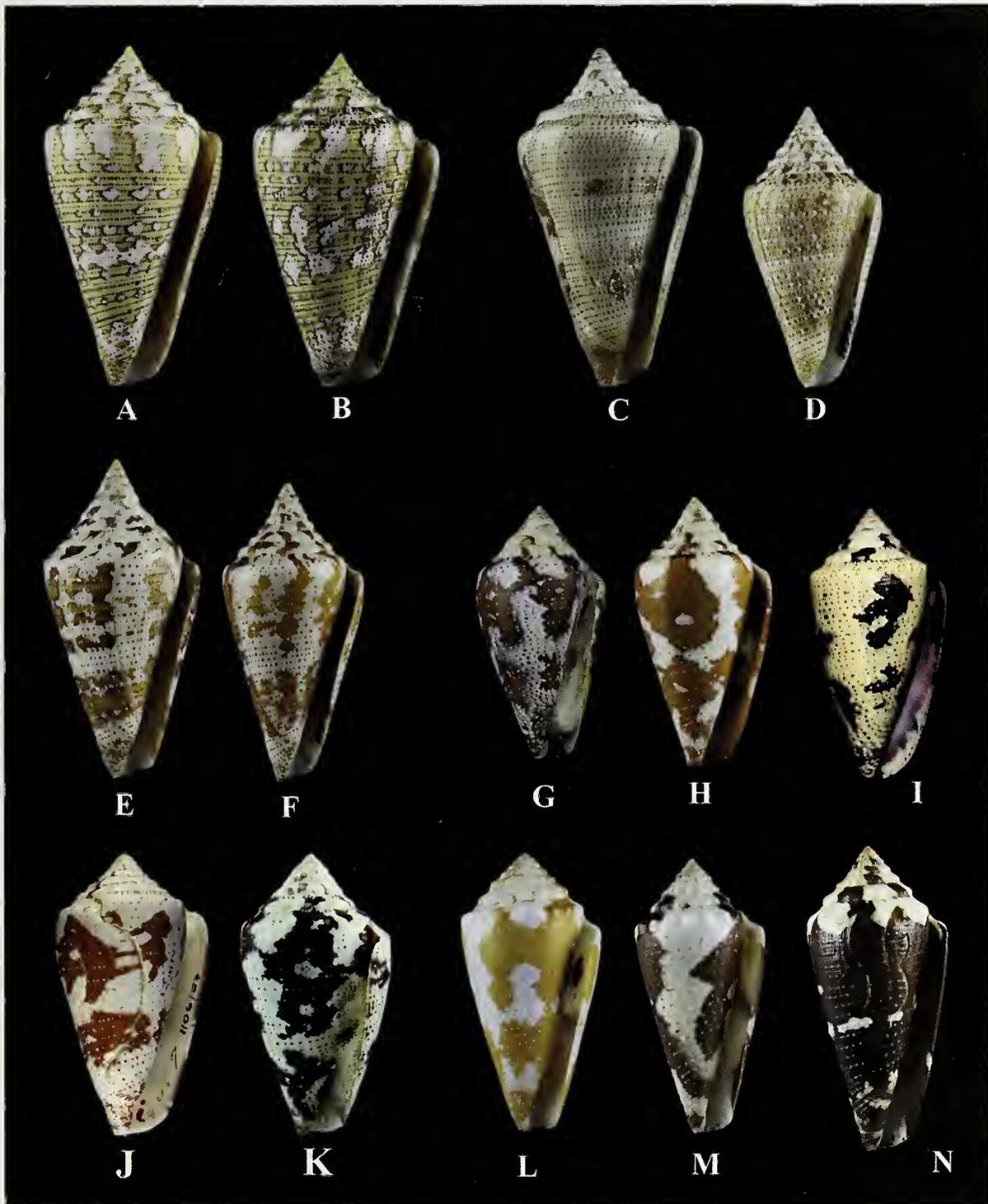


Figure 5: Various related *Tenorioconus* species. **A, B** = *T. mappa* (Lightfoot, 1786) 57.40 and 56.69 mm from Tobago; **C, D** = *T. granarius* (Kiener, 1847) 56.49 mm (*sanctaemarthae* form, from the Gulf of Colombia; from the Rick Negus Collection) and 44.41 mm from Colombia; **E, F** = *T. sanguineus* (Kiener, 1847) 47.60 and 38.58 mm from Colombia (from the Rick Negus Collection); **G, H, I** = *T. curassaviensis* (Hwass, 1792) 38.65 mm, 40.69 mm (from the Rick Negus Collection), and 39.20 mm (from the Petuch Collection) from Malmok, Aruba; **J, K** = *T. caracanus* (Hwass, 1792) Holotype 47 mm from off Caracas, Venezuela (photo courtesy of Paul Kersten), and 34.4mm from coastal Venezuela (photo courtesy of Alexander Medvedev); **L, M, N** = *T. aurantius* (Hwass, 1792) 46.55 mm from Bonaire, 43.33 mm from Curacao, and 52.80 mm from Curacao (from the Rick Negus Collection).

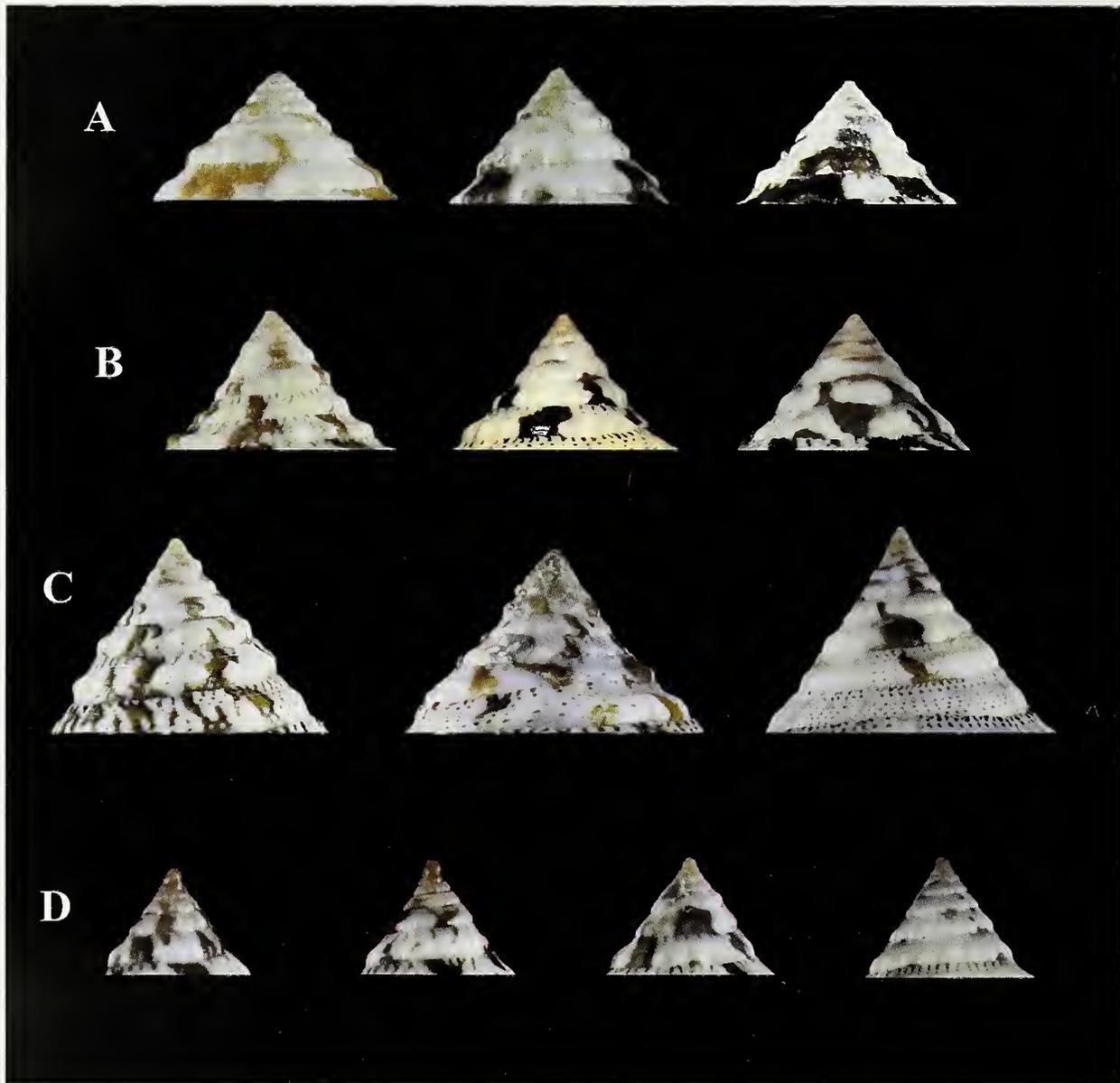


Figure 6: Spire images. **A** = *T. aurantius*; **B** = *T. curassaviensis*; **C** = *T. monicae*; **D** = *T. rosi*.

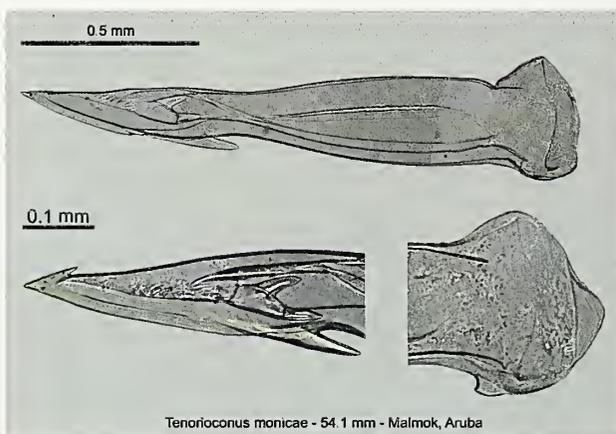


Figure 8: Radular study of a specimen of *Tenorioconus monicae* from Carlos Afonso collection, taken in Malmok, Aruba (shell length 54.1 mm). Radula has 22 teeth in radular sac. Radular tooth of medium relative size (Shell length/tooth length = 43), with the typical features corresponding an specialised amphinomid polychaete eater (as other members of genus *Tenorioconus*): radular tooth broad and stout; anterior portion shorter than posterior portion; small apical barb opposing to a strong, sharply pointed blade covering most of the anterior portion of the tooth; 8 denticles in serration arranged in one row becoming two rows; penultimate serration enlarged and internal; large pointed terminating cusp; small lateral basal cusp present. The different radular morphology along with the presence of the columellar restriction in *T. monicae* (characteristic of the *T. mappa* complex) is consistent with the hypothesis of a distinct species. (Radular study and image courtesy of Manuel J. Tenorio)



Have a shell collection you would like to sell?

The San Diego Shell Club is interested in high quality estate collections comprised of any and all types of shells, marine or land, and all genera and species. Your shells will be used to generate income to support the Club's efforts in continuing public education about shells and conservation of marine life throughout the world. If you have considered selling your collection to a dealer and were unhappy with the offer, then please contact Dave Waller, SDSC Acquisition Chairperson, at dwaller@dbwipmg.com to schedule a time to review your collection and provide you with another offer to consider.

CLUB NEWS

May 2015, Regular Meeting, held at the Holiday Inn Express

Meeting called to order at 12:00 noon

- Prior minutes were accepted as read.
- Treasurer's report was presented, followed by social media and the Editor's report.
- Dr. Andrew Nosal was introduced as the speaker and delivered a fascinating program on the Leopard Shark colony off La Jolla.
- Pizza and drinks were provided for those in attendance.
- Shells and shell books were available for a silent auction.
- Plans for the Club's exhibit at the San Diego County Fair were discussed.
- There was no door prize.

Meeting adjourned at 2:10 p.m.

June 2015, Shell Bazaar, held at Larry Buck's home

- Members got together at the Bucks home to enjoy a relaxing day with excellent weather.
- Pizza, snacks and drinks were provided for the event.
- Some wonderful shells were displayed, viewed, discussed, sold and traded.
- There was some light discussion about the Club's display at the San Diego County Fair, its success and exhibits at future Fairs.

Carol Skoglund and *Gradiconus skoglundae*

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I noted Carole Hertz's nice tribute to Carol Skoglund (Festivus 47(1):74-79). Here I want to add details on a species of *Gradiconus* (Conidae) that was named for Carol. In this book Tenorio, Tucker & Chaney also honored three other researchers that had major influences on malacology of the eastern Pacific. Images of the holotypes for these three species are presented here in Figure 1, images 1 through 4. Four new species of cone shells described by Tenorio et al., 2012 (A Conchological Iconography The Families Conilithidae and Conidae The Cones of the Eastern Pacific, ConchBooks, Hackenheim, Germany, 112 pp., pls. 225-312) honored prominent researchers that worked with east Pacific cone shells. These images were also used in Tucker and Tenorio (2013), Illustrated Catalog of the Living Cone Shells, MDM Publishing, Wellington, Florida, iv + 517 pp. All images were made by J. K. Tucker and composed by M. J. Tenorio

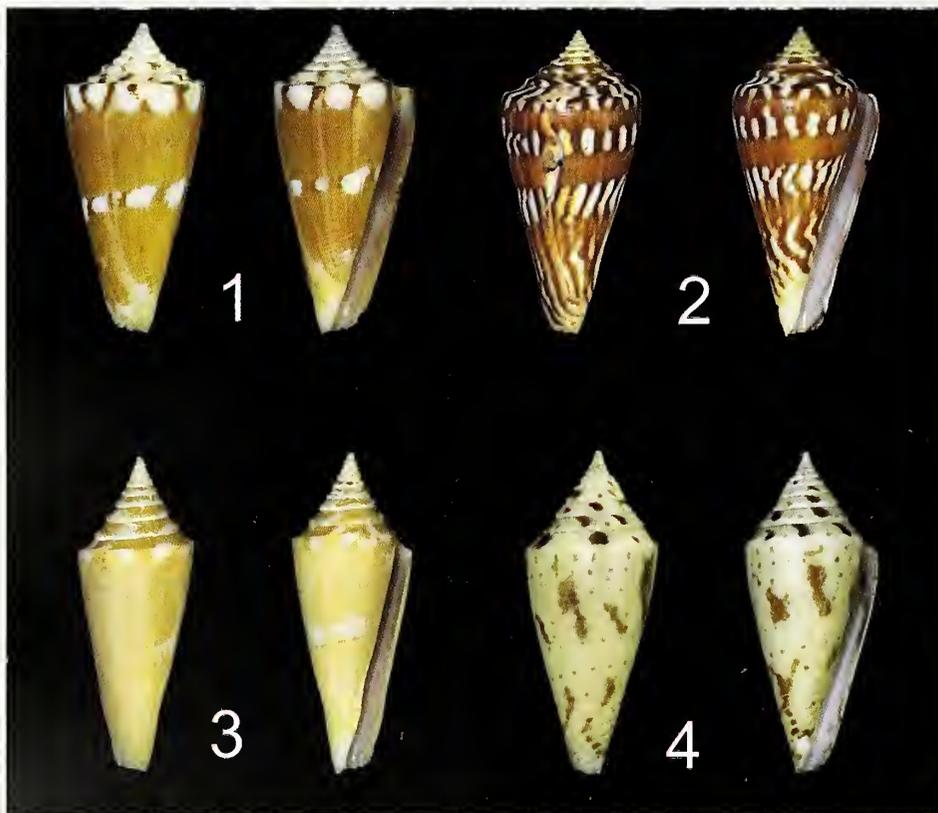


Figure 1: Images 1. *Dauciconus kaiserae* Tenorio, Tucker & Chaney, 2012, holotype SBMNH 98005, 21 mm shell length, type locality is northeast of Isla Manuelita, Isla del Coco, Costa Rica, 05°33'44"N, 087°02'49"W, collected in 110 m water depth on a gravel and sand bottom. The species was named for Kirstie L. Kaiser, who actively studied the mollusks of the oceanic islands of the tropical eastern Pacific. The sample included the holotype and 10 paratypes.

2. *Dauciconus shaskyi* Tenorio, Tucker & Chaney, 2012, holotype SBMNH 98001, 34.8 mm shell length, type locality is northeast of Isla Manuelita, Isla del Coco, Costa Rica, 05°33'44"N, 087°02'49"W, collected at 120 m water depth on a fine coral rubble bottom. The species was named for Dr. Donald Robert Shasky, MD, who focused on mollusks from Isla del Coco and who recognized that this was an undescribed species. The sample included the holotype and 7 paratypes.

3. *Gradiconus nybakkeni* Tenorio, Tucker & Chaney, 2012, holotype SBMNH 424123, 26.4 mm shell length, type locality is Bahia Los Frailes, Baja California Sur, Mexico, 23°22'N, 109°24'W, collected at 47 to 60 m water depth. The species was named for Dr. James Willard Nybakken, Professor of Biology and a founder of the Moss Landing Marine Laboratories. The sample included the holotype and 29 paratypes. 4. *Gradiconus skoglundae* Tenorio, Tucker & Chaney, 2012, holotype SBMNH 92586, 24.9 mm shell length, type locality is Bahia Los Frailes, Baja California Sur, Mexico, 23°22'N, 109°24'W, collected at 45.7 to 60.4 m water depth. The species was named for Carol Skoglund a student of mollusks from the tropical eastern Pacific for over 50 years. The sample included the holotype and 14 paratypes.

“My Pet Cowrie” - *Macrocypraea cervus* Linnaeus, 1771

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One of my favorite shelling trips was in May, 2012. We had started annually returning to the Florida Keys for camping, shelling and some great photography. Sunshine Key RV resort is a favorite campground with plenty of wildlife and great access to the water. It's just after the seven mile bridge. Patiently awaiting the next low tide we set up camp. It's always exciting to shell the first low tide anywhere.

My brother decides to snorkel the high tide and returns with three beautiful *Macrocypraea cervus*. He was grinning ear to ear. I know the look so grab the cooler. I filled it with fresh seawater, added two-battery operated air pumps and presto instant aquarium. We also added some comfort items they were used to seeing. Daily you must change the water adding fresh seawater for them a chore to say the least.



Figure 1: *Macrocypraea cervus* in tank with mantle fully extended.

Gorgeous flowing mantel they wasted no time in displaying their beauty. I fell in love immediately. I knew I must take one home to study and learn what I could. One in particular became my new buddy. For some reason the research became more important than his shell. I thought to myself well I'll get it after when he dies from being not in his natural home. So I thought.

The journey home was easier than I thought. I carried enough extra water to do a water change mid-way home. Having a marine aquarium already at home with correct pH and salinity that matched the Keys I knew he would be ok once he got there. He survived! Wow, now I could enjoy and watch every move he made.

High energy creature his mantel engulfs his entire shell. The mantle keeps that beautiful shell shiny and free of flaws. Purplish molted with small peaks and valleys perfect camouflage. He has two eyes, much like a big snail does. He is nocturnal mostly, usually hiding under a ledge during the day. I noticed whenever I turned the lights on he would immediately start to move to a hidden place. He is an algae grazer but I have noticed him eagerly joining the hermits when I pinned small fish for them to devour. Very interesting I thought usually they graze on algae.



Figure 2: *Macrocypraea cervus* with shell partially exposed.

But they do have a radula which is a tongue like band in the mouth, set with rows of teeth. I am going to enjoy this guy I thought. Beautiful and graceful, he moves with ease over the bottom and surrounding mounds of reef rock. I had built a reef wall very close to the grow lights which are mounted above the pond like aquarium. He sometimes would graze partially out of the water over this mound. The lights damaged his shell. I was so mad. I wanted that shell. Now I knew he would be released to maybe breed again. I had formed a particular liking to this one.

Three years have passed and I decided it was time to release this enchanting tank inhabitant. I have learned so much from him I decided it was time before he incurred anymore damage. He had reached full maturity. It was time. On this last trip to the Keys, almost exactly three years to the date, I prepared to return him to where he was obtained so he could continue on and maybe reproduce. To return him much care was involved. Water change mid-way on our journey and again battery-operated air pumps. Messy to say the least but he was worth it. On arrival I waded to an area close to where he came from placed him in a very grassy area and away he went just as he had never left. I so enjoyed this creature, many beautiful photos and lots of hours of joy so releasing him felt right. I will never forget my pet Cowrie what an amazing creature.

Mission Bay Mysteries

Robyn Waayers
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Two shells that have proved difficult to identify have turned up at Mission Bay in the past few months.

One is a small orange scallop that I found on February 19, 2015 at Ski Beach on Vacation Isle. It is 17 mm wide, and was washed up along the high tide line. It stood out from the surroundings with its bright orange color. A variety of excellent ideas have been proposed regarding its determination, including that it might be non-native, or recently moved northward from a more southerly distribution. But there is still no consensus regarding what this little shell actually is.

Another shell that still defies concrete determination is a small gastropod, found June 5, 2015 in Mariner's Basin, which looks very much like a member of the genus *Pseudomelatomia*, but it is not a good match to *P. penicillata*, which has prominent axial tubercles. Maybe it is a variant of that species, though. It is 26 mm long and had a dark brown periostracum (removed in the photo).



Figure 1: *Pseudomelatomia* species



Figure 2: Unknown Pectinidae species

San Diego Shell Club at the Fair - Paul Tuskes

The San Diego Shell Club had an outstanding shell exhibit at the June/July San Diego County Fair this year, thanks to the suggestion of Dave Waller. The Club display was in the Gems and Mineral section and received a great deal of attention. The display cabinets and lighting were influenced by Larry Buck who worked hard to ensure it was ready for the Fair. Marty Schuler did the central art work and business cards for visitors to take away. Most Shell Club board members and Marty Schuler donated time at the display, to answer questions and encourage visitors to come to a meeting. The number of people who stopped to look at the shells and ask questions was amazing. I don't know how many thousands of people stopped to read the information and view the shells. David Waller and David Berschauer used two shelves to exhibit California abalone and present information on the State Marine Mollusk effort. Paul Tuskes put in a display on Mission Bay, and Rick Negus had three shelves of attractive shells from around the world. It was fun to answer questions about the display and the San Diego Shell Club. Visitor comments and their interest were rewarding.



José and Marcus Coltro

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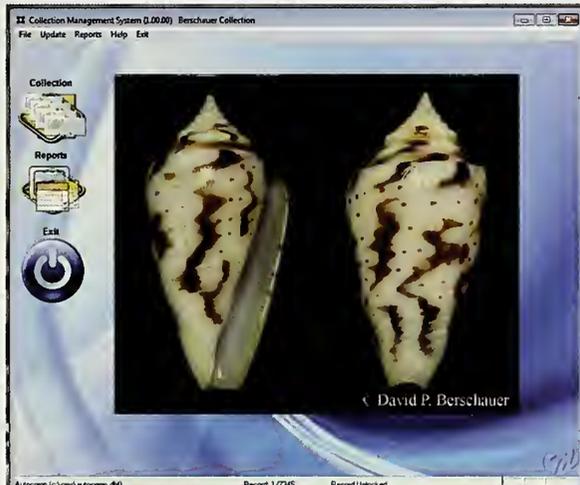
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- Umbilia hesitata portlandensis

rusty annulus.....

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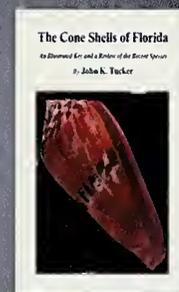
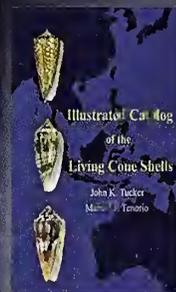
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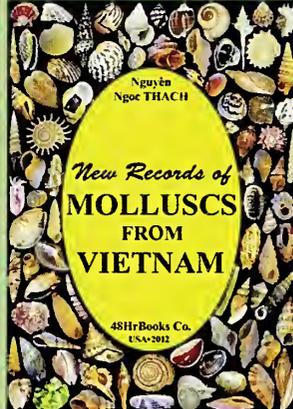


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BACK COVER: *Tenorioconus* poster. Top row = *Tenorioconus archon*, *T. cedonulli*, *T. mappa*, *T. granarius sanctaemarthae*; Second row = *T. dominicanus*, *T. panamicus*, *T. granarius*; Third row = *T. harlandi*, *T. sanguineus* (2 specimens), *T. monicae*; Fourth row = *T. aurantius* (3 color forms), *T. rosi* (2 specimens); Fifth row = *T. curassaviensis* (4 color forms), and cf. *T. aurantius* / *T. rosi*. (Photos courtesy of David P. Berschauer; artistic layout by Martin Schuler)



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Vol. 47(4)

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New Cones from Australia and Aruba

What are Species?

A New Land Snail from Vietnam

Cape Verde Abalone

***Jaspidiconus* - Expert Opinions**

Quarterly Publication of the San Diego Shell Club



THE FESTIVUS

A publication of the San Diego Shell Club

Volume: 47

November 2015

ISSUE 4

Editor Emerita Carole Hertz (1979–2014)

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REGULAR CLUB MEETINGS

Club meetings are held every month on the third Thursday of the month, except April, September and December, at either 7:30 p.m. in Room 104, Casa del Prado, Balboa Park, San Diego, or at 12:00 noon at Holiday Inn Express, 751 Raintree Drive, Carlsbad, conference room as noticed.

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FRONT COVER:

Live specimen of *Fasciolaria tulipa* (Linnaeus, 1758) on vermiform reef on Demijohn Key, Florida. Red form. Photo by David Berschauer. (Cover artistic credit: Martin Schuler)

MISSION STATEMENT

The San Diego Shell Club was founded in 1961 as a non-profit organization for educational and scientific purposes. More particularly to enjoy, promote the study and promote the conservation of Mollusca, and associated marine life through lectures, club meetings and field trips. Our membership is diverse and includes beginning collectors, amateurs and scientists, divers, underwater photographers and dealers.

THE FESTIVUS is the official quarterly publication of the San Diego Shell Club, Inc. and is issued as part of membership dues in February, May, August and November. *The Festivus* publishes articles that are peer reviewed by our volunteer Scientific Review Board (which are of a scientific nature, including new taxa articles), as well as articles of general interest to malacologists, conchologists, and shell collectors of every level. Members of the Peer Review Board are selected to review individual articles based upon their chosen field and preference. Available by request or on our website are:

- Guidelines for Authors
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UPCOMING CLUB EVENTS:

November Auction: 11/14/2015

Holiday Party: 12/12/2015

Publication date: November 6, 2015

TABLE OF CONTENTS

President's Corner	p. 217
Peer Reviewed Articles	
• Additions to the Cone Shell Faunas of Australia and Aruba (Conidae, Conilithidae)	p. 219
By Edward J. Petuch, David P. Berschauer, and André Poremski	
• What are Species? Or, on Asking the Wrong Question	p. 229
By Kirk Fitzhugh	
• Taxonomic Note - new species: <i>Typhinellus jacolombi</i> Houart, 2015	p. 239
• <i>Bertia setzeri</i> , a New Species of Land Snail from Vietnam (Gastropoda: Stylommatophora: Dyakiidae)	p. 240
By Nguyen Ngoc Thach	
• Iconography and Distribution of the Cape Verde Island Abalone, <i>Haliotis tuberculata fernandesi</i> Owen & Afonso, 2012, with Comparisons to <i>H. tuberculata coccinea</i> Reeve, 1846, of the Canary Islands	p. 243
By Buzz Owen, Peter Ryall, and Aaron D. Pan	
• <i>Jaspidiconus</i> : what are the options?	p. 250
By John K. Tucker	
Club News	p. 256
Articles of General Interest	
• Orchids in the Park	p. 257
By Paul Tuskes	
• Sunny September Party	p. 257
By David P. Berschauer	
• William Swainson F.R.S., F.L.S.	p. 258
By Mary Agnes Wotton	
• Shelling on the Gulf Coast of Florida (Part 1 of 2)	p. 262
By Robyn Waayers	



New Taxa published in *The Festivus* in 2015: Volumes 47(1) through 47(4)

Species and subspecies:

Carinapex albarnesi Wiedrick, 2015, *C. alisonkayae* Wiedrick, 2015, *C. amirowlandae* Wiedrick, 2015, *C. cernohorskyi* Wiedrick, 2015, *C. chaneyi* Wiedrick, 2015, *C. johnwiedricki* Wiedrick, 2015, *C. lindseygrovesi* Wiedrick, 2015, *C. mooreorum* Wiedrick, 2015, *C. philippiensis* Wiedrick, 2015, *C. solomonensis* Wiedrick, 2015; *Chicoreus (Triplex) cnissodus ceylonensis* Houart, 2015; *Dalliconus edpetuchi* Monnier, Limpalaër, Roux & Berschauer, 2015; *Vepicardium eichhorsti* Thach, 2015; *Erosaria acicularis marcuscoltroi* Petuch & Myers, 2015, *Morum berschaueri* Petuch & Myers, 2015; *Amphidromus taluensis* Gra-tes, 2015, *A. luangensis* Gra-tes, 2015, *A. taluensis borealis* Gra-tes, 2015; *Tenorioconus monicae* Petuch & Berschauer, 2015, *T. rosi* Petuch & Berschauer, 2015; *Tesselliconus devorsinei* Petuch, Berschauer & Poremski, 2015, *Jaspidiconus vantwoudti* Petuch, Berschauer & Poremski, 2015; and *Bertia setzeri* Thach, 2015.

President's Corner

Come on. Literally come. We're getting more shells out there – carrots to lure you in and sometimes pizza. May I suggest attending one of our two auctions held in April and November. If you come, I suggest scrutinizing our silent auction material and our one and five dollar tables whichever we set out. Stuff can get miscategorized as in OMG! Would you look at this?!!



This year the Club will be placing more emphasis on Field Trips. So please plan on participating in one of these fun adventures.

And finally, passing the gavel to David Berschauer; there will be more time for me for other things, like field trips, *etc.* A special thanks to all of you for your kind words of support over the last two years. – Woosh! It's gone by that fast. Now onwards and forwards for 2016 – cheers.

Larry Buck

Changing of the Guard

by David B. Waller

I'm going to miss that smiling face in the President's Corner.

The time has come for a changing of the guard. David Berschauer, Co-Editor of *The Festivus*, will be taking the position of President for 2016 and with the current slate of Officers it promises to be another fantastic year for our club.

But before we move Larry into the Past President's position, I would like to give a brief overview of the accomplishments of the San Diego Shell Club over the past two years under the competent leadership of Mr. Buck. In Larry's first address to the membership in *The Festivus* he set out a very aggressive plan to revitalize our Club whose membership was dwindling so much that we, as the Board, were uncertain of our Club's future. Larry's primary goal was to increase membership. With this in mind he envisioned an entirely new *Festivus* that would appeal to the broad spectrum of individuals that comprise our membership. He proposed a stronger presence on social media, particularly Facebook, that would appeal to a broader age group. He suggested a new Club website to provide more information to our viewers, proposed special Club publications, increased public interaction through increased Club activities and even took steps to strengthen our club. Sounds like a lot of blah-blah, but let's take a look at the results.

1. **The New *Festivus*:** Our worldwide membership has grown significantly primarily because our members want our new journal. We have seen a steady increase in membership over the past two years more than doubling the membership from when Larry took office. We are now selling the *Festivus* through two dealers in Europe which is generating an additional revenue stream for our Club.

2. **Facebook:** Our social media presence started when Larry took office and our viewing membership now exceeds 500. This has proven to be a valuable vehicle for introducing new members to our Club. To date we have received over 35 new members from Facebook alone and those memberships have come from all over the United States.

3. **New Website:** Our new website has become a site where members can ask questions about shells, order copies of the *Festivus*, purchase supplements and renew membership or become members. The website is generating about 20 to 25 e-mails a month. With our new PayPal option for paying on-line our accounting has become significantly easier.

4. **New Publications:** Our Club has now produced two publications one on Australian abalone and one on living and fossil whelks. The Australian abalone publication recovered its publication costs in just a few months and has begun to generate income for the club. The second publication is expected to issue in mid-November and has almost paid for its publications cost before reaching the newsstands. This second publication is expected to be a great success.

5. **Increased Public Interaction:** Our Club now holds two auctions per year generating a significant income for the Club. The Club has instituted the Shell Show and Sale in Balboa Park, reestablished our relationship with the Del Mar Fair, who at the end of the 2015 fair formally asked us back to exhibit in 2016, conducted two art contests on shells, reinstated the Shell Bazaar and is conducting the Most Beautiful Shell Contest on our Facebook page. All of these activities have contributed to public awareness of our Club.

6. **Strengthened our Club:** Our Club now has insurance to protect its assets. In addition, we now have an annual budget and have instituted a formal accounting of the Club's income for tax purposes. In 2015, the Club officially operated in the black and it does not appear that this will change in the near future.

7. **Other stuff:** Well how about hosting the 2018 Conchologists of America Conference in San Diego an event that will bring about 200 shell collectors to sunny San Diego. How about establishing alternating meeting sites so that members living south of San Diego and those living north of San Diego (including Orange and Los Angeles Counties) can both enjoy our meetings.

So did Larry do his job? Absolutely! All of these things have increased our membership over 70% in two years. A number that is amazing considering most clubs, big and small, are on the decline. It is also important to note that the Club's bank account currently has the same balance as it did when Larry took office.

Congratulations Larry you deserve a standing ovation.

Additions to the Cone Shell Faunas of Australia and Aruba (Conidae, Conilithidae)

Edward J. Petuch¹, David P. Berschauer², and André Poremski³

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ABSTRACT Two new cone shells, one in the family Conidae and one in the family Conilithidae, are described from eastern Australia and Aruba. The new conid, *Tesselliconus devorsinei* n. sp., was dredged from 30 m depth off southern Queensland, Australia, and represents the newest member of a poorly-known deeper Neritic Zone *Tesselliconus* species complex that includes *T. sandwichensis* and *T. athenae* from Hawaii, *T. kashiwajimensis* from southern Japan, and *T. edaphus* from the Panamic Province. The new conilithid, *Jaspidiconus vantwoudti* n. sp., was found to be endemic to the Dutch Antilles island of Aruba, where it occurs in shallow subtidal rocky areas in the surf and surge zone.

KEY WORDS

Cone shells, Conidae, Conilithidae, *Tesselliconus*, *Jaspidiconus*, Queensland, Australia, Aruba, *Tesselliconus devorsinei*, *Jaspidiconus vantwoudti*.

INTRODUCTION

The peripheral edges of marine molluscan provinces and subprovinces have long been known to be areas where speciation has accelerated due to genetic isolation and exposure to marginal environmental conditions (Briggs, 1974, 1995; Petuch, 1982; Petuch, 2013; Valentine, 1973; Vermeij, 1978). Due to restricted gene flow and differences in ecological conditions, these peripheral areas typically produce large numbers of endemic species, often unique to single islands or small geographical areas. Two classic examples of the peripheral areas of provinces and subprovinces include the extreme southernmost coast of Queensland, Australia and the island of Aruba in the southern Caribbean Sea. The deeper water

areas offshore of Cape Moreton and Moreton Island, Queensland are known to house a large number of endemic marine gastropods, particularly in the families Volutidae and Conidae. Due to cooler water conditions produced by upwellings, this geographically-small area represents the extreme southernmost edge of the Solanderian Province of the Australian Region and contains oceanographic conditions that are barely marginal for most of its tropical faunal components. Similarly, Aruba represents the westernmost edge of the Grenadian Subprovince of the Caribbean Province and is subject to upwelling-driven cooler water conditions. Like the Cape Moreton area, the coastline of Aruba is known to contain numerous examples of large endemic gastropods.

Intensive field work, incorporating both diving and dredging, has recently been undertaken by several inspired amateur naturalists in the peripheral areas of both southern Queensland and Aruba. These efforts have led to the discovery of two new endemic cone shells, both of which represent peripheral isolate sibling species that belong to wide-ranging species complexes. These cone shells, including a new Australian species in the genus *Tesselliconus* (family Conidae) and a new Aruban species in the genus *Jaspidiconus* (family Conilithidae), are described in the following sections. Their discovery demonstrates the importance of biogeographical peripheral areas as centers of speciation and evolution in the world's oceans.

SYSTEMATICS

Class Gastropoda

Subclass Orthogastropoda

Superorder Caenogastropoda

Order Sorbeoconcha

Infraorder Neogastropoda

Superfamily Conoidea

Family Conidae

Subfamily Puncticulinae

Genus *Tesselliconus* da Motta, 1991

Tesselliconus devorsinei Petuch, Berschauer, and Poremski, new species (Figure 1A-C)

Description: Shell of average size for genus, stocky, subturbinate, broad across shoulder; shell with distinctly concave sides, with widest area just below shoulder angle; shoulder angled but slightly rounded; spire elevated, with early whorls raised above plane of spire; early whorls broadly pyramidal in shape, distinctly truncated, heavily ornamented with strong spiral cords and small low rounded beads; spire whorls ornamented with 3 large spiral cords, with cord

along suture being twice as thick as other two cords; body whorl shiny, ornamented with 22-24 incised spiral grooves which become stronger and better developed toward anterior end; spiral grooves vary in development, with some specimens having heavily-sculptured shells and others being smoother and more polished; anterior third of body whorl heavily sculptured with numerous deeply-incised spiral sulci, often arranged in pairs; largest and most deeply-incised sulci contain fine, closely-packed tiny pits; shell color white or pale violet-white, overlaid with 3 wide bands of pale orange-tan, one around shoulder, one posterior of mid-body line, and one anterior of mid-body line; wide color bands with variable number of rows of large, rectangular orange-tan spots; mid-body area with wide white band containing two rows of widely-spaced, large, rectangular orange spots; anterior tip bright violet-purple; spire white, marked with large, evenly-spaced, elongated dark orange-tan flammules; spire flammules extend onto edge of shoulder, producing checkered pattern; spire flammules of body whorl and previous whorls fuse to form distinct radiating pattern; aperture proportionally narrow, arcuate, following curvature of body whorl outline; interior of aperture colored pale yellow-cream; protoconch white, proportionally large, mammilate, composed of two rounded whorls; periostracum thin, smooth, translucent.

Type Material: HOLOTYPE - length 29 mm, width 17 mm (Figure 1A, B), QM M080845, molluscan collection of the Biodiversity Section, Queensland Museum, Brisbane, Queensland, Australia. Other material includes a 30 mm specimen (David Berschauer collection, Figure 1C, D), a 34 mm specimen (E.J. Petuch collection), and a 37 mm specimen (Remy Devorsine collection), all from the same locality and depth as the holotype.

Type Locality: Dredged from 15 fathoms (27.5 m) depth, due east of Mooloolaba, Queensland State, Australia.

Range: At present, known only from the southern coast of Queensland, off Mooloolaba, but may range to Cape Moreton and Moreton Bay and possibly extreme northernmost New South Wales.

Ecology: The new species occurs within the Neritic Zone, on coral rubble and carbonate sand substrates, in depths of around 30 m.

Etymology: Named for Remy Devorsine of Avoca Beach, New South Wales, Australia, who dredged the new species from off Mooloolaba.

Discussion: Of the seven known species in the genus *Tesselliconus*, *T. devorsinei* is most similar to the eastern Indian Ocean - southwestern Pacific *T. suturatus* (Reeve, 1844) (Figure 2A, B), particularly in having a stocky, barrel-shaped shell profile. The new Australian species differs from its widespread congener, however, in being a much more sculptured shell, with numerous deeply-incised spiral cords and threads, in being a much more colorful shell, having rows of orange-tan checkers and rectangular dots on a pale violet base color, and in having a completely different sculpture pattern on the spire whorls, with three large spiral cords and numerous strong coronations and rounded beads and in having a distinctive raised, truncated pyramid shape to the early whorls (Figures 1B, D). The early whorls of *T. suturatus*, on the other hand, are much smoother, having only two large raised spiral cords and are only slightly exerted, forming a small acutely-angled pyramidal structure that is devoid of coronations.

With its checkered color pattern, *T. devorsinei* is also similar to *T. tessulatus* (Born, 1778) (type of the genus; Figure 2C), but differs in being a stockier, less elongated, and more inflated shell, and in being a more heavily sculptured shell, with incised spiral sulci on the body whorl and in having a truncated pyramidal spire that is ornamented with large spiral cords and rounded coronations. The highly ornate spire whorls of the new species are also reminiscent of another deep water *Tesselliconus* species, *T. athenae* (Filmer, 2011) from 105 fathoms (192 m) depth off Keehi Lagoon, Oahu, Hawaii (Figure 2D). *Tesselliconus devorsinei* differs from this deep water Hawaiian endemic in having a lower, less elevated spire, and in having a distinct truncated pyramid shape to the early spire whorls. The new species is also similar in appearance to another Hawaiian endemic *Tesselliconus*, *T. sandwichensis* (Walls, 1978) (Figures 2E, F), but differs in having a stockier, less elongated shell, in having deeply-incised spiral cords on the body whorl, and in having a different spire whorl configuration, with a truncated pyramid shape and heavy sculpture composed of large spiral cords and low knobs and coronations.

With the exception of the widespread, shallow water *Tesselliconus suturatus* and *T. tessulatus*, all the other known congeneric species are found in deeper, offshore areas along the outer edges of the biogeographical limits of the genus. These peripheral endemic species may represent disparate populations of *Tesselliconus* which became isolated on the fringes of the Indo - Pacific Region during the Pleistocene. Since that time, these peripheral isolates have evolved into a complex of sibling species, with each being restricted to a limited geographical area. This peripheral isolate sibling species complex includes:

- *Tesselliconus athenae* (Filmer, 2011) - endemic to deep water areas off Oahu, Hawaii
- *Tesselliconus devorsinei* Petuch, Berschauer, and Poremski, n. sp. - endemic to deeper water off southernmost Queensland, Australia
- *Tesselliconus edaphus* (Dall, 1910) - restricted to the Panamic Province, from the Gulf of California to Panama and Cocos Island
- *Tesselliconus kashiwajimensis* (Shikama, 1971) - restricted to southern Japan, the Ryukyu Islands
- *Tesselliconus sandwichensis* (Walls, 1978) - endemic to the Hawaiian Islands

Future research into the deep water and deep Neritic Zone cone faunas of other fringe areas of the Indo-Pacific, such as northwestern Australia and the Marquesas and Tuamotu Islands of eastern Polynesia, may yield other, previously-unknown, members of this species complex.

Family Conilithidae

Subfamily Conilithinae

Genus *Jaspidiconus* Petuch, 2004

Jaspidiconus vantwoudti Petuch, Berschauer, and Poremski, new species (Figure 3A-F; Figure 4 C, D)

Description: Shell small for genus, averaging only around 14 mm, stocky and inflated, broad across shoulder, with high, broadly pyramidal spire and rounded, convex sides; spire with distinctly sloping whorls; shoulder angled, bordered by small, rounded carina; body whorl shiny, ornamented with 20-24 faint, slightly-incised, evenly-spaced spiral sulci; sulci become stronger and better-developed toward anterior end; spire whorls smooth, ornamented with very numerous, closely-packed, radiating curved threads, which correspond to growth increments (Figure 3C, D); aperture proportionally wide and flaring, becoming wider toward anterior end;

base shell color bright pink, overlaid with variable amounts of darker pink or purplish-pink amorphous flammules; spire whorls marked with prominent large, widely-spaced, dark pink or pinkish-purple amorphous flammules; interior of aperture pink, becoming darker farther within interior; protoconch proportionally very large and prominent, shiny, composed of 2 rounded, domed whorls; protoconch color deep purple-pink; periostracum very thin, smooth, transparent.

Type Material: HOLOTYPE - length 12.4 mm, width 6.5 mm (Figure 3A, C), LACM 3432, type collection of the Department of Malacology, Los Angeles County Museum of Natural History, Los Angeles, California. Other material includes a 14 mm specimen in the research collection of E.J. Petuch (Figure 3B, D), a 12.4 mm specimen in the Berschauer collection, and a 13.4 mm specimen in the Poremski collection, all from the same locality and depth as the holotype.

Type Locality: Collected in 2 m depth, on exposed hard, rocky surface in high current and surge, near Arashi Beach, Noord District, Aruba.

Range: Known only from Aruba, to which the new species appears to be endemic.

Ecology: The new species prefers shallow water exposed rocky platforms, in areas with strong currents and wave surge.

Etymology: The taxon honors Alain Van't Woudt of Den Hoorn, The Netherlands, who collected the type lot on Aruba.

Discussion: The Grenadian Subprovince of the Caribbean Molluscan Province, which extends from Aruba to Anguilla, and encompasses all the island chains off the Venezuelan coast and the Lesser Antilles, is now known to house

three pink or pinkish-orange, similar-appearing endemic *Jaspidiconus* species: *J. berschaueri* from the northern Lesser Antilles (Windward Islands), particularly Sint Maarten; *J. arawak* from the southern Lesser Antilles (Leeward Islands), especially the Grenadines; and *J. vantwoudti* from Aruba (Netherlands Antilles). The new Aruban endemic described here is most similar to *J. arawak* (Figure 4A), but differs in being a smaller and stubbier shell with a smoother and shinier body whorl that lacks any pustules or beads, in having a more rounded and less developed shoulder carina, in having large, prominent dark pink or pinkish-purple patches on the spire whorls, in lacking the rows of tiny tan dots around the shoulder carina and sutures of the spire whorls, and in having a proportionally much larger and more domed protoconch. The new Aruban species differs from the Windward Islands *J. berschaueri* (Figure 4B) in being a smaller, stockier, and much less elongated shell with a proportionally lower and less elevated spire, in being a much smoother and less sculptured shell that is devoid of any prominent beads or pustules, in lacking large tan dots along the edge of the shoulder carina, and in having a proportionally much larger protoconch.

These three pink cones form a distinctive species complex that is restricted to the Grenadian Subprovince. Throughout the area extending from Tobago to Los Roques Atoll, members of this species complex often occur together with the much larger, variably-colored, and heavily-sculptured *J. jaspideus* (Gmelin, 1791) (see Petuch, 2013: 133). Unlike the restricted ranges of the three Grenadian Subprovince endemics, the type of the genus *Jaspidiconus*, is a widespread species which ranges from Tobago all the way to Panama and may co-occur with the three pink species in certain localities. Of these four southern Caribbean *Jaspidiconus* species, the new

Aruban endemic also has one of the most unusual habitat preferences of any of the known species of *Jaspidiconus*. Most of the members of this group of small cones prefer sandy environments, preferably clean carbonate sand or muddy quartz sand, along the entire western Atlantic, from Cape Hatteras, North Carolina to Santa Catarina State, Brazil. *Jaspidiconus vantwoudti* is the only species of its genus known to prefer open, exposed rocky platforms in shallow, high surge and strong current areas. The closely-related and similar-appearing *J. arawak* and *J. berschaueri* both prefer quiet water, clean carbonate sand areas near living coral reefs and coral rubble, as does the sympatric and widespread *J. jaspideus*. Because of its bright pink shell color, *Jaspidiconus vantwoudti* has often been referred to the taxon “*Jaspidiconus fluviamaris* Petuch and Sargent, 2011” by other workers and collectors. That species, however, is restricted to the Floridian Subprovince of the Carolinian Molluscan Province and ranges only from the Dry Tortugas island chain of the southeastern Gulf of Mexico, through the Florida Keys, and northward to Palm Beach County, Florida. Although having the same intense pink and pinkish-purple color of the new Aruban endemic, *J. fluviamaris* differs in being a larger and more elongated shell with a distinctly cylindrical shape and much straighter sides, and in having distinctly stepped, scalariform spire whorls that differ greatly from the sloping spire whorls of *J. vantwoudti*.

The new *Jaspidiconus* is the sixth-known endemic cone shell to be found on Aruba and its discovery underscores the uniqueness of the Aruban molluscan fauna. This Aruban endemic cone fauna is now known to include the conids *Arubaconus hieroglyphus* (Duclos, 1833), *Tenorioconus curassaviensis* (Hwass, 1792), *Tenorioconus monicae* Petuch and Berschauer, 2015, and *Tenorioconus rosi* Petuch and

Berschauer, 2015, and the conilithids *Perplexiconus wendrosi* (Tenorio and Afonso, 2013) and *Jaspidiconus vantwoudti* (see Petuch, 2013: 134-137 and Petuch and Berschauer, 2015: 195-205 for a review of the endemic marine gastropods of Aruba).

ACKNOWLEDGMENTS

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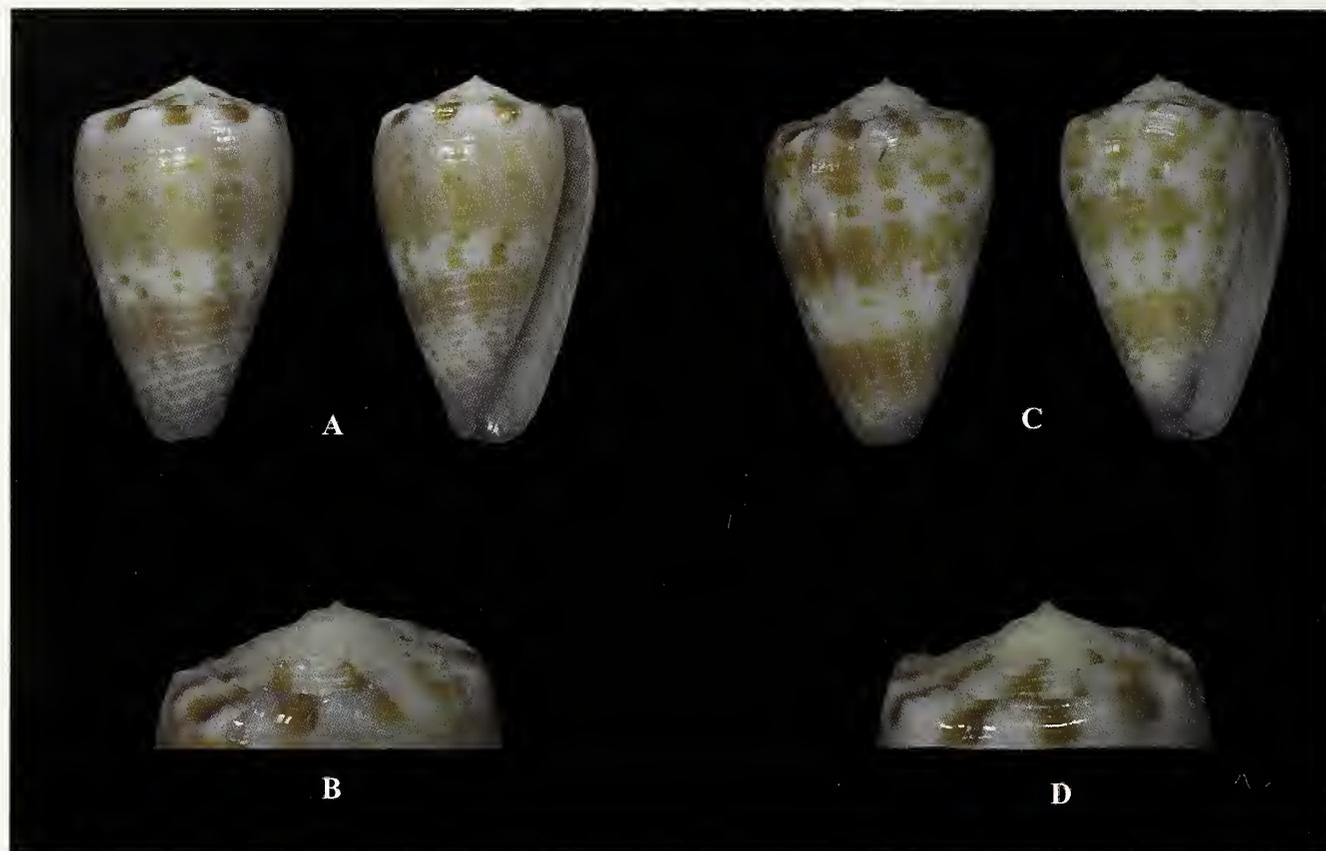


Figure 1. *Tesselliconus devorsinei* new species. **A=** Holotype (QM M080845, molluscan collection of the Biodiversity Section, Queensland Museum, Brisbane, Queensland, Australia), length 29 mm; **B=** close-up view of the spire of the holotype, showing the distinctive truncated pyramid shape and beaded sculpture of the early whorls; **C=** specimen with wide bands of orange-tan rectangular spots, length 30 mm, Berschauer Collection; **D=** close-up view of the spire of the 30 mm specimen, showing the distinctive truncated pyramid spire. Both specimens were dredged from 15 fathoms (27.5 m) depth east of Mooloolaba, Queensland, Australia.

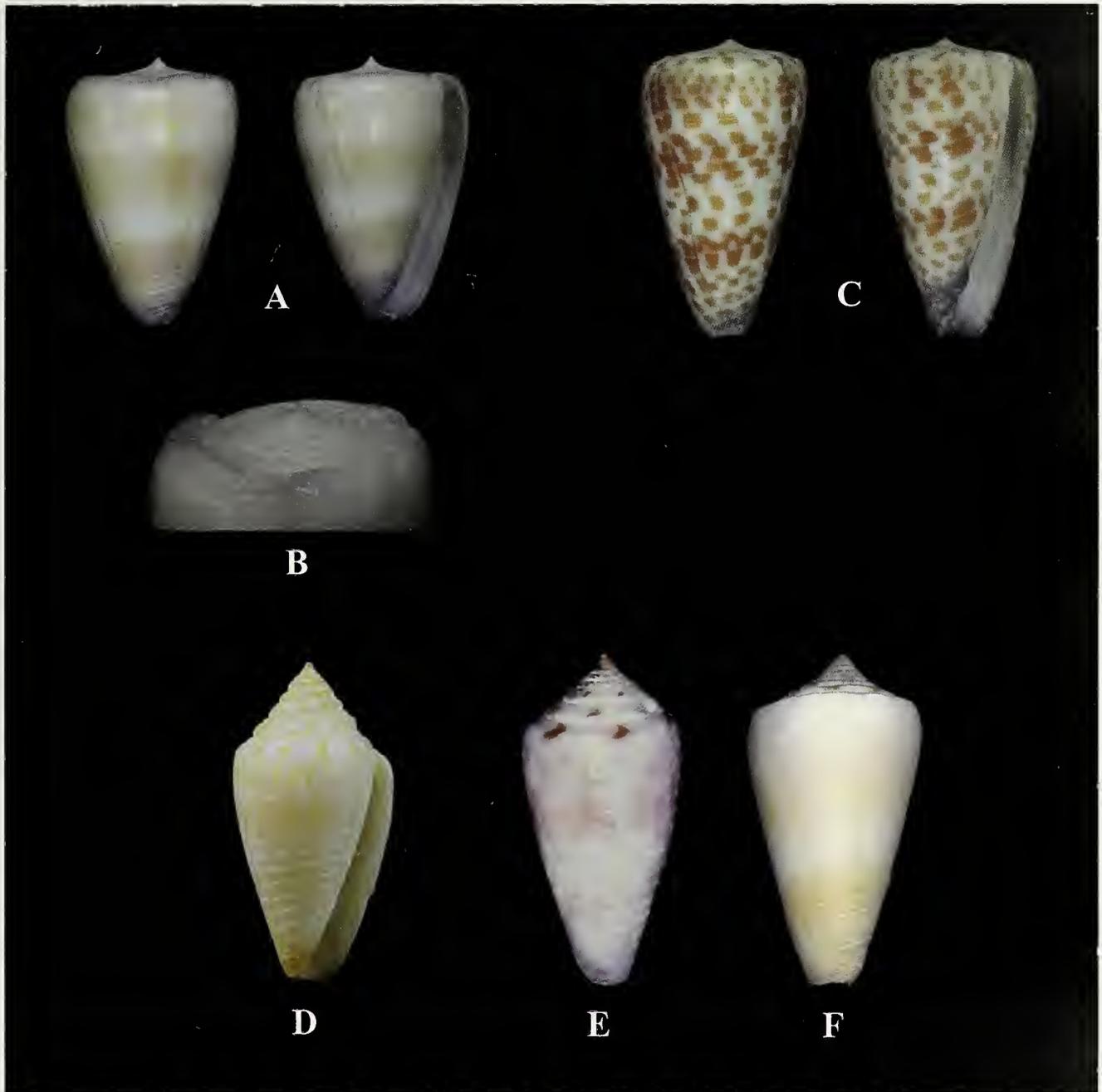


Figure 2. *Tesselliconus* species, for comparison with *T. devorsinei*. **A**= *Tesselliconus suturatus* (Reeve, 1844), length 43 mm, 3 m depth in clean coral sand, off Fitzroy Reef, Great Barrier Reef, Queensland, Australia; **B**= close-up view of the spire of *T. suturatus*, showing the narrow, acutely-angled early whorls which lack the beaded sculpture seen on *T. devorsinei*; **C**= *Tesselliconus tessulatus* (Born, 1778), length 49 mm, 2 m depth in clean coral sand, Sykes Reef, Swain Group, Great Barrier Reef, Queensland, Australia; **D**= *Tesselliconus athenae* (Filmer, 2011), holotype, length 22.6 mm, dredged from 105 fathoms (192 m) depth off Keehi Lagoon, Oahu, Hawaii; **E**= *Tesselliconus sandwichensis* (Walls, 1978), holotype, length 14.4 mm, in sand on reef off Pokai Bay, Oahu, Hawaii; **F**= *Tesselliconus sandwichensis* (Walls, 1978), length 35 mm, on deep reefs off Oahu, Hawaii; photo courtesy of Paul Kersten.

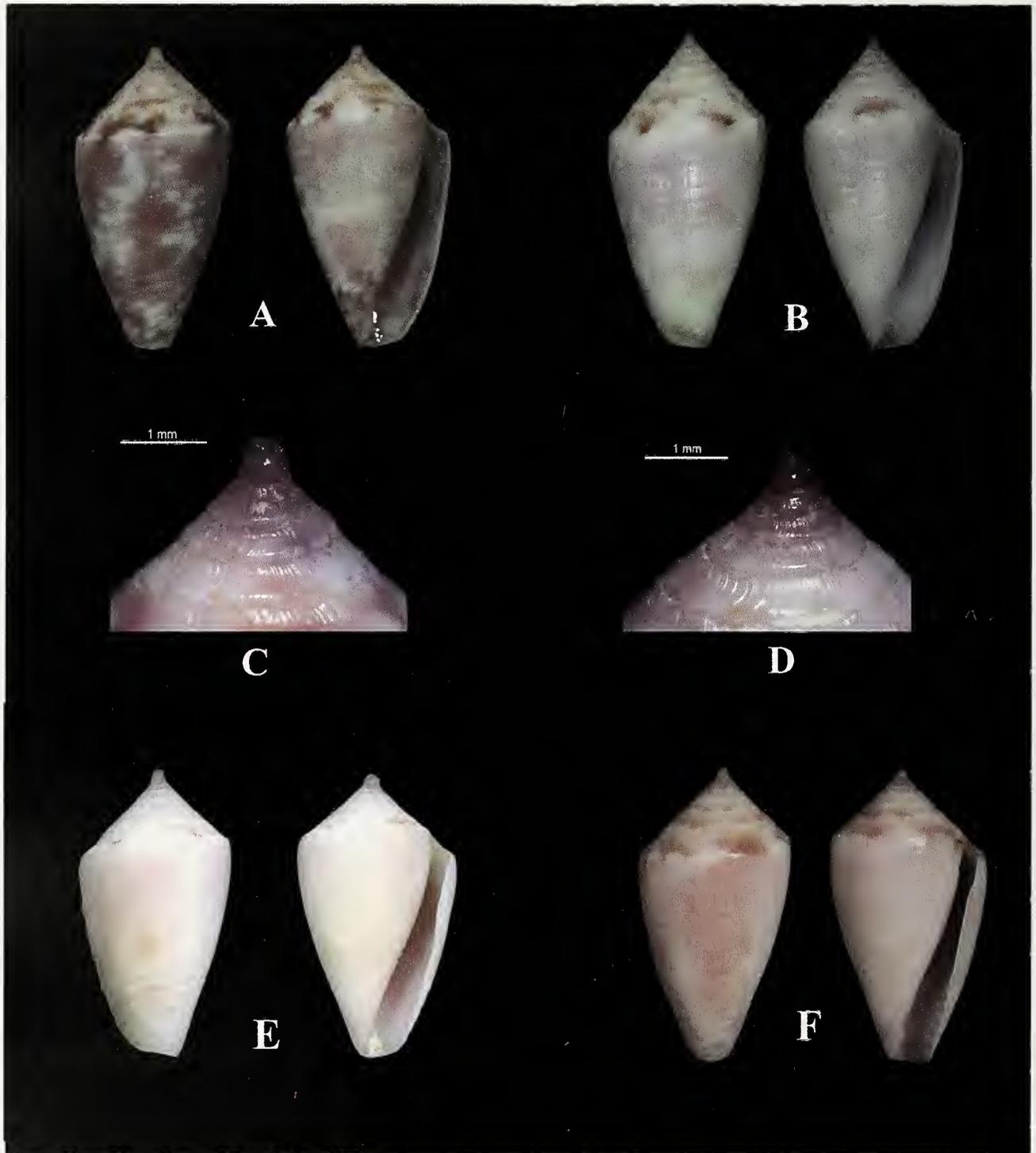


Figure 3. *Jaspidicomus vantwoudti* new species. **A**= Holotype (LACM 3422, type collection of the Department of Malacology, Los Angeles County Museum of Natural History, Los Angeles, California), length 12.5 mm; **B**= length 14 mm. Petuch Collection; **C**= close-up of the spire of the holotype, showing details of the proportionally-large, bulbous protoconch; **D**= close-up of the spire of the 14 mm specimen in the Petuch Collection, showing details of the proportionally-large protoconch; **E**= specimen length 12.6 mm; **F**= specimen length 11.8 mm. All specimens collected on exposed rocky platforms in 1-2 m depths, in areas of strong currents and wave surge, near Arashi Beach, Aruba.



Figure 4. *Jaspidiconus* species from the Grenadian Subprovince of the Caribbean Molluscan Province. **A=** *Jaspidiconus arawak* Petuch and Myers, 2014, holotype, length 15 mm, from 3 m depth, in carbonate sand near coral reef, off Petit Martinique, Grenadines; **B=** *Jaspidiconus berschaueri* Petuch and Myers, 2014, length, holotype, length 18 mm, found in coral rubble in beach drift, Sint Maarten Island, Lesser Antilles; **C=** *Jaspidiconus vantwoudti* Petuch, Berschauer, and Poremski, new species, length 12.8 mm, near Arashi Beach, Aruba, for comparison with *J. arawak* and *J. berschaueri*; **D=** *Jaspidiconus vantwoudti* Petuch, Berschauer, and Poremski, new species, length 13.4 mm, near Arashi Beach, Aruba, for comparison with *J. arawak* and *J. berschaueri*.

Note: Club members, mark your calendars! The November Auction is scheduled for Saturday, November 14, 2015, beginning at 1:00 p.m. in the conference room at the Holiday Inn Express located at 751 Raintree Drive, Carlsbad. Food and beverages will be made available by the Club. An auction list will be e-mailed to all members prior to the event.



What are Species? Or, on Asking the Wrong Question

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ABSTRACT The question, ‘What are species?’, has had a long history in biological systematics with no success at achieving a scientifically viable consensus. This failure is due in large part to the obsession with this one taxon to the exclusion of asking the epistemically more relevant question, ‘What are taxa?’ The problem has been exacerbated by the fact that systematics rarely operates in accordance with the overarching goal of scientific inquiry. This essay offers solutions by defining ‘taxon’ and ‘species’ such that they are consistent with that goal. Some notable consequences are then discussed.

INTRODUCTION

Biologists have maintained an obsession with the biological status of species for several hundred years (Mayden, 1997; Stamos, 2003; Wilkins, 2009a, 2009b; Richards, 2010). The outcome thus far is that over 25 species concepts have been put forward. Ironically, from the voluminous literature on the subject, especially after the advent of Darwinian and neo-Darwinian thinking, consensus on the subject remains elusive. Biologists gravitate to one school of thought or another, often consistent with the organisms that are one’s specialty or one’s general perspective on the nature of biological systematics, or both.

The time is long overdue to cut through all the indecision, which means approaching that interminable question, ‘What are species?’, from an entirely different point of view; one that is not derived from within the limits of biological thinking. Rather, the search for a solution should begin outside biology. We must look to the generally acknowledged reason we engage in scientific inquiry as well as understand the basic principles of reasoning we apply in response to observations of organisms. When we consider the nature of the relations

that exist between an observer and the organisms they perceive, coupled with the goal of inquiry, we find that asking ‘What are species?’ is not the appropriate question. In this essay, I will show that the question we should have been asking all along is ‘What are taxa, and how do they serve the goal of scientific inquiry?’ It is only after answering that question that the subsidiary ‘What are species?’ can be answered. But answering that question will expose the notable deficiencies of the one term species for accurately representing the products of our interactions with organisms in the name of inquiry.

Pursuing the task outlined above first requires acknowledging the goal of scientific inquiry. Next we will need to take a short foray into the nature of reasoning to be able to link our reactions to the observations of organisms with the goal of inquiry. This provides the basis for stating the goal of biological systematics, which should be consistent with the goal of science, as well as showing that the term taxonomy is synonymous with systematics rather than being a sub-operation within or distinct from systematics. And since the field of science is systematics, as the act of systematization, our concern is not with classification since the latter

does not serve the intended purpose. We will then have a clearer conception of how to proceed from observations of organisms to the conclusions we call species, as well as all other taxa. And from there it is straightforward to give basic definitions of taxon and species that are consistent with scientific inquiry. The implications of those definitions for DNA ‘barcoding’ will be discussed, as well as pointing out that a single definition of species is both too biased and limited to effectively encompass all of the endeavors in systematics and biology.

THE GOAL OF SCIENTIFIC INQUIRY

To what end do people involve themselves in a field of science? Certainly if you ask a physicist working with the Large Hadron Collider you will receive an answer very different from a malacologist examining the radulae from a group of gastropods. But while answers from different fields of science might appear dissimilar, it is the overarching objective of all scientists that is distinctly uniform. Simply put, the goal of inquiry in the sciences is to pursue causal understanding (Hempel, 1965; Hanson, 1958; Salmon, 1984a; Mahner & Bunge, 1997; Thagard, 2004; de Regt *et al.*, 2009; Hoyningen-Huene, 2013). We want to know why things are as they are, as well as anticipate what we might encounter in the future. The philosopher of science, Carl G. Hempel, offered a good characterization of the goal of scientific inquiry:

“Broadly speaking, the vocabulary of science has two basic functions: first, to permit an adequate *description* of the things and events that are the objects of scientific investigation; second, to permit the establishment of general laws or theories by means of which particular events may be *explained*

and *predicted* and thus *scientifically understood*; for to understand a phenomenon scientifically is to show that it occurs in accordance with general laws or theoretical principles.” (Hempel, 1965: 139, emphasis original)

Note that while descriptions of the objects and events we encounter are of utmost importance, they are the impetus to pursue causally understanding what is observed. Such pursuit is in the form of explanations of the present by way of what occurred in the past. And the better that causal understanding, the more effectively we can anticipate what might occur into the future.

As we will see later, the interplay between the descriptive and causal understanding form the basis of systematics, and is critical to correctly referring to all taxa, including species. But first we must understand the relations between observations, descriptions, and the pursuit of understanding, which derive from the basic principles of reasoning.

THE NATURE OF REASONING, FROM PERCEPTIONS TO HYPOTHESES

In its simplest form, reasoning is the act of proceeding from evidence to conclusion(s). It is the act of making an inference (Salmon, 1984b). If presented as a set of statements, called an argument, the evidence comprises the premises that support a statement that is the conclusion. The ancient Greeks recognized that the content of and relations between premises and conclusion allows for a classification of reasoning. The ideal form of reasoning is deduction, and it is on the basis of the rules of valid deduction that all other forms of reasoning are compared. Of these rules for deduction, the most basic is that if the premises are true, then

the conclusion must be true. Consider this example,

- [1] All humans are mortal
 Kirk is a human

 Kirk is mortal.

The line separates the premises above from the conclusion below. Given that the premises are true, the conclusion must be true. In fact, the conclusion is already implied by the premises since I am a subset of the group 'humans.' Valid deductions are indicated by a single line, whereas non-deductive reasoning is denoted by a double line separating premises and conclusion. For instance, changing the relations of premises and conclusion in [1] will give a non-deductive argument,

- [2] All humans are mortal
 Kirk is mortal

 Kirk is a human.

While the premises are true, they cannot guarantee the truth of the conclusion. At best, the conclusion has some probability of being true, contingent on the content of the premises. The fact that I am mortal does not necessarily mean I am human, as mortality applies to all organisms. In standard logic, any argument that is not deductive is said to be inductive, as indicated by the double line. The conclusion contains or implies information not stated in the premises. In other words, the content of the conclusion goes beyond what is offered by the premises.

While the rules of deduction have the benefit of providing the foundation from which all reasoning is compared, deduction is of limited use for scientific inquiry. We saw earlier that a deductive conclusion only reiterates what

already is in the premises; it does not allow for introducing or considering new ideas. The act of explaining phenomena for the purpose of understanding requires that we go beyond mere descriptions; we have to consider unobserved and sometimes unobservable objects and events. Thus, growth of scientific knowledge is not by way of deduction. But to label all non-deductive reasoning as inductive is not an effective approach to characterize the actions in scientific inquiry. Subtleties have to be acknowledged.

At a minimum, inquiry in everyday life as well as the sciences proceeds from surprising or unexpected observations to inferences of hypotheses that offer explanatory accounts of those observations. This involves a form of non-deductive reasoning known as abduction or abductive reasoning (Thagard, 1988; Josephson & Josephson, 1994; Aliseda, 2006; see Fitzhugh 2006a, 2008, 2010, 2012, 2014 for considerations of abduction in relation to biological systematics and evolutionary biology). Abduction has the form,

- [3] Background knowledge
 Theory X : if cause x occurs, effect y will
 ensue
 Surprising effect e_y is observed

 Hypothesis h_x : cause x occurred.

Abductive reasoning is the source of both hypotheses and theories, and also represents the everyday cognitive process proceeding from our sense data to observation statements. An observation statement is a hypothesis accounting for sense data by way of the existence of some object. And as we will see in the next section, references to taxa, species, or phylogenetic hypotheses are all products of abduction, which will be the key to properly defining terms like taxa and species.

Though this essay will not pursue these issues, brief mention should be made of the relations of abduction to the broader context of scientific inquiry. Abduction is the productive component of inquiry; it is the stage in which new ideas are put forward. As with any non-deductive inference, hypotheses are probable, not certain. Empirically evaluating the credibility of a hypothesis then requires that it be tested, which involves two steps. First, if the hypothesis is true, then specific consequences should be anticipated, such that those consequences, as potential test evidence can offer support for the hypothesis. The prediction of potential test evidence is deductive,

- [4] Background knowledge
 Theory X : if cause x occurs, effect y will ensue
 Given hypothesis h_x : cause x occurred
 Proposed conditions to carry out test
-
- Effect e_y originally prompting h_x
Predicted test evidence, i.e. independent effects associated as narrowly as possible with causal conditions outlined in h_x should be observed.

Subsequent to the prediction of test evidence, the hypothesis is subjected to testing by determining if the test evidence does occur. Hypothesis testing is an instance of induction,

- [5] Background knowledge
 Theory(ies) relevant to original effects
 Test conditions a, b, c , etc., established
Predicted test evidence is observed/not observed pursuant to test conditions
-
- Hypothesis h_x is confirmed/disconfirmed.

Since hypothesis testing is non-deductive, finding evidence that confirms a hypothesis offers support for the hypothesis but the truth of

the hypothesis remains probabilistic. Future test evidence could reduce confidence in lieu of an alternative explanation.

THE GOAL OF BIOLOGICAL SYSTEMATICS AND HOW IT IS ATTAINED

Having presented an overview of the goal of scientific inquiry and the basic steps taken in the pursuit of that inquiry, we can identify the goal of systematics. Consistent with all the sciences, systematics pursues causal understanding of the differentially shared features of organisms. Unlike the nebulous view that systematics seeks to find the 'tree of life' or 'reconstruct phylogeny,' the more precise characterization is that systematics deals with hypotheses across a spectrum of causal contexts, ranging from the descriptions of organisms to ontogenetic, reproductive, intraspecific, specific, and phylogenetic hypotheses, among others (Hennig, 1966: fig. 6). The goal of systematics is therefore consistent with the intent of systematization (Hoyningen-Huene, 2013). This means use of the term taxonomy is unnecessary. While systematics and taxonomy are often considered synonymous, current usage tends to equate taxonomy with species 'descriptions' and systematics with phylogenetic hypotheses. Since species are not described, as shown in the next section, all actions within systematics serve the purpose of systematization, which makes it straightforward to show that all taxa are inferential products directed at our desire to acquire causal understanding of organisms. Similarly, classification cannot be equated with systematization. A process of grouping objects according to shared properties lacks the theoretical and causal depth desired in systematics.

FORMAL DEFINITIONS OF 'TAXON' AND 'SPECIES'

Reiterating what has been developed in the previous two sections, we encounter surprising or unexpected objects and events every day and in most instances spontaneously infer by way of abduction at least tentative answers to implied or explicit questions. For instance,

“Why is traffic so slow on this street (as opposed to moving the speed limit)?”

– “Perhaps there’s a wreck down the street.”

Or,

“Why is broken glass on the sidewalk (as opposed to being clean)?”

– “Maybe someone dropped a bottle.”

Notice that both questions refer to what is observed in contrast to what is expected. It is that contrast that prompts inquiry in the form of proceeding from observations to abductive inferences to possible causes as answers to questions.

Let’s extend such considerations to systematics. The objects of concern in biology are organisms. We observe individuals at particular moments during their life history, what Hennig (1966) referred to as *semaphoronts*, and we perceive these individuals by way of their properties or characters. It is our differential observations of characters among semaphoronts that prompt causal questions, leading to abductive inferences of hypotheses that explain these differences. Those explanations address a host of different observations, thus the inferences to

explanations require different sets of theories depending on what are being explained. The discussion so far has centered on our reactions to conditions of observed objects; reactions in the form of abductive inferences to explanatory hypotheses. Those hypotheses are what are often called *taxa*, whether species, genera, families, classes, etc. Since taxa are explanatory hypotheses, the consequence is that we *do not* observe or describe taxa. As noted already, taxa are nothing more than inferential reactions, in the form of explanatory hypotheses, to observations among semaphoronts. This means formal definitions of *taxon*, *species (partim)*¹, and *supraspecific taxon* (= phylogenetic hypothesis) would be as follows (cf. Fitzhugh, 2005, 2009, 2013):

Taxon: Any of a number of classes of explanatory hypotheses in biological systematics that causally account for differentially shared characters among observed organisms.

Species (partim): An explanatory account of the occurrences of the same character(s) among gonochoristic or cross-fertilizing hermaphroditic individuals by way of character origin and subsequent fixation within reproductively isolated populations. This is but one of at least five possible classes of explanatory hypotheses commonly called species. The other definitions will be given later.

¹ As will be noted later, the term species entails at least five different classes of causal conditions, such that it is not possible to give a definition that is appropriate to all of them.

Supraspecific taxon: A class of explanatory hypotheses accounting for particular characters by way of character origin/fixation among members of an ancestral population, and subsequent population splitting events. Collectively known as phylogenetic hypotheses.

Per the structure of abduction in [3], formal representations of inferences to specific and supraspecific/phylogenetic hypotheses take the respective forms:

[6] **Species (*partim*) Theory**: If character Y originates among gonochoristic or cross-fertilizing hermaphroditic individuals of a reproductively isolated population with character X , and Y subsequently becomes fixed throughout the population, then individuals observed in the present will exhibit character Y .

Observations (effects): Individuals have a dorsal margin with antennae in contrast to a smooth dorsal margin as seen among individuals to which other specific hypotheses (a -us, b -us, etc.) refer.

Causal Conditions (specific hypothesis y -us²): The antennate dorsal margin condition originated within a reproductively isolated population with smooth dorsal margins and eventually became fixed throughout the population.

[7] **Phylogenetic Theory**: If character X exists among individuals of a reproductively isolated, gonochoristic or cross-fertilizing hermaphroditic population and character Y originates and becomes fixed within the population, followed by the population being divided into two or more reproductively isolated populations, then individuals to which descendant species hypotheses refer would exhibit Y .

Observations (effects): Individuals to which specific hypotheses x -us and y -us refer have ventrolateral margins with appendages in contrast to smooth as seen among individuals to which other species hypotheses (a -us, b -us, etc.) refer.

Causal Conditions (phylogenetic hypothesis X -us): Ventrolateral margin appendages originated within a reproductively isolated population with smooth ventrolateral margins, and the appendage condition became fixed in the population (= ancestral species hypothesis), followed by a population splitting event that resulted in two or more reproductively isolated populations.

Notice that while specific and phylogenetic hypotheses are inferred by way of abduction, the respective theories used differ in that the former considers character origin/fixation within reproductively isolated populations, and the latter refers to character origin/fixation followed by population splitting events. The representations in [6] and [7] are highly schematic in that neither actually stipulates details regarding the various causal mechanisms necessary to offer useful explanatory accounts. Yet, this lack of causal specifics is typical in references to specific and phylogenetic hypotheses, e.g. cladograms. The intentional

² The uninomial name used here and in [7] follows from Fitzhugh's (2008) argument that a species hypothesis is inferred separate from the phylogenetic hypothesis referred to by the rank of genus, and should be recognized as such. The binomen required by the International Codes of Nomenclature incurs the requirement that monotypic genera be recognized when in fact the genus name is empirically vacuous and cannot be defined.

limitation of the definition of species in [6] to intersexual organisms highlights the fact that the term species requires special consideration regarding several different classes of reproduction and genetic exchange, which will be discussed later (see **THE PROBLEM WITH SPECIES**).

Finally, let me reiterate that neither species nor any other taxa have the status of individuals; they are causal accounts intentionally inferred as part of the goal of inquiry. To speak of a 'species description' means describing the observed features of organisms, not the species. A formal species name refers to a hypothesis, e.g. specific hypothesis *y-us* in [6]. What is required is a definition of that formal name; that being an explanatory account of particular characters of organisms. The same conditions apply to supraspecific taxa, regardless of rank. And in the case of these latter taxa, all are phylogenetic hypotheses, e.g. [7].

THE PROBLEM WITH SPECIES

The definition of species in the previous section (see also [6]) is intentionally limited in scope for the fact that the one term cannot accurately entail the variety of causal events typical across all organisms, especially those that do not display the uniformity of sexual reproduction. Fitzhugh (2013) identified at least five classes of causal events to which the term species have been applied:

Species₁ (cf. [6]): if character *Y* originates among gonochoristic or cross-fertilizing hermaphroditic individuals of a reproductively isolated population with character *X*, and *Y* subsequently becomes fixed throughout the population, then individuals observed in the present will exhibit character *Y*. This is essentially

equivalent to the 'biological species concept.'

Species₂: if character *Y* simultaneously originates and is fixed by hybridization, e.g. polyploidy, among gonochoristic or cross-fertilizing hermaphroditic individuals to which respective 'species₁' hypotheses refer, such that subsequent interbreeding events are limited to individuals with *Y*, then individuals observed in the present will exhibit *Y*. This is a common occurrence among plants that exhibit polyploidy, wherein polyploid individuals immediately result in reproductive isolation.

Species₃: if character *X* exists among individuals with obligate reproduction that is asexual, apomictic/parthenogenetic, or self-fertilizing, and character *Y* originates, then individuals observed in the present exhibiting *X* and *Y* are respective reproductive products of individuals with those characters. This characterization addresses the most distinct limitation of the 'biological species concept.' Among organisms that are obligate asexual, parthenogenetic, or self-fertilizing, the introduction of novel characters result in divergent lineages of individuals with those characters explained by the species₃ hypothesis. A complicating factor that will not be pursued here is that phylogenetic hypotheses (cf. [7]) are not applicable to these kinds of organisms since the only type of 'lineage splitting' that occurs is by way of reproductive events, not population splitting events.

Species₄: if character *Y* originates among individuals with *X* during one of the alternative phases of asexual or sexual reproductive events, and *Y* subsequently becomes fixed throughout the population during tokogeny, then individuals observed in the present will exhibit *Y*. This class of hypothesis considers organisms with metagenetic or ‘alternation of generation’ life histories, as observed for instance among some cnidarians [e.g. alternate polyp (asexual) and jellyfish (sexual) stages; sporocysts (asexual) and adult (sexual) digenetic trematodes].

Species₅: if character *X* exists among individuals and character *Y* subsequently occurs due to horizontal genetic exchange with other individuals, then individuals observed in the present exhibiting *X* and *Y* are respective reproductive products of individuals with those characters. Horizontal gene transfer is a widespread phenomenon, especially among bacteria. The standard species hypothesis, e.g. *species₁*, aimed at sexually reproducing organisms cannot accommodate hypotheses explaining characters obtained via horizontal genetic exchange.

What is most apparent is that the one term species is inadequate to represent the variety of non-phylogenetic hypotheses required to explain the presence of shared characters among organisms. The five classes of hypotheses outlined here are not immediate solutions to the problem, but rather illustrate that the problem exists and needs to be acknowledged.

As noted in the previous section that all taxa, including species, represent explanatory hypotheses. Taxa do not have the status of individuals or things, and when one points to an organism-as-semaphoront they are not referring to a species, genus, etc. Hypotheses are explanatory constructs. Their relations to organisms only stand as vehicles that provide causal understanding, per the goal of scientific inquiry.

DISPELLING THREE MYTHS: DNA BARCODING, ‘CRYPTIC’ SPECIES, AND THE PREEMINENCE OF SEQUENCE DATA

The fact that species are multiple classes of explanatory hypotheses, and phylogenetic hypotheses also have explanatory standing, has significant implications for the growing methodological fad known as DNA barcoding. The reliance on snippets of DNA to ‘identify’ species suffers from the erroneous premise that species can be regarded as spatio-temporally localized individuals. As species do not have this quality, sequence data cannot serve as a surrogate for the actuality that species hypotheses can and do refer to explanations of characters other than nucleotides. Barcoding fails on both epistemic and scientific grounds (Fitzhugh, in prep.).

There is a common tendency among systematists to think that sequence data offer clues to ‘cryptic’ species, where ‘traditional’ (*i.e.* ‘morphological’) characters fail to discriminate between species. This is a specious perspective that derives not only from the failure to recognize species as explanatory hypotheses, but also not understanding the abductive inferences that lead to those hypotheses. No one class of characters, sequence data in this case, can be held up as the basis for inferring species hypotheses. Instead, the decision-making

process of what observed effects to include in the minor premises of an abductive inference to species hypotheses, *cf.* [6], will depend upon the investigator's choices of what observations are to be conjoined with the major premise that is a particular theory, *cf.* species₁ through species₅ in the previous section. Excluding all observations except sequence data is irrational if it is the case that there are non-sequence data that have to be explained via the same theory. And, since species are neither class constructs nor ontological individuals, there can be no 'cryptic' species; only explanatory hypotheses that fulfill the inferential requirements necessary to attain rational conclusions.

Finally, the view that sequence data offer some sort of superior avenue to inferring species suffers from not understanding that causal understanding is our goal (Fitzhugh, 2006b, 2012, 2014, in prep.). The tools of such understanding include the theories of natural selection and genetic drift. But as it is the case that selection cannot operate at the level of individual nucleotides, but rather at the higher organizational levels of phenotypes, we would have to restrict explanations of sequence data to drift, which is not entirely realistic. Explaining particular phenotypes by way of selection will determine distributions of lower-level structures, including associated sequences by the phenomenon of downward causation (Campbell, 1974; Ellis, 2012; Martínez & Esposito, 2014). The consequence is that the naïve inclusion of sequence data in inferences of specific and phylogenetic hypotheses, coupled with the exclusion of other relevant characters that are in need of being explained, will result in hypotheses that have little if any explanatory merit. There must be discrimination between sequences to be explained by drift as opposed to higher-level selection for particular phenotypes. In other words, not all sequence data can serve the purposes of inferring taxa at the exclusion of

other characters also in need of being explained. Like barcoding, the popular bias toward sequence data is founded on significant misunderstandings of the goal of biological systematics as a scientific endeavor.

CONCLUSIONS

The title of this essay alludes to the view that asking 'What are species?' is not the right question. The relevant question is, 'What are taxa?' I have provided the answer to the latter question such that the former can be cogently answered. If you now feel confused about what is a species, then I have done my job. You should feel confused for the fact that the pursuit of causal understanding within biological systems is not always a clear-cut process and cannot be represented by simple classificatory procedures. Systematics is about systematization. There are no activities called taxonomy or classification *simpliciter* that usurp the intent of systematization. There are only our efforts to describe objects, *not* species, and pursue causal understanding of our observations through the inferences of various taxa-as-explanatory hypotheses. Recent tradition in systematics has focused too much effort on methodology at the expense of integrating the coherent philosophical foundations that pervade all sciences. And the victims of this neglect have been thoughtful treatments of the question, 'What are taxa?'

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Taxonomic Note - new species: *Typhinellus jacolombi* Houart, 2015

This new species from the Caribbean sea, apparently endemic to Portobelo Bay, Panama, is relatively large for the genus ranging in size from 19 to 28 mm in length, and is substantially broader in length/width ratio than other species in the genus, with a spiral sculpture of low, rounded, broad smooth primary and secondary cords and narrow tertiary cords, a long tapering broad ventrally sealed anal tube, a small and rounded protoconch, with color ranging from completely white to light brown. The holotype figured above measures 19.2 mm in length. (Houart, R. 2015. Description of a new species of *Typhinellus* (Gastropoda: Muricidae: Typhinae) from the Western Atlantic. *Zootaxa* 4007(3) 427-432.) Photo credit: Roland Houart, with permission.

***Bertia setzeri*, a New Species of Land Snail from Vietnam
(Gastropoda: Stylommatophora: Dyakiidae)**

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ABSTRACT A new species of genus *Bertia* Ancey, 1887 is described from Khánh Hòa, Central Vietnam and compared to three species of this genus: *Bertia cambojiensis* (Reeve, 1860), *Bertia pergrandis* (Smith, 1893) and *Bertia brookei* (Adams & Reeve, 1848).

KEYWORDS Mollusca, Gastropoda, Stylommatophora, Dyakiidae, *Bertia*, Nha Trang, Khánh Vĩnh, Khánh Hòa, Bình Định, Central Vietnam, land snail, new.

INTRODUCTION: *Bertia* is a genus of the family Dyakiidae. At the end of 2014, an unknown land snail was found that was not included in the works by Schileyko (2011). It belongs to the genus *Bertia* and is described herein.

Abbreviations:

ANSP = Academy of Natural Sciences, Philadelphia, USA

NHMUK = National Museum of Natural History, London, England

NNT = Collection N.N.Thach

SYSTEMATICS:

Class Gastropoda Cuvier, 1797

Order Stylommatophora Schmidt, 1855

Family: Dyakiidae Gude & Woodward, 1921

Genus: *Bertia* Ancey, 1887

Type species: *Helix cambojiensis* Reeve, 1860

Bertia setzeri n. sp.

Figure 1, Images 1-4 and 17-20

Diagnosis: The new species is characterized by completely black base with the shell width much larger than its height.

Description: Shell large (70-75 mm in average adult size, reaching 78.6 mm in width) heliciform sinistral much wider than high with 5.5 whorls. Spire low and inflated, sutures deep. Body whorl swollen, periphery rounded with a moderately strong spiral rib. Sculpture consists of many broad radial ribs at body whorl (each rib is a series of 3-4 riblets) and numerous small granules formed by intersections of fine radial and spiral ribs at penultimate whorl. Aperture wide obliquely ovate and and bluish at upper part with external pattern visible within and darker at lower part, outer lip wide thin and not angulated. Base inflated, strongly convex and sculptured with numerous radial ribs. Umbilicus broad open and deep, periostracum thin and straw-colored. Color red-brown at dorsal side and completely black at ventral side. Illustrated holotype was damaged at periphery.

Type material: Holotype 78.6 mm wide in ANSP (Fig.1, Images 1-4). Paratype 1: 75 mm wide in NNT (Fig. 1, Images 17-20). Paratype 2: 73.8 mm wide and Paratype 3: 76.2 mm wide in Ex-NNT (not illustrated).

Type locality: At the border of Khánh Vĩnh District and Nha Trang outskirts, Khánh Hòa Province, Central Vietnam.

Range and habitat: Known only from the type locality. The specimens were found among leaf litter.

Etymology: This new species was named in honor of Steve Setzer of the United States for his interest in the terrestrial snails of Vietnam.

DISCUSSION:

• *Bertia setzeri* n.sp. is close to *Bertia cambojiensis* (Reeve, 1860) (Fig. 1, Images 5-8) but differs in shell width much larger than shell height, completely black base, lack of dark brown spiral band along suture of each whorl

and other characters that are summarized in Table 1.

• *Bertia setzeri* is close to *Bertia pergrandis* (Smith, 1893) (Fig. 1, Images 9-12) but differing in completely black base, convex (not angulate) outer lip and other characters that are summarized in Table 1.

• *Bertia setzeri* is close to *Bertia brookei* (Adams & Reeve, 1848) (Fig.1, Images 13-16) but differs in completely black base, not concave outer lip at umbilical area, vivid yellow (not grayish brown) foot, black (not orange-colored) eyes of the live animal and other characters that are summarized in Table 1.

Table 1: Comparison of *Bertia setzeri* vs *B. cambojiensis*, *B. pergrandis* & *B. brookei*

	<i>Bertia setzeri</i>	<i>Bertia cambojiensis</i>	<i>Bertia pergrandis</i>	<i>Bertia brookei</i>
Umbilicus	Broad, open and deep	Moderately broad, open and shallow	Broad, widely open and deep	Mostly covered by columella, shallow
Umbilical area	Black	Black or red-brown	White	Red-brown
Base color	Completely black	Black or red-brown encircled by white band	White, encircled by red-brown band	Completely red-brown
Peripheral rib	Moderately strong	Obsolete	Very strong	Sharp, very strong
Locality	Vietnam (Khánh Hòa Province)	Cambodia	Vietnam (Bình Định Province)	Indonesia, Malaysia

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I want to thank the members of my team who worked diligently at the end of 2014 to collect land snails of Central Vietnam for scientific study. I am also grateful to Prof. Fred Naggs and Dr. Jonathan Ablett of London National Museum of Natural History for the photos of *Bertia cambojiensis* and *Bertia pergrandis* stored at this Museum, to Bernard Dupont for the photos of *Bertia brookei* and to Christa Hemmen for supplying the original description of *Bertia pergrandis*. Thanks are also due to the reviewers for useful comments.

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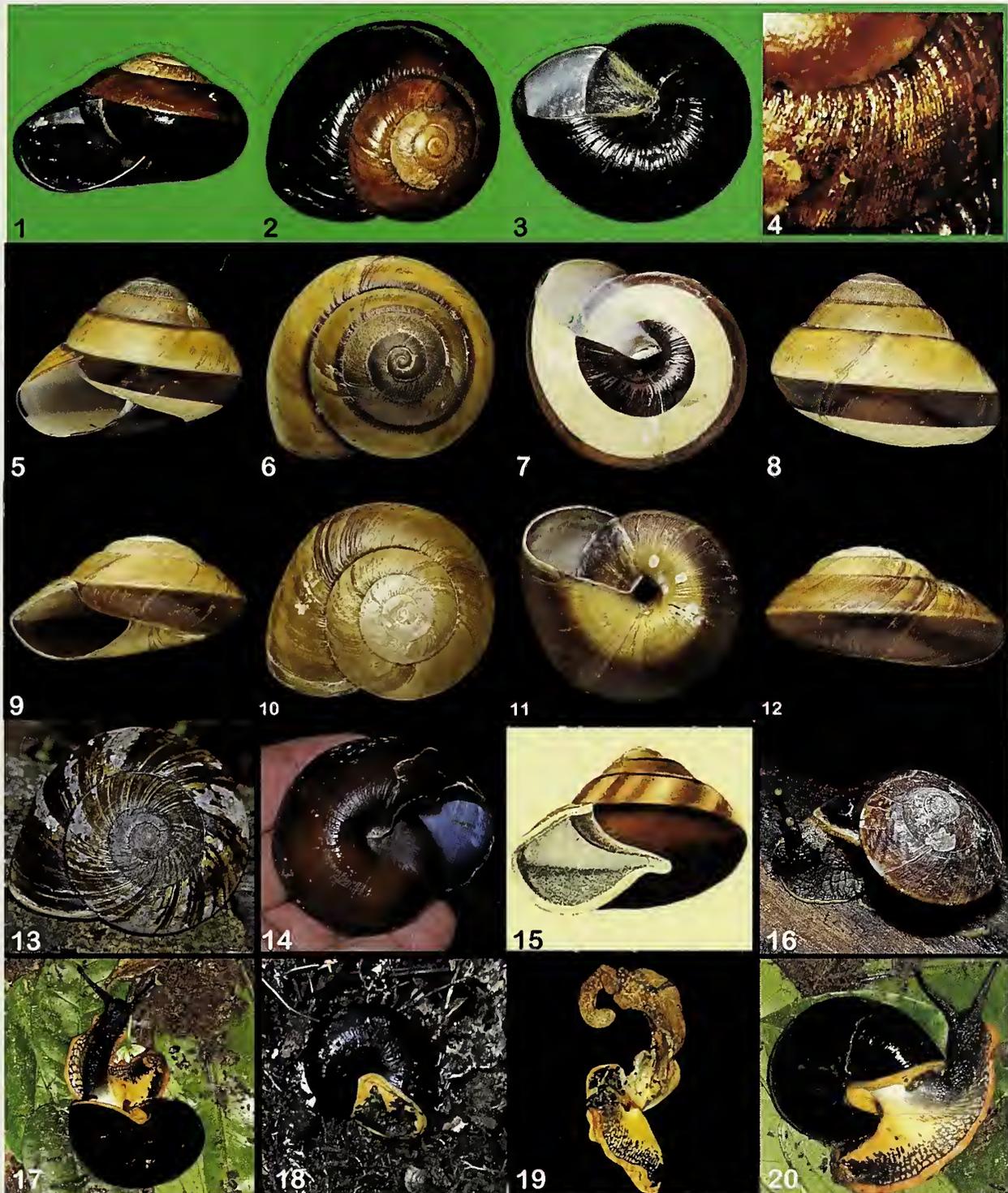


Figure 1. Images 1-4: *Bertia sertzeri* n.sp., Khánh Hòa, Vietnam, Holotype 78.6 mm wide, Image No. 4 shows sculpture at penultimate whorl with many granules, ANSP; Images 5-8: *Bertia cambojiensis*, Syntype at NHMUK for comparison; Images 9-12: *Bertia pergrandis*, Syntype at NHMUK for comparison; Images 13-16: *Bertia brookei* for comparison, Image Nos. 13, 14 and 16 by Bernard Dupont, Image No. 15 by Reeve; Images 17-20: *Bertia sertzeri* n.sp., Paratype, 75mm wide, with animal when alive, Image No. 19 shows internal organs of the snail, NNT.

**Iconography and Distribution of the Cape Verde Island Abalone,
Haliotis tuberculata fernandesi Owen & Afonso, 2012, with Comparisons to
H. tuberculata coccinea Reeve, 1846, of the Canary Islands**

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ABSTRACT Specimens of *Haliotis tuberculata fernandesi* collected from Santa Luzia Island, Cape Verde Islands, are illustrated to provide additional representatives of this subspecies. Comparisons are made with *Haliotis tuberculata coccinea* Reeve, 1846, of the Canary Islands. Differences in shell morphology between the two subspecies are discussed in greater detail.

INTRODUCTION

The Cape Verde Islands, located nearly 600 km off the west coast of Senegal, are the southernmost archipelago in Macronesia and are unique amongst these island groups in possessing a mixture of marine fauna and flora composed of tropical (often amphi-) Atlantic and warm temperate Mediterranean - Atlantic elements, as well as extensive endemics (Afonso *et al.* 2008; Afonso & Tenorio 2011; Duda & Rolán 2004; John *et al.* 2004; Lüning *et al.* 1990; Morri *et al.* 2000; Wirtz 2001, 2009).

Haliotis tuberculata fernandesi Owen & Afonso 2012, the southernmost subspecies of *H. tuberculata* in the Cape Verde Islands, represents an endemic derived from the warm temperate Atlantic (Wirtz 2001; Owen & Afonso 2012). When *Haliotis tuberculata fernandesi* was initially described in 2012, only a handful of specimens were known from collections and were limited to Boavista, Sal, and São Vicente Islands (Owen & Afonso 2012; Fig. 1). Additional specimens were also reported from Santa Luzia and Santiago Islands, but were not available for study (Fig. 1). Recently, collected material from Santa Luzia

Island provides additional examples of *Haliotis tuberculata fernandesi* and reinforces the subspecific designation of this taxon in comparison to other Eastern Atlantic haliotids, particularly *H. tuberculata coccinea*. The aim of this report is to provide additional images of the Cape Verde subspecies of *Haliotis tuberculata*, characteristics that separate it from *H. tuberculata coccinea*, and an updated distribution map of the Cape Verde abalone.

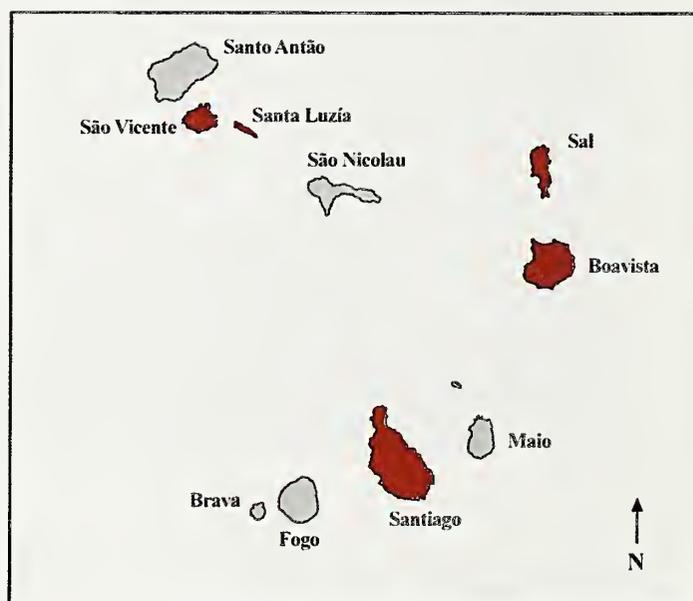


Fig. 1. Map of Cape Verde Islands. (Islands specimens taken from are shaded in red)

Material and Methods: Shells were faintly moistened with mineral oil and the excess was wicked away. Specimens were photographed with a Canon A650 digital camera (12 megapixel resolution) or scanned with a HP ScanJet G 4010 scanner.

Abbreviations of collections:

BOC: Buzz Owen Collection, Gualala, California, USA; DDC: Dwayne Dinucci Collection, Union City, California; FFC: Franck Frydman Collection, Paris, France; NMNZ: Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand; PRC: Peter Ryall Collection, Austria; RFC: Ramiro Fladeiro Collection, Valhascos, Portugal; RKC: Robert Kershaw Collection, Narooma, NSW, Australia.

Material Examined: *Haliotis tuberculata fernandesi*, Cape Verde Islands, >80 shells; *H. tuberculata coccinea*, Canary Islands, >100 shells.

Taxonomic Note: The type specimen of *H. tuberculata coccinea* (described in Reeve, 1846, as *Haliotis coccinea*) is incorrectly attributed as being from “Cape Verd Islands”. However, the strong spiral ribbing and bright red coloration of the specimen are indicative of the Canary Islands population (Geiger & Owen, 2012).

RESULTS

Four photo plates are included and show the differences between these two *Haliotis tuberculata* subspecies: three illustrate 45 specimens of *H. tuberculata fernandesi* from the Cape Verde Islands, and a single plate illustrates 15 shells of *H. tuberculata coccinea* from the Canary Islands. The latter were selected from five different islands in the archipelago. Most of the Cape Verde material was collected from Santa Luzía Island from March - July 2015.

Description: Most Santa Luzía Is. shells of *H. tuberculata fernandesi* are similar in coloration to specimens collected from the other islands in the Cape Verde archipelago (particularly Sal Island), usually moderate pink to dark purple-red. However, the large sample size also shows other color variants including brown and (mostly) yellow specimens. Additionally, many of the shells are marked with bright flammae or display patches of green, white, brown and yellow. Specimens lack strong spiral ribbing, being smooth or with very faint and shallow ribs (Pl. 3). By contrast, *H. tuberculata coccinea* (Pl. 4) has very deep and pronounced ribbing, with an occasional exception (bottom row this plate). They also lack purple-red coloration, which is the dominant color form in the Cape Verde Island subspecies.

Biological Note: Of the greater than 75 specimens examined from Santa Luzía Island, approximately 25% exhibit predation damage at the anterior margin (Plate 3). Each of these specimens survived a predation attempt and later deposited new shell growth. Interestingly, this predation damage is similar to that produced by labrid (wrasse) or balistid (triggerfish) reef fish. Similar damage can be observed among shells of *Haliotis rubiginosa* Reeve, 1846, from Lord Howe Island (Owen, pers. obs.).

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Haliotis tuberculata fernandesi
 Santa Luzia Is., Cape Verde Islands.
 35.5 mm. 3-4 m. Probable fish damage
 at anterior margin.



Plate 1. *Haliotis tuberculata fernandesi* Owen & Afonso, 2012. Cape Verde Islands, various localities.

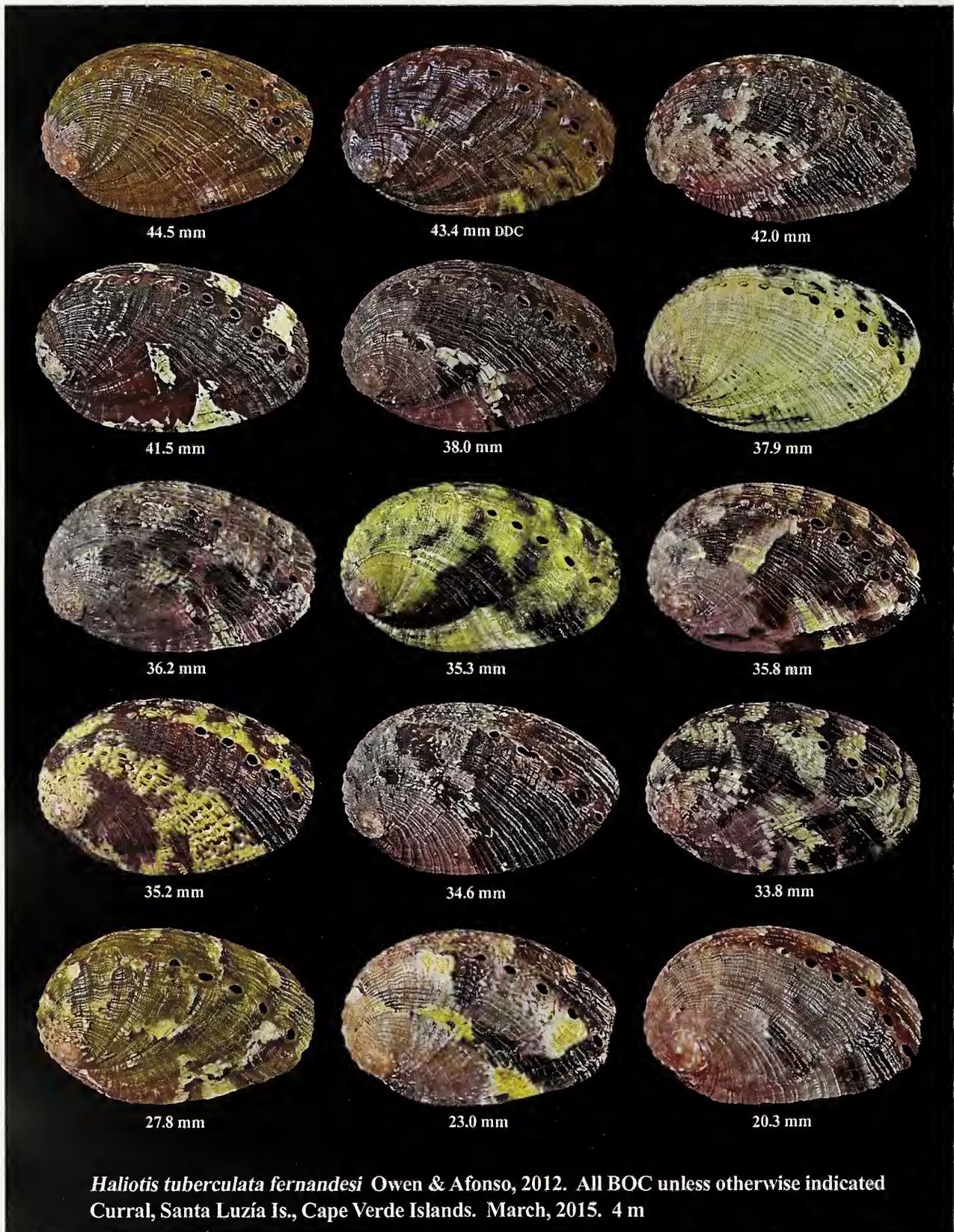


Plate 2. *Haliotis tuberculata fernandesi* Owen & Afonso, 2012. Buzz Owen Collection. Curral, Santa Luzia Is., Cape Verde Is.

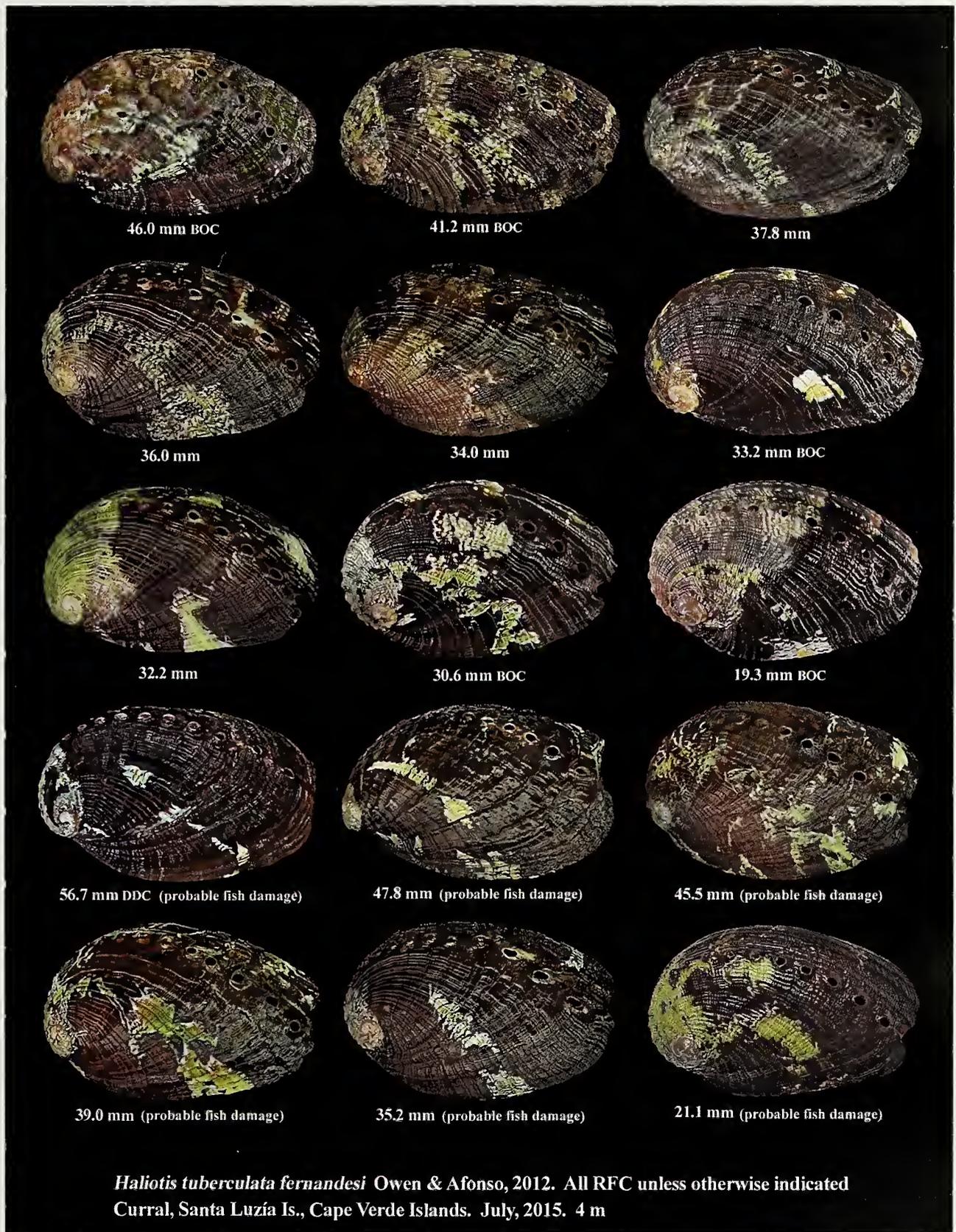


Plate 3. *Haliotis tuberculata fernandesi* Owen & Afonso, 2012. Ramiro Fladeiro Collection. Curral, Santa Luzia Is.

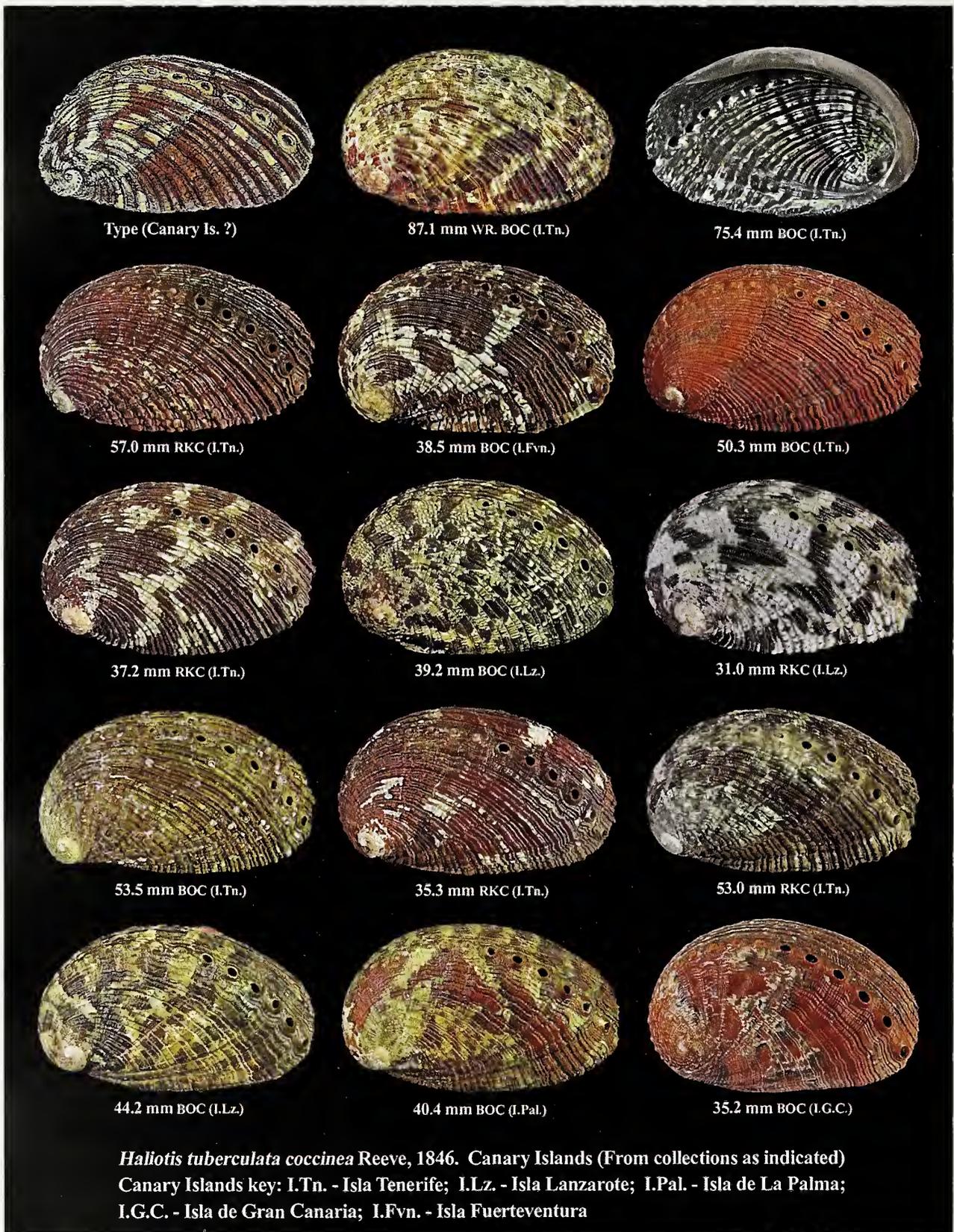


Plate 4. *Haliotis tuberculata coccinea* Reeve, 1846. Canary Islands.

Jaspidiconus: what are the options?

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ABSTRACT The number of species of *Jaspidiconus* recognized in three recently published works are compared. These references varied in the number of species recognized as valid ranged from 6 to 36 taxa. Using a metric, Percentage synonyms, the degree to which taxa are lumped was measured. The Percentage synonyms varied from 0 in the base document to 69% and 56% in the other documents. Such variation among publications by different authors suggests that morphological species concepts are too subjective to allow direct comparisons among publications or identification of valid species. In contrast, use of molecular methods may avoid the problems of the subjective morphological species concepts. However, molecular methods are only valid when they are applied to geographically coded samples to arrive at clades in the phylogram. Use of molecular methods for samples that have previously been identified to taxon by morphological methods is biased by the need to identify samples to species first to obtain a phylogram.

KEYWORDS Morphological species concepts, *Jaspidiconus*, metric comparisons, western Atlantic.

INTRODUCTION

I enjoyed David Berschauer's Iconography of the *Jaspidiconus* and the comparison of the Cape Verde *Africonus* 'species flock' in the eastern Atlantic and the large number of potentially valid species of *Jaspidiconus* in the western Atlantic (Berschauer, 2015). He noted that the two were similar in that they have paucispiral protoconchs suggesting that they do not have extended dispersive larval stages. Normally this situation is taken as evidence that snails with this sort of protoconch do not have as good dispersal abilities when compared to snails with multispiral protoconch and supposed longer free floating larval stages (see Berschauer's discussion). The length of the larval periods associated with various protoconch morphologies is for the most part unknown so any assumptions made are hypotheses but seem to be reasonable ones. I would like to have seen comparisons between *Jaspidiconus* and other genera (e.g., *Kohniconus*

and *Dalliconus*) of Conilithidae (see Tucker & Tenorio, 2009 and 2013) most of which have multispiral protoconchs and with others such as *Perplexiconus* and *Coltroconus*, two conilithid genera along with *Artemidiconus* of the Conorbidae all of which have paucispiral protoconchs, but are not considered here. These last three genera all have relatively few species even if suggested synonyms are listed as valid. The last two also have relatively restricted ranges (i.e., mostly in Brazil) compared to *Jaspidiconus*. What this means, I think, is that dispersal ability is not the only determinant of the number of species that any particular genus will produce. However, biogeographic influence on systematics is not the purpose of this paper. Rather, it is to show exactly how little we actually know about all of these species of *Jaspidiconus*. I intend to do this by using Berschauer's (2015) most recent account and comparing it to accounts by other authors from the 21st century. Given the assumption that we know what we are talking

about, these species lists should more or less agree with each other. After all, we are all looking at the same shells.

MATERIALS

I am using Berschauer's (2015) Iconography as a guide to possibly valid species based on the biogeographic provinces of Petuch (2013). I am also listing the species as either valid species or synonyms from Tucker & Tenorio (2013) and from Kohn (2014). Geographically, Tucker & Tenorio (2013) cover all of the provinces and subprovinces listed by Berschauer (2015). Kohn (2014) excluded the Brazilian provinces recognized by Petuch (2013). I have selected this comparative material because it is easily available to collectors of cone shells. This list is admittedly somewhat biased because I was the coauthor of one of the three references that I surveyed. Other available references were not used because they cover smaller geographic areas (e.g., Tucker, 2012). Others (e.g., Abbott, 1974) are too old and do not include many of the newly described species of this last decade of systematic research on cone shells (see Table 1).

Because Kohn (2014) did not cover the entire western Atlantic region and did not have access to descriptions of many new species of *Jaspidiconus*, I have prepared a metric in Table 1 allowing Kohn's book to be compared to Tucker & Tenorio (2013). It uses 'Percentage synonyms' in order to judge degree of lumping (or splitting) (Table 1). A higher value indicates a greater degree of 'lumping' than does a lower value, which would indicate a greater degree of 'splitting'. The value for Percentage synonyms is 0% for the species included by Berschauer (2015). Berschauer (2015) did not list synonyms and all illustrated species were considered valid species.

DISCUSSION

Based on Percentage synonyms the book by Kohn (2014) most strongly lumps the various *Jaspidiconus* species together and at roughly twice the rate compared to Berschauer's listing. Kohn (2014) only discusses six species of *Jaspidiconus*. In contrast, Tucker and Tenorio (2013) took more of a splitters' approach to the species of *Jaspidiconus*. They listed 22 *Jaspidiconus* taxa. Kohn's 69% Percentage synonyms is about a third higher than is the 56% for Tucker & Tenorio (2013). The two percentage synonyms of 69% versus 56% for what are essentially the same species of *Jaspidiconus* indicates the general lack of congruence in the systematics of *Jaspidiconus*. It is further demonstrated by the relatively few taxa (6) used by Kohn (2014) compared to Tucker & Tenorio's (2013) 22 taxa and Berschauer's (2015) 36 taxa. Moreover for both Kohn and Tucker & Tenorio all of the Net changes are negative. In other words neither list species as valid that are not also listed as valid by Berschauer.

Such discrepancies may indicate that shell morphology cannot reliably be used to distinguish the species of *Jaspidiconus*. Apparently competent or expert students of cone shells can differ by as much as 50% in the number of valid species of *Jaspidiconus* that they recognize. There is no objective way to evaluate these classification schemes. Obviously, use of shell morphology as a basis for identifying species of *Jaspidiconus* will require precise identification and definition of shell morphological traits.

One possible method that may help clear up the systematics of the *Jaspidiconus* is use of DNA or RNA from mitochondrial genes. A preliminary tree (subtree A. Kohn, 2014, p. 420) included four taxa of the *Jaspidiconus* including

J. stearnsii, *J. mindanus*, *J. jaspideus*, and *J. pealii* (species nomenclature follows Kohn, 2014). This tree is not of much use because it includes only four of the 36 taxa that Berschauer (2015) listed as potentially valid species. A better approach may be to completely ignore the possible taxation as an identifier but instead use as many individuals from the many provinces and subprovinces without using taxon as an identifier. If there is more than one taxon, then these should show up in the trees as separate clades. The clades can be judged on this basis and on the possible relatedness of the various geographically defined taxa. Once sufficient individuals are processed, the known clades can be matched to the morphological species. Molecular genetics cannot work so long as all the factors including geographic origin are not included in the analysis. It is not possible to construct trees from animals already identified to species prior to producing the tree without introducing collector bias. Puillandre *et al.* (2014) demonstrates the value of approaching a species level problem using many individuals identified where they came from rather than being identified by subjective shell morphological traits.

ACKNOWLEDGEMENTS

I thank David P. Berschauer for discussions of the *Jaspidiconus* problems. Dr. Edward J. Petuch kindly provided me copies of his books and reprints of his papers. Dr. Manuel J. Tenorio discussed the status of the recently described species of *Jaspidiconus*.

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Table 1. Comparisons of the systematics of *Jaspidicomus* in publications by Berschauer (2015), Kohn (2014) and Tucker & Tenorio (2013).

Berschauer species	Subprovince	Endemic to	Kohn	Net change	T & T ⁵	Net change
<i>pfluegeri</i>	Georgian	Not endemic	<i>J. pealii</i>	-1	<i>J. jaspideus ssp</i>	-1
<i>fluviamaris</i>	Floridian	Not endemic	Not included		<i>J. fluviamaris</i>	
<i>pealii</i>	Floridian	Florida Keys	<i>J. pealii</i>		<i>J. jaspideus ssp</i>	-1
<i>vanhyningi</i>	Floridian	Not endemic	<i>J. jaspideus</i> ¹	-1	<i>J. vanhyningi</i>	
<i>mindanus</i>	Floridian etc	Not endemic	<i>J. mindanus</i> ⁴		<i>J. mindanus</i>	
<i>stearnsii</i>	Suwannean	Suwannean Subprov.	<i>J. stearnsii</i> ²		<i>J. jaspideus ssp</i>	-1
<i>mindanus bermudensis</i>	Bermudan	Bermuda	<i>J. mindanus</i>	-1	<i>J. mindanus ssp</i>	
<i>branhamae</i>	Bahamian	Abacos	<i>J. pealii</i>	-1	<i>J. j. pealii</i>	-1
<i>exumaensis</i>	Bahamian	Exuma Sound	Not included		<i>J. j. pealii</i> *	-1
<i>herndli</i>	Bahamian	Great Bahama Bank	Not included		<i>J. herndli</i> *	
<i>nodiferus</i>	Bahamian	Not endemic	<i>J. jaspideus</i>	-1	<i>J. j. pealii</i>	-1
<i>oleiniki</i>	Bahamian	Bimini Chain	Not included		<i>J. j. pealii</i>	-1
<i>verrucosus</i>	Bahamian	Not endemic	<i>J. jaspideus</i>	-1	<i>J. j. pealii</i>	-1
<i>agassizii</i>	Antillean	St. Croix	Not included		<i>J. m. mindanus</i>	-1
<i>anaglypticus</i>	Antillean	Puerto Rico	<i>J. pusio</i>	-1	<i>J. anaglypticus</i>	
<i>berschaueri</i>	Antillean	St. Maartin	Not included		<i>J. berschaueri</i> *	
<i>duvali</i>	Multiple	Guadeloupe	<i>J. pusio</i>	-1	<i>J. pusio</i>	-1
<i>mackintoshi</i>	Antillean	Virgin Islands	Not included		<i>J. m. mindanus</i>	-1
<i>alexandremonteiroi</i>	Nicaraguan	Cayos Miskitos	Not included		<i>T. ceruttii</i> *	-1
<i>allamandi</i>	Nicaraguan	Roatan Island	Not included		<i>J. allamandi</i>	
<i>roatanensis</i>	Nicaraguan	Roatan Island	Not included		<i>J. roatanensis</i>	

<i>sargenti</i>	Nicaraguan	Roatan Island	Not included		<i>J. j. jaspideus</i>	-1
<i>acutimarginatus</i>	Venezuelan	Not endemic	<i>J. jaspideus</i>	-1	<i>J. j. jaspideus</i>	-1
<i>jaspideus</i>	Multiple	Not endemic	<i>J. jaspideus</i>		<i>J. j. jaspideus</i>	
<i>arawak</i>	Grenadian	Grenadine Islands	Not included		<i>J. arawak*</i>	
Subtotal		0/36		-9/13		-14/25
Percent synonyms		0%		69%		56%
<i>pusio</i>	Multiple	Not endemic	<i>J. pusio</i> ³		<i>J. pusio</i>	
<i>damasoi</i>	Cearaian	Ceara coast	Not included		<i>J. damasoi</i>	
<i>damasomonteiroi</i>	Cearaian	Not endemic	Not included		<i>J. damasomonteiroi*</i>	
<i>ericmonnieri</i>	Bahian	Bahian Subprovince	Not included		<i>J. ericmonnieri*</i>	
<i>henckesi</i>	Bahian	Todos os Santo Bay	Not included		<i>J. henckesi</i>	
<i>marinae</i>	Bahian	Porto Itaparica Is.	Not included		<i>J. marinae*</i>	
<i>ogum</i>	Bahian	Aratuba, Itaparica Is.	Not included		<i>J. ogum*</i>	
<i>pomponeti</i>	Bahian	Todos os Santo Bay	Not included		<i>J. pomponeti*</i>	
<i>poremskii</i>	Bahian	Bahia State	Not included		<i>J. poremskii*</i>	
<i>pusillus</i>	Multiple	Brazilian Province	<i>J. pusio</i>	-1	<i>J. pusio</i>	-1
<i>simonei</i>	Paulian	Not endemic	Not included		<i>J. simonei*</i>	
Number of taxa		36		6		22
Deviation				-10		-15

* indicates species that are discussed on the *Illustrated Catalog of Living Cone Shells* web site (www.conecatalogupdate.com/taxa-described-in-2014). Most of them are accepted as tentatively valid species pending further study. However, they were not included in the printed version of Tucker & Tenorio (2013).

1. Kohn included *sulcatus* Mühlfeld, 1816; *corrugatus* Sowerby II, 1870, *verrucosus piraticus* Clench, 1942; *pseudojaspideus* Nowell-Usticke, 1968 as synonyms of *J. jaspideus*.

2. Kohn included *stictus* A. Adams, 1854, as an unused senior synonym for *J. stearnsii*.

3. Kohn included *minutus* Reeve, 1844; *crebrisulcatus* Sowerby II, 1857, and *boubeae* Sowerby III, 1903 as synonyms of *J. pusio*.

4. Kohn included *elventinus* Duclos, 1833, *rosaceus* Sowerby I, 1834, *cretaceus* Kiener, 1847, *lymani* Clench, 1942, and *karinae* Nowell-Usticke 1968 as synonyms of *J. mindanus*.

5. "T & T" is Tucker and Tenorio, 2013.



Comparison plate: *Jaspidiconus vantwoudti* new species herein by Petuch, Berschauer and Poremski, 2015. Additional specimens from the André Poremski collection. Top row: 11.8 mm and 12.1 mm; middle specimen 13.4 mm; bottom row: 12.5 mm and 12.9 mm. Specimens collected at Arashi Beach, Aruba, in coarse rubble at 6 to 8 feet of water in a high wave action environment. Photos by André Poremski.



Have a shell collection you would like to sell?

The San Diego Shell Club is interested in high quality estate collections comprised of any and all types of shells, marine or land, and all genera and species. Your shells will be used to generate income to support the Club's efforts in continuing public education about shells and conservation of marine life throughout the world. If you have considered selling your collection to a dealer and were unhappy with the offer, then please contact Dave Waller, SDSC Acquisition Chairperson, at dwaller@dbwipmg.com to schedule a time to review your collection and provide you with another offer to consider.

CLUB NEWS

July 16, 2015, Regular Meeting, held at Casa del Prado

Meeting called to order at 7:30 p.m.

- Prior minutes were read and accepted.
- Treasurer's report was presented, followed by social media and the Editor's report.
- Announcements were made about the August Shell Show & Sale, and the September party.
- David Waller and Paul Tuskes reported on the success of the Club's exhibit at the Fair.
- Paul Tuskes introduced Paul Valentich-Scott and made a presentation of the Club's "Festivus Award" for outstanding lifetime achievement in malacology to Paul Valentich-Scott and Eugene V. Coan.
- Thereafter Paul Valentich-Scott gave a fascinating presentation on the future of bivalve research, with a Power Point presentation and extensive color images.
- The door prize was won by Marilyn Goldammer.

Meeting adjourned at 9:15 p.m.

August 16, 2015: No Regular Meeting. Shell Show & Sale in Balboa Park.

September 13, 2015: No Regular Meeting. September Party.

Orchids in the Park

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The shell exhibit and sale at Balboa Park on Sunday the 16th of August was a big success from all perspectives. Many new members who had joined after the San Diego Fair came to visit, tell stories and purchase shells, and then enjoy the park. Members present included: Marty Schuler, David Berschauer, Rick Negus, Paul Tuskes, Robyn Waayers, Rob Martinsen, Bob Abela, Larry Catarius, and Dennis and Laura Willoughby. David Berschauer, Marty Schuler and Paul Tuskes had shell displays and educational information. Rick and Cheryl Negus, and Rob Martinsen had a wide variety of shells



for sale. The Club also had some books and a “one dollar table” of shells for sale. Members enjoyed visiting with each other, and I may have found a new dive partner. We also spent a great deal of time talking to the hundreds of visitors who came in to see the shells and talk about their experiences. The dollar table was a hit with both adults and children. Special events like this are not only good publicity and attract new members, they also give current members a chance to visit and share experiences. If you were a couch potato that weekend ... you missed the boat.

Sunny September Party

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Silvana Vollero graciously held this year's annual end of summer party at their lovely home in San Diego, on Sunday, September 13, 2015. The weather gods were kind to us as we had a nice sunny day; it is southern California after all. There was a fantastic turn out, with over 30 Club members, their spouses and children in attendance. Fantastic home made food, beverages, deserts, and comradery and conversation were enjoyed by all. Needless to say shells and shell books made an appearance at the party. Silvana and Bob were wonderful hosts, and we thank them for hosting an enjoyable get together.



William Swainson F.R.S., F.L.S.

Mary Agnes Wotton, Wellington Shell Club
ma.wotton@xtra.co.nz

Most shell collectors are familiar with the name of Swainson in connection with conchology but like myself, might not have been aware of his reputation as an unsurpassed illustrator of birds, molluscs, plants and other natural creatures, not to mention his sketches made of places visited during his career with the Commissary-General (Supply Corp) of the British army of occupation based in Palermo, Italy (1806-1815). His sketches of Wellington, to which he emigrated with his family in 1841, are some of the most valuable pictorial records of the city's earliest years.



William, in his own words, had “*a passion for natural history even when a small child; and every spare moment I could command was divided between drawing and collecting.*” His father John Timothy Swainson, a Collector of Customs, in his spare time was a naturalist and a foundation member of the Linnean Society. During his time in the army, William amassed vast collections from Mediterranean countries which he visited, studying zoology and botany in his spare time and making sketches of shells, fishes, birds and flowers as well as landscapes. Ill health caused him to retire from the army and on his return to England he began pursuing his interest in natural history more seriously and became a Fellow of the Linnean Society. Supported by Sir Joseph Banks, he was also elected a Fellow of the Royal Society in 1820.



In 1815 Swainson went on a three year expedition to Brazil, again amassing considerable collections especially of shells, insects, birds and ferns. However, on his return to England he was largely ignored by the scientific community in spite of his membership in the Linnean Society – he was an amateur naturalist who had collected unscientifically for the trade in natural curiosities. He had “a portfolio of drawings, representing the most striking and picturesque and vegetable scenery, together with maps of the different routes pursued.” It was printed without any comment, or one word of praise. “*I abandoned all intention of publishing them in a separate work. I was discouraged by the idea, that the unpatronised researches of an unknown individual might probably be thought insignificant, when compared to those of naturalists sent out by governments, and which the editor lavishly praised in the same number of his Journal.*” He mentions this to show how the feelings of young authors may be influenced and their “energies repressed”. As he had no academic qualifications, in 1820 Swainson to his acute disappointment, was passed over for a position as a keeper at the British Museum for which he had applied, although he had impressive testimonials.

In 1820 Swainson met Mary Parkes at the Mayor's Ball in London, attended by 900 people. She was an inveterate writer and kept a Pocket Book diary at this time where she recorded her meetings with Swainson. On 29 Nov. she wrote "*We spent three hours with Mr. Swainson and Mrs. Traill was with us, looking over his rich collection of shells, insects and birds. No gratification can be higher than that of being allowed to participate in the enjoyments of a mind so rich and elegant as his. His shells are most choice and picked and he possesses many which he believes are solely his. The cardiums are magnificent and most choice. The cypraeas are a great pride to him for he has a beautiful series of old and young of this species. For the spindle shell he has been offered thirty pounds and if he had bought two of his cardiums they would have been worth five pounds each. The nautilus is the largest ever seen is worth twenty guineas and the wentle trap is magnificent. The turbo's are most beautiful and the pecten's – in short – all.....*"

Around this time Swainson's friend John Audubon, the world's finest bird artist, introduced him to the new technique of colour lithography. He began experimenting with the process as "something that might be used in producing zoological plates fit for colouring". This he brought to a high degree of artistic excellence. He worked hard for long hours. 1820 saw the publication by Longman of his "Treatise of Malacology: or, the natural classification of shells and shell fish". "Zoological Illustrations of new, rare or interesting Animals...from the classes of Ornithology, Entomology and Conchology" was published in 1821, the first of three volumes. It was produced in a series of monthly parts for which he paid himself and it was well received. The final volume was published in 1823. Swainson had already started working on his "Exotic Conchology", unable to issue more than four parts of the first edition in 1821-1822. A re-issue was published in 1834 with 16 additional plates and the second edition appeared in 1841, the year he emigrated to New Zealand. Original copies of this work are currently available between US\$4,800 and US\$7,600.

Swainson married Mary Parkes in 1823, his half-brother the Rev. Mr. Charles Swainson officiating, beginning the happiest and most productive years of his life. In 1828 the two spent 3 months in France, her parents looking after the two children, Willie born in 1824 and Mary in 1826. John Audubon, accompanied them to France where most of their time was spent in Paris with Swainson regularly visiting the Museum. Mary Parkes kept a journal of their visit with the following entry for Oct. 7, 1828: "*I again went to the Musee and at three o'clock we went to the Prince Massena's to see again his rich cabinets of birds and shells. The latter are truly magnificent in their perfection, for they were Lamarck's and the Prince gave trente mille cent francs for the whole, and he is perpetually adding to it. It is not only one fine specimen of a species, but in most instances several fine specimens of the same shell. Where he has not the species, he places a drawing, and this is particularly the case with the Cones which is a most extensive collection, contained in two long divisions, on each side one range of drawers. I counted one hundred and sixty drawers. The shells are gummed on pieces of book binders board, coloured white, and each row divided by a strip of black wood; the Pictens were most beautiful, and the Patella were of surprising polish.*"

At the age of 45, Swainson was at the height of his scientific career and looked forward to extending his reputation as one of the world's leading naturalists then in February 1835, a year later, his beloved wife Mary died leaving him devastated and with five children to bring up. Everything seemed to be going adversely against him – his advocacy of the quinary system, an unaccepted

method of zoological classification, was ridiculed and his fortunes in other directions plummeted too. He became disillusioned and critical of the British scientific establishment which had failed to embrace his ideas, all of which inclined him to think there was no future for him and his family in England. It was then that he finally decided to emigrate to New Zealand. William was elected a member of the First Colony of New Zealand, and the New Zealand Land Company, as it was then called. He was also a member of the Church of England committee for the appointment of a bishop to New Zealand. Except for his shell collection and other less perishable objects, his other collections were sold to raise necessary funds.

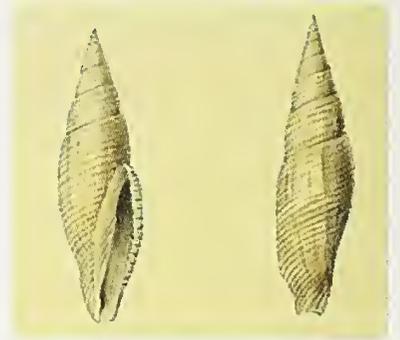
William had advertised for a governess and engaged a Miss Ann Grasby. However, the New Zealand Company had strict views about unattached gentlewomen aboard ship and refused permission. A man might emigrate perfectly decorously with a wife in tow but not with a governess-help. William decided to marry her in spite of the children's opposition and Ann became William's second wife. They set sail for New Zealand in 1840. But Swainson's troubles had just begun.

Arriving at Port Nicholson on 24 May 1841 with his second wife and four of his children – the youngest Edwin was left in Gibraltar with foster parents – Swainson decided to live in Wellington, settling for the time being at High Cliffs, a house belonging to a Mr. Watt “at the further extremity of town”. William's dream of pursuing his scientific interests at leisure in the new colony may have earned him near enough to a free passage, but there was small chance of realizing them: there was quite simply far too much to do. The family lived at Thorndon in the city for two years while their house was being built on property purchased in the Hutt Valley. The floors of the house, called Hawkshead after the Swainson family's sometime ancestral village in Westmoreland, England, were laid down in January 1843. The doors and windows were still in Hokianga, having been delivered there as it was the Swainson's original destination. It was not until June of the same year that the family moved into their home on the banks of the Hutt River. By 1846 he was well settled in the Hutt Valley but after two laborious years, only a small portion of the property had been cleared of bush.



Though he worked habitually on his own, William had joined prestigious societies, readily accepting honorary membership on an impressive list of scientific bodies. But he considered science dead in this country – or at least stillborn. To make ends meet, Swainson sold off large collections which he had left behind in England but bad luck followed as a consignment of lithographic plates was wrecked off Cape Terawhiti and some of his bird and insect species decayed. He also had trouble with the Maoris relating to his occupation of the Hutt land. Finally when this was sorted out, he had a bit more time to devote to his old studies. He wrote to the naturalist Walter Mantell in October 1846:

"I seem now to have exhausted the Valley of the Hutt, as far as I can ramble therein, so that now I am directing my attentions to the inhabitants of the ocean, namely Shells.Animal Life is as little developed on New Zealand Islands as are honest men. To be serious, the land is geologically new, but then the Ocean is as old as the Creation and therefore should abound with animal forms peculiar to that element.... In England, for instance, we have but four species of Patella (limpets) while on the Port Nicholson rocks I have already found seven besides a new Syphonaria, other localities will no doubt possess other species, particularly as the rocky nature of all the Coasts are peculiarly adapted to these adhesive Molluscs. Mr. Taylor, also, stimulates me to a Conchology of New Zealand..." But in his usual fashion, he bit off more than he could comfortably chew: the conchology of New Zealand, the treatise on Adhesive Molluscs and the zoological chapter for the Acheron book – all remained unwritten.

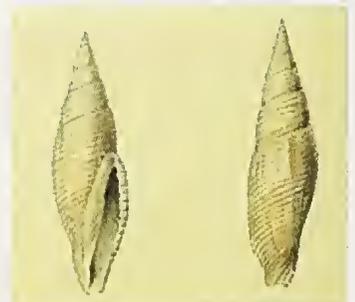


Misfortunes continued for Swainson when in February 1848, a fire destroyed much of Hawkshead. Lack of money was a constant issue for Swainson and in 1851 he sailed on the survey ship Acheron to Australia to arrange the sale of some land he owned. In August he received a letter from Walter Mantell advising him of his election as an honorary member of the NZ Royal Society. He replied *"....This is the first intimation I have received that such a Society was in being, or that there existed in Wellington generally, the slightest regard or appreciation for scientific pursuits."* His letter was quite scathing and he declined the honour. Swainson remained in Australia until 1854 doing botanical surveys for the Victorian government.



On December 7, 1855, Swainson died of heart failure at his home in the Hutt Valley, living out the latter part of his life in hardship, toil and frustration in a society that set little store by his skills. His grave is among the trees behind the Lower Hutt Library. Many of his papers, letters and mementoes were destroyed by his widow. Swainson helped swell the collections of many European museums, where other biologists put his specimens to better use, including Charles Darwin. Swainson named a number of molluscan species particularly in Mitridae Swainson, 1829, including *Mitra carbonaria* Swainson, 1822 from Australia and New

Zealand, and one in his genus *Cancilla* Swainson, 1840. His friend Broderip named one after him – *Mitra swainsonii* Broderip, 1836. *Canarium mutabile* (Swainson, 1821) and *Theristrombus thersites*, (Swainson, 1823) both Strombiidae from the Kermadec Islands were named by Swainson as also *Janthina globosa* Swainson, 1822. Originally named by Marwick, *Alcithoe swainsoni*, became a synonym of *Alcithoe arabica* (Gmelin, 1791). Several bird species have been named for Swainson by various scientists including Audubon.



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Shelling on the Gulf Coast of Florida (Part 1 of 2)

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In early January of this year, I was finally able to make a trip I've been thinking of since childhood - a trip to the beaches of Florida for shelling. We focused on the Gulf Coast, choosing a motel that served as home base in Englewood, Florida (which is a little bit north of Fort Myers). We then took day trips to points north and south from there. I made a point of doing some homework in advance of the trip regarding rules and regulations pertaining to shell collecting. I highly recommend this page of the Florida Fish and Wildlife Conservation Commission's web site, outlining the regulations concerning recreational shell collecting: <http://myfwc.com/fishing/saltwater/recreational/sea-shells/>.

Florida has a lot of excellent State Parks and other well-maintained natural areas along the Gulf Coast. No live shelling is allowed in the state parks, and other localities restrict live shelling as well, such as Sanibel Island. If one arrives before low tide, one has a chance to still find many nice specimens of empty shells in these localities. The competition is pretty fierce, though, and the beaches quickly fill up with eager bag-toting shellers!

Day One: We explored a bit in the Englewood area in the afternoon (after a red-eye flight from San Diego the night before!). Manasota Key has nice gulf-facing beaches, but also has public access to Lemon Bay, which is sandwiched between the key and the mainland. One can explore the shallow water near the mangroves on the bay side, and many interesting mollusks can be found here. The light was failing when we explored the bay side on this day, but immature Florida crown conchs were "hanging out" on the muddy beach and in the shallow water. One appeared to be feeding on a mysterious object that might have been an old octopus's arm.



Melongena corona, Florida Crown Conch, Manasota Key, Florida.



Melongena corona, Florida Crown Conch, Manasota Key, Florida.

Lightning whelks were common on the bay side as well, some feeding on the numerous oysters that are thick at the base of the mangroves.



Sinistrofulgur sinistrum, Lightning Whelk, Manasota Key, Florida

Day Two: This was our Sanibel Island day, but we unwisely got a slightly late start in the morning and arrived at Lighthouse Beach on Sanibel about 10 minutes past the peak low tide (which was around 8:30 a.m.). At that point the hoards of shellers who got there earlier had scooped up most of the easy-to-find empty shells. There were many live mollusks on the sand bars exposed by low tide, though, so I focused on photography of them, as opposed to collecting.



Bulla occidentalis, Atlantic Bubbles, Lighthouse Beach, Sanibel Island, Florida.



Immature *Strombus alatus*, Florida Fighting Conch. This beach had many live immatures, and we saw no adults. Lighthouse Beach, Sanibel Island, Florida.



Live *Phrontis vibex*, Bruised Nassa. Lighthouse Beach, Sanibel Island, Florida.



Americoliva sayana, Lettered Olive, burrowing in the sand. Sometimes These olives leave shallow trenches several inches long on the sand. Lighthouse Beach, Sanibel Island, Florida.



Live Lettered Olives, a very common species. Lighthouse Beach, Sanibel Island, Florida.



A colorful live *Ficus communis*, Paper Fig Shell. Lighthouse Beach, Sanibel Island, Florida.



Strioterebrum dislocatum, the Eastern Auger. Many immatures of this species were burrowing in the sand. Lighthouse Beach, Sanibel Island, Florida.

Before leaving Sanibel, we paid a visit to Gulfside Park and its adjacent beach. I brought snorkeling equipment and decided to give it a shot at this beach, but the water was so turbid that visibility was essentially zero. The beach itself was littered with Rigid Pen Shells, most in fairly poor condition. Sea whips had washed up, but none with simnias attached. Ponderous arks were scattered along the wrack line, also, which are extremely common in Florida, but I was happy to scoop up some with both valves intact and the mossy periostracum present.

We left Sanibel in the early afternoon, as I wanted to explore Manasota Key in the daylight more. We had several hours to do just that, and found a large banded tulip, more lightning whelks and Florida crown conchs on the bay side. Stay tuned for Part 2 in the next issue of *The Festivus*. (End of Part 1 of 2)



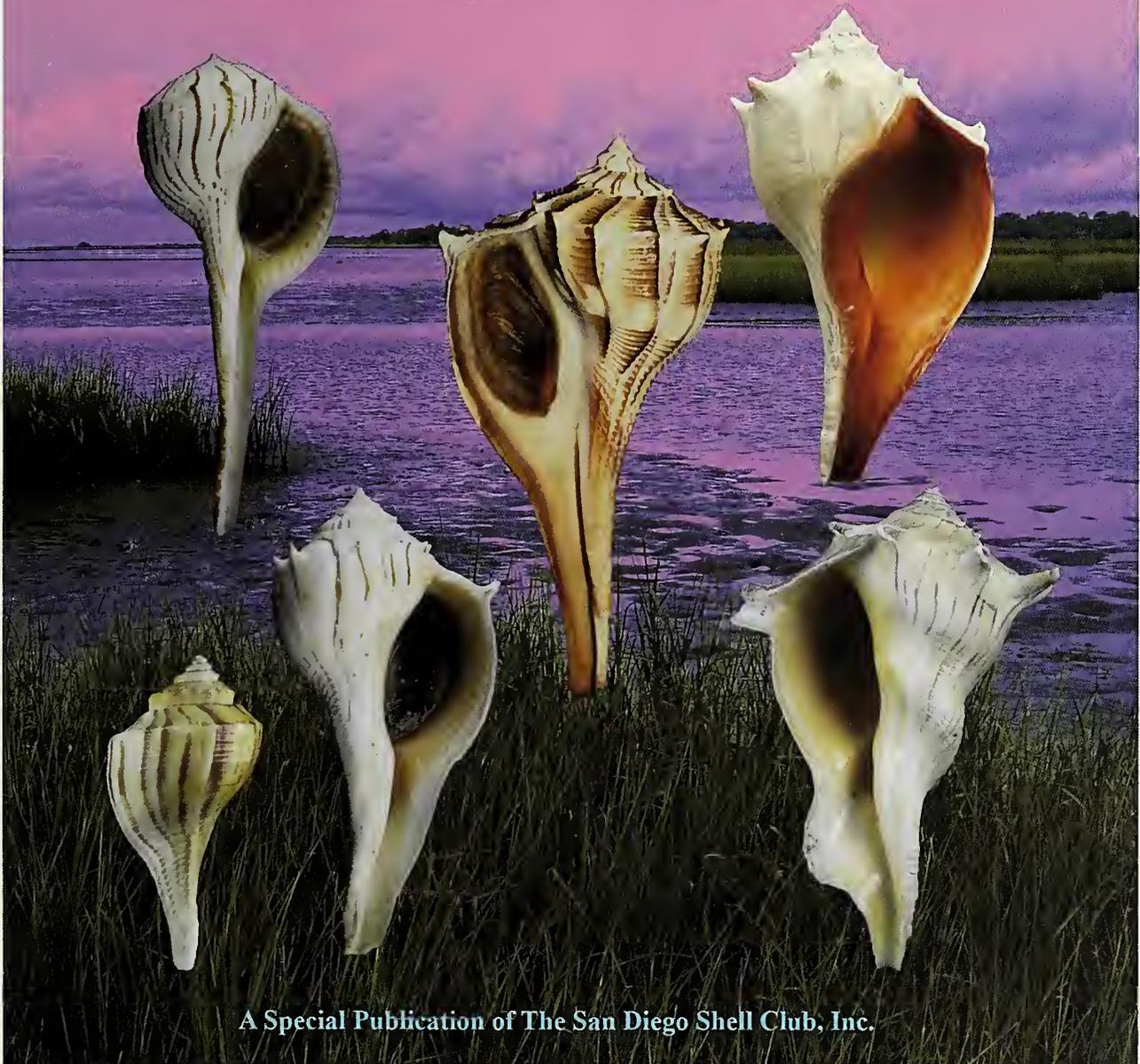
Cinctura hunteria, Manasota Key, Florida.



Sinistrofulgur sinistrum, Manasota Key, Florida. A younger individual, with more distinct markings.

The Living and Fossil Busycon Whelks: Iconic Mollusks of Eastern North America

Edward J. Petuch, Robert F. Myers, and David P. Berschauer



A Special Publication of The San Diego Shell Club, Inc.

Published October 2015 by The San Diego Shell Club. This book presents a taxonomic revision of the “Busycon whelks” with detailed information on 6 living and 8 extinct genera belonging to 4 subfamilies, and 17 recent and 112 fossil species, together with distribution maps and over 100 color figures. Priced at \$80.00 plus shipping costs.

Congratulations for excellent field work!

The Editors would like to take this time to congratulate Leo G. Ros and Monica Moron of Aruba for their excellent field work as amateur malacologists in discovering three new endemic species of cone snails in Aruban waters in the last three years: *Perplexiconus wendrosi* Tenorio & Afonso, 2013, *Tenorioconus monicae* Petuch & Berschauer, 2015, and *T. rosi* Petuch & Berschauer, 2015.



Leo G. Ros, of Noord, Aruba is the founder of the Aruba Shell Club (est. 2012) and is an avid naturalist and molluscan explorer who discovered three new cone species and, through his extensive diving and exploration around the island, has greatly contributed to our knowledge of the Aruban molluscan fauna.

Monica Moron of Noord, Aruba (originally from Punto Fijo, Venezuela) studied graphic design at Instituto Universitario de Tecnologia Rodolfo Loero Arismendi (Iutirla), and has been interested in shells since childhood as her family and neighbors in Venezuela were fishermen. Monica is an avid amateur naturalist and one of the co-discoverers of these new cone snail species.



Perplexiconus wendrosi



Tenorioconus monicae



Tenorioconus rosi



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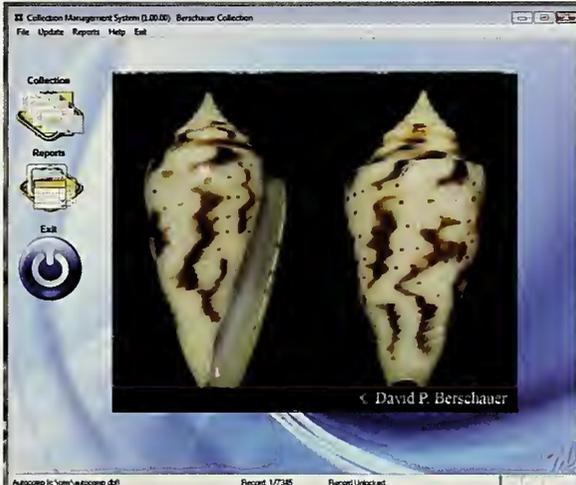
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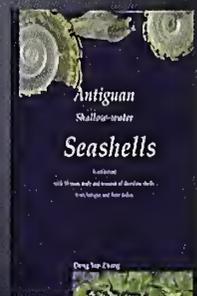
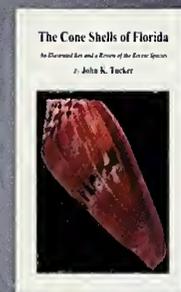
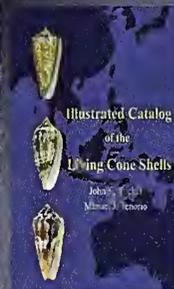
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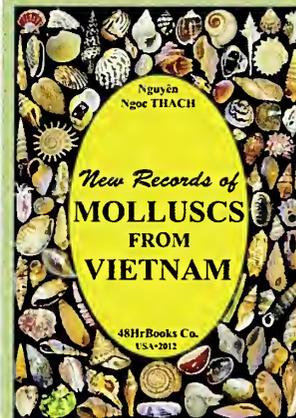
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